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Networked Simulation System For Air Traffic Control Training

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I. Introduction

At the present time most training for air traffic controllers is still on the job training. This is one of the few occupations left where this is the case. Let us try to understand why this is so and what is happening now in order to change that.

Many years ago most professions trained people mainly by having the student essentially "lean over the shoulder" of the great masters and then after a while the student started to gain increasing proficiency. Apprenticeships were the rule rather than the exception in fields ranging from sculpture to law. However, this trend is turning as more efficient and effective methods of training are discovered. Sculpture students now study materials and techniques of a wide variety of artists from a wide variety of cultures and historical periods. Though not every student becomes a professional, students cannot blame their failure on the personality or the lack of teaching ability in one overseer. Though individual schools differ, law students now study the same type and volume of material; an objective examination determines their fitness of the field.

In the field of pilot training or space exploration an enormous amount of the training is now done with the use of highly realistic simulators. Cockpit simulation offers an objective method of testing. This paper will describe a similar objective training atmosphere for air traffic controllers. The training system described is not only able to provide an objective simulation for testing; but also is able to provide uniform instruction.

The three authors of this paper have been involved with the installation of such a system at National University in San Diego. A set of six air traffic control simulators are networked together along with six pseudo pilot stations and one instructor station. The system will achieve the look and feel of a tracon or enroute center while providing objective training and testing of air traffic controllers.

We will describe a simulation capable of the ARTSII, ARTSIII, TPX-42, or any other radar display. The system is called ATCoach*, which provides a fast and efficient method of developing graduated exercises to keep increasing the proficiency of the trainee. Four criteria were used in designing the system: cost, performance, reliability, and growth potential. Some of these ideas are discussed in a previous paper by Gerald S. Ratzer entitled "Low Cost, High Performance ATC Simulation Available" (Ratzer, 1989).

II. Traditional Air Traffic Simulation vs ATCoach*

For a typical example of traditional air traffic control simulation, we choose the ARTS IIIA Enhanced Target Generator (ETG). The advantages of ATCoach over the ETG include independence of normal facility operation, greater accessibility, ease of scenario development, and availability of hardware.

The ETG shares tracks from the ARTS IIIA operational program central track stores (CTS). Many facilities do not have the track capacity to run an entire training problem during busy periods, and many large facilities are continually busy. Moreover, the ETG is an on-call utility program that shares memory addresses with other utility programs, including diagnostic programs. An equipment malfunction requiring the use of any diagnostic program would preclude the use of the ETG while the diagnostic is running. Additionally, any ARTS IIIA on-call program requires the ARTS IIIA to be completely operational, i.e., full-up processors and memory modules of level zero. If for any reason, the system is reduced, even to level one, then on-call programs, including ETG, are inhibited. In contrast, the use of ATCoach does not affect normal facility operations.

Often a Full Performance Level (FPL) controller or supervisor enjoys sharpening his/her skills with exceptionally high level (110%) scenarios. Yet the ETG offers no easy way to enable such supplemental training. The presence of an automation or training specialist is required for every ETG exercise. In contrast, an FPL or trainee can run ATCoach with a friend as a pseudo-pilot, or with no assistance at all.

Often, creating a training exercise, or scenario, on the ETG may take days or even weeks. One often needs as many as three eighty-column card entries for each target generated. The cards must then be written onto a magnetic tape for testing, and finally written onto the operational disk for regular use. The testing generally uncovers errors which require another complex utility program to correct (and necessitating an ARTS processor and two memory modules which are, as previously mentioned, scarce resources). Producing an ATCoach scenario is so relatively simple and fast that it can be used not only for training, but also for more temporary uses such as testing proposed new procedural changes, video map changes, etc.

III. ATCoach

The ATCoach system combines a highly realistic simulation with an

*ATCoach is a registered trademark.

expert system in order to provide an ideal teaching environment. An expert system is a system which (Weiss and Kulikowski, 1984):

1. handles real-world, complex problems requiring an expert's interpretation
2. solves these problems using a computer model of expert human reasoning, reaching the same conclusions that the human expert would reach if faced with a comparable problem
3. includes a knowledge base of relations and rules which link evidence to conclusions

The human experts which ATCoach seeks to imitate are air traffic control instructors. The way in which it imitates the instructor is to point out procedural and technique errors, and to reinforce techniques which produce positive results. The ATCoach expert is event-driven. It constantly monitors the scenario and instantly responds to situations. It allows a student to practice and learn independently.

