Measuring Safety's RETURN ON INVESTMENT

By SUSAN JERVIS and TERRY R. COLLINS

In today's competitive environment, both private industry and government agencies are challenged to decrease their overhead costs and operating expenses. Often, safety programs are included in these cutbacks. As a result, safety managers at these facilities may be faced with difficult decisions regarding the best way to implement and maintain effective safety and health programs within the limitations of scarce resources.

Similar fiscal challenges are faced in many organizations—even some that participate in OSHA's Voluntary Protection Programs (VPP), who fear they may lose their coveted Star status because of forced cutbacks (Finnegan 13). To address such situations, safety managers need a decision tool to help determine which safety program elements offer the best return on investment (ROI).

BACKGROUND & OBJECTIVE

To develop such a tool, a model safety management program that is recognized as both effective and comprehensive must be identified. In the authors' opinion, VPP is the most-viable candidate for such a model. This program is generic and can be successfully applied to any type of organization or industry. Once program requirements have been implemented, VPP represents the most-comprehensive safety and occupational health management system approach described within OSHA guidance. VPP also encompasses elements of other systems approaches that are identified in various OSHA guidelines and standards (Redinger and Levine 575).

VPP embodies several well-known management practices that apply equally as well to safety management or general business management. In fact, the similarities between effective safety programs and successful financial and quality programs are striking. In financial rankings compiled by *Forbes* in 1999, one can see a clear relationship between a company's excellence in safety and its excellence in productivity and financial results. Among those listed, 10 of the most-successful U.S. businesses were VPP participants (Laws 92).

Thus, the tool described here is based on the comprehensive model for a safety management system outlined in VPP. While participation in the program offers several benefits, some organizations may choose not to pursue formal VPP recognition. Nonetheless, many major VPP elements can be institutionalized to enhance any organization's safety program.

This article quantitatively examines the relative benefits and resource costs associated with these major VPP elements. Safety managers can then use this cost-benefit information to focus and direct their programs. To accomplish this objective, the analytical hierarchy process is used to rank the identified elements based on their benefit-to-cost ratio.

