Chapter 11
Teams and Teamwork: Implications for Team Training within the Aircraft Inspection and Maintenance Environment

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11.0 INTRODUCTION

This report is divided into four sections. In the first section, Background and Literature Review, we review state-of-the-art literature on team training. In the next section, we outline a general framework for considering/evaluating tasks' potential for team training, also identifying team training strategies for improving different team competencies. In the section on Team Training for Aircraft Inspection Maintenance, we outline implications of team training for aircraft/inspection tasks and report results of a study evaluating effectiveness of team training for an aircraft maintenance task. In the final section, Team Training for A & P Schools, we describe how team training could be incorporated in an A & P school curriculum and provide a functional description of a computer-based team training tool. We performed this project in close cooperation with a major maintenance repair facility and an A & P school so that results address the aviation community's concerns.

11.1 BACKGROUND AND LITERATURE REVIEW

11.1.1 Introduction

Previous FAA reports on human factors in aviation maintenance (Shepherd, 1991; FAA, 1993) have recognized the importance of training. To this point, training for aircraft maintenance and inspection systems, essentially, has aimed at improving individual skills (Shepherd and Parker, 1990), ranging from improving diagnostic skills through aircraft maintenance training (Johnson, 1990(a)) to acquiring and enhancing visual inspection skills to improve airframe structural inspection (Shepherd, 1993; Gramopadhye et al., 1992). Researchers have tended to concentrate on improving the overall training program either with training methodology (e.g., Drury and Gramopadhye, 1990; Desormiere, 1990) or with the training delivery system's technology for on-the-job training, classroom training, tutoring, and computer-based training (Gordon, 1994; Johnson et al., 1992; Drury et al., In Press). While there has been much study of individual skills, there has been little on developing team skills.

Task analysis of aircraft inspection and maintenance activities (Shepherd, 1990) reveals that the aircraft maintenance/inspection system is complex, requiring above-average coordination, communication, and cooperation among inspectors, maintenance personnel, supervisors, and members of other subsystems-planning, stores, and shops-to be effective and efficient. Many maintenance activities technicians or inspectors undertake can be performed more effectively and efficiently with a team. Though the airline industry widely recognizes advantages of teamwork (Hackman, 1990), individual AMTs, not the teams they work with, are held responsible for faulty work. The individual AMT licensing process and concerns about personal liability often result in AMTs and supervisors being unwilling to share knowledge and responsibility across shifts or with less-experienced, less-skilled colleagues. This problem is exacerbated by the fact that experienced inspectors and mechanics are retiring and are being replaced with a younger, less-experienced workforce. The newer AMTs lack the knowledge and skills of the experienced AMTs they replace and also are not trained to work as a team member.

The FAA continually addresses the problem of individual development of initial AMT skills. The newly established Part 66 of the FAR specifically addresses significant technological advancements in the aviation industry, as well as the past decade's advancements in training and instructional methodologies. The FAA, through its Office of Aviation Medicine, has funded efforts to develop advanced training tools for future AMTs. New training technologies under development, e.g., intelligent tutoring systems and embedded training, will be available to A & P training schools. Application of new training technologies should help reduce the gap between AMTs' current skills and those skills necessary to maintain advanced systems.

The effort invested in developing individual skills has led to a revised FAR, to new training tools (e.g., Johnson, 1990(b); Johnson 1992) applying advanced technology, and to development of advanced training delivery systems (Gramopadhye, Drury and Prabhu, In Press). The area now needing attention is development of team skills. In addition to fundamental skills, today's employers require creativity, an ability to communicate, and an ability to work in a team. Team skills are often not well-developed or part of the background of AMTs now joining the workforce. The problem is made more urgent since the aviation maintenance workforce is much younger and less-experienced, usually without experience working on military aircraft. The younger workforce does not carry the passion for airplanes older workers expect. An FAA report (FAA, 1991) stated, "People today join airlines for many reasons beyond the love of planes. This clear shift plus other changes in labor work force confound the long-service employee. Older employees are somewhat dismayed with the newer mechanics' acquired skills, their lassez-faire attitude, and their high turnover."

Inspectors and maintenance technicians are challenged to work autonomously while being part of a team. In a typical maintenance environment, an inspector looks for and reports defects. A maintenance person repairs the reported defect and works with the original inspector or the buy-back inspector to ensure that work meets standards. During the repair process, inspectors and maintenance technicians work as a team with colleagues from the same and the next shift, as well as with personnel from areas like planning or stores, to ensure that the task is completed (FAA, 1991). In any typical maintenance environment, a technician must learn to be a team member, to communicate, and to coordinate activities with other technicians and inspectors. However, AMTs joining the workforce lack team skills. The current A & P curriculum often encourages students to compete, so that new AMTs often are not prepared to work cooperatively. To prepare student AMTs for workplace realities, we need to find new ways to build students' technological, interpersonal, and sociotechnical competence while incorporating team training and communication skills into the curriculum.

The present study's general objective was to present the importance of teamwork and team training in the aircraft inspection environment by focusing on teams and strategies to improve team performance. We expected results to help prepare new AMTs for teamwork in the aircraft inspection environment. The study's specific objectives were the following:

- To understand the role of teamwork and team training in the aircraft inspection/maintenance environment
- To evaluate the effectiveness of a team training activity with AMTs from an A & P school
- To develop guidelines and suggestions for incorporating team training in the A & P school curriculum
- To use results obtained from earlier activities to develop functional specifications for a computer-based tool for team training.

To ensure that our project addressed the aviation community's needs, we conducted the project in cooperation with a major aircraft repair and overhauling facility and with an FAA-licensed A & P school.

11.1.2 Literature on Teams

Teams have received a great deal of attention in recent research literature (Salas, et al., 1992; Driksell and Salas, 1992; Glickman, et al., 1987). There is consensus among those who study industrial and organizational behavior that teams/work groups will be the cornerstone of future American industry (Cannon-Bowers et al., 1992; Cummings, 1981; Shea and Guzzo, 1987). Teamwork will be essential because tomorrow's task demands are likely to exceed individual capabilities; hence, individuals will need to work together more. Teamwork will assume a critical role for achieve desired performance. Due to inherent complexities of studying teams in organizations, the abundant literature is fragmented, incomplete, and often contradictory. However, it is important to glean from past work any findings that can help us understand teamwork, team performance, and strategies for improving team skills.

The review of the team literature that follows is limited to the objectives of this study and to a greater extent restricted to teams who perform in a complex and dynamic environment similar to the environment of aircraft inspection/maintenance, which takes place at sites ranging from those of large international carriers, through startup and regional airlines, to the fixed based operators associated with general aviation (Drury et al., 1990). Previous FAA reports detail the complexity of the aircraft inspection/maintenance environment, clearly indicating above average coordination, cooperation and communication necessary to accomplish tasks. Additionally, the importance of teams has been emphasized in the National Plan for Aviation in Human Factors (FAA, 1991), where both the industry and government groups agreed that additional research needs to be conducted to evaluate teamwork in the aircraft maintenance/inspection environment.

11.1.3 Team and Teamwork Defined

A definition of what constitutes a team facilitates our discussion on teams in the aircraft inspection and maintenance environment. Throughout the literature, *team* and *teamwork* are defined differently. The following definition of *team* is consistent with the nature of the effort required for aircraft inspection/maintenance tasks (Morgan et al., 1986 p6): "a team is a distinguishable set of two or more individuals who interact interdependently and adaptively to achieve specified, shared and valued objectives.• A number of principles have been proposed to ensure that teams work effectively in any situation. Scholtes (1992) suggests that effective teamwork depends on the following ten essential ingredients:

1. Clarity in team goals

2. An improvement plan

3. Clearly defined roles of team members

4. Clear communication

5. Beneficial team behavior

6. Well-defined decision procedures

7. Balanced participation

8. Established ground rules

9. Awareness of the group process

10. Use of scientific approach.

For teams to be effective, its members must work collectively to achieve the overall task objective. To accomplish an objective, some sort of task dependency must exist among team members. According to Salas et al. (1992), the completion of a task objective necessitates the following:

a) exchange: dynamic exchange of information and resources among team members

b) coordination: coordination of different task activities and adjustments to changes in task structure

c) organizational structure: some sort of organizational structure of members.

Research in team and teamwork has shown that training facilitates the entire team process (Glickman et al., 1987; Salas et al., 1992; Swezey and Salas, 1992).

Most literature on teams in the aviation industry has focused on the CRM (Crew Resources Management) training program, which focuses on cockpit training for air crews (FAA, 1993; Helmreich, et al., 1989; Helmreich and Wilheim, 1991; Foushee and Manos, 1981). CRM typically encompasses several team concepts, including team communication skills, interaction, situational awareness, assertiveness, and leadership skills. Although CRM programs have existed for more than a decade, there has been only limited use of the programs for maintenance and inspection crews. To date, little research has evaluated teams working in the aircraft maintenance environment. However, since they realize the importance of teams, several aircraft carriers and repair facilities have developed in-house training programs. These programs often are part of larger management training programs, focusing on teaching management and non-management personnel to improve safety and efficiency (e.g., Robertson et al, 1994; Taggart, 1990). They are not specifically developed for maintenance and inspection personnel.

