

A Human Factors Approach to Aviation Maintenance and Inspection Training: The Task Analytic Training System

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ABSTRACT

Most aviation maintenance environments rely on a form of on-the-job training which is actually a degenerating buddy system. Training is generally the responsibility of the lead mechanic who may or may not be the most knowledgeable or experienced person and who may or may not want to be involved with training. The Task Analytic Training System (TATS) provides a highly structured, performance-based model that involves full workforce participation in the design, development and implementation of the training. Through incorporation of basic human factors principles such as decision making, communication, team building, and work management, either directly or as a function of the techniques involved, the TATS process results not only in better training and procedures, but an overall improvement of attitude and morale. The theoretical background of the model is addressed by illustrating how proven training methodologies are blended with human factors principles resulting in a unique, team-driven approach to training. The paper discusses major elements of the model including needs identification, outlining targeted jobs, writing and verifying training procedures, an approval system, sequencing of training, certifying trainers, implementing, employing tracking mechanisms, evaluating, and establishing a maintenance/audit plan.

BACKGROUND AND INTRODUCTION

The Task Analytic Training System (TATS) is a training model uniquely combining proven training methodologies of job task analysis and job instruction training with human factors principles resulting in a highly disciplined, interactive approach to training. This generic model was implemented in the non-destructive testing areas of the Boeing Commercial Airplane Group to address on-the-job training. New and experienced inspectors needed an on-going comprehensive, structured training system designed to continuously improve the quality and reliability of inspections. They needed a system that would provide first-time, remedial and recurrent training. Subsequently a modified version of the same model was employed in designing and developing the Crew Resource Management (CRM) course for Boeing's instructor pilots, test pilots, and ground school instructors. The Task Analytic Training System has been incorporated as part of the Boeing Maintenance Error Management program to be implemented in Boeing factories and customer airlines.

Any type of training must take into account three factors: skill, knowledge, and attitude. In order to blend these factors, the Task Analytic Training System is composed of three interacting components: job task analysis; job instruction training; and human factors principles ([Figure 6-1, appendix](#)). These components are not new. The packaging, however, is unique. The job task analysis and job instruction training methods (which have been modified to meet the training needs of various clients) first appeared before World War II. The human performance-based approach is founded on basic human factors principles.

Skill and knowledge alone are not sufficient to ensure a well-trained and productive employee. An attitude which values work is critical to the success of any training program. Productivity relates directly to both ability and willingness to do work. Knowledgeable, skilled employees produce little when they dislike the job, have no personal goals for the work, and see limited personal reward for effort. Attitude must be designed into the training system. One of the salient features of the Task Analytic Training System is the positive effect it has on employee attitude and morale.

Another feature is the heavy reliance on people resources and the value of crew coordination. In complex systems where the work of many people combines into a single flow or outcome, or when tasks require group efforts, skills such as communication, decision making, problem solving, conflict resolution and work management may become critical elements for task completion. When activities require more than a single individual, the Task Analytic Training System incorporates "Team Task Analysis".

PROBLEMS WITH TRADITIONAL TRAINING METHODS

There are several drawbacks with traditional industrial training methods. First, the training staff normally write the program. Typically, they have either little hands-on experience or none at all. The result is that the training material has little resemblance to what actually occurs on the job.

Second, the terminology is often unfamiliar to the staff. Training, to be effective, must be in the same "language" the worker uses.

Third, and extremely important, there is generally no employee ownership of the training program because of little or no participation from the workforce. Worker participation is crucial to the success of any training program. A basic assumption of the Task Analytic Training System is that people deserve the right to know what is going on around them, especially when it influences their jobs.

A fourth problem with traditional training programs is that frequently training programs get put on the shelf and are forgotten. There is no follow-up or evaluation of the programs.

Fifth, most airline maintenance environments rely on a form of on-the-job training which is actually a degenerating buddy system. Training is generally the responsibility of the lead mechanic who may or may not be the most knowledgeable or experienced person and who may or may not want to be involved with training. The result is that-- (1) valuable details are left out of procedures, (2) mistakes are perpetuated, (3) there is a lack of consistency from one person to another, one shift to another, etc., and (4) shortcuts are developed due to lack of understanding as to why things are done the way they are.

