A MACROERGONOMICS TOOL FOR ASSESSING WORK SYSTEM PROCESSES: SYSTEMS ANALYSIS TOOL (SAT)

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A macroergonomics tool for assessing work system processes, the Systems Analysis Tool (SAT) is described. The seven-step methodology is discussed involving defining the problem and, developing and evaluating strategic systematic solutions. An evaluation scorecard which includes an Economic Advantage analysis is used to determine the cost/benefits of each proposed alternative or program solution based on direct and indirect costs and compensation. A decision criteria table is constructed providing a basis for a trade-off comparison of micro-ergonomic and macroergonomic alternative solutions. The benefit of the SAT is the integration of micro- and macroergonomic approaches for solving organizational problems. Work system changes implemented by companies that incorporate a macroergonomic, systems approach demonstrate positive results in minimizing negative health effects based on financial and indirect costs and improved employee and business unit effectiveness.

INTRODUCTION

Understanding the effects of organizational and work environment change requires a macroergonomic approach incorporating systems tools and processes. With a macroergonomics approach, systems tools and processes are used to develop strategic level criteria for the design of the work environment, and social & technical sub-systems that are congruent with the organizational mission. Unless directed by strategic level criteria, problem-solving tools such as ergonomic analysis for workstation or job design will do little to enhance organizational effectiveness. Prior research suggests that there is the potential for translating the findings from a macroergonomic approach into relevant office design and organizational planning interventions (e.g., Brill, Margulis, & Konar, 1984; Hendrick & Kleiner, 2002b; Hedge, Sterling, & Sterling, 1986; O'Neill, 1998; Robertson & O'Neill, 1994; Robertson & Rahimi, 1990).

Effectiveness, stress and performance problems are complex and multivariate in nature. Due to the characteristics of these problems, many of the underlying causal factors in an analysis of the work place may be under-identified or completely omitted. In addressing these multi-causal problems, various work environment change programs and intervention strategies are developed and implemented.

This paper will present a description of the Systems Analysis Tool (SAT) and the seven-step process. The goal of implementing this SAT methodology is to systematically assess work systems processes to not only identify problems within a system, but also to design for a purpose which focuses on the alignment of the sub-systems in supporting the goals of the organization.

THE SYSTEMS ANALYSIS TOOL (SAT)

The SAT is a modification of one proposed by Mosard (1982; 1983) which is based on earlier work in systems engineering by A.D. Hall (1969). There are seven steps to the SAT methodology, consisting of:

1. defining the problem
2. setting the objectives and developing an evaluation criteria table
3. developing alternatives
4. modeling alternatives
5. evaluating alternatives
6. electing an alternative
7. planning for implementation, evaluation, & modification.

Defining the problem

A high level of complexity is generally inherent to large-scale problems and issues. This in turn necessitates a formal, systematic analytical approach to problem definition (Mosard, 1982). Thus, step 1 in the systems analysis approach involves defining the problem. Warfield (1974) proposed an analytical tool that has proven useful in defining large complex problems, called a "problem factor tree," which develops the problem, sub-problems, and causal factors, including their interrelationships. In this process, the major problem is broken into smaller sub-parts (Mosard, 1982).

To develop a problem factors tree, the problem factors are precisely stated and carefully linked together through an iterative process (Mosard, 1982). The lower level problem factors in the model contribute to the major problem. Feedback loops may also be incorporated. Thus, the problem factor tree depicts a hierarchical, logical structure for understanding the elements of a problem.

A problem factor tree should incorporate causal factors and sub-problems that represent the integration of micro-ergonomic and macroergonomic office and job design issues. This initial step of the system analysis could be applied to developing an understanding of the technical and social sub-systems as well as the work environment sub-system. Other robust and valid systems tools that are based on socio-technical processes may be applied in concert with this particular system approach and model (Hendrick & Kleiner, 2002a, 2002b; Kleiner, 2002; Taylor & Felton, 1993).

Setting Objectives and Developing Evaluation Criteria

In step 2 the objectives and evaluation criteria are developed for use in selecting the best alternative for achieving the objectives. An "objective tree" is created as part of this process. An objective tree is a hierarchical, graphical structure of objectives that addresses the problems that have been identified (Mosard, 1983). The objective tree is created by first identifying the major needs, goals, objectives and sub-objectives. The objective tree is graphically depicted. The upper half of the tree consists of these identified goals, objectives and sub-objectives as well as the lower level objectives which contribute to the attainment of the middle level objectives. These, in turn contribute to the upper level needs or goals (Warfield, 1972). To facilitate the development of the objectives tree, the degree of interaction between objectives, constraints, and the persons/groups involved in the process should be analyzed (Mosard, 1982).

Developing Alternatives

Step 3 of the systems analysis approach involves developing alternative approaches to attaining the objectives and sub-objectives. Alternatives are defined as a specified set of activities, tasks or programs designed to accomplish an objective (Mosard, 1982). These alternatives and associated set of activities are shown on the lower portion of the objective tree, thus creating an objective /activity tree. Hybrid alternatives may be created which incorporate the best features of several of the initially identified alternatives.

After the objectives and alternatives are selected, a preliminary decision criteria table is developed. This criteria table is used to evaluate the usefulness of each of the alternatives as methods for accomplishing the objectives. Decision criteria typically include risks, costs, benefits, and measures of effectiveness, which are based on short-term and long-term perspectives (Mosard, 1982; 1983).

