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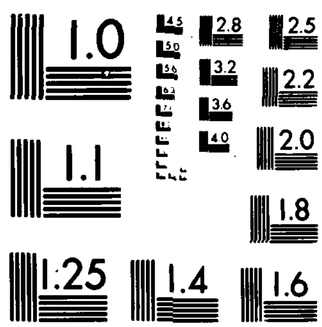

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NAVY OCCUPATIONAL SAFETY AND HEALTH — RESOURCE ALLOCATION CONCEPTS

Final Technical Report

March 1982

Prepared by:

Arlie G. Capps

Submitted to:

Department of the Navy
Office of Naval Research
Arlington, VA 22217

Attention:

Scientific Officer Code 434
Operations Research Program

SRI Project 1552
Contract N00014-80-C-0399

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Analytical problems and policy issues are described as observed ~~by SRI~~ in developing an OSH deficiency abatement project decision tool for the Navy. The recommended design of this simple, yet practical, resource allocation tool has been completed and reported separately. This present paper summarizes the critical design choices ~~SRI~~ made in developing the tool for centralized Navy management of scarce OSH resources.

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I INTRODUCTION

The Navy has only limited resources to correct occupational safety and health (OSH) deficiencies. In any given year, the backlog of requests from Navy shore installations for funds to correct such deficiencies usually far exceeds the funds available for this purpose. To manage this problem, the Navy recently instituted centralized management of the OSH Deficiency Abatement Program,* and identified a need for a consistent and systematic method of allocating resources among competing OSH project funding requests.

In May 1979, SRI International began research to design such a method under the sponsorship of the Office of Naval Research. Instructions from the Chief of Naval Operations (OP 45) stated that the method "must be simple enough to use routinely, yet complex enough to effectively evaluate and integrate numerous kinds and degrees of both health and safety hazards." Moreover, SRI was required to develop a method capable of operating satisfactorily without a large commitment of additional Navy manpower or a significant increase in the current workload of Navy safety, health, and administrative personnel.

SRI performed the research in two phases. Phase I involved design of the method for simple OSH projects and field tests of its application. In Phase II we expanded the method for use with large, complex projects and analyzed the results of the first year of operational trials.

At the beginning of Phase I, we reviewed SRI's prior work in decision analysis and resource allocation, as well as the published work of others. Risk analysis theory was the basis for our preliminary design, but we introduced empirical and iterative methods to translate our ideas into practical concepts.

With this approach, the design of the method progressed steadily into field testing of the most promising of these concepts. Supported by our field test results, we selected the most appropriate concept, one that used matrix techniques to evaluate and aggregate more than 20 items of basic data needed to characterize and rate a project in terms of the hazard, the corrective action proposed, and the facility requirement.

In the SRI concept, the project data would automatically be processed in a computer, producing indices that rank each project

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* The overall Navy Occupational Safety and Health Program (NAVOSH) has three components: the Deficiency Abatement Program, the Navy OSH Inspection Program; and Workplace Monitoring and Health Record Surveillance.

according to its priority based on certain features. The project requests, with their basic data and indices, would be forwarded for review through the chain of command to the NAVOSH program manager responsible for preparing the yearly OSH budget. In the review chain, the project requests would be approved and ranked by each major claimant administratively responsible for the Navy's support type activities (e.g., training centers, supply centers, shipyards, aircraft rework centers).

SRI completed Phase I in October 1979 at which time we recommended to the Navy that the method, then in its prototype form, be applied for a limited operational trial during 1980. After this recommendation was accepted, the new method was integrated into NAVOSH procedures beginning in February 1980. SRI used the inputs derived from analysis of the 1980 prioritizing results to modify the prototype and complete the development of the method in Phase II.

As of February 1981, the method was only partially integrated into the NAVOSH control report system (OCR), a computer data management and reporting system. More than 300 projects are listed in the February 1981 OCR, but only approximately 25% of these listings have been assigned priority scores. Obviously, the method will be of little benefit in resource allocation as long as all projects submitted are not scored.

The Navy is addressing the problems of updating existing records, adding newly required data, and integrating the new system into the ongoing OSH program at this time. All NAVOSH projects are expected to be updated and entered into the OCR files and reported by September 1981.

SRI has analyzed the relative priority among the project requests in the available sample of 72 projects and found the results encouraging. The true test, however, will come when all records are complete and the method is actually exercised as a resource allocation tool, possibly for the FY '82 program budget.

The technical details of SRI's NAVOSH research in Navy terms of reference are contained in "NAVOSH Priority Methodology," by SRI International (March 1981). In the present, more general review, we highlight important problems and choices in producing a practical ranking system for scoring diverse hazard abatement projects. The method is described, but procedures developed to apply it are omitted. This paper is designed for the reader more interested in resource allocation and OSH prioritization principles than in the details of applying a specific method to Navy projects.

Section II describes the OSH-specific analytical problems in the design of a project prioritization system. How we dealt with these problems in this study for the Navy and the rationale behind the design choices are outlined in Section III.

The concluding section describes the structure of the resource allocation tool SRI has recommended to the Navy. Once fully integrated into the NAVOSH program, currently planned for September 1981, the tool's record keeping and reporting capability alone should greatly simplify planning and programming of NAVOSH projects. By aiding in systematic setting of priorities, the tool should immediately allow more effective allocation of resources.

