OFFICE ergonomics

Analyzing the Problem & Creating Solutions

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Traditionally, employers have approached ergonomics issues related to the office environment by focusing on individual workstation components such as the keyboard, monitor, work surface or chair. Although such features are important, tackling ergonomics issues related to office environment design requires a systems viewpoint.

A systems approach entails analysis of other physical environmental aspects (e.g., layout, storage, adjustability); job characteristics (e.g., job demands, pacing); organizational context (e.g., career path, shiftwork, job security); technology characteristics (e.g., computer interface design, screen design); and psychosocial variables (e.g., job control, decision-making latitude, participation). These factors impact individual, group and organizational performance (Smith and Carayon-Sainfort 67; Robertson and Rahimi 55; O'Neill 1; Sauter and Swanson 3). Understanding their interrelationships and their potential influences on health, stress, work and organizational goals helps the safety practitioner develop potentially more-effective solutions for office-environment-related problems.

One successful systems analysis approach is the seven-step, systems analysis tool (SAT) developed by Mosard (81). The tool produces a series of diagrams, flowcharts, criteria tables and resource models, as well as a cost/benefit table, schedule and evaluation metrics. To illustrate one approach to systems analysis, this article presents a modified SAT, based on the work of Mosard (81) and Hall (156). The modified tool guides development of alternative solutions by evaluating the cost-benefit of each; selecting and implementing solutions; and providing feedback and measurement of improved worker performance.

APPLYING AN SAT: UNDERSTANDING OFFICE WORK SYSTEMS

The SAT should be applied at the strategic business unit or departmental level, where specific objectives and issues are identified. (Individual and group needs may also be identified at this point.) The seven SAT steps are:

1) Define the problem: The Problem Factor Tree.

2) Set objectives, develop an evaluation criteria table and devise alternatives: The Objectives/Activities Tree.

3) Model alternatives: The Input-Output Flow Diagram.

4) Evaluate alternatives: The Criteria Scorecard and Cost/Benefit Analysis.

5) Select an alternative: The Decision Table of Future Conditions.

6) Plan for implementation: Scheduling and Management Project Flow.

7) Evaluation, feedback and modification process.

Step 1: Define the Problem

The problem factor tree (PFT) attempts to describe the problem, sub-problems and likely causal factors, as well as their interrelationships, in a logical hierarchical structure. To develop the PFT (Figure 1), the analyst assumes that the major office work system problem is a composite of typical office work performance issues such as an increase in turnover, lost workdays and workers' compensation (WC) claims and a decrease in performance and effectiveness related to technology and work systems design (Hedge, et al 419; Hendrick 713; Kuorinka and Forcier 1; Amick, et al 97). Psychological and physiological stressors are present as well (Smith and Carayon-Sainfort 67; Moon and Sauter 1; Westgaard 75). Arrows in the diagram indicate the direction in which causal factors contribute to the major problem.

Psychological stressors can be subdivided into psychosocial disturbances and perceived lack of environmental control (Karasek and Theorell 1; O'Neill 1; Moon and Sauter 1; Robertson and O'Neill 517). Further investigation of possible causal factors (depicted at the base of the tree) reveals more-specific contributors related to lack of job content, and poor job and workstation design (Moon and Sauter 1; Amick, et al 97; O'Neill 1).

Job content and design are the main elements of the social sub-system, and several related individual- and group-level factors (shown in the middle of the tree) are further identified. Suspect job design components may include teamwork or collaboration problems at the departmental level (such as cross-functional teams) or at the individual level (such as work pace).

Visual and musculoskeletal discomforts are among the many sub-problems that can arise with regard to physiological stress (Grieco, et al 1). Screen design, work-

