ESTABLISHING TRAINING REQUIREMENTS FOR THE GENERAL AVIATION INSPECTION TRAINING SYSTEM (GAITS): A COMPUTER BASED TRAINING SOFTWARE

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Abstract: General Aviation (GA) constitutes a significant, but often ignored, portion of the aviation system. It is crucial that GA be reliable if we are to ensure the safety of the overall air transportation system. The inspection/maintenance system, which is responsible for identifying and fixing defects, is a key component of this system. In response to this need, this paper reports task analyses of aircraft inspection operations at geographically dispersed GA facilities operated under the Federal Aviation Regulation (FAR) Part 91, 135, and 145. Recommendations forthcoming from this analysis will be used to devise a computer based inspection training program focused on improving the aircraft inspector's performance. This report briefly outlines activities pursued in Year 1 of the research. The introduction provides a brief background for the study, the next section outlines the methodology adopted, detailing the task analyses conducted.

INTRODUCTION

Aircraft in the General Aviation (GA) environment have their maintenance scheduled initially by a team that includes the FAA, aircraft manufacturers, and start-up operators, although these schedules may be taken and modified to suit individual requirements and meet legal approval. In many cases the customer may follow a manufacturer's inspection program, which calls for 100 hrs. and a yearly inspection. Within these schedules, there are checks at various intervals, often designated as flight line checks; overnight checks; and A, B, C and, the heaviest, D checks. The objective of these checks is to conduct both routine and non-routine maintenance of the aircraft. This maintenance includes scheduling the repair of known problems; replacing items after a certain air time, number of cycles, or calendar time; repairing defects discovered previously, for example from reports logged by pilot and crew or from line inspection, or items deferred from previous maintenance; and performing scheduled repairs.

One of the areas reported in need of improvement is the human inspection of aircrafts, as this process has been widely reported as a cause of several errors/accidents in the aircraft maintenance industry (see FAA, 1991; FAA, 1993; Hobbs and Williamson, 1995 and the 1995 Continental Express crash). This problem has been attributed to a lack of well-defined inspection procedures for use by the aircraft maintenance industry. In response, the industry has developed ad-hoc measures and general guidelines to assist various personnel involved in the inspection process. This has resulted in various organizations developing their own internal procedures, which vary in their level of instruction/detail. Because of this situation, inspection procedures are not standardized across the industry. Moreover, they are often not based on sound principles of human factors design.

The two goals that need to be achieved by a maintenance/inspection program are safety and profitability. While safety is of paramount concern, profitability can be realized only when safety is achieved economically. For human inspectors, this means that in addition to performing the inspection task, they have to be sensitive to both efficiency, the speed measure, and effectiveness, the accuracy measure, if they are to optimize their performance. The interrelationship between these performance measures and task factors, among others, is seen in Figure 1.

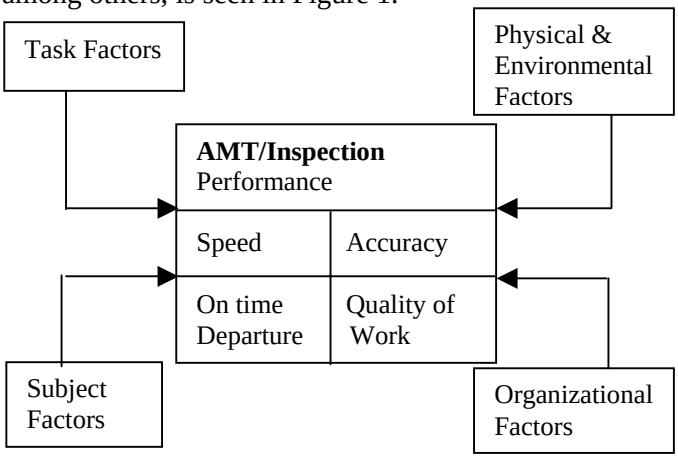

Figure 1. Factors Impacting Aircraft Inspection Performance

These two conflicting goals of safety and profitability are embodied in the inspection function in the form of *accuracy* and *speed*, respectively. Accuracy denotes detecting the defects that must be remedied for the safe operation of the aircraft while keeping false alarms to a minimum. Speed means the task must be performed in a timely manner without the excessive utilization of

resources. As can be seen, it is crucial that inspectors work not only effectively, that is, detect all potential defects, but also efficiently. The problem is further compounded in the GA inspection environment with its large differences in the size and type of maintenance facilities, organizational and physical environment, and inspector experience and technical skills.

In response to this need, a task analysis of inspection activities was conducted at representative GA facilities, with the research looking at the entire inspection process to identify training requirements, to help minimize inspection errors. The specific objectives of Year 1, were to analyze the inspection process at representative aircraft maintenance sites, develop a taxonomy of errors and identify training requirements to prevent the ill effects of the errors.

METHODOLOGY

Literature Review

As a first step a detailed literature review was conducted. The literature is available online and can be accessed through the following website (http://www.ces.clemson.edu/~agramop/cur_act.htm). Figure 2 shows a screenshot of the database.

