YEAR 2: DEVELOPMENT OF THE GENERAL AVIATION INSPECTION TRAINING SYSTEMS (GAITS)

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Abstract: Inspection is an important step in ensuring product quality especially in aircraft industry where safety is the highest priority. Since safety is involved, effective strategies need to be set to improve quality and reliability of aircraft inspection/maintenance and for reducing errors. Humans play a critical role in visual inspection of airframe structures. Major advancements have been made in aircraft inspection, but General Aviation (GA) lags behind. Strategies that lead to improvement in inspection processes with GA environment will ensure reliability of the overall air transportation system. Training is one such strategy where advanced technology can be used for inspection training and reducing errors. A hierarchical task analytic (HTA) approach was used to systematically record and analyze the aircraft inspection/maintenance systems in geographically dispersed GA facilities. Using the task analytic approach a computer based training system (GAITS: General Aviation Inspection Training System) was developed for aircraft inspection that is anticipated to standardize and systematize the inspection process in GA. This report documents the work involved in the development of General Aviation Inspection Training Systems in the GA environment.

INTRODUCTION

Inspection in aircraft maintenance is mostly visual in nature and comprises of 90% of all inspection. Due to this fact the importance of effective human inspection is critical for airworthiness of General Aviation aircrafts. Added to the fact that the aircraft inspection/maintenance being a complex system with many interrelated human and machine components, the significance of ensuring inspector reliability becomes the essence of maintaining an effective and efficient system. Studies in the area of aircraft inspection and maintenance reveal the importance of correct inspection techniques and human decision making performance. Completely eliminating errors committed by the inspectors is always a difficult goal but efforts should be taken to understand the causal factors which lead to error occurrences and emphasis should be laid on training to eliminate the possibility of error occurrence. This report focus on development of a Computer Based Training tool entitled General Aviation Inspection Training Systems (GAITS) designed to help improve the human inspection and decision making performance for aircraft inspection tasks.

TASK ANALYSIS

The development of the GAITS Program followed the classic training program development methodology. As a first step the requirements, needs and goals of the training program were analyzed. Next, a detailed task analysis of the operations was conducted to determine the knowledge, skills, and abilities necessary for the job in order to specify the behavioral objectives of the training program. The team partners at geographically dispersed GA maintenance sites located within the continental US provided the research team with access to their facilities, personnel, and documentation and allowed the research team to analyze their existing inspection protocol at different times of the shift. The objective of this task analysis was to identify human-machine system mismatches that could lead to errors through shadowing, observing, and interviewing techniques. The goal of the task analysis, which was to understand how the existing system works, was achieved using a formal hierarchical task analytic approach. Table 1 shows a representative task analysis for the search function.

ERROR TAXONOMY DEVELOPMENT

For all inspection functions, the lists of all possible errors were listed and this was mapped using Rouse and Rouse's (1983) error taxonomy to identify the error genotypes. Having this information, expert human factors knowledge was applied to the sub-task to identify specific interventions (e.g., provide job-aids) to minimize the negative effects due to specific error shaping factors and to improve performance on the sub-task. Training needs were developed for producing the correct outcome. As shown in Table 2, the inspection function is "Inspect the frames and structures for cracks, corrosion, loose and for missing rivets". Errors for that particular inspection function were classified using Rouse and Rouse's error classification scheme and training content was established to prevent the occurrence of errors.

YEAR 2 ACTIVITIES:

In year 2, the research team outlined the methods, content and delivery system for use in GAITS. These are described in the paragraph below.

TRAINING METHODS FOR INSPECTION

The basic principles which have been effectively incorporated within GAITS include pre-training, feedback, active training, progressive parts proposes that training should be imparted in a top-down manner, with the general level being taught before the specifics.

Feedback

Accurate and rapid feedback should be provided to the trainees so that they know whether the defects were classified correctly or the search strategies effective. Feedback can be classified as either performance or process. Performance feedback typically consists of information on search times, search errors and decision errors while process feedback provides information to the trainee about the search process, such as areas missed. It has been found that performance can be improved if trainees are provided feedback in the form of knowledge of results coupled with some attempt at performing the task. This is applicable to learning facts, concepts, and procedures as well as to problem solving, cognitive strategies and motor skills. Immediate feedback should be provided at the beginning of the training program, and it should be delayed until the "operational level" is reached. Providing regular feedback beyond the training session helps to keep an inspector calibrated.

Active Training

A trainee should respond actively after each new piece of material is presented by, for example, identifying a fault type or making decision on the degree of a defect. Czaja and Drury (1981) demonstrated the effectiveness of this approach for a complex inspection task.