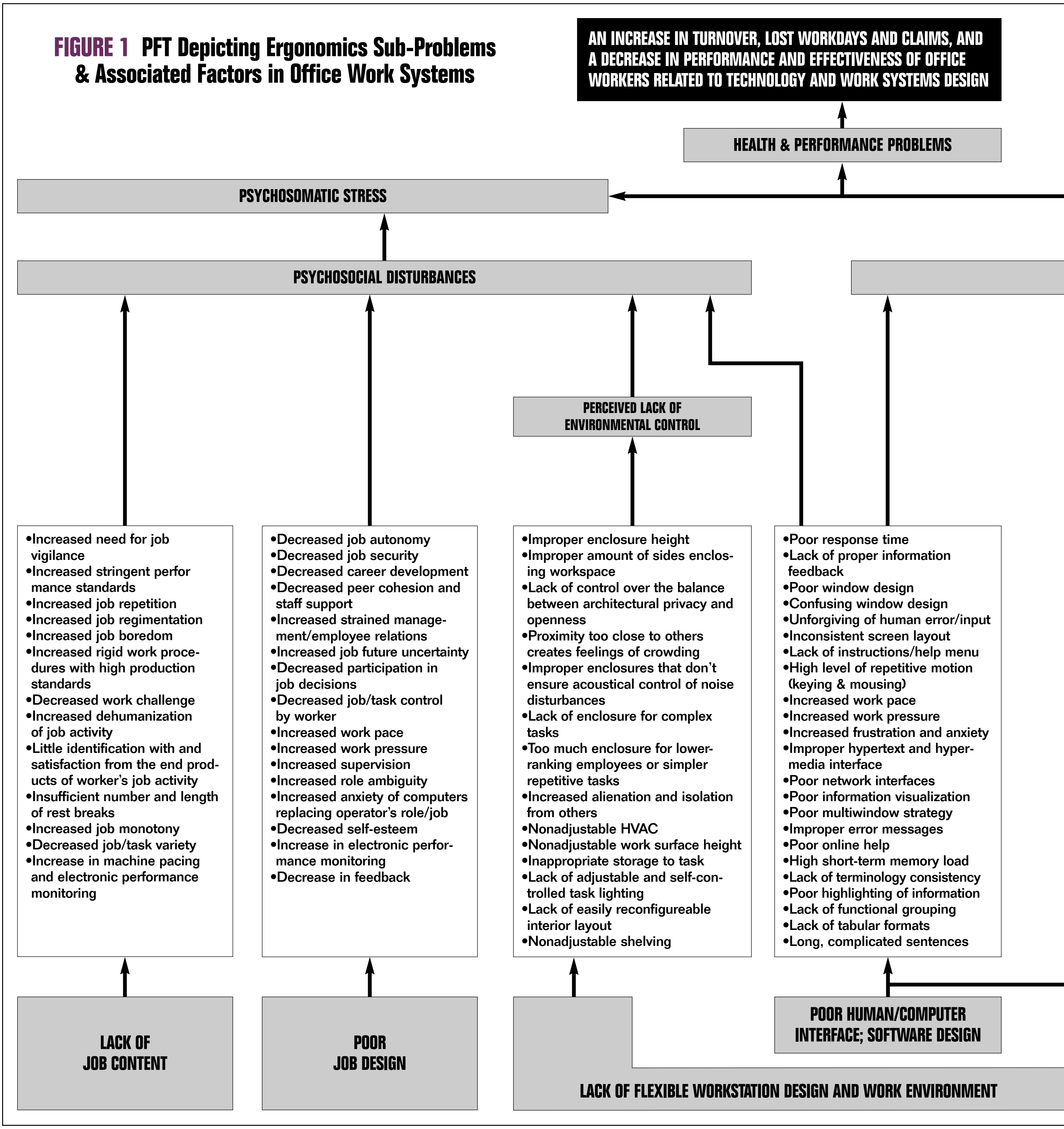


FIGURE 1 PFT Depicting Ergonomics Sub-Problems & Associated Factors in Office Work Systems

station design and configuration, and flexibility issues further contribute to both sub-problems (Smith and Cohen 11637).