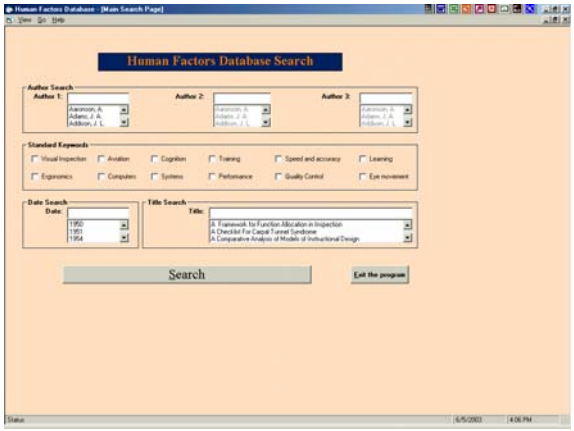

Figure 2. Screenshot of the database.

Following this step, the study analyzed the inspection process at representative GA aircraft maintenance sites, including the norms, information transfer procedures, guidelines and FAA-mandated procedures. Next, a detailed error taxonomy was developed to help classify the typical inspection errors. These errors were then analyzed and interventions identified to develop a standardized inspection process to minimize them. During this phase of the study, the researchers focused on the mechanic/inspectors, their respective supervisors, and the various entities they interact with. Following this step, recommendations were developed to support improved inspection performance.

Task Analysis of Inspection Operations at GA Facilities

A detailed task analysis of the operations was conducted using data collected through shadowing, observation, and interviewing techniques. The team partners at representative 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 research team worked with the managers, line supervisor/shift foremen, and more than 100 inspectors and aircraft maintenance technicians. The research team visited sites with both light and heavy inspection and maintenance work governed by FAR Part 91, 135, and 145. The researchers conducted follow-up interviews with the various personnel involved to ensure that all aspects of the inspection process were covered. These interviews discussed issues concerning the tasks they were undertaking or had just performed and general issues concerning their work environment, both physical and organizational.

The study was initiated with a meeting between the members of the research team and the airline personnel to outline its objectives and scope. The objective 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 task analytic approach (Gramopadhye and Thaker, 1998). The first step in this approach is to develop a description of the task, outlining in detail the steps necessary to accomplish the final goal. While various formats can be used to describe a task, this study used a hierarchical one in conjunction with a column format. Figure 3 show a sample hierarchical task analysis (HTA) used for the inspection process. Each step was later described in detail in a column format similar to that used by FAA (1991). This column format identified the specific human subsystem--attention, sensing, perception, decision, memory, control, feedback, communication, and output--required for the completion of each step (Table 1). Using this format enabled the analysts to identify clearly the specific cognitive and manual processes critical in the performance of the tasks, identifying the opportunities for error. As an example, for Sub-Task 1.3, Memory was identified as a critical sub-process; observable errors occurring over various shifts at different sites were tabulated for all technicians for this specific sub-

component (see data in Table 2.). Follow-up interviews, questionnaires and observational techniques were used to identify and isolate error-causing mechanisms. This data was later mapped using Rouse and Rouse's (1983) error taxonomy to identify the error genotypes (Table 3). 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 training needs to improve performance on the sub-task.

Following the analysis of inspection, a comprehensive error classification scheme was developed to classify the potential errors by expanding each step of the task analysis into sub-steps and then listing all the failure modes for each, using the Failure Modes and Effects Analysis (FMEA) approach (Hobbs and Williamson, 1995). These represent the error phenotypes, the specific, observable errors providing the basis for error control. Error prevention and the development of design principles /interventions for error avoidance rely on genotype identification, associated behavioral mechanism and system interaction. The phenotypes were characterized by the relevant aspects of the system components (e.g., human, task, environment, etc.) with which they interact. The resulting list of phenotypes, error correctability and type, and the relevant error shaping factors, enable designers to recognize these errors and design control mechanism to mitigate their effects. For this purpose, Rouse and Rouse's (1983) behavioral framework was used to classify errors during an inspection process and to identify the genotypes associated with each phenotype. This methodology yielded the mechanism of error formation within the task content. 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 and aircraft mission flights.

TRAINING REQUIREMENTS

Following observations and discussions with various inspectors and a detailed task analysis of the inspection processes, training recommendations were identified and mapped using The American Society for Nondestructive Testing (2001) requirements (Table 4) for the following four representative tasks: (1) Cabin and under floor inspection; (2) Landing gear inspection; (3) Inspection of Aileron; and (4) Inspection of elevator. Having performed the task analyses, it now forms as the basis for developing a computer based inspection training program to support inspectors in the GA environment (GAITS – Figure 3). Moreover it will be used to establish the content, methods, and delivery system for the training program.

