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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Application of Industrial Engineering Techniques to Reduce Workers' Compensation and Environmental Costs - Deliverable K, Final Report

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

in cooperation with
National Steel and Shipbuilding Company
San Diego, California

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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

PANEL SP-8 INDUSTRIAL ENGINEERING

Report Number 0526

**APPLICATION OF INDUSTRIAL ENGINEERING TECHNIQUES TO
REDUCE WORKERS' COMPENSATION AND ENVIRONMENTAL
COSTS**

SUBMITTED BY:

**NATIONAL STEEL AND SHIPBUILDING COMPANY
SAN DIEGO, CALIFORNIA**

**In Cooperation with:
Gulf Coast Region Maritime Technology Center
University of New Orleans
New Orleans, Louisiana**

DELIVERABLE K

FINAL REPORT

PROJECT ENGINEER RECOMMENDATIONS

Project Engineer Recommendations

The processes and procedures used by these process improvement teams, (Steel Erection, Electrical, Paint and Blast) represent a base model for reducing workers compensation and occupational injuries. There is a wealth of research and information available to the industry from sources such as, OSHA, Council on Ergonomic and Management, and other governmental and private health organizations, to reduce injuries. Some of the information, research, and recommendations contained in these reports, were utilized during this project to help reduce or prevent further occurrence of injuries and workers compensation cost.

What makes this research project different from conventional projects is this; the employees, who actually perform the work, are the individuals involved in the problem solving process. When an organization is committed to reducing injuries and providing a safe environment, buy-in at the lowest employee level can be attained. The success of a business enterprise in the 1990's requires empowering employees to take responsible and accountable actions to assure personal safety on the job. This may sound like the "antiquated" expressions, "the employees are at fault", or "it is human nature", or "they are resistant to change." Quite contrary, management has to put in place, the proper tools, proper training, instill a culture change by living example and most importantly, be a learning organization committed to change. Once the employees are equipped, job performance in a safe, responsible and accountable manner is possible.

In order to reduce injuries and workers compensation costs in our shipyards, I believe that three basic domains should be examined: the environment (including tools, equipment, and climate of work setting), the person (including attitudes, beliefs, and personalities of the employees) and behavior (including safe and at-risk work practices, as well as intervening for a coworkers safety. These factors are interactive, dynamic, and reciprocal; influencing one factor eventually has impact on the other two. For example, changes in the environment have indirect effects on people's behaviors and attitudes, and behavior change usually results in some change in the environment. Thus, a Total Safety Culture (E.Geller 1997) must address each of these domains during the development and implementation of intervention strategies and throughout the ongoing evaluation and refinement of each process for achieving a Total Safety Culture. Each employee, whether CEO, Manager, Supervisor, or President has the right to return home in the same physical condition they came to work in.

Internal (observable) personnel factors continually influence observable behaviors, while changes in observable behaviors continually affect changes in person factors. Thus, it's possible to educate a person into safe behaviors (e.g., through education, coaching, and consensus building exercises), and it's possible to train

a person into safe thinking (e.g., through behavior management techniques). In an industrial setting, it is most cost-effective to target behaviors directly through behavior management interventions (e.g., behavior prompts, feedback, and rewards) implemented by the employees themselves. Small changes in behavior can result in attitude change, followed by more behavior change and more desired attitude change. This spiraling of behavior feeding attitude, feeding behaviors, feeding attitudes (and so on) can lead to employees becoming totally committed to a total safety culture, as reflected in their daily behaviors. And all of this could start with a relatively insignificant behavior change in one employee, a small win.

Intervention agents are needed to initiate increases in safe behavior throughout an organization and to nurture these small wins into a total safety culture. In other words, a total safety culture requires that employees accept responsibility of intervening for the safety of both themselves and others. In fact, in a total safety culture all employees look for ways to make behavior and environmental conditions safer; and when they find one, they intervene with appropriate consideration of relevant person factors. Thus, in a total safety culture all employees are continually involved in the safety process. In other words, all employees "actively care" for the achievement of a total safety culture.

Other concepts such as, communication, team building, and training in the total organizational culture will determine a successful safety program. Many organizations carry one or more of these concepts in their Vision, Mission and Goal statements, but are these concepts really understood in the context of safety? In my recommendations I will identify and define each individual concept in their context of organizational culture. After being apart of the individual process improvement teams, I've noticed a sub-culture that operates within the vision, mission and goals of the company. All organizations possess some form and shape of culture, and in some cases, there may be more than one culture in existence. Organization culture is sometimes difficult to define, and even more difficult to assess, measure and, if needed, to change. These observations were based on **historical methodology** to determine past practices of problem solving, teambuilding, and overall concern and values and attitudes of the personnel.

The remainder of the my recommendations will focus on the following concepts:

- A. Communication**
- B. Problem Solving In-Groups: When and Why**
- C. Organizational culture**
- D. Three cultures of management**

A. COMMUNICATION

The term communication is broad in that, people use it in a variety of ways that are only vaguely related. Family members, business entities, scientist, and certain organizations use the term differently but there is clearly some relationship among the uses of the word. A survey of the ways in which scholars use the word will show that there is no single, universally accepted usage. Some definitions are long and complex, others are brief and simple. What I am going to give is a working definition that will help achieve results for process improvement teams. For the purposes of this report **communication** *refers to the process of human beings responding to the face-to-face symbolic behavior of other persons.*

Communication is a Process

We often talk about communication as if it occurred in discrete, individual acts. In fact, communication is a continuous, ongoing process. Consider, for example, a friend's compliment about your appearance. Your interpretation of those words will depend on a long series of experiences stretching far back in time: How have others judged your appearance? How do you feel about your looks? How honest has your friend been in the past? How have you been feeling about one another recently? All this history will help shape your response to the other person's remark. In turn, the words you speak and the way you say them will shape the way your friend behaves towards you and others- both in this situation and the future. My point here is that, not only the words you speak but, your attitude towards your employees will determine the success or failure of your team.