Step 2: Set Objectives & Develop Alternatives

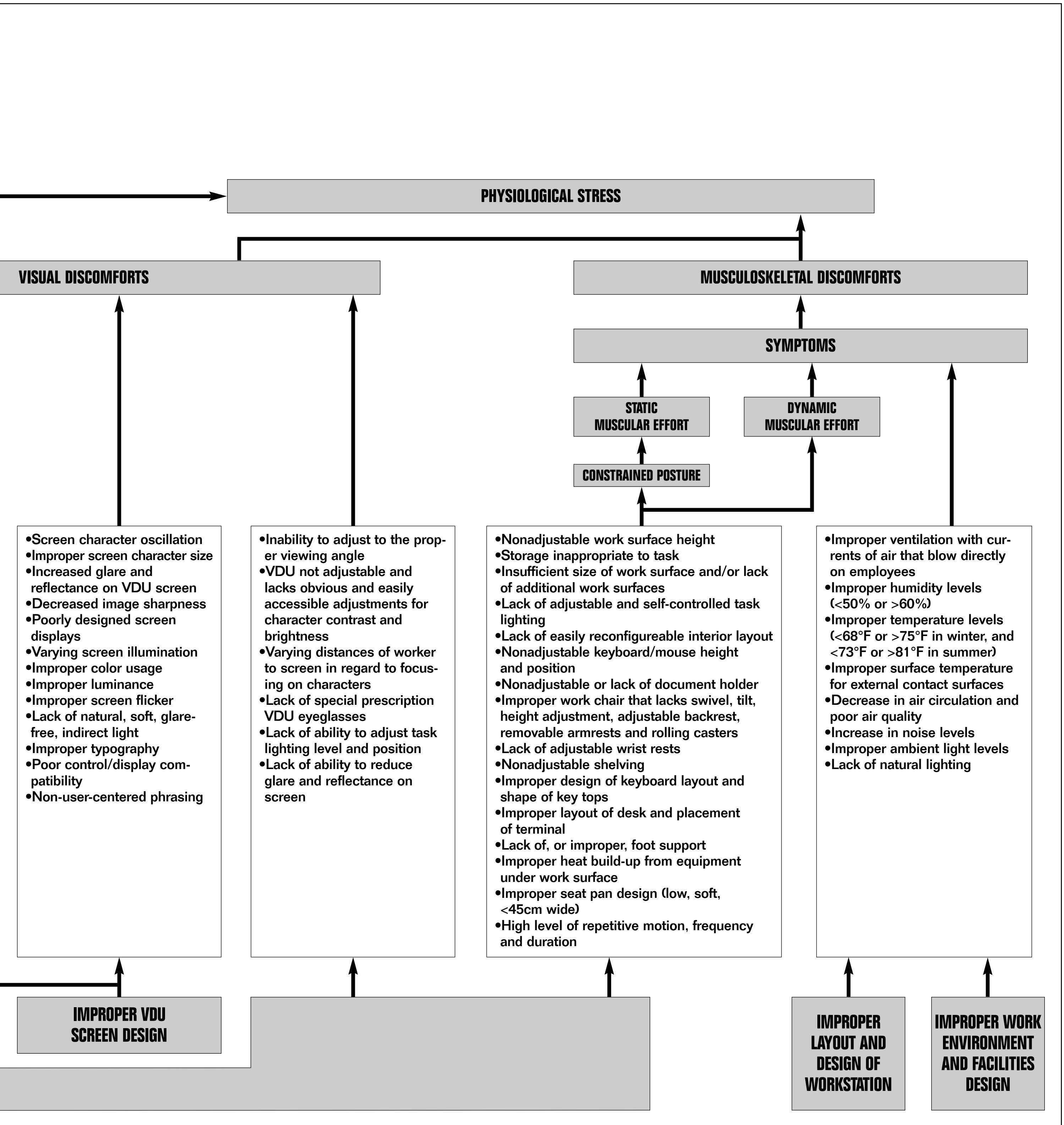
Once the problem is defined, overall program goals, objectives and intervention strategies are developed. The objectives/activities tree (OAT) is a hierarchical, graphical depiction of objectives and solution alternatives developed to address problems identified in the PFT.

To create the OAT, the analyst first proposes major program needs, goals and objectives (as illustrated in the upper half of Figure 2).

For instance, in this example, the major need is to "decrease turnover, lost workdays and WC claims, and to increase worker performance and effectiveness by improving work systems design." The objective is to "reduce physiological and psychological stressors."

Next, four possible solution alternatives are identified. These include redesign of the job and its content (A); ergonomic redesign of the workstation and environment (B); and two hybrid options that incorporate one or more of these along with training and technology-transfer components (C and D). The analyst may create such hybrid options to incorporate the best features of initially identified options (in this case, A and B).

Several potential associated activities or action steps are then proposed for each



alternative (lower half of Figure 2). These solution alternatives and related activities are based on case studies, field research and longitudinal studies; they represent approaches that have been used by companies to achieve the major objective listed at the top of Figure 2 (Smith and Carayon-Sainfort 67; Robertson, et al 984; O'Neill; Sauter, et al 1).

In step 5, one solution alternative is selected and becomes the sub-objective in the OAT.