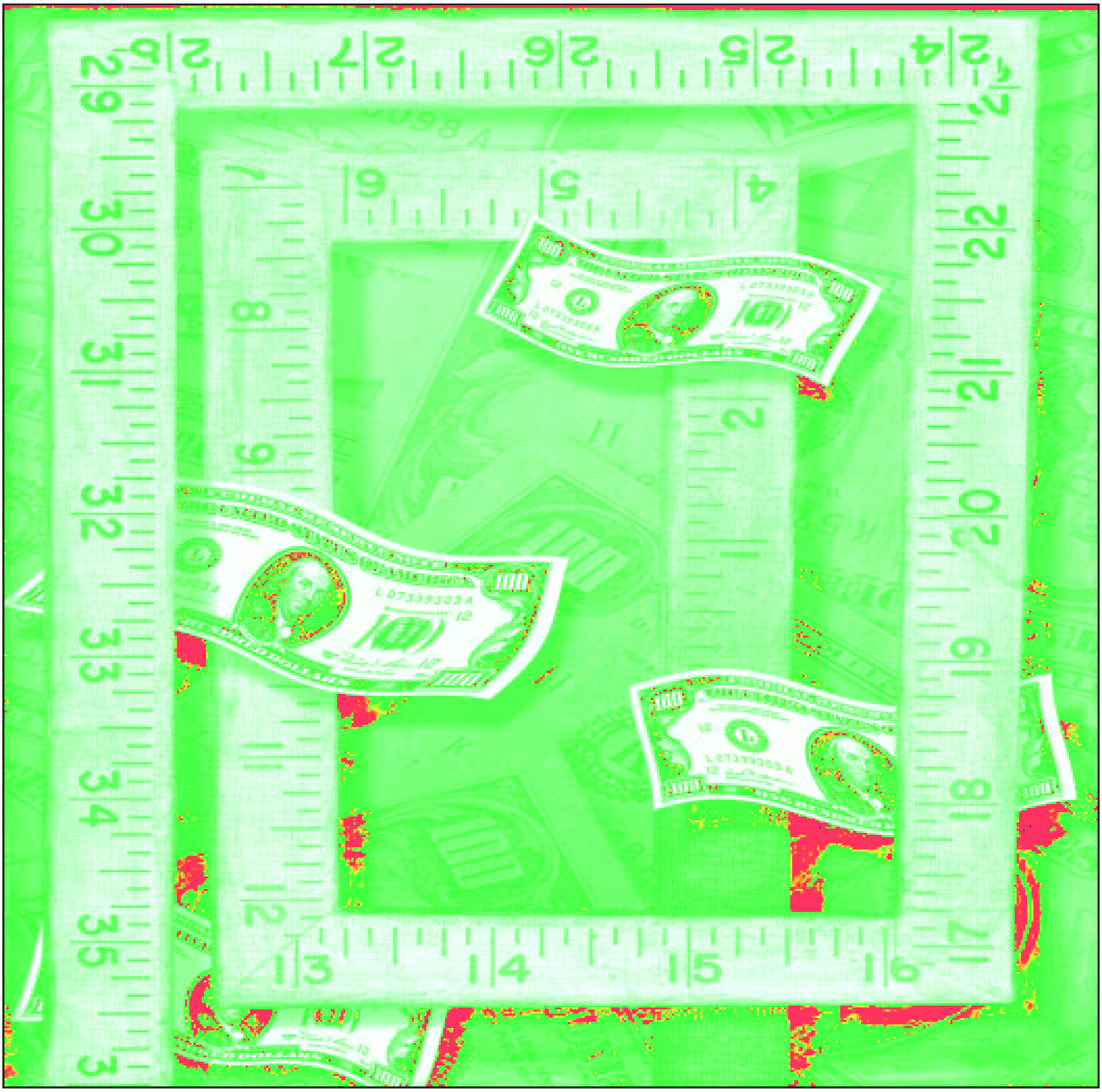
DEFINITION OF VPP ELEMENTS

VPP contains seven major elements; this article examines all except accident experience. In the authors' opinion, although accident rates are an integral aspect of VPP recognition, historic accident experience is an element that depends on successful implementation of the six managerial-type safety program elements which are the focus of this article. These are: management leadership and employee involvement; worksite analysis; hazard prevention and control; safety and health training; documentation review; and concurrence of bargaining agent. The baseline definition for each element was formulated from the subelements and tasks that OSHA provides as part of its VPP eligibility checklist (OSHA).

Management Leadership & Employee Involvement

Managerial commitment to safety, as well as top management's personal involvement in the safety program, characterize this element. To qualify, an organization must integrate safety and health concerns into the overall business planning cycle and must manage its safety program in the same manner as productivity and quality programs.

Under this element, a firm must have a written safety and health program that is both size- and industry-appropriate. The safety and health policy must also clearly assign safety and health responsibilities; such accountability must be documented for all levels of management—from top executives to line supervisors. Personnel must have adequate authority—and resources—to execute their assigned safety responsibilities. In addition, an organization must provide



the same level of safety protection it gives its employees to contract workers.

According to VPP requirements, employees must be involved in all aspects of the safety and health program. Additionally, the safety program must be audited annually; this audit should include review of written narrative reports, change recommendations, action plans and verification procedures.

Worksite Analysis

To qualify here, an organization must have a method—such as a comprehensive safety and industrial hygiene survey—to identify existing or potential workplace hazards. It must also have a procedure for conducting pre-use hazard analysis of new processes, materials or equipment. Toxic substances and noise must be monitored regularly.

In addition, a company must conduct quarterly self-inspections that include written documentation to track corrective action. The site should also employ routine hazard analysis procedures (e.g., job hazard analysis, preliminary hazard analysis) that ultimately result in improved work practices and procedures and/or employee training.

Under this element, an organization should have a written hazard reporting system that enables employees to share their safety-related observations with management without fear of reprisal. Any accident investigation conducted must include written documentation of findings. In addition, the organization should have a method of documenting all identified hazards and tracking them through control or elimination. Finally, the company must analyze trends for injury/illness experience and hazards in order to identify patterns and make appropriate adjustments.

Hazard Prevention & Control

According to these criteria, an organization must have access to the services of certified safety and health professionals. It should also use engineering and administrative controls to address site-specific hazards, and must track all efforts to correct these hazards.

