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**THE EFFECTS OF CREW RESOURCE MANAGEMENT (CRM)
TRAINING IN AIRLINE MAINTENANCE:
RESULTS FOLLOWING THREE YEAR'S EXPERIENCE¹**

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JUL 28 1995
CASE

THE EFFECTS OF CREW RESOURCE MANAGEMENT (CRM) TRAINING

IN AIRLINE MAINTENANCE:

RESULTS FOLLOWING THREE YEAR'S EXPERIENCE

Report of Work Completed through 12-31-94

SUMMARY

This report describes three year's evaluation of the effects of one airline's Crew Resource Management (CRM) training operation for maintenance. This evaluation focuses on the post-training attitudes of maintenance managers' and technical support professionals, their reported behaviors, and the safety, efficiency and dependable maintenance performance of their units. The results reveal a strong positive effect of the training.

The overall program represents the use of CRM training as a long-term commitment to improving performance through effective communication at all levels in airline maintenance operations. The initial findings described in our previous progress reports are reinforced and elaborated here. The current results benefit from the entire pre-post training survey, which now represents total attendance of all managers and staff professionals. Additionally there are now full results from the two-month, six-month, and 12-month follow-up questionnaires, together with as many as 33 months of post-training performance data, using several indicators.

In this present report, we examine participants' attitudes, their reported behaviors following the training, the performance of their work units, and the relationships among these variables. Attitudes include those measured immediately before and after the training as well as attitudes of the participants months after their training. Performance includes measures, by work units, of on-time flight departures, on-schedule maintenance releases, occupational and aircraft safety, and efficient labor costs. We report changes in these performance measures following training, as well their relationships with the training participants' attitudes.

Highlights of results from this training program include increased safety and improved costs associated with positive attitudes about the use of more assertive communication, and the improved management of stress. Improved on-time performance is also related to those improved attitudes, as well as favorable attitudes about participative management. More specific results are as follows:

1) We note positive trends in a number of the company's overall maintenance performance indicators for the months after the onset of training (variously 27 to 34 months, depending on the measure), compared with the months before (varying from 5 to 17 by measure). Measures in the Safety Performance category improve in the 32 months measured after the training. In addition, results in the Dependability Performance category continue to improve in the 27 months measured after the onset of training. The available measure for Efficiency also shows generally effective performance during the first 18 months following training, but then performance slips for the remaining 16 months measured.

2) Comparisons of managers' attitudes immediately after their training, with their pre-training attitudes, show significant improvement for most of those expected. Improvement is noted in attitudes about "willingness to share command responsibility," "usefulness of communication & coordination," and "recognition that stressors effect management decision making." The same attitudes of these managers two-, six-, and 12-months later, reveal that these favorable post-training attitudes remain at those high levels in the months after the training. The fourth attitude scale measured, "willingness to voice disagreement" (a measure of assertiveness), although showing no significant change immediately following training, improved significantly above the pre-training levels two months after training and it remained at that higher level six and 12 months afterwards. The influence of the training on all the expected participant attitudes is thus a stable and robust change, and not merely a brief "honeymoon effect."

3) Other analyses of the data look at the relationships between pre-, and post-training attitudes and maintenance performance over several years. In this "time-lagged" correlation analysis we tested the effects for performance before the onset of the training program, before the subsequent surveys, and for effects on performance months after the training and/or follow-up surveys began.

We found a pattern of significant relationships between the participants' pre-training and post-training attitudes and performance. Attitudes about skills and behaviors specifically taught in the CRM training were more predictive of subsequent maintenance performance. Attitudes, immediately following training, about the value of communication & coordination, as well as about the "value of stress management," were found to be related to on-time scheduled maintenance performance both prior to and after the training began.

The strongest effects of CRM training appear on respondent attitudes two months after their training. Examination of that two-month follow up survey reveals that attitudes about sharing command responsibility, and about assertiveness (both of these are "active" beliefs emphasized in the training, and which require behavioral support to reinforce them), are related to subsequent on-time flight departures, and occupational safety. Attitude about sharing responsibility is also related to many months of timely maintenance work both before and after the training began. Overall, the correlations between performance and the attitudes measured in this two-month follow-up survey are remarkably strong and indicate that lessons learned from the CRM training have consolidated by two months afterward, and in "active" ways.

The six-month follow-up results show a retreat from the effects in the 2-month survey. The 6-month results reveal that only prior maintenance performance is related to surveyed opinions about delegation, communication and stress management.

By the 12-month follow-up survey, the CRM training effects have returned to mirror aspects of the post and 2-month surveys. Results of this later survey suggest that the lapse at 6 months probably represents a consolidation of the training effects rather than their elimination. Training participants continued to develop the skills they learned in CRM and used them to good effect. Attitudes about the value of assertiveness one year after CRM training were related to many months of occupational safety both before and after that survey was taken. Attitudes, a year after training, toward sharing command decisions were (reminiscent of the 2 month results) also related to many months of occupational safety. Finally, 12-month attitudes about managing stress effects were associated with improved performance in the very stressful performance areas of meeting ambitious goals for cost saving, and for timely maintenance. These findings strongly suggest that lessons of stress management, learned during training more than a year earlier, had also developed and matured for the training participants.

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Los Angeles, December 1994

THE STUDY

Background

The CRM program reported here is first-time training in several team-related concepts, including communication skills, self-knowledge, situational awareness, and assertiveness skills for maintenance management and support staff personnel in one large U.S. airline (hereinafter called "the company"). Maintenance (or "Technical Operations") in this company includes engineering, quality assurance, technical planning, systems & procedures, contracts administration and purchasing, as well as the more direct maintenance functions of line- and base-maintenance, inspection, shops and material services. The company succeeded in training all of its maintenance directors, managers, supervisors and assistant supervisors, engineers, planners, coordinators, and schedulers, as well as a large part of its inspection staff. According to company records, 2,199 people in total completed the CRM for Maintenance course between June 1991 and March 1994.

CRM training in airline maintenance operations was highly unusual when introduced into the present organization. This exceptional example has been intensively studied over a three year period. The first papers (*cf.*, Taylor, 1991a, 1991b) reported the methodological and measurement characteristics of the attitude and performance indicators we used. Subsequent reports have been limited to a relatively small sample of participants, and a small number of months of maintenance performance data subsequent to the training. A summary report of the first six months experience (prepared by Taylor, Bettencourt & Robertson, at the University of Southern California in 1992) was published in the FAA Office of Aviation Medicine's second annual human factors R&D progress

report (Galaxy, 1993); and a subsequent report on the first full year's experience (also prepared at the University of Southern California in 1993) has been included in the FAA Office of Aviation Medicine's third progress report (Galaxy, 1994). Several shorter papers dealing with selected topics from this study have also been published (Stelly & Taylor, 1992; Taylor, Robertson, Peck, & Stelly, 1993; Robertson, Taylor, Stelly, & Wagner, In Press). The present report concludes the evaluation of the company's initial program, by documenting the mutual effects between training-related attitudes and behaviors and work unit performance, as well as the persistence and stability of the attitude and behavioral changes following the training.

The effectiveness of this training, as measured by its ongoing evaluation, can help direct the airline industry's maintenance human resources practices in the future and guide the development of future ATA and FAA training policies and regulations.

The analyses reported below assess the relationships among respondents' training-induced attitudes about a variety of management and organizational items and maintenance unit performance.

The Purpose of the Program and of the Course.

The program's champion was the company's Senior Vice President for Technical Operations. He announced that his aim for the joint training and evaluation program was to improve human resource (HR) management by using science-based tools and techniques for evaluating the training outcomes and using those results for continuously improving the program's effectiveness (Fotos, 1991).

This particular training program originally began with advice and assistance from the company's flight operations training group who had nearly a decade's experience with their own CRM program. After that initial assistance, the company's flight operations and technical operations (i.e., maintenance) CRM programs were directed and administered separately. During the first three years of that maintenance CRM program it continued to be managed and administered by maintenance personnel, and the trainers were mainly maintenance people too.

The purpose of the training, as reiterated by trainers on the first day of each training session, was "To equip all maintenance personnel (management first) with the skill to use all resources to improve safety and efficiency."

Course objectives. The objectives (the more specific goals of the training) were also clearly stated during the trainers' introductory remarks:

- 1) Diagnose organizational "norms" and their effect on safety.
- 2) Promote assertive behavior.

- 3) Understand individual leadership styles.
- 4) Understand and manage stress.
- 5) Enhance rational problem solving and decision making skills.
- 6) Enhance interpersonal skills

The course was designed for the objectives. The aims and objectives of the training were achieved by following a course syllabus containing 12 modules (Appendix A contains the syllabus).

The first phase of training completed. By the conclusion of this phase of the CRM training intervention, in February, 1994, nearly 2,200 participants had attended the course. Called "the first phase" of training, it included all Technical Operations management and staff professionals, and it is the subject of this present report. During early 1994, the usual number of new hires or recent promotions to management ranks continued to attend the CRM course and those sessions were also attended, for a few months, by Aircraft Inspectors, as the beginning of a second phase which would include all mechanics and inspectors in the training. The present analysis uses data from the entire sample of maintenance management, salaried professional staff, and inspectors (n=2,199) who participated in the "first phase" training course between June 1991 and March 1994.

Individual respondents as the focus of analyses. To explore some of the effects of the training on all individuals, the data from all training participants will be used. The remaining (and majority of those) analyses, however, examine the attitudes of respondents who (through the use of their confidential code numbers) can be matched between the pre-training survey and the later ones.

Maintenance work units as the focus of analyses. The maintenance performance data (classified into categories of "safety," "dependability," and "efficiency") were measured by work units, not by individual respondents. The analyses described in this report illustrate the effect of changes in respondent attitudes upon the maintenance performance of their work-units. For managers these are the units they lead, and for staff professionals, maintenance foremen, and inspectors these units are the stations and locations to which they belong. In order to accomplish that examination of attitudes correlated with performance, the individual respondent's attitude data were combined into averages for the appropriate units.

The "Crew Resources Mgt/Tech Operations Questionnaire" (CRM/TOQ)

Prior experience in measurement of attitudes related to CRM training. The Cockpit Management Attitudes Questionnaire (CMAQ) has long been a recognized measure for assessing flight crew attitudes. It is useful as a training, evaluation and research tool (*cf.*, Helmreich, Foushee, Benson, & Russini, 1986). The 1990 CMAQ

questionnaire contained 25 items measuring attitudes that are either conceptually or empirically related to CRM. Taggart (1990) revised the CMAQ for use in a maintenance department, and reported positive initial results following CRM training conducted for maintenance managers in late 1989.

Two previous studies have explored the CMAQ instrument for a consistent internal structure using the Factor Analysis technique (Gregorich, Helmreich, & Wilhelm, 1990; Sherman, 1992). In these two studies, using samples of flight crews and air traffic controllers, the authors showed that the relationships among the 25 CMAQ items clustered into the following four constellations of attitudes:

- 1) Sharing Command Responsibility,
- 2) Value of Communication & Coordination,
- 3) Recognizing and Managing Stressor Effects,
- 4) Avoidance of Interpersonal Conflict

Gregorich, et al. (1990) eventually reduced their set from four to three composites by dropping "Avoidance of Interpersonal Conflict." 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." Those authors combined the individual CMAQ items into three or four composite index scales, respectively, 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.

Measurement of attitudes in the present study. The "Crew Resources Management/Technical Operations Questionnaire" (CRM/TOQ) developed for the present study is a modified version of Taggart's revised CMAQ. In choosing to draw on the CMAQ to obtain a "good" measure of the complex concepts of CRM training, the company and the researchers wished to start with a survey, already proven valid as a measure of CRM training in the airline industry. The two parties also wanted more maintenance related measures than the CMAQ provided -- in particular they wished to measure opinions, important in maintenance, but which were not expected to change following the training; as well as rather more specific expectations for future use, as well as reports of how the training was subsequently used. The CRM/TOQ followed the successful format set by the CMAQ, in that it is a short questionnaire, yet having enough items to provide convergence to a smaller, easily used, set of concepts.

The CRM/TOQ contains 26 multiple response items. The company's modifications of the CMAQ involved removing five questions and adding six others. The five questions were removed because they either lacked predictive validity as reported by earlier flight

crew studies (Helmreich, et al., 1986) or, in the company's opinion, lacked relevance to maintenance.

