Chapter 3
System for Training of Aviation Regulations

Terry Chandler, Ph.D.
Galaxy Scientific Corporation

3.0 Introduction

The ability to use FAA regulatory documents is a requirement for all who are associated with operations, maintenance, and surveillance of aircraft and associated air transportation systems and services. Schools, airlines, manufacturers, and the government require thorough knowledge, as well as reasonable appreciation, of the Federal Aviation Regulations (FARs) and the host of associated documents.

Table 3.1 Sources of Information for Needs Assessment

•Mike Monroney Aeronautical Center
•Embry-Riddle Aeronautical University
•Clayton State College - Aviation Dept.
•Atlanta Area Technical School

Studying FAA regulatory documents is difficult. Instructors are given the arduous task of conveying the meaning of subtle and seemingly ambiguous material to a student body who do not always recognize the importance of what they are learning. The two most difficult aspects of learning the regulations are a) learning how to navigate through the FARs and other related documents and b) comprehending the meaning of particular statements within the FARs. FARs are legal documents written precisely to define the regulations pertaining to aviation. Unfortunately, it is not easy for most people to extract the intent of each statement from this style of writing. In addition, it is not always obvious where one needs to look to get a complete sense of the regulations' intent. Often, information relevant to a task is distributed across many parts of the FARs. For example, knowing one's eligibility to perform an IFR inspection may not be obvious when specifications for how to do the inspection are outlined in Part 43, Appendices E and F, but the privileges and limitations for who can perform the inspection are stated in 91.411b and 91.413c.

The purpose of the System for Training in Aviation Regulations (STAR) project is to aid instructors in teaching about the FARs (and other related documents) by providing a system that motivates the student to understand why learning the FARs is both relevant and necessary, develops students' study and cognitive skills in document research and understanding, and c) makes the content of the FARs more interesting and therefore more memorable.

Our approach to designing and developing STAR is to incorporate multimedia presentations and storytelling techniques within several different types of learning environments. The goal is to provide a comprehensive curriculum for acquiring the skills and content necessary for efficient document research and comprehension.

3.1 Phase V Overview

The project began in earnest on October 3, 1994. In the six months ending April 1, 1995, the project team will have conducted a needs analysis, developed a research approach guiding the design of STAR, and built the initial prototype. A preliminary evaluation of the prototype will be conducted prior to April 1. A great deal of time has also been spent assessing the best way to integrate digital document products with government-owned multimedia training systems. A detailed discussion of each of these areas is presented below.

3.2 User-Centered Design

We are employing a user-centered approach to technical design (Chandler, 1994; Rasmussen, 1992; Greenbaum & Kyng, 1991; Norman, 1986). Instructors from the FAA Academy in Oklahoma City, three Part 147 schools, and one flight training academy were interviewed regarding current instructional practices. Table 3.1 shows the sources of information for our needs assessment.

Instructors were asked to identify the major issues preventing students from learning aviation regulations and to try to envision how a CBT system could address some of these difficult instructional issues. The responses to our inquires were as varied as the people in attendance, but a pattern did emerge. Table 3.2 summarizes the learning issues instructors identified and areas where CBT could support instruction.

As a result of these interviews, several general research questions emerged to guide the development of STAR and its evaluation. Table 3.3 lists the research questions. Our answer to the question "How do we induce students to think deeply about the subject?" will embody our philosophical approach to instruction. This will become more apparent during the discussion below of the design overview. "Which learning situations are most effective for what types of learning?" is the question that will guide the experiments for evaluating STAR's success as an instructional system. The other three questions identify technical issues pertinent to user interface design and system functionality that we will need to address throughout the project.

Table 3.3 Research Questions

- How do we induce the students to think deeply about the subject?
- Which learning situations are most effective for what kinds of learning?
- When is it more effective to use what kinds of presentation types to convey the salient points in the learning environment?
- What kinds of information retrieval mechanisms are the most valuable to students? to instructors?
- How can we translate digitized material meant for a personal computer into a medium suitable for distance learning broadcasting?