A sixth problem is that traditional training focuses on tasks in a generic "context-free" setting. There are many local features of the work environment that contribute to the success of the training such as:

1. Task completion may be hindered by the need to "unlearn" old methods.
2. Task completion may need to accommodate frequent personnel shifts or shift changes.
3. Task completion may require the availability of information resources, equipment, etc. which are beyond the typical task description.
4. Task completion may run up against cross organizational conflicts (e.g., incompatibility of procedures, terminology).
5. Task completion may be hindered by physical aspects of the workplace (inadequate space, environmental and safety conditions).

WHAT, WHY, HOW, WHERE, WHEN

WHAT is the Task Analytic Training System?

The training system is a generic process, a performance based, hands-on approach applicable to any job and organizational style. It provides comprehensive, structured, on-the-job training. The model can be used effectively for both technical and "soft skills" training. Human factors principles such as decision making, communication, team building, and work management are either built directly into the model or are present as a function of the techniques involved. In general the process enhances mutual respect and trust, goal-directed behavior, self-esteem, and responsiveness to new ideas and contributions.

WHY was the training system developed?

1. To provide new workers with structured on-the-job training.
2. To provide recurrent and remedial training to experienced workers.
3. To establish standardized procedures.
4. To positively affect attitude and morale.
5. To provide consistency between workers.
6. To incorporate changes in materials, equipment, and processes.
7. To incorporate aspects of crew coordination into task analyses as required, supported by the relevant team skills training.

HOW was the system developed?

The first step in the development of any training program is to obtain management commitment. Management has to agree that training is important and be willing to dedicate the necessary time and resources. Otherwise, the program is already doomed to failure. The Task Analytic Training System is based on full workforce participation. Everyone is encouraged to participate in some way. During the development stage of the program, key personnel include a design team, an approval team, and a team facilitator.

The design team consists of three to five content experts (knowledgeable workers). Their primary task is to perform a job task analysis and write training modules on the identified tasks. The modules are short, step-by-step procedures required to perform specific tasks. Criteria used in selecting employees to serve on the design team are:

1. Credibility with peers, supervision, and staff.
2. Willing and able to communicate what they believe.
3. Experts on most of the job being analyzed.
4. Willing to go along with the group even if they don't completely agree.

The approval team is made up of knowledgeable workers, key supervisors, and technical experts. They review and approve all modules for accuracy and completeness, and for compatibility with current procedures and policies. In addition, they determine the administrative requirements for the implementation of any changes.

The facilitator functions as a progress expert and is present at all design team meetings to keep the team on track, help handle disagreements, and coordinate all activities. Strengthening communication links to avoid misunderstandings is a constant task for the TATS facilitator. Although not a job expert, the facilitator contributes expertise in guiding the team through the task analysis and the eight implementation steps.

WHERE can the training be applied?

This training system can be used with new operations or with those already in existence. The program can be effectively applied in areas of high turnover, or in any situation that requires workers to be retrained. A primary advantage of having a structured, comprehensive on-the-job training program is that workers are very quickly trained in new skills with minimum disruption of the day-to-day schedule.

The design team may decide to apply the system to critical elements only, or the entire job. The team has ownership of the system and directs its development to answer the needs of the work force. Critical tasks may be addressed right away, if necessary, since modules may be written in any order.

The system can exist alone as a new training program or can be easily integrated into an existing program. The design team is encouraged to use material from sources already available and not to reinvent the wheel.

WHEN can the training system be applied?

Training can begin early in the development process. It is not necessary to wait until all modules are written to begin training. The training can be remedial, recurrent or first time training. The system (or process) is on-going. Modules are written and used as needs arise -- new materials, new equipment changes in processes, etc. The flexibility of the modules, or short procedures, allows for individual training plans. Due to prior experience, everyone will not need training in all areas.

HUMAN FACTORS PRINCIPLES of the TASK ANALYTIC TRAINING SYSTEM

The Task Analytical Training System is based on human factors principles which are, in turn, based on present day social psychology, organizational and management theories. On the basis of these principles, there are five assumptions which are reflected in the training program.

The first assumption is that human behavior is goal directed. We assume that in the workplace, a person's primary goal is to make a contribution both as an individual and as a significant member of his or her work group. It is through this active contribution to the work process that individuals feel job satisfaction, and work groups sustain high morale. The achievement of these goals is the basis for building a motivated workforce in which workers are productive, responsible and cooperative. When workers are not given the chance to contribute, or when their work is undermined, an unmotivated workforce may develop in which individuals become counterproductive and less caring about their work.

