CHAPTER SIX
THE EFFECTS OF CREW RESOURCE MANAGEMENT (CRM) TRAINING IN AIRLINE MAINTENANCE:RESULTS FOLLOWING ONE YEAR'S EXPERIENCE (Report of Work Completed through 6-30-92)

6.0 SUMMARY

This report describes the first full year's evaluation of the effects of one airline's Crew Resource Management (CRM) training program. This evaluation focuses on maintenance managers' attitudes, their reported behaviors, and the maintenance performance of their units. The results reveal a strong positive effect of the training.

The overall program represents a long-term commitment to improving safe, dependable, and efficient performance through effective communication at all levels in airline maintenance operations (Appendix Part 1, Appendix Part 2, Appendix Part 3, and Appendix Part 4 contain the current syllabus). The initial findings described in a previous progress report (Galaxy Scientific Corporation, 1992) are reinforced and elaborated here. The current results benefit from a larger sample size. Additional months of performance data and results from six- and twelve-month follow-up questionnaires also contribute to the value of this data set.

In the present report, we examine maintenance performance changes following training, as well as the relationships noted between the post-training attitudes and performance. Maintenance performance reported here includes safety from ground damage, safety from injury, maintenance costs in overtime paid, delays in RON (remain in station overnight) aircraft departures, as well as dependability of on-time departures for other scheduled flights. We further describe these measures in Table 6.1.

Table 6.1 Technical Operations Performance Measures Available by Work Unit
(maximum number of work units possible are in parentheses)

I. MEASURES OF EFFICIENCY

A. Cost

1. % Overtime paid to total wage bill[b] (60)

II. MEASURES OF SAFETY

B. Safety of Aircraft

2. Number of Ground Damage Incidents[a] (44)

C. Personal Safety

3. % Occupational Injury Days Lost[a] (60)

III. Measures of Dependability

D. Departure Performance (Line Station data only, n=31)

4. % Departure within 5 minutes[a]
5. % Departure within 15 minutes[a]
6. % Departure within 60 minutes[b]
7. % Departure over 60 minutes, but not canceled[c]
8. Number of Delays due to late from Maintenance[a] (n=35)

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a = Measures evaluated **most** sensitive to effects of CRM training
b = Measures evaluated **moderately** sensitive to effects of CRM training
c = Measures evaluated **least** sensitive to effects of CRM training

Table 6.1 Technical Operations Performance Measures Available by Work Unit

The analyses reported here examine training effects on performance, on attitudes and on indicators of behavior. In particular, we compare managers' immediate post-training attitudes with their follow-up attitudes about a variety of management and organizational factors. We also test the relationship of attitudes with maintenance performance measures. Highlights of results from this training program include increased safety and improved costs from management of stress, and improved on-time performance from the application of more assertive communications. More specific results are as follows:

1. We noted positive trends in a number of the company's overall maintenance performance for the 12 months after the onset of training, compared with the 12 months before. The two performance categories of Efficiency (Figure 6.3) and Safety (Figures 6.4-6.5) improve after the training. In addition, most of the overall results of Dependability performance remain stable in the 12 months after the onset of training (Figures 6.6, 6.7, 6.8, 6.9, and 6.10).

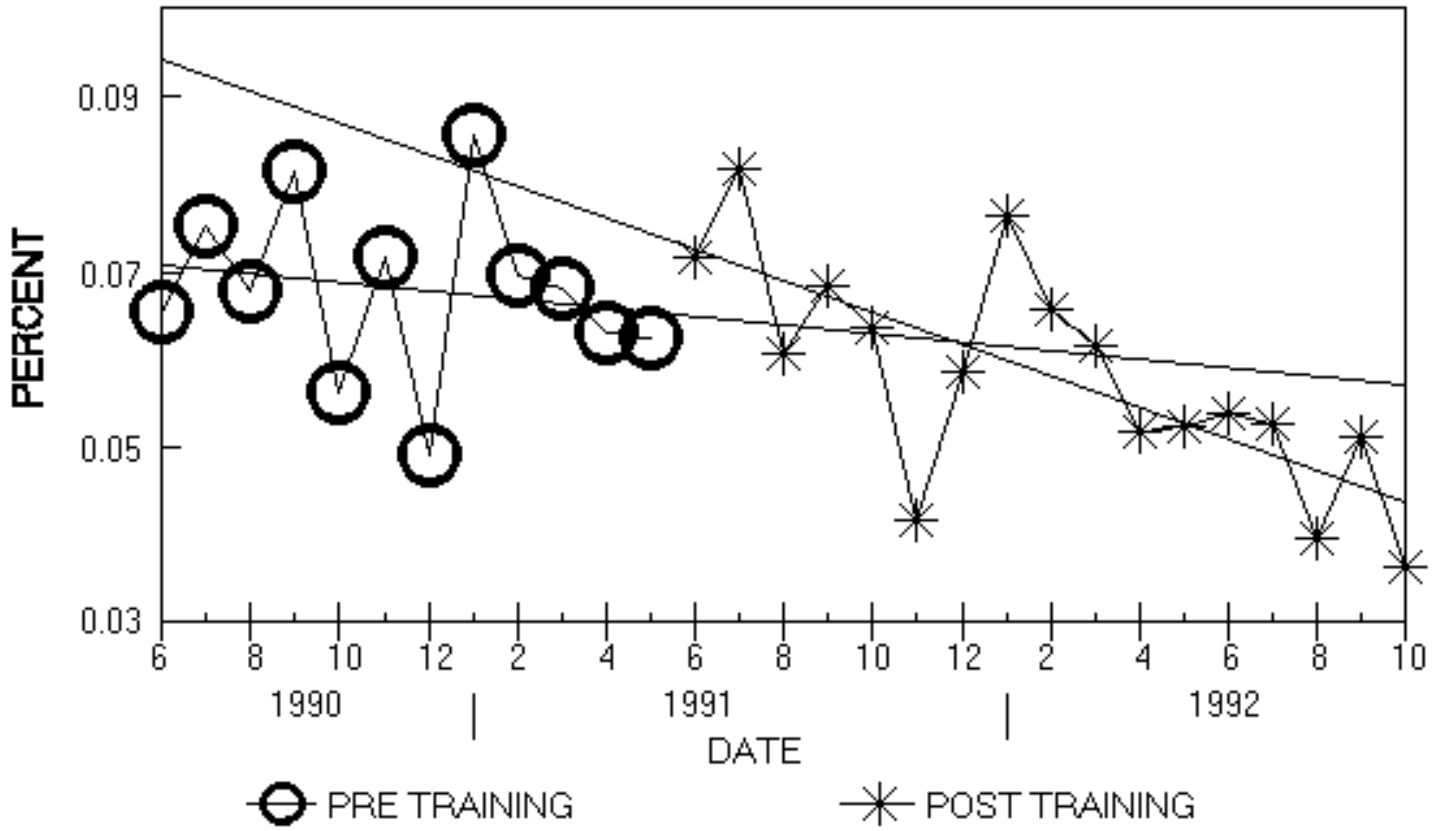


Figure 6.3 Efficiency Overtime (time series)

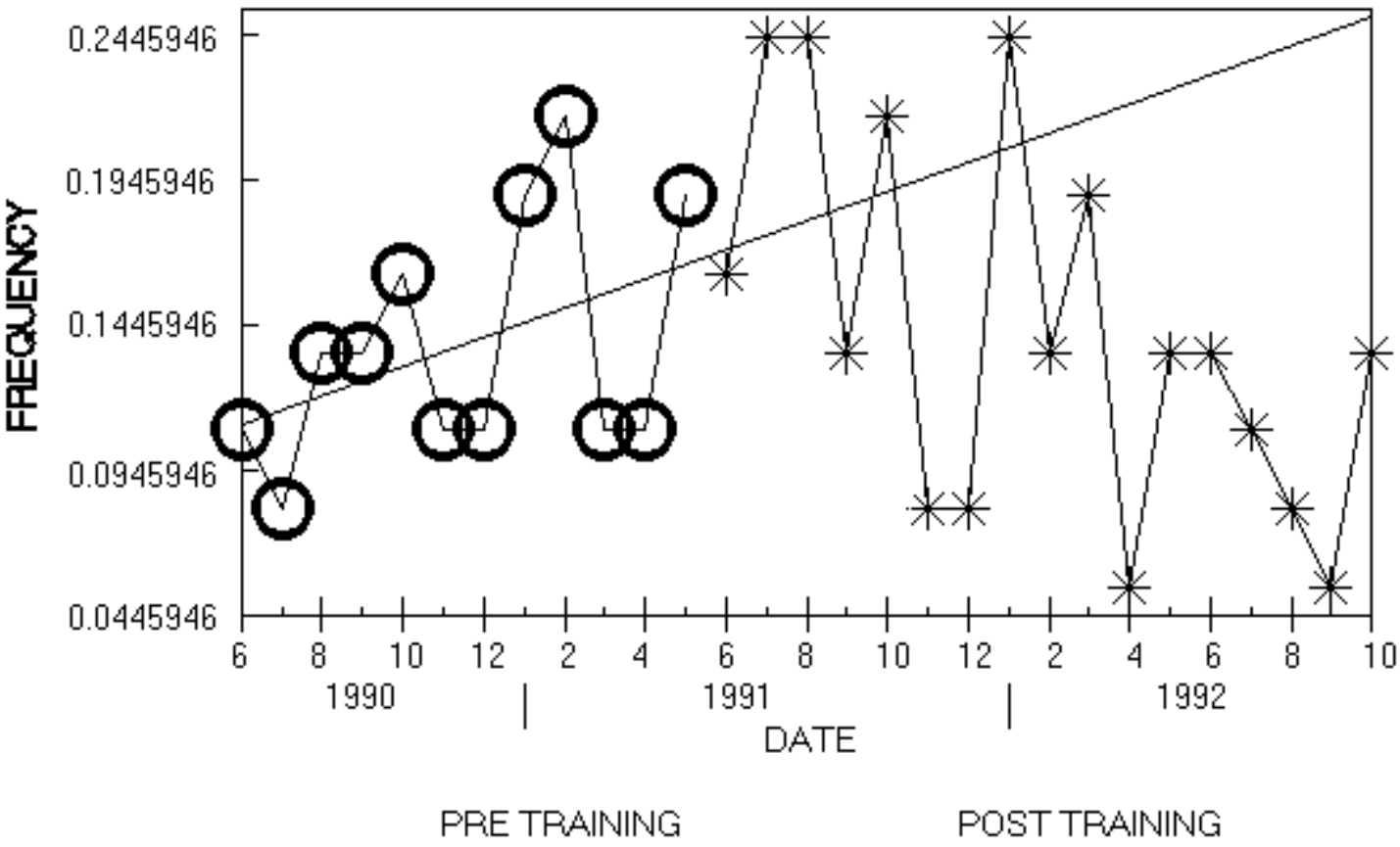


Figure 6.4 Safety Ground Damage (time series)

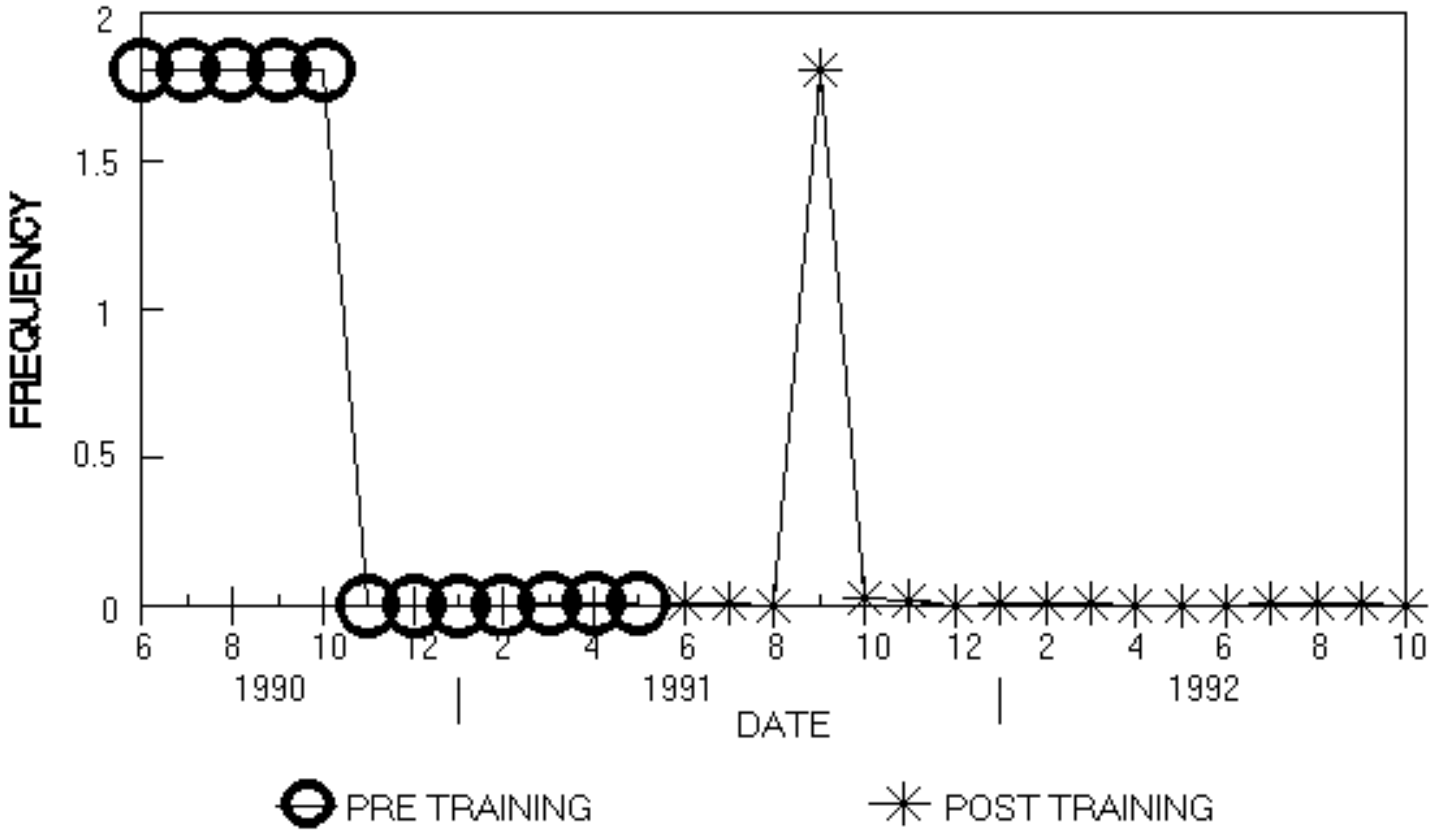


Figure 6.5 Safety Occupational Injury (time series)