11.1.4 Team Evolution

To understand how training can provide measurable changes in team behavior that enhance the efficiency and effectiveness of teamwork in aircraft maintenance, we must examine the evolution of teams. Then we can develop effective intervention strategies that can impact teamwork. In recent years, several conceptual frameworks and theories have been proposed to explain the team-evolution process. In this section, we review salient frameworks and theories, drawing upon previous researchers' work to develop a new framework for understanding the team process in the aircraft maintenance environment. The theories described below are only representative; our aim in including them is to explain team performance and training.

Hackman's (1983) normative model offers a comprehensive conceptualization of group process in the organizational environment. Though the model is not developed for a highly structured team, it emphasizes organizational input and the effort, skills, and strategies of team members bring to accomplish team goals. Gersick (1988) described a time and transition model for teams, focusing on the dynamic, evolving nature of team performance. The model shows how exchange of information and resources among team members can result in effective team performance. In Gladstein's (1984) Group Effectiveness Model, group effectiveness is a function of different group processes, such as communication and strategy discussions, moderated by group task demands, such as task complexity and environmental uncertainty. This is one of the few models tested with a large sample of teams in the work environment. Morgan et al.'s (1986) Team Evolution and Maturation Model (TEAM) hypothesizes that teamwork develops through several phases, beginning with loosely organized groups of individuals and proceeding to become a highly effective team over time. This model conceptualizes a team as going through developmental phases and proceeding from ineptness and exploratory interactions to the final level of effective, efficient team performance. The model considers two distinguishable types of team activities through the steps of team evolution: task-related activities and team-related generic activities. Task-related activities are associated with developing operational skills to perform technical tasks; team-related activities are involved in developing team interaction, e.g., relationships, coordination, and interaction.

Other models of team performance emphasize a task analytic approach to team training, e.g., Naylor and Dickinson, 1969; Shiflett et al., 1982. These models consider team performance as a function of the sub-task the team has to perform. They imply that the organization and task complexity establish optimal work and communication and interact to determine individual and team training requirements for enhanced team performance. Tannenbaum et al. (1992) integrate previously described models in a framework for team performance and team training. Canon-Bowers et al. (In Press) state that, since teams operate in diverse work environment performing a wide variety of tasks, constructs such as teamwork and team training can only be understood in the context within which they occur. Tannenbaum et al. (1992) proposed framework explains this context.

11.2 FRAMEWORK FOR TEAMWORK IN THE AIRCRAFT MAINTENANCE ENVIRONMENT

Having reviewed various frameworks and theories, we now propose our framework for considering the team process in the aircraft maintenance environment. Drawing from task analysis of aircraft inspection and maintenance operations (Drury et al., 1990; FAA, 1991), from site visits to repair facilities, from observations made with training personnel and A & P school instructors, and from a detailed review of the team models, we developed the framework shown as Figure 11.1 (Chapter 11 - Appendix). This framework serves as a first step for understanding teamwork in aircraft inspection and maintenance operations; it could be seen as an extension of Tannenbaum et al.'s (1992) team effectiveness model.

The framework illustrates the interaction among internal factors, external factors, the team process, training strategies, and outcome measures. External and internal factors effect the team process. External factors are categorized as follows:

Organizational factors: organization's size , type (e.g., airline, general aviation, repair facility),

reward structure, management structure, communication norms, and organizational climate.

Environmental factors: level of environmental stress (work conduct in hangars or flight-line) and environmental uncertainty.

Equipment factors: automation, complexity, specialization, equipment availability, and safety.

Task factors: task organization (type of aircraft check: A-, B-, C-, or Heavy-check), task type (e.g., avionics, power plant, hydraulics, sheet metal, frame), task complexity, and task structure.

The internal factors, composed of individual and team skills, can be categorized as follows:

Individual skills factor: This represents individual team members' skills and is best represented by AMTs' knowledge, skills, and abilities. In an aircraft inspection/maintenance environment, the individual skills factor is determined by AMTs' experience working on different aircraft types and with different aircraft systems.

Team skills factor: The team members' ability to work together productively is dependent on their interpersonal skills, on the team's composition, on the number of people in the team, and on how long members have worked together. We identified team skills relevant to aircraft maintenance tasks and present them in Table 11.1 (Chapter 11 - Appendix). The name for each team skill is based on suggestions by Salas et al (1992); they were established after a comprehensive review of the literature on teams. According to Morgan et al. (1986), team skills that are isolated and identified can provide a framework for team performance assessments. Although attitude is not considered a team skill dimension *per se*, it is a "cognitive" entity that can be acquired through training (Gagne, 1988); hence, it is shown separately in Table 11.1 (Chapter 11 - Appendix). Previous studies have shown that attitude is important for teamwork and team performance.

External and internal factors impact team interaction, as well as the team process. However, team development is evolutionary: a team matures over time (Morgan et al., 1986). When viewed in light of Morgan et al.'s (1986) TEAM model, individual skills reflect task behavior and represent team members' abilities to perform assigned technical tasks; team skills reflect team members ability for successful interaction and coordination. Both skill acquisition and team evolution can be enhanced through training (Morgan et al., 1987). Specific ways for imparting individual training to AMTs has been widely covered in the literature; hence, our effort focuses only on team training.

AMTs are members of not only one team, but of several teams working on different, yet similar tasks. At an aircraft repair facility, an AMT may work on different subsystems of various aircraft and with different team members over a scheduled maintenance period. For such situations, it is critical to identify generic skills (Cannon-Bowers, et al., In Press) and to train team members accordingly. Cannon-Bowers et al. refer to these as "transportable team skills." At the same time, training AMTs on transportable skills, in itself, may not be sufficient to ensure successful team performance. For such performance, AMTs need training on task-specific team skills, focusing on aircraft inspection and maintenance tasks. Methodology for this type of team training is outlined in the section on Team Training.

The entire team's output can be determined by examining the changes in measures of individual and team process and of task performance.

Individual process measures: These measures identify changes in an individual's task knowledge, skills and ability after he or she takes part in a team activity, also reflecting changes in an individual's mental model and understanding of an entire task.

Team process measures: These measures identify evolution of new team processes by changes in members' specific team skills, i.e., coordination, communication, leadership, and interpersonal skills.

Task performance measures: Performance of an aircraft inspection or maintenance task is measured on the dimensions of accuracy, speed, and safety. Accuracy measures the quality of a job the team completed. Speed measures time required to accomplish a task. Safety refers to the team members ability to adhere to safety procedures by not endangering themselves or other team members. Measurement procedures used to evaluate teams must be sensitive to typical speed/accuracy tradeoffs.

We used our understanding of teamwork to identify specific strategies for training AMTs in A & P schools. In the following section, we outline these strategies. Later in the report, we identify specific team projects which could be incorporated into A & P school curricula and report results of the study we conducted to evaluate how team training improves team skills for an aircraft maintenance task.

11.3 Team Training

Team performance is a function of the average skills of its members. Individual skills appear to be a necessary, but not sufficient, condition for effective team performance; and the correlation between average skill level and average team performance is typically small (Bass and Barett, 1981; Teborg et al., 1976). According to Steiner (1972), team performance is dependent on team members' ability to perform assigned tasks and on their ability to coordinate work flow and to communicate effectively. This process can be facilitated by team training.

Development of a team training program follows classic training program development methodology. It begins with a thorough analysis of the training program's requirements and needs (goals). The next step is establishing knowledge, skills and abilities necessary for the job; these are used to specify the training program's behavioral objectives forming the basis for evaluating the training program. The knowledge, skills, and abilities currently required for aircraft maintenance does not include team skills. Team training is instruction team members receive as a unit to enhance team performance (Nieva et al., 1978). It includes training strategies to enhance team skills. When team training must be combined with individual training in a single program, research shows team training to be most efficient and effective when team members first develop individual skills. Swezey and Salas' (1992) taxonomy identifies characteristics of team training to incorporate in every training program as communication, task organization, team decision-making, team organization, and information transmission. Specific strategies to enhance AMT team skills are outlined below.

11.3.1 Lecture

Lecture is most appropriate for transportable team skills and can be used to introduce basics of teams, teamwork, and the role of teams in enhancing performance. Lectures are most beneficial for team organization/collaboration in identifying the nature of interdependencies for team members and developing an understanding of the team's structure. AMTs can be taught how other members influence their performance, what contributions other AMTs make , the roles of inspectors, and cleanup crews, and for what conditions they must adapt their performance. For example, members should know what to do when particular equipment is unavailable, when a specific inspector is not available or when a member is assigned to a new task. Lecture can also be used to train AMTs in proper communication by giving examples of good and poor communication. AMTs can be taught what type of communication-written and oral-they should have with other members; to whom they must pass information, e.g., writing up a non-routine workcard or passing work to the next shift; and from whom they must receive instructions. Communication includes both technical and non-technical information. Team members should be trained on how to provide and receive performance feedback on individual and team performance so that individual members and the team as a whole use it to enhance performance.

11.3.2 Team Meetings

Team meetings, i.e., group interaction methods, are another popular technique (Goldstein, 1986). This consists of bringing AMTs together to interact in a relatively unstructured environment. Team meetings can be effective for analyzing interpersonal problems and for developing effective understanding and coordination among team members.