II ANALYTICAL PROBLEMS

SRI's research team encountered the following principal analytical problems during the design and development of the NAVOSH priority method:

- Defining "priority" in OSH-relevant terms
- Selecting realistic measurement standards for OSH priority
- Identifying data needs
- Structuring the scoring method
- Devising practical means of integrating and reducing data
- Applying the method to combination projects.*

Defining Priority

The literature of operations research and decision theory is replete with techniques for allocating scarce resources under various constraints. Most of the techniques are deterministic--they assume that the decision variables and rules are clear-cut and well-defined. A few add an explicit consideration of uncertainty and take into account attitudes toward risk by decision makers and those they represent. Even in the latter cases, however, the theories usually require that the parameters relevant to the allocation problem be precisely quantified. In our OSH problem, as with many real-world problems, the formal analysis techniques have significant drawbacks because the needed information is either not applicable or too costly to gather.

In principle, a cost-effectiveness approach is an appealing technique for the allocation of NAVOSH funds. The effectiveness of each candidate project could be measured in terms of the savings in annual injuries and illnesses that the abatement project promised, which could be compared with the cost of the project to get an effectiveness ratio. This ratio could be used to rank the projects, and the projects would be funded from the list until the budget was exhausted. The procedure can be shown to satisfy the classic allocation conditions:

$$\text{Max} \sum_i U(P_i)$$

$$\text{subject to} \sum_i C(P_i) \leq B$$

where $U(P_i)$ is the utility of project P_i, in terms of the illness and injury avoided,

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* Combination projects are those addressing multiple hazards at a single facility, single hazards at multiple facilities, or multiple hazards at multiple facilities.

$C(P_i)$ is the project cost

B is the annual budget.

The two major deficiencies of the cost-effectiveness approach for the NAVOSH allocation problem are that: (1) The variety of risks to safety and health are exceedingly difficult to express and quantify in a common unit of utility; (2) The solution is constrained not only by the budget, but also by the necessity to meet health and safety standards. The constraint to meet standards implies that meeting a standard may be more important in project selection than the absolute utility gained, even if the costs are identical.

We therefore decided to use a technique that depended on scoring various qualitites of each project, including qualities that relate to their ability to meet standards, their costs, and their general contribution to the Navy's mission. Thus, a set of specific qualities must serve as the basis for preferences among OSH projects. Each quality in the set should contribute a specific dimension to the preference. Each should relate in a defined way to the kinds of projects that Navy organizations propose to correct health or safety deficiencies discovered in Navy workplaces ashore. In addition, each quality or feature should be readily observable and measurable or judgmentally weighted.

Project requests on file at Navy headquarters contained few such qualities. The requests identified the kinds of hazards and gave only minimal qualifying descriptions such as "severe" or "moderate." They rarely contained an estimate of the potential impact of the hazard in terms of how many people are subjected to the hazard, how often, or for how long. The technical adequacy of the proposed corrective action was affirmed without showing it to have the least cost among technically feasible alternatives. The importance of abating the deficiency in order to continue the operation in the facility was not shown, nor were the ways described in which the hazardous condition hampered the organization's ability to perform its support mission.

The existing procedures for submitting project requests contained only a limited sketch of how OSH project preferences were to be determined. What did appear made priority decisions subjective, or in effect, verbal contests.

A better priority method was needed because a simple statement could not concisely express the many qualities needed to adequately characterize and rank NAVOSH projects. The complex qualities of OSH projects affected the entire research effort.

Selecting Measurement Standards

Realistic ways were needed to describe the intensity or degree of the qualities we might choose as the basis of preference. For example, consider "hazard severity," a principal prioritization feature. We needed a way to measure and state the relative degree of severity among thousands of potential hazards that may be cited. How to measure the relative intensities of the hazards must be standardized or brought to a standard base for comparison. Quantifying how many people may be exposed is not difficult, but quantifying how long and how often may be. For health hazards, we need to know safe thresholds of exposure and the chronological relationship between exposure, dosage, limiting dosage, and latent effects. The standards for measuring these aspects of hazard severity are imprecise for most health hazards at present. Nevertheless, some measurement of hazard intensity must be made.

The technical adequacy of a proposed corrective action will be judged against engineering standards, practices, and specifications. For new proposed solutions, extrapolations or "good engineering" judgments may be the only available measurement of technical adequacy. Although costs of construction and equipment may be readily estimated in dollars or labor units, some costs such as reduced quality of life require more judgmental units. Quantified and judgmental costs must be expressed in commensurate terms to compare costs of alternative actions and to identify the least costly option.

To include a quality related to the mission of a facility requires specialized Navy judgments about the "influence on the state of readiness," "potential for relocating elsewhere," and other factors. Navy personnel with the responsibility or authority to make such judgments must be identified.

Interactions among individual qualities should also be considered. How these are handled can affect the sensitivity of the priority method.

Identifying Data Needs

In our review of projects on file, we noted significant variations in the kinds, amounts, and accuracy levels of data submitted. Different types and sizes of projects may require different data, but similar projects should contain comparable data. In general, data items that affect priority should be expressed in realistic, standardized units appropriate for all projects.

Data requirements should not be excessive. A clear relationship between the quantity of data and how the data are used should be evident. When data demands appear excessive or unjustified, all data are not likely to be submitted, which could prevent effective use of the priority method. On the other hand, not requiring reasonably available data is misleading, giving the impression that project proposal preparation and prioritization are perfunctory exercises. The problem here is to develop a balanced list of data needs and demonstrate how each item of data will contribute to the realism, validity, and equity of the priority method.

Structuring a Scoring Method

In designing a prioritization system, one must match its output to its intended use. A "pass or fail" might suffice in some applications, but not when decisions are being made on acceptance, rejection, or postponement of OSH projects on the basis of programmed budget limits. However, assigning every project a unique score to permit rank ordering may be unnecessary. A scoring method that sorts projects into classes of relative merit may be adequate.