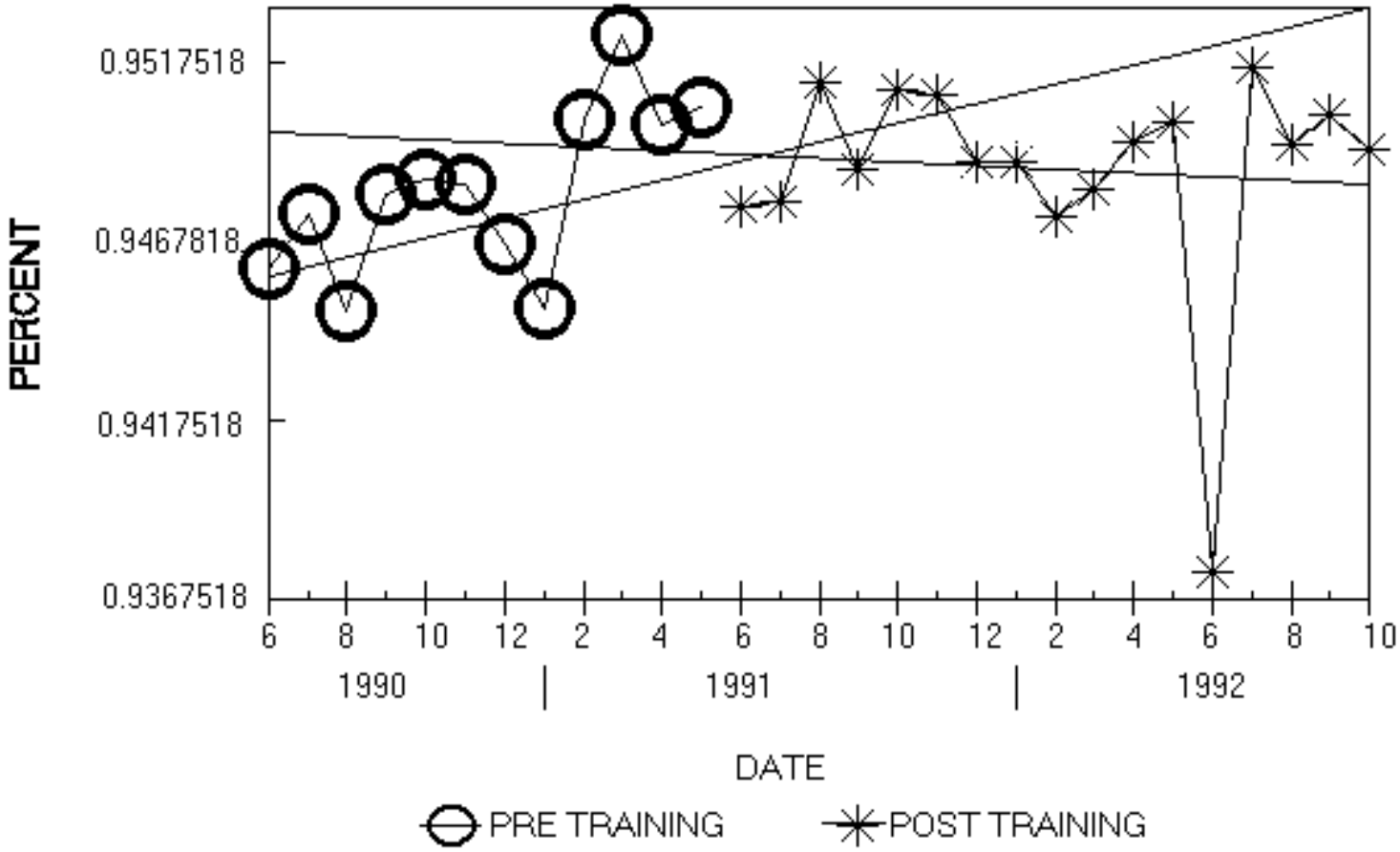


Figure 6.6 Dependability Departure in 5 Minutes (time series)

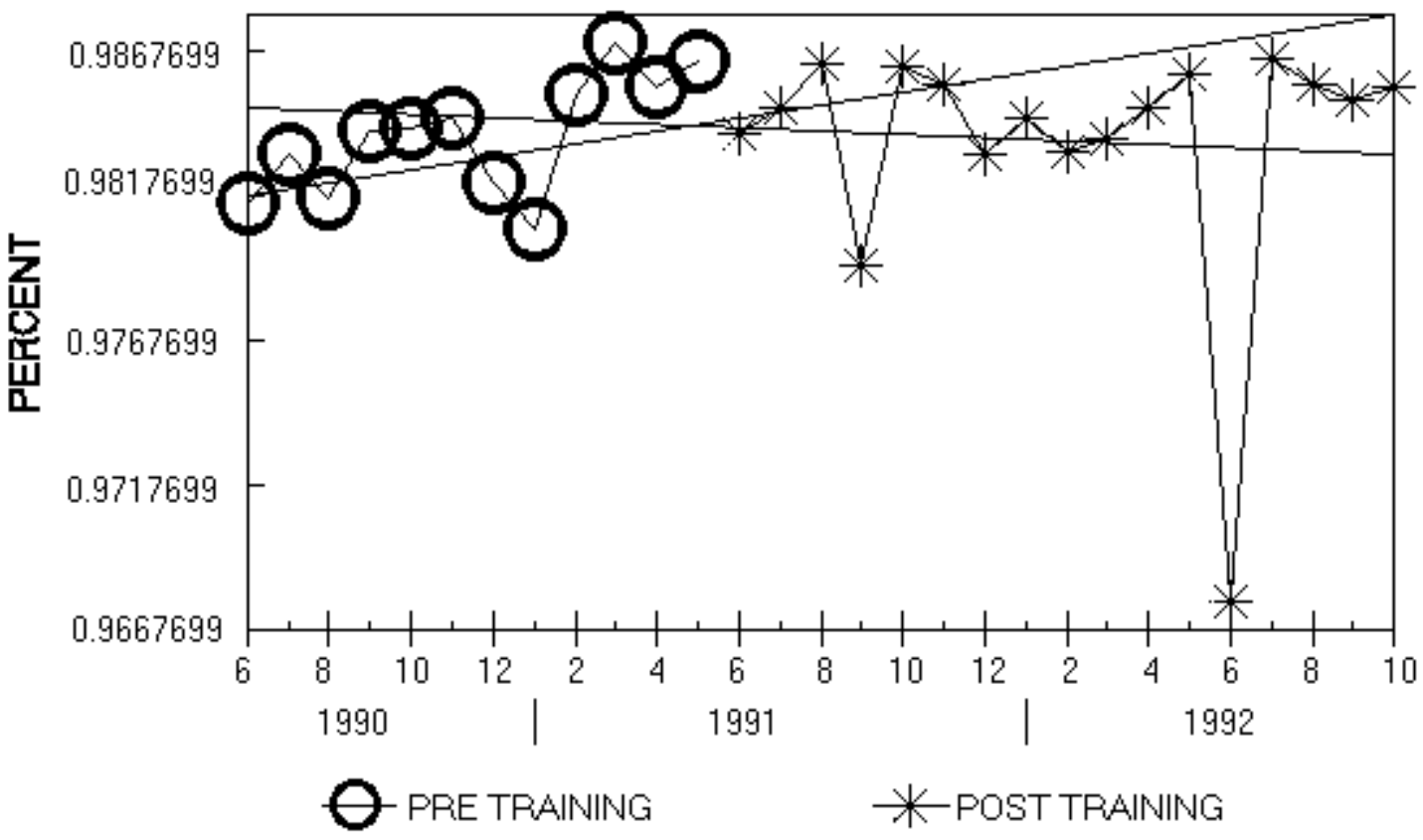


Figure 6.7 Dependability Departure in 15 Minutes (time series)

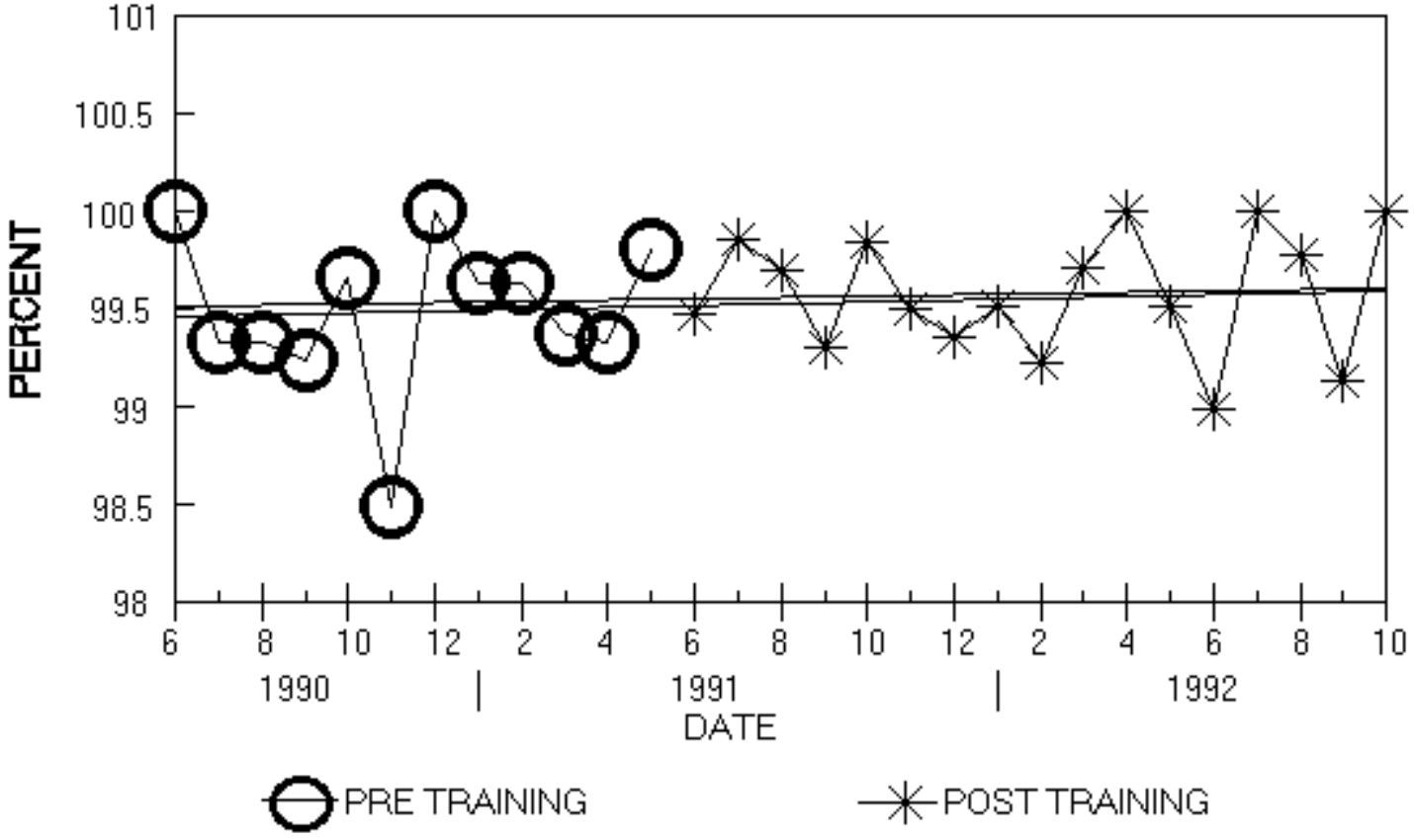


Figure 6.8 Dependability Departure in 60 Minutes (time series)