11.3.3 Role-Playing

Role-playing can be used for training generic team skills. Members become aware of each other's roles (Cannon-Bowers, et al., In Press) by interacting with each other in role-playing situations. They can learn the knowledge, skills, and abilities each task requires. For example, a mechanic can become aware of skills an NDT inspector has and constraints under which he or she works. Role-playing helps each member develop a better understanding, e.g., mental model, of each task and of interdependencies between and among tasks. With role-playing, trainees have the opportunity to experience on-the-job problems and to explore specific solutions to them (Gordon, 1994).

11.3.4 Task Demonstration

Task demonstration has been successfully used for team training. A task demonstration assists trainees by showing where and how individual team members make inputs and can be most helpful for context-specific skills (Cannon-Bowers, et al., In Press). A passive demonstration could be a computer simulation of a task or an illustration consisting of flow diagrams. A passive demonstration helps trainees identify critical task elements; determine how each team member contributes; understand the sequence of subtasks; establish step-by-step procedures; and identify requirements for coordination, equipment and tooling. For aircraft maintenance, when computer simulation of all tasks is not feasible, cross-training is possible with simulations of representative tasks sharing the same critical elements.

11.3.5 Feedforward Training

Feedforward training, proven effective for individuals (Drury and Gramopadhye, 1990), improves performance when applied to teams (Fredericksen and White, 1989). Feedforward training can take the forms of physical guidance, demonstrations, or verbal advice. It advises team members about upcoming situations so that they are prepared. For example, trainees learn how a team should resolve conflicts arising due to equipment being unavailable, or how to respond when instruction procedures , e.g., on workcard, are not clear and are ambiguous, or when a member is assigned a different task.

11.3.6 Team Decision-Making

Team decision-making requires educating the team on how to utilize various pieces of information to reach an optimal decision (Hogan, et al., 1991). The method involves training members on decision-making techniques, ranging from decision by consensus to brainstorming, to using nominal group techniques. Not all these techniques apply to or are relevant for training AMT teams. The team decision-making dimension is similar to communication because teams need to know what, why, where and how information can be accessed for optimal decisions (Swezey and Salas, 1992).

11.3.7 Feedback Training

Feedback training, i.e., knowledge of results, is beneficial for individual skills training (Patrick, 1992; Czaja and Drury, 1981), and a similar effect exists for teams (Dyer, 1984; Nieva, et al., 1978). In fact, practice without feedback degrades a team's proficiency. Cannon-Bowers et al (In Press) write, "Feedback improves skill acquisition and subsequent task performance by reinforcing learning, by providing cues for goal setting and adjustment, and by reducing the negative effects of self-serving attributions and social loafing."

The following factors are essential for providing effective feedback:

Timing: Feedback should be timely. Team performance is generally superior when feedback is immediate, rather than delayed.

Focus: Feedback's focus is important. Providing feedback on only certain aspects of a task results in performance improvements on only that aspect of the task. Team training should not emphasize one aspect of team performance more than others.

Sequence: Initial feedback should be provided on one aspect of a task; later feedback, on all aspects of a task. This sequence allows trainees to focus on all aspects of team tasks.

Feedback Mix: The ratio of individual to team feedback also effects team performance. Individual feedback should be provided during the initial training session to train individuals to a criterion level of performance. Feedback on later sessions should address team aspects of performance. This strategy ensures that individual skills are suitably developed before team feedback is provided while also preventing individual members from developing misconceptions about their own performance when the team receives feedback.

11.4 Team Training Study

To test the effectiveness and usefulness of team training as a strategy for improving team performance for aircraft maintenance, we conducted a study with AMTs from an FAA-licensed A & P school. Current analyses are based on the hypothesis that teams successfully completing team training exhibit specific interaction, communication, and coordination behaviors enhancing their performance. In this study, we addressed the following questions:

- Does team training effectively improve overall team performance?
- Do effective and less-effective teams display different types of team behaviors?
- Can team training enhance interactive/communication behaviors?

We designed the experiment described below to test the hypothesis and to answer the questions. We do not provide complete details below, but eventually will publish them as a sequence of technical papers.

11.4.1 Subjects

The participants in this study were 24 male students AMTs between 20 and 30 years old from an FAA-licensed A & P school. All subjects were in the second year of a two-year curriculum.

11.4.2 Task

The task consisted of two distinct sessions: the removal and the installation of a turbine engine from a Beechcraft airplane. Major phases in the removal of the engine are external preparation, engine preparation, and engine extraction. Major phases in engine installation are engine installation, engine preparation, and external preparation. Details of each phase are outlined in Table 11.2 (Chapter 11 - Appendix). We selected this task based on its high potential for teamwork. It necessitates more than one person and requires a significantly high degree of coordination and communication between team members for its successful completion.

11.4.3 Procedure

Each subject completed a demographics form (Table 11.3, Chapter 11 - Appendix) and was randomly assigned to one of eight three-person teams. Four teams served as the control group, and remaining four teams received team skills training (this was team training group). Initially, all subjects in the control group and the team training group received individual skills training that provided technical information on how a turbine engine works, on the theory of turbine engines, and on major steps for removing and installing the engine. Subjects also received detailed information about different tools and their proper uses; tools used are listed in the Chapter 11 - Appendix as Table 11.4. After individual skills training, teams in the training group received team training. Before starting the team training, teams in the training group performed a warm-up team exercise (see Chapter 11 - Appendix, Table 11.5).

The team training program was developed in cooperation with trainers and key personnel of a major aircraft repair and overhaul facility and instructors from an A & P school. The training program used some, though not all, of the team training strategies we described above. We combined the team skills with team training research to develop a behaviorally based, team training program focused on improving specific team skills. First, we tested the team training program using AMTs from our partner repair facility for a specific aircraft maintenance task. However, we do not report results of the field study at the aircraft repair facility; they are forthcoming in other papers. We modified and refined our team training program based on the field study's results and used the revised version in the current study. The training program had five stages, with each stage requiring 2-3 hours (see Chapter 11 - Appendix, Table 11.6). Teams remained intact through the entire team training process and the study's duration.

Following team training, teams in the training group performed the engine removal and installation task. Teams in the control group performed the same task. Unlike the team training groups, control group teams performed the task directly after they received individual skills training. When they completed the entire task, we debriefed all teams and thanked them for participating.

11.5 Measuring Teamwork Skills, Team Attitude, and Task Performance

11.5.1 Teamwork Skills

A series of recent studies conducted with military teams offer insight into measuring the team process (Morgan, et al., 1986; Baker and Salas, 1992). Studies in teamwork assessment show that it is possible to observe and record changes in team behavior and to discriminate more-effective from less-effective teams (Oser, et al., 1989). Our detailed review of teamwork measurement literature suggests that team process measures rely heavily on observation (Schiflett, et al., 1985; Morgan, et al., 1986) and that team studies use behaviorally anchored rating scales for data collection. For the current study, assessment tools (rating scales) were developed and refined to measure teamwork skills and team task performance.

We collected two types of data on the previously mentioned team skill dimensions by interviewing team members and instructors. One type of data reflected instructors' observations; the other, team members' perceptions. We collected the first type of data with the instructors' interviews (Chapter 11 - Appendix, Table 11.7). We collected the second type with the post-session interviews (Chapter 11 - Appendix, Table 11.8). Both the interviews use a Likert-type, seven point, agree-disagree scale: trainees and instructors indicated their response to each item. Instructors and student AMTs completed the respective interviews on completion of each session, i.e., engine removal and engine installation.

11.5.2 Team Attitude

Attitude measures attempt to gauge the trainees' opinions about whether they believe that training and teamwork will improve team performance. One of the most popular attitude measurement questionnaires is the CMAQ (Cockpit Management Attitudes Questionairre) for assessing commercial aviators' attitudes about team training (Helmreich et al., 1986). In the current study, we used a modified version of an attitude questionnaire (Chapter 11 - Appendix, Tables 11.9 and 11.10) in our interviews, administering it to student AMTs before the study's commencement and after its completion.

11.5.3 Task Performance

In addition to data on team behavior, data were also collected on speed, accuracy, and safety measures. We recorded this data using the data collection instrument in Chapter 11 - Appendix, Table 11.11. Data were collected on the above-listed task performance measures for each phase of the engine removal and engine installation tasks. Results are reported with the Task Performance Summary Table (see Chapter 11 - Appendix, Table 11.12).

11.6 Results and Discussion

This study's results are indicative since comparisons are based on only four teams per group (training, control). However, these results do generally indicate that we are heading in the right direction. The data collection instruments and task performance summary provided data for 24 individuals from 8 teams. These data are reported in this section, divided into findings based on data from the instructors' evaluations, from self-evaluations, and from the task performance summary.

Figures 11.2 and 11.3 (Chapter 11 - Appendix) show instructors' overall ratings for the trained and untrained teams on each team skill dimension. The instructor's ratings on the instructors' interview were mapped onto different team skills. The chart shows that teams which had team training were ranked equal to or better than teams which did not have team training on each team skill dimension for both engine removal and engine installation phases. These results suggest that teamwork skills of the teams receiving training were perceived to be much better than those of teams not receiving training. Since no data were collected on individual team members, it is not possible to assess each individual's relative performance.

