IMPROVING INSPECTOR'S PERFORMANCE AND REDUCING ERRORS - GENERAL AVIATION INSPECTION TRAINING SYSTEMS (GAITS)

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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 paper documents the work involved in the development of General Aviation Inspection Training Systems.

1.0 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 [3 , 4] 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 paper discusses 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.

2.0 TASK ANALYSIS

The development of the GAITS Program followed the classic training program development methodology (Figure 1). 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 14 different 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. [1]. Table 1 shows a sample task for an inspection task.

3.0 ERROR TAXONOMY DEVELOPMENT

For a particular inspection function, in our case "Search by Fixation in Field or View", we developed all possible errors that could occur during the performance of inspection function. There are several error classification schemes, many of the schemes can be roughly categorized as either behavior oriented, task oriented or system oriented. The behavior oriented schemes attempt to classify human behavior independent of a specific task or application domain. Task and system oriented schemes reflect particular domains, either at the specific task level or system level - which covers a variety of tasks [4]. These labels are not mutually exclusive with respect to any particular scheme. Errors are classified under each general category. They are observation of system state (EC 1), choice of procedure (EC 2),

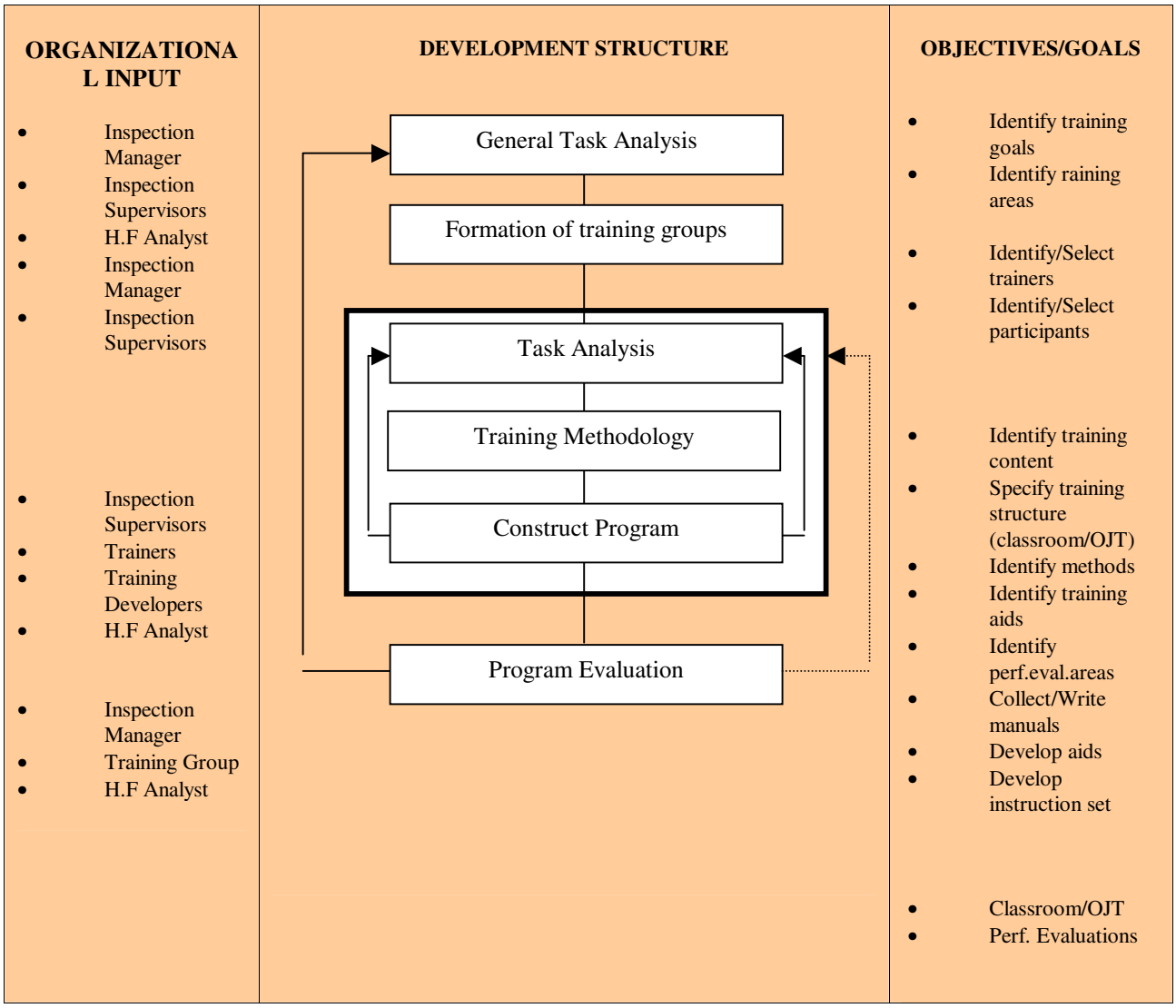

Figure 1. Model for Training Program Development in General Aviation

	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**				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.

Table 1. Task Analysis

testing of hypothesis (EC 3), choice of goal (EC 4), choice of procedure (EC 5) and Execution of procedure (EC6). This error framework, which classifies human errors based on causes as well as contributing factors and events, has been employed to record and analyze human errors in several contexts such as detection and diagnostics, trouble-shooting of the aircraft mission flights.

3.1 Error Classification

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 (see Table 3) and to improve performance on the sub-task. Training needs were developed for producing the correct outcome. In our case, the inspection function was "Inspect the frames and structures for cracks, corrosion, loose and for missing rivets" (Figure 2). There are four possible errors, which were classified under choice of procedure (EC 5) and Execution of procedure (EC 6). Training content was established to prevent the occurrence of errors. Table 2 shows the error classification list, correct outcome and the training need.