Progressive Parts Training

Progressive parts training methodology was successfully applied to industrial skills by Salvendy and Seymour (1973). In this methodology, parts of the task are taught to criterion, with successively larger sequences of parts being introduced.

Schema Training

The aim of schema training is that trainees must be able to generalize their training to new experiences and situations. For example, schemas need to be generated projecting every site and extent of the defects found on a plane wing so that the inspector is able to detect and classify a defect wherever it occurs. Thus, the inspector needs to develop a schema for defects to allow for a correct response in novel situations. The key to the development of a schema is to expose the trainee to controlled variability during training.

Feedforward Training

Feedforward training cues the trainee as to what should be perceived. When novice inspectors try to find defects on an airframe, the indications may not be obvious, unless they know what to look for and where to search.

STRUCTURE AND CONTENT OF GAITS

System specifications and structure

GAITS was developed using Macromedia Authorware 6.5, Macromedia Flash MX and Microsoft Access. The development work was carried on a Pentium(R) 4, 2.4 GHz platform with a 17" resolution monitor, 256 MB RAM, 1.5 MB video RAM, 57.2 GB hard drive and a multi-speed CD drive. The development methodology utilized an integrated task analytic and iterative software development methodology. The training program uses text, graphics, animation, video and audio. The inputs the system are entered through a keyboard and a two-button mouse. GAITS consists of four main modules namely 1) Introduction 2) Training 3) Simulator and 4) Design and Analysis (Figure 1). The software combines graphical user interface technologies along with good usability features. System users interact with the software through a user-friendly interface. Considering ease of use and information utilization, the tool uses a multi-media presentational approach.

Introduction

The Introduction module provides information to the trainee about various facets of the program. It consists of the following

a. Overview: The module gives an overview of the CBT tool. It introduces the trainee to different aspects in the software such as training of search and decision making.

b. Types of inspection: It provides the information about various kinds of inspections, which take place in the General Aviation (GA) environment. In addition to this, different levels of visual inspection are discussed in this module.

c. FAR's (Federal Aviation Regulations): The module also discusses the FAR's as they relate to general aviation procedures and guidelines. In addition to this, the introduction module describes the

common tools, which are used in visual inspection, and the factors namely process, physical, subject and organizational, which affect the inspection performance.

Training

The Training module is divided into six units namely Initiate, Access, Search, Decision, Respond and Return (Figure 2), which look into various aspects of the inspection process. The different units, which comprise the Training module, help the trainee understand the conditions, which lead to error occurrence. The module also prescribes correct inspection procedures and steps to prevent error occurrence. Additionally each unit contains a quiz, which checks the trainee's knowledge and the extent to which the trainee has understood the material. (Figure 3 and Figure 4 show the screen shots from the Decision unit.)

Simulator

In order to check trainee's knowledge the simulator provides an utility of simulating an actual structural inspection task. This provides hands on experience in conducting inspection. Additional utility included in the simulator is to check the trainee's performance on the simulated inspection task. The performance of a trainee is tracked using the Design and Analysis.

Design and Analysis

Design and Analysis module enables the instructor to create scenarios to tailor training based on training needs. Moreover it allows analysis of performance scores of the trainee. Once the trainees undergo training in the training module, they can perform actual inspection tasks using the computer simulator. Using the Design and Analysis module the instructor can 1) analyze the results of the students' performance in the training and simulator modules; 2) customize training for each individual. Figure 5 shows how an instructor can create scenarios for wing inspection by selecting alternate images. Based on the performance of the trainee, future scenarios can be developed, such that it helps develop specific inspection skills that are lacking.

DISCUSSION AND CONCLUSIONS

It is anticipated that the use of this training program will result in the following:

Standardization

The use of a computer-based inspection training system eliminates the problems arising from using actual airframe structures and the non-standardization in training resulting from the use of different sets of defects by different instructors. The aim is that all the trainees will be trained to the same set of standards on the same set of defects.

Adaptability

This computer-based training tool can be tailored to accommodate individual differences in inspection abilities. Images of airframe structures containing defects can be created to train inspectors on particular facets of the inspection task.

Convenience

Retraining can be accomplished more conveniently, and trainees can work on the system whenever they have time available. Also, trainees can work individually, eliminating the intimidation created by a classroom environment or by the presence of an instructor.

Record keeping

The utilities of Design and Analysis allow the instructor to monitor and track individual performance easily. The record keeping process is built into and automated on the software. Individual performance can be tracked initially for training and later for retraining.