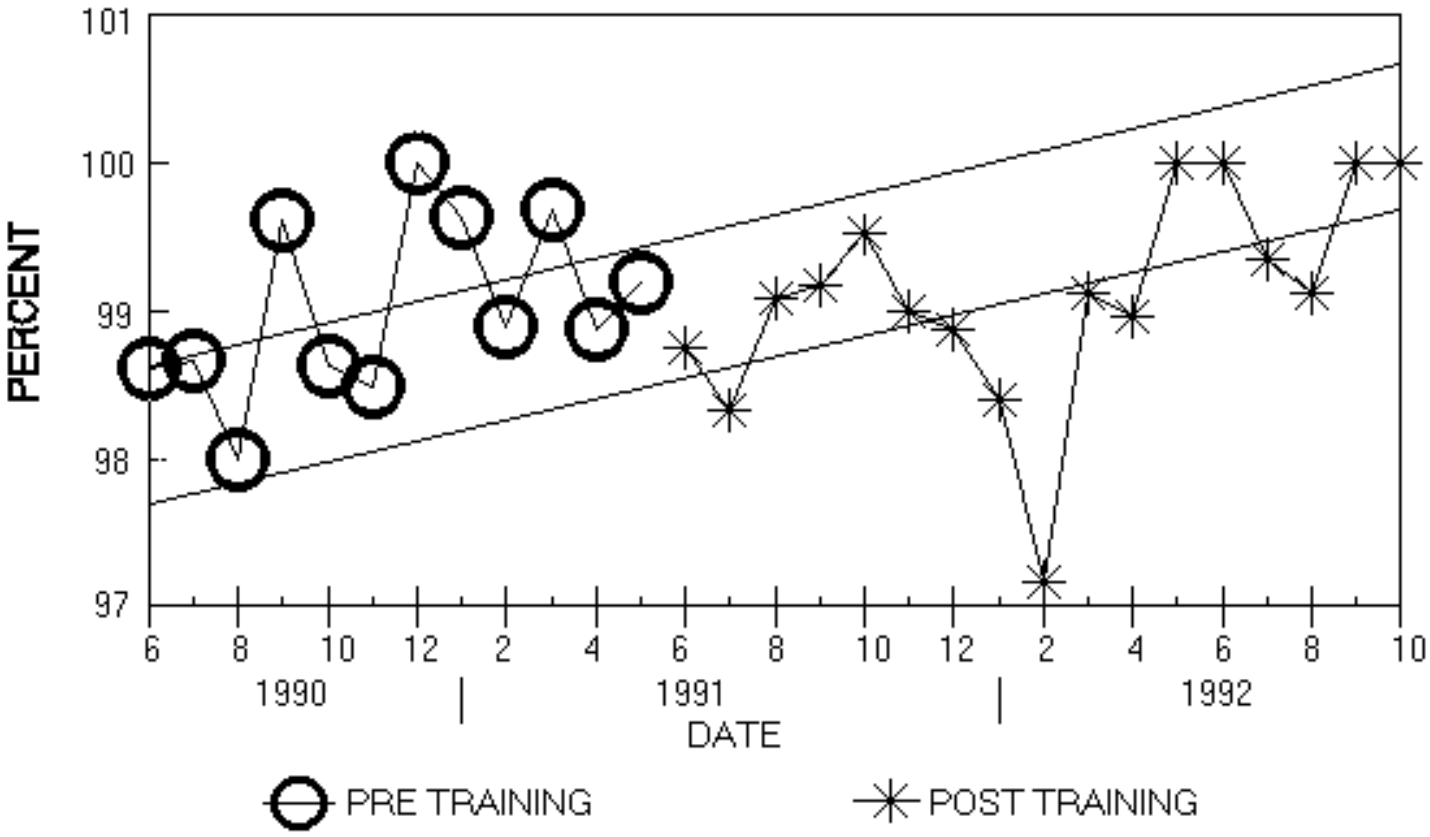


Figure 6.9 Dependability Flights Not Cancelled (time series)

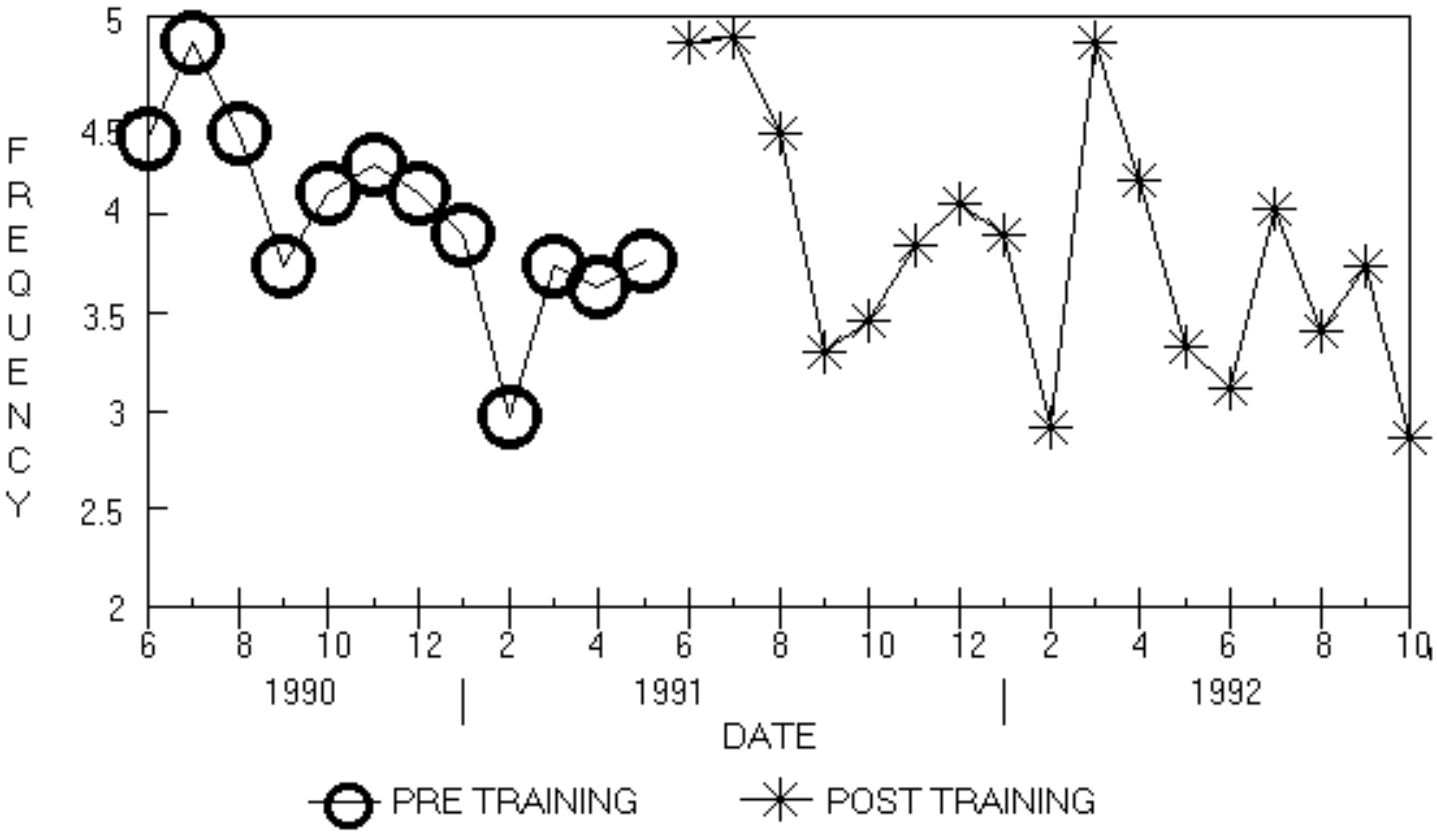
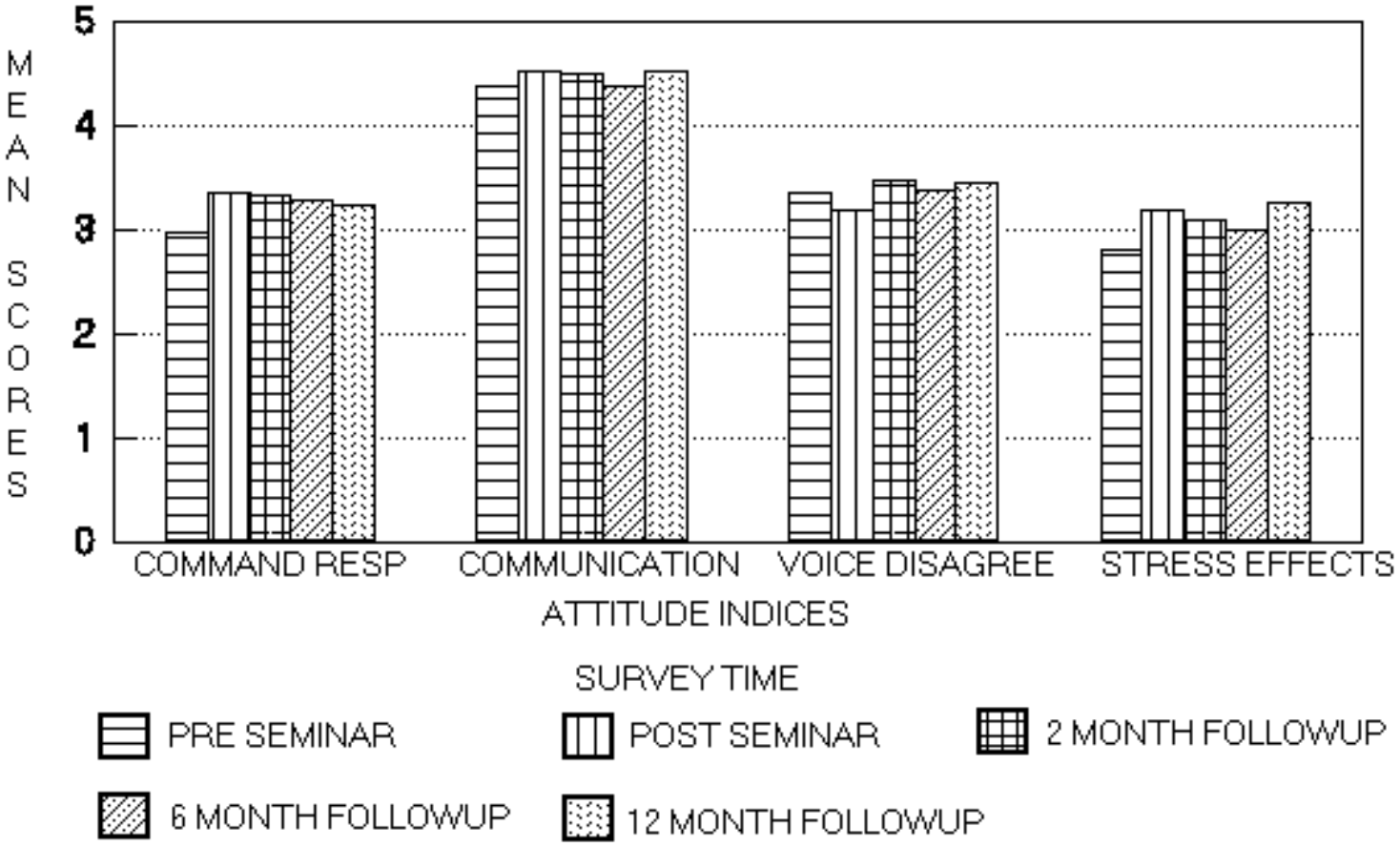