Understanding the intended use by centralized Navy management of the scoring method requires knowledge of the Navy's planning, programming, and budgeting system and its cycle of yearly funding. Because perhaps several hundred projects compete for a relatively small budget ($10 to $20 million yearly), the scoring method must not be overly costly to administer; a system of automated data processing and scoring would be ideal. In addition, policy matters such as dollar thresholds and ceilings, and different appropriations for different kinds of projects, complicate the already technically complex scoring problem.

Data Reduction and Integration

Related to the problems of data needs and the scoring method was the analytical problem of manipulating data to achieve comparable, useful outputs. A true systems analysis approach was needed to handle these interrelations and to arrive at a simultaneous solution to these interdependent problems. But the constraint of using essentially existing resources to administer the priority-setting method restricted the design to relatively unsophisticated data manipulation. Although manual reduction and integration is often feasible, computer manipulation may be more satisfactory because of the anticipated a large volume of projects and reporting requirements.

Scoring Combination Projects

SRI's Phase II research examined the problem of applying a priority-setting method designed for relatively simple projects, namely single hazard/single facility projects, to the more complex types of projects concerning multiple hazards and/or multiple facilities in a single project. These usually large projects, predicated on cost savings, introduced a number of prioritization difficulties, especially (1) scoring a project that had hazards of different kinds and differing intensities, and (2) identifying OSH relevant costs among the total costs. The second problem was more than a priority problem; it also involved the question of how to determine if OSH funding or some other type of funds was the most appropriate way of correcting the OSH deficiencies.

These combination projects constitute a particularly important class of possible OSH projects because they usually involve significant costs and promise to improve efficiency, productivity, or both while correcting the OSH deficiencies. For these projects, however, a decision must be made on whether to authorize the use of OSH funds, and if so, how the project should be ranked in the competition for funds. Although few in number at present, these projects, if allowed to dominate OSH budgets, could cause many smaller single projects to be postponed indefinitely. Unless combination projects are carefully screened, applicants might combine single hazard/single facility projects without necessarily producing cost savings in an effort to enhance their chances of early funding. This problem extends beyond priority questions and involves policy issues.

III THE CHOICES

For each problem area described above, we evaluated different approaches and alternative solutions. Possible design elements were screened for technical robustness, acceptability to safety and health professionals, and ease of integration into an effective prioritization component of the NAVOSH Deficiency Abatement Program. Selected elements were then integrated into system concepts and subjected to field tests. In making our final choices, we relied primarily on field test feedback from operating personnel whose job it would be to make the priority method work.

Defining Priority

For a preliminary definition of NAVOSH priority, we listed the preference features that might be used to score OSH projects. We included in our working definition the way the priority method would serve the user. Assuming that rank ordering of all projects was the goal, we considered conditions under which ranking one project ahead of another would mean funding one but not the other, or when it might mean funding one ahead of the other.

Another concept for determining priority is to give special attention to a class or a group of projects. This appears to be the purpose of the Department of Defense (DoD) priority system based on the risk assessment codes (RAC) shown in Table 1. Hazard severity combined with mishap probability in the matrix produces classes of projects, IA through IIID, which may then be assigned indices indicating relative importance or merit. Periodically, user instructions may be issued referencing the indices, such as, "Submit only projects with indices of 1 or 2."

After reviewing more than 20 different priority methods and the purposes for which they were used, we selected group ranking as the best design tool for setting NAVOSH priority. We wanted to build a user's view into the priority-setting method, specifically, the degree of urgency he believed should be given to correcting the hazard and the degree of benefit he believed funding projects in the group would bring to the NAVOSH program.

This concept of priority was partly drawn from the DoD priority-setting system, but we have broadened the RAC significantly by providing a better rationale for the group score. Many items of data are analyzed and integrated into the scoring indices to support the

Table 1

RISK ASSESSMENT CODE MATRIX

Hazard Severity	Mishap Probability A	B	C	D
I	1	1	2	3
II	1	2	3	4
III	2	3	4	5

Key:

I	Catastrophic--Hazard may cause death
II	Critical--Hazard may cause severe injury or illness
III	Marginal--Hazard may cause minor injury or illness
A	Mishap likely to occur immediately or in a short time
B	Mishap probably will occur in time
C	Mishap may occur in time
D	Mishap unlikely to occur.

assignment of a particular group score. The overall objective of our method is to provide Navy management with a systematic way of funding those projects that correct the most severe hazards at the earliest possible time.

Selecting Measurement Standards

A major problem in using the RAC is that instructions for its use do not adequately specify the standards by which hazard severity and mishap probability are to be judged. The codes could even be unsupported opinions of the safety or health personnel, or some other project originator on the staff of the installation commander. Because many originators prepared the project descriptions and justifications, not all equally skilled in exposition, a wide variation can be expected in the validity of the assigned RAC. Unless some way is prescribed to calibrate the RAC assigned, an originator is free to assign the highest RAC he feels he can *justify if questioned*; he knows this practice should enhance his chances of getting his project funded. Our review of the OSH project files found many instances of bias of this kind. Under the RAC method, selecting projects for funding could become little more than a "beauty contest."

Our method should eliminate, insofar as possible, opportunities for uneven competition or bias, even though not all data can be quantified, and important judgments will unavoidably still be required, particularly in weighting factors. Moreover, the approach should not rely on a "cookbook" of hazards listing relative scores and mishap probabilities, which could lead to an enormous effort to codify thousands of hazards without supporting scientific or actuarial data in most instances. Standardization of a sort would result, but how accurately the hazard and the score selected from the standard list represented the actual hazard would remain uncertain.

We therefore developed a list of all reasonably available, quantifiable information to be submitted for each specific feature that characterizes priority. The items of data to be submitted by the project originator are listed in a standardized form together with units in which to express them. This list includes items where judgments are needed, providing descriptive multiple choices for the judgments.