It is interesting to note that performance differences between trained and untrained teams are much larger on the engine removal phase (first session) than on the engine installation phase (second session). Teams which did not receive training showed improvement and better teamwork in the latter phase (engine installation). This could be because team interaction patterns are established, lessons are learned, and communication norms develop as the task proceeds. Experience helps refine the team's interaction process so that it works more effectively on subsequent tasks. Much of the team evolution and maturation process for teams not receiving training was completed "on-the-job," while a large portion of this process for trained teams was completed during training. Despite differences, the data indicate team evolution and maturation effects for both teams. These results add weight to the claim that effective team behaviors can be identified and enhanced by having teams engage in those behaviors in a training environment.

To understand individual team members' perception of their team's performance, we analyzed the Post-session self-evaluation interview. Results are reported in the Chapter 11 - Appendix as Figures 11.4 and 11.5. Although the instructors' analysis of trained and untrained teams revealed a large difference in various team behaviors, we did not find a similar large effect here. Nevertheless, results of the self-evaluation interview are that the trained group's mean score was higher than the control group's on five of six team skills measures on the engine removal task and on four of six measures on the engine installation task. To gauge teams' attitudes towards teamwork and their understanding of the principles of teamwork, we analyzed pre- and post-training interviews. Figure 11.6 (Chapter 11 - Appendix) shows that, although scores for both the trained and the untrained groups are comparable on the pre-training interviews, there are differences on the post-training interviews. The trained group's higher scores on six of eight questions reflect the effect of training in and understanding of teamwork and team principles.

To understand whether improved team performance translated into improved task performance, we collected task performance measures for both groups. The data for the trained and control groups are summarized in Table 11.12 (Chapter 11 - Appendix). Measure 1 relates to speed; measures 2, 3 and 4, to accuracy; and measures 5 and 6, to safety. Teams in the untrained (control) group required significantly more time to complete the engine removal task. However, there was not a large difference on the engine installation task. This result could be attributed to the lack of coordination and communication among members of the control group present in the first stage and absent in the second. Over time, teams in the control group improved coordination and communication, resulting in reduced task time on the engine installation task. Similarly, the trained group made fewer errors for both engine removal and installation tasks and had superior scores on accuracy measures 2, 3 and 4. No significant differences were observed between the groups on safety measures. The most important result is that trained teams with effective team behaviors were overall more effective and more efficient. Trained teams demonstrated more behavior involving coordination and communication skills, i.e., coordinating gathering information, conveying the right information to the right person at the right time in the right format, receiving relevant information; error-correction skills, i.e., providing team members with performance feedback and helping resolve errors; and interpersonal skills; i.e., leadership, displaying appreciation for help provided, and making team-building statements. These behaviors resulted in improved task performance.

A correlation exists between successful team behavior and task performance. Though limited in its sample size, this study's results indicate that training AMTs on team skills improve coordination and communication skills. In turn, this translates into improved task performance.

11.7 Conclusions

This study was a first effort devoted expressly to evaluating the effect of team training in the aircraft maintenance environment. The study's implications are encouraging as to the potential team training has for improving team performance and overall task performance. We draw the following specific conclusions from this study:

- It is possible to identify team skills and to train student AMTs in teamwork skills critical for successful team performance in the aircraft maintenance environment.
- Teams which receive team training exhibit a larger percentage of behaviors related to team performance. Also, results suggest that members of teams which did not receive team training do not exhibit the high percentages of team behaviors as members of more-effective teams.

Based on this study's results, training for student AMTs should emphasize generic and context-specific team skills, focusing on coordination, communication, interpersonal, and leadership skills. Our findings provide insight for developing future team training systems and for improving existing instructional technology. The elements of the team training program outlined in this study can easily be incorporated into A & P school curricula to prepare student AMTs for teamwork. Further, elements of the team training program can also be incorporated into formal methodology used to train AMTs at different aircraft sites. The operational setting for the current study provided the opportunity to observe teams in the field, rather than in a laboratory. Although results are encouraging, additional team research is needed to fully understand complex interactions existing in a team environment for different tasks and conditions. The following section outlines how team training can be incorporated in a typical A & P school curriculum and provides a functional description of a computer-based tool for team training which will be developed under Phase VI of this contract.

11.8 Future applications of TEAM TRAINING WITHIN A & P SCHOOL CURRICULUM

The previous study demonstrated team training's effectiveness for improving both teamwork skills and task performance for a specific aircraft maintenance task, using student AMTs. The results of the controlled study and recognition of the important role of teamwork establish a need to identify team projects which can train student AMTs in teamwork skills and prepare them for cooperative environments. This section outlines specific team-training projects which could be used in a typical FAA-licensed A & P school curriculum. Table 11.13 (Chapter 11 - Appendix) outlines a typical A & P school curriculum, and Chapter 11 - Appendix, Table 11.14 presents a condensed overview of various team projects which could be incorporated therein.

11.8.1 Computer-Based Tool for Team Training

As computer-based technology becomes increasingly cheaper, the future will see an increased application of advanced technology in training. Over the past decade, instructional technologists have provided numerous technology-based training devices promising improved efficiency and effectiveness. Examples include computer simulation, interactive video discs, and other derivatives of computer-based applications (Johnson, 1990(a)). The compact disc read only memory (CD-ROM) and digital video interactive (DVI) are examples of other types of technologies which will provide future "multi-media" training systems. Technologies such as Computer-Aided Instruction (CAI), Computer-Based Training (CBT), and Intelligent Tutoring System (ITS) are being used today, ushering in a revolution in training. Several new technologies have found a place in maintenance training (Johnson, 1990(a), 1992; Shepherd, 1992).

Hypermedia is a tool/instructional system finding acceptance as a tool for learning among learning theorists. Hypermedia involves non-linear organization of information, linking together discrete blocks (chunks) of information to create an information network. It can also be seen as a non-sequential method for presenting and accessing information in which users can move freely according to their needs. Hypermedia information is multimedia: text, graphics, animation, and audio. If information is only text, it is known as hypertext. Hypermedia systems have found extensive use in applications ranging from browsing to training. Jonassen and Gabringer (1990) list examples of hypermedia in instructional tools such as language learning, science teaching, and browsing in encyclopedias. Christensen, et al. (1993) developed a hypermedia-based instructional tool for teaching hypermedia system design. Koshy, et al. (In Press) developed a hypermedia version of a maintenance manual for diagnostic training. In each case, hypermedia was useful for learning and training applications.

The current research effort was devoted expressly to facilitating understanding and to examining how team members interact and how team training can facilitate teamwork in the aircraft maintenance environment. Having met these goals, our next step is to consider training media which uses instructional techniques developed in this phase of the research in order to develop a training program enhancing team skills. Hypermedia has the potential to enhance learning and could prove to be useful for improving certain aspects of teamwork. In the next phase of our research, we propose to develop a hypermedia-based training tool designed to support learning teamwork in the aircraft inspection and maintenance environment. We provide a functional description of the proposed training tool below.

11.8.2 Functional Description

The Aircraft Maintenance Team Training (AMTT) software will be a computer-based hypermedia system for team training. It will be developed for student AMTs, focusing on generic and context-specific team skills. The system will be programmed using Visual Basic/Tool Book to operate on an IBM-compatible computer (486 DX2/66 Hz , 8 Mb of RAM), using Microsoft Windows and utilizing multiple media such as sound, text, animation and graphics. AMTT will consist of the two basic modules and other sub-modules outlined below.

11.8.2.1 The Trainee's Module

The Trainee's Module will train AMT's on various aspects of teamwork, including generic and context-specific team skills. It will include the following basic elements:

11.8.2.1.1 Team Overview Module

Introduction: This module will introduce trainees to the basics and objectives of teamwork (team mission). This module will use the Landing on the Moon exercise to demonstrate the importance of teamwork. The importance of and need for teamwork in aircraft inspection and maintenance will also be emphasized, identifying basic team skills and illustrating each skill's importance.

Tools for Making Team Decisions: This submodule will introduce trainees to decision-making techniques, providing examples of using the techniques in the aircraft maintenance environment.

Team Communication: This submodule will introduce trainees to aspects of written and verbal/nonverbal team communication, providing illustrations of appropriate and inappropriate communication in the aircraft maintenance environment. Specifically, communication examples will focus on: format, direction, frequency, length, conditions, context, and time. The importance of good communication for team performance will be emphasized.

Team Feedback: This submodule will provide trainees with guidelines for providing, receiving, and using feedback to communicate with other AMTs clearly about how tasks are being performed.

Team Coordination: This submodule will focus on the coordination required for team members to ensure well-orchestrated teamwork.

Team Leadership: This submodule will focus on the critical role of team leadership for accomplishing team tasks. For example, team members will be shown how to handle information overload under stressful conditions, specific behaviors exhibiting leadership and assertiveness, and methods of motivating others.

Team Evaluation: This submodule will expose the trainees to the instruments used to evaluate individual and team performance on a task.

Each submodule will first introduce trainees to basic principles and the provides examples applying the principles to enhance teamwork in the aircraft maintenance environment. Trainees will make an active response as they are exposed to new material and will be provided with immediate feedback as to their answer's correctness. This stage will be followed by a question and answer session for the material.