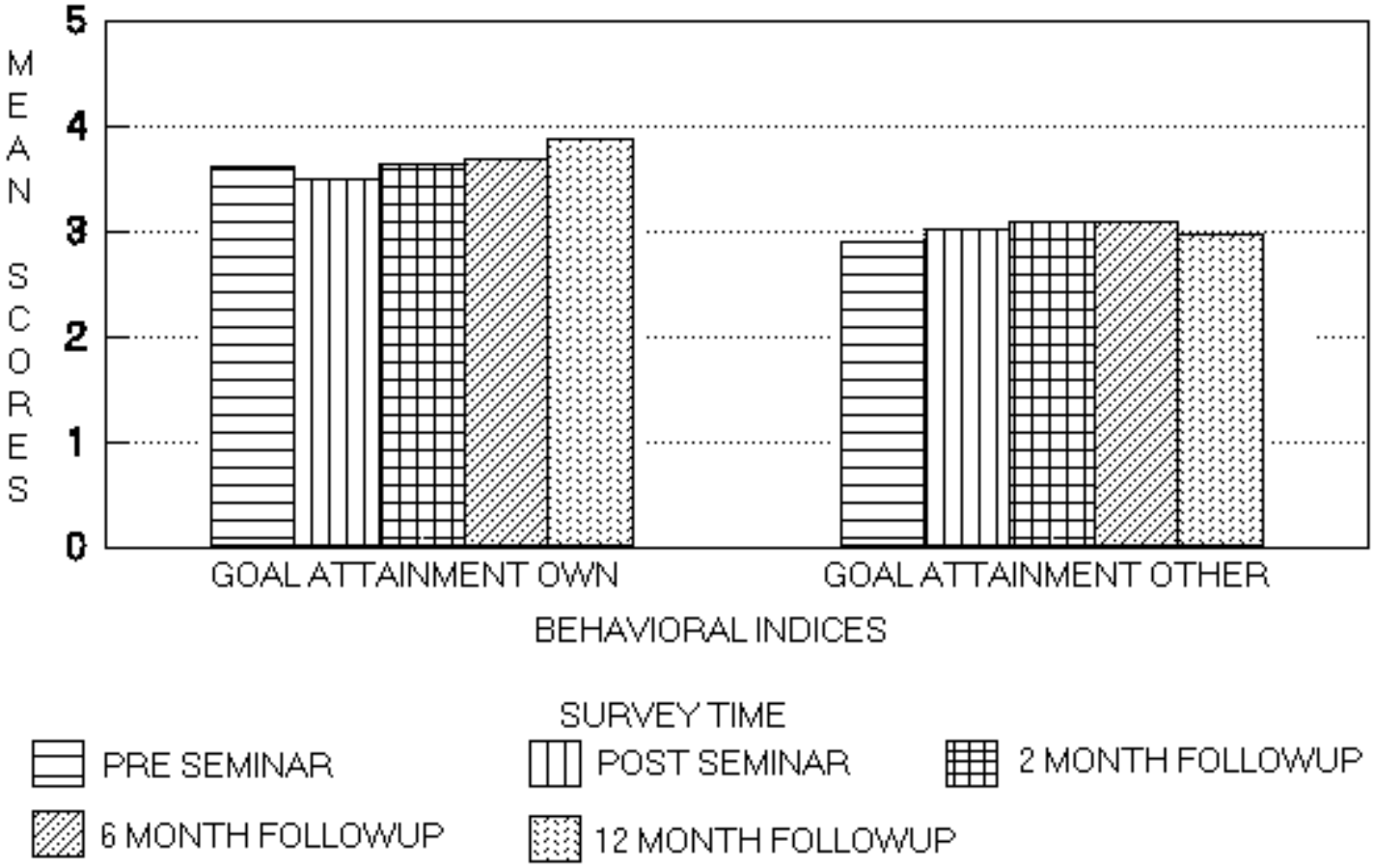
Figure 6.10 Dependability Late From Maintenance (time series)

2. Comparisons of managers' attitudes immediately after their training with their attitudes months later confirm that the effects of training on beliefs are stable. Comparison of managers' attitudes before and after their training showed a showed significant improvement in three of the four attitude indicators. Improvement took place in attitudes about "willingness to share command responsibility," "usefulness of communication & coordination," and "recognition that stressors affect management decision-making" (Galaxy Scientific Corporation, 1992). The present report goes beyond that examination of pre-post test comparison of attitudes to look at the same attitudes shown by these managers months later. This test of the questionnaire data shows that the favorable post-training attitudes remain at those high levels two months, six months, and twelve months after the training. The influence of the training on managers' attitudes is thus a stable and robust change and not merely a brief "honeymoon effect." We present these comparisons graphically in Figures 6.1 and 6.2.



n=450, pre; n=1036, post; n=352, 2 mo.;
n=261, 6 mo.; n=76, 12 mo.;
p=ns

Figure 6.1 Attitude Indices Pre, Post, Two, Six, Twelve Months



n=450, pre; n=973, post; n=314, 2 mo.;
n=234, 6 mo.; n=72, 12 mo.
p=ns

Figure 6.2 Behavioral Indices Pre, Post, Two, Six, Twelve Months

3. Another analysis of the data looks at the relationships between the post-training attitudes and maintenance results over several months. In this "time-lagged" analysis, we test the effects for performance before the training, performance at the same time as the training, and performance months after the training. As we describe in the main body of this report, we found a pattern of significant relationships (in the expected direction) between the managers' **immediate post-training attitudes** and performance. Specifically, some attitudes are associated with concurrent performance of work units, as well as performance several months later. Effective performance, as measured by the dependability measures, in the months before the training are associated with favorable post-training feelings about communication and coordination and the importance of work stresses in management decision-making (cf., Tables 6.7, 6.8, 6.9, 6.10, and 6.11). Furthermore, these two attitude measures are also significantly related to on-time performance in the months following the training (Table 6.7).

Table 6.7 Spearman-Rho Correlations between Post-training CRM/TOQ Results and Maintenance Dependability Performance for Departures within Five Minutes

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	.29	.17	.38*	.28	.19	.00	.24
Communication and Coordination	.36*	.24	.05	.35*	.41**	.20	.09
Recognition of Stressor Effects	.32*	.05	.05	.35*	.41**	.08	.15
Willingness to Voice Disagreement	.29	.17	.07	.15	.25	.18	.13
Goal Attainment with Own Group	.25	.15	.09	.28	.45**	.28	.08
Goal Attainment with Other Groups	.21	.08	.01	.18	.35	.28	.01

n = 27. Shaded cells are months concurrent with the training (and the assessment) and unshaded cells are the months following training.
*p < .05, **p < .01

Table 6.8 Spearman-Rho Correlations between Post-training CRM/TOQ Results and Maintenance Dependability Performance for Departures within Fifteen Minutes

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	.23	.20	.42**	.20	.18	.03	.29
Communication and Coordination	.36*	.21	.05	.18	.28	.10	.03
Recognition of Stressor Effects	.21	.15	.18	.28	.28	.15	.16
Willingness to Voice Disagreement	.30*	.09	.07	.17	.23	.03	.17
Goal Attainment with Own Group	.24	.10	.00	.38*	.48**	.07	.31
Goal Attainment with Other Groups	.31	.11	.00	.10	.36*	.17	.04

n = 26. Shaded cells are months concurrent with the training (and the assessment) and unshaded cells are the months following training.
*p < .05, **p < .01

Table 6.9 Spearman-Rho Correlations between Post-training CRM/TOQ Results and Maintenance Dependability Performance for Departures within Forty Minutes

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	.17	.22	.30	.16	.11	-.14	.14
Communication and Coordination	.30*	.07	-.02	.25	.09	.08	.21
Recognition of Stressor Effects	.45**	.22	.17	.07	-.01	.11	.08
Willingness to Voice Disagreement	.21	.13	.05	-.04	.02	-.05	.00
Goal Attainment with Own Group	.05	.09	.15	.14	.07	-.08	.02
Goal Attainment with Other Groups	.19	-.08	-.09	.28	.32	-.09	-.04

n = 27. Shaded cells are months concurrent with the training (and the assessment) and unshaded cells are the months following training.
*p < .05, **p < .01

Table 6.10 Spearman-Rho Correlations between Post-training CRM/TOQ Results and Maintenance Dependability Performance for Sixty Minutes, Not Canceled

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	.08	.04	.20	.05	.00	-.10	.20
Communication and Coordination	(-.44**)	[illegible]	.39*	.00	.00	.24	.16
Recognition of Stressor Effects	[illegible]	[illegible]	.40*	-.19	.00	-.25	.39
Willingness to Voice Disagreement	.08	.03	.30	-.03	-.30	-.20	.30
Goal Attainment with Own Group	-.19	.03	.03	.19	-.26	.08	.25
Goal Attainment with Other Groups	.20	.17	.13	.04	-.27	-.47**	.28

n = 27. Shaded [illegible] with the training (and the measurement) and included [illegible] months following training.
*p < .05, **p < .01

Table 6.11 Spearman-Rho Correlations between Post-training CRM/TOQ Results and Maintenance Dependability Performance for Delay Due to Late from Maintenance[1]

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	-.15	-.37*	-.27	-.12	-.33*	-.17	-.28
Communication and Coordination	-.30*	-.40**	-.52**	-.40*	-.37*	-.37*	-.24
Recognition of Stressor Effects	-.09	-.23	-.20	-.30	-.21	-.14	-.40*
Willingness to Voice Disagreement	-.10	-.22	-.20	-.18	-.19	-.11	-.20
Goal Attainment with Own Group	-.10	-.22	-.20	-.18	-.16	-.11	-.20
Goal Attainment with Other Groups	.06	-.22	-.12	-.39*	-.27	-.09	-.13

n = 18. Shaded [illegible] with the training (and the measurement) and included [illegible] months following training.
[1]Note: Those have more [illegible] performance is positive, [illegible] the direction of the correlation should be negative.
*p < .05, **p < .01

4. The pattern of relationships between **attitudes assessed two months after training,** and performance is somewhat different. These "follow-up attitudes" have more sustained relationships with performance over the several months examined than attitudes immediately following the training. A low rate of ground damage incidents before and during the period of the two-month follow-up survey is most related to three indices in the follow-up measure. Those three are the "recognition of stressor effects on decision-making," and the participant reports of "work goal sharing" within and between work groups (Table 6.13). Measures of assertiveness and of sharing command responsibility are consistently related to on-time performance (Table 6.15) and to the other measures of dependability (Tables 6.16, 6.17, and 6.18).

Table 6.13 Spearman-Rho Correlations between Two Month Follow-up CRM/TOQ Results and Maintenance Safety Performance for Ground Damage[1]

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	-.22	-.25	.09	-.10	-.44*	-.19	-.16
Communication and Coordination	-.37	-.21	.10	.09	-.27	-.37	-.28
Recognition of Stressor Effects	.13	-.47*	.19	-.49*	-.43*	-.26	-.11
Willingness to Voice Disagreement	.05	-.04	.19	-.05	-.18	-.30	-.00
Goal Attainment with Own Group	-.10	-.53**	.23	-.46*	-.46*	-.22	-.37
Goal Attainment with Other Groups	-.23	-.62**	-.13	-.43*	-.44*	-.01	-.40

n = 18. Shaded area are months concurrent with the two month follow-up survey for the sample of training participants examined.
[1]Note: These items score lower when performance is positive, thus the direction of the statistics should be negative.
*p < .05, **p < .01

Table 6.15 Spearman-Rho Correlations between Two Month Follow-up CRM/TOQ Results and Maintenance Dependability Performance for Departures within Five Minutes

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	.54**	.27	.30	.28	.14	.49*	.40
Communication and Coordination	-.06	-.18	-.16	.10	.09	-.21	-.02
Recognition of Stressor Effects	.33	.17	.11	.19	-.04	.27	.26
Willingness to Voice Disagreement	.64**	.69**	.69**	.52**	.67**	.69**	.65**
Goal Attainment with Own Group	.43*	.53	.51*	.65**	.64**	.32	.49*
Goal Attainment with Other Groups	-.03	.10	.20	.26	.21	.04	.21

n = 17. Shaded area are months concurrent with the two month follow-up survey for the sample of training participants examined.
*p < .05, **p < .01

Table 6.16 Spearman-Rho Correlations between Two Month Follow-up CRM/TOQ Results and Maintenance Dependability Performance for Departures within Fifteen Minutes

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	.42*	.21	.34	.23	.05	.45*	.34
Communication and Coordination	.31	-.23	.17	.00	.10	-.30	.11
Recognition of Stressor Effects	.31	.13	.21	.19	.07	.10	.33
Willingness to Voice Disagreement	.62**	.65**	.74**	.57**	.46*	.70**	.47*
Goal Attainment with Own Group	.42*	.52*	.51*	.62**	.57**	.31	.40*
Goal Attainment with Other Groups	.01	.12	.19	.24	.28	.07	.22

n = 17. Shaded area are months concurrent with the two month follow-up survey for the sample of training participants examined.
*p < .05, **p < .01

Table 6.17 Spearman-Rho Correlations between Two Month Follow-up CRM/TOQ Results and Maintenance Dependability Performance for Departures within Sixty Minutes

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	.46*	.23	.10	.31	-.14	.61**	.36
Communication and Coordination	-.25	-.16	.37	-.23	-.28	-.53*	.16
Recognition of Stressor Effects	35	.22	.21	.11	-.33	.03	.39
Willingness to Voice Disagreement	.66**	.63*	.70**	.43*	.26	.68**	.31
Goal Attainment with Own Group	38	.37	.63	.40	.48	-.13	.25
Goal Attainment with Other Groups	-.10	.07	.02	.10	.41	-.38	.28

n = 17. Shaded area are months concurrent with the two month follow-up survey for the sample of training participants examined.
*p < .05, **p < .01

Table 6.18 Spearman-Rho Correlations between Two Month Follow-up CRM/TOQ Results and Maintenance Dependability Performance for Departures within Sixty Minutes, Not Canceled

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	(-.64**)	-.21	.00	(-.44*)	(-.66**)	(-.67**)	.36
Communication and Coordination	.24	-.00	-.08	.34	.31	.29	.16
Recognition of Stressor Effects	-.31	.09	.12	-.32	-.30	-.32	.39
Willingness to Voice Disagreement	-.14	-.30	-.03	-.17	-.31	-.40	.31
Goal Attainment with Own Group	.07	-.19	-.19	.09	-.01	-.09	.25
Goal Attainment with Other Groups	.23	-.10	.05	.23	.04	.37	.28

n = 17. Shaded area are months concurrent with the two month follow-up survey for the sample of training participants examined.
*p < .05, **p < .01

5. Managers' self-reports of their behavior for the six- and twelve-month follow-up surveys confirm change from more passive behaviors to more active and interactive behaviors. Passive behaviors can be accomplished by oneself and do not require the cooperation of others. It is for that reason that we find those self-reports consistent with our expectations. The passive behaviors of "better listening" and "being more aware of others" are reported as most used two months after the training, but they do not increase appreciably in the six-month and twelve-month surveys. On the other hand, the active behaviors of "communicating" and "dealing better with others" increase markedly in written descriptions by participants twelve months after the training (Figure 6.12). This latter result offers powerful implications for the long-term effects of the training. It appears that during the CRM training these managers learn some skills that they begin to use right away, and others that they apply only months afterward.

