Chapter 7. Ergonomics

The purpose of this chapter is to provide an overview of the relationship of ergonomics to the other elements of a typical human factors program. The objective will be to provide the user with the resources to identify ergonomics-based interventions to human performance problems encountered.

In the United States, the terms “Human Factors” and “Ergonomics” are often thought of as being synonymous. However, there are many who distinguish between the two by saying that “human factors” deals with the psychological and social aspects of a given work situation, e.g., sensation, perception, motivation, reaction time, and “ergonomics” deals with the more physical aspects of the situation, e.g. lifting, repetitive motion, awkward postures.

Ergonomics as defined in [Chapter 2] of this specification is:

"The applied science having the objective of adapting work or working conditions to enhance performance of the worker."

The primary focus of ergonomics is on the recognition that humans have physical and psychological characteristics that must be considered if the human is to be effective in the performance of his/her job. There are a number of benefits to applying ergonomics toward solving workplace problems:

Most, if not all work situations involve some interplay between physical and psychological issues. Humans may work in groups that have to deal with deadline pressures, awkward postures, external stressors, poorly written procedures, and the inadequate tools**.**

Working to increase the “fit” between the workers and the work using just physical ergonomics, or just psycho/social human factors, will not address all of the contributing factors to the problems within a given situation.

Every work situation has constraints attached to it. There may be no way to change a procedure, or it may be cost prohibitive to change the type certificate of an aircraft to make maintaining it more “user friendly.” Using a more “holistic” approach allows the freedom to deal with constraints by looking at the physical, psychological, and social parts of the problem.

As an illustration, a problem that may manifest itself in an “ergonomic way,” (workers who must get in to awkward postures to lift heavy items), may be caused by a “human factors” issue (an organizational culture that does not allocate resources to maintain equipment to aid in accomplishing the task with less physical effort).

7-1. Needs Assessment/Analysis

Ergonomic analysis often includes discussions of models of system performance such as the **Software-Hardware-Environment-Liveware (SHEL)** (International Civil Aviation Organization - ICAO Circular Human Factors Digest No. 1 "Fundamental Human Factors Concepts", Circular 216-AN/131) [DeGreen70], or People-Environment-Actions-Resources model.[Johnson98]. These models help to explain the many factors that can have an impact on how and why we do what we do. These types of models can be very useful in analyzing and working to resolve current problems. Often, the term **"ergonomic audit"** is used to describe the process of evaluating the human factor/ergonomic influence in a situation. Ergonomic audit can also be taken to mean that some form of problem or undesirable condition has been identified and an audit has been undertaken to find possible intervention or prevention strategies.

Human Factors/Ergonomics professionals look at a problem from two viewpoints in order to determine whether to *fit the job to the person and or fit the person to the job.*

Whether using a "model" for the basis of an analysis, or just looking for some kind of structure to help get started, there are several relevant categories that should be understood when trying to apply ergonomic interventions:

- The People Involved: How do people interact and behave in groups in relation to the work process and task?
- The Tools and Technology: How are tools and technology used? How do they affect the users' ability to do their job?
- The Organization: How does the organization affect the workers' ability to do their job?
- The Work Processes: How do the written procedures and norms affect people and the quality of the work products?
- The Task: How does the task affect the workers' ability to do their jobs?
- The Environment: What affect does the physical environment have on the workers and the job?

7-2. Ergonomic Goals

The goals of ergonomic interventions should be understood and identified. The goals of the ergonomic audit should be to determine the benefits of an intervention. It should be noted that the goals of an ergonomic intervention are not one-dimensional; i.e., several objectives may be achieved through an intervention. A few possible objectives for the intervention could be:

- Reduced error
- Fewer injuries or illness
- Fewer health problems
- Increased productivity
- Higher quality

7-3. Ergonomic Interventions

Ergonomic interventions can be categorized in a number of different ways, but should include consideration of the following elements:

- Reduction of work-related injuries and hazards
- Reduction of musculoskeletal risk factors including, but not limited to repetition, forceful exertion, awkward posture, vibration, mechanical stress, or static stress
- Enhancing safety in design of job aids and tasks
- Employing user-centered design principles
- Considering anthropometric factors in workstation design
- Considering primary senses (vision, hearing, taste, smell, tactile)

7-4. Ergonomic Intervention Example

The best way to illustrate how a set of ergonomic interventions can be applied is to provide an example:

Inspector John Doe missed a crack on an inspection. This crack was later found and corrected. Traditional investigation into a mistake like this would stop at assigning blame to the inspector. An ***ergonomic audit*** *would take this inquiry further to analyze why the inspector failed to detect the crack. Investigative findings might include:*

- *There have been seven past cases of missed cracks at this work area*
- *The inspector involved was newly assigned to this particular fleet*
- *There were no safety rails around the aircraft in the area to be inspected*
- *The area to be inspected was on a part of the aircraft that was not easy to get to (the inspector got into an awkward posture to get as close as possible to the area)*
- *There was a lack of detailed procedures for this inspection*
- *The inspection was done under a tight deadline (overnight check, aircraft needed for revenue service the next morning).*
- *A single inspector performed the inspection with one 35-minute break for rest during an eight-hour shift*
- *Two of the seven inspectors on the crew had family problems that were not resolved-resulting in high absenteeism and increased workload for the remaining inspectors*
- *The aircraft was outside and it was quite rainy for the shift*

The application of human performance principles in this situation, using such models as SHEL or PEAR for instance, suggest ways of dealing with some of the problems that present themselves as well as the constraints of the situation:

7-4-1. People

Are a large percentage new to the work group?

What training are they given to help them become familiar with their new assignment?