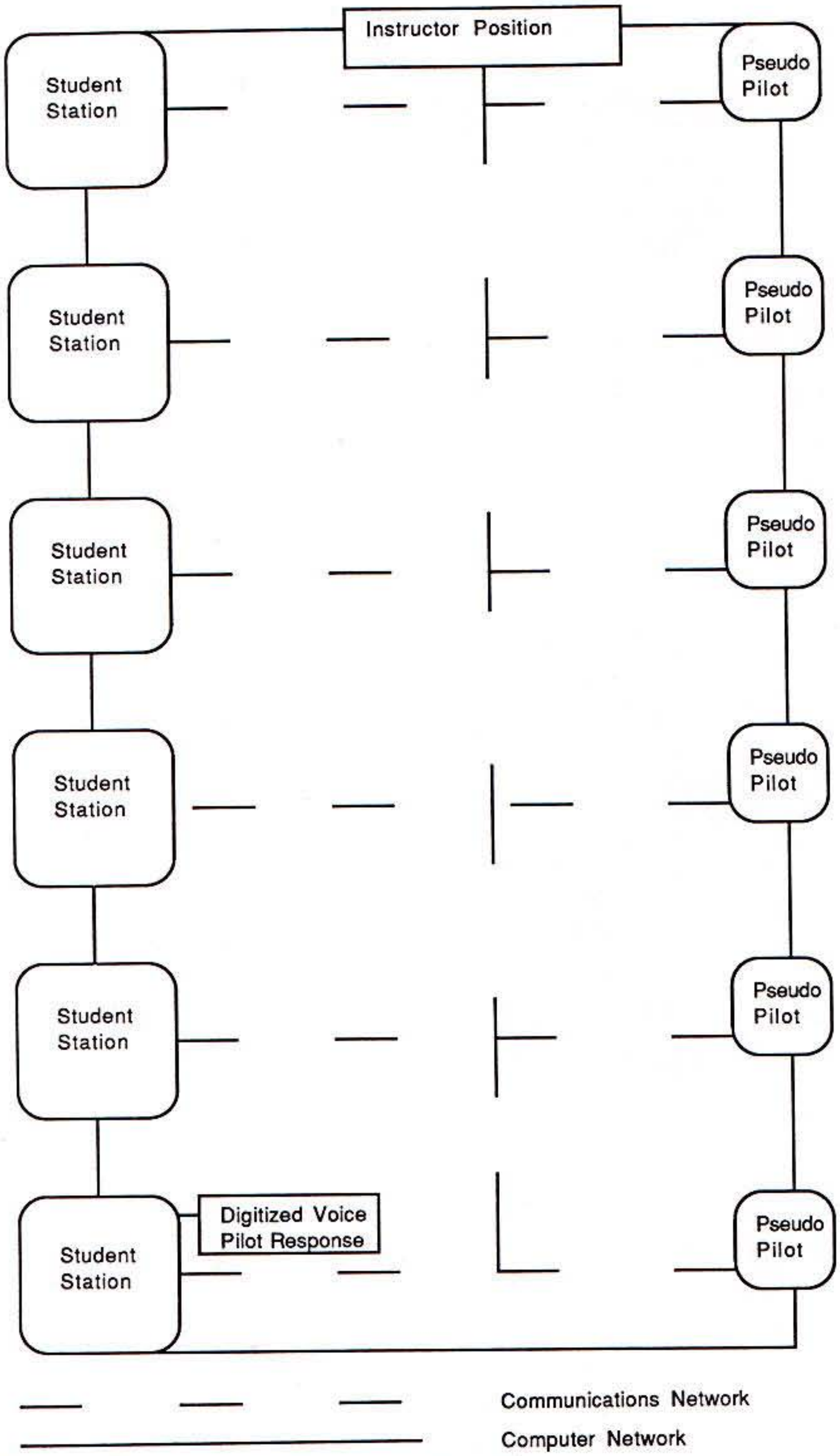


Figure 1. National University Simulation Configuration

Almost anyone can memorize the rules in the FAA's 7110.65. However, an air traffic controller is constantly improving technique. As Herb Armstrong observed (Armstrong, 1987):

> Setting up and operating a radar console or using a microphone are easy functions. Deciding which of ten fast moving aircraft should be first for an ILS approach can be extremely difficult. This is a high performance skill, requiring literally hundreds of hours of training.

