

# Electronic Ergonomic Audit System for Maintenance and Inspection

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This paper describes an ergonomic auditing software system, one of the tools used for performance enhancement of aircraft inspectors. This tool was developed at Galaxy Scientific Corporation, in cooperation with the State University of New York at Buffalo, for the Federal Aviation Administration (FAA), Office of Aviation Medicine (AAM). The purpose of the development task was to integrate a variety of ergonomic audit tools into a comprehensive package. This ergonomic auditing system called "ERgoNomic Audit Program" (or ERNAP), carries out an ergonomic evaluation for maintenance and inspection operations. The package consists of a user interface, an expert system, a help module, a printing module, and a reference database. The user interface supports user learning, helps guide the user through the steps, describes the less familiar ergonomic principles, allows the user to access on-line help and is simple to use. The expert system evaluates the user inputs based on the reference database and different models of analysis. This package maintains consistency with the *Human Factors Guide for Aviation Maintenance* which is on demonstration during this session.

## INTRODUCTION

The purpose of this development effort was to integrate a variety of ergonomic audit tools that were developed at different universities into a comprehensive software package. The ERgoNomic Audit Program (ERNAP), developed by Galaxy Scientific Corporation, in cooperation with State University of New York at Buffalo, for the Federal Aviation Administration Office of Aviation Medicine, carries out an evaluation audit for maintenance and inspection operations. ERNAP can also be used to guide designers to build ergonomically efficient procedures and systems. ERNAP is simple to use, and it evaluates existing and proposed tasks and setups in the application of Ergonomic principles and suggests ergonomic interventions.

## THE AUDIT PROGRAM



*Documentation:* Concerns itself with information readability, information content, i.e., text & graphics and information organization.

*Communication:* Between-shift communication and availability of lead mechanics/supervisors for questions and concerns.

*Visual Characteristics:* Overall lighting characteristics of the hanger, i.e., overhead lighting, condition of overhead lighting, and glare from the daylight.

*Electrical/pneumatic equipment issues:* Evaluation of the equipment which uses controls, i.e., ease of control, intuitiveness of controls, and labeling of controls for consistency and readability.

*Access Equipment:* Evaluation of ladders and scaffold for safety, availability and reliability.

## B. Maintenance Phase

*Documentation:* Physical handling of documents and the environmental conditions effecting their readability, i.e., weather and light.

*Communication:* Communication issues between coworkers and supervisors, and whether or not suggestions by mechanics are taken into consideration.

*Task lighting:* The overall lighting available to the mechanic for completing the task. Evaluates the points such as light levels, whether personal or portable lighting is used, and whether the lighting equipment is causing interference with the work task.

*Thermal issues:* The current conditions of thermals in the environment in which the task is being performed.

*Operator perception:* Operator perceptions of the work environment at present, during summer and during winter.

*Auditory issues:* Determine if the sound levels in the current work environment will cause hearing loss or interfere with tasks or speech.

*Electric and pneumatic issues:* The availability of any electrical/pneumatic equipment, whether the equipment is working or not, and ease of using the equipment in the work environment.

*Access equipment:* Availability of ladders and scaffolds, whether the equipment is working or not, and ease of using the equipment in the work environment.

*Handtools:* Evaluates the use of hand tools, whether or not the hand tools are designed properly to prevent fatigue and injury, and usability by both left- and right-handed people.

*Force requirements:* Forces exerted by the mechanic while completing a maintenance task. Posture, hand positioning and time duration are all accounted for.

*Manual Material Handling:* Uses [NIOSH](#) 1991 equation to determine if the mechanic is handling loads over the recommended lifting weight.

*Vibration:* Amount of vibration a mechanic encounters for the duration of the task. Determines if there are possible detrimental effects to the mechanic because of the exposure.

*Repetitive motion:* The number and frequency of limb angles deviating from neutral while performing the task. Takes into consideration arm, wrist, shoulder, neck and back positioning.

*Access:* Access to the work environment; whether it is difficult or dangerous, or if there is conflict with other work being performed at the same time.

*Posture:* Evaluates different whole-body postures the mechanic must assume in order to perform the given task.

*Safety:* Examines the safety of the work environment and what the mechanic is doing to make it safer, e. g., meaning of personal protective devices.

*Hazardous material:* Lists the types of chemicals involved in the maintenance process, whether or not the chemicals are being used properly, if disposal guidelines are being followed, and if the company is following current EPA requirements for hazardous material safety equipment.

### C. Post-Maintenance Phase

*Buy-back:* Usefulness of feedback information to the mechanic and whether or not buy-back is from the same individual who assigned the work.

By using separate modules, ERNAP allows the users to make specific or comprehensive audits.

#### ***2. File handling module.***

This module consists of a database which stores all the relevant information about the audit, such as the modules selected for audit, the information entered into these modules, audit description, etc.

#### ***3. Expert system module.***

This module analyzes all the information entered by the user and is based on a rule-based expert system, CLIPS. After analysis, this module presents the analysis and suggestions in a suitable format.

#### ***4. Printing module.***

This module caters to the printing requirements. The user can either print the modules themselves or the analyses.

## ***5. Help module.***

This module provides an on-line help to the user. Hot words on the checklists are linked to the help topics within the help module. The help module can also be referred to in its entirety. A glossary of terms is also provided to help the users better understand the terminology.