FIGURE 1 Survey Form for Resources Comparison Between VPP Elements

	Item on Left Greater					Item on Right Greater				
	Extreme	Significant	Moderate	Slight	Equal	Slight	Moderate	Significant	Extreme	
Mgmt. Leadership & Employee Involvement			X							Worksite Analysis
Mgmt. Leadership & Employee Involvement		X								Hazard Prevention and Control
Mgmt. Leadership & Employee Involvement							X			Safety and Health Training
Mgmt. Leadership & Employee Involvement		X								Review of Documentation
Mgmt. Leadership & Employee Involvement			X							Concurrence by Bargaining Agent
Worksite Analysis		X								Hazard Prevention and Control
Worksite Analysis						X				Safety and Health Training
Worksite Analysis		X								Review of Documentation
Worksite Analysis			X							Concurrence by Bargaining Agent
Hazard Prevention and Control							X			Safety and Health Training
Hazard Prevention and Control				X						Review of Documentation
Hazard Prevention and Control						X				Concurrence by Bargaining Agent
Safety and Health Training			X							Review of Documentation
Safety and Health Training			X							Concurrence by Bargaining Agent
Review of Documentation							X			Concurrence by Bargaining Agent

FIGURE 2 Survey Form for Benefit Comparison Between VPP Elements

	Item on Left Greater					Item on Right Greater				
	Extreme	Significant	Moderate	Slight	Equal	Slight	Moderate	Significant	Extreme	
Mgmt. Leadership & Employee Involvement		X								Worksite Analysis
Mgmt. Leadership & Employee Involvement			X							Hazard Prevention and Control
Mgmt. Leadership & Employee Involvement				X						Safety and Health Training
Mgmt. Leadership & Employee Involvement		X								Review of Documentation
Mgmt. Leadership & Employee Involvement					X					Concurrence by Bargaining Agent
Worksite Analysis			X							Hazard Prevention and Control
Worksite Analysis				X						Safety and Health Training
Worksite Analysis		X								Review of Documentation
Worksite Analysis			X							Concurrence by Bargaining Agent
Hazard Prevention and Control							X			Safety and Health Training
Hazard Prevention and Control			X							Review of Documentation
Hazard Prevention and Control					X					Concurrence by Bargaining Agent
Safety and Health Training		X								Review of Documentation
Safety and Health Training			X							Concurrence by Bargaining Agent
Review of Documentation						X				Concurrence by Bargaining Agent

FIGURE 3 Resource Survey Response Transferred to Matrix

Resources	**Management Leadership & Employee Involvement**	**Worksite Analysis**	**Hazard Prevention & Control**	**Safety & Health Training**	**Review of Documentation**	**Concurrence of Bargaining Agent**
Management Leadership & Employee Involvement	1.00	5.00	7.00	1/5 = 0.20	7.00	5.00
Worksite Analysis	1/5 = 0.20	1.00	7.00	1/3 = 0.33	7.00	5.00
Hazard Prevention & Control	1/7 = 0.14	1/7 = 0.14	1.00	1/5 = 0.20	3.00	1/3 = 0.33
Safety & Health Training	5.00	3.00	5.00	1.00	5.00	5.00
Review of Documentation	1/7 = 0.14	1/7 = 0.14	1/3 = 0.33	1/5 = 0.20	1.00	1/5 = 0.20
Concurrence of Bargaining Agent	1/5 = 0.20	1/5 = 0.20	3.00	1/5 = 0.20	5.00	1.00
Column Total	**6.68**	**9.48**	**23.33**	**2.13**	**28.00**	**16.53**

Furthermore, employees must follow all written safety rules and practices; among other issues, these rules should address the use and maintenance of personal protective equipment (PPE). The organization must have a consistent disciplinary system that applies to all employees (including supervisors and managers).

The facility should have onsite medical and emergency services—or be able to obtain them easily from a local provider—and first-aid- and CPR-trained personnel available onsite during all shifts. Where appropriate, the company should work with occupational health professionals to conduct hazard analyses.

Safety & Health Training

Managers, supervisors and employees must receive training on their safety responsibilities. Beyond job-specific training required for OSHA compliance, all personnel must be trained in PPE use/maintenance. All training should be documented and assessed to determine its adequacy. In addition, the facility should conduct emergency preparedness drills (which include mock evacuations).

Review of Documentation

To participate in VPP, an organization must allow OSHA representatives to review all of its written safety and health program documentation. On its face, this element seems appropriate only for an organization seeking VPP recognition; however, the underlying value of preparing complete program documentation will be examined in further detail later.

Concurrence of Bargaining Agents

An organization seeking VPP recognition must obtain signed statements from any collective bargaining agents at the site before it can be accepted into the program. Similar to the documentation review element, this element is included due to the benefits it produces beyond the VPP application process.