We decided to focus our attention on the training of Aviation Maintenance Technicians (AMTs) for the first two phases of this project and, then to incorporate training for pilots later. We sought the assistance of Jack Moore, Dean of Clayton State College - Aviation Department, as our domain expert for this phase of the project. He and other instructors of Part 147 schools in Atlanta have provided stories, examples, strategies, technical information and documentation to be used as a basis for developing the curriculum. We will expand this information base to other Part 147 schools around the country during the second phase of the project.

3.3 Design Overview

Table 3.2 Summary Learning Issues and Where CBT Could Support Instruction

Students need help in

- knowing who the players are (e.g., owner, AMT, pilot, FAA maintenance inspector), what their responsibilities are to each other, and for what regulations each must be responsible
- understanding the objectives of the FARs and when and how to apply them
- understanding the codependency of regulations to each other
- learning to extract the root meaning from the FARs' legalese
- performing document research procedures
- recognizing when appropriate (or optimal) procedures are applicable
- integrating the individual pieces of their job tasks into a total picture

CBT could support instruction with

- a system that supports multimedia presentations during class lectures
- a series of scenarios that elucidate the subtle applications of the regulation
- drill and practice sessions that show each student where his or her weak points are
- a mechanism that allows instructors to monitor how the students are doing
- technical aids that support students while they go through the learning process

When teaching subtle information such as aviation regulations, there are advantages to providing students with many vantage points to the same body of information. Experiencing complex material repeatedly under different circumstances provides the learner with multiple opportunities to gain a deep understanding of the subject. Each vantage point not only covers different aspects of the same material, but also reinforces different kinds of study skills. In addition, information conveyed through one learning environment may be more salient to a learner than another approach. Students with different learning styles are more likely to benefit when different vantage points are provided. In this way, we provide students not only with multiple ways of viewing the information, but also with multiple opportunities to learn.

The core of the system is a document browser that has full text searching capabilities both within and among documents. This allows students to search and view the documents in their entirety. It also gives students practice in manipulating the documents on-line, a practice that we anticipate will be the norm in the future.

Several instructors identified a desire to have multimedia clips punctuate important points they make during lectures about the regulations. They see this as a means for making their instruction more interesting and motivational for the students. Instructors at the FAA Academy in Oklahoma are particularly interested in this since they are developing a center for distance learning.

The document browser is designed to support efficient review of media clips to augment class presentations. Associated with each document are all the multimedia information clips presented in the other learning environments. For example, a video about instrument inspection will be indexed with the document section that discusses instrument inspection. The browser becomes an archive for the documents and all the media clips. Each media clip is further indexed by one of nine information types listed in Table 3.4. A "Very Important Point" information type, for example, may warn students of a regulation that is often violated and why or how it gets violated. A "For Your Information" information type may point out the subtle difference between when an inspection must be completed every 2 years vs. every 24 months. A "For Example" may show a student what a correct log entry looks like. By using the documents themselves as indexes, augmented with classifying the media clips into information types, we have developed a simple system for organizing what is often a very difficult body of information to catalog. We see this as a natural way for instructors to review media clips relevant to the material they will be covering in class.

Surrounding the document browser (Figure 3.1) are four categories of learning environments: overviews, scenarios, brain teasers, and technical support. Overviews show students how FARs are organized, how different parts are related to each other, and who is responsible for what aspects of those regulations. Scenarios are interactive stories that set each student into a true-to-life situation where the regulations are often subtle. The scenarios present students with choices they need to make within the context of a given situation and show the students the consequences of those actions. It is important to note that there is often more than one right or wrong answer and that understanding why one action is wrong in a particular context is just as important as understanding why another action is right.

Table 3.4 Media Information Types

•General Procedures
•Strategies for Within Document Search
•Strategies for Between Document Search
•For Your Information (FYI)
•Very Important Point (VIP)
•For Example
•Personal Experience
•System Information
•Terminology

Brain teasers present challenges to the student. They require students to exercise certain skills they will need to develop in order to efficiently search the regulations and understand what they find. Brain teasers can vary in complexity. They can be of the "FAR Jeopardy" variety where students can practice quick responses to specific facts. Brain teasers can also be of the "project" variety where solving a challenge entails a deep understanding of both the search process and the regulations themselves. We see this area as a space where instructors can develop their own challenges for their own students.