A confirmatory Factor Analysis was undertaken for the data obtained with the CRM/TOQ (Taylor, 1991a). Results for the items drawn from the revised CMAQ were similar to those of Gregorich, et al. (1990), and subsequently with Sherman (1992). As in Sherman's study, the CRM/TOQ's fourth composite was statistically strong, and was therefore retained as the reflected index "Willingness to Voice Disagreement."

Six questions were also added to the CRM/TOQ, based on items intended to measure respondents' perceptions of behaviors dealing with setting and attainment of work goals (Geirland & Cotter, 1990). These six individual items were considered important to add because the work of maintenance managers differs from that of Flight Operations' officers (as managers) in the typically longer time required for Technical Operation's goal attainment and the relatively greater ambiguity of those goals. In addition, because goal setting and attainment were not covered in the CRM training such items could act as "control questions" about events in the respondents' work lives which were not predicted to change in a consistent or positive way following the training. These questionnaire items were separately tested by Factor Analysis and results suggested a two factor structure: "Goal sharing in one's own group," and "Goal sharing with other groups."

Table 1 displays the six scales calculated from the CRM/TOQ and which are used to test the effects of the CRM training on individual participants. Table 1 presents those six scales and the numbers of the individual item used to calculate each one. The individual item numbers correspond to the numbering of the sample questionnaire located in Appendix B.

TABLE 1
Scales Used to Test Individual Effects of CRM Training

SCALE	CONSTITUENT ITEMS (See Appendix B)
<i>Scales Sensitive to CRM</i>	
Sharing Command Responsibility	6, 8, 11, 13, 19 (reflected)
Communication & Coordination	5, 12, 14, 16, 17
Managing Stress	9, 20
Assertiveness	1, 2 (reflected)
<i>"Control Scales"</i>	
Sharing Goals in own Group	21, 22, 23, 24
Sharing Goals with other Groups	25, 26

Measurement Characteristics of the CRM/TOQ. Both reliability and validity of the separate items and the composite scales were tested, and they demonstrated good measurement qualities (Taylor, 1991a).

Four versions of the CRM/TOQ. There are four versions of the CRM/TOQ questionnaire which were used in various phases of this project.

1. A "Baseline Questionnaire" was mailed to all 1,800 maintenance managers, supervisors, and assistant supervisors in the company in May 1991, before the training was announced. The results of this baseline assessment of management attitudes were used in the Factor Analysis described above and were also used to establish the reliability and validity of the CRM/TOQ (Taylor, 1991a). The Baseline data were also compared with the subsequent "Pre-training" survey and the comparable questions' mean scores were found to be virtually indistinguishable from one another (Taylor, Bettencourt & Robertson [Galaxy], 1993). The baseline survey played no further role in the present study. The first 26 multiple choice questions were the same for all subsequent versions of the CRM/TOQ.
2. A "pre-training" questionnaire was completed by all participants immediately before each workshop began. Respondents were asked to choose a private identification (I.D.) or code number and to write it on their questionnaire. It was explained that this number would allow their responses to be compared with their responses on subsequent, follow up questionnaires, but without identifying them. These pre-training attitudes were subsequently compared with attitudes immediately after the training, as well as with attitudes measured months later.
3. A "post-training" questionnaire was completed by participants at each workshop's conclusion. Respondents, again, wrote their I.D. code on the questionnaire; and were asked to note that number in their course workbook to help them remember it for later "follow-up" questionnaires. The training facilitators collected and mailed the completed pre-training and post-training questionnaires to the University for processing. Data from this post-training version of the CRM/TOQ were compared with the pre-training questionnaire data. As described further below, three attitude scales had statistically higher mean scores immediately following training. The fourth attitude, "assertiveness," was not statistically higher immediately after training than before. The two opinion scales about goal sharing were not statistically different before and after the training.
4. "Follow-up" questionnaires were individually mailed by the company to all past participants two, six, and twelve months following their CRM training. Respondents were again asked to include their private I.D. code on their questionnaires, so that those follow-up surveys could be matched with the earlier questionnaires. They were provided an pre-addressed and stamped envelope with which to return the questionnaires to the University for processing. Although the 2, 6, and 12 month 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 CRM/TOQ Follow-up questionnaire is included in Appendix B).

Questionnaire return rates. Table 2 presents the return rates for the five surveys reported here. The total number of surveys returned and the percentage returned are shown for each survey.

TABLE 2

Sample Size And Response Ratios: Five Surveys

CRM/TOQ Questionnaires Received by October, 1994 (2,199) total participants)

SURVEY	TOTAL RETURN	RETURN RATE
Pre-training Survey	2,056	93%
Post-training Survey	2,053	93%
2-month Follow-up Survey	810	37%
6-month Follow-up Survey	722	33%
12-month Follow-up Survey	540	25%

The high return rate for the pre and post-training surveys result from participants being asked to complete the questionnaires while they were present in the training sessions. Lower return rates for the subsequent follow-up surveys is the normal result of surveys conducted by mail, but the 25%-37% return rates displayed in Table 2 are lower than desired. During the first year of the CRM program, we reported that the follow-up survey return rates ranged from 40%-45% (Taylor, Bettencourt & Robertson [Galaxy], 1993). During the intervening two years, although maintenance management continued to fully support their CRM program, the company experienced considerable turbulence in its markets and it reacted with several waves of staff reductions and station changes (including closures in several cases). These changes introduced consequent personnel moves which made it extremely difficult for the CRM course administrators to subsequently locate course participants to send them surveys. The lower follow-up survey return rates for the entire three years reflect this administrative difficulty -- using out of date or incorrect address lists caused many questionnaires not to be sent to their intended recipients. Although lower morale due to layoffs and station closures can be hypothesized to contribute to a lower return rate, the stable attitudes measured in the considerable number of follow-up questionnaires received do not reflect it.

Testing the effects of missing data on scale scores. In any survey instrument like the CRM/TOQ, individual respondents will occasionally make a mistake or omit an answer to a specific question. Such errors and omissions result in "missing data" (unusable answer, or no answer given). When individual items with missing data must be used with others with valid responses to form scales, such as we have done for the present study, the research investigator faces the choice of dealing with missing data on individual questions in three ways. The investigator 1) can eliminate the scale in question for that respondent entirely, or 2) can calculate the scale score without the individual item included, or 3) can substitute the population mean score for that item to replace that respondent's "missing data." Each approach has advantages. The first and second alternatives use only actual data, but the former reduces the sample size, and the latter biases the scale in favor of the remaining items. The third alternative maintains the sample size with a minimum distortion of the resulting score for the total sample.

We compared both the first and the third alternatives and tested the degree of possible distortion introduced by replacing missing responses in individual items with the sample mean before calculating the scale score. There are four attitude scales, and two "control scales" (cf., Table 1), measured for the two pre and post-training administrations of the CRM/TOQ questionnaire, for a total of 12 modified scale mean scores. The increase in total sample "n" using this modification was between 50 and 255, depending on the particular scale in question. As noted above, the total number of questionnaires returned was, 2,056 for pre-training, and 2,053 for post-training samples (cf., Table 2). The smallest "n's" using the unmodified scales were 1,801 and 1,804 for the pre-training "goal sharing" scales. After replacing the missing data for every individual item used to construct a scale the obtained "n" for every scale in the pretest and posttest was returned to 2,056 and 2,053 respectively.

Mean values for the 12 scales, modified to correct for missing data, were compared with the 12 unmodified ones. Eleven of the 12 scales so modified were unchanged from the original (unmodified) data set. Only one of the "control scales," *"My unit shares goals with other work units in Technical Operations,"* was considerably higher in its modified form for the pre-test sample (0.30 scale point higher on a five-point scale). The modified post-test score for this scale was undifferentiated from the unmodified version. For 11 of the 12 items tested, using the population mean score to replace missing data was a net benefit -- it increased the sample size without affecting the scores themselves. The question of the outlier, however, still remains.

Why should this one scale behave so differently from the rest? The answer is that a number of administrative and management people reported very positive contact with other groups and, coincidentally, they also did not answer all the questions on that topic. The original data collected during the first few months of the program (June-Aug., 1991) showed a tendency to over-evaluate the items comprising this scale (cf., Taylor 1991a). A disproportionate number of respondents during those first few months of training were senior executives and managers. These respondents, as a group, probably feel more certain in their views, and thus would be expected to have a lower missing data rate, and would also be more likely to have an answer to questions about "other groups" in Technical Operations. After that initial few months, the pre-training mean scores for that scale, settled to a lower level which

remained unchanged from the post-training scores for the remainder of the nearly three years we measured. The individual questions dealing with goal sharing with other groups had a higher missing data rate (were answered less often) than all other multiple response questions. As time passed, an increasing number of respondents did not answer one or both of the questions asking about the topic. Later respondents probably felt less certain about this concept and those source behaviors. In the final sample there are 252 (roughly 12% of the population) pre-training subjects who did not answer one or both of the questions comprising the scale, "My unit shares goals with other work units in Technical Operations." When we examined the differences across the various departments in Tech Operations, we found that pre-training modified scale scores for the mechanical trades departments (line, base, and shop maintenance) were largely unchanged from their original data. However, personnel in the other Technical Operations departments (many of them higher managers) showed marked increases in their scores when their pre-training data set was modified, which means that the one item in the scale that they did answer, they answered very positively. Adding the sample averages to these very high scores appreciably raised the total scores for this scale. The fact that his group would both answer positively and skip questions on this topic is either a coincidence or an unknown measurement artifact affecting that one scale. Modifying all scales by replacing missing data with population means was used in all analyses in the present report.

Testing CRM/TOQ questionnaire sensitivity. The quantitative questions in the CRM/TOQ were designed to obtain four independent attitude scales (*cf.*, Table 1) and several individual opinion items, all specifically sensitive to the CRM training curriculum. There were also two "control" scales, dealing with perception of goal setting and attainment, which were specifically intended not to be sensitive to the training. As noted in the preceding section, one of these control scales was the only one of the six which was affected by the scale modification procedure to correct for missing data. Table 3 presents additional evidence for the differences between the CRM attitude scales and the control scales. Table 3 is a intercorrelation matrix between the four attitude and the two control scales from the pre-training survey and those six scales from the post-training survey. The cell entries are Pearson Product Moment Correlation coefficients ("r") and those in *italics* are statistically significant at the .05 confidence level or higher. **Boldface** coefficients are those above $r = .49$, representing unusually high correlations, - those which account for at least 25% of the joint variance of the two correlated scales. That would mean that about 25% of a given attitude scale's fluctuation was explained by the fluctuation of the other scale in correlation with it.