THE ANALYTIC HIERARCHY PROCESS

The analytic hierarchy process is a useful procedure to apply when attempting to analyze and solve problems quantitatively. Since the process incorporates judgments and personal values, it depends on the experience and knowledge of the person making the comparisons. This process has been applied successfully to many real-world problems and is particularly useful when allocating resources, planning and analyzing the impact of policy (Saaty 23-24).

Using the analytic hierarchy process to evaluate VPP elements requires several steps. First, each VPP element must be compared in a pairwise function to the other elements. Next, the analyst develops priorities between each pair of VPP elements. These comparisons are then synthesized to yield an overall set of priorities. The consistency is checked between elements and rank order determined based on the results of expert judgment.

The process can be applied to various cost-benefit problems. "The results offer two extensions over traditional benefit-to-cost methods: a) we are able to quantify intangible, non-economic factors which have so far not been integrated into decision making and b) we can make explicit and informed tradeoffs among multiple selection criteria, including multiple performance objectives and output activities" (Saaty and Kearns 178).

The comparison between major VPP elements is based on the perceived benefits and resources expended to implement and maintain each element. By applying the analytic hierarchy process twice, the analyst obtains two rankings: one based on the relative resources expended to implement and maintain a particular element, one based on the relative benefit realized from that process. The two rankings can then be transformed into a benefit-to-cost ratio, also referred to as a "preference ratio" (Saaty and Kearns 179).

As element rankings are developed and results interpreted, one must keep in mind the comparisons used in developing the hierarchy. For example, in the cost hierarchy, a high ranking indicates a relatively high "cost" associated with implementing and maintaining a particular element. Conversely, a high benefit ranking indicates a high level of desirability associated with a given element (Saaty and Kearns 182).

The analytic hierarchy process relies on a matrix format to recognize and manipulate the comparison of VPP elements. When one element is compared to itself, the comparison is equal and must yield a value of unity. This ensures that the diagonal of the matrix is filled with the numerical value of 1. To help achieve consistency in the comparison matrix, the reciprocal value is used for reverse comparisons. Specifically, if the comparison of element A to element B yields a numerical rating of five, the reciprocal value (i.e., 1/5) is automatically used for comparison of element B to element A.

The survey form used to collect data guided the respondent through the pairwise comparisons of VPP elements in a logical, systematic manner. The form was designed to obtain a single pairwise comparison for each element without asking the respondent to indicate the reverse comparison. This ensures that comparisons remain consistent throughout (Tribble 187).

On the survey form, comparisons are divided into nine categories. Rather than using numbers to describe the relationship between two elements, five verbal descriptions were provided. These terms—equal, slight, moderate, significant and extreme—are the same terms used in the analytic hierarchy process literature (Saaty 78). The nine levels of differentiation are considered to be reasonable and reflect the degree to which people can discriminate between the intensity of relationships between two elements (Saaty 77). Once the survey is complete, the descriptive terms are converted into numerical values. These numerical values are then transferred into the comparison matrix using the diagonal and reciprocal rules previously described. The matrix is then normalized to develop the priority vector and the final relative rankings.

Safety managers face difficult decisions regarding the best way to implement and maintain an effective safety program within the limitations of scarce resources. They need a decision tool to help determine which elements offer the best return on investment.

FIGURE 4 Resource Matrix Normalized & Priorities Calculated

Resources	Management Leadership & Employee Involvement	Worksite Analysis	Hazard Prevention & Control	Safety & Health Training	Review of Documentation	Concurrence of Bargaining Agent	Row Sum	Priority Vector
Management Leadership & Employee Involvement	1.00/6.68	5.00/9.48	7.00/23.33	0.20/2.13	7.00/28.00	5.00/16.53	1.62	0.27
Worksite Analysis	0.20/6.68	1.00/9.48	7.00/23.33	0.33/2.13	7.00/28.00	5.00/16.53	1.14	0.19
Hazard Prevention & Control	0.14/6.68	0.14/9.48	1.00/23.33	0.20/2.13	3.00/28.00	0.33/16.53	0.31	0.05
Safety & Health Training	5.00/6.68	3.00/9.48	5.00/23.33	1.00/2.13	5.00/28.00	5.00/16.53	2.23	0.37
Review of Documentation	0.14/6.68	0.14/9.48	0.33/23.33	0.20/2.13	1.00/28.00	0.20/16.53	0.19	0.03
Concurrence of Bargaining Agent	0.20/6.68	0.20/9.48	3.00/23.33	0.20/2.13	5.00/28.00	1.00/16.53	0.51	0.08
	1	1	1	1	1	1		

