IMPROVING AIR TRAFFIC CONTROLLER TRAINING

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Abstract

In recent years, the nation's air transportation system has undergone a series of profound changes. One aspect of the system which has received some scrutiny is the role of the air traffic controllers and the need to increase the staffing of control facilities. This article examines the field of air traffic control and the characteristics necessary to work in the field. Then, using sound educational and training theory, suggests some ways that air traffic controller training may be improved.

Over the past decade, the U.S. air traffic control system has undergone a series of unprecedented challenges. Deregulation freed the airlines to expand, creating continually increasing demand. The economic recovery of the mid- and late-1980's combined with low fares to bring thousands more travellers to the ticket counter. In the midst of deregulation, the 1981 PATCO strike reduced the staffing of the system overnight. Today, eight years after the strike, many major air traffic control facilities remain understaffed (Aviation Safety Commission, 21; Mead, 1989, 2-5). In addition, the National Airspace System (NAS) Plan is introducing a new generation of technology and automation which will impose further demands on the system and its personnel (Proctor; Flight Plan for Training, 1-5).

The public perception is that the air traffic system is straining. This perception is exacerbated by reports that near collisions are occurring more frequently and that the margin of safety is growing uncomfortably thin. This perception is not totally accurate. The accident rates for major and national air carriers and for regional carriers continue to decline. The number of reported near mid-air collisions and systems errors (loss of minimum separation between two aircraft under air traffic control) increased sharply between 1983 and 1987. But those increases may be the result of more accurate detection and reporting of errors rather than an actual increased risk (Aviation Safety Commission, 15-17). Nevertheless, one cannot deny that for the next decades the air traffic system faces an environment of change and increasing complexity.

Various groups have offered solutions that range from structural changes, to moving current projects along more quickly, to hiring (or rehiring) more controllers. But no one solution offers a panacea. Air traffic control must be approached as a system of interdependent subsystems, each of which faces challenges and problems which will require different, but interrelated, solutions.

While a total solution must address all issues, increasing staffing levels in air traffic control facilities is necessarily an integral part of any solution. Several major facilities are seriously understaffed and the current inflow of new controllers is barely keeping up with the attrition caused by retirements. In recent testimony before the House Subcommittee on Investigations and Oversight, Kenneth M. Mead (1987) of the Government Accounting Office stated that FY 1987 attrition was nine percent higher than trainee hiring at terminals and four percent higher at centers. But increasing staffing levels is not merely a question of hiring more controllers. Controllers must go through an extensive training program during which they learn the complex skills necessary to their job. This is where a major part of the staffing problem lies--the training program as it now exists is insufficient to meet the needs of the system. Several factors contribute to this insufficiency. (For a more detailed discussion of the ATC training issues cited below, see HumRRO 1988.)

First, all controllers must pass through the Federal Aviation Administration Academy at the Aeronautical Center in Oklahoma City. Thus, the limitations of that facility are a major constraint on the number of controllers in the training pipeline. The number of trainees that this single facility can handle becomes the upper limit on the number of new controllers available to the system.

Second, the number of controllers in the pipeline is further reduced by inefficiencies in the Academy program. The Academy is, in fact, not a training program, but rather a screening program (HumRRO, 12; Flight Plan for Training, 3-5). This approach results in an inordinately high attrition rate during training--

averaging more than 41 percent from 1981-1987. Thus, the capacity of the Academy is effectively reduced by half (Mead, 1989, 3; HumRRO, 1984).

Third, since the Academy program is used to screen candidates, the task of actually training new controllers falls to the field facilities (Flight Plan for Training, 5). But understaffing leaves them unprepared to handle the training load. Trainees who survive the Academy screen often face bottlenecks in the field facilities which further slow their progress through the pipeline. Many facilities have a minimal permanent training staff, and smaller facilities have no training staff at all. Trainees are therefore frequently required to guide themselves through training manuals and computer-based instruction without benefits of an instructor (HumRRO, 12-20).

Most facilities lack simulation capability so training must be done on operational positions with live traffic. This precludes the development of incremental training scenarios designed along sound educational principles to facilitate the development of high performance skills. When simulators are available in the field, they are embedded in the facility's operational computers and are therefore unavailable much of the time. Furthermore, they usually have only a few training positions available. Thus, they become additional bottlenecks in the flow of trainees (HumRRO, 12-20).

The training program is not only inefficient, but it is also inadequate. The training provided is not the most appropriate for the types of skills to be developed. The design of the training program must acknowledge certain facts about ATC skills and training strategy that seem to be ignored or, at best, only unconsciously recognized in the present system. Much of what is done in the training program seems less related to the nature of the skills required and the type of training needed to learn them than to the legal defensibility of the program (HumRRO, 24).

A major step toward a solution to the problems of the air traffic control system, then, would be to redesign the training system. First, the system can be made more efficient by providing alternatives to the FAA Academy. Second, more training can be accomplished prior to sending trainees to the field facilities. Third, the training can be designed with an understanding of the types of training necessary to develop the kinds of skills a controller needs. By so doing, training will be more appropriate, trainees will progress more rapidly and attain a higher skill level before moving to the field facilities, and the wasteful attrition rates of the past will be significantly reduced.