TABLE 3
Intercorrelations among Pre-training and Post-training Survey Scales

	Pre-Training: Delegating Command Responsibility	Pre-Training: Communication & Cooperation	Pre-Training: Managing Stress Effects	Pre-Training: Assertiveness	Pre-Training Control: Goal Sharing within Group	Pre-Training Control: Goal Sharing with Others	Post-Training: Delegating Command Responsibility	Post-Training: Communication & Cooperation	Post-Training: Managing Stress Effects	Post-Training: Assertiveness	Post-Training Control: Goal Sharing within Group	Post-Training Control: Goal Sharing with Others
Pre-Training: Del. Command Resp.	-											
Pre-Training: Communic & Coord.	.31	-										
Pre-Training: Mng. Stress Effects	.50	.39	-									
Pre-Training: Assertiveness	.28	-.01	.10	-								
Pre-Training Control Item: Goal Sharing w/Gp.	.01	.12	-.04	.01	-							
Pre-Training Control Item: Goal Shr w/Others	.05	.08	0.0	-.01	.74	-						
Post-Training: Del. Command Resp.	.52	0.0	.22	.26	0.0	.02	-					
Post-Training: Communic & Coord.	-.03	.38	.03	-.02	.13	.08	0.0	-				
Post-Training: Mng. Stress Effects	.23	.04	.48	.11	0.0	0.0	.35	.08	-			
Post-Training: Assertiveness	.18	-.02	.06	.47	.02	0.0	.28	-.04	.11	-		
Post-Training Control Item: Goal Sharing w/Gp.	-.14	.11	-.09	-.06	.44	.16	-.12	.21	-.10	-.03	-	
Post-Training Control Item: Goal Shr w/Others	-.15	.03	-.07	-.09	.24	.23	-.18	.11	-.12	-.09	.47	-
n = 1,822												

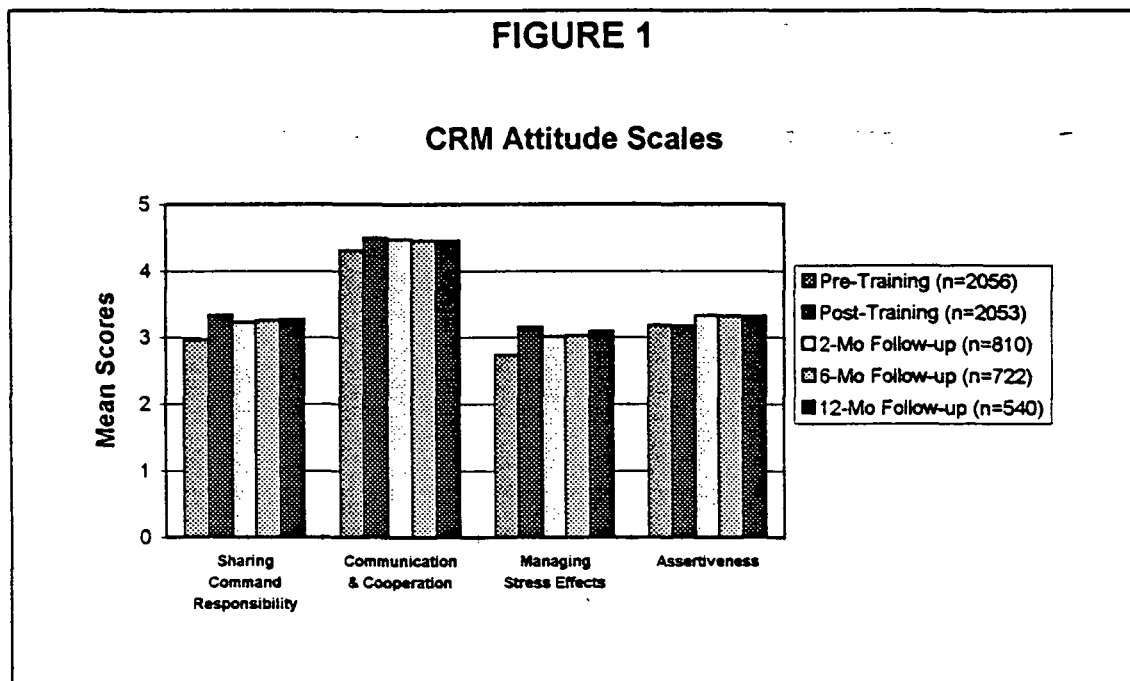
The pattern of intercorrelations in Table 3 shows that the best predictor of later attitudes are the same attitudes at the earlier time period. The pattern also shows the two control scales are more related to themselves and to one another than they are related to the CRM attitude scales. These results demonstrate that the four CRM attitudes are largely independent of one another (a desirable condition), and that they are also little related of the two control scales. If anything, there is a slight tendency for the CRM scales to be inversely (if only modestly) related to the control scales. That means there is a slight, but believable, tendency for scale scores on the goal sharing scales to decrease as scores on the CRM attitudes increase. The patterns of intercorrelations found in Table 3 were replicated in intercorrelations between the Post-training survey and the 2-month, 6-month, and 12-month Follow-up surveys.

RESULTS SECTION 1:

COMPARISON OF ATTITUDES OVER TIME

All available survey responses are used for these initial comparisons.

Attitude change from pre-training to post-training surveys. Results using all respondents who completed the CRM/TOQ immediately before and immediately after training demonstrated that many of the intended effects on participants' attitudes were achieved. Figure 1 presents the pre, post, 2, 6, and 12 month comparisons for the four attitude scales using all responses.

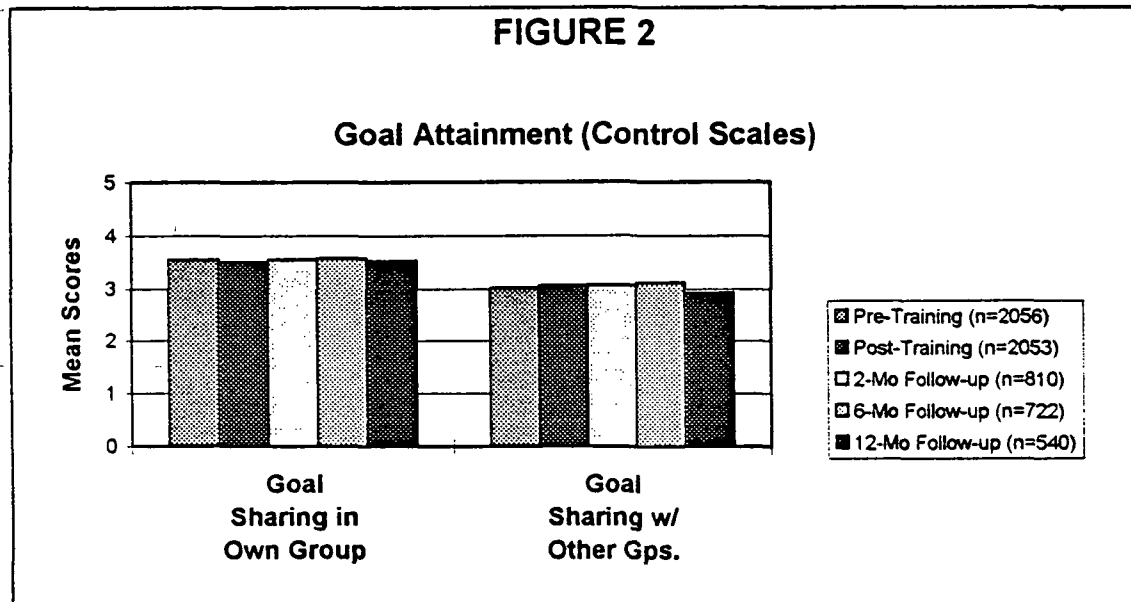


The attitude index scores for "Sharing Command Responsibility," "Communication & Coordination," and "Managing Stressor Effects," all increased immediately following training. A Multiple Analysis of Variance (MANOVA) "F" was used to test the differences among same-scale values for the pre- and post-training surveys and established that the pre-post differences noted were statistically significant statistic ($F=6.77$, $df = 2156, 4$; $p<.000$). "Willingness to Voice Disagreement," a measure of assertiveness and a central topic of the training, did not increase significantly immediately after the training.

Attitude change in follow-up surveys. Once again the MANOVA "F" statistic was used to test the differences among the same-scale values for the four surveys taken subsequent to the training. With one notable exception, there were no significant differences found among the post-training, two, six and 12-month surveys. That exception is the assertiveness scale, "Willingness to Voice Disagreement," which increased

significantly between the post and 2-month surveys. All four attitude scale scores remained high thereafter over the remaining period.

Change in the Control Variables for the Pre-Post and Follow-up surveys. The two "Goal Sharing" measures were also compared over the same time period as the four attitude scales. The goal sharing scales were not expected to change as a result of the CRM training. Although goal setting and attainment are important aspects of maintenance work, the training was not designed to directly influence either attitudes or perceptions about that aspect of management. Figure 2 presents the pre, post, 2, 6, and 12 month comparisons for the two goal sharing scales using all responses. The MANOVA "F" test was applied to these data and was found not to be statistically significant ($F=1.29$, $p>.05$, $df=2156,4$).



Matching Questionnaire Responses Over Time

Matched questionnaires and sample size. For the remainder of the analyses in this report the results for the CRM/TOQ will be reported in terms of the largest number of individual surveys received after training that could be **matched**, by I.D. code, to their pre-training counterpart.

CRM training participants were asked to include a confidential identification number on the top of their pre-training questionnaire and to write that number on the front page of their training notebook. They were encouraged to invent a six-digit number known only to them to ensure complete confidentiality. The participants were alerted that they would be asked to use the number again on a similar questionnaire at the completion

of the training, as well as three more questionnaires which would be mailed to them in the months to follow. This I.D. number, it was explained, would be used over the times sampled to compare answers respondent by respondent rather than merely by groups over the four time periods. Participants were assured that the numbers they chose were not intended to identify or single out individuals, but merely to match earlier answers on the questionnaires with later ones. They were also told that this questionnaire, and all others to follow, would be sent directly to the University for processing, tabulating, and summarization.

Rationale for the "matched respondents" sample. Using a matched sample insures the comparisons made over time are made with the same core group of people, which provides added validity to the time-lagged results obtained. One practical cost of this matching is that the size of the matched sample for each of the three follow-up surveys is reduced, over the total, by the number of respondents who did not include a recognizable code with their completed questionnaire. The benefit of using such a sample, however clearly outweighs the penalty of a reduced sample size. Using matched respondents overtime guarantees that a work group's average attitude scores, compared over time, will be drawn from the same sample. There need be no concern that differences found over time are the result of comparing respondents who are incomparable with one another.

Table 4 displays the number (and percentage) of respondents whose later answers could be matched with their answers to the previous questionnaires. For the analyses included in this report the sample used is of respondents whose subsequent answers were matched to their pre-training responses. Table 4 shows that sample, matched to their pre-training responses (shown in the upper row in Table 4), to include between 74% and 88% of the total responses available.

TABLE 4
Numbers of Questionnaires Matched with Previous Surveys

	Post-training Survey (n=2,053)	2 Month Follow- up Survey (n=810)	6 Month Follow- up Survey (n=722)	12 Month Follow-up Survey (n=540)
Matched with the Pre-training survey (n=2,056)	1,822 (88%)	598 (74%)	548 (76%)	415 (77%)
Matched with Post-training Survey (n=2,053)	-	561 (69%)	520 (72%)	387 (72%)

Testing for differences among the matched samples, over time. The demographic characteristics for the post-training sample, and the three follow-up samples were

compared with one another, in order to test for possible differences in the composition of the four groups. Table 5 presents those comparisons for age, occupation, department, education and prior experience.

TABLE 5
Demographic Comparisons Among the Four After-Training Surveys

Demographic Item	Post-trng. Survey	2 Month Survey	6 Month Survey	12 Month Survey	Statistical Test	Significance Level
Job Title (9)						
Engineers	6.6%	8.8%	9.3%	12.4%	$\chi^2=82.4$	.000
Inspectors	9.6%	3.8%	3.5%	1.8%	df=24	
Department (6)						
Engineering	7.1%	9.3%	10.8%	13.1%	$\chi^2=51.0$	.000
Qual. Cont.	11.3%	7.3%	6.7%	6.6%	df=15	
Location (City = 14)	n/a	n/a	n/a	n/a	$\chi^2=28.6$	ns
					df=39	
Mean Age in years	42.0	43.0	42.5	43.9	"F" = 3.73	.001
					df=3, 3220	
Education						
Mean years College	5.7	5.2	6.3	5.7	"F" = .29	ns
					df=3, 3196	
Mean years Trade Sch.	5.1	4.4	5.5	4.9	"F" = .32	ns
					df=3, 3242	
Military Exp., Mean Years	6.1	5.7	6.5	6.3	"F" = .18	ns
					df=3, 3327	

Age, years of education, and years experience were tested using the ANOVA "F," while the differences among the four survey samples on occupation, and department (being categorical or "nominal scale" data) were examined using the "chi-square" (χ^2) test. Of all the tests performed for these data, only age, occupation and department were found to show significant differences among the four time samples. Not unexpectedly, the average age of the matched sample increases from 42 years at the time of training, to almost 44 years at the last follow-up survey. Because many 12 months surveys were sent out late and delays were seen in their return, this increased age doubtless reflects the mere passage of time. Closer examination of the results for occupation revealed that of all the occupations a disproportionately large number of Engineers, and small number of Aircraft Inspectors, are found in the 12 month sample when compared with those occupations' in the post-training survey. Likewise, for the test of differences among departments show that Engineering Department and Quality Control (the Inspectors' department) to show disproportionately higher and lower numbers, respectively, at 12 months following their training. Given that Engineers and Inspectors, together, account for only 15-17% of the

total sample of matched respondents, the effect of their over and under-sampling at 12 months is unlikely to affect the overall results reported below.

Number of work units represented in the "matched sample." The total of all 1,822 matched respondents in the post-test sample, includes the members of over 50 organizational units drawn from all parts of Technical Operations: (Supply, Quality, Base Maintenance, Line Maintenance, Shops, Stores, Materials, Engineering, Planning, and Administration). 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. These differences are described in the following section.