FIGURE 5 Ranking of VPP Elements by Resources Required

Resources	Priority Vector	Relative Value	Rank
Review of Documentation	0.03	1.00	6
Hazard Prevention & Control	0.51	1.59	5
Concurrence of Bargaining Agent	0.08	2.66	4
Worksite Analysis	0.19	5.94	3
Management Leadership & Employee Involvement	0.27	8.44	2
Safety & Health Training	0.37	11.56	1

FIGURE 6 Ranking of VPP Elements by Benefit

Resources	Priority Vector	Relative Value	Rank
Review of Documentation	0.02	1.00	6
Hazard Prevention & Control	0.07	3.50	5
Concurrence of Bargaining Agent	0.11	5.30	4
Safety & Health Training	0.20	9.90	3
Worksite Analysis	0.24	11.80	2
Management Leadership & Employee Involvement	0.36	18.00	1

FIGURE 7 Benefit to Cost Rankings of VPP Elements

	Benefit (Rank)	Resource Cost (Rank)	Benefit/Cost Ratio	Rank
Management Leadership & Employee Involvement	0.36 (1)	0.27 (2)	1.33	2
Worksite Analysis	0.24 (2)	0.19 (3)	1.24	4
Hazard Prevention & Control	0.07 (5)	0.05 (5)	1.37	1
Safety & Health Training	0.20 (3)	0.37 (1)	0.54	6
Review of Documentation	0.03 (6)	0.03 (6)	0.63	5
Concurrence of Bargaining Agent	0.11 (4)	0.09 (4)	1.25	3

At first glance, the resulting benefit-to-cost ratios seem surprising. The authors had a preconceived notion that "management leadership and employee involvement" would offer the greatest benefits to a safety program compared to the amount of resources expended to establish the element. Although not initially evident, an extensive amount of time and effort must be expended to obtain continued involvement by the organization's workforce.

MODEL BASED ON JUDGMENT & EXPERIENCE

Although safety programs often share common elements, implementation of those elements can vary greatly between companies. To develop a tool using the analytic hierarchy process, one must identify a target audience and limit the scope of the development process. In this case, the target is a military organization (based on the authors' experience); the respondent in this model was the safety director of the only military organization currently recognized as a VPP site.

The military culture is uniquely different from private enterprise and other federal agencies. The military operates under its own internal regulations as well as OSHA regulations; in addition, military organizations are hierarchical in nature with a strict chain of command. Consequently, experiences associated with establishing and maintaining VPP elements will differ from those within the private sector.

Although this model uses military culture as its baseline, the methodology is flexible and can be easily expanded to address other types of organizations and safety cultures. To expand the methodology to private industry, one should involve as many experts as possible. The analytic hierarchy process literature recommends that the experts reach a consensus for each pairwise comparison and use the consensus value in developing the priority matrix and subsequent rankings (Saaty 5).

DATA COLLECTION

To provide a common baseline between the authors and respondent (in this case, the military safety director), the survey package included definitions of the VPP elements. The two forms were designed to lead the respondent through each pairwise comparison.

The respondent was asked to rate the relative resources (e.g., personnel, time, monetary) required to establish and maintain each element. For example, the respondent was asked to rank the resources required to establish and maintain "management leadership and employee involvement" versus "worksite analysis" based on personal experience implementing VPP. Next, the respondent was asked to rank the resources needed for "management leadership and employee involvement" versus "hazard analysis" and so on. On the second survey form, the participant was asked to rate the perceived benefit associated with satisfying one VPP element versus another.

The two forms were identical in format in order to eliminate confusion (Figures 1 and 2). In addition, the format was structured so that each VPP element was compared only to the remaining elements. The form did not ask the respondent to compare "management leadership and employee involvement" with "hazard analysis," then later ask the participant to make the reverse comparison of these two elements. This technique was used to eliminate potential inconsistencies in responses.

For this analysis, "resources required" are considered an "investment" in the VPP element and the "perceived benefit" is synonymous with "return" on that investment. Once individual rankings for resources and benefits are developed, the two are combined and the six VPP elements studied are ranked based on benefit-to-cost ratio. The ultimate result of this process is a quantitative measure of ROI for each major element assessed. The benefit-to-cost ratio serves as a decision model for the safety manager trying to determine the best value for safety program efforts.