### **Description of the System**

On starting ERNAP, the first screen comes up showing information about ERNAP. Following this the next screen comes up as shown in ([Figure 8-1, appendix](#)). The user has the option to either select begin a "New" or "Open" an existing Audit. Selecting "Cancel" shall bring the user to the main screen of ERNAP as shown in ([Figure 8-2, appendix](#)). ERNAP then waits on the user to either begin a "New" ergonomic audit or "Open" a saved ergonomic audit. By selecting "Open", the user can revisit earlier audits. Selecting "Begin a New Evaluation" starts a completely new ergonomic audit and selecting "Open an Existing Audit" starts a previously conducted audit.

These options are available to the user in the "pull-down" menus. Selecting either of these (Open or New), shows the different modules of ergonomic evaluation. The user at this point can select any or all of the ergonomic audits. This can be done by selecting the check boxes provided against each audit, as shown in ([Figure 8-3, appendix](#)).

ERNAP will step through only those modules that are selected by the user, thus allowing a partial audit. Once the user has started the audits, ERNAP starts with the first module and presents the user with specific questions related to the operation being audited. ([Figure 8-4, appendix](#)) shows an example. ERNAP uses a simple user interface for the input of information related to the operation under audit. The user interface has been developed based on the principles of human-computer interaction.

The user can either use a "mouse" to make the selections or use the "tab" key in combination with the "enter" key on the keyboard. On each module, help is provided to the user on the terminology used in the questions asked by ERNAP. Clicking the mouse on the hot words brings up more information about that section of the audit. The user can also get general help from the "Help" section of the "pull down menu". This provides information about ERNAP, its developers, and other relevant information. Furthermore, help on the menu item selected is shown in a status box towards the bottom of ERNAP main screen. The user can also directly go to the required audit by selecting the audit module from the "pull down menu". The index tabs help the user move to different sections within each module. The user can exit from ERNAP by selecting the "exit ERNAP" option in the pull down menu. After the user completes all the audits that were selected earlier, the expert system CLIPS, analyzes this information and compares it with the standards database. Based on its analysis, it provides the user with suggestions. The analysis is based on existing models developed by researchers, the National Institute of Occupational Safety Hazards and the Occupational Safety and Health Administration. This information about its findings and its suggestions is presented to the user, as shown in ([Figure 8-5, appendix](#)).

The Expert System module helps update the database, based on new research. Specific information is provided to the user about the operations that were under audit. ERNAP shows the results of the audit to the user when requested. ERNAP also saves this information in a file. This information from the file can also be printed by selecting "print audit" from the pull down menu.

## INSTALLATION AND SYSTEM REQUIREMENTS

ERNAP requires a IBM-PC compatible - 486 with SVGA monitor running MS Windows 3.1 and having at least 4MB RAM. However, it is recommended to have 8MB RAM. It has been designed to run in the 640 x 480 resolution, but can adapt to the 1024 x 780 resolution. ERNAP can be installed from the CD-ROM by either double clicking the "setup.exe" under the ERNAP directory, or by running "setup.exe" directly from the File manager (or Program Manager) from within the windows environment.

## DISTRIBUTION

ERNAP shall be available with the CD-ROM for E-Guide, the *Human Factors Guide for Aviation Maintenance*.

## REFERENCES

- Meghashyam, Gopinath** (1995). A Computer based Ergonomic Assessment System for Manual Material Handling. *Master's Thesis*, Dept. Of Industrial Engineering, Clemson University.
- Pusey, Edward** (1994). A Computer based Ergonomic Assessment System. *Master's Thesis*, Dept. Of Industrial Engineering, Clemson University.
- Drury, C. G.** (1994). Ergonomics on the hangar floor. *Proceedings of the Human Factors and Ergonomics Society 1994*.
- Prabhu, P. and Drury, C. G.** (1992). A framework for the design of the aircraft inspection information environment. *Proceedings of the Seventh Federal Aviation Administration Meeting on Human Factors Issues in Aircraft Maintenance and Inspection*, Atlanta, GA, 83-92.
- Latorella, K. A. and Drury, C. G.** (1992). A framework for human reliability in aircraft inspection. *Proceedings of the Seventh Federal Aviation Administration Meeting on Human Factors Issues in Aircraft Maintenance and Inspection*, Atlanta, GA, 71-82.
- Drury, C. G., Prabhu, P. and Gramopadhye, A.** (1990). Task Analysis of Aircraft Inspection Activities: Methods and Findings. *Proceedings of the Human Factors Society 34th Annual Conference*, Santa Monica, California, 1181-1185.

## APPENDIX

  
**Figure 8-1:** Begin a "New" or "Open" an Existing Document

  
**Figure 8-2:** Main ERNAP Screen

  
**Figure 8-3:** Sample Module of Ergonomic Evaluation

  
**Figure 8-4:** Example Questions

  
**Figure 8-5:** ERNAP Analysis

**Table 8-1:** Classification of Modules in ERNAP

Human Factors Grouping	Pre-Maintenance Phase	Maintenance Phase	Post-Maintenance Phase
Information Requirements	1. Documentation 2. Communication	6. Documentation 7. Communication	23. Buy-back
Environment Characteristics	3. Visual 10. Thermal Perception 11. Auditory Characteristics	8. Task Lighting 9. Thermal Characteristics	
Equipment/ Job Aids	4. Equipment Design 5. Access Equipment	12. Equipment Availability 13. Access Availability	
Physical Activity/ Workspace	14. Hand Tools 15. Force Exertion 16. Manual Materials Handling 17. Vibration 18. Repetitive Motion 19. Physical Access 20. Posture 21. Safety 22. Hazardous Materials		