RESULTS SECTION 2: TRENDS IN MAINTENANCE PERFORMANCE BEFORE AND AFTER THE ONSET OF CRM TRAINING

Performance Data Described

Maintenance managers in the company collected performance data in abundance. Table 6 presents the five measures used as end-result criteria in the present study.

TABLE 6
Performance Measures Selected for Test

PERFORMANCE MEASURES	MAXIMUM WORK UNITS MEASURED	RATED SENSITIVITY (1 = most sensitive to trng)
SAFETY		
<u>Aircraft Safety</u> (number of maintenance-related ground damage incidents per flight)	38	1
<u>Occupational Safety</u> (lost time injuries, per 1000 hours)	55	1
DEPENDABILITY		
<u>On-time Departures</u> (% departures w/in 5 minutes of schedule)	31	1
<u>On-time Maintenance</u> (delays due to late from planned maintenance, per 100 scheduled aircraft)	35	1
EFFICIENCY		
<u>Contained Overtime Cost</u> (% overtime paid to total wage bill)	55	2

Three conditions were met in order to include these measures in the work-unit analysis reported here. First (and obviously) the performance measures need to be available by work unit (i.e., line station, shop, warehouse, etc.), and not just by department or function. Second the measures must be ones that people in the work unit can affect by their actions, or can effectively adapt to; and not merely ones that are conveniently assigned to a unit, but for which little can be done. The third condition applied was that the measures not be directly related to (or completely determined by) other measures in the set. The five performance measures used in the present analysis are included in the company's categories of "safety," "dependability," and "efficiency." "Quality" measures used by the company are available only for the whole department. Because they cannot be applied to the specific maintenance units, quality measure are not included in this present analysis.

The trainers and administrators of the CRM course evaluated all the available performance measures and predicted which of them would be more sensitive to effects of CRM training. Their conclusions were that four measures would be the most readily improved by the training. These four performance measures included the two safety items "ground damage" and "days lost to occupational injury," and two dependability measures, "flight departures within 5 minutes," and "delays in 'scheduled work' (e.g., overnight repairs, and overhaul) due to maintenance error". Their lower ranked performance measures in responsiveness to training included the efficiency measure of "overtime paid."

Performance Rates and Trends Before and After the CRM Training Began.

The "before" and "after" scores for the five performance measures were plotted, and their trends compared over the time period for which measures were available.

Measures of Safety Performance: Safety of Aircraft and Personal Safety. Figure 3 presents before-and after-training comparisons of number of Ground-Damage incidents for 38 work units.

FIGURE 3

Aircraft Safety (Ground Damage)

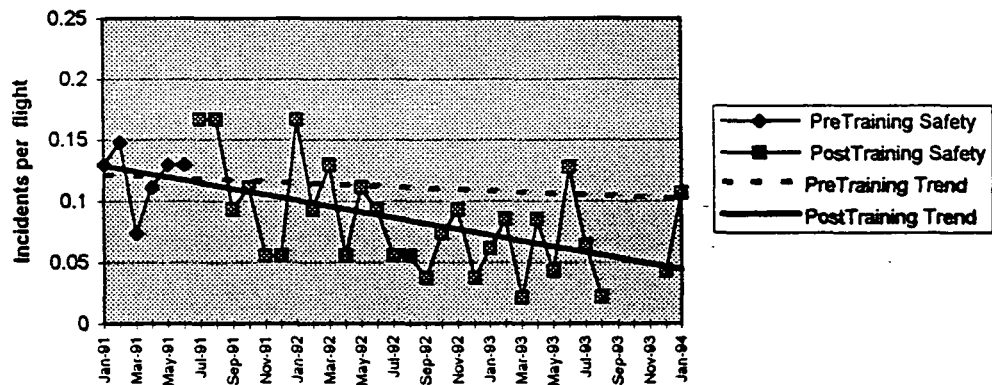


Figure 3 shows a strengthening of the trend for the decreased number of ground damage incidents (measured in incidents per flight), for the 30 months (for which there were data available) after the CRM training began, when compared with the six months before. The reduced rate for ground damage incidents appears to be related in time to the CRM training.

FIGURE 4

Occupational Safety (Lost time Injuries)

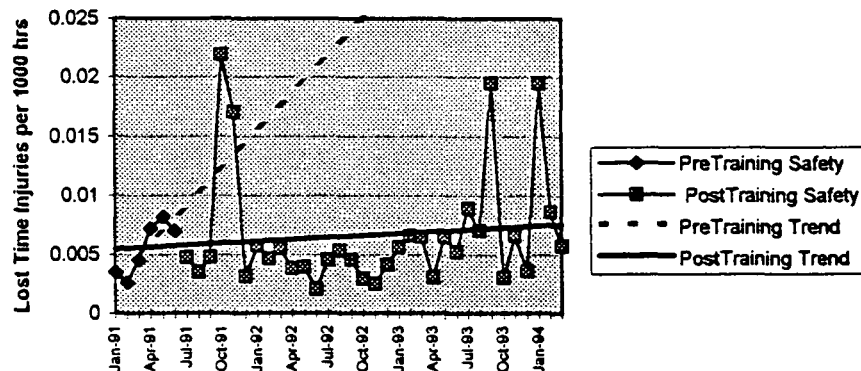


Figure 4 shows the rate of lost time injuries, per 1000 hours worked, for 55 work units. In Figure 4 we see a virtual reversal for the after training trend for occupational injury for the 33 months after the onset of training, compared with the six months before.

Measures of Dependability. Figure 5 presents before- and after-training comparisons for "Departures within 5 minutes of schedule" for the 31 line maintenance stations for which this measure is relevant.

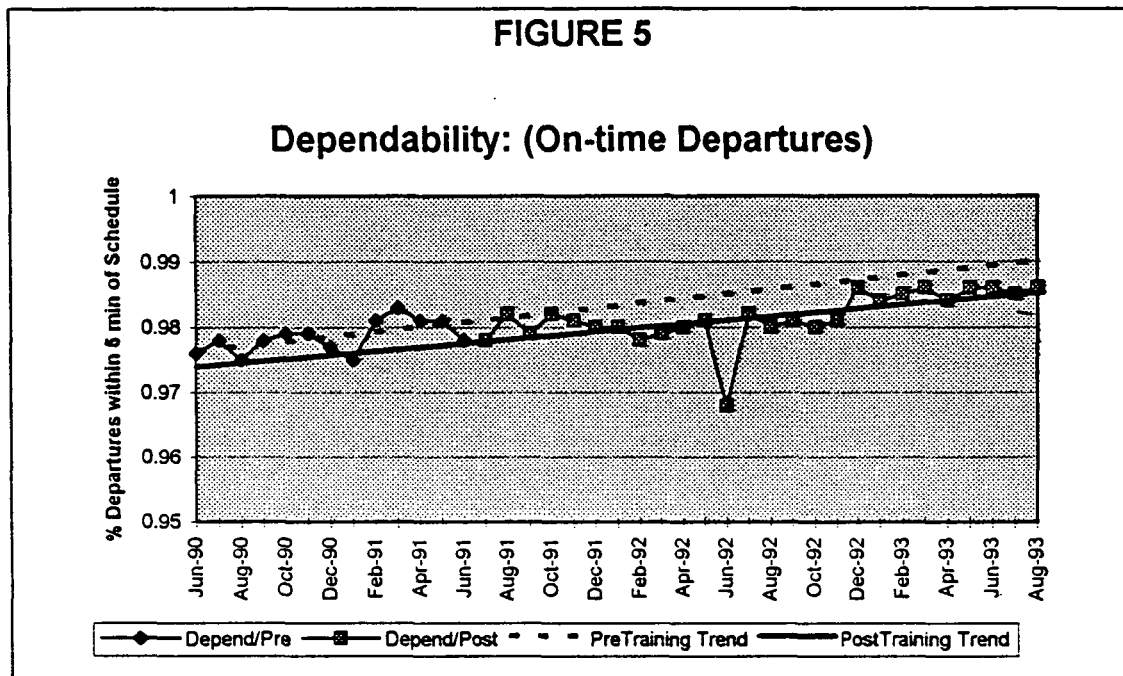
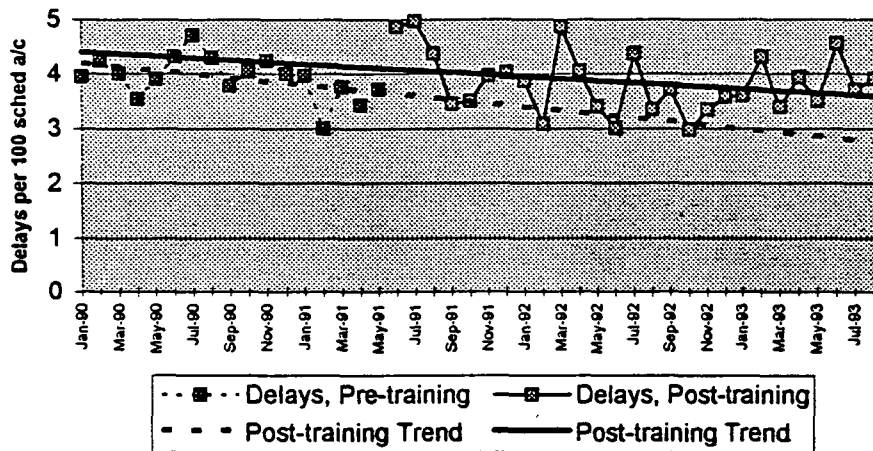


Figure 5 demonstrates that line maintenance responsibility for on-time departures continues to steadily improve both before and after the training began. Although the performance was trending up in the period preceding the training, this chart shows a higher level of performance, overall, at the end of the second year following the onset of CRM training.

Figure 6 shows before and after comparisons for the other indicator of dependability, "On-time planned maintenance" -- measured by the number of aircraft delays due to late from scheduled (or planned) maintenance -- for 35 work units (including line and heavy maintenance stations).

FIGURE 6

Dependability: Late from Planned Maintenance



Although the overall rate for "On-time maintenance" (i.e., delays due to being late from scheduled maintenance declining) continually improved over the period measured, no appreciable change in that rate is noted in the years following the onset of CRM training, when compared with the period before the training began.

Measure of Efficiency. Figure 7 shows the pre-post comparisons for the percentage of hours of overtime charged for the 55 work units measured.

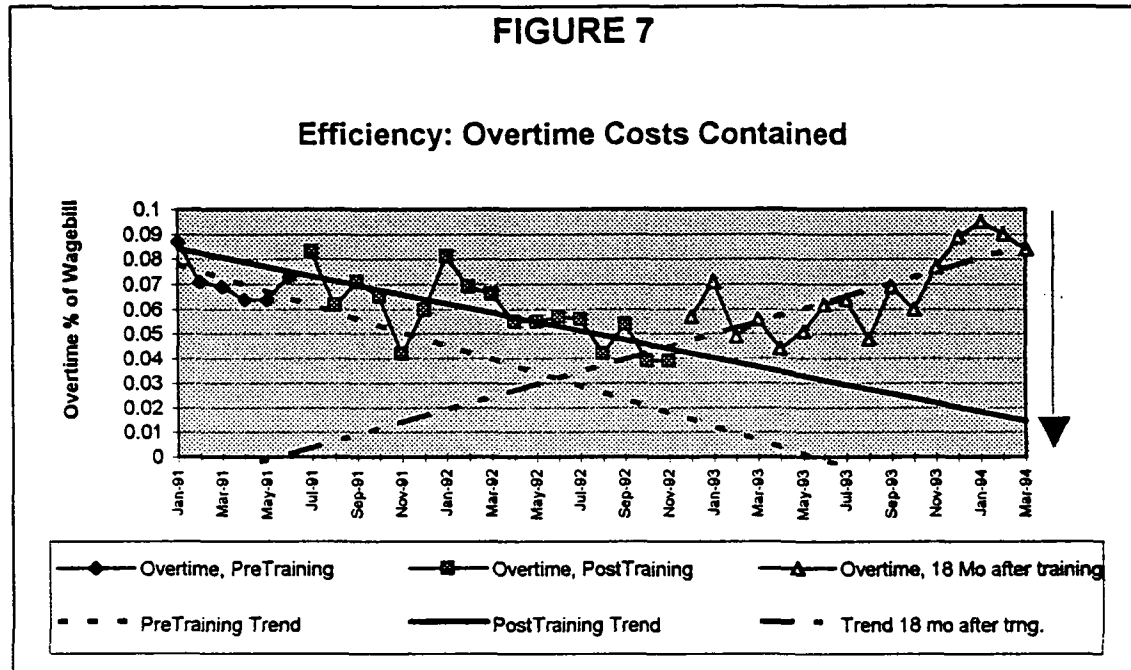


Figure 7 shows that the trend of overtime expenses for the 16 months following the onset of CRM training continues the rate of improvement, but that trend then reverses from December, 1992 for the remaining 16 months for which we have data. The initial improved cost performance appears coincident with the training, and may be affected by it. An alternative explanation is that these rates were more affected by top management policy in 1991 and 1992, which at first sustained tight controls on overtime expenses, and then undertook a labor force reduction which required increased overtime for the remaining staff. Further analyses below examine this possible effect of changed policy and of CRM-related skills used in coping with it.