Are procedures written to help newly hired or newly transferred workers do their job?

Is the pressure to get the aircraft out actual or perceived?

What, if any, Personal Protective Equipment (PPE) are the inspectors wearing?

What is the impact of the awkward postures on the inspector?

What are people limitations?

7-4-2. Tools and Technology

Is there a better way for inspectors to get up close to the area?

Are there tools to help inspect the area?

Is there a technology that could help make the crack more visible to the inspector?

What tools are available to help inspect the area?

What is the condition and calibration of tooling?

7-4-3. Organization

Is there pressure to get the aircraft out?

Is that pressure the result of unrealistic scheduling of the check or task?

Is there a requirement for safety rails?

What PPE is required?

Who purchases the PPE (the organization or the workers)?

Are there qualification requirements to complete the task?

7-4-4. Work Processes

Are inspection processes or procedures accurately documented and known by the workforce?

Does the inspection require use of written criteria to determine pass/fail?

Is it standard for the inspectors to perform the inspection outside?

Should workflow allow for more repetitive breaks or rotating personnel?

7-4-5. Task

Does this inspection need to be performed at this point in the check?

Is there a better place in the maintenance program for the inspection? (perhaps when the area is more completely disassembled)

Are there norms for doing this task that have not been explained to the new inspector?

Is the procedure an adequate depiction of the way the job is done?

7-4-6. Environment

Are there extremes in the weather during certain times of year or year round?

Can this work be done in another area where weather would not be as much of a factor?

Can this area of the aircraft be shielded from the elements while this work is being performed?

In the answers to these and more questions, people responsible for the implementation of human factors/ ergonomics interventions would be able to suggest several ways to reduce error and the risk of missing a crack. In doing so, they will also work to reduce the risk of injury.

Examples of ergonomic interventions in this case could include:

- Redesign the procedures using a group of inspectors both new and experienced with the fleet.
- A familiarization training module for people new to the inspection force or aircraft
- Design a new technology to enable inspectors to see the area and do close inspection from a safe and less awkward position
- Design a harness to provide the inspector with a safe support close to the work
- Inspect the area when it is more accessible
- Do the inspection in a hangar during a more in-depth check
- Design a canopy for the workers to be under if the work is performed outside; provide appropriate lighting for the task

An excellent starting point for ergonomic audit information is the FAA Human Factors Guide for Aviation Maintenance 3.0.[FAA98a] It provides an ergonomic audit checklist that can be a starting point for anyone desiring to begin a structured evaluation of the workplace.

7-5. Validation

After ergonomic interventions are identified and user-centered principles applied, then the applicability and effectiveness needs to be validated with a representative sample group. The most common ways to perform this validation are:

- User testing
- Organizational metrics

In user testing, a number of parameters must be considered to ensure that the testing is representative of the user population. Factors such as history with the system/task, training and qualifications, linguistic ability, knowledge level, age, gender, physical limitations and capabilities, and attitudes or motivation must all be considered when performing user testing. Failure to adequately identify one or more significant constraints may undermine the long-term effectiveness of the ergonomic interventions.

The ergonomic interventions may be tracked against reliable organizational metrics that can be directly tied to their implementation. Workplace injury, lost workdays, reduced re-work, reduced ground damage, etc., are all measurable with regards to the effects of ergonomic interventions.

7-6. Adoption

Often, the adoption of ergonomic interventions will be dependent on resource availability. Justification for resource expenditures may depend on a cost benefit analysis that can be made for adoption of the solution. If the intervention or prevention proposed has had the benefit of good user testing, then the business case is much easier to make. Benefits such as increased inspection accuracy, decreased task span-time, and reduced personnel injury exposure can make adoption of ergonomic interventions more easily justifiable.

7-7. Implementation

Implementation of ergonomic interventions should be coordinated through the various maintenance staff functions that they impact. If the ergonomic intervention is a “system” solution having broad-scale effect, then a structured system-wide approach will have to be employed to ensure consistent implementation and measurable results. If the intervention or prevention is more local in nature, affecting a shop or hanger, then the implementation can typically be coordinated through local management.

7-8. Evaluation and Measurement

Evaluation of the effectiveness of the ergonomic interventions or preventions again must be tied to reliable organizational metrics to monitor success and progress. If the chosen metrics do not reflect the desired results after a satisfactory time period has passed, then either the intervention or prevention strategies must be re-evaluated as to whether or not it was implemented correctly, or another strategy should be tried. The risk of this approach is that a continuous "de-stabilization loop" is established that may have negative system effects. The desire to "tweak" or fine-tune interventions must be resisted, or done only after it has been verified that a truly different intervention or prevention strategy is required.

See [Section 7-5], Validation, of this chapter for examples of organizational metrics that can be employed as measurement tools to gauge the effectiveness of ergonomic interventions or preventions. If existing metrics are judged to be deficient then another alternative is to perform site visits to directly observe the effects of the implemented strategy, or to utilize surveys to measure the workforce opinion of strategy effectiveness.

7-9. Feedback

As with all other elements of a human factors program, feedback is an essential element in the constant cycle of evaluation and improvement. Other sections of this specification have highlighted that feedback must be honest, timely, and acted upon in order for any program to be credible. The same holds true for feedback provided as part of the ergonomic intervention or prevention implementation process. Where the benefit is increased safety of people, or identified reduction in injury potential, then the feedback may be generated from the local area to the rest of the organization. Where the benefit is more system-wide in nature (as reflected in some organizational metric) then the feedback may be generated from a centralized management level out to the local workgroups. Either way, it is important to recognize that feedback is part of a continuous loop.