11.8.2.1.2 Team Building Exercise Module

This module's objective is to demonstrate the application of basic principles of teamwork emphasized in the Team Overview Module. Trainees will undertake a series of exercises requiring them to demonstrate their understanding of principles. The training will use training strategies such as role-playing, feedforward, and feedback. For example, roles of various team members will be modeled for certain task situations, using knowledge from experts. Examples of how interactions could proceed, with examples of poor and good behavior, will be demonstrated via simulation. Trainees will comment on the behavior's appropriateness and will be asked for inputs or suggestions to improve team performance. Trainees will be given guidance and feedback during and after the session.

11.8.2.1.3 Task Simulation Module

This module will provide trainees with graphical demonstration, animation, and flow charts of different scenarios for select aircraft maintenance tasks. Team members using this module can interact cooperatively to identify ways to improve teamwork for the representative simulated aircraft maintenance tasks.

11.8.2.2 The Instructors Module

11.8.2.2.1 Assessment Module

This module will provide the instructors with a means to assess trainees' understanding of using team principles and will allow instructors to evaluate trainee's and the team's performance while interacting with AMTT software. The module will provide the instructor with various data collection instruments used by both trainees and instructors.

11.8.2.2.2 Report Generation Module

The Report Generation Module will allow instructors to print reports of results. It will also allow instructors to generate printouts of data collection instruments and select material in the Team Overview Module. This will allow instructors to use the material in a classroom environment and to use data collection instruments for field study.

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Chapter 11 Appendix Team Training

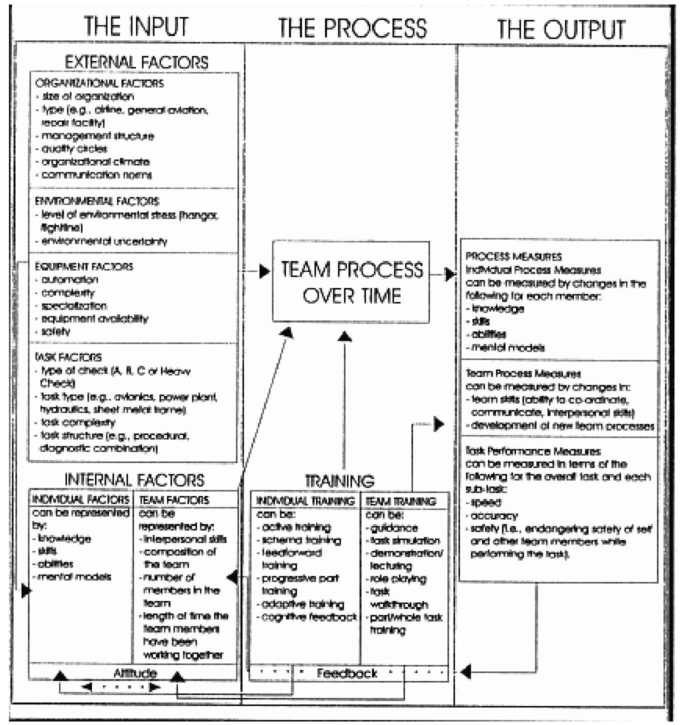

Figure 11.1 A Modified TEAM Effectiveness Model

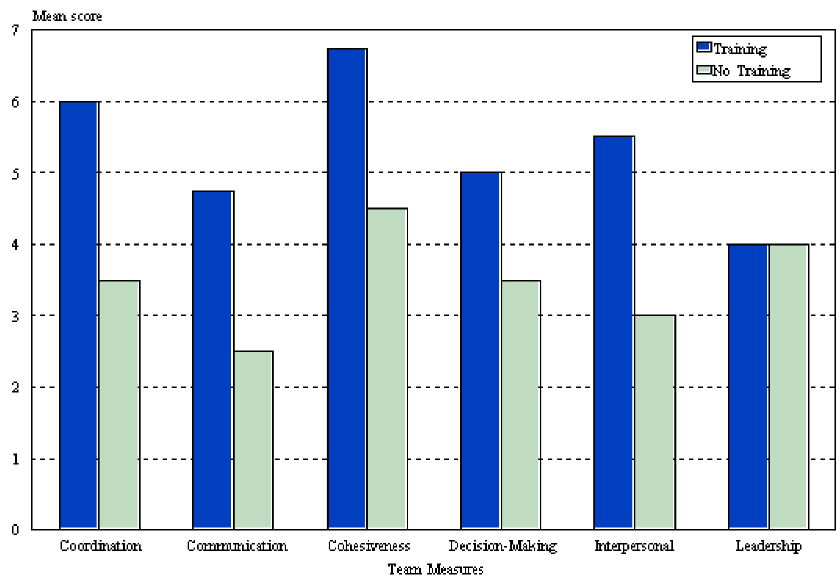

Figure 11.2 Evaluation of Team Performance Measures by Instructor - Engine Removal

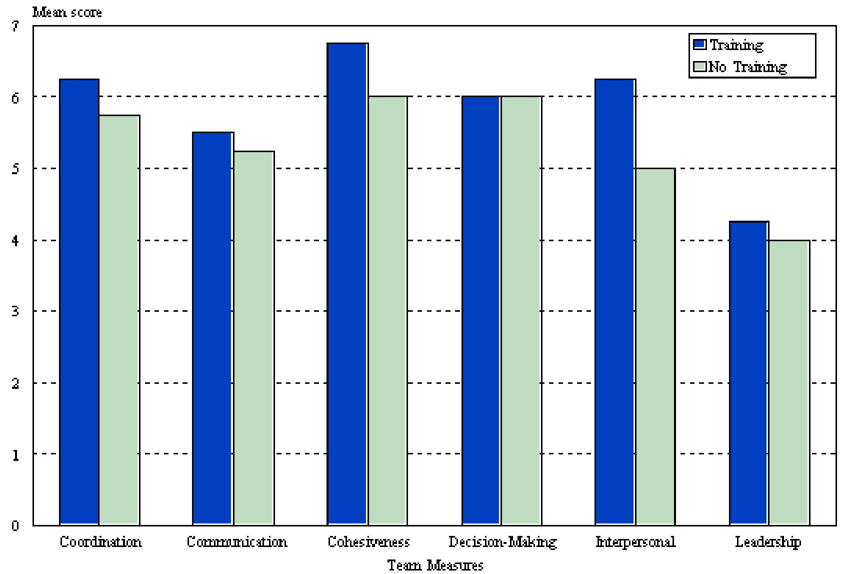

Figure 11.3 Evaluation of Team Performance Measures by Instructor - Engine Installation