RESULTS SECTION 3: TESTING RELATIONSHIPS BETWEEN ATTITUDES AND PERFORMANCE

The data sets used in the attitude-performance analyses. There were five data sets we used for the attitude-performance analyses. By the completion of the current phase of the CRM training, in March, 1994, 1,822 of the 2,199 participants attending one of the CRM workshops had completed questionnaires such that they could be included in the "matched samples" of the pre-, and post-training surveys as well as the 2, 6, and 12 month follow-up surveys. Of those 1,822, 1,692 participants had also provided valid departmental identification and, thus, could be included in one of the five data sets. The first of those data sets was comprized of 395 participants who were employed in the Technical Operations department's Line Maintenance division. Attitudes from those 395 Line Maintenance participants in 31 work units are tested against the Line Maintenance measure of "*On-time departures*." For the second data set, Base Maintenance division added another 266 participants (in 4 hangar locations), which together with Line Maintenance participants provides a total of 661 training participants (in 35 work units) for the source of attitude data examined in relationship with the maintenance measure "*On-time maintenance*." The third data set added another 477 (in three more city-site locations) from the Technical Operations department's direct support divisions, of Quality Control (n=192), Prime Shops (n=111), and Materials Service (n=174), to test the performance measure "*Aircraft safety*." That third data set is composed of 1,138 maintenance and support personnel in 38 work units. For the fourth and fifth data sets, participants in the remaining Technical Operations units for Planning (n=194), Engineering (n=120), and Administration (n=240) were added to the data sets above for a total of sample of 1,692 participants in 55 work units. These samples were used to test attitudes against the performance measures of "*Occupational safety*," and "*Overtime costs contained*."

The correlation statistics used in the present analysis. The relationships between the attitude indices and the performance measures, as presented in Tables 7-11 below, were calculated using the Spearman Rank-order Correlation statistic ("Rho," or ρ). The use of Rho is advisable in this case because the distributions of these five performance measures narrow the choices to t non-parametric statistical tests for optimal analytic power (Taylor, 1991b). The measured results of four of the five performance measures are "improving" when they decline numerically (i.e., the absence of delays due to late from planned maintenance, the absence of occupational injuries, the absence of ground damage incidents, and reduction of overtime costs). To simplify the presentation of findings all results in Tables 7-11 are described as postive coefficients when the original correlations are in the expected direction (i.e., favorable attitudes equal better performance).

Lead and Lag Effects Between Performance and Attitudes Over Time

A part of the following analysis examines the leading impact of performance prior to the CRM training on participants' subsequent attitudes. The more central part of the evaluation of CRM training however, is the analysis of those attitudes' lagged effects on subsequent maintenance performance. We are interested mainly in the training's longer-term effects on attitudes, and their lagged effect on performance following the training.

The relationships between the pre-training questionnaire scales and maintenance unit performance measures. The first associations examined here are the four pre-training attitude scales (measured at the beginning of each training session) with the five maintenance performance indicators. Table 7 contains the percentages for statistically significant correlations between each of the four attitudes and each of the five performance indicators. The larger percentages, of 1/3 (33%) or greater, are boldfaced as a visual aid.

TABLE 7
Percent of Significant Correlations
Between Pre-training Attitudes and Performance

	Pre-Training Attitude Scales			
	Sharing Command Responsibility	Communication & Coordination	Managing Stress Effects	Assertiveness
Dependability				
Departures within 5 min of schedule				
13 months before training	40	40	33	20
26 months after training	33	40	11	15
On-time maintenance				
17 months before training	6	39	0	6
27 months after training	0	40	7	15
Safety				
Occupational Safety				
6 months before training	40	40	20	0
33 months after training	6	68	3	24
Aircraft Safety				
6 months before training	0	40	0	20
28 months after training	6	13	10	3
Efficiency				
Overtime paid				
6 months before training	0	20	0	0
33 months after training	42	11	15	21

Table 7 shows that the pre-training survey attitude scale "Communication & Coordination" has a large number of statistically significant relationships with four of the

five pre-training performance indicators. That means that good performance before the CRM training began was quite widely related to positive pre-training attitudes about communication & coordination. That pre-training scale measuring communication & coordination attitudes was widely related to post-training dependability and occupational safety as well. Taken together, these results suggest that although communication and coordination is an important value to managers and professionals in the most effective units, CRM training may not be a crucial intervention for this effect. This communication and coordination scale had a remarkably high initial mean score (*cf.* Figure 1), which suggests the possibility that the scale may contain a "social desirability" bias. "Communication and cooperation" is also quite a general concept and can have vague or multiple meanings. It is also a somewhat "passive concept." Because its constituent questions have fewer specific behavioral references than the other more specific attitudes measured with the CRM/TOQ.

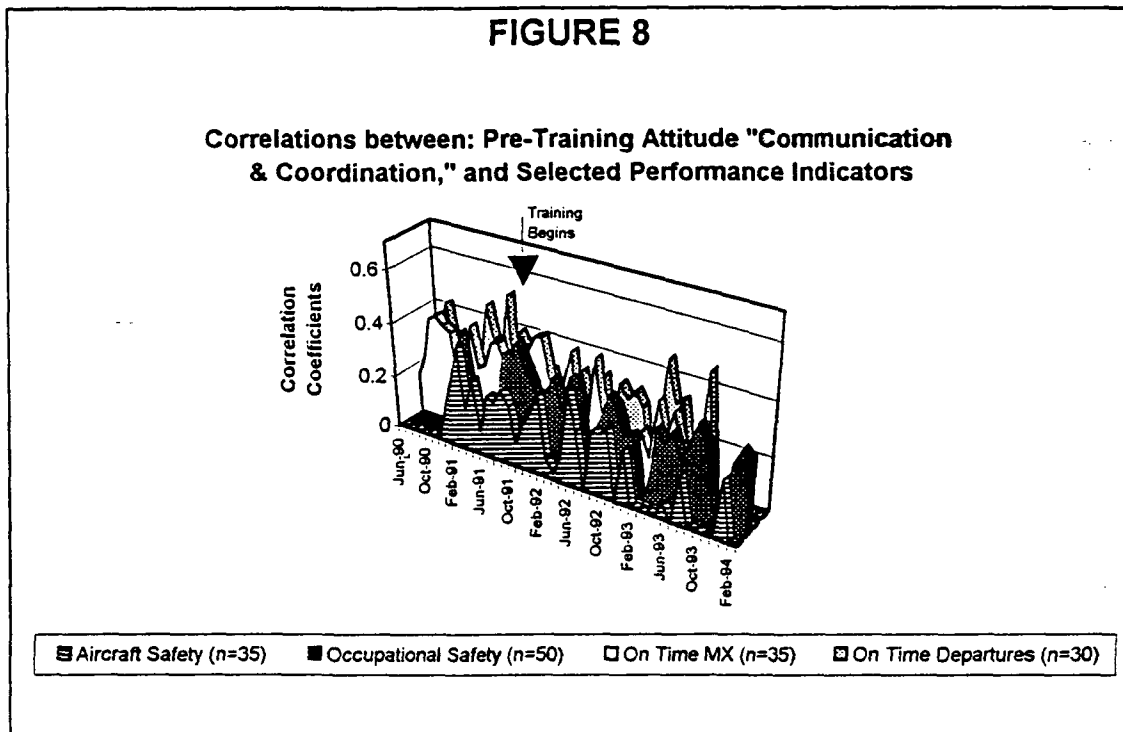


Figure 8 plots all of the individual correlations between "communication & cooperation and the four performance indicators most related to it. Figure 8 reveals a large number of months in which the correlations between that attitude and the four performance measures are as high as .40. Over time some of those correlations, particularly for aircraft safety and on-time maintenance, decline in size. To illustrate this Table 7 shows "communication & coordination" related to "aircraft safety" 40% of the months measured before training began in June, 1991. In Figure 8, aircraft safety is shown as the first profile of the four. That profile of relationships between and communication &

coordination with aircraft safety demonstrates that the correlations are higher and proportionately more numerous before the training began, than afterwards.

Table 7 also shows that another pre-training attitude with many significant correlations with performance is "Sharing Command Responsibility." This attitude scale is seen to be frequently related to line station dependability ("departures within 5 minutes of schedule") both before and after training began. Pre-training "sharing responsibility." is also related to containing subsequent overtime costs. Figure 9 displays the all the correlations between the pre-training attitude toward sharing responsibility, and overtime costs.

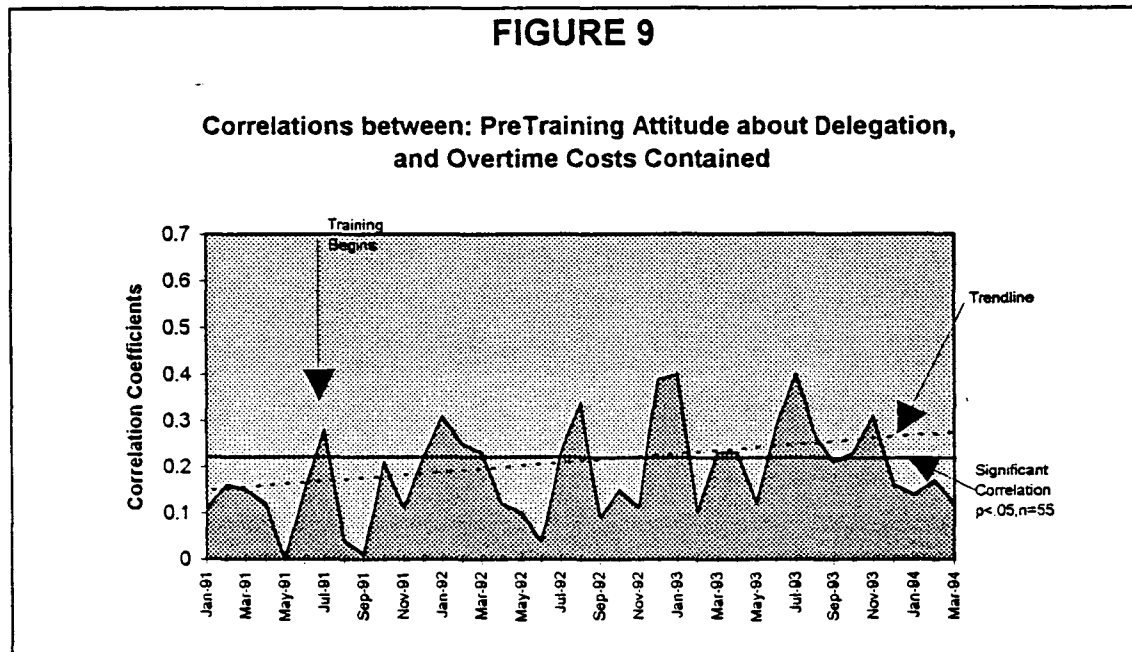


Figure 9 is a more simple two-dimensional presentation than Figure 8. Figure 9 allows for the inclusion of two additional features. The first feature is a solid line showing the level of significance ($p = .22$, $p < 5\%$) for this performance measure using the 55 work units available for this series. The second feature is a dotted trendline (calculated by the Least-Squares Regression method) for the correlation coefficients over time. Figure 9 provides the information from Table 7 in graphical form. It shows that of the 33 months of overtime measured after training, 14 of them (42%) had correlations above the significance level. Furthermore, the trendline in Figure 9 shows an upward slope which confirms that the correlations between pre-training feelings about participation ("sharing responsibility") and subsequent coping with restrictive overtime policy become more strongly related over the nearly three year period, 6/91-3/94. The results in Figure 9 clearly show that managers and staff professionals who hold more participative values before they attended training are subsequently successful in coping with overtime costs. Whether the CRM training can impact to further increase that value will be tested below.