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).	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. Sample Error Classification

Errors from task analysis	Error Shaping Factors						Suggested Improvements
	Human	Task	Work Space	Equipment/ Tools	Documentation	Environment (Organizational And Physical)	
E3.1.1.1 Does not know how to inspect the frames and structures for cracks, corrosion, loose and missing rivets (EC 5).	lack of knowledge					Lack of training, Loose adherence to system procedures	• Training, Job Aid • Procedure development • Enforcement

Table 3. Sample Error Shaping Factors

4.0 STRUCTURE OF GAITS

4.1 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 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. 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.

4.2 Introduction

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

4.2.1 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.

4.2.2 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.

4.2.3 FAR's (Federal Aviation Regulations)

The module also discusses the FAR's as they relate to general aviation procedures and guidelines.

Figure 2. Performance objectives for Decision making unit

In addition to this, the introduction module decribes the common tools that are used in visual inspection and the factors namely process, physical, subject and organizational which affect the inspection performance.

4.3 Training

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

4.4 Simulator

Training module makes the trainee understand the proper way of inspection. In order to check trainee's knowledge for the correct ways of inspection the simulator provides an utility of simulating an aircraft part and the inspection conditions, to provide hands on experience of the inspection process to the trainee. 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 module Design and Analysis that is described next.

4.5 Design and Analysis

The Design and Analysis module provides utilities of setting questions for the Training module, developing schemas by manipulating various task complexity factors for the Simulator and tracking the performance of the trainee based on the questions in the Training module and the inspection performance in the Simulator.

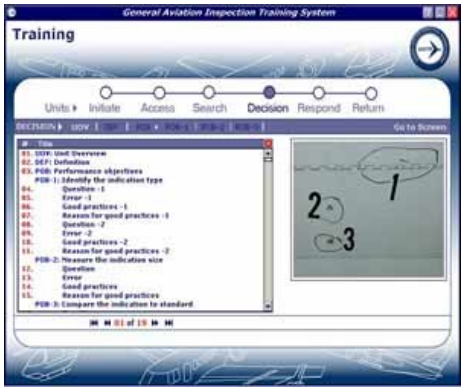

Figure 3. Menu used for navigation in Decision making unit.