Armstrong suggests that the skills of air traffic control be broken down into component tasks, such as course recognition, conflict recognition, and course interceptions. Neither ETG or on the job training provide the number of hours necessary to successfully develop isolated skills before they must be combined and put into practice. ATCoach allows a student to practice isolated skills while comfortably unsupervised.

For computer gurus, the ATCoach system is a BSD4.2 Unix based, X-Window application written in C. It runs on an ethernet network to allow multiple student stations to hand-off from one controller to another. Pseudo-pilot stations are X11-smart terminals also running on ethernet, so pseudo-pilots may monitor the aircraft of any student on the network.

IV. The National University System

National University is an accredited university which has schedules, locations and degree programs designed to fit into a working adult's schedule. At National University, students take one course per month throughout the year, attending classes two evenings per week. The faculty at NU is composed of highly qualified instructors who are professional cur-

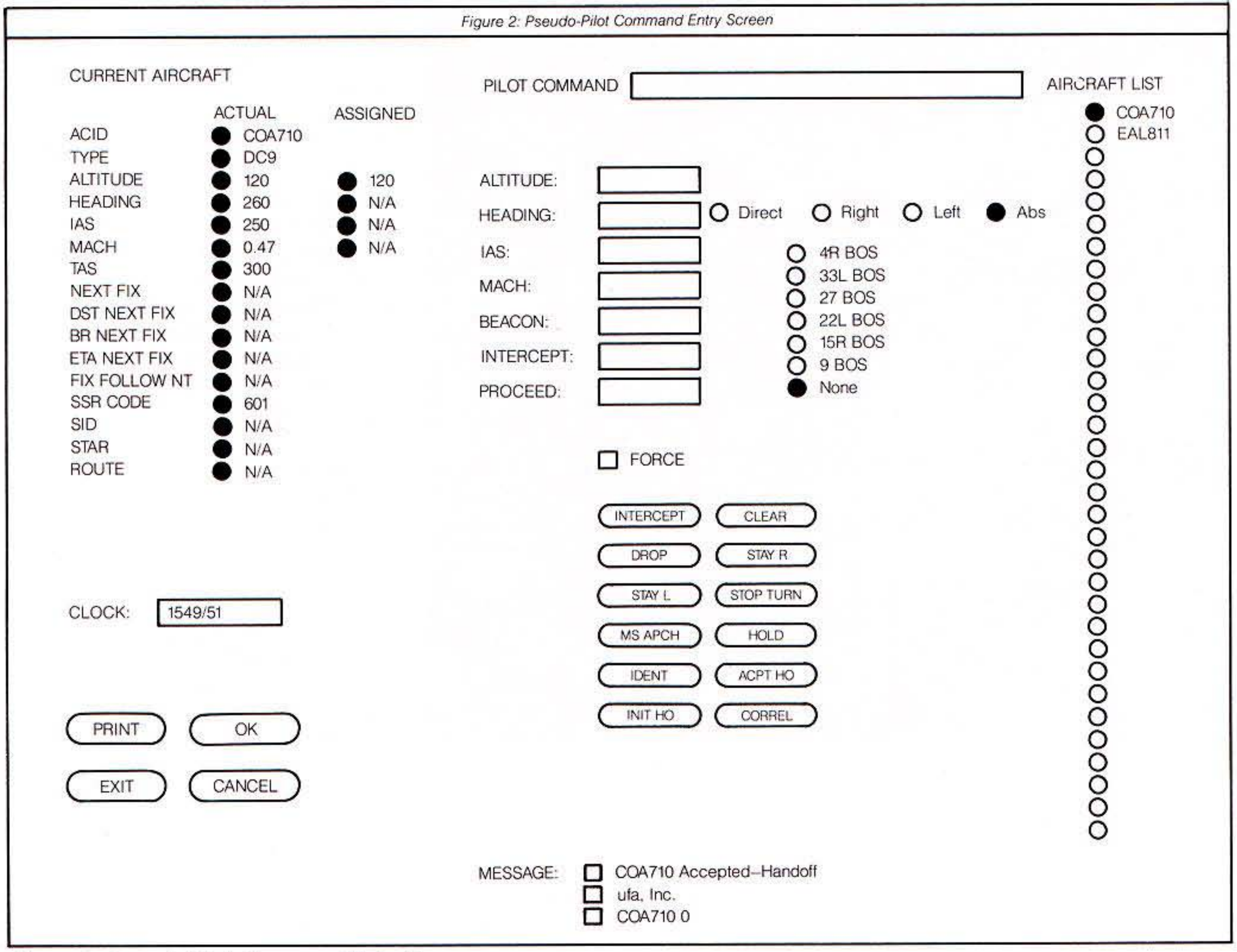


Figure 2. Pseudo-Pilot Command Entry Screen

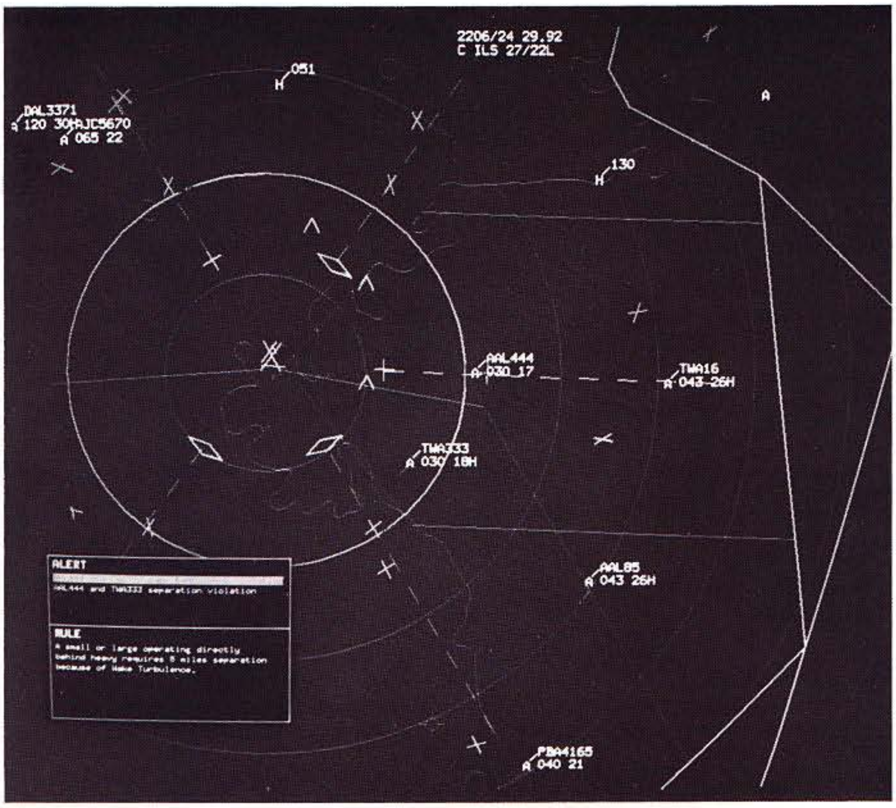
rently practicing in their fields. This enables them to keep abreast of the latest changes and innovations in their area of expertise and brings real-life work experiences into the classroom.

An example of the relevant curricula at National University is the Airway Science degree program with emphasis on Airway Science Management, Aircraft Systems Management, Airway Electronics Systems, Airway Computer Science and Aviation Maintenance Management. Students who graduate from the Airway science program have a head start as they enter the FAA Academy or airline training programs.

National University School of Aerospace Studies is the only institution of higher learning in the Southwestern United States to offer all five of the Airway Science degree programs which are recognized by the FAA. National University received an FAA grant to support the Airway Science Program in the School of Aerospace Studies, with the intent of developing a cadre of qualified college graduates well-suited to the aerospace occupations necessary to support the nation's National Airspace Systems Plan.

Initial planning to provide state-of-the-art Air Traffic Control Education included the use of computer assisted simulation. Detailed, comprehensive requests for bids were prepared based on inputs from many sources including active duty air specialist, computer science engineers, educators and financial advisors. UFA, Inc. of Newton, Massachusetts was selected as the winning bidder to design, develop, install and maintain the Air Traffic Control Simulator System (ATCSS) at N.U.'s main campus in Mission Valley, San Diego. The system was installed in July, 1989.