The relationships between the post-training questionnaire scales and maintenance unit performance measures. Table 8 displays the percent of significant correlations between attitudes obtained from the post-training survey and the five performance items.

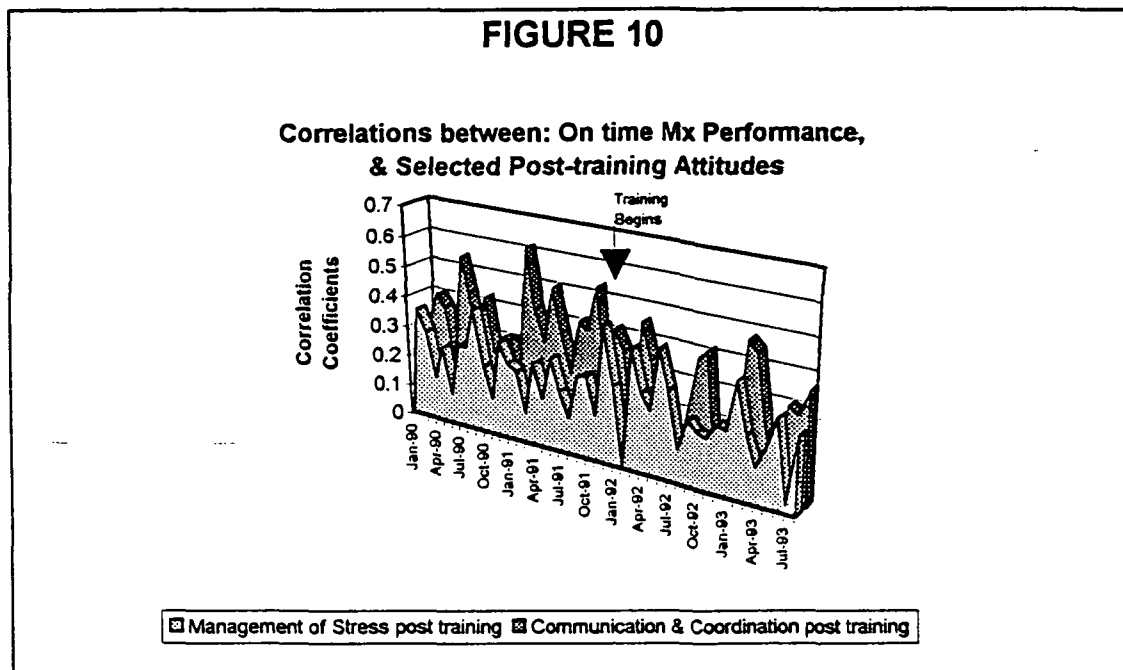
TABLE 8
Percent of Significant Correlations
Between Post-training Attitudes and Performance

	Post-Training Attitude Scales			
	Sharing Command Responsibility	Communication & Coordination	Managing Stress Effects	Assertiveness
Dependability				
Departures within 5 min of schedule				
13 months before training	0	58	17	17
26 months after training	7	29	17	4
On-time maintenance				
17 months before training	6	53	41	24
27 months after training	7	33	37	22
Safety				
Occupational Safety				
6 months before training	20	20	0	0
33 months after training	9	3	3	18
Aircraft Safety				
6 months before training	40	0	20	0
28 months after training	3	9	3	3
Efficiency				
Overtime paid				
6 months before training	40	0	0	0
33 months after training	18	3	12	3

Improved attitude about "sharing command responsibility" is seen in Table 8 to be related to preceding months of good aircraft safety (lower damage) and lower overtime costs. These results suggest that the CRM training's immediate positive effect on attitudes about participation cannot be credited with subsequent performance. Table 8 also shows that the post-training attitudes about communication & coordination, and the "value of stress management," are both very frequently related to on-time scheduled maintenance performance both prior to and after the training began. As noted above, the attitude scale measuring "communication & coordination," may be subject to some "social desirability" bias, but it is apparently also sensitive to the effects of the training. Because the attitude about stress management is lower overall before the CRM training, and the training specifically targeted improving stress management, it seems even more likely that the training has a direct effect on that attitude and can be credited with subsequent

performance related to it. Thus, the number of significant correlations between stress management and performance for the months after the training began, are likely to be the result of CRM training.

Figure 10 displays all of the correlations between on-time scheduled maintenance performance and the two post training attitudes, "communication and coordination," and "stress management." Figure 10 reveals that the pattern for correlations between the two attitudes, and pre and post training performance, is similar although communication & coordination has higher correlations before the onset of training, with on-schedule maintenance, than does stress management.



The relationships between the follow-up surveys and maintenance unit performance measures. Tables 9, 10 and 11 display the percent of significant correlations between attitudes obtained from the 2-month, 6-month, and 12-month follow-up surveys, respectively, and the five performance items.

TABLE 9
Percent of Significant Correlations
Between 2-Month Follow-up Attitudes and Performance

	2 Month Attitude Scales			
	Sharing Command Responsibility	Communication & Coordination	Managing Stress Effects	Assertiveness
Dependability				
Departures within 5 min of schedule				
13 months before training	75	8	17	33
26 months after training	52	11	7	52
On-time maintenance				
17 months before training	65	0	0	0
27 months after training	78	4	4	11
Safety				
Occupational Safety				
6 months before training	20	20	0	100
33 months after training	32	3	9	62
Aircraft Safety				
6 months before training	40	20	20	20
28 months after training	29	4	14	21
Efficiency				
Overtime paid				
6 months before training	0	20	20	20
33 months after training	9	3	21	3

Table 9 displays the proportion of significant correlations between maintenance unit performance and attitudes from the follow-up survey obtained 2-months after training for those respondents with questionnaires matched to their pre-training survey. The more passive belief about "communication & coordination" was not found related to subsequent maintenance performance in this or in any later survey. Examination of these 2-month follow up results, reveals stronger relationships with performance, using attitudes about "sharing command responsibility," and the value of "assertiveness," than the immediate post-training survey showed. Both "sharing command responsibility," and "assertiveness," are "active" beliefs, the behavioral skills for which were emphasized in the training; and which require continued behavioral support, following the training, to reinforce them. Sharing responsibility, measured 2 months after training, shows a great many months of

significant correlations to post training performance for all dependability and safety indicators.

Figure 11 displays all of these correlations for the "command delegation" scale. Note how high many of the correlations are -- particularly with the two dependability scales (on-time departures, and on-schedule maintenance).

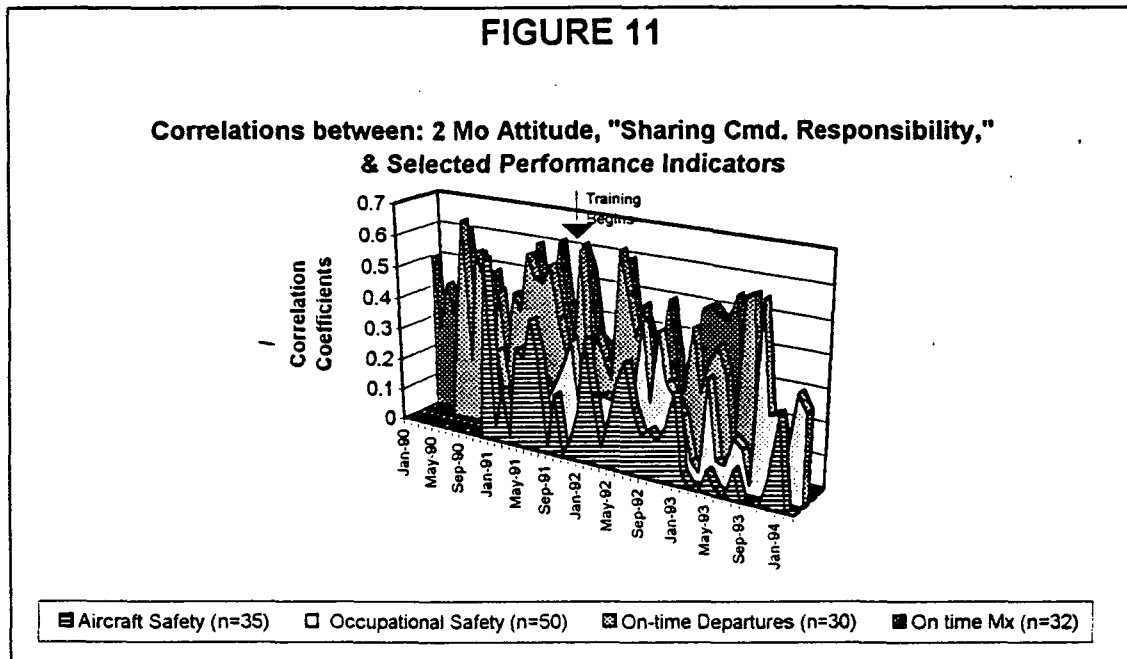
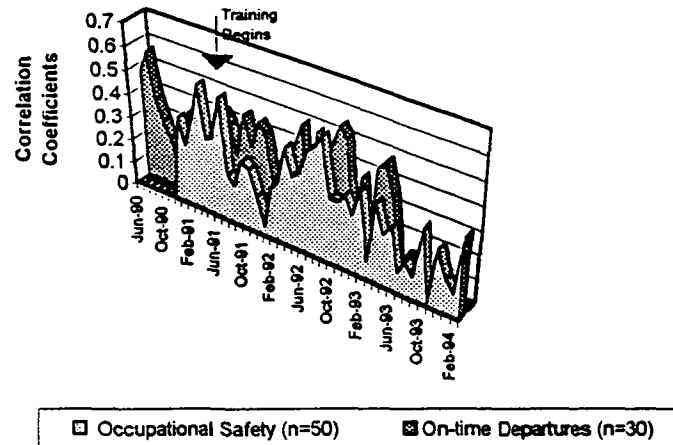


Table 9 also shows that assertiveness is related to many (mostly subsequent) months of on-time departures, and occupational safety. Figure 12 displays these correlations between "assertiveness" two months after training, and performance.

FIGURE 12

**Correlations between: 2 Mo Assertiveness Attitude,
& Selected Performance Indicators**



Overall, the results from this two-month follow-up survey are remarkably strong and suggest that lessons learned from the CRM training have consolidated by two months afterward, and in more "active" ways.

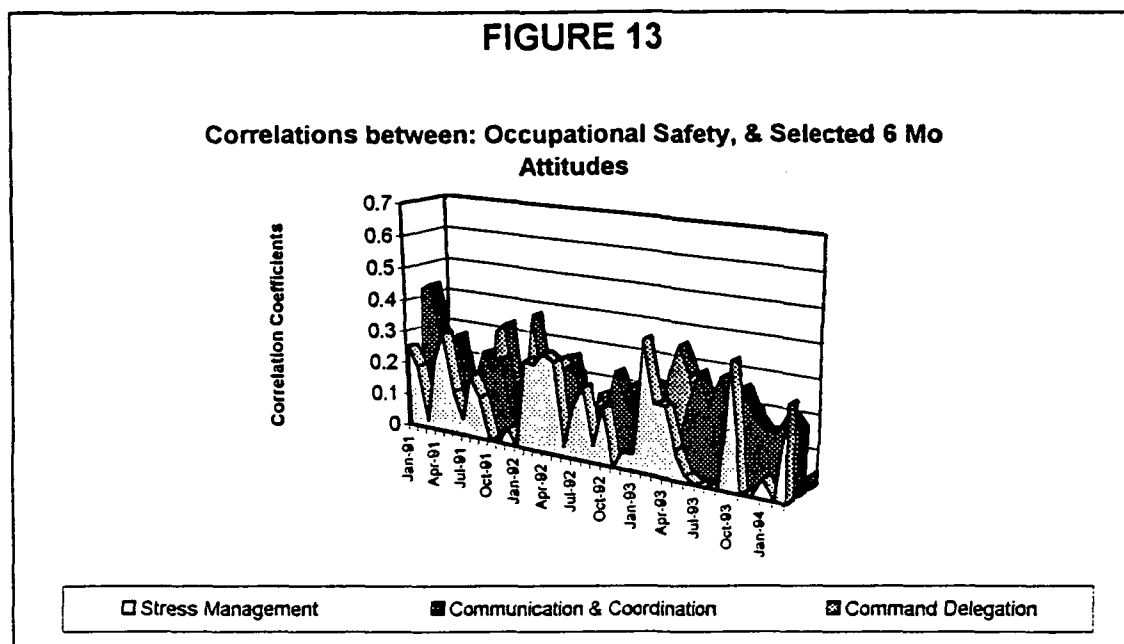
Table 10 displays the percentage of significant correlations between the attitudes measured six months after training and all available months of performance results.