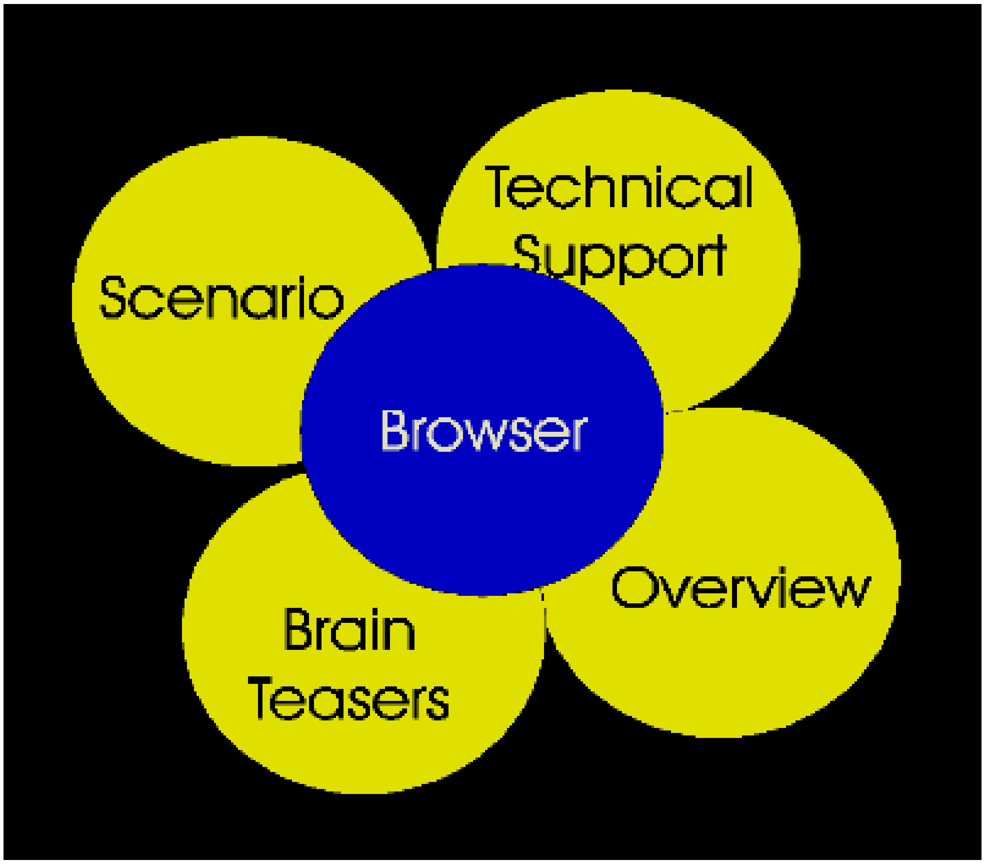

Figure 3.1 Learning Environments Identified for STAR

Technical supports are comprehension aids such as a technical dictionary. Another example is an interactive timeline showing the progression of ownership of a particular type certificate by different manufacturers. These aids provide "as needed information" that can be explored in their own right or use in conjunction with other, more formal learning environments.

Each learning environment could be a stand-alone application. Together they provide multiple vantage points for the student to explore aviation regulations. Part of our assessment of the total project will be to identify which learning environments are most effective for what types of learning. By focusing on the evaluation in this manner, we not only will assess the effectiveness of the application, but gain a better understanding of what types of learning is occurring (or needs to occur) and how we should tailor our training systems to achieve specific learning objectives.

Our long-term goal is to develop authoring tools for the most successful learning environments so that the domain expert, i.e., the instructor, can contribute directly to the system rather than remain dependent on application engineers for knowledge acquisition and implementation. In this way, the system can take on a life of its own becoming a repository of pedagogical expertise in aviation training.