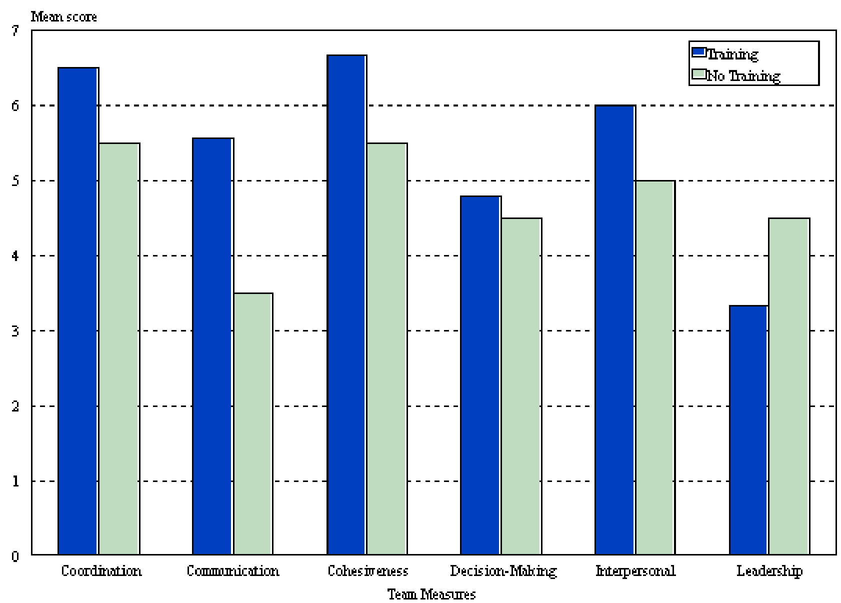

Figure 11.4 Self Evaluation - Engine Removal

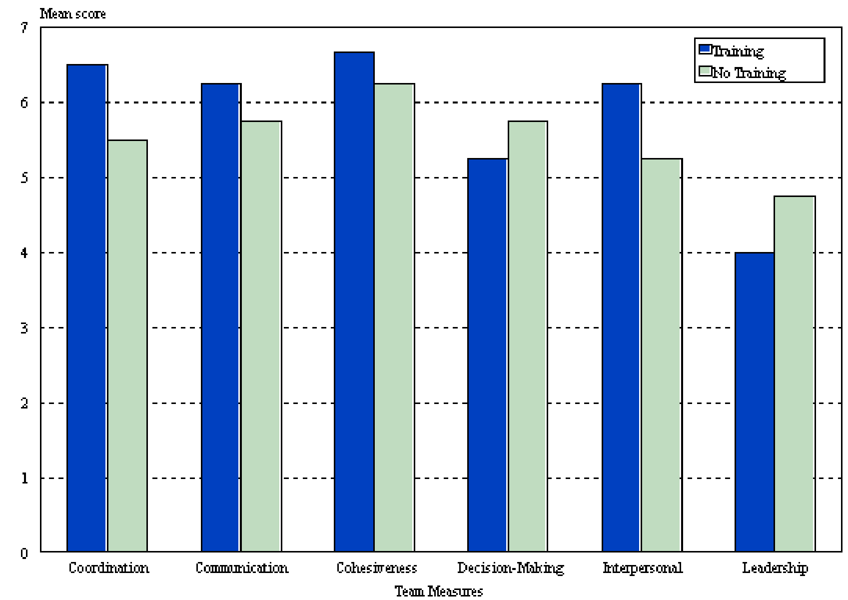

Figure 11.5 Self Evaluation - Engine Installation

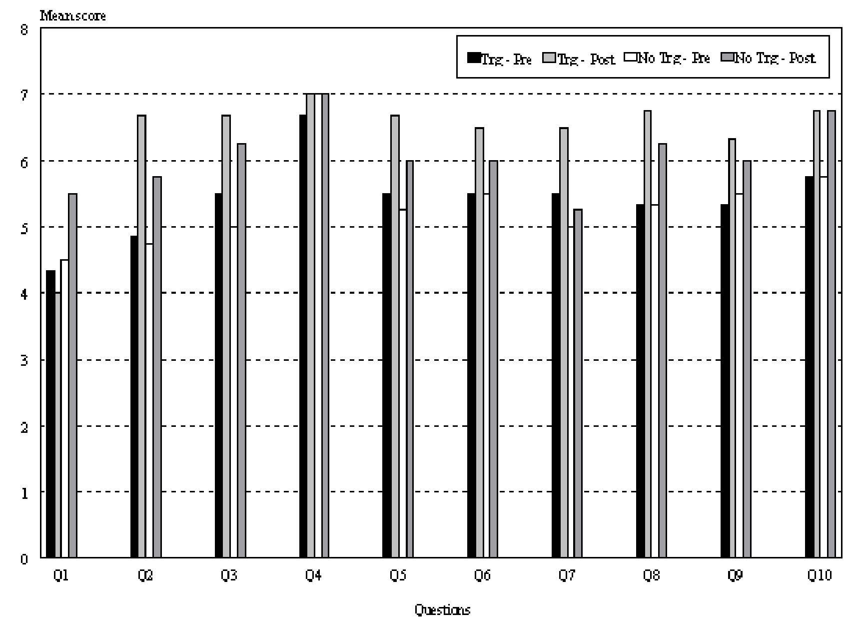

Figure 11.6 Pre and Post Training Data

Table 11.1 Team Skills

Team Skills	Description
1. Coordination	This refers to the team's ability to organize available resources and activities so as to accomplish the goal within the temporal constraints.

2. Communication The process by which the team members clearly and accurately exchange information, using established procedures and language. It also encompasses the team members' ability to receive and provide constructive feedback on the performance of other team member(s) so as to help achieve the team goal.

3. Cohesiveness This refers to the process by which all members of the team develop compatible models of the system and work together as one unit.

4. Decision-Making This refers to the process by which teams can use judgement, analytical technique, and consensus methods to arrive at decisions by pooling together information and resources.

5. Interpersonal This refers to team members' abilities to employ cooperative behavior to resolve interpersonal problems and optimize member interactions.

6. Leadership This refers to the ability to assign, plan, organize, and motivate members to accomplish the goal.

7. Attitude

Table 11.2 Task Decomposition by Phases

ENGINE REMOVAL	**ENGINE INSTALLATION**
1. **External Preparation**	1. **Engine Installation**
a) Set up tail stand	a) Install Engine
b) Disconnect electric power	b) Connect top V-brace
c) Remove top cowling	c) Connect lower engine mounts
d) Disconnect actuator	d) Put bulhead bolts
e) Remove bottom cowling	e) Unmount sling and hoist from engine
2. **Engine Preparation**	2. **Engine Preparation**
a) Remove hoses and fittings	a) Install propeller
b) Disconnect electrical leads	b) Fill oil
c) Disconnect engine controls	c) Connect engine controls
d) Drain oil	d) Connect electrical leads
e) Remove propeller	e) Put back hoses and fittings
3. **Engine Extraction**	3. **External Preparation**
a) Mount sling and hoist on engine	a) Put back bottom cowling
b) Remove bulkhead bolts	b) Connect actuator
c) Disconnect lower engine mounts	c) Put back top cowling
d) Disconnect top V-brace	d) Connect electric power
e) Extract Engine	e) Remove tail stand

Table 11.3 Demographics Form

DEMOGRAPHICS FORM

The following information will remain confidential and is for research purposes only. Each team member should fill in all questions carefully and completely.

1. Have you attended a technical or vocational school other than this school?

Yes _______ No _______

2. If you answered yes to question 1, what type of technical training did you receive?

____

____

3. Have you ever worked in a team environment prior to this class?

Yes _______ No _______ Not Sure _______

4. If you answered yes to question 3, where did you work as a team member?

School ________ Work ______ Other ________

4 (a). What kind of work were you involved in as a team member?

____

5. Have you ever been fully employed prior to attending this school?

Yes ________ No ________

6. What kind of work did you do?

____

____

7. Have you ever had any team training before?

Yes ________ No _________

8. What skills did you learn?

____

9. Sex: Male _________ Female ________

10. Age: 17-20_________ 21-30 ________ 31-40 ________ 41-50 ________ 51-60 ________ 61+ ________

Table 11.4 Tool Description

STUDENT TOOL LIST - REQUIRED TOOLS

1. Tool box **6. Socket Set 1/4" Drive**
No larger than 20 inches high X 20 inches long. (No 5/32" Regular 6 pt
Rollaways) 3/16"
7/32"
2. Chain and lock 1/4"
9/32"
3. Open-End Wrenches 5/16"
1/4 x 5/16" 11/32"
3/8 x 7/16" 3/8"
1/2 x 9/16" 7/16"
9/16 x 5/8" 1/2"
5/8 x 3/4" 1/4" Deep 6 pt
11/16 x 13/16" 5/16"
3/4 x 7/8" 3/8"
15/16 x 1" 7/16"
1/2"
4. Box-End Wrenches Ratchet
1/4 x 5/16" Spinner Handle
3/8 x 7/16" Ext. 1 1/2"
1/2 x 9/16" Ext. 3"
9/16 x 5/8" Universal Joint
11/16 x 13/16"
3/4 x 7/8" **7. Screw Drivers**
15/16 x 1" Set of ten -
Range of Slotted and Phillips
5. Socket Set 3/8" Drive with a stubby of each.
3/8" Regular 12 pt
7/16" **8. Punch**
1/2" Deep 6 pt Pin Punch
9/16" 1/16 - 1/8"
5/8" Center Punch
11/16" 3/8"
3/4" Prick Punch
13/16" 3/8"
15/8" Plug Line-Up Tools
Ratchet 3/16 x 9 & 5/32 x 7"
3" Ext.
Case **9. Allen Wrenches**
6" Ext. Long
7/8" Deep Spark Plug Socket 5/64"
Universal Joint 3/32"
7/64"
1/8"
9/64"
5/32"
3/16"
7/32"
1/4"

___10. Adjustable Wrenches - 10" **OPTIONAL TOOLS**

11. Measuring Tape 12 ft. **1. Cold Chisels**
1/4, 3/8, 1/2, 3/4"
12. Hammer, Ball Peen 8 oz.
2. Allen Wrenches
13. Hammer, Plastic Tip Short
.050"
14. Flash Light 2 Cell 1/16"
5/64"
15. Pliers, Common 8" 3/32"
7/64"
16. Pliers, Diagonal 7" 9/64"

17. Pliers, Longnose 8" **3. Adjustable Wrenches - 6"**

18. Pliers, Duckbill **4. Machinist Square**

19. Pocket Knife 4" **5. Hacksaw**

20. Sheet Metal Snips **6. Hacksaw blades**
Left
Right **7. Pliers Arc Joint 9"**

21. 10X Magnifying Glass **8. Socket Set 1/2" Drive**
Socket Regular 12 pt
22. File Set - 8" or larger 7/16"
1 - Bastard 1/2"
1 - Round 9/16"
1 - Half Round 5/8"
1 - Triangular 3/4"
11/16"
23. File Handles 13/16"
7/8"
24. File Card 15/16"
1"
25. 1 - Extension Type Inspector Mirror Deep 12 pt
1/2" Ext. 6"
26. 1 - Mechanical Finger, 10 - 14 inch 9/16" Ext. 3"
5/8"
27. 1 - Retrieving Magnet, 10 - 14 inch 3/4"
11/16"
28. 1 - Thickness Gage Set 13/16"
.002 - .035 or better 7/8"
15/16"
Ratchet
Universal Joint

Table 11.5 Team Exercise on Lost on the Moon

Lost On The Moon Exercise

Your spaceship has just crashed-landed on the moon. You were scheduled to rendezvous with a mother ship 200 miles away on the lighted surface of the moon, but the rough landing has ruined your ship and destroyed all the equipment on board, except for the 15 items listed below.

Your crew's survival depends on reaching the mother ship, so you must choose the items based on their importance for survival. Place number one by the most important for survival. Place two by the second most important, and so on through number 15, the least important.