The second assumption is that people resources can improve performance and the work processes. This is, in part, because people are active problem solvers, creative decision makers and holders of critical knowledge, skills and experience which can generate new ideas and solutions for problems. Furthermore, having an active role in solving problems is a hallmark of job satisfaction. People who are encouraged to be creative and active participants feel they can make a difference and have an impact on the work environment. The Task Analytic Training System uses work groups to generate solutions by having them ask questions such as, "What is the best way to do this job?"

The third assumption is that work is performed in a social context. People do not operate in isolation. Everything we do, as individuals or in groups, relates in some way to other people (e.g., members of your own work group, your work group's prior or later shift, supervisors, instructors, other related work units). Most problems cannot be solved by one person in isolation. Rather, cooperation and the contribution of the people resources around us solve problems. The study of human error has paid little attention to the fact that behavior is not solitary, In fact, the social dynamics of the work environment, including management styles have a tremendous effect on error rates.

Fourth, use is more important than possession. The skills and knowledge a person has do not count unless they are put to use. In order for TATS to succeed, workers and management must commit to an attitude that values work, worker participation, and job satisfaction over and above the possession of the skills and knowledge requirements alone.

The fifth assumption is that people and organizations produce synergy; that is, the whole is greater than the sum of its separate parts. The Task Analytic Training System is based on maximizing the benefits of using people resources. The quality and quantity of individuals' independent work is not as effective as the same work accomplished cooperatively. Similarly, crews may work independently within a larger organizational system, but their work will be more effective if their respective jobs are designed, analyzed and trained within a systems perspective.

DESCRIPTION OF THE TASK ANALYTIC TRAINING SYSTEM

The working elements of the Task Analytic Training System consist of: needs analysis, outlining targeted jobs, writing and verifying procedures (modules), an approval system, sequencing training, implementing, debugging, evaluating, and establishing a maintenance/audit plan ([Figure 6-2, appendix](#)).

The system, when in operation, will do the following:

1. Establish written, agreed-upon performance standards which are measurable and observable.
2. Train and verify that employees are working to established standards.
3. Audit, on a regular basis, to assure sustained performance and to initiate appropriate corrective action.
4. Provide a plan to continue using the system with a trained facilitator.

Much of the success of the Task Analytical Training System is due to the process itself. The eight step process guarantees employee ownership of the program. A description of the process follows:

Need Identification - Step 1

Identification of the problem as a training concern is the first step. If workers are able to do the job, but are prevented from doing so because of organizational constraints, there is not a training problem. Once the need is established and a job is identified, the facilitator discusses the training system process with the workforce. Together they evaluate the usefulness of the system in that area. The facilitator then gains their commitment to continue. During this initial phase, the teams must be established and the roles and responsibilities set up. On the basis of the needs identified, this is also a good time to begin defining the measurable objectives of the program. These may include overall performance and training goals, as well as specific performance standards associated with particular tasks.

Job Task Analysis - Step 2

In breaking the targeted job down into task segments, the design team asks the following two questions: (1) What do you need to know or be able to do to be a qualified (job title)? and (2) Can you teach and can someone learn that in one-half hour?

Answers to question 1 are written on wall charts. Question 2 results in further breakdown of the major tasks into smaller segments. Repeated use to the two questions ends when the job experts agree that the branch of the "tree" takes no more than one-half hour to teach/learn. The task breakdown continues until the tasks take no more than one-half hour to teach and learn ([Figure 6-3, appendix](#)). One-half hour segments:

1. Fit the attention span of average learners.
2. Provide manageable blocks of material for ease of instruction and learning.
3. Allow flexibility in situations where operating conditions require short periods of training away from the job.
4. May be modified as specifications change.
5. Give trainees a sense of accomplishment as they build a solid skill base.

Project Plan - Step 3

After the job breakdown is complete, the team designs a plan to keep the rest of the project on schedule. Identified tasks are ranked according to frequency, criticality, difficulty, degree of danger, etc. Some modules may need to be completed first in order to begin training on those tasks right away. Depending on the program objectives defined, the project plan may include systematic data collection in order to track specific performance and training goals. A benefit of putting the project plan together as a group is the assurance of buy-in or group ownership. People tend to support their own ideas. Upon completion of the plan, the team obtains supervisory approval. This helps strengthen management involvement and commitment.