3.4 Cooperation with Digital Document Providers

Digital documentation is a critical component of STAR and other document-oriented training systems such as *The Human Factors Guide* (see Chapter 4) and The Inspector Handbook (see chapter 4), currently under development at Galaxy Scientific - Atlanta. Over the last four months, the digital documents group has identified what functionality such a system must support, who the key commercial publishers are, and the feasibility for a commercial vendor's product to be integrated into a government-owned multimedia training system.

The details of this evaluation are presented in chapter 4. To summarize our findings, it became apparent that what is needed are functions that give each system designer the power to do full text search of documents and, the flexibility to display the retrieved document in a manner consistent with the training system's interface. Though the group continues to evaluate the commercial market, the FAA Hypermedia Information System (HIS) seems to be best suited for providing that flexibility. We have begun the process of extracting the functional components from HIS so that they can be used by the different training systems.

3.5 The STAR Prototype

For the first phase of system development, we began building a prototype for the document browser and the scenario learning environment. Scenarios lend themselves to capturing the instructional information. When a Part 147 instructor tells of a typical situation where interpreting the regulations is subtle, personal experiences, examples, "By the Way" information, warnings, document search strategies, and general procedures naturally flow from the telling of the scenario. This information is not found in textbooks or the regulations themselves, but is crucial to an in-depth understanding of the regulations. The interchange of stories is not only the most common way that we exchange information, but is considered the optimal form for retention of the information received (Bruner, 1990; Shank, 1990). The document browser serves primarily to organize the information that is being collected.

Scenarios are essentially interactive stories. Through a slide show presentation, students are told of an unclear situation where several actions are possible. They are asked a question about what they should do given the situation and are presented with several actions that they could take. Following is the textual passage presented to the user for the opening scene of the special inspections scenario.

> You are a technician with both A and P ratings. During a 100 hr inspection on an IFR equipped C-172, you notice that the altimeter and transponder have not been tested and inspected in the last 24 months. When you inform the owner that these tests and inspections are due, he asks: "If these tests and inspections are due, why didn't you do them as part of the 100 hour inspection?" How do you respond to this question?

Once a student chooses an answer, a new scene in the scenario is presented. The new scene shows the consequences of the action and the rationale for why the student should or should not have made that choice. Imbedded in each explanation are references to relevant FAR passages and other supporting documents and examples. For example, a student might be shown a sample of a correct log entry for the type of maintenance work he or she did or a comparison between two passages from the FARs where a distinction needs to be made.

Although for each scenario there is the "best" path to take, our objective is not to train students to take that path. Rather, to get the most out of the scenario, they should explore all the paths. By doing so, they acquire a deep understanding of the situation and an appreciation for the subtle distinctions they need to make with respect to fully comprehending the intent of the regulations. In this sense, there is no right answer, only deeper understanding. How we entice students to explore all of the scenario paths rather than just to find the "right" answer is part of the larger research question about inducing students to think deeply about the subject.

While each scene in the scenario has a multimedia presentation that "tells the story", students also have access to other relevant material that has bearing on the situation. In the gray scale background graphic used to set the scene seen in Figure 3.2, there are colored items in the picture. When a user clicks on one of the colored items, a video or detailed graphic or explanation of the item is presented. In our instrument flight scenario, for instance, clicking on the altimeter will bring up a video that explains the functionality of an altimeter in the aircraft. Also, along the bottom of the screen are buttons that access other related information categorized by information type, e.g., FYI, Personal Experience, General Procedures, etc. Students may navigate through the scenario but also can explore the details of each scene in its own right.

Figure 3.2 Colored Items Can Be Selected For Detailed Explanations

As stated previously, the most important research question that we will be addressing in this project is, "How do we induce the students to think deeply about the subject?" The cognitive and educational literature claims that to achieve this goal the student needs to be actively involved in the learning task (Brown, 1992; Scardamalia & Bereiter, 1992; Resnick, 1991; Bransford et. al., 1990; Papert, 1980). They need to be asking the hard questions and trying to answer them. There is always a risk of losing the students by challenging them with something that is beyond their technical knowledge, skill level, imagination, or, on the opposite end of the scale, boring them to death. While scenarios in their present "canned" state do not necessarily induce the students to think for themselves, they may serve as a stepping stone to the more open-ended challenges presented in the brain teaser learning environment. Scenarios do show the students the kind of thinking process they need to employ in order to make sophisticated decisions about ill-specified problems. By mimicking the reasoning presented in the scenarios, students should be able to solve the brain teaser challenges. It will be important, when developing the brain teaser learning environment in the next phase of research, that some of the brain teasers are similar in structure to those in the scenarios so that students can practice transferring reasoning skills to new situations.