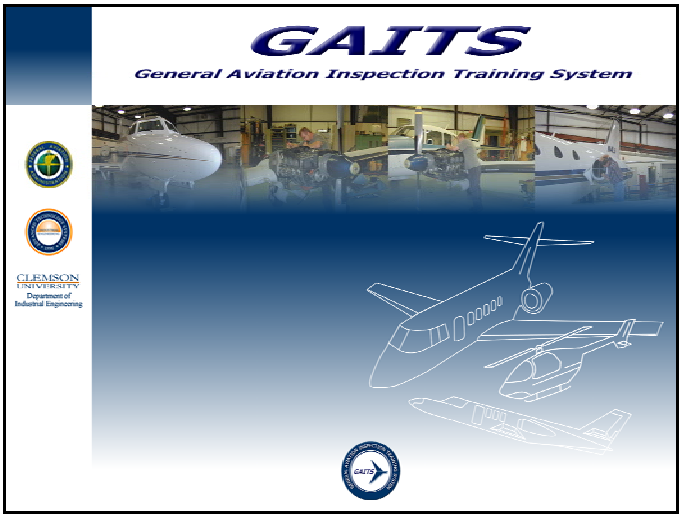

Figure 3. GAITS logo screen

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Table 1: Sample Task Analysis of the Inspection Process

	Task Analysis									
TASK DESCRIPTION	**A**	**S**	**P**	**D**	**M**	**C**	**F**	**O**	**OBSERVATIONS**	**CONTENT**
1.0 INITIATE INSPECTION										
1.1 Use Documentation to Plan Task										
1.1.1 Read Documentation	**X**	**X**							Read the work card correctly.	Consists information on: • Identifying the correct document. • Reading the correct information.
1.1.2 Plan task, strategy and mental model	**X**	**X**	**X**		**X**				Did not plan the task appropriately. (E 1.1.2.2) Planned the search strategy. Created an appropriate mental model.	Consists information on: • tasks • strategies • mental models • planning the appropriate task • planning the appropriate strategy • creating appropriate mental models

A: Attention S: Senses P: Perception D: Decision Making M: Memory C: Control F: Feedback O: Others

Table 2: Sample Error Taxonomy

TASK DESCRIPTION	ERRORS	OUTCOME	TRAINING NEEDS
1.0 INITIATE INSPECTION			
1.1 Use Documentation to Plan Task			
1.1.1 Read Documentation	E1.1.1.1 Does not have the correct documentation (EC1). E1.1.1.2 Does not have the documentation (EC 1). E1.1.1.3 Does read the document incorrectly (EC 6). E1.1.1.4 Does not know how to read the document (EC 5). E1.1.1.5 Does not interpret the document correctly (EC 3).	Does know to locate, read and interpret the correct documentation.	Are the inspectors trained to locate the correct documentation? Are the inspectors trained to read and interpret the correct documentation?

EC1 – Observation of system state
EC2 – Choice of hypothesis
EC3 – Testing of hypothesis
EC4 – Choice of goal
EC5 – Choice of procedure
EC6 – Execution of procedure

Table 3: Mapping errors using Rouse's taxonomy.

EC 1 TYPE ERROR	TRAINING NEEDS
E1.1.1.1 Does not have the correct documentation (EC1). E1.1.1.2 Does not have the documentation (EC 1).	Are the inspectors trained to locate the correct documentation?
E1.1.3.1 Does not know about the different types of defects (EC 1). E1.1.3.2 Does not know all the defects (EC 1). E1.1.3.3 Does not know about the criticality of defects (EC 1). E1.1.3.4 Does map the defects with criticality incorrectly (EC 1). E1.1.3.5 Does not know how often the defects occur (EC 1). E1.1.3.6 Does not know about the location of the defects (EC 1). E1.1.3.7 Does map the defects with location incorrectly (EC 1).	Are the inspectors trained to detect the different types of defects? Are the inspectors trained to map the defects with criticality? Are the inspectors trained to determine the probability of the occurring defects? Are the inspectors trained to locate the defects correctly?

Table 4: Mapping training needs using The American Society of Nondestructive Testing (ASNT) requirements.

Training Content	ASNT Specifications			Training Methods	Training Delivery Systems
	Level 1	Level 2	Level 3		
3.1.3 • Consists information on how to inspect an aircraft cable pulley. • Consists information on the tools required to inspect an aircraft cable pulley.	4.0 Equipment 6.0 Visual testing to specific procedures	5.10 Position	1.3 Test object characteristics 4.0 Interpretation/ Evaluation		
3.1.4 • Consists information on how to inspect the cables. • Consists information on the tools required to inspect the cables.	4.0 Equipment 6.0 Visual testing to specific procedures	5.10 Position	1.3 Test object characteristics 4.0 Interpretation/ Evaluation		
3.1.5 • Consists information on how to identify the radar cable. • Consists information on how to inspect the radar cable. • Consists information on the tools required to inspect the radar cable.	4.0 Equipment 6.0 Visual testing to specific procedures	5.10 Position	1.3 Test object characteristics 4.0 Interpretation/ Evaluation		