Item	Your Ranking 1 to 15	Your Error Score	NASA's Ranking 1 to 15	Team Ranking 1 to 15	Team Error Score
Box of matches					
Food concentrate					
Fifty feet of nylon rope					
Parachute silk					
Solar-powered portable heating unit					
Two .45 caliber pistols					
One case of dehydrated milk					
Two 100 pounds tanks of oxygen					
Stellar map (of the moon's constellations)					
Self-inflating life raft					
Magnetic compass					
Five gallons of water					
Signal flares					
First-aid kit containing injection needles					
Solar-powered FM receiver - transmitter					
YOUR TOTAL ERROR SCORE					

Table 11.5 (continued...)

Lost On The Moon - Team Rules

1. Avoid arguing for your own ranking. Present your position as lucidly and logically as possible, but listen to the other members' reactions and consider them carefully before you press your point.

2. Do not assume that someone must win and someone must lose when discussion reaches a stalemate. Instead, look for the next-most-acceptable alternative for all parties.

3. Do not change your mind simply to avoid conflict and to reach agreement and harmony. When agreement seems to come too quickly and easily, be suspicious. Explore the reasons and be sure everyone accepts the solution for basically similar or complementary reasons.

4. Avoid conflict-reducing techniques such as majority vote, averages, coin-flips and bargaining. When a dissenting member finally agrees, don't feel that he or she must be rewarded by having his or her own way on some later point.

5. Differences of opinion are natural and expected. Seek them out and try to involve everyone in the decision process. Disagreements can help the group's decision because with a wide range of information and opinions, there is a greater chance that the group will hit upon more adequate solutions.

Lost On the Moon - Scoring

	Team 1	Team 2	Team 3	Team 4
Total Error Points	_______	_______	_______	_______

Error points are absolute difference between your rank and NASA's (disregarding plus or minus signs)

0 - 25 execellent

26 - 32 good

33 - 45 average

46 - 55 fair

56 - 70 poor

71 - 112 very poor (suggest possible faking or use of earth bound logic)

Table 11.5 (continued...) Lost On The Moon - Answers

Item	NASA's Reasoning	NASA Rank	Team 1 Rank	Error Points	Team 2 Rank	Error Points	Team 3 Rank	Error Points	Team 4 Rank	Error Points
Box of matches	No Oxygen on moon to sustain flame: worthless	15								
Food concentrate	Efficient means of supplying energy requirements	4								
Fifty feet of nylon rope	Useful in scaling cliffs, tying injured together	6								
Parachute silk	Protection from sun's rays	8								
Solar-powered portable heating units	Not needed unless on dark side	13								
Two .45 caliber pistols	Possible means of self propulsion	11								
One case of dehydrated Pet milk	Bulkier duplication of food concentrate	12								
Two 100 pound tanks of oxygen	Most pressing survival need	1								
Stellar map (of the moon's constellations)	Primary means of navigation	3								
Self-inflating life raft	CO2 bottle in military raft may be used for propulsion	9								
Magnetic compass	Magnetic field on moon is not polarized: worthless	14								
Five gallons of water	Replacement for tremendous liquid loss on lighted side	2								
Signal flares	Distress signal when mother ship is sighted	10								
First-aid kit containing injection needles	Needles for vitamins, medicines, etc. Will fit aperture in NASA space suit	7								
Solar-powered FM receiver transmitter	For communication with mother ship, but requires line of sight (short range)	5								

Table 11.6 Team Training Program

Session 1 - Basics of Teamwork

Goals

Provide trainees an understanding of teams, need for teamwork, introduction to team concepts, and an outline of future sessions

Major Elements

- Initial attitude survey
- Why there is a need for teams
- Establish the need for consistency and clarity in goals: team goals and individual goals
- Goals of team building
- Team work exercise
- Overview of future sessions

Session 2: Decision Making

Goals

Introduce trainees to scientific approach to decision-making

Major Elements

- expose trainees to different tools for decision-making
- identify the merits and demerits of the tools
- use of decision-making tools within the aircraft/maintenance environment context (which tool? when to use? How to use?)
- exercise involving different tools
- decision-making by consensus

Session 3: Group Dynamics 1: Communication and Interpersonal

Goals

To provide each trainee with an understanding of the essential elements of communication

Identify steps to minimize interpersonal problems

Major elements

- establish need for oral communication and written communication
- principles of good communication (format, terminology, direction, when, how, how much/little)
- examples of appropriate forms of communications (written and oral) within the aircraft maintenance environment
- importance of providing team members with positive and negative feedback and how to receive feedback (When to give? How it works? How to receive? ...)
- exercise involving correct and incorrect communication within the aircraft maintenance environment

Table 11.6 (continued...) Team Training Program

Session 4: Group Dynamics 2: Coordination and Cohesiveness

Goals

To train on the importance of coordination and cohesiveness in achieving the team goal

Major Elements

- Methods to eliminate barriers and behavioral problems
- Demonstrate the importance of coordination as it relates to aircraft maintenance and inspection
- provide examples of good and bad coordination and demonstrate the effects on task performance
- Identify every member's role and explain interdependency
- Help establish accurate expectations of the contributions of other team members to overall performance

<u>Session 5: Team Activity</u>

Goals

To demonstrate how team skills can improve team performance for an aircraft inspection/maintenance task

Major Elements

- construct examples of team activity
- illustrate importance of different team skills in accomplishing the activity
- role play
- provide feedback to teams

Table 11.7 INSTRUCTORS' INTERVIEW PERFORMANCE MEASUREMENTS

The purpose of this questionnaire is to evaluate the effectiveness of team training on team performance. The facilitator is in a position to observe any improvements or lack of improvements in team performance, so please take time to consider each statement. All responses will be kept confidential.

Rate each statement on a scale of 1 - 7

Number of times,

Lowest, Poor, **Neutral** **Highest, Best, Always,**

Never, etc. **Very, etc.**

1 2 3 4 5 6 7

	Team 1	Team 2	Team 3	Team 4
1. The team members worked well together.				
2. The team resolved conflicts effectively.				
3. All members of the team participated in the decision-making process				
4. The team members discussed new ways to tackle the task.				
5. The team was effective in establishing ground rules.				
6. One person dominated the team.				
7. There was at least one person who was disruptive.				
8. There was at least one person who did not participate in team discussions.				
9. One member took charge of assigning the tasks and coordinating activities of other team members.				
10. Team members provided each other with performance fedback				

11. The team members worked cohesively.

12. Team members responded well to team training.

13. The team members follow the agenda (accomplished the objectives).

14. There was a noticeable improvement due to team training.

Table 11.8 POST SESSION INTERVIEW

Please rate the following statements on a scale of 1 - 7 by circling the response that best fits your opinion concerning the statement. All response will be kept confidential.

Definitely Not **Definitely**

1. The team followed the agenda for the session. 1 2 3 4 5 6 7

2. You were satisfied with the level of participation by team members. 1 2 3 4 5 6 7

3. Everyone contributed and was involved in team decisions. 1 2 3 4 5 6 7

4. You had a good attitude about your work and the task. 1 2 3 4 5 6 7

5. Team members allowed personality conflicts to interfere with work. 1 2 3 4 5 6 7

6. You were satisfied with the level of the teams' achievement towards the established goal. 1 2 3 4 5 6 7

7. Team members were able to settle conflicts effectively among themselves 1 2 3 4 5 6 7

8. You feel the teams' performance was very good. 1 2 3 4 5 6 7

9. You feel the final result of the task was very good. 1 2 3 4 5 6 7

10. Your opinion was considered. 1 2 3 4 5 6 7

11. One member took charge of assigning the tasks and coordinating the activities of other team members. 1 2 3 4 5 6 7

12. Team members were aware of each others

responsibilities. 1 2 3 4 5 6 7

13. You were satisfied with the material used for team training. 1 2 3 4 5 6 7

14. You were satisfied with the material used for technical training. 1 2 3 4 5 6 7

15. If provided with another opportunity, you would want to participate in a team activity. 1 2 3 4 5 6 7

16. If provided with another opportunity, you would participate in a team activity with the same group. 1 2 3 4 5 6 7

Table 11.9 PRE-TRAINING INTERVIEW

Please circle the response that best reflects your opinion of each statement. All responses will be kept confidential.

	Strongly Disagree			Neutral			Strongly Agree
1. I believe teamwork is the best way to accomplish work tasks in all situations.	1	2	3	4	5	6	7
2. In team environments, it is important to follow an agenda.	1	2	3	4	5	6	7
3. All team members should contribute to team decisions.	1	2	3	4	5	6	7
4. If one team member doesn't understand, other team members should help him or her.	1	2	3	4	5	6	7
5. Team leaders should keep the team on track to accomplish goals.	1	2	3	4	5	6	7
6. Team decisions are superior to individual decisions.	1	2	3	4	5	6	7
7. All tasks are not suited for team environments.	1	2	3	4	5	6	7

8. I am comfortable participating
in team decisions. 1 2 3 4 5 6 7

9. The success of the team is important
to each individual. 1 2 3 4 5 6 7

10. Training improves team
performance. 1 2 3 4 5 6 7

Table 11.10 POST-TRAINING INTERVIEW

Please circle the response that best reflects your opinion of each statement. All responses will be kept confidential.