APPLICATION OF THE PROCESS TO VPP

Following established procedures for implementing this process, survey responses are transferred to the matrix. As noted, all descriptive-phrase responses are translated into corresponding numerical values. Each VPP element is automatically assigned the descriptive term of equal when compared to itself. This eventually creates a matrix containing 1s down the diagonal. As for numerical values, the term "equal" is assigned number 1; "slight" is number 3; "moderate" is 5; "significant" is 7"; and "extreme" is 9; these terms are the same as those described in leading references (Saaty 78).

Assigning numerical values in this manner provides a consistent means to transform qualitative information into quantitative data for further analysis. Once numerical values are assigned, numerical data is transferred to the matrix format. As indicated, the matrix diagonal contains the number 1 and reciprocal values are used to quantify a reverse comparison. To help illustrate this step, Figure 3 shows survey results transformed into matrix format.

The next step is to normalize each matrix column to a numerical value of 1. This is done by dividing each entry in the column by the sum of that column. After completing this step for all six columns, the priority vector is calculated. This vector is obtained by calculating an average for each row of the matrix. Figure 4 shows the normalized matrix along with each row's associated resource priority. The six row averages form the priority vector.

The priority vector is used to calculate the value of elements relative to the other elements. For example, resources invested to prepare "documentation for review" is found to have the lowest relative value of 1. Using the lowest value for an element, relative values of all remaining elements are easily calculated. Once complete, elements are assigned a ranking from 1 to 6, with 1 being the most resources invested in establishing an element, 6 being the smallest amount of resources invested in a given element. Similar calculations are conducted for the matrix that addresses benefit. Figures 5 and 6 show final rankings.

ANALYTIC HIERARCHY PROCESS RESULTS

In this application, "safety and health training" requires the largest resource investment. In fact, this element requires 12 times the amount of resources necessary to prepare safety program documentation for OSHA review. Resource rankings, in order from highest to lowest resource requirement, are 1) safety and health training; 2) management leadership and employee involvement; 3) worksite analysis; 4) concurrence of bargaining agents; 5) hazard prevention and control; and 6) review of documentation.

By contrast, "management leadership and employee involvement" is perceived as being 18 times more beneficial than preparing "documentation for review." Benefit rankings, from greatest to least perceived benefit, are 1) management leadership and employee involvement; 2) worksite analysis; 3) safety and health training; 4) concurrence of bargaining agent; 5) hazard prevention and control; and 6) review of documentation.

To develop a benefit-to-cost ratio, the benefit priority associated with each VPP element is divided by the resource priority associated with the same element (Figure 7). Elements in rank order from highest benefit-to-cost ratio to lowest are 1) hazard prevention and control; 2) management leadership and employee involvement; 3) concurrence of bargaining agent; 4) worksite analysis; 5) review of documentation; and 6) safety and health training.

DISCUSSION OF THE RESULTS

At first glance, the resulting benefit-to-cost ratios seem surprising. When this study began, the authors had a preconceived notion that "management leadership and employee involvement" would offer the greatest benefits to a safety program compared to the amount of resources expended to establish the element. This preconception was primarily based on the fact that management leadership does not generally require great resource expenditures, yet most management sources agree that it is crucial to an effective safety program. Although not initially evident, an extensive amount of time and effort must be expended to obtain continued involvement by the organization's workforce.

Based on the VPP experience of the survey respondent, "hazard prevention and control" provides the greatest benefit for the amount of resources expended to establish/sustain that element. This particular element focuses on many typical components of a successful safety program. For example, a company will recognize benefits from having access to: qualified safety and health professionals; onsite or local medical and emergency services; and first-aid- and CPR-trained personnel on all shifts.

By having access to safety professionals, a facility is better able to formulate written safety rules and procedures and develop appropriate hazard controls. Without core safety staff, the company will not have the resources needed to conduct hazard analyses, develop written safety rules, monitor regulatory compliance and track corrective actions. The results of this analysis support the concern by VPP participants that their status in the program may be jeopardized by cuts in safety staffing levels.

Next in terms of greatest benefit per cost is "management leadership and employee involvement." As noted, although this element was expected to have the highest benefit-to-cost ratio, this analysis indicates that it requires a larger expenditure of resources due to the effort required to ensure that all personnel are actively involved in the safety program.