Table 6.12 Spearman-Rho Correlations between Two Month Follow-up CRM/TOQ Results and Maintenance Efficiency Performance % Overtime Paid to Total Wage[1]

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	.00	.00	.03	-.06	.09	-.07	-.12
Communication and Coordination	-.09	-.16	-.01	-.09	-.19	-.11	.07
Recognition of Stressor Effects	.09	.21	.25	-.02	-.21	-.12	**-.38***
Willingness to Voice Disagreement	-.15	-.09	-.07	-.13	.09	-.18	-.15
Goal Attainment with Own Group	-.03	-.07	-.05	-.09	.00	.03	.30
Goal Attainment with Other Groups	-.11	-.14	-.17	-.19	-.15	-.21	.20

n = 32. Shaded area are months concurrent with the two month follow-up survey for the sample of training participants examined.
[1]Note: These items score lower when performance is positive, thus the direction of the statistics should be negative.
* $p < .05$, ** $p < .01$

Methods used in the study

Maintenance managers' attitudes are measured based on a questionnaire developed a decade ago by NASA and The University of Texas. The NASA/UT program has used that questionnaire to evaluate the results of CRM flight crew training in a large number of U.S. and foreign carriers (Helmreich, Foushee, Benson, & Russini, 1986). Questionnaire data for the present study were collected before, and immediately after, the training, as well as two months after, six months after, and twelve months after. The managers were requested to choose an identification number (known only to them) and to use that number on all questionnaires they completed. Using these numbers, it was possible to match the same managers' answers to the same questions over the various time intervals.

All questionnaires used here included 26 separate multiple choice questions, which we later collapsed into six composite index measures. Of these six composites, four are measures of attitudes which the CRM training should influence, and two are perceptions of goal attainment behavior that the training should not predictably change. The first four composites measure attitudes about "sharing command responsibility," "communicating & coordinating," "managing stressors," and "assertiveness." The other two composites measured managers' attitudes about sharing work goals within their own groups, and between work groups.

In addition to the multiple choice questions, all questionnaires administered after the training included several open-ended questions. Those open-ended questions explore how the managers expected to use what they learned from the training, how they did use it, and what they thought would improve the training. This report describes the results, using the six questionnaire composite measures and the four open-ended items.

6.1 BACKGROUND

The CRM training reported here is first-time training in several team-related concepts, including communication skills, self-knowledge, situational awareness, and assertiveness skills for maintenance management personnel in one large U.S. airline (hereafter called "the company"). Maintenance 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. It is the company's intention to train all of its 1,800 maintenance directors, managers, supervisors, and assistant supervisors.

CRM training in airline maintenance operations is unique to the present organization. This exceptional example has been intensively studied during its first 18 months. The first reports (c.f. Taylor, 1991a, 1991b) were limited to a relatively small sample of participants and a small number of months of post-training maintenance performance data. A summary report of the first six months was published in the FAA Office of Aviation Medicine's Second Annual Human Factors Research and Development Progress Report (Galaxy Scientific Corporation, 1992). The present report continues to document the company's CRM training efforts and particularly examines the effects of training-related attitudes on subsequent performance, as well as the stability of post-training attitude changes.

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 managers' post-training attitudes about a variety of management and organizational factors and maintenance unit performance.

6.2 THE PURPOSE OF THE PROGRAM AND OF THE COURSE

The program's champion is the company's Senior Vice President for Maintenance. He has stated that his aim for the training and evaluation program is to improve human resource (HR) management. This HR progress, he believes, will be hastened by using science-based tools and techniques for evaluating the training outcomes and using those results for continuously improving the program's effectiveness.

This particular training program originally began with help from the company's flight operations training group who had nearly a decade's experience with their own CRM program. Now, however, the training is a maintenance program entirely. The program is managed and administered by maintenance people, and the trainers (in conjunction with professional human factors consultants) are maintenance people too.

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

6.2.1 Course Objectives

The objectives (the more specific goals of the training) are also clearly stated during the trainers' introductory remarks. They are as follows:

1. Diagnose organizational "norms" and their effects 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

6.2.2 The Course as Designed for the Objectives

The aims and objectives of the training are achieved by following a course syllabus containing 12 modules (Appendix Part 1, Appendix Part 2, Appendix Part 3, and Appendix Part 4 contain the current syllabus).

6.2.3 State of Training Completed

At the time of this writing more than 1000 maintenance Managers have attended the CRM training course. Thus, the present analysis uses data from over half of the whole maintenance management staff who will eventually complete the training. By September 1992 all of senior management had attended the course. The people remaining to complete the course are maintenance management personnel, mainly maintenance supervisors and assistant supervisors located in the company's three largest cities.

6.2.4 Maintenance Work Units as the Focus of the Analyses

The analyses described in this report illustrate the effect of changes in management attitudes upon the maintenance performance of their work-units. In order to achieve this examination of attitude correlations with performance, the individual manager's data are combined into averages for the units to which they belong. The maintenance performance data (classified into categories of "safety," "quality," "dependability," and "efficiency") are also constructed into measures for the same work units.

6.3 THE 'CREW RESOURCE MGT/TECH OPS QUESTIONNAIRE' (CRM/TOQ)

6.3.1 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 (Helmreich et al., 1986). The CMAQ questionnaire contains 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 recent studies involved the close analysis of the CMAQ instrument through the use of Factor Analysis, a technique to explore for a consistent internal structure (Gregorich, Helmreich, & Wilhelm, 1990; Sherman, 1992). In these studies the authors showed, for separate samples of flight crews and air traffic controllers, that the relationships among the 25 CMAQ items were clustered into the following four constellations of attitudes:

Sharing Command Responsibility

Value of Communication & Coordination

Recognizing Stressor Effects

Avoidance of Interpersonal Conflict.

Those authors combined the individual CMAQ items into the four composite indices to obtain more stable indicators of each concept. Such index scales permit a more detailed assessment of the separate but related attitudes than a single total score for the entire questionnaire. They also provide more accurate and reliable results than are available from each of the individual questionnaire items alone. Although Gregorich, et al. (1990) eventually reduced the set from four to three composites by dropping "Avoidance of Interpersonal Conflict," Sherman found a much more robust fourth factor, which he titled "Advocacy and Assertiveness."

6.3.2 Measurement of Attitudes in the Present Study

The "Crew Resources Management/Technical Operations Questionnaire" (CRM/TOQ) used in the present study is a modified version of Taggart's revised CMAQ. In obtaining a "good" measure of the complex concepts of CRM training, the present company's goal was to start with a proven survey shown to be valid with CRM training in the airline industry. In following the lead of the CMAQ, the CRM/TOQ is a short questionnaire with enough items to provide convergence to a smaller 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 in the present study (Taylor, 1991a). Results for the items drawn from the revised CMAQ were similar to those of Gregorich, et al. (1990) and Sherman (1992). As in the latter study, the CRM/TOQ's fourth composite was statistically strong, and was therefore retained as the reflected index "Willingness to Voice Disagreement."

Attitude change from pre-training to post-training using the CRM/TOQ was examined in the previous progress report (Galaxy Scientific Corporation, 1992). "Sharing Command Responsibility," "Communication & Coordination," and "Recognizing Stressor Effects," all increased significantly following training. "Willingness to Voice Disagreement" decreased (non-significantly) for the whole sample following training, but it rose significantly for the supervisors (the largest single group in the sample to that date) when they were viewed separately from assistant supervisors and directors.

Six questions were added to the CRM/TOQ, based on items intended to measure respondents' perceptions of behaviors dealing with attainment of work goals (Geirland & Cotter, 1990). These six items were considered important to add because the work of maintenance managers differs from that of flight crew 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 they could act as "control questions" which were not predicted to change in a consistent or positive way following the training. These items loaded onto two factors in the Factor Analysis: "Goal Attainment in Own Group" and "Goal Attainment with Other Groups." The goal attainment scales were not expected to change because goal attainment was not a topic covered in the training, and because there would not be time, during the training, to change the behaviors that were the focus of the measures. Similar to attitudes, these perceptions can be influenced by exposure to new information or by reconsidering initial assessments. These perceptions did change during the CRM training and they have proven to be also related to maintenance performance.

There are four versions of the CRM/TOQ questionnaire that have been used in various phases of this project. Although the first two versions are not part of the present analysis, they are described with the latter versions below.

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 factor analyzed and were also used to assess the reliability and validity of the CRM/TOQ (Taylor, 1991a). The Baseline version will not be further discussed.
2. A "pre-training" questionnaire is completed by all participants in the first minutes of the workshop. Respondents place a confidential identification (I.D.) number or code on the questionnaire so that their responses can be compared with their responses on subsequent, follow up questionnaires. These pre- training attitudes have been compared with post-training attitudes to test the effects of the training (Galaxy Scientific Corporation, 1992). Further results using the pre-training questionnaire will not be discussed here.
3. A "post-training" questionnaire is completed by all participants at the workshop's conclusion. Respondents write their I.D. code on the questionnaire, and are asked to note the number in their course workbook to help them remember it for later "follow-up" questionnaires (see version 4 below). The training facilitators collect and mail the completed pre-training and post-training questionnaires to the University for processing. Data from this post-training version of the CRM/TOQ have been compared with the pre-training questionnaire data, as noted above. The present report will discuss responses from the post-training questionnaire and will compare these matched responses with the participants matched responses to version number 4, the "follow-up" questionnaires.
4. "Follow-up" questionnaires are individually mailed by the company to all past participants two, six, and twelve months following their CRM training. Respondents are asked to include their I.D. code so that these follow-up questionnaires can be matched with the earlier questionnaires and to return the questionnaires to the University for confidential processing. Although the two, six, and twelve month follow-up surveys are all identical in form, they measure the respondents' thoughts, assessments, and attitudes over increasingly remote periods from the training.

6.3.3 Sample Size and Response Ratio

The following is the ratio of post-training and follow-up CRM/TOQ questionnaires processed by July 1992, to those distributed:

1,040 post-training questionnaires, (93%)

365 two-month follow-up questionnaires, (44%)

255 six-month follow-up questionnaires, (42%)

76 twelve-month follow-up questionnaires, (40%).

6.4 RESULTS SECTION 1: COMPARISON OF POST-TRAINING ATTITUDES WITH TWO-MONTH, SIX-MONTH, AND TWELVE MONTH FOLLOW-UP SURVEYS

Figures 6.1 and 6.2 present the comparisons for the four attitude scales and the two goal-attainment scales respectively using all the responses available without regard for matched responses. No significant differences were found among the post-training, two, six and twelve-month surveys. All four attitude scales and the two "Goal Attainment" measures remain high in the year following CRM training. The tests shown in Figures 6.1 and 6.2, in turn, have been compared with survey data which were *directly matched*, by individual respondent I.D. number, among the several follow-up questionnaires, and the results are remarkably similar. In this way, the potency of examining the responses from the same individuals matched over time, was combined with the power of the larger unmatched sample of responses for comparison.

6.4.1 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 **matched** individual responses available, i.e., those that can be matched by I.D. code number across the various surveys. The practical implication of this matching is that the total size of the matched sample is limited by the number of smallest wave of data. For example, by July 1992 (13 months after the onset of the training) there were 74 people who returned the twelve month follow-up questionnaire, 64 of whom included an I.D. number that could be matched to their earlier questionnaires. Any statistical tests of comparisons between post-training and twelve-month follow-up questionnaires would necessarily be based on that limiting twelve-month sample size of 64. Using, instead, only the two-month follow-up questionnaires, the number of respondents whose I.D. numbers matched to their post-training questionnaires could rise much higher.

6.5 PERFORMANCE DATA DESCRIBED

Maintenance managers in the company already collect performance data in abundance. Table 6.1 presents the eight measures used as end-result criteria in the present study. 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, and not merely ones that are conveniently assigned to a unit, but for which it can do little. The third condition applied was that the measures not be directly related to (or completely determined by) other measures in the set. The eight performance measures used in the present analysis are included in the company's categories of "safety," "dependability," and "efficiency." The "quality" measures used by the company cannot at this time be applied to the specific maintenance units, so they are not included in this present analysis.

The trainers and administrators of the CRM course evaluated the performance measures and predicted which of them would be more sensitive to effects of CRM training. The results of their evaluation are footnoted in Table 6.1. Their conclusions were that five measures were the most readily improved by the training. These five performance measures included the two aircraft safety items ground damage and days lost to occupational injury, and dependability measures, based on departures within 5 and 15 minutes and delays due to maintenance error. Their second ranked performance measures likely to improve in response to training included the dependability of departures within 60 minutes and the efficiency of overtime paid. A performance indicator rated least likely to improve as a function of the training was departures later than 60 minutes.

6.5.1 Performance Measures and Attitudes

The present analysis examines the impact of pretraining performance on management attitudes, and those attitudes' lagged effects on the measures of concurrent and subsequent maintenance performance. We are focused mainly on the training's longer-term effects on attitudes, which are related to performance **following** the training **as well as occurring at the same time.** Therefore, the sample selected included as many matched responses to follow-up questionnaires as possible, yet left the months between January and July 1992, to permit a test of "lagged" performance effects.