Write The Training Modules - Step 4

Initially, two or three modules are selected in order for the team to learn the writing format. The level of complexity written into a module is critical. Too little detail means the module is unusable because of insufficient information. Too much detail results in a standard operating procedure which is cumbersome and difficult to modify. Generally, writers include enough material to serve as memory joggers for an instructor experienced doing the job. The easy-to-read-and-use format promotes workforce acceptance and increases the likelihood of the modules being used for quick task references. Each module has a cover sheet ([Figure 6-4, appendix](#)) which prepares the instructor and trainee to try out the tasks written in the modules. It is critical that the objective defined for each module be able to serve as a measurable, and standard criterion for a trainee's task performance.

During the writing phase, the team engages in various activities: meeting other teams in different areas; discussion, forms and formats; providing periodic reviews to management; and verifying modules on-site. Each module is verified on-site at least twice: (1) by a trainee with an instructor, and (2) by at least one member of the approval team. Also, during the writing phase, the team conducts workforce overviews to review modules with workers not on the design or approval teams. All members of the workforce are encouraged to contribute.

Training Implementation Plan - Step 5

Near the completion of module writing, the team, together with supervision, prepares a preliminary implementation plan. They conduct workforce evaluations to determine: who needs training in which modules and by what dates, who will do the training, and how results of training will be measured. A person is assigned to prepare individual plans, taking into consideration prior skills and knowledge brought to the job by trainees and a logical sequence for presenting the modules.

Tryout, Evaluate, and Modify - Step

6

Important with the first, and subsequent use(s) of the training modules is the attention paid to the "fitness for use" of the documents. This term refers to how closely the training materials meet the needs of the workers. The Task Analytic Training System encourages any additions, deletions, or corrections ([Figure 6-5, appendix](#)). Anyone may suggest changes, including the trainees. This is also the time to make sure that the performance standards are adequate and that both instructors and trainees share a clear understanding of what counts as "successful task completion".

Set-Up Maintenance Plan And Audit - Step 7

Teams distribute manuals in work centers for use as resource guides. All personnel, from line managers to operating staff, have some ownership of the system. To keep the manuals up-to-date, each manual includes copies of change sheets. Change sheets are simple forms for identifying modules and the changes required. One member of the workforce is assigned to serve as an administrative coordinator to handle the records, forms, manual updates, etc.

The facilitator schedules annual audits to assess the status of the Task Analytic Training System in the particular work area. The audit is a checklist evaluation of critical areas of the process. During this evaluation, the facilitator looks for: signs of program obsolescence, identification of new training needs, opportunities to streamline the process to make it more cost-effective, and organizational changes that impact training.

Start Training - Step 8

The Task Analytic Training System incorporates traditional job instruction training (JIT) techniques. First, an instructor demonstrates the skills to the trainee. Next, the instructor coaches the trainee through the elements of the task, while the trainee performs them. Third, the trainee does the task without coaching. Both instructor and trainee discuss results afterwards. Trainees are then encouraged to practice the new skills until they feel comfortable with them. At the conclusion of training, evaluation questionnaires are given to both trainees and instructors. The questions are open-ended to solicit as much spontaneous information about the training and content, as well as training implementation, as possible.

SUMMARY

The Task Analytic Training System is uniquely based on three interacting components: (1) job task analysis, (2) job instruction training, and (3) human factors principles. All three components interact to tie in skill, knowledge, and attitude. Attitude is the key and must be designed into the program. The training system is a generic process applicable to any job. It provides a highly structured and disciplined on-the-job training program that is on-going. By the nature of its design, it addresses remedial, recurrent and first time training. When successful task completion involves more than one person or more than one team, the system is adapted to incorporate team task analysis into training modules. The Task Analytic Training System produces a trained workforce whose performance can be observed and measured against carefully identified standards. In addition, the system can provide overall performance and training enhancements that can be tracked as an integral part of the initial project plan and the continuing maintenance and audit plans ([Figure 6-6, appendix](#)).

The critical role of full worker participation in the training program development is key to the success of the program. It is a system that develops the people resources of the company by encouraging the contribution of all, and stressing cooperation with others as the solution to problems.

Currently, the Task Analytic Training System is evaluated subjectively by the recipients of the program. Future research may yield data to support the system's claims of *higher* output in terms of productivity and quality.

APPENDIX



Figure 6-1 Three Components of Task Analytic Training System



Figure 6-2 The Working Elements of TATS



Figure 6-3 The Job Task Analysis Breakdown



Figure 6-4 Training Module Cover Sheet



Figure 6-5 Module Development Process



Figure 6-6 Summary