Our rationale was to minimize the need for extensive narration. Soliciting standard detailed basic data and judgments from originators should minimize the need for narrative statements but still produce all of the necessary factual information concerning the hazard and the corrective action, if seasoned with on-site judgment.

Identifying Data Needs

Specific data items required were identified by first dividing the preference definition into three main types of decision factors--risk, corrective action, and facility requirements. The risk and corrective action factors were divided into a second level of detail that we called decision parameters. At the third level of detail, we listed fundamental data and other information items characterizing in turn the decision parameters and the major decision factors. This formed the tree of data needs shown in Figure 1.

The data tree treats safety and health hazards separately with parallel but differing basic data items, to align our data with standard OSH data classifications. The units, or ways in which to express the data items, reflect OSH measurement units and the advice of operating safety and industrial hygiene personnel experienced in applying the test protocols.

Structuring a Scoring Method

During the course of this research, we reviewed many methods of scoring preference.* We found two general types predominating. The first type uses mathematical expressions to calculate some figure of merit; the second uses a matrix or a series of matrices to produce a numerical index or a qualitative indicator (e.g., check marks, worded judgments, colors).

When all data items are quantified and readily available, and when the relationships between factors and the intended output are well

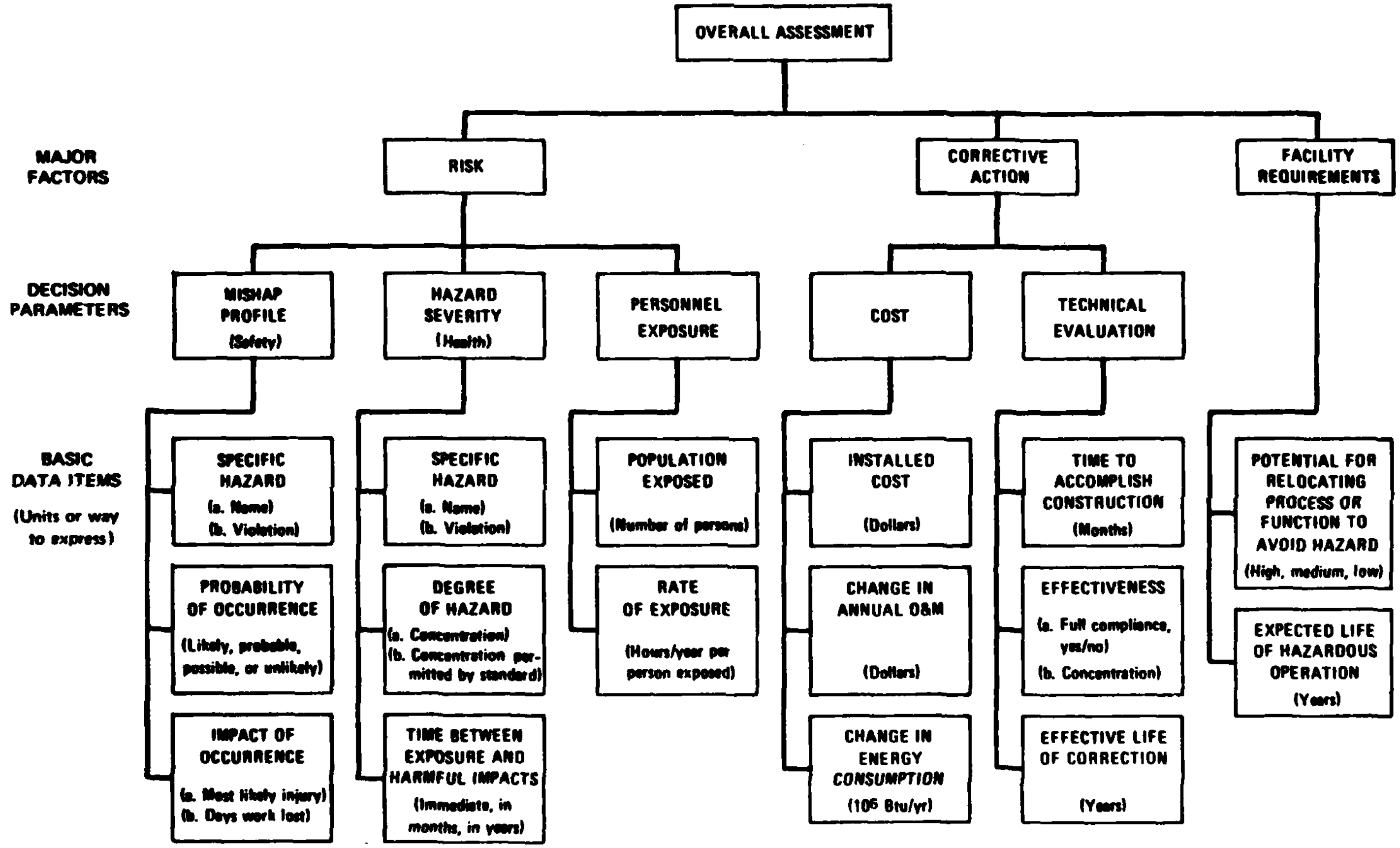

FIGURE 1. STRUCTURE OF HAZARD CONTROL ASSESSMENT

defined, mathematical equations are particularly useful. Mathematical models are valuable tools when the data are less well defined. Too often, however, the equations or models must be greatly simplified because of data deficiencies. The resulting weak expression (plus caveats) provides grossly simplified relationships that must be bridged ultimately with assumptions.

Because of anticipated difficulties in pursuing the mathematical approach to combining the more than 20 varied data items that must be considered, we chose to use a matrix system. This route provides the most direct way to translate the basic data items (shown on the Figure 1 data tree) into indices capable of screening several hundred projects and distributing them amongst a manageable number of rank-ordered small groups.