At National University this summer, there has been installed a six student station system which includes six pseudo pilots and one instructor station (see Figure 1). The student positions are high speed workstations (Apollo 3000's and 3500s) with 23″ green Moniterm displays in cabinet consoles. The pseudo pilots are Visual Technology XDS640 terminals. The limiting factor in such a network has traditionally been the number of aircraft one pseudo-pilot can handle. The use of X-Windows in both the simulation and the pseudo-pilot station allows a pseudo-pilot to switch aircraft characteristic displays in microseconds. It allows him/her to enter changes with a mouse, thus cutting down the number of keystrokes re-



Simulator automatically detects and displays (in box) violation of ATC separation standards.

quired per entry. It also allows for future expansion simply by adding more stations to the network. The graphics pseudo-pilot screen is shown in figure 2.

The number of aircraft modelled is virtually unlimited. Modeled characteristics include climb rates, descent rates, cruise speed, stall speed, ceilings, etc. for each aircraft. The number of aircraft per scenario is also virtually unlimited.

Standard procedures such as SIDS, STARS, and holding patterns are all accurately simulated. These are user-defined site variables along with navigational aids such as ILS approaches, markers, and beacons. Other user-defined site variables include MSAW digital terrain maps and intersection display symbols.

Scenarios can be easily built using a tool called scenario builder. This flexible menu allows an instructor to choose how many aircraft in an exercise, how long it will be, what percentage will be jets or props, what percentage will come from certain headings, etc. The variables not assigned percentages are generated randomly. This allows an instructor to build practice scenarios in seconds. The scenario builder also allows an instructor to specify exact information for each aircraft. Live data could be used as a practice scenario.

Since air traffic control is at least 50% communication, the National University system will simulate a control environment in that respect also. For example, headsets with push to talk communication are used by each of the students. Each of the pilots then responds just as if the student were listening to a real pilot. The instructor will be able to interrupt or just listen on any channel.

An additional component of the National University system is digitized voice pilot response. A student can work by himself and have the automatic pilot response take the place of a live pseudo-pilot. The digitized pilot response may even be used in conjunction with a live pseudo-pilot, relieving him/her of the responsibility of answering every routine instruction. The digitized voice system is a live human voice recorded digitally as opposed to synthesized computer voice.

Curriculum has been developed to exploit the capabilities for simulation in ATC training. ATCoach scenarios are being developed to provide component (isolated) skills training. The difficulty of the scenarios gradually progresses towards technique training. The isolated skills are then utilized in more complex scenarios. These exercises enable the student to develop skill levels leading to a better understanding of complex air traffic control problems.

This "component training" will start with learning to direct a single aircraft target through a route of flight very similar to a "road race maze". As the student becomes proficient in this skill, additional stages of instruction will be introduced. The number and types of aircraft will be increased and landing and takeoff clearances with departures and arrivals will be introduced. Students successful in these early stages will be afforded the opportunity to be exposed to altitude and heading conflicts complicated with "pop-up" traffic.

The computerized control simulator curriculum will provide the student with the opportunity to experience the excitement and challenges of the modern radar air traffic control environment. Beginning with a detailed introduction to the complex safety regulations of the Federal Aviation Administration, training will progress from basic computer games into the advanced and difficult radar approach control scenarios. Building upon fundamental skills developed by directing computerized aircraft targets during the game playing period, the student will receive individualized training based on the complex San Diego radar approach control area and other site specific areas of interest.

In addition, each beginning student will learn to act as a "pseudo pilot" and respond to controller instructions by turning, climbing, and descending the computerized aircraft target as directed via an intercom communication system with proper and concise verbal phrasesology. This is one of the series of training stages involving step-by-step procedures, individualized instruction, and review of recorded control sessions. Computerized simulation and playback of scenarios allows each student to become skilled at each of the many varied techniques of the experienced radar controller prior to advancing in training. As the individual skills are practiced and learned the student will begin to perform as a sector controller, not only responsible for all aircraft movement within a designated geographical area but also learning to transfer and accept control of aircraft to and from other student controllers. Students will gain not only an insight into the actual physical and mental requirements of radar approach control, but should be capable of measuring their own potential in the field of air traffic control.

Students will be introduced to computer-simulation during their first class in Air Traffic Control. Students selecting a career path to professional air traffic controller will be required to participate in a second class in air traffic control in which greater class time will be required on the ATCoach simulator. Student evaluations will be conducted to measure levels of understanding and skills. The evaluations will dictate the amount of additional computer time required. The training flexibility provided by ATCoach will be invaluable in that the individual may improve skill levels during off-time hours. The incorporation of the simulator in the Airway Science Educational program will greatly increase the students comprehension levels of ATC complexities. Knowledge transfer into the "real world" of air traffic control by the use of realistic simulation will reduce the time for an air traffic controller to become full performance level qualified.