6.5.2 The Sample Used for the Present 'Lagged Attitude-Performance Analysis'

By January 1, 1992, 570 of the 573 managers attending one of the CRM workshops had completed an immediate post-training questionnaire. Four-hundred four of those 570 managers were employed in one of the five maintenance-oriented departments in the Maintenance Division -- line maintenance, base maintenance, inspection, shops, and materials service. The data file containing the 404 maintenance managers was matched, by confidential identification number, to the file containing the 2-month follow-up questionnaires, 225 of which had been completed and returned. The total actually matched by I.D. number was 181. This sample represents the direct maintenance managers who attended the CRM workshop during June through December 1991 and who answered the two month follow-up questions. The sample provided the two-month time interval between measurements of attitudes and up to six months between measures of attitudes and performance. The demographic characteristics of this sample are presented in Tables 6.2 and 6.3, below. The tables show that this sample includes mainly line maintenance supervisors, who are in their 30's, male, many of whom have some college education.

Table 6.2 Demographics of CRM Managers Attendees (June-December, 1991) Matched with Their Two Month Follow-up Survey (n=181), Categorical Percentages

Job Title	Assistant Supervisor	Super-visor	Manager	Director	Engineer	Co-ordinator	Quality Assurance
	29%	47%	17%	2%	1%	1%	3%
Dept.	Line	Base	Quality	Shop	Material		
	54%	10%	12%	11%	13%		
Total Years Working at the Company	2-6 yrs	7-10 yrs	11-17 yrs	21-25 yrs	26-48 yrs		
	52%	20%	7%	8%	13%		
Years Working in Present Position	0-5 yrs	6-10 yrs	11-20 yrs	21-30 yrs	31-45 yrs		
	79%	10%	3%	6%	2%		
Years Working with Other Airlines	0-5 yrs	6-10 yrs	11-15 yrs	16-25 yrs	26-35 yrs		
	68%	7%	8%	13%	4%		

Table 6.3 Demographics of CRM Managers Attendees (June-December, 1991) Matched with Their Two Month Follow-up Survey (n=181), Categorical Percentages

Age	20-29 yrs	30-39 yrs	40-49 yrs	50-60 yrs	61-70 yrs
	6%	42%	23%	21%	8%
Sex	Male	Female			
	98%	2%			
Years in Military	0-5 yrs	6-10 yrs	11-20 yrs	21-30 yrs	
	93%	3%	1%	3%	
Years in Trade School	0-1.5 yrs	2-4 yrs	5-10 yrs	15-20 yrs	
	55%	41%	4%	.01%	
Years in College	0-1.5 yrs	2-3.5 yrs	4-5 yrs	6-7 yrs	
	52%	31%	17%	.01%	
Company	Company 1	Company 2			
	99%	1%			

6.6 RESULTS SECTION 2: TESTING RELATIONSHIPS OF POST-TRAINING ATTITUDES WITH PERFORMANCE

The first associations examined here are among post-training attitudes measured at the end of each training session and maintenance performance for seven combined two-month intervals (Jun/Jul'91; Aug/Sept'91; Oct/Nov'91; Dec'91/Jan'92; Feb/Mar'92; Apr/May'92; Jun/Jul'92). Performance measures are analyzed for the periods prior to and concurrent with the training (Jun-Dec'91), and two, four and six months following training (Jan-July '92). The individual months of performance are combined into two-month increments to improve the distribution characteristics.

The distributions of the performance measures require that non-parametric statistical tests be used for optimal analytic power (cf., Taylor, 1991b). Therefore, the relationships between the attitude indices and the performance measures are indicated by the Spearman Rank-order Correlation ("Rho"), as presented in Tables 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 6.10, and 6.11.

Table 6.4 Spearman-Rho Correlations between Post-training CRM/TOQ Results and Maintenance Efficiency Performance for % Overtime Paid to Total Wageball[1]

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1991
Sharing Command Responsibility	-.12	.05	-.16	-.06	-.06	-.10	-.06
Communication and Coordination	.06	-.08	-.09	.19	-.16	-.07	.04
Recognition of Stressor Effects	.16	-.10	.09	.08	-.24	-.03	.02
Willingness to Voice Disagreement	-.10	.00	.04	.11	-.12	-.12	-.37*
Goal Attainment with Own Group	.11	.02	-.09	.16	-.01	.03	.05
Goal Attainment with Other Groups	.09	-.02	.23	.12	-.12	.01	.14

n = 39. Shaded area are months concurrent with the training (and the measurement) and unshaded area are the months following training.
[1]Note: These items score lower when performance is positive, thus the direction of the statistics should be negative.
*p < .05, **p < .01

Table 6.5 Spearman-Rho Correlations between Post-training CRM/TOQ Results and Maintenance Safety Performance for Ground Damage[1]

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	.14	.07	.13	-.21	-.30	-.10	-.23
Communication and Coordination	-.09	-.07	.06	.12	-.14	.08	-.01
Recognition of Stressor Effects	.26	.30	.29	.13	.04	-.14	-.10
Willingness to Voice Disagreement	-.22	-.20	.20	-.19	-.38*	-.14	-.31
Goal Attainment with Own Group	-.22	-.11	-.38*	-.22	-.09	-.11	.00
Goal Attainment with Other Groups	-.36	-.42*	-.22	-.20	-.21	-.16	-.07

n = 31. Shaded area are months concurrent with the training (and the measurement) and unshaded area are the months following training.
[1]Note: These items score lower when performance is positive, thus the direction of the statistics should be negative.
*p < .05, **p < .01

Table 6.6 Spearman-Rho Correlations between Post-training CRM/TOQ Results and Maintenance Safety performance for Occupational Injury Days Lost[1]

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	-.09	.14	.09	-.13	-.03	.03	-.10
Communication and Coordination	-.24	.25	.20	.06	-.13	-.03	-.13
Recognition of Stressor Effects	-.02	.07	-.03	.20	-.18	.05	-.17
Willingness to Voice Disagreement	-.03	-.02	.25	.04	-.10	-.10	-.28*
Goal Attainment with Own Group	.10	-.20	-.32*	-.20	-.30*	-.14	-.41**
Goal Attainment with Other Groups	.06	.14	-.30*	-.16	-.50**	-.20	-.34**

n = 42. Shaded areas are months concurrent with the training (and the measurement) and unshaded areas are the months following training.
[1]Note: These items score lower when performance is positive, thus the direction of the statistics should be negative.
*p < .05, **p < .01

6.6.1 The Relationships Between the Post-Training Questionnaire Scales and Maintenance Unit Performance Measures

The overtime performance measure described here was rated by the trainers as only moderately likely to improve as a result of the training. We will start with that one, to explain the way these tables are set up and to provide a contrast with the more interesting and/or consistent results in the remaining tables.

6.6.1.1 "Percent of Overtime to Total Wages"

The six rows of Table 6.4 are comprised of the four attitude scales and the two goal-attainment scales. The seven columns represent performance in overtime costs for seven different time periods. Jun/Jul, Aug/ Sept, and Oct/Nov 1991 represent the concurrent performance, while Dec/Jan, Feb/Mar, Apr/May, and Jun/ Jul 1992 represent performance following training. The cell entries in Table 6.4 are Rho coefficients testing the degree of relationship between the six questionnaire scales and the overtime measure at the seven different times. The calculations are derived from work-groups. Even a large company like this one has only 60 work units in maintenance that report overtime used. Table 6.4 shows that 39 of those 60 work units were included in this analysis. The missing ones were dropped for a variety of reasons, including the fact that less than one third of all the managers had been through the training by January 1992.

There is only one statistically significant relationship and no consistent pattern of results in Table 6.4, as there are negative relationships as well as positive ones. In fact, this efficiency measure of labor costs was rated by the trainers to be less influenced by the training than would be other performance measures. Thus, this table is essentially an example of an absence of training effect.

6.6.1.2 "Number of Ground Damage Incidents"

In Table 6.5 the safety measure of Ground Damage incidents shows one significant association, in the expected direction, between assertiveness ("Willingness to Voice Disagreement") in one period following training. This result, taken with the others in the same row displaying the same direction of relationship, suggests that people intervene and speak up more when aircraft may be damaged in those groups with higher scores for this attitude. There are two other significant relationships in the expected direction between the goal attainment scales and concurrent ground damage performance.

6.6.1.3. "Occupational Injury Days Lost"

"Occupational Injury Days Lost" is the second safety-related performance indicator to be examined. Table 6.6 shows the pattern of results indicating that the two goal attainment scales account for most of the significant differences in performance. Occupational injury rates are consistently lower, both concurrently with training and subsequent to it, in work units where managers and supervisors believe that team goals are shared within their units, and between them. Although goal attainment shows a strong association with this performance, it is not a specific management value addressed by the CRM training. Of the attitude improvements intended to be affected by the training, Willingness to Voice Disagreement is again significantly related to later safety performance. Other post-training attitudes don't show much uniformity of pattern in relationships with this performance indicator.

6.6.1.4 "Aircraft Departures Within Five Minutes of Schedule"

This dependability measure involves only the line maintenance stations. Table 6.7 contains 27 data points. One relationship between concurrent, on-time performance and sharing command responsibility is significant. Several concurrent and subsequent measures of departures within 5 minutes are related to communication and to recognition of stressor effects. This is not surprising, as managers of large line stations, during the busiest hours, must relinquish moment-to-moment decisions or they will slow things down. Likewise, they must ensure communication among everyone involved and recognize that the adverse consequences of stress are also related to dependable performance. Work in line stations creates some of the highest levels of work-related stress in maintenance. Relationships in Table 6.7 signify that there are differences in management attitudes toward sharing their power, communicating, and managing stress such that the more these attitudes improve, the more the on-time departures.

With respect to the pattern of results for all of Table 6.7, the proportion of significant and directional relationships between six immediate post-training attitudes and the seven maintenance performance measures, to the total number of tests conducted, is substantially better than that expected by chance alone. Eight Spearman "Rhos" of the 42 total were significant p.05 (8/42 = 19% > 5%), and three of those were significant $p < .01$ (3/42 = 7% > 1%).

Tables 6.8, 6.9, 6.10, and 6.11 present relationships between the six questionnaire items and further measures of dependability.

6.6.1.5 "Departures Within Fifteen Minutes"

Table 6.8 shows that command responsibility, communication & coordination, and assertiveness are all significantly and positively related to departures within 15 minutes of schedule during the period concurrent with the training. The two goal attainment scales are related to this performance measure subsequent to the training.

6.6.1.6 Departures Within Sixty Minutes"

Table 6.9 displays only two significant relationships to departures within 60 minutes. This performance measure was one of those the trainers felt would be only moderately sensitive to training effects. In fact the two significant relationships represent a proportion we could expect by chance alone (2/42 = 5%).

6.6.1.7 "Departures Over Sixty Minutes, Not Canceled"

The measure, "departures over 60 minutes, but not canceled," (Table 6.10) is one that the trainers felt would be least sensitive to training effects. Although Table 6.10 shows three significant positive correlations (only slightly above a chance expectation for the table overall), it also contains one significant negative relationship (opposite to that expected). Given the absence of any pattern to the relationships in Table 6.10, we may conclude that post-training attitudes and perceptions do not have an effect on this performance.

6.6.1.8 "Delay Due to Late from Maintenance"

Table 6.11 presents relationships between post-training questionnaire responses and delays due to late from maintenance. This is a measure of the number of aircraft, either scheduled to remain in station overnight (RON) or on the ground (AOG) for repair, which are not ready for morning flights. "Communication & Coordination" is significantly correlated and in the expected direction with this performance measure concurrently with training and subsequent to it. These results indicate that as more managers communicate and coordinate among themselves and with mechanics, the lower the number of delays due to the aircraft being late from maintenance.

6.7 RESULTS SECTION 3: THE RELATIONSHIPS BETWEEN THE TWO-MONTH FOLLOW-UP QUESTIONNAIRE SCALES AND MAINTENANCE UNIT PERFORMANCE MEASURES

The same eight performance measures are examined again, using the matched group of maintenance managers' two month follow-up questionnaires. Although Tables 6.12, 6.13, 6.14, 6.15, 6.16, 6.17, 6.18, and 6.19 are arranged in the same manner as Tables 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 6.10, and 6.11 above, they differ in the performance periods preceding, concurrent with, and subsequent to the survey. Because the follow-up surveys (for the present sample) took place between October 1991 and February 1992, the first two performance periods (Jun/Jul, Aug/Sept'91) are "pre-survey," Oct'91-Mar'92 are "concurrent" with the survey, and Apr-Jul'92 are subsequent to the training. As in the preceding section the performance measures will be examined for "Efficiency," "Safety" and "Dependability," respectively.