A training program must be designed around the knowledge and skills it is meant to convey. The selection of instructional strategies, technologies, and approaches will hinge upon what is to be taught and the level of learning to be attained. A hierarchy of learning goals is often used to determine an appropriate educational approach. One such hierarchy is:

1. Knowledge -- recall of information;
2. Comprehension -- understanding how and why;
3. Application -- performing;
4. Analysis -- investigation;
5. Synthesis -- creating new information;
6. Evaluation -- determining the value or accuracy of the information;
7. Knowledge Integration -- performing tasks skillfully.

* (Adapted from Brophy and Good as cited in HumRRO)

Determining the appropriate level of learning for an instructional program depends on the tasks for which the student is being trained. The initial step in this determination is a job task analysis which makes the functions of the job and the requisite talents explicit.

Functions of an Air Traffic Controller

An air traffic controller is very much an information processor. The core skills of ATC can be viewed as falling into three main functions: information acquisition, information processing, and output (Figure 1).

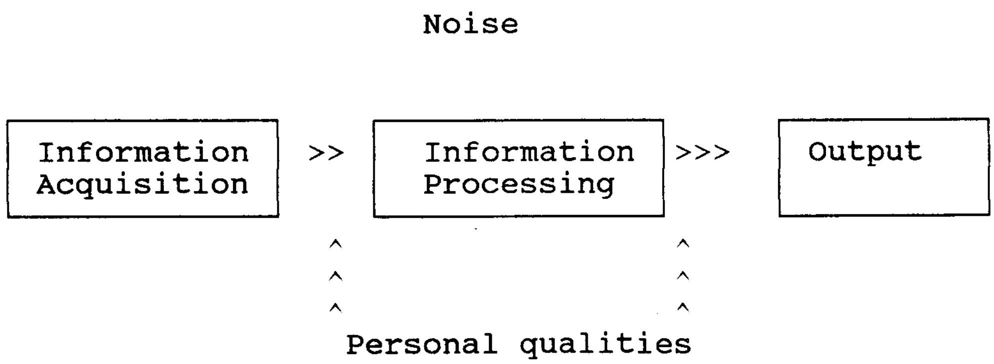
The information acquisition function takes place in a dynamic environment which requires the controller to divide and switch attention among multiple sources--pilot transmission, the radar scope, communications with adjacent controllers, weather reports, etc. The controller must constantly adjust to this dynamic environment and new information while checking and updating information continually. He must absorb new information while making decisions.

Decision-making is a part of the second function--information processing. The controller must have a good sense of spatial patterns and time in order to construct a three-dimensional picture of the airspace and the traffic situation. He must apply syllogistic reasoning to project forward from the current situation and make further adjustments according to these projections.

The controller must be able to absorb and process information in order to make crucial decisions quickly and then execute those decisions and/or communicate them to others. This is the output function--putting decisions into action by communicating with pilots and/or other controllers.

Furthermore, the controller must perform these functions in a "noisy" environment. The context in which the controller operates is replete with distractions, fluctuations between routine and non-routine tasks, short cycle repetition, sporadic time pressure, and demand level variation (Page, 1985; Stein, 1984; Zaitseva & Tokarev, 1986).

Figure 1.



Core Skills

Information acquisition
- Divide and switch attention
- Multiple sources
- Absorb new information while making decisions
- Adjust constantly to dynamic situation/new information
- Checking and updating information

Information processing
- Project forward
- Form and maintain three-dimensional picture of airspace
- Syllogistic reasoning
- Spatial patterns
- Time sense

Output
- Develop crucial decisions quickly
- Execute decisions
- Communicate decisions

Noise – Context

Sporadic time pressure and demand level
Distractions
Fluctuations between routine/non-routine
Short cycle repetition

Personal qualities

Syllogistic reasoning ability
Short term recall
Decisiveness and confidence
Conscientiousness/responsibility
Self-control
Ability to work within a team
Ability and willingness to work to set standards.

Acquiring Complex Skills

The difficult tasks for a controller, then, are planning rather than performance tasks, and they require cognitive rather than psychomotor skills. In order to operate in the noisy environment of ATC, these complex skills must become automatic. Researchers have identified methods to accomplish this.

Human information processing occurs in two fundamental ways. Controlled processing operates in short-term or active memory. It is a relatively slow, serial process which requires little training to develop. It can be considered conscious processing such as we use in decision-making and problem-solving. It is limited by the number of items one can hold in active memory at one time--usually about seven. In order to develop a complex skill, these limits must be overcome (Schneider, undated, 2-5; Schneider and Regian, 3-4; HumRRO, 1-2).

The second type of human information processing is automatic processing resident in long-term memory. Long-term memory holds factual knowledge (which is easily stated and passed on) and procedural knowledge (which is not easily explained without demonstration). Procedural knowledge is automatic processing--it is rapid parallel processing requiring little effort, but it does require extensive and consistent training to develop (Schneider, undated, 3-5; Schneider and Regian, 3-4; HumRRO, 2-3).