By using group scoring instead of individual project ranking, the budget cutoff should fall on one group, which could require a final competition for funds among only the equal ranked projects within that group. However, the matrices can be readily designed to produce small groups. With the budget cutoff falling on a small group, minor adjustments of the budget level can include (or exclude) the entire targeted group of projects. (Our choice would be to end the yearly program above the target group, reserving the remaining funds for contingencies.) Moreover, the matrix method by its inherent flexibility can handle changing policy issues easily by changing grid sizes, number of grids, index values, or a combination of these. *Finally, a series of* matrices with inputs matched to the chain of command review process will permit the final score to accumulate through the review process.

Applying the Method to Combination Projects

At the completion of Phase I research the prototype method, could adequately rank several hundred single hazard/single facility projects in preference groups. The prototype needed adjustment or modifications, however, to work with any large, complex project concerning more than one hazard and facility.For example, the prototype method contained no provision for assigning a single risk assessment score to a multiple

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* W. Schubert and L. C. Goheen, "Methodology for Navy Occupational Safety and Health Analysis; Phase I: Current Techniques," SRI International, Menlo Park, California (September 1979).

hazard project with hazards of several different degrees of severity. Two choices were considered:

(1) Adding some aggregating factor or new matrix to weight the individual hazards on the basis of their cost avoidance contribution to the total cost avoidance of the combination project.

(2) Calculating a simple "average" risk index for the combination project.

The first option is attractive because it follows an underlying principle of combination projects, cost avoidance through combining work items. However, it requires a significant amount of new cost data and several stages of analysis to produce meaningful weights. The second option, the simple averaging approach, requires no new data to be produced and submitted by the project originator. Consequently, we devised a direct procedure for calculating the "average" risk index and tested it for acceptability by operating personnel. The procedure involved determining a risk index for each hazard, then computing the arithmetic average of the separate indices for use as the composite risk index.

Before the project is approved for NAVOSH funding, it is important to determine whether the project is justifiably an OSH funding candidate. This complication is a subtle, indirect result of secondary economic analysis and life cycle costing required for all large projects. Investment costs having little or nothing to do with correcting the OSH hazards cited are often included to a varying degree, because it is usually possible by adding non-OSH items--for example, a new facility or additional space--to (1) reduce the Net Present Value (NPV) or the Uniform Annual Cost (UAC) of the project by decreasing the operating and maintenance costs over the life of the facility, or (2) increase productivity. Current policy requires that the alternative corrective action offering the least NPV or UAC, among those considered, must be proposed. Despite a least NPV, more investment costs may be required than would be needed by funding the OSH items as separate projects.

Two good objectives are at cross purposes here--saving money overall, and reserving OSH funds for OSH purposes. How to balance these objectives while prioritizing large OSH projects is a policy matter. This complication does not arise with small projects; if a simple, small project contained non-OSH costs, it would be rejected or returned for rework before being scored by the prototype.

Rather than adjust the hazard assessment code (HAC) of the prototype in some manner, we added a fourth project assessment factor, the OSH relevance value (ORV). The OSH relevance value is given by the simple formula:

$$\text{ORV} = \frac{D + \frac{S}{a} + \frac{O}{b}}{T}$$

where D = Costs directly related to OSH

S = Costs supporting or facilitating OSH

O = Non-OSH cost

T = D + S + O

a, b = arbitrary constants.

In testing this formula, we assigned values of 2 and 4 to a and b, respectively. Applying the formula to sample projects produced decimal values of ORV easily interpreted by all NAVOSH personnel.*

Providing the additional ORV factor does not resolve the issue of conflicting policy objectives, but it does provide NAVOSH management with a direct indicator on which to take action. For example, assuming that the project originators are required to compute the ORV for all large (including combination) projects, the major claimants and the NAVOSH program manager have some interesting programming options. Major claimants can consider the ORV and the HAC in developing their project ranking list. The NAVOSH program manager has the option of double

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* Note that all small projects should have an ORV of 1.

ranking the projects--by HAC and ORV--to decide which projects to reject or postpone. Alternatively, giving precedence to the HAC, he might develop a trial budget on HAC scores alone without considering the ORV. Within the target* group of equal HACs, he might arrange the projects by ORV, funding those with highest ORV until the budget cutoff is reached.

Our research ended before we could develop a strategy for balancing the HAC and the ORV. At this point, we have provided the Navy with a useful resource allocation tool, the HAC, and a second measure, the ORV, that may aid in deciding the relative justifiability of including a project in the NAVOSH program.

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* Group on which the budget cutoff falls.

IV THE RECOMMENDED PRIORITY METHOD--A NAVOSH RESOURCE ALLOCATION TOOL

The resource allocation tool SRI recommended for NAVOSH management is a system of interacting matrices. Entering the basic data of a project into this system automatically assigns a group rank score to the project. The system of matrices and the way they enable the data to be translated into a group score are described below.

The diagrammed structure of the method (Figure 1) is reorganized in Figure 2 to show the general flow of data through the system. In preparing the project request, the originator provides itemized data using a standard worksheet, Table 2. The multiple choice format of the worksheet is an important feature of the system because the worksheet lists the complete data to be provided in units matching the cells of the matrices.

Figure 3 shows how the hazard assessment code, or group score, is sequentially generated through indices produced in the system of matrices.

The series of interrelated matrices comprising the priority method is shown in Figures 4, 5, and 6. Each cell of every matrix is assigned a number (1 through 5, with 1 meaning highest weight) indicating the relative weight of the cells. These cell values are ordinal values assigned judgmentally and are not meant to denote cardinal values.