TABLE 10
Percent of Significant Correlations
Between 6-Month Follow-up Attitudes and Performance

	6 Month Attitude Scales			
	Sharing Command Responsibility	Communication & Coordination	Managing Stress Effects	Assertiveness
Dependability				
Departures within 5 min of schedule				
13 months before training	16	42	0	0
26 months after training	4	26	0	0
On-time maintenance				
17 months before training	18	18	0	6
27 months after training	19	0	4	4
Safety				
Occupational Safety				
6 months before training	40	80	40	0
33 months after training	21	18	21	3
Aircraft Safety				
6 months before training	20	40	0	0
28 months after training	9	6	6	0
Efficiency				
Overtime paid				
6 months before training	0	20	20	20
33 months after training	9	3	21	3

These 6 months survey results show a lapse in the effects of CRM training compared with the 2-month follow-up survey. They reveal that only prior maintenance performance is related to opinions about delegation, communication, and stress management, surveyed six months after training. Pretraining occupational safety, was the only performance indicator widely correlated to three of the four attitude scales measured six months after training.

Figure 13 displays all the correlations for occupational safety and the three attitudes. Although many of the correlations in Table 10 are statistically significant, most of them are lower in size than those seen for the two month follow-up survey in Figures 11 and 12.



By the 12-month follow-up survey, the training effects have returned to mirror aspects of the post and 2-month surveys. Table 11 presents the percentage of significant correlations between the five performance measures and those attitudes.

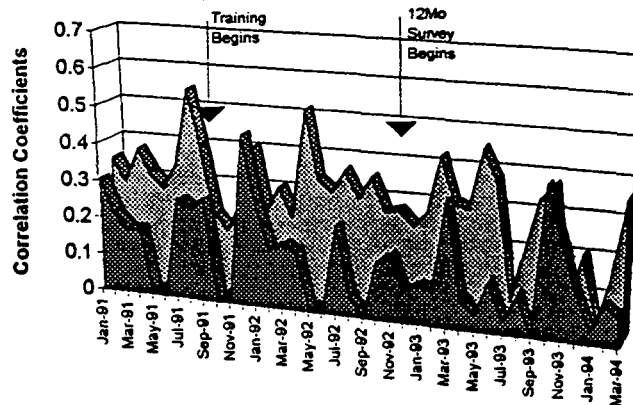
TABLE 11
Percent of Significant Correlations
Between 12-Month Follow-up Attitudes and Performance

12 Month Attitude Scales				
	Sharing Command Responsibility	Communication & Coordination	Managing Stress Effects	Assertive- ness
Dependability				
Departures within 5 min of schedule				
30 months before survey	25	0	13	0
14 months after survey	7	0	13	7
On-time maintenance				
25 months before survey	6	6	23	0
14 months after survey	11	0	52	0
Safety				
Occupational Safety				
18 months before survey	35	12	18	76
21 months after survey	9	5	14	68
Aircraft Safety				
18 months before survey	6	6	12	0
16 months after survey	0	5	0	5
Efficiency				
Overtime paid				
18 months before survey	24	6	29	18
21 months after survey	27	27	50	5

According to Table 11, attitudes about the value of assertiveness one year after CRM training were related to a great many months of occupational safety both before and after that survey was taken. Attitudes, a year after training, toward sharing command decisions were (reminiscent of the 2 month results) also related to many months of occupational safety, but this time, in the months **before** the 12-month survey. Similar to the 2 month results, assertiveness attitudes were also related to many months of occupational safety performance. Figure 14 shows the correlations between occupational safety and the two 12 month attitudes "sharing command" and "assertiveness."

FIGURE 14

**Correlations between: Occupational Safety,
and Selected 12 Mo Attitudes**



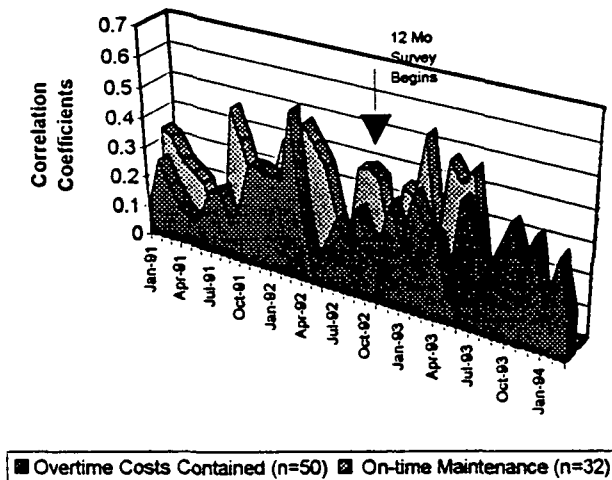
■ Command Delegation 12 months after training ■ Assertiveness 12 months after training

When compared with the decline of subsequent training results from the six month follow-up outcomes these continued improvement of relationships with attitudes after 12 months reflects further strengthening of the training effects. This suggests that the observed diminution of associations using the earlier, six month attitude data (*cf.*, Figure 13); conceals an internal consolidation of training effects rather than their alleviation. In effect, maintenance managers and staff professionals recognized, in the months following CRM training, that their new knowledge and attitudes about participation was of value and that communication, and the effect of practicing the appropriate behaviors, could have an effect on their units' safety.

Another, very interesting outcome of the 12-month survey, shown in Table 11, were the relationships between managing stress effects and the many subsequent months of on-schedule maintenance, and overtime cost savings. These results follow June 1992, a full year after the onset of CRM training in June 1991. They represent performance for both of these very stressful requirements (holding to planned maintenance schedules and staying within required overtime levels) for an additional lagged period during which the lessons of stress management, learned during training a year earlier, had also consolidated for the training participants. Figure 15 presents the correlations between those stressful requirements and 12 month attitudes toward stress management.

FIGURE 15

**Correlations between: 12 Mo Stress Management Attitude,
and Selected "Stressful" Indicators**

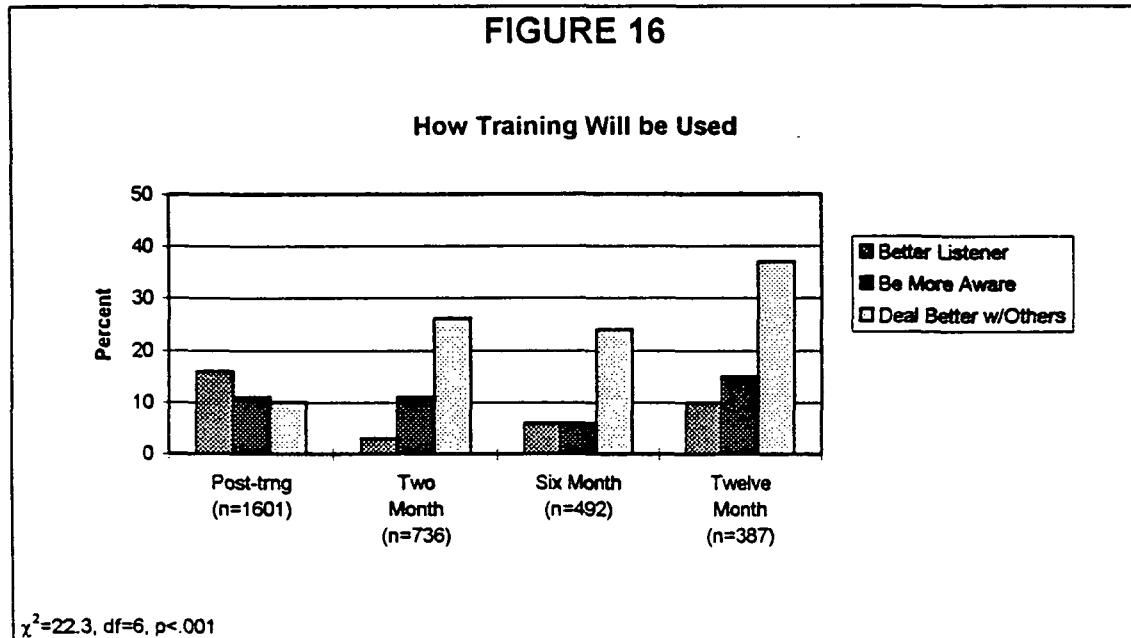


RESULTS SECTION 4:

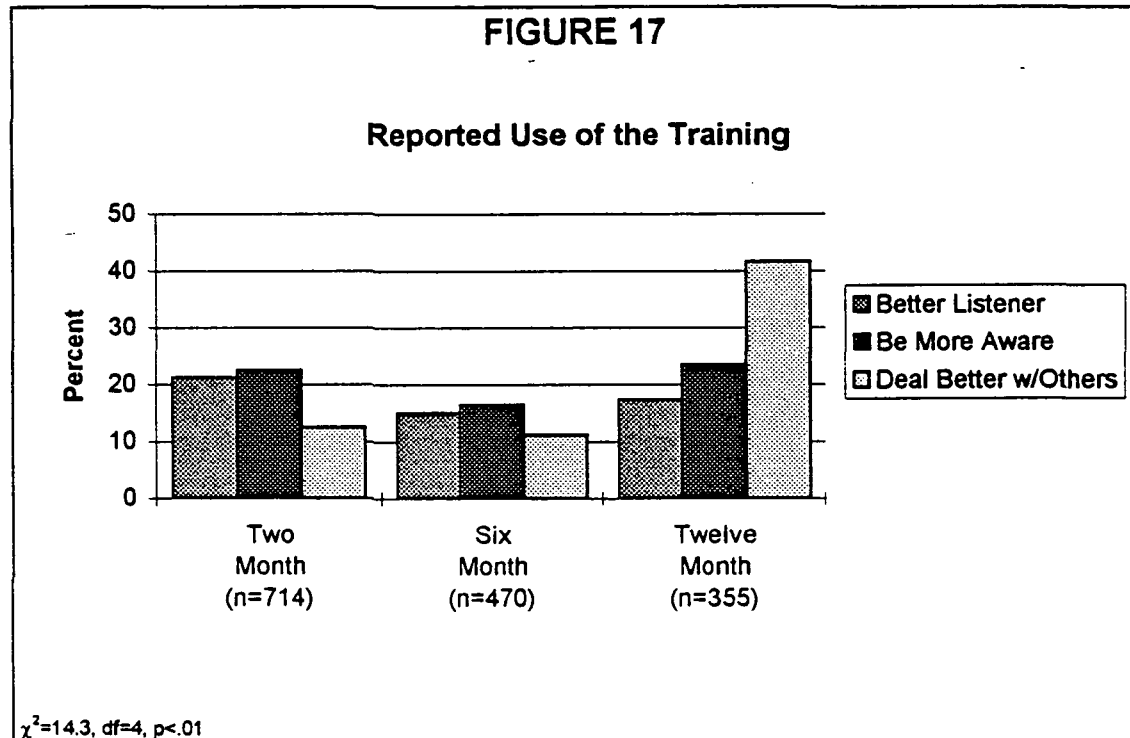
**MANAGERS SELF-REPORTS OF BEHAVIOR CHANGE:
ANALYSIS OF RESULTS OF FIELD INTERVIEWS, AND
WRITTEN COMMENTS FROM THE POST-TRAINING
AND FOLLOW-UP CRM/TOQ**

Two open-ended questions were asked of the maintenance managers concerning the intended use of the CRM training and its application to the job. What follows are the results of these two questions. The full sample available by October, 1994 is employed in the following analyses.

Intended use of CRM training. Figure 16 shows that respondents steadily increased their reported intention to do what we classified as actively “dealing with others” over the four surveys taken after training. They correspondingly reduced their reported intention to passively “be a better listener.”



Reported use of CRM training. Figure 17 shows that, after two months, respondents reported less passive ('better listener') application of the training. By 12 months after their training these respondents reported activities we could classify as "dealing better with others." Thus, in the months following training, increasing use of active skills from the training was intended and achieved.