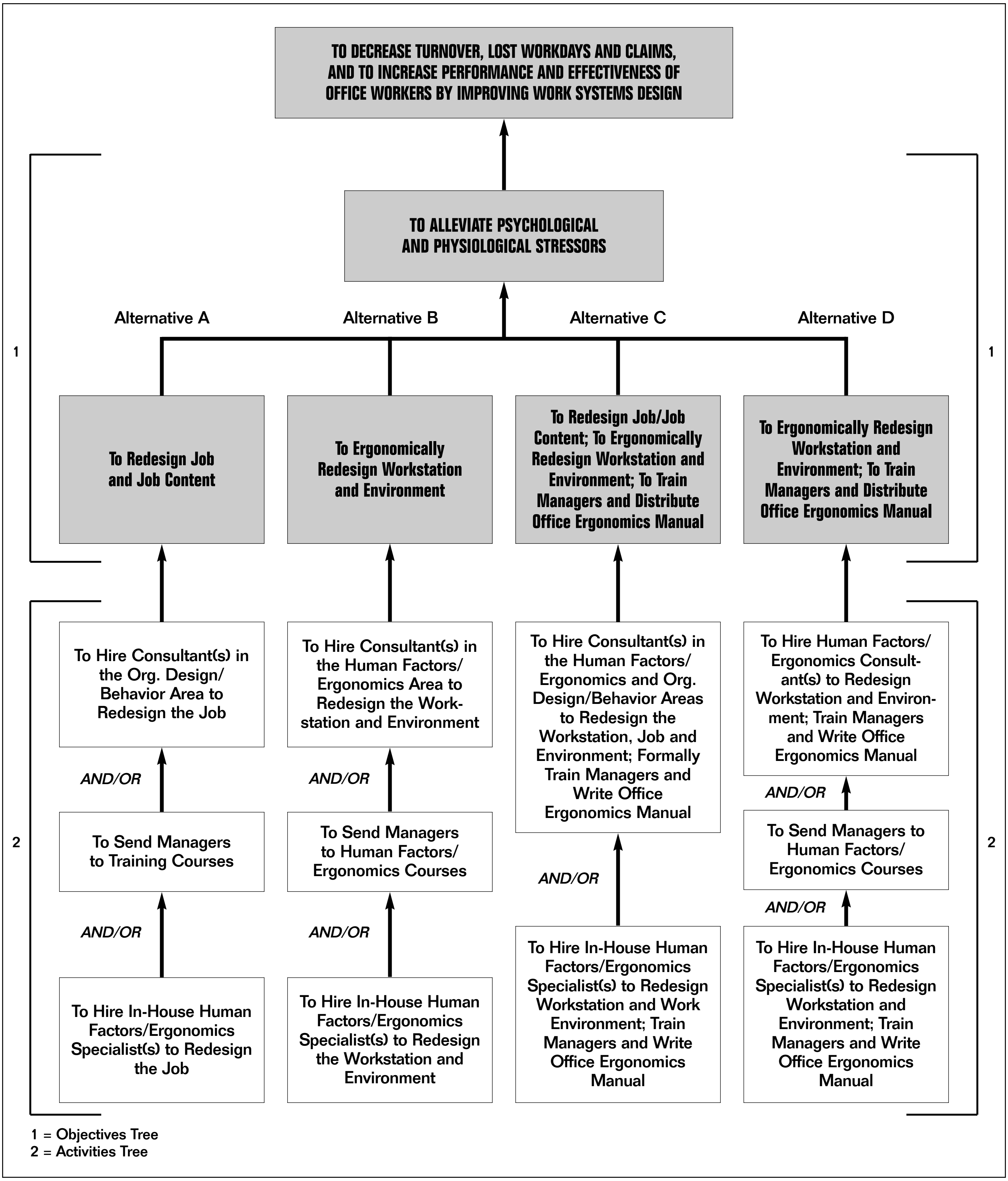
Step 3: Model Alternatives

In this step, each alternative and its associated activities are modeled in order to estimate gross resource requirements and assess potential effectiveness. Typically, a descriptive or predictive model is used; common modeling techniques include flowcharts and simulations.