The number of cells in a matrix has no absolute significance. In general, we determine the matrix size by experimentation to allow a practical spread for realistically observable units of data. Also, the weighting scheme of 1 through 5 for cell values was arbitrarily chosen. Our experience with group coding of field test data indicated that using these values would produce an adequate number of rationally spread groups.

Both the matrix size and the cell values are design elements providing system flexibility. By using the specific matrix configuration shown in Figures 4, 5, and 6, the analyst can rank the projects into groups--the group with the highest possible priority will score 111; the lowest, 555.

In analyzing the coded scores of 72 projects available in the OCR, we found that the scores were spread into 20 groups, an adequate number. On the basis of accepted definitions of hazard severity and urgency of abatement, the rank order of the groups was rational. With these preliminary results, we predict that this new resource allocation tool will improve NAVOSH centralized management by increasing order and equity in the program planning and budgeting of NAVOSH resources.

MAJOR FACTORS IN HAZARD CONTROL ASSESSMENT	DECISION PARAMETERS	BASIC DATA	HOW TO EXPRESS	INPUT	CALCULATED	OUTPUT
RISK (TYPE OR RISK, i.e. HEALTH OR SAFETY, IS IN OTHER OCR FIELD)		1	INDEX a. SAFETY b. HEALTH		I	O
	MISHAP PROFILE (Safety)	2	INDEX			
		3 SPECIFIC HAZARD	a NAME	X		
			b VIOLATION	X		
		4 PROBABILITY OF OCCURRENCE OF INJURY	LIKELY/PROBABLE/POSSIBLE/UNLIKELY	X	OR	
		5 IMPACT OF OCCURRENCE	a MOST LIKELY INJURY	X		
			b DAYS WORK LOST PER RECORDED INCIDENT	X		
	HAZARD SEVERITY (Health)	6	INDEX		I	
		7 SPECIFIC HAZARD	a NAME	X		
			b VIOLATION	X		
		8 DEGREE OF HAZARD	a CONCENTRATION, e.g. libers/cc, ppm, mg/m^3)	X		
			b CONCENTRATION PERMITTED BY STANDARD	X		
		9 TIME BETWEEN EXPOSURE AND HARMFUL IMPACTS	IMMEDIATE/IN MONTHS/IN YEARS	X		
	PERSONNEL EXPOSURE	10	INDEX		I	
		11 POPULATION EXPOSED	NUMBER OF PERSONS	X		
		12 RATE OF EXPOSURE	HOURS/YEAR PER PERSON EXPOSED	X		
CORRECTIVE ACTION		13	INDEX			O
	COST OF CORRECTIVE ACTION	14	INDEX		I	
		15 INSTALLED COST OF CORRECTION (Including environmental control tech.)	DOLLARS	X		
		16 CHANGE IN ANNUAL O&M COST (Caused by correction)	DOLLARS	X		
		17 CHANGE IN ENERGY CONSUMPTION (Caused by correction)	10^6 Btu/Yr	X		
	TECHNICAL EVALUATION	18	INDEX		I	
		19 TIME TO ACCOMPLISH (Construction)	MONTHS	X		
		20 EFFECTIVENESS OF CORRECTIVE ACTION	a FULL COMPLIANCE Yes/No (Safety)	X		
			b CONCENTRATION, e.g. libers/cc, ppm (Health)	X		
		21 EFFECTIVE LIFE OF CORRECTION	YEARS	X		
FACILITY REQUIREMENTS		22	INDEX		I	O
		23 POTENTIAL FOR RELOCATING THE PROCESS OR FUNCTION TO ANOTHER SITE TO AVOID HAZARD	HIGH/MEDIUM/LOW	X		
		24 EXPECTED LIFE OF HAZADOUS OPERATION	YEARS	X		
OVERALL EVALUATION		25	INDEX			A

X = Data provided by activity on project

}——► Combination of bracketed items produces item indicated

I = Calculated indices

O = Output provided to users

A = Overall assessment as a three digit combination of the output indices

FIGURE 2. HAZARD CONTROL ASSESSMENT DATA FLOW

Table 2
NAVOSH DATA WORKSHEET

ACTIVITY________________________ INITIATED BY:________________________
ACTIVITY PROJECT NO.______________ DATE:________________________
PROJECT TITLE:____
EFD:________ UIC:________ CLAIMANT:________ SUB CLAIMANT:________

RISK

Check one SAFETY HEALTH

SAFETY	HEALTH
Specific Hazard________________	Specific Hazard________________
Hazard Violation (Regulations)______	Hazard Violation (Regulations)________
Probability (Check one) Likely Probable Possible Unlikely	Concentration of Hazard:__________ Units:__________
Severity of most likely injury______	Current Standards:______________ Units:______________
	Time Between Exposure and Harmful Impacts (Check One) Immediate In Months In Years

POPULATION

Normal Working Population Exposed to Hazard (Employees) (Check One)

1-4 Employees	5-9 Employees	10-50 Employees	>50 Employees

Rate Of Exposure To Hazard (Hours/Year per Person Exposed) (Check One)

40	40-150	151-959	960-2000	>2000

Table 2 (Concluded)

CORRECTIVE ACTION

Installed Cost of Corrective Action ($\$ x10^3$) (Check One)

40	40-60	61-80	81-100	>100

Change in Annual O&M Cost ($\$ x10^3$) (Check One)

<(-5)	(-5)-0	1-5	6-10	>10

Change In Energy Consumption Cuased by Corrective Action (10^6 BTu/Year)

(Check One)

<(-500)	(-500)-0	1-500	501-1000	>1000

Time To Accomplish the Construction of Corrective Action (Months) (Check One)