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Table 1: Task Analysis

TASK DESCRIPTION	ERRORS	OUTCOME	TRAINING NEEDS
3.1 Search by Fixation in Field of View			
3.1.1 Inspect the frames and structures for cracks, corrosion, loose and for missing rivets.	E3.1.1.1 Does not know how to inspect the frames and structures for cracks, corrosion, loose and missing rivets (EC 5). E3.1.1.2 Does not know how to identify the cracks, corrosion, loose and missing rivets (EC 5). E3.1.1.3 Does not bring the correct tools to inspect the frames and structures (EC 6). E3.1.1.4 Does not inspect the frames and structures for cracks, corrosion, loose and missing rivets (EC 6).	Does inspect the frames and structures for cracks, corrosion, loose and for missing rivets.	Are the inspectors trained on detecting the different type of defects like cracks, corrosion, loose and missing rivets?

Table 2: Error Classification

	Task Analysis									
TASK DESCRIPTION	**A**	**S**	**P**	**D**	**M**	**C**	**F**	**O**	**OBSERVATIONS**	**CONTENT**
3.0 SEARCH FOR INDICATIONS										
3.1 Search by Fixation in Field of View										
3.1.1 Inspect the frames and structures for cracks, corrosion, loose and missing rivets	**X**		**X**		**X**				Systematically inspected one frame and structure at a time for cracks, corrosion, loose and missing rivets.	Consists information on how to inspect the frames and structures for cracks, corrosion, loose and missing rivets. Consists information on all the different types of defects. Consists information on the tools required to inspect the frames and structures.

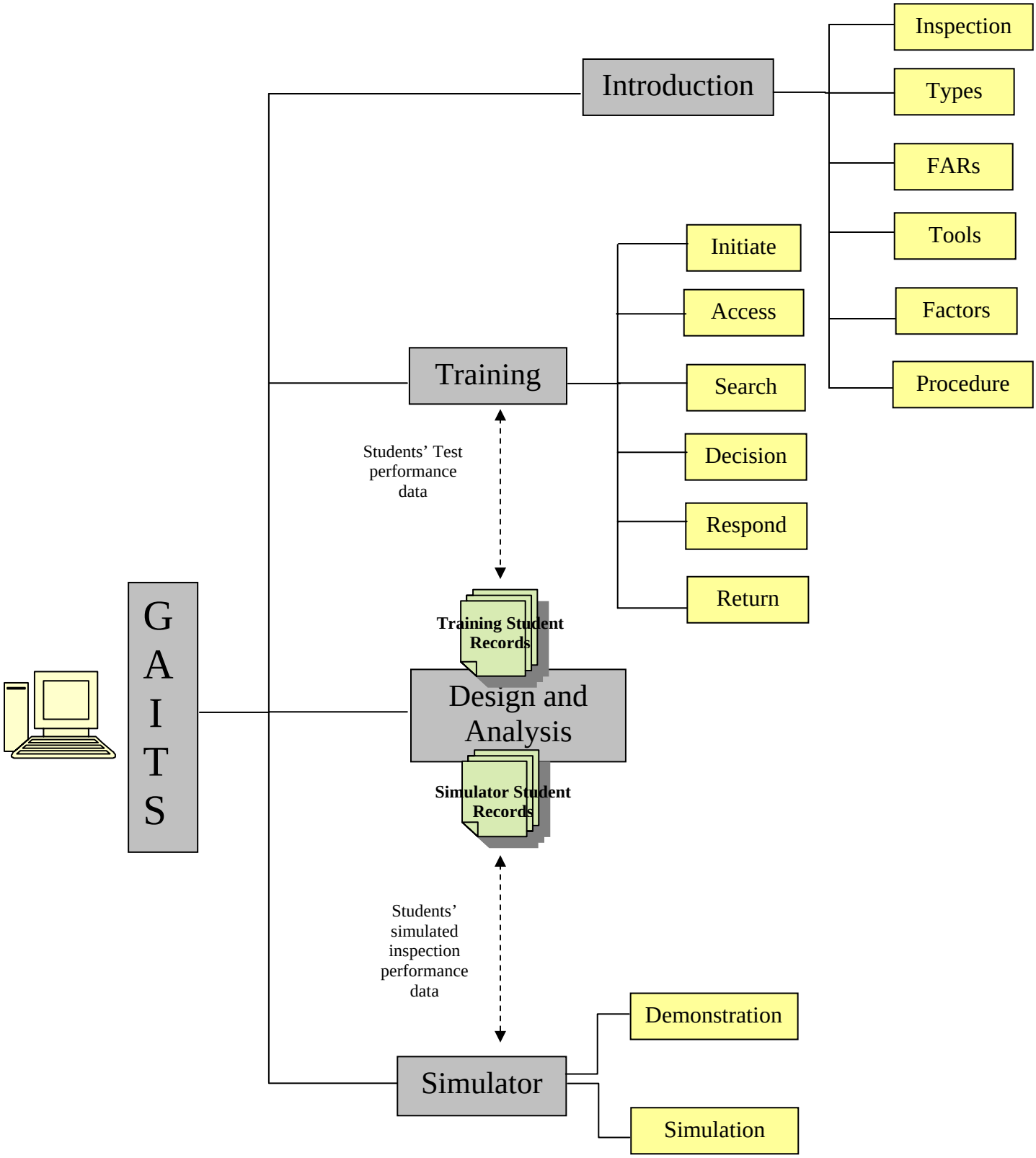

Figure 1: Structure of GAITS

Figure 2: Main screen of Training module.