For illustration purposes, Figure 3 presents an input-output flow diagram (IOFD) (Mosard 81). The inputs are resources—such as people, funds and information—that will likely be needed to implement a solution and set of activities. Outputs are the results or products of the activities. As Figure 3 shows, some outputs become sources of inputs to other sub-systems, which permits a more-complete representation of the entire system.

The IOFD consists of two phases: redesign and operation. Redesign phase inputs include contributions from two general areas—human and financial resources. The human resources compo-

FIGURE 2 An Objectives/Activities Tree



nent encompasses individuals such as industrial psychologists, managers, employees, human resource managers, ergonomists, facility operations, trainers, and safety and health managers.

Outputs from the redesign phase become inputs for the operation phase. For example, in the job redesign program, managers and employees have acquired new skills, and jobs have been analyzed and modified. In phase two, managers and employees interact within these redesigned work systems and the results of these interactions are presented as final outputs (e.g., increases in performance, decreases in job stress, lost workdays and WC cases). These outputs can be generally grouped into one of three change categories: employee and group behaviors, organizational factors and reductions in business cost.

Step 4: Evaluate Alternatives

At this point, each modeled alternative and its associated set of activities is evaluated according to several major decision criteria (e.g., project cost, risk of failure, potential effectiveness, benefits for all appropriate future conditions); these criteria may include both short- and long-term perspectives.

Table 1 presents an example evaluation criteria scorecard for use in evaluating the four alternatives originally proposed in Figure 2. For illustration purposes, each criterion is assigned equal weight, and their sum provides an overall rating. Weighted criteria could be assigned to each alternative based on the importance of each criterion.

An economic advantage analysis is then performed to assess the cost-effectiveness (cost and benefits) of each alternative (Robertson and Rahimi 55; Robertson, et al, 984). Key metrics include:

1) human resource costs such as compensation, salary, turnover and absenteeism, WC costs and related injury costs;

2) facilities costs such as rentable space, operating costs, furniture investments, technology and information investments, work environment strategy costs and construction costs;

3) effectiveness measures such as: organizational (process efficiency, work environment change, customer satisfaction, space utilization); unit and departmental (product development time, successful projects, number of customers); and group and individual (error rates, amount of completed work, quality). Output from this analysis is expressed in terms of the potential benefits of a particular alternative and is typically expressed as a percentage of the annual investment in human resources demonstrated over "X" years.

TABLE 1 Cost/Benefit Analysis[1]

ALTERNATIVES	PROJECT COST	RISK OF FAILURE	EFFECTIVENESS	BENEFITS	OVERALL RATING
ALTERNATIVE A: Redesign Job/ Job Content Ratings:	-3 ($175,000)[2]	-2	+5	+6 (10%)[3]	6 (Moderate)
ALTERNATIVE B: Ergonomically Redesign Workstation and Environment Ratings:	-4 ($370,000)[2]	-3	+5	+6 (10%)[3]	4 (Moderate)
ALTERNATIVE C: Redesign Job/ Job Content, Ergonomically Redesign Workstation and Environment, Train Managers and Distribute Manual Ratings:	-8 ($590,000)[2]	-1	+9	+9 (26%)[3]	9 (High)
ALTERNATIVE D: Ergonomically Redesign Workstation and Environment, Train Managers and Distribute Manual Ratings:	-6 ($440,000)[2]	-2	+7	+8 (17%)[3]	7 (Moderate/High)

[1]In the four categories of Effectiveness, Risk of Failure, Cost and Benefits, each alternative (A through D) was subjectively rated on a scale ranging from 0 to 10 or 0 to -10. Since Risk of Failure and Project Cost are potentially negative characteristics, the rating scale ranged from 0 to -10. Effectiveness and benefits are positive outcomes and, therefore, were rated on a 0 to 10 scale. The scores for each category were summed to determine the overall rating for each alternative. Along with the numerical ratings, Table 1 shows subjective descriptors of the ratings in parenthesis (in the Overall Rating column). It also provides estimated project costs, anticipated net changes in employee productivity and descriptive labels for overall ratings in parenthesis.

[2]Cost per 100 employees. [3]Benefits are evaluated in terms of percent-increase in worker productivity.