Modeling the Alternatives

The fourth step of the systems analysis approach is modeling the alternatives. A descriptive or predictive model representing each alternative set of activities (or representing the entire system must be presented. This is accomplished in such a way as to allow alternative configurations of the systems to be analyzed. The system element interrelationship and/or gross resource requirements is depicted in order to determine the effectiveness of each alternative set of activities as well as other consequences (Mosard, 1983). There are many possibilities of modeling techniques that may be utilized, such as flow charts, simulation, and system dynamics modeling.

One model that may be used is the input-output flow diagram (Mosard, 1982). This is a simplified modeling technique that allows alternative configurations of the system to be analyzed. In utilizing the input-output flow diagram, the inputs consist of people, resources, and information, and the outputs are the results and products. These outputs can, in themselves, become the sources of inputs to other subsystems, and thus extend the diagram to fully represent the entire system being analyzed. There are two phases for this model: the redesign phase and the operation phase. There are many inputs for phase I which may include human resources and funding. These activities for each respective redesign project or program are listed. At the end of the redesign phase, the outputs become the inputs for the second phase -- the operation phase. For example, in a job redesign program, managers and employees have acquired new skills and the jobs have been analyzed and redesigned. In phase II, the managers and the employees will now interact within their own work system and the results of these interactions are presented in the outputs (e.g., increase in performance, decrease in job stress, decrease in litigation cases and worker's compensation cases). Overall, these outputs fall in the categories of changes in employee behaviors, organizational factors, and reduction in business costs.

Evaluating the Alternatives

Step five of the systems analysis methodology is evaluating alternatives. This is accomplished by measuring and comparing each alternative set of activities utilizing the major decision criteria. These criteria include: project cost, risk of failure, effectiveness, and benefits for all appropriate future conditions. In this study, an evaluation criteria scorecard is developed for use in evaluating and comparing alternatives. The scorecard is based on a long-term perspective and incorporates the preliminary decision criteria that were defined earlier.

To complete a comprehensive cost/effective analysis in this step, an Economic Advantage analysis is conducted. The Economic Advantage analysis identifies costs/benefits categories and measures to provide a high level economic analysis for each alternative and its potential financial impact (O'Neill, 1998, Oxenburgh, 1997; Robertson, Robinson, O'Neill, & Sless, 1998). This analysis further provides the detail which links the costs for each internal micro-macro work environment program and/or feature of the physical work environment to the potential leverage in the investment in compensation for the employees receiving the improved environment.

The economic advantage analysis identifies costs and effectiveness metrics, including: 1) Human Resource costs: (e.g., compensation, salary; turnover and absenteeism, workers' compensation costs, injury costs); 2) Facilities costs: (work environment), (e.g., rentable space, operating costs, annual facility costs, furniture investments, technology & information investments, work environment strategy costs, construction costs); and 3) Effectiveness measures: organizational (e.g., process efficiency), work environment changes, customer satisfaction, space utilization; unit/department (e.g., product development time, successful projects, number of customers; group and individual (e.g., error rates, amount of completed work, quality) (Robertson, et al., 1998). These costs/benefits metrics are used for each proposed alternative to determine the economic advantage of each alternative or program/activities as may be expressed as a percentage of annual compensation demonstrated over "X" years.

Selecting an alternative

In this step, the importance or weight as specified in a future condition state is establish for each of the evaluation criteria. These weighting values are based on either objective or subjective measures. A decision table is created structuring the evaluation information. The alternatives are listed on the "y" axis and the future condition statements are on the "x" axis. A probability is determined for each of the stated future conditions. An example of a future condition is the probability and level of funding for the program. Thus, each alternative would be evaluated in terms of level of funding and the probability of being funded.

Implementation, Evaluation, and Modification

Several activities occur in this step in order to define, establish and develop the evaluation processes of providing feedback to the organization regarding the results of the work environment-macroergonomic program. Using the information gathered from the evaluation and feedback processes, selected modifications to the program should occur. This process is viewed as a continuous feedback loop applying the systems analysis approach to solve problems and to measure the effectiveness of the selected program. At this stage of the systems analysis, a schedule and a sequence of tasks, responsibilities and requirements should be developed for the implementation activities. This schedule might include a contingency plan with scheduled decision points and decision responsibilities. There are several scheduling techniques that are available that can be used as well as various database software for creating new databases containing effectiveness measures, costs, and other pertinent metrics collected during the systems analysis.

CONCLUSION

This paper describes a systems analysis tool (SAT) with a seven-step methodology that can be used to assess work system processes based on a macroergonomic approach. In applying SAT, salient variables that influence employee health, stress, and performance can be identified. Typically, companies focus on atomistic solutions for reducing work system problems. This results in narrow short term and ineffective solutions. The important benefit of the SAT described in this paper, is the effective integration of micro-ergonomic and macroergonomic approaches for solving organizational problems. This analysis assists strategic and organizational planners in evaluating alternative programs designed to address the identified objectives and problems based on direct and indirect economic metrics. Strategic companies are now determining how to allocate corporate resources to address work system problems, due to rising health and operating costs and recent state and federal legislation.

Applying this systems analysis approach can enhance an organization's competitive edge by improving the interaction and fit of the office worker, the job, and the physical environment, resulting in a more healthful and effective work environment.

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