Table 6.14 Spearman-Rho Correlations between Two Month Follow-up CRM/TOQ Results and Maintenance Safety Performance for Occupational Injury[1]

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	.06	.08	.17	.29	.18	.07	.03
Communication and Coordination	-.04	-.16	.27	-.16	.17	.05	-.22
Recognition of Stressor Effects	.03	.02	.07	.39	-.10	-.03	-.19
Willingness to Voice Disagreement	-.38*	-.12	-.13	.09	-.14	-.42**	-.17
Goal Attainment with Own Group	-.05	-.20	.17	.00	.00	-.07	.04
Goal Attainment with Other Groups	-.10	-.15	-.33*	.04	-.10	-.09	.01

n = 28. Shaded area are months concurrent with the two month follow-up survey for the sample of training participants examined.
[1]Note: These scores score lower when performance is positive, thus the direction of the statistics should be negative.
*p < .05, **p < .01

Table 6.19 Spearman-Rho Correlations between Two Month Follow-up CRM/TOQ Results and Maintenance Dependability Performance for Delays Due to Late from Maintenance[1]

	Jun/Jul 1991	Aug/ Sep	Oct/ Nov	Dec/ Jan	Feb/ Mar	Apr/ May	Jun/Jul 1992
Sharing Command Responsibility	-.61**	-.26	.68	.22	-.18	-.47	-.44*
Communication and Coordination	-.05	-.01	.09	.39	-.09	.00	-.30
Recognition of Stressor Effects	-.56**	-.38	-.39	.33	-.27	-.65**	-.45*
Willingness to Voice Disagreement	-.33	-.40*	-.28	.08	-.20	-.43	-.13
Goal Attainment with Own Group	-.57**	-.69**	-.62**	.10	-.56	-.27	-.46*
Goal Attainment with Other Groups	-.19	-.31	-.49*	-.24	-.40	-.20	-.30

n = 10. Shaded area are months concurrent with the two month follow-up survey for the sample of training participants examined.
[1]Note: This performance item scores lower when performance is positive, thus the direction of the statistics should be negative.
*p < .05, **p < .01

6.7.1 'Overtime Paid to Total Wages'

Table 6.12 shows a similar absence of results for two-month follow-up attitudes as those presented above for post-training attitudes and overtime performance. Only one significant relationship is noted in Table 6.12, between recognition of stressor effects and June/July 1992 overtime. In fact, the trainers had rated overtime as only moderately sensitive to the training effects. A more powerful impact on overtime may originate from upper management policy and dictum. Using the data from both Tables 6.4 and 6.12, that assumption seems substantiated.

6.7.2 'Number of Ground Damage Incidents'

This safety measure in Table 6.13 shows ten significant associations, in the expected direction, between "Recognition of Stressor Effects," "Sharing Command Responsibility," and goal attainment, after the CRM training, but concurrent with the two month follow-up survey. Recognition of the effect of stressors on decision making is also related to the performance prior to the two month follow-up questionnaire, as are the two goal attainment scales.

6.7.3 'Occupational Injury Days Lost'

Only three significant relationships are seen in Table 6.14, which is only barely above chance probability. "Willingness to Voice Disagreement" is correlated with this performance, both before and after the survey period. One of the goal attainment scales is also significantly correlated with this safety-related performance indicator.

6.7.4 'Departures within Five Minutes'

This pattern of results for departures within 5 minutes in Table 6.15 differs from that shown for the immediate post-training survey. This two-month follow-up shows "Sharing Command Responsibility" is still positively related to 5 minute departures. The relationship between departures within 5 minutes and both assertiveness and goal attainment within ones' own group, though, is much more sustained over time. There is very clearly an effect of assertiveness ("Willingness to Voice Disagreement") and goal attainment within work units, upon on-time departures.

6.7.5 'Departures within Fifteen Minutes'

Table 6.16 Departures within 15 minutes shows the same pattern of results as departures within 5 minutes. That is, command responsibility, assertiveness, and shared goals within the group are positively and significantly related to this "dependability."

6.7.6 'Departures within Sixty Minutes'

Similar to the other dependability measures, departures within 60 minutes continues to show significant positive correlations with command responsibility and assertiveness as shown in Table 6.17. Shared goals, however, is no longer strongly associated with dependability performance. In addition, the communication & coordination scale shows a significant negative relationship with 60 minute departures following the survey, that is, favorable attitudes toward communication and coordination two-months after training, are correlated with poor 60 minute departure performance.

6.7.7 "Flight departures not Canceled, but over Sixty Minutes Late"

The pattern is consistent and negative for sharing command responsibility depicted in Table 6.18. Anecdotal evidence suggests that the maintenance control department often directs line maintenance to hold an aircraft and its passengers and to require periodic updates of departure times, resulting in delays of over an hour. This protracted and indirect arrangement for holding a flight causes local maintenance employees and managers to feel impotent, and probably obliged to provide unrealistic departure time estimates regardless of their ability to do so. The negative, largely concurrent, relationships in Table 6.18suggest that as more aircraft are held over one hour in an attempt to repair them, line station management feel that command responsibility is not shared; rather, it is usurped by others.

6.7.8 'Flights Delayed Due to Late from Maintenance'

Like its counterpart (Table 6.11) for the immediate post-training questionnaire data, Table 6.19 shows a pattern of significant correlations in the expected directions. Differences between the two, however, are revealed in an increase in effect of "Recognition of Stressors" for this follow-up measure, and the disappearance of any effect of follow-up "Communication & Coordination" with this dependability indicator. "Goal Attainment with Own Group" measured two months after training is also significantly correlated with this performance index.

6.7.9 A Note on the Different Patterns

The patterns of relationships with maintenance performance between the post-training surveys and the two-month follow-up questionnaires for this same sample are different. These differences have been noted, but they require some explanation. Whereas the post-training survey represents virtually all the CRM training participants in 1991, the two-month survey was returned by approximately 55% of participants, and I.D. codes could be matched with the post-training set for about 80% of those. Although this is a very good return for such surveys, it is nonetheless limited. Examination of the demographic characteristics of the two-month follow-up sample reported here shows that some station (city) locations are over-represented, and some occupations and hierarchical levels are under-represented whereas others are over-represented. In particular the proportion of assistant maintenance supervisors for several large cities is lower for the two-month follow-up than for the post-training questionnaire. These proportions, in turn, contribute to the differences in the work unit mean scores on the "assertiveness" and "command responsibility" scales between the two surveys.

6.8 RESULTS SECTION 4: TRENDS IN MAINTENANCE PERFORMANCE TWELVE MONTHS BEFORE AND TWELVE MONTHS AFTER THE ONSET OF CRM TRAINING

To study the trends in the eight maintenance performance indicators 12 months before and 12 months after the commencement of the CRM training, comparisons are presented here. There are two trend lines in each of the Figures 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, and 6.10. Each figure presents one of the eight performance indicators. One line in each figure estimates the trend for the 12 months preceding CRM training and the other line shows the trend after the onset of training. The discussion below will focus on the post-training trends for the performance categories of efficiency, safety and dependability.

6.8.1 Efficiency

6.8.1.1 Overtime Wages Paid

One trend analysis was conducted for efficiency concerning the performance measure of overtime. Figure 6.3 shows that the trend of overtime expenses for the 12 months following June 1991 (the onset of the CRM training) improves at a faster rate than it had in the 12 months preceding. Improved cost performance appears coincident with the training, and may be affected by it.

6.8.2 Safety

Two trend analyses were performed for the safety performance measure consisting of ground damage and occupational injury. These are shown in Figures 6.4 and 6.5.

6.8.2.1 Number of Ground Damage Incidents

Figure 6.4 shows a clear reversal of trends for the number of ground damage incidents, in the year before and the year after June 1991. Reduced ground damage incidents is clearly related in time to the CRM training.

6.8.2.2 Occupational Injury Rates

Occupational injury rates, shown in Figure 6.5, already show a sharp decline in the year preceding the training, but the injury rates remain low during the following year. The training may have some effect on keeping these rates low.

6.8.3 Dependability

Five trend analyses were conducted for the dependability performance measures regarding departure times and delays due to maintenance. These are shown in Figures 6.6, 6.7, 6.8, 6.9, and 6.10.

6.8.3.1 "Departures within Five Minutes of Schedule"

Figure 6.6 shows a slightly higher level of performance, overall, in the post-training year, but the performance was trending up in the year preceding the training. The apparent effect of the CRM training on 5 minute performance overall is to maintain pretraining performance levels.

6.8.3.2 "Departures within Fifteen Minutes of Schedule"

The pattern in Figure 6.7 shows a similar trend to departures within 5 minutes. That is, performance improves (the trend is up) in the year preceding the onset of CRM training, and that performance remains high and stable in the year following. Like departures within 5 minutes, the overall effect of the CRM training on 15 minute performance is cloudy, although results from the follow-up survey demonstrates the relationship between assertiveness and dependability (cf., Tables 6.15-6.16).

6.8.3.3 "Departures within Sixty Minutes of Schedule"

In Figure 6.8, the performance remains the same (quite undifferentiated) between the year preceding and the year following the onset of CRM training. The training appears to have no impact on this performance.

6.8.3.4 "Flights Delayed over Sixty Minutes, but not Canceled"

The trend lines in Figure 6.9 show a very similar slope between the before- and after-training time periods. Here also the training appears to have neither positive nor negative impact on this performance indicator.

6.8.3.5 "Frequency of Late Flights due to Maintenance."

No appreciable improvement in "Late from Maintenance" is noted in Figure 6.10 for the year following the onset of CRM training, although the trend is toward improved performance during both years.

6.9 RESULTS SECTION 5: MANAGERS SELF-REPORTS OF BEHAVIOR CHANGE: WRITTEN COMMENTS FROM THE POST-TRAINING AND FOLLOW-UP CRM/TOQ WRITTEN COMMENTS FROM THE POST-TRAINING AND FOLLOW-UP

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 July 1992 is employed in the following analysis.

6.9.1 Intended Use of CRM Training

On the post-training, two, six, and twelve month follow-up questionnaires, participants were asked to write their responses to a question concerning how they expected to use the CRM training on the job. Content coding of the answers to this question resulted in four categories of response: "Better listening;" "More awareness of others;" "Dealing better with others;" and "Better communication." These categories represent two types of self-perception of potential behavior change: the first two categories show a "passive" improvement made within the person, while the last two categories show an "active" transfer of information by direct interpersonal approaches.

6.9.1.1 "How will You Use the CRM Training"

Figure 6.11 presents the results of the question, coded into the categories, for all four measurement waves. As the figure shows, expectations for all four categories are low in approbation as measured by frequency of response (none of the four categories accounts for as much as 25% of those answering) immediately following the training. In the subsequent waves of measurement in the months following, the two "passive" categories show a flat and low pattern, while two "active" categories (dealing better with others and better communication) increase. "Dealing better with others" includes statements such as more "problem solving activities," "team work," and "group consensual decision making." The shifting pattern from passive and reactive involvement, to more active information transfer and working with others is clearly shown in Figure 6.11.

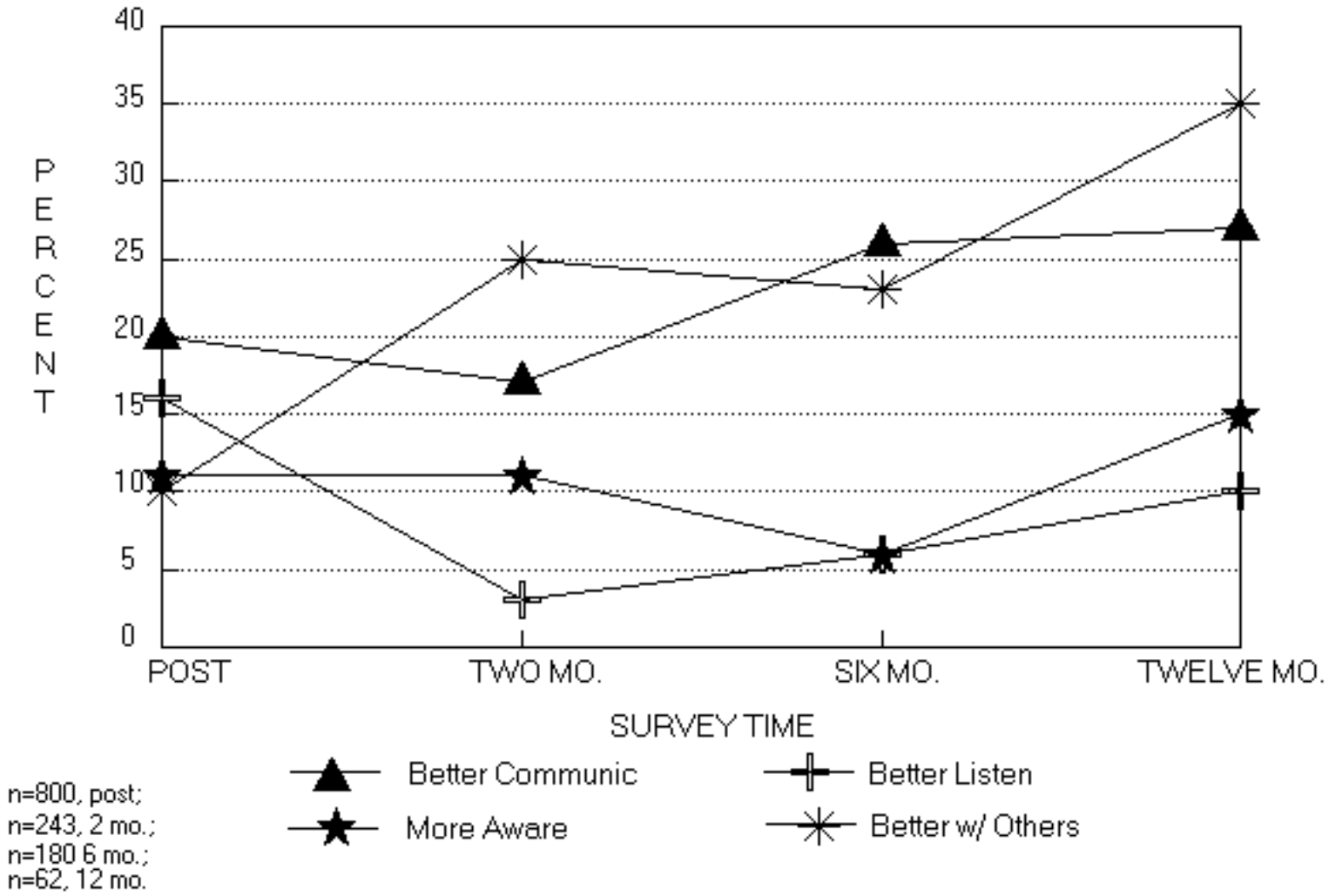


Figure 6.11 Percent Written Responses - How Training will be Used

6.9.2 How Training was Used on the Job

For the sample of participants who returned the two, six and twelve month follow-up questionnaires, responses to the question of how they actually used the CRM training on the job were content coded. The trainees' self-perception of behavior responses were coded in the same four categories as the other open ended question regarding the intended use of the CRM training.