TABLE 2 Decision Table: Selecting an Alternative

FUTURE CONDITIONS (e.g., funding) Probability of Funding	HIGH LEVEL OF FUNDING 0.5	MODERATE LEVEL OF FUNDING 0.25	LOW LEVEL OF FUNDING 0.25
ALTERNATIVE A Ratings[1]	3	2	1
ALTERNATIVE B Ratings[1]	4	1	2
ALTERNATIVE C Ratings[1]	1	4	4
ALTERNATIVE D Ratings[1]	2	3	3

[1]The numbers indicate the selection preference rankings based on the probability assigned criteria and the overall rating scores for each alternative from Table 1.

Step 5: Select An Alternative

This step involves creating decision tables. Each table includes an assessment of the alternatives according to the probability of a future condition within the organizational environment. Table 2 presents a decision table that uses the available level of funding (or budget) as the future condition along with the expected probability of that condition.

Each alternative is then assessed against the level of the future condition (in this case high, medium or low available funds) and the probability of that level. For each future condition level, the analyst ranks each alternative, indicating a first (and subsequent) choices. According to Table 2, when available funding is high, a more-comprehensive, aggressive alternative is preferred; when funding is low, less-ambitious approaches may be more realistic. The alternative that emerges as the winner at this point then becomes the sub-objective in the OAT and proceeds to implementation.

Step 6: Implementation

Now, the analyst develops a traditional project schedule and sequence of tasks, responsibilities and requirements. The schedule may include a contingency plan with decision points and corresponding responsibilities. Several familiar scheduling techniques, as well as various software programs, can be used to facilitate this process.

Step 7: Evaluation, Modification & Feedback

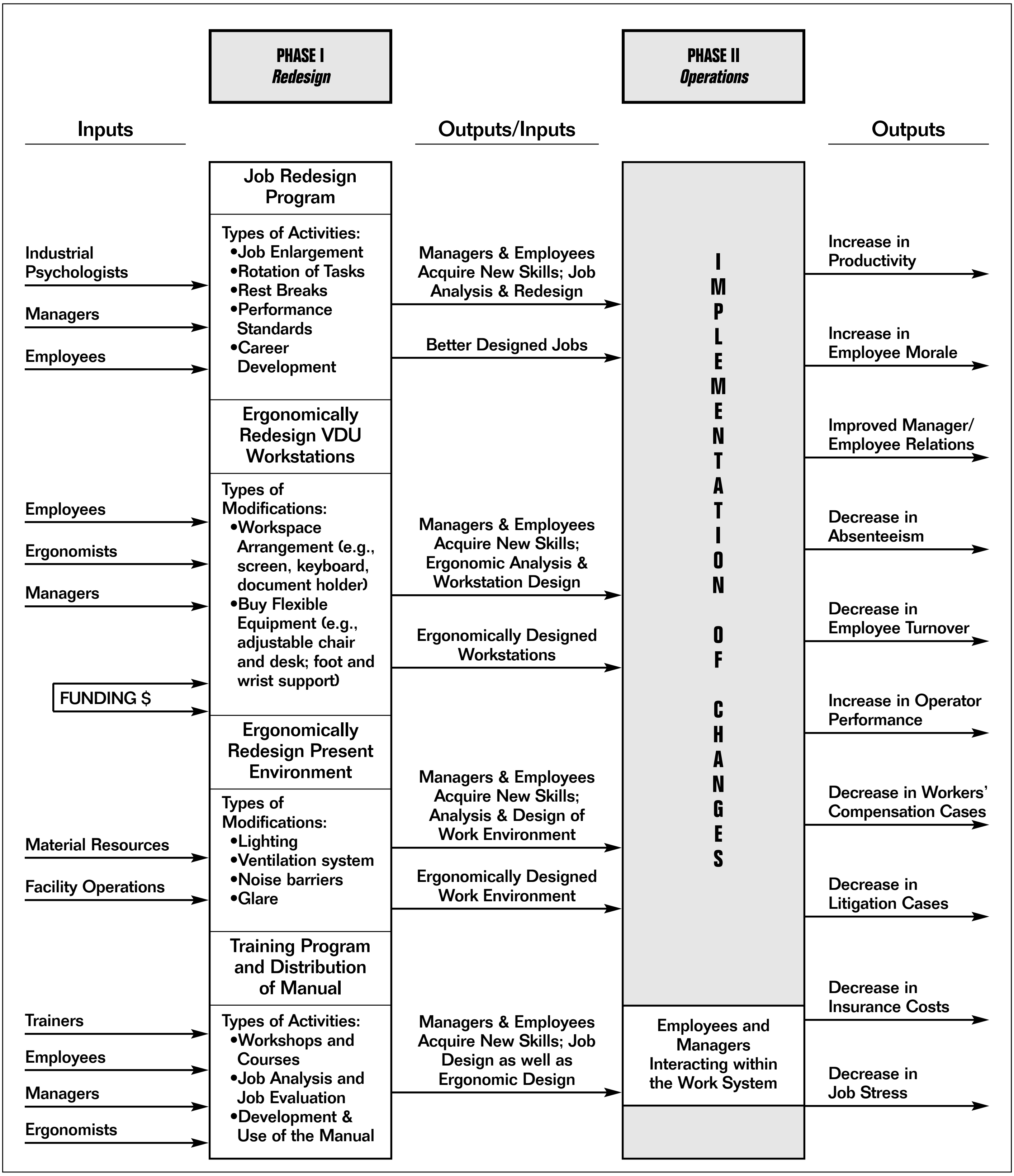
Activities at this point help define, establish and develop the evaluation processes that will provide feedback on the results of the selected intervention. This process includes five levels (Table 3). This evaluation measurement model has been widely used in industry (Gordon 1; Oxenburgh 150).