1-3	4-6	7-9	10-12	>12

EFFECTIVENESS OF CORRECTIVE ACTION

Safety--Full Compliance (Check One)
Yes No

Health--Concentration: ____________
Units: ____________

Effective Life Of Solution (Years) ____________________________

FACILITY

Potential for Relocating the Process or Function to Avoid the Hazard (Check One)

HIGH	MEDIUM	LOW

Expected Life of Hazardous Operation (Years) ______________________

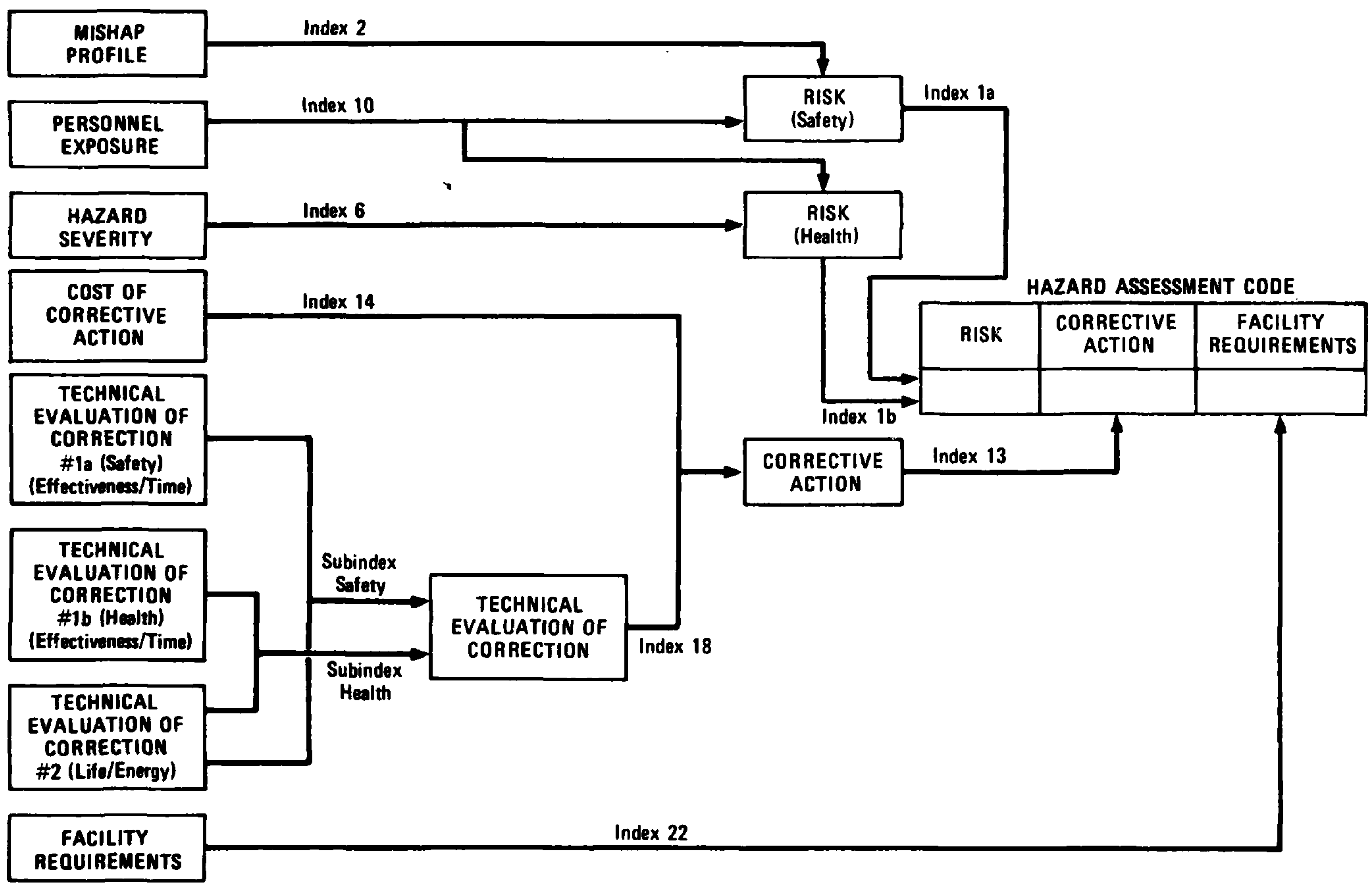

FIGURE 3. DIAGRAM OF THE HAZARD ASSESSMENT CODE AS GENERATED BY THE NAVOSH PRIORITY METHOD

SAFETY MISHAP PROFILE

5 IMPACT OF OCCURRENCE (Days lost per incident) / 4* PROBABILITY OF OCCURRENCE OF INJURY	LIKELY	PROBABLE	POSSIBLE	UNLIKELY
4200	1	1	2	3
2500–4199	1	2	2	3
1200–2499	1	2	3	4
400–1199	1	2	3	4
100–399	1	3	3	4
30–99	2	3	4	5
< 30	2	3	4	5

Index 2 → SAFETY MISHAP PROFILE

PERSONNEL EXPOSURE

12 EXPOSURE (Hours/yr per person exposed) / 11 POPULATION (PERSONS)	> 50	10–49	5–9	1–4
≥ 2000	1	1	2	2
960–1999	1	1	2	3
160–959	2	2	3	4
40–159	2	3	4	5
< 40	3	4	5	5

Index 10 → PERSONNEL EXPOSURE (Safety)

Index 10 → PERSONNEL EXPOSURE (Health)

HEALTH HAZARD SEVERITY

8 CONCENTRATION / 9 TIME BETWEEN EXPOSURES AND HARMFUL IMPACTS	IMMEDIATE	IN MONTHS	IN YEARS
STANDARD EXISTS			
ABOVE CEILING	1	1	1
> 2 x STANDARD	1	1	2
< 2 x STANDARD	1	2	3
NO STANDARD			
SEVERE RISK	1	1	1
MODERATE RISK	1	2	3
LOW RISK	2	3	5