5.0 CUSTOMIZATION OF GAITS

Once the trainees undergo training in the training module, they can perform actual inspection tasks using a 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. Thus the 'Design and Analysis' module provides the instructor with an opportunity to customize the simulator module of GAITS.

The Design and Analysis module enables the instructor to customize the training program to suit individual training needs. For example, an inspector who is having a hard time locating corrosion defects in the hangar floor can be exposed to different types, severity, and location of corrosion. Similarly the simulator can be tailored to provide specific feedback based on errors made.

Figures 4 and 5 show how an instructor can create scenarios for wing and door inspection by selecting alternate images. Based on the performance of the trainee, future scenarios can be developed, such that it helps develop inspection skills that are lacking. In the following figures, it can be seen that the instructor can build a wing by selecting different sections with different defect types.

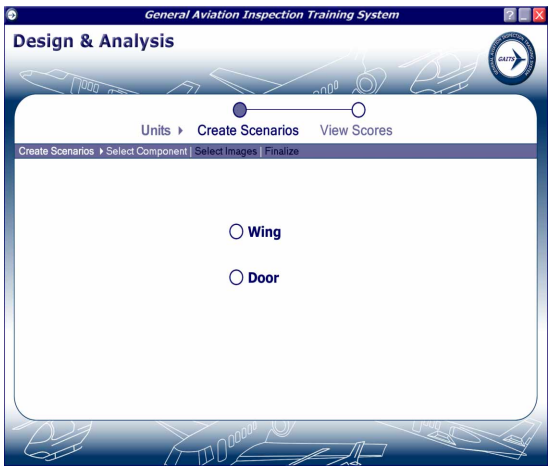

Figure 4. Selection of Airframe Structure

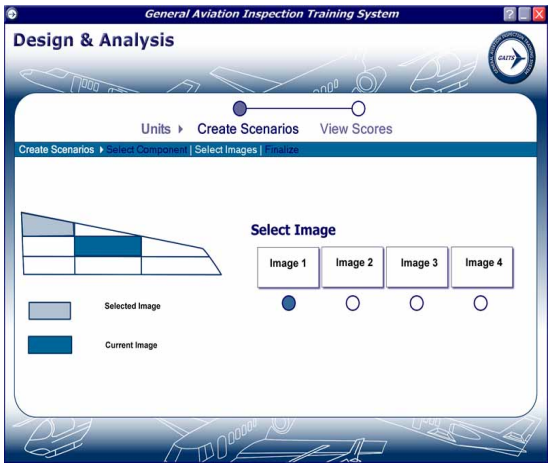

Figure 5. Building a Wing

This module of GAITS software thus allows the instructor to train his students according to the needs of that particular GA environment and at the same time follow the standard procedures. Another feature of this module enables analysis of student performance. Figure 6 shows a prototypical screen for analysis. In this screen the instructor will be able to view the students' performance in the two modules namely 'training' and 'simulator'.

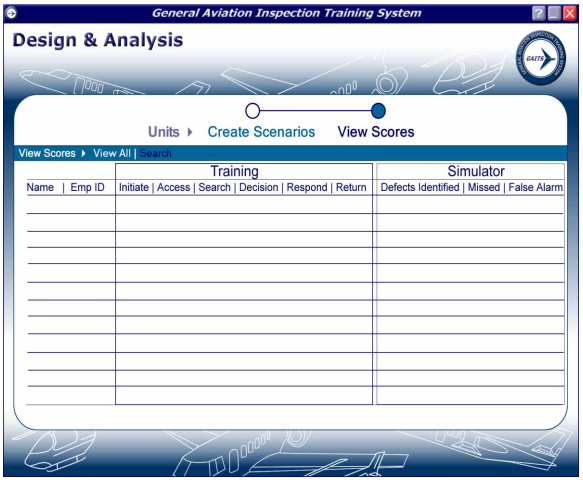

Figure 6. Prototypical Screen for Analysis

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