Some aspects of this element offer high payoff with low resource expenditure; these include managerial commitment and assignment of adequate authority to execute safety responsibilities. So, although this element is ranked second in the benefit-to-cost analysis, it remains crucial to setting the organization's overall safety culture.

Other aspects of this element—such as annual safety and health program evaluations—may have a high cost yet deliver a high value that may go unrecognized. Other high-cost factors include the requirement to provide equal safety protection to contract workers.

"Concurrence of the bargaining agent" ranked third in the benefit-to-cost ratio, far below the first two. However, it offers some potential for program benefits. For example, union support will allow new safety initiatives to be implemented more easily and with wider employee acceptance. However, the effort needed to obtain union buy-in can vary significantly, which makes this element the most variable between organizations.

"Worksite analysis" is next; this element includes tasks associated with monitoring work-related hazards, such as pre-use analysis of new processes to identify hazards, self-inspections, accident investigations and trends analysis. Although "worksite analysis" ranked second in terms of benefits realized, the resources it requires give it a third-place ranking. Overall, tasks associated with maintaining this element can be labor-intensive.

The fifth element in the ratio ranking is "safety and health training." Most people would agree that adequate safety training is essential. However, the ranking in this analysis raises a question about whether it provides the best use of limited resources. In addition, the documentation and assessment factors of this element are resource-intensive. Thus, application of this benefit-to-cost ratio may lead safety managers to complete job-specific, OSHA-required training as a top priority, then provide supplementary training as resources permit.

The final element is preparing "documentation for review." The perceived benefit of satisfying this element is low as are the resources needed to maintain it. This ranking is no surprise and is consistent with theories that a written program is not as valuable as a well-functioning program that lacks documentation. If program resourcing is not an issue, then the effort to compile and organize all program documentation is a great finishing touch.

USING THE RESULTS

The analysis described here can be a valuable tool to safety professionals trying to target limited resources for maximum impact. Although situations will vary by location, the benefit-to-cost ratio provides a simple method of determining which safety program elements offer the greatest benefits in terms of improving safety performance.

Based on this study, the analytic hierarchy process is an effective way to determine the costs and benefits associated with specific elements in a safety program. Although the model presented was directed toward a military organization, the fundamental principles outlined can be easily adapted to any safety program.

When modifying this method for general industry application, it is best to obtain the expert judgment of others in similar types of industries/operations. Overall, this method will give safety professionals a systematic way of directing resources to obtain the most benefit for the organization. ■

REFERENCES

Finnegan, L. "Downsizing Safety: It Can Get Ugly." *Occupational Hazards.* Oct. 1998: 13-15.

Laws, J. "Assuring Best Practices." *Occupational Health & Safety.* July 2000: 92-94.

OSHA. "Voluntary Protection Programs for Federal Worksites." Washington, DC: U.S. Dept. of Labor, OSHA, Oct. 1997. <http://www.osha.gov/oshprogs/vpp/vppflyer.pdf>.

Redinger, C.F. and S.P. Levine. "Development and Evaluation of the Michigan Occupational Health and Safety Management System Assessment Instrument: A Universal OHSMS Performance Measurement Tool." *AIHA Journal.* 59(1998): 572-581.

Saaty, T.L. *Decision Making for Leaders: The Analytical Hierarchy Process for Decisions in a Complex World.* Belmont, CA: Wadsworth Inc., 1982.

Saaty, T.L. and K.P. Kearns. *Analytical Planning: The Organization of Systems.* Elmsford, NY: Pergamon Press, 1985.

Tribble, A.C. "A Comprehensive Model of System Safety: A Tool for Determining Return on Investment." *Proceedings of 18th International System Safety Conference.* Fort Worth, TX: System Safety Society, 2000. 182-191.

Susan Jervis, *CSP, is a system safety engineer for the U.S. Army Military Command headquartered in Alexandria, VA. Jervis holds a B.S. in Engineering Science and Mechanics from Virginia Tech University and is pursuing an M.S. in Engineering at the University of Arkansas. She is a professional member of ASSE's National Capital Chapter.*

Terry R. Collins, *Ph.D., P.E., is an assistant professor in the Industrial Engineering Dept. at the University of Arkansas. He has also been a faculty member at the University of Houston and Oklahoma State University. Collins has 19 years' safety-related experience in the agriculture processing, telecommunications and transportation industries.*

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