3.6 User Acceptance and Training Effectiveness

The culminating event for this phase of the project is to present the STAR prototype at the 34th Annual Conference of ATEC in April 1995. The conference will provide a wide audience of aviation instructors from across the nation. We will use this forum as a vehicle to give us feedback on the STAR concept and design, and also an opportunity to tap conference attendees expertise. We will set-up several vehicles (including a video camera) for capturing their stories and experiences for further development of the system.

In preparation for the conference, the project team will first conduct an in-house technical evaluation at Galaxy Scientific. That session will focus primarily on compatibility issues in the user interface design (Maddox & Johnson, 1986). The instructors and a select group of students at Clayton State College will also have an opportunity to evaluate the STAR prototype. We will ask them to focus on system understandability, content accuracy, information presentation and ease of use (Maddox & Johnson, 1986). Formal evaluations of the system in a classroom setting will begin in Phase VI.

3.7 Future Research Phases

Phase V will draw to a close in April 1995.

Table 3.5 Tasks for Phases VI and VII.

Phase VI
•Convert the scenario and document browser into fully functioning Learning Environments.
•System evaluation - non-directed setting.
•System evaluation - formal classroom setting.
•Develop prototypes of the overview, technical support and brain teaser learning environments.

Phase VII
•Convert the overview, technical support and brain teaser into fully functional Learning Environments.
•Conduct comparative study between traditional instruction and instruction incorporating STAR.
•Expand content of system to include curriculum for Aviation Flight Schools.
•Assess potential for converting training systems into authoring systems.

Table 3.5 outlines the tasks for Phases VI and VII. System Evaluation will be an important part of Phase VI. We will be analyzing what the students learn from the system in both a non-directed and a directed setting. First, we will evaluate the robustness of the system and how students explore the system when it is not tied to a formal class activity. A history trace will be kept of each student's activity on the system. The second part of the evaluation will be in a more formal classroom setting where students will be asked to use the system in the context of one or more classroom tasks. The focus here will be on what the students learn. Pre- and post-testing will be one instrument for this analysis. Another instrument will be based on the pedagogical dimensions developed by Reeves (1994) for evaluating interactive learning environments. Analysis of students' history trace will also be made to see if patterns emerge between learning success and application use. These results will be the bases for making decisions with regard to incorporating intelligent tutoring agents into STAR.

In preparation for the extensive evaluation of the system, the scenario and document browser will be developed into fully functional learning environments. The major task to fulfill this goal is producing the curriculum and multimedia materials to build at least one complete instructional unit. An example unit could be a series of scenarios about AMT's privileges and limitations. To show the extent of the instructional possibilities, we will also create several different types of scenarios that are not part of the core unit. In tandem with these other efforts, prototypes for the "overview", "technical support" and "brain teaser" learning environments will be developed and initial evaluations of their interface design, robustness, and content accuracy will be conducted during Phase VI.

A comparative study between traditional instruction and instruction incorporating STAR as an integral part of the curriculum will be made during Phase VII. In preparation for this study, the overview, technical support, and brain teaser prototypes will be developed into full learning environments. The content of the training system will be expanded to training pilots and the potential for converting the training systems into authoring systems will be assessed.

3.8 Summary

The STAR project gives us an opportunity to bring out the complexity, subtlety, and interesting aspects of what is normally thought to be a dry subject. It provides a vehicle for practicing skills in document research and complex decision-making. It gives students practice with computerized tasks that they will be expected to use with facility in the near future. It provides a vehicle for interacting with the subject matter from several different vantage points, increasing the chances of each student acquiring an in-depth understanding of the material. And, as researchers, it gives us the opportunity to evaluate what instructional vehicles are best suited to achieve the learning objectives we have set for our students. This indeed is an opportunity.

3.9 References

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