	Strongly Disagree	Neutral	Strongly Agree

1. I believe teamwork is the best way to accomplish work tasks in all situations. 1 2 3 4 5 6 7

2. In team environments, it is important to follow an agenda. 1 2 3 4 5 6 7

3. All team members should contribute to team decisions. 1 2 3 4 5 6 7

4. If one team member doesn't understand, other team members should help him or her. 1 2 3 4 5 6 7

5. Team leaders should keep the team on track to accomplish goals. 1 2 3 4 5 6 7

6. Team decisions are superior to individual decisions. 1 2 3 4 5 6 7

7. All tasks are not suited for team environments. 1 2 3 4 5 6 7

8. I am comfortable participating in team decisions. 1 2 3 4 5 6 7

9. The success of the team is important to each individual. 1 2 3 4 5 6 7

10. Training improves team performance. 1 2 3 4 5 6 7

Table 11.11 Data Collection Instrument on Team Performance

1. Total time to complete the entire task.

----

1 (a). Total time to complete the External Preparation Phase.

----

1 (b). Total time to complete the Engine Preparation Phase.

----

1 (c). Total time to complete the Engine Extraction Phase.

2. Total number of mistakes made by the team while completing the entire task.

----

2 (a). Total number of mistakes made by the team during External Preparation Phase.

----

2 (b). Total number of mistakes made by the team during Engine Preparation Phase.

----

2 (c). Total number of mistakes made by the team during Engine Extraction Phase.

3. Number of times the instructor had to point out the mistakes being made and correct them during the entire task.

----

3 (a). Number of times the instructor had to point out the mistakes being made and correct them during the External Preparation Phase.

----

3 (b). Number of times the instructor had to point out the mistakes being made and correct them during the Engine Preparation Phase.

----

3 (c). Number of times the instructor had to point out the mistakes being made and correct them during the Engine Extraction Phase.

4. Number of times team did not follow correct procedures during the entire task.

----

4 (a). Number of times team did not follow correct procedures during the External Preparation Phase.

----

4 (b). Number of times team did not follow correct procedures during the Engine Preparation Phase.

----

4 (c). Number of times team did not follow correct procedures during the Engine Extraction Phase.

Table 11.12 Summary of Task Performance

Engine Removal (averaged over 4 teams)

Task Performance Measures	Training Group	Control Group
1. Total time taken to complete the task of engine removal (hrs./mins.)	6 hrs 10 mins.	7hrs 38 mins.
2. Number of mistakes made by the team during engine removal	3	9
3. Number of times the instructor had to point out the mistakes being made and correct them during the task of engine removal	3	6
4. Number of times the team did not follow correct procedures during the task of engine removal	1	5
5. Number of times safety of fellow team members was endangered during the task of engine removal	0	0
6. Number of times safety procedures were not followed during the task of engine removal	3	1

Engine Installation (averaged over 4 teams)

Task Performance Measures	Training Group	Control Group
1. Total time taken to complete the task of engine installation (hrs./mins.)	13 hrs 32 mins.	14 hrs 15 mins
2. Total number of mistakes made by the team during engine installation	1	5
3. Number of times the instructor had to point out the mistakes being made and correct them during the task of engine installation	2	6
4. Number of times the team did not follow correct procedures during the task of engine installation	2	4
5. Number of times safety of fellow team members was endangered during the task of engine installation	0	0
6. Number of times safety procedures were not followed during the task of engine installation	1	2

Table 11.13 AMP School Curriculum

Year 1	**Year 2**
Fall Semester	**Fall Semester**
General Regulations	Bonded Structures & Welding
Aircraft Drawings	Utility & Warning Systems
Ground Handling and Servicing	Landing Gear Systems
Materials and Corrosion Control	Airframe Inspection
Assembly and Rigging	Propellers and Components
Algebra, Geometry, and Trigonometry I	Professional Communications
Spring Semester	**Spring Semester**
Basic Aircraft Electricity	Lubricating Systems
Wood, Dope, Fabric, and Finishes	Ignition Systems
Sheet Metal Layout and Repair	Turbine Engine Overhaul
Reciprocating Engine Overhaul	Engine Inspection
Conceptual Physics I	Engine Electrical, Instrument, and Fire Protection Elective
Summer	**Summer**
Aircraft Environmental Systems	Powerplant Fuel Systems
Hydraulics and Pneumatic Systems	Induction Cooling and Exhaust
Aircraft Electric Systems	

Aircraft Fuel Systems Technology and Culture Elective
Personal/Interpersonal Psychology

Table 11.14 Team Projects

Year 1

<u>Course: Ground Handling and Services</u>

Team project title: Aircraft towing

Number of team members: 4

Description: Given an aircraft and aircraft towing equipment, the team will tow aircraft from the hangar to a preselected location within the areas marked for the landing gear. All the movement of aircraft will be conducted in a highly precautious and coordinated manner. Team members will have to follow standard operating procedures.

Team project title: Aircraft operation

Number of members in a team: 3

Description: Given manufacturers' operating instructions, team will locate, select, connect, and operate ground support equipment. Team will start and operate engine through normal operating range and perform shut down procedures.

<u>Course: Assembly and Rigging</u>

Team project title: Installing flight control

Number of members in a team: 4

Description: Team members will identify appropriate service manuals, tools, equipment, and forms. Team members will assign roles to remove, inspect, repair, and reinstall one flight control and make required maintenance record entries. All work performed needs to meet manufacturers' specifications. Team members will play the role of inspector, buy-back inspector, and maintenance personnel.

Team project: Installing vertical stabilizer

Number of members in team: 4

Description: Team members will identify appropriate service manuals, tools, equipment, and forms. Team members will assign roles to remove, inspect, repair, and reinstall vertical stabilizer and make required maintenance record entries. All work performed needs to meet manufacturers' specifications. Team members will play the role of inspector, buy-back inspector, and maintenance personnel.

Team project: Aircraft control rigging (different sub-systems)

Number of members in team: 3

Description: Given an aircraft with cable operated flight control system, service manuals, tools, and equipment. The team will have to coordinate work and assign roles to inspect the system for proper rigging, record the discrepancy, and make repairs, rig the flight controls, and record the work The members will play the role of a inspection and maintenance crew on a rigging check.

Table 11.14 (continued...) Team Projects

Year 2

<u>Course: Utility and Warning Systems</u>

Team project title: Position Indicating and Warning Systems

Number of members in a team: 4

Description: Given an aircraft with retractable landing gear and position indicating and warning systems, ground support equipment, and the manufacturers' maintenance and service instructions, the team will have members with assigned roles of an inspector, buy-back inspector, and maintenance personnel. The team will first perform an operational check of the landing gear, inspect components of the position indicating and warning system (inspectors), troubleshoot and repair malfunctions (maintenance crew), and ensure that the work meets standards (buy-back inspector).

Course: Landing Gear Systems

Team project title: Aircraft Jacking

Number of members in a team: 4

Description: Given an aircraft with operational retractable landing gear, manufacturers' service manuals; other information, and ground support equipment, the team will have to assign roles and coordinate work to accomplish the following: jack the aircraft, check, inspect, repair, and service the landing gear so that work is accomplished within the allowed time frame. The team will have to ensure that the operation of the systems and the manufacturers' adjustment procedures are followed precisely and that the system meets "return-to-service• standards.

Course: Airframe Inspection

Team Project: Airframe Inspection and Maintenance

Number of members in a team: 4

Description: Given an operational aircraft ground support equipment and manufacturers' service manuals, the team will have members with assigned roles of an inspector, buy-back inspector, and maintenance personnel. The inspector (first team member) will perform an annual inspection of the aircraft, record conditions at the time of inspection, and make the appropriate aircraft record entries to communicate information to other members of the team (maintenance crew consisting of 2 team members). Team members responsible for maintenance activities will conduct maintenance and have it inspected by another inspector (fourth member of the team) to ensure that the maintenance work meets standards.

Course: Turbine Engine Overhaul

Team Project: Engine Overhaul

Number of members: 4

Description: Given a turbojet or turboprop engine, manufacturers' maintenance manuals, special tools, and shop equipment, working as a team, the team will disassemble , clean, inspect, identify repairs, and reassemble both cold and hot sections of the engine within a specified time frame. All activities and practices will be performed in accordance with manufacturers' maintenance instructions.

Team Project: Engine Removal and Installation

Number of members: 4

Table 11.14 (continued...) Team Projects

Description: Given an aircraft with an operational turbojet engine, manufacturers' maintenance manuals, and engine removal and installation equipment, working as a team, the team will perform the engine removal and reinstallation procedures to meet manufacturers' standards and within the allocated time frame.

Course: Reciprocating Engine Overhaul

Team Project: Engine Overhaul

Number of members: 4

Description: Given a reciprocating engine, manufacturers' maintenance manuals, and special tools and shop equipment, working as a team, the team will disassemble , clean, inspect, identify repairs, and reassemble the engine within a specified time frame. All activities and practices will be performed in accordance with manufacturers' maintenance instructions.

Team Project: Engine Removal and Installation

Number of members: 4

Description: Given an aircraft with an operational reciprocating engine, manufacturers' maintenance manuals, and engine removal and installation equipment, working as a team, the team will perform the engine removal and reinstallation procedures to meet manufacturers' standards in the allocated time frame.