Air traffic control requires both types of information processing, but automatic processing of procedural knowledge is predominant in the controller's dynamic world. Building these automatic skills requires extensive training following a logical sequence of skill acquisition. The skill must first be decomposed into component tasks which build upon preceding components. Then the student is trained on each component successively. Upon mastering one component, the student moves on to the next, which requires continuing use of the preceding skill while learning the new. This process is called part-task training (Schneider, undated 2-5).

Automatic processing of each skill is developed through consistent developmental steps. First, the procedure is learned as a series of sequential steps, each requiring attention and each taking up the limited space in active memory. This is a level of factual knowledge. With practice, the procedure develops into a coherent unit, gradually taking up less active memory space until it becomes procedural knowledge. At this point, the student can move to the next part-task in the training (Schneider, undated, 4-6; Schneider and Regian, 3-5).

The success of this process depends on the application of several instructional techniques. One technique is to group or "chunk" meaningful information. This helps to overcome the limits of short-term memory by building a smaller number of larger bits of information to be processed. Thus, a telephone number is easier to recall than seven random digits because it is a meaningful chunk of information (HumRRO, 2).

A second technique is to tie procedures to a discernible event. Activities which are randomized cannot be made automatic. This indicates the importance of learning things in context and tied to a job related outcome (HumRRO, 3).

An Educational Approach for ATC Training

These principles of human learning lead to an approach to training complex tasks such as air traffic control:

1. Training must be functional and in a job-related context;
2. Training of complex tasks must be broken down into smaller sequences of procedures;
3. These smaller sequences must be learned through large amounts of practice in order to become automatic; and
4. Training must be experiential and performance-related to the greatest extent possible.

This amounts to a part-task training approach which makes extensive use of simulation and automation to supplement rather than replace the instructor. The instructor is necessary to guide student progress, answer questions that arise, demonstrate alternative techniques and procedures, and provide subjective feedback to enhance student progress.

Because of the complex, dynamic nature of the tasks, the lower levels of learning--knowledge, comprehension, and application--are adequate only for initial stages of training. The performance of ATC functions requires the higher levels--analysis of the situation, synthesis of solutions to the situation, and evaluation of the implementation of the solutions on a continuing, real-time basis.

Under the present training program, application is the highest level reached by most training at the FAA Academy. To some extent, analysis and synthesis are acquired during on-the-job phases of training in the field facilities. Evaluation skills are largely developed through experience, often after the end of formal training. The rather vague concept of "technique" frequently referred to by controllers is perhaps related to the development to evaluative skills.

A well-designed training program following the principles outlined above can be expected to develop more of the higher levels of learning in the training environment prior to the trainee proceeding to the field. A program which utilizes appropriate technology in the way of simulators and interactive training devices can facilitate the development of analytical and synthesis skills. Also, because the development of such a training program will of necessity require that much of the procedural knowledge now implicit in the training be explicated, the process of learning to the evaluative level may also be accelerated. The result will be a controller who is both better trained and at a higher level of learning than is currently possible.

References

Aviation Safety Commission. (1988, April). Report to the President (Two volumes).

Brophy, J., & Good, T. L. (1986). Teacher behavior and student achievement. In M. C. Wittrock (Ed.), Handbook of research on teaching (3rd ed., pp. 328-375). New York: MacMillan Publishing Company. (As quoted in HumRRO)

Federal Aviation Administration. (1989, January). Flight plan for training: FAA training initiatives management plan. FAA Office of Training and Higher Education.

Human Resources Research Organization International, Inc. (HumRRO). (1988, January 28). ATC training analysis study: Design of the next generation ATC training system (Phase I Interim Report).

Mead, K. M. (1987, July). FAA air traffic controller staffing and related issues. Testimony to Subcommittee on Investigations of the House Committee on Post Office and Civil Service, UDAGO.

Mead, K. M. (1989, May). Serious problems continue to trouble the air traffic control work force. Testimony to Subcommittee on Investigations and Oversight, Committee on Public Works and Transportation, House of Representatives.

Page, J. E. (1985, October). Selecting people as air traffic controllers. Presented at CONVEX 85, Guild of ATC Officers, Bournemouth, UK.

Proctor, P. (1988, August 15). FAA academy prepares for advanced ATC systems. Aviation Week and Space Technology, pp. 36-37.

Schneider, W. (Undated Paper). Perceptual training for air intercept control tasks. University of Pittsburgh Learning Research and Development Plan.

Schneider, W., & Regian, W. (1988). Developing automatic component skills for air intercept controllers (Report No. N00014-86-K-0671). Office of Naval Research.

Stein, E. S. (1984). Controller workload: Past - present - future. 29th Annual ATCA Fall Conference Proceedings.

University of Pittsburgh. (1989, January 11-13). The future of the civil aviation system. Recommendations from a symposium of national aviation leaders.

Zaitseva, E. N., & Tokarev, V. F. (1985, September). System developed for psychological selection of air traffic controllers. The Controller.