A multidisciplinary team ensures a diversity of viewpoints and critical inputs when developing evaluation measures for each level. This team may include representatives from human resources, finance, occupational safety and health, risk management, facilities, information services and engineering.

Specific measures are defined at each evaluation level. Some may already exist within the organization; others will need to be developed. Table 3 provides examples of previously used measures (Gordon 1; Robertson and O'Neill 517). Via the evaluation process, the analyst can identify outcome measures that will most likely reflect the impact of the selected alternative. This critical information can then be provided to the program team, a management decision maker or the organization as a whole.

Feedback regarding program effectiveness begins the cycle of continuous improvement. Using information gathered, the analyst can assess, then implement, potential modifications. This is the

FIGURE 3 Inputs-Outputs Flow Analysis Model for Alternative C (redesign and operation phase)



process of applying the systems analysis approach to solve office ergonomics problems and measure the effectiveness of the selected alternative.

CONCLUSION

A systems analysis model facilitates decision making by enabling a company to thoroughly identify salient variables that affect safety and performance in the office environment. Traditionally, a reductionist approach—one that relies on narrow interventions to reduce specific stressors—has been popular. However, such an approach fails to consider the multi-variate nature of today's safety problems and, as a result, may produce less-than-optimal solutions.

The important benefit of the systems model described in this article is the integration and incorporation of a broader approach to solving office organizational problems. Companies are responding to rising costs of employment, including benefit costs, by allocating resources to address office-technology-related problems (Robertson, et al 984; O'Neill 1). The systems analysis approach can help an organization become more-competitive by improving the fit between office worker, job design and physical environment, and can promote a safer, more-efficient work environment. ■

TABLE 3 Evaluation Process: Five-Level Process & Evaluation Measures

LEVEL	EXAMPLES EVALUATION MEASURES
1) BASELINE ASSESSMENT	Measurements taken prior to implementing the intervention. These could include: • Safety and health performance indicators (e.g., lost workdays, absenteeism, frequency, severity rates). • Productivity data (e.g., individual performance, strategic business units, organizational performance, market share, customer satisfaction, balance scorecard. • Users' and managers' current skills, knowledge, abilities, attitudes and opinions.
2) REACTION	Users' and managers' reaction to the intervention, including managerial response. Measures could include: • Surveys. • Semi-structured interviews. • Users' perceptions of the usefulness and relevance of the intervention to their job.
3) LEARNING	Users' and managers' degree of learning (knowledge, skills and abilities). Measures could include: • Surveys (same as pre-knowledge). • Semi-structured interviews. • Observations; attitude change; opinions.
4) PERFORMANCE	Users', managers' and business unit performance. Measures could include: • Surveys; self-reported performance, perceptions, intent of behavior changes. • Semi-structured interviews: attitude, behavior and productivity changes. • Observations: Behavior changes; team performance changes (collaboration and communication). • Unit or departmental performance measures (e.g., products, project completion; quantity and quality of service).
5) ORGANIZATIONAL RESULTS	Performance and productivity measures such as: • Safety and health performance measures (e.g., lost workdays, frequency and severity rates). • Strategic organizational performance measures (first to market, product innovation, customer satisfaction).

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