Index 6 → HEALTH HAZARD SEVERITY

SAFETY MISHAP PROFILE

PERSONNEL EXPOSURE	1	2	3	4	5
1	1	1	2	2	3
2	1	2	3	3	4
3	2	3	3	4	4
4	2	3	4	4	5
5	3	4	4	5	5

Safety Risk Index 1a → (See page 3)

HEALTH HAZARD SEVERITY

PERSONNEL EXPOSURE	1	2	3	4	5
1	1	1	2	2	3
2	1	2	3	3	4
3	2	3	3	4	4
4	2	3	4	4	5
5	3	4	4	5	5

Health Risk Index 1b → (See page 3)

* NUMBERS CORRESPOND TO BASIC DATA ITEMS SHOWN ON EXHIBIT A

FIGURE 4. HAZARD CONTROL ASSESSMENT FOR RISK

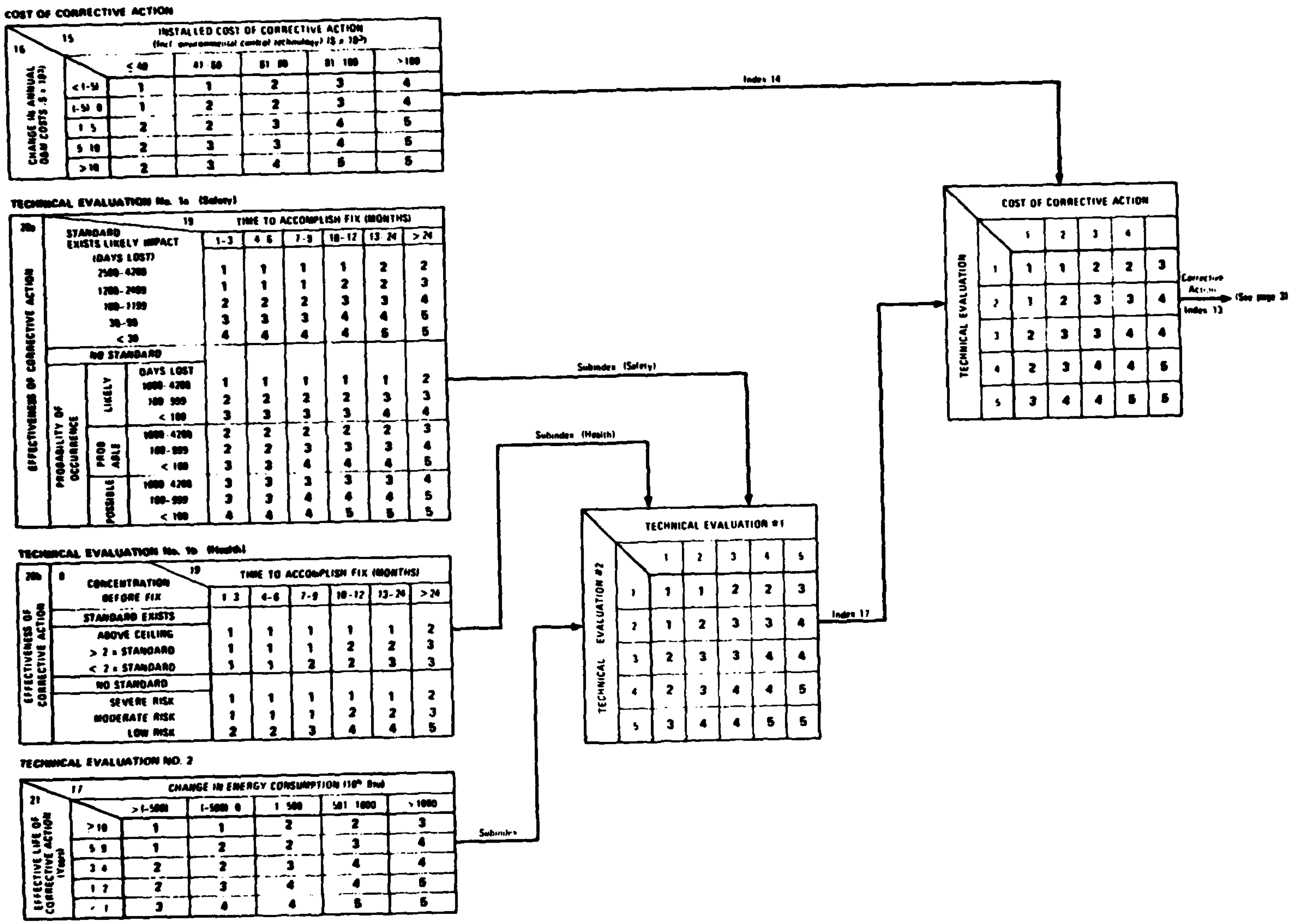

FIGURE 5. HAZARD CONTROL ASSESSMENT (CORRECTIVE ACTION)

FACILITY REQUIREMENTS

Expected Life of Hazardous Operation (Years) (24) \ Potential for Relocating the Process or Function to Avoid Hazard (23)	LOW	MEDIUM	HIGH
>10	1	2	4
6–10	2	3	4
3–5	2	3	4
1–2	3	4	5
< 1	3	4	5

Facility Requirements Index 22

OVERALL EVALUATION

	RISK (1a 1b) — FROM PAGE 1	CORRECTIVE ACTION (13) — FROM PAGE 2	FACILITY REQUIREMENT (22)
SCORES			

FIGURE 6. HAZARD CONTROL ASSESSMENT

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