The FAA has plans to spend $15 billion by the end of the century to modernize the air traffic control system. This ambitious, challenging and long-needed modernization plan requires that individuals be trained and educated to flourish in this highly technical environment—men and women who can think, plan, and organize an approach to air traffic control. The worry-free environment of the air traffic control simulator allows a person to thus analyze the air traffic control environment.

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Appendix:

Partial Listing of Software Specifications Met by ATCoach™

ATCoach™ can present both complex and simple exercises involving different numbers of aircraft simultaneously. An ATCoach™ exercise may be as simple as one slow-moving aircraft following a straight path or as complex as a virtually unlimited number of aircraft, each on a different, constantly changing flight plan. These exercises may be done simultaneously in different sectors of the same scenario, or in two different, simultaneously running scenarios.

The ATCoach™ display can be off-centered at any time during a scenario with a two character keyboard entry and a mouse click on the new screen center.

Exercise preparation may be performed standalone by a single user or by as many users as the ATCoach™ network allows. A written scenario is easily understood and adapted by a user other than the creator of the scenario. Scenarios may be tailored to a specific topic for instruction. They may utilize flight plans defined in the site adaptation file without redefinition. The same scenario may be run in standalone or network mode, depending on the number of students in the exercise.

ATCoach™ is capable of representing aircraft with full data blocks, limited data blocks, or no data blocks. The data block information is updated with the position of the aircraft. It is included on the pseudo-pilot screen along with other information necessary for tracking purposes.

Information displayed for radar targets includes minimum safe altitude warning (MSAW), conflict alert, aircraft identification information, heavy jet indication, ground speed in knots, and mode C altitude information. In addition, a 3 character scratch pad may be time-shared in the second line of the full data block. Beacon codes are a display option for the controller. Also included are the situation identifiers EMR, RD, and HJ.

ATCoach™ has the ability to prepare exercise maps by drawing them with a mouse or trackball directly onto the screen. It is also capable of interface with a map digitizer.

ATCoach™ is completely site adaptable. It is capable of simulating any airspace in the world.

Any ATCoach™ scenario may be frozen and restarted with two-character keyboard entries from either the pseudo-pilot or student station. Any scenario may be played back through a menu selection.

An instructor may freeze an individual aircraft at any point in the scenario by forcing its velocity to zero, and may restart it by instantly resuming the previous velocity. This action will not affect any other aircraft in the scenario.

ATCoach™ scenarios may be vocally recorded for simultaneous replay.

ATCoach™ is capable of data-sharing with the FAA flow-control system because they both use Apollo computer file management. However, this interface is not currently legal. ATCoach™ can simulate real-time data collected from other sources and entered into the ATCoach™ system.

All ATCoach™ configurations include a tracker/roller ball which is used for handoff functions, data tag modifications, target track acquisitions, display changes, and other peripheral changes.

The ATCoach™ pseudo-pilot station monitors the following aircraft numeric data:
altitude, speed, heading, ias, tas, mach, next fix, bearing next fix, distance next fix, rta next fix, eta next fix, fix following next, beacon code, SID, STAR, route

The pseudo-pilot station is capable of the following operations:

a. input transponders
b. input ident features
c. change altitude and speed simultaneously with a single keystroke
d. proceed RNAV by any route
e. change headings
f. change altitude and heading simultaneously with a single keystroke
g. issue departure releases
h. simulate no-gyro aircraft
i. freeze entire scenario or individual aircraft
j. delete aircraft
k. create aircraft
l. change scope scale
m. enter aircraft in holding pattern
n. turn on or off conflict alert of random aircraft
o. handoff aircraft from one airspace to another
p. clear aircraft in holding to final, descent, and land
q. modify target tag angles, and elongate leader lines

The student station is capable of enacting any pseudo-pilot command, and in addition, draw vector lines to predict future aircraft position or model airspace.

ATCoach™ has auto-acquire capabilities which enables it to automatically acquire data tags under specified air parameters.

Future addition of voice recognition may be accomplished through an additional piece of hardware which communicates to the current configuration Apollo hardware.

Color capability and flexible programming techniques render ATCoach™ capable of an upgrade to the advanced automation system.