CONCLUSIONS

The increased safety, dependability and improved costs associated with positive attitudes following the CRM training are strong effects, and they are attributable to that training. The impressive number and size of the correlations between post training attitudes and performance, together with the longitudinal association with performance months after the training are very convincing evidence for the positive effects of CRM training.

Comparisons of managers' attitudes immediately after their training with their pre-training attitudes show significant improvement. Improvement took place in attitudes about "willingness to share command responsibility," "usefulness of communication & coordination," and "recognition that stressors affect decision making." The same attitudes of these managers two-, six-, and 12-months later reveal that these favorable post-training attitudes remain at those positive levels in the months after the training. The fourth attitude scale measured, "willingness to voice disagreement" (a measure of assertiveness), although showing no significant change immediately following training, improved significantly above the pre-training levels two months after training and it remained at that higher level six and 12 months afterwards. The influence of the training on all the expected participant attitudes is thus a stable and robust change and not merely a brief "honeymoon" effect.

Other analyses of the data looked at the relationships between the four attitudes and maintenance results over several years. In this "time-lagged" or longitudinal correlation analysis we tested the effects of the training program on performance. We compared performance before the onset of the training, to attitudes in subsequent time periods, as well as comparing attitudes with later performance results. We found an explainable pattern of significant relationships between the participant's pre-training and post-training attitudes, and between those attitudes and performance. Positive attitudes about "assertiveness," "sharing responsibility," and "stress management" -- all skills and behaviors specifically taught in the CRM training -- were more predictive of subsequent performance. Positive attitudes about the more passive belief, "communication and cooperation," seemed less sensitive to the CRM training and were less predictive of subsequent performance. That attitude, communication & coordination, was not found related to maintenance performance in any of the follow-up surveys. Positive attitudes were apparently initially valuable, as they suggested a sensitivity to more specific behaviors and later attitudes about assertiveness, stress management, and delegation.

Associations between positive post-training attitudes and subsequent performance were even stronger when attitudes were measured at 2 months and at 12 months after the training. Overall, the survey results from these 2 month and 12 month follow-up surveys are remarkably strong and indicate that lessons learned from the CRM training consolidate and strengthen in the months afterward, and in more "active" or practical ways. In most cases the strongest relationships were found in the months following the measurement and they then trended downward for the remaining period.

The strong implication is that CRM training for maintenance managers and support professionals is effective if the behaviors taught are given time to develop. Once competence and early success is achieved consolidation takes hold and reinforces the positive attitudes making them more enduring. Simply letting time take its course does not assure the continued success of the program. The period between two months and one year following initial training should be an ideal time for recurrent training to sharpen the skills and to strengthen management resolve. Additionally the motivation and logic to extend the CRM training to mechanics is strong among past participants and this diffusion should be realized. With diffusion to mechanics, and recurrent training for all participants,

we should then expect to find that ever increasing maintenance performance would be the outcome of the positive attitudes and inspiration resulting from "crew resource management."

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Technical Operations Division Crew Coordination Concepts Syllabus

APPENDIX A

Module	Time	Facilitator	Method	Objective
Day 1 Introduction	8:15am (30 min)	TO	Introduce self. Cover facilities, restrooms, telephones, breaks, lunches, closing time. What have you heard about course? Review PURPOSE, OBJECTIVES. WORKING AGREEMENTS. Collect Pre-seminar questionnaire. Explain purpose & importance of ID #. Group introduces themselves.	Position program as helpful in dev. mgt. skills. Get group talking and energized. Set the tone of the workshop. Clarify expectations, yours/theirs. Remove teacher-student relationship.
Portland Video	8:45am (45 min)	HF	Show video; identify resource mgt. problems; relate Portland problems to work place. Prepare flipchart.	Attention getter. Identify mgt. problems faced; problems become course focus/overview.
Expectations	9:30am (15 min)	HF	Develop expectations of individuals in course. Write on chart. compare to course objectives.	Get expectations from group, compare to course illustrate differences if any.
Break	9:45am (15 min)			
Testing Assumptions/ DC-10 Video GUM	10:00am (120 min)	TO	Introduce concept of Perception vs Reality. Show DC-10 Video GUM. Tablework: What were "Chain of Events" that led to the accident? Discuss "ASSUMPTIONS" that led or contributed to accident. How can we test our assumptions? What could each person have done differently?	Test Assumptions by: Advocacy - "Speaking Out" Inquiry - "Ask Questions" Active Listening - "Listening"
Lunch	12:00pm (60 min)			

Technical Operations Division Crew Coordination Concepts Syllabus

Module	Time	Facilitator	Method	Objective
Behaviors	1:00pm (75 min)	HF	Discuss use of instruments; admin. SDI; develop Behav Dim Model; discuss concept of "Assertive Behavior."	Understand behavior differences; understand strengths and weaknesses of behavior styles; assertiveness involves using a variety of styles (positively).
Break	2:15pm (15 min)			
Behaviors Cont'd	2:30pm (60 min)	HF	Score SDI; Interpret SDI; draw arrows; discuss/apply "Assertiveness"	People are different; behaviors influence communication, values, perceptions of others, decision making & conflict resolution methods. Behavior modification approp. for effective supervision.
Break	3:30pm (15 min)			
Stress Management	3:45pm (60 min)	TO/HF	TO-Introduce/understand stress What are sources of stress in our jobs? Develop list of Stressors. HF-Identify body's reaction to stress. Ways to deal with stress. TO-Work on how to deal with 2 examples. ETR'S, MANPOWER, PARTS AVAILABILITY	Stress is normal; stress can be managed; Recognize signs of excess stress. Effects of safety & efficiency. Application of CCC to reduce stress.

Technical Operations Division Crew Coordination Concepts Syllabus

Module	Time	Facilitator	Method	Objective
Day 2 Opening DC-10 Video GUM 041	8:15am (30 min)	TO	Show GUM 041 video with breakfast. Address loose ends from Day 1; Outline schedule for Day 2. Review lessons learned in context of video (Gum 041).	Transition and clarification; group at ease with where they've been and are heading; NOT A REVIEW!
Sub Arctic Survival	8:45am (60 min)	TO	Purpose of simulation. Make individual decisions (step 1). Make group decisions (step 2).	Tie into Day 1; position as a competition This is fun!
Break	9:45am (15 min)			
SAS II	10:00am (60 min)	IIF	Define/develop rational decision process; apply process to simulation; complete SAS; critique team effect; develop lessons learned/appl to job.	Problem solving involves a rational process; consensus decisions are better than individual decisions Interpersonal skills impact decision-making.
Break	11:00am (15 min)			
Norms/ EAL 855	11:15am (45 min)	TO	Identify role of norms in Tech Ops. Introduce concept, give examples. Allow time to review EAL 855. Assign each table a role. What were norms that led to accident? Groups develop lists of good/bad CO Norms. Discuss how to manage norms and prevent accidents.	Norms play powerful role in organizations. Have a direct impact on safety & efficiency. Assumptions must be tested. Norms are unwritten rules enforced by the group. Mgt & FAA are powerless to change norms.
Lunch	12:00pm (60 min)			

Technical Operations Division Crew Coordination Concepts Syllabus

Module	Time	Facilitator	Method	Objective
Listening & Communicating	1:00pm (60 min)	HF	Tie into SAS; Sleep exercise. Communication model; listening barriers; listening tips.	Listening is a learned skill. Poor listening limits quality decision making.
Break	2:00pm (15 min)			
Supporting/Confronting	2:15pm (60 min)	TO/HF	Use interactive dilemmas. Conduct 1st dilemma. Critique/lessons learned from 1st. Conduct second dilemma. How was second different from first?	Application of behavioral skills/style. Understand the variety of approaches; language is important. Use role play to demonstrate skills/lack of and need of practice.
Break	3:15pm (15 min)			
Wrap-up Evaluation/ Questionnaire	3:30pm (45 min)	TO/HF	Take Home concepts? USC/CAL Questionnaire explanation I.D. #s on questionnaires.	Pledge to do something different/better. Feedback for program enhancement; participants feel good about experience.

APPENDIX B

Date _____

TECHNICAL OPERATIONS DIVISION
CCC WORKSHOP SURVEY

"Six-month Follow-up" Questionnaire

Please enter the five digit Personal Identification Number
that you selected at the beginning of the seminar.

Identification Code _____

Now, please answer by writing beside each item the number that best
reflects your personal attitude. Choose the number from the scale
below. All data are strictly confidential.

*****Scale*****

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

- ___ 1. Technical Operations 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. Casual, social conversation on the job during periods of low workload can improve Technical Operations team coordination.
- ___ 4. Good communications and team coordination are as important as technical proficiency for aircraft safety and operational effectiveness.
- ___ 5. We should be aware of and sensitive to the personal problems of other Technical Operations team members.
- ___ 6. The manager, supervisor, or assistant supervisor in charge should take hands-on-control and make all decisions in emergency and non-standard situations.
- ___ 7. The manager, supervisor, or assistant supervisor in charge should verbalize plans for procedures or actions and should be sure that the information is understood and acknowledged by the other Technical Operations team members.

*****Scale*****

- | | 1 | 2 | 3 | 4 | 5 |
|---------|---|----------------------|---------|-------------------|-------------------|
| | Disagree
Strongly | Disagree
Slightly | Neutral | Agree
Slightly | Agree
Strongly |
| ___ 8. | Technical Operations team members should not question the decisions or actions of the manager, supervisor, or assistant supervisor except when they threaten the safety of the operation. | | | | |
| ___ 9. | Even when fatigued, I perform effectively during critical phases of work. | | | | |
| ___ 10. | Managers, supervisors, and assistant supervisors should encourage questions during normal operations and in special situations. | | | | |
| ___ 11. | There are no circumstances where the subordinate should assume control of a project. | | | | |
| ___ 12. | A debriefing and critique of procedures and decisions after each major task is an important part of developing and maintaining effective team coordination. | | | | |
| ___ 13. | Overall, successful Technical Operations management is primarily a function of the manager's, supervisor's, or assistant supervisor's technical proficiency. | | | | |
| ___ 14. | Training is one of the manager's most important responsibilities. | | | | |
| ___ 15. | Because individuals function less effectively under high stress, good team coordination is more important in emergency or abnormal situations. | | | | |
| ___ 16. | The start-of-shift team briefing is important for safety and for effective team management. | | | | |
| ___ 17. | Effective team coordination requires each person to take into account the personalities of other team members. | | | | |
| ___ 18. | The responsibilities of the manager, supervisor, or assistant supervisor include coordination between his or her work team and other support areas. | | | | |
| ___ 19. | A truly professional manager, supervisor, or assistant supervisor can leave personal problems behind. | | | | |
| ___ 20. | My decision-making ability is as good in abnormal situations as in routine daily operations. | | | | |

*****Scale*****

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

In the following questions, "my management group" refers to those people who report to the same manager that I do.

- ___ 21. I am kept informed by others in my management group about the goals and objectives of this organization (e.g., cost, quality, service, etc.).
- ___ 22. Work goals and priorities are understood and agreed to by members of my management group.

In the following items, "my work group" refers to those people who report to me.

- ___ 23. Employees in my work group receive detailed feedback regarding the organization's performance.
- ___ 24. 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.
- ___ 25. Employees in other groups within Technical Operations plan and coordinate their activities effectively together with people in my work group.
- ___ 26. Employees in other groups, departments and divisions throughout the company act as if they share many of the same organizational goals that we do.

27. How useful has the CCC training been for others? (circle one)

A Waste of Time	Slightly Useful	Somewhat Useful	Very Useful	Extremely Useful
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28. How much has the CCC training changed your behavior on the job? (circle one)

No Change	A Slight Change	A Moderate Change	A Large Change
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29. What changes have you made as a result of the CCC training?

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

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

32. What do you think could be done to improve CCC training?

Year of birth	_____
Total years at	_____
Sex (M or F)	_____

CURRENT DEPARTMENT	
_____	Line Maintenance
_____	Base Maintenance
_____	Quality Control
_____	Planning
_____	Shop
_____	Material Services
_____	Engineering
_____	Other

WORK LOCATION - CITY	_____
:	_____

Job Title:	_____
Years in present position:	_____
Past experience/training (# of years):	
Military	_____
Trade School	_____
College	_____
Other Airline	_____

This completes the Questionnaire
Thanks for your help.