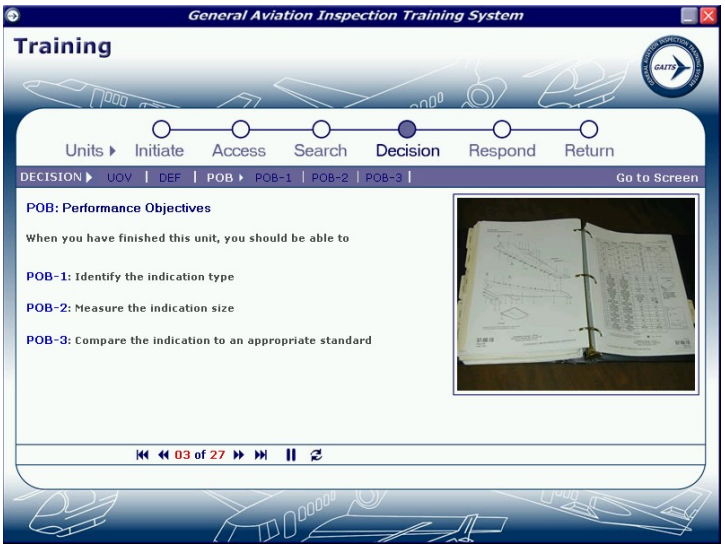

Figure 3: Performance Objectives screen of the Decision Making unit

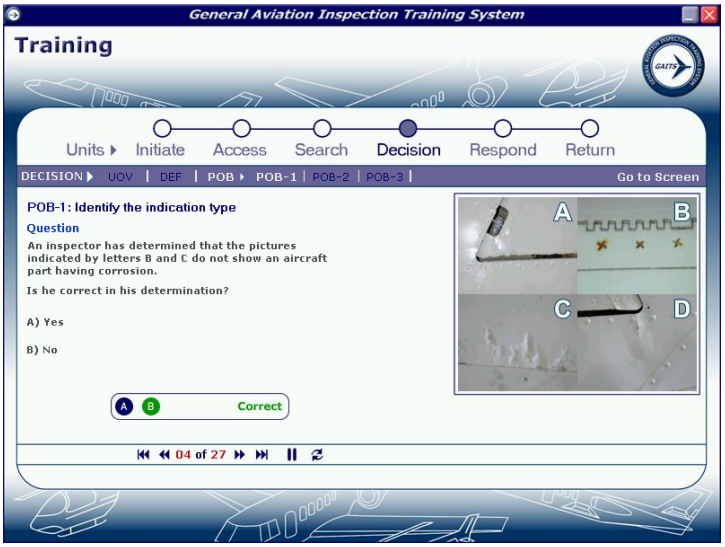

Figure 4: Question slide of the Decision Making unit

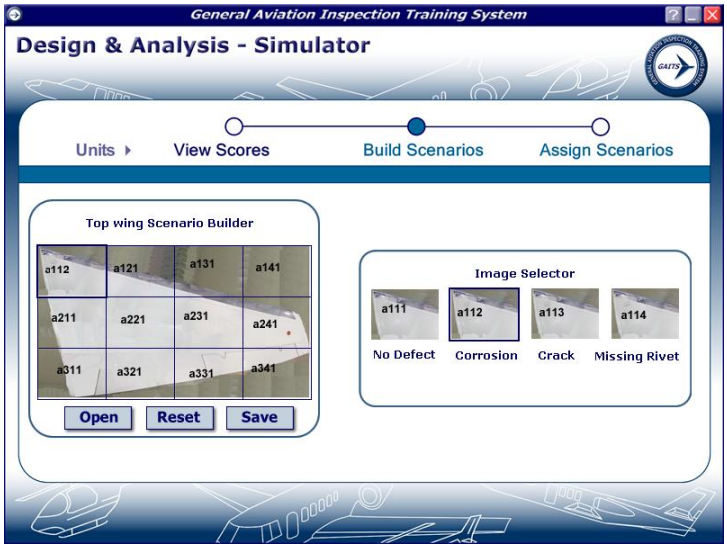

Figure 5: Scenario Builder screen of the Design and Analysis module.