6.9.2.1 "How did you Use the CRM training?"

Figure 6.12 presents the graphed percentages of how the training was used on the job for the survey periods of two, six and twelve months. Better listening tended to decrease in reported percentage from 20% for two months to 17% for six months and 13% for twelve months. The other passive category, "be more aware of others," showed a stable pattern over time for the two and six month survey periods and increased to 23% for the twelve month survey period. The active category of "deal better with others" displayed high percentages for both two and six months (25% and 21% respectively) and rose substantially for twelve months with 40%. Better communication also showed a high percentage of use, for all three follow-up questionnaires. These open-ended responses appear to confirm that improved interpersonal behaviors have resulted from the positive attitudes that followed the training. Furthermore, the preferred behaviors tend to have shifted from those people could do by themselves (e.g., "be a better listener" and "being more aware of others"), to behaviors that involve others, such as "communicating better" and "dealing better with others."

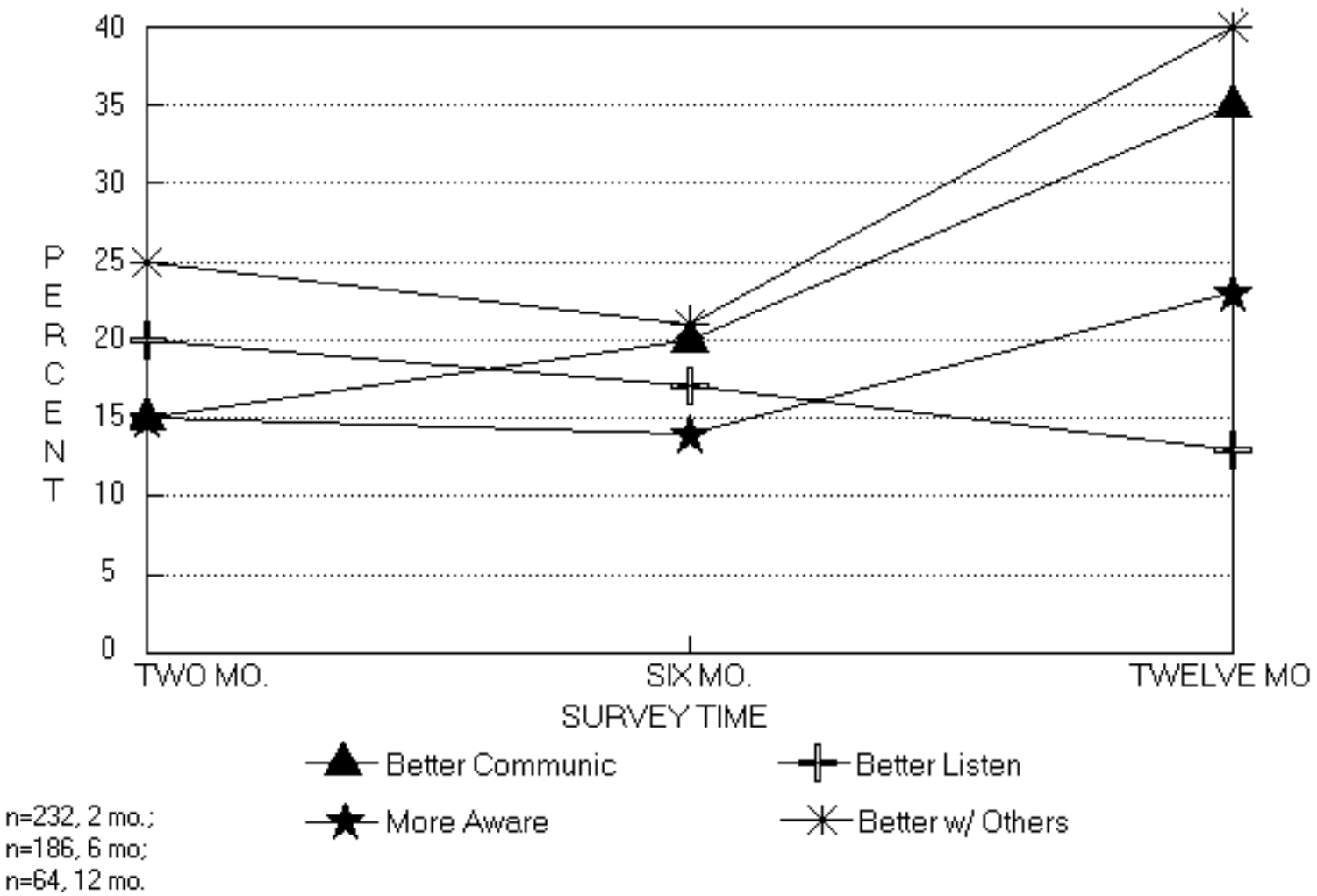


Figure 6.12 Percent Written Responses - How Training was Used

6.9.3 Other Evidence for Improved Behavior Patterns Following Training

6.9.3.1 Anecdote Concerning Behavior Change

The use of anecdotal data for reporting trainees' behavior change on the job and the application of the knowledge learned from the training is recommended by Blakeslee (1982) and Ford (1989). One such anecdotal case involves a long-term employee who was planning to quit due to the supervisor's management style. After attending the CRM training course and returning to work, the boss's style changed considerably. The supervisor was apparently actively applying the concepts of the CRM training to the work environment. Only after this supervisor had actively committed to this new management style, did the employee decide not to quit the company. After this incident occurred, and the employee's turn to attend the CRM came, the change in the supervisor's behavior was described to the training facilitators. The employee commented that what had happened to the supervisor must be attributable to the CRM training. The employee stated that the boss's behavior had obviously changed after the training and now reflected many of the CRM principles and concepts in daily work.

6.9.4 Specific Reactions to the Course Itself -- Suggestions for Its Improvement

6.9.4.1 Good Aspects of the Training

On the post-training and two, six and twelve month follow-up CRM/TOQ, there was an open ended question consisting of "what aspects of the training were particularly good?" The participants written-in responses were content coded and the categories of comments with the highest frequencies were selected and percentages calculated. The five resulting categories include specific CRM course topics and they are shown in Table 6.20. All four survey periods including post-training, two, six and twelve month participants responses are presented in Table 6.20. Results for these four survey periods indicated that the Strength Development Inventory or personality (behavioral) style self-analysis exercise had the highest reported enthusiasm for all four survey periods.

Table 6.20 Written-in Responses Indicating Particularly Good Aspects of Training for Post-training, Two, Six and Twelve Month Follow-up

	SURVEY PERIOD			
	Post-training	Two Month Follow-up	Six Month Follow-up	Twelve Month Follow-up
Response				
Strength Development Inventory	17%	11%	18%	19%
Communication	9%	3%	14%	16%
Listening Skills	8%	3%	5%	6%
Assertiveness	11%	4%	2%	5%
Stress Management	10%	7%	10%	8%

For the post-training survey period, the assertiveness module was rated as the second highest, (particularly good) aspect of the CRM training. Also, for the post-training survey results, the stress management training module was rated nearly the same by the participants, followed by the communication and listening skills modules.

6.9.4.2 Training Improvements

The open-ended question "what do you think could be done to improve the training?" was asked in order to gain information to make the CRM training course better. All of the participants' written-in responses were content coded and the categories of comments with the highest frequencies were selected and percentages calculated. Results of the content coding indicating how the training might be improved for the three survey periods of post-training, two, six and twelve month are shown in Table 6.21. For the post-training survey period, the largest category of responses was that the training does not need any improvements; "do nothing" or "it's fine as it is." Second in order was the comment that the participants would like more training similar to this or "bring us back for follow-up training." As Table 6.21 shows, the other four categories for the post-training survey were all similar in frequency.

Table 6.21 Percentage of Written-in Responses Indicating How Training Might be Improved for Post-training, Two, Six and Twelve Month Follow-up

	SURVEY PERIOD			
	Post-training	Two Month Follow-up	Six Month Follow-up	Twelve Month Follow-up
Response				
Needs Nothing	35%	16%	12%	14%
More Training & Follow-up	11%	27%	28%	29%
More Role Playing	7%	11%	4%	7%
Add Time to Training	7%	5%	4%	5%
More Case Studies	6%	7%	7%	8%
Better Mix of Participants	6%	5%	7%	6%

Results of the participants' responses for the two, six and twelve months follow-up survey period showed that the largest single category of comments was for recurrent training and ("bring us back for follow-up training"). The next largest response category for all three surveys was the "needs nothing" responses. These comments seem to indicate that most respondents showed approval of the program and perhaps more important, wanted more training like it. Participants in roughly similar proportions to their post- training responses, suggested more role playing and case studies, adding more time to the training and having a better mix of participants.

6.9.4.3 General Analysis of Open Ended Responses

Analysis of the open ended question pertaining to the particularly good aspects of the CRM training seminar, indicates that for all four survey time periods the participants found the strength development inventory or analysis of ones' behavioral style to be particularly good. In this training module, the participants were given information concerning their behavioral style with the implications of that style for human interactions and management practices. Furthermore, it appeared that learning ones' behavioral style under various workloads and conflict situations heightens the awareness and appreciation of how people will react and manage. Many maintenance managers wrote that having understood ones' behavioral style brought a sense of clarity of how other people were responding to them under various leadership and working situations. Also, understanding one's boss's behavioral style alerted them of why the boss was managing the work units in a particularly way. The stress management, assertiveness and communication training modules were all mentioned as particularly good aspects of the CRM training. It follows from this that after the trainees understood their own behavioral style and their boss's behavioral style, learning how to become more assertive, manage stress better and communicate more effectively under stressful conditions was deemed important. Active listening skills assisted the technical manager in better communicating and understanding the working situation.

Over time, the design of the CRM training program was still considered as "fine" and it "needs nothing." What was clearly being stated by the participants was the need for more training and follow-up courses that incorporated more role playing exercises, along with more case studies. It appears, by what they report to practice over time, that the technical managers have attempted to apply as much as they can to their work environment; now they want some more constructive practice and study on how to further improve their resource management skills. A refresher course on crew coordination concepts skills seems to be important to these maintenance managers. Many of them indicated that they would like to work more with the professionals in this area of CRM and interact with other technical managers in practicing and applying these skills. These data are consistent with developments in the company to produce a follow-up CRM course for these managers, including a broader mix of participants, more "real life" case studies and more role-playing exercises.

Other written-in comments reinforce the generally positive response to the training. Several of the participants wrote that because this course was well designed and delivered, it was the first time they did not fall asleep in the training seminar! The authors observed several of the training sessions, and noted a high level of activity and involvement of the participants. We observed that everyone was actively participating and interacting with others during the course exercises. Many of the managers were taking notes in their training manual and studying the material during breaks. Several of the participants stated that they went home and discussed the material with their family members and commented on how the course material could be reasonably easy in applying it to their home situation as well as at work.

6.10 CONCLUSIONS

The combined results of the five major analyses reported here reveal a strong and positive effect of the maintenance management CRM training after its first full year of implementation. Although all maintenance management personnel have not yet been trained, a sizable portion of them have. Additionally, a full 12 months of post-training performance data provide a good sample of performance effects following the onset of training.

The stability of the follow-up measures for individual respondents is established, although there appears to be some sampling effect in the follow-up data caused by a variable return rate by station and hierarchical level.

Many individuals report changing their behavior to take advantage of what they learned in the CRM training. Most measures of maintenance performance improve in the year following the onset of the training when compared with the same period before the training. Furthermore (despite the sampling effect noted above), the improved attitudes toward sharing responsibility, coordinating, speaking up, and recognizing stressor effects are significantly related to concurrent and subsequent maintenance performance.

Additional survey data have been, and continue to be, collected in the months following training. Larger sample sizes and longer time periods will become available for analysis in the coming months and we expect some of the variability in longitudinal group data to decrease. Based on the time-lagged results shown in the present report we can expect to see even stronger evidence for the power of the CRM training in improving safety in the future.

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