This simple example shows that it's accurate to talk about "acts" of communication as if they occurred in isolation. To put it differently, communication isn't a series of incidents pasted together like photographs in a scrapbook; instead, it is more like a motion picture in which the meaning comes from the unfolding of an interrelated series of images.

Communication Competence

It's easy to recognize good communicators, and even easier to spot poor ones. Lee Iacocca, past CEO of Chrysler Corporation, was able to revive that corporation from bankruptcy, not because of leadership skills alone but with effective communication skills. The characteristic that distinguishes effective communicators from their less successful counterparts is **communication competence**. Most communication experts agree that communication competence is the ability to get what you seek from others in a manner that maintains the relationship on terms acceptable to both you and the other person. Ideally, an effective team will display communication

competence in results, relationships, and overall team interaction with other groups. The definition may seem both vague and verbose, but a closer look shows that it suggests several important characteristics of communication competence.

Your own experience shows that a variety of communication styles can be effective.

Some very successful people are serious, while others use humor; some are gregarious, while others are quiet; and some are straightforward, while others hint diplomatically. Just as there are many kinds of beautiful music and art, there are many kinds of competent communication.

Because competent behavior varies so much from one situation and person to another, it is a mistake to think that communication competence is a trait that a person either possesses or lacks. It's more accurate to talk about degrees or areas of competence. In order for teams to be successful in meeting challenges and performing tasks, their degree of communication competence must be consistently improved.

There are two sets of communications skills that any group must possess in order to come up with successful solutions. The first has to do with the group task itself: how to analyze the problem, choose the best solution, and make it work. A second area involves building and maintaining good relationships: making sure, first, that members feel good about each other and second, that they enjoy the experience of working together.

B. PROBLEM-SOLVING IN GROUPS: WHY AND WHEN

To many people, groups are to communication what Twinkies are to food, a joke. This unflattering reputation is at least partly justified. Most of us would wind up with a handsome sum if we had a dollar for every hour wasted in-group. On the other hand, it's unfair to view all groups as bad, especially when this accusation implies that other types of communication are by nature superior. Is group problem solving a waste of effort, or is it the best way to manage a task? As with most matters the truth falls somewhere between these two extremes. Groups do have their shortcomings, which will be discussed later.

1. Advantages of Group Problem-Solving

Research over fifty years that has compared problem-solving by groups and by individuals shows that, in most cases, groups can produce more solutions to a problem than individuals working alone...and that the solutions will be of higher quality. Groups have proved superior at a wide range of tasks, everything from assembling jigsaw puzzles to solving complex reasoning problems. There are several reasons why groups are effective.

- a. **Resources:** For many tasks, groups possess a greater collection of resources than do most individuals. Sometimes the resources are physical. For example, three or four people can put up a tent or dig a ditch better than a lone person. But on other problems the pooled resources lead to qualitatively better solutions. Think, for instance, about times when you have studied with other students for a test, and you will remember how much better the group was at preparing for all the questions that might be asked and at developing answers to them. (This, of course, assumes that the study group members cared enough about the exam to have studied for it before the group meeting.) Groups not only have more resources than individuals; through interaction among the members they also are better able to mobilize them. Talking about an upcoming test with others can jog your memory about items you might not have thought of if you had been working alone.

- b. **Accuracy:** Another benefit of group work is the increased likelihood of catching errors. At one time or another, we all make mistakes, like the man who built a boat in his basement and then wasn't able to get it out the door. Working in a group increases the chance that foolish errors like this won't slip by. Sometimes, of course, errors aren't so obvious, which makes groups even more valuable as an error-checking mechanism. Another side to the error-detecting story is the risk that group members will support each other in a bad idea.

- c. **Commitment:** Besides coming up with superior solutions, groups also generate higher commitment to carrying them out. Members are most likely to accept solutions they have helped create, and they will work harder to carry out those actions. This fact has led to the principle of participative decision making, in which the people who live with a plan help make it. This is an especially important principle for those in authority such as supervisors, teachers, and parents. As supervisors, we have seen the difference between the sullen compliance of employees who have been forced to accept a new procedure in which they disagree and the much willing cooperation of work groups who have helped to develop it. Though the benefits of participative decision making are great, I need to insert a qualification here: There are times when an autocratic approach of imposing a decision without discussion is most effective.

2. When to Use Groups for Problem-Solving

Despite their advantages, groups aren't always the best way to solve a problem. Many jobs can be tackled more quickly and easily—even more efficiently by one or more people working independently. Answering the following questions will help you decide when to solve a problem using a group, and when to tackle it alone.

- a. **Is the job Beyond the Capacity of One Person?** Some jobs are simply too big for one person to manage. They may call for more information than a single person possesses or can gather. Some jobs also require more time and energy than one person can spare. It's both unrealistic and unfair to expect one or two people to do all this work.

- b. **Is individuals' Tasks Interdependent?** Remember that a group is more than a collection of individuals working side by side. The best tasks for groups are ones where the individuals can help one another in some way. Think of a group of disgruntled renters considering how to protest unfair landlords. In order to get anywhere, they realize that they have to assign areas of responsibility to each member: researching the law, seeking additional members, publicizing their complaint, and so on. It's easy to see that these jobs are interdependent.
Even when everyone is working on the same job, there can be interdependence if different members fulfill the various functional roles. Some people might be better at task-related roles like information giving, diagnosing, and summarizing. Others might contribute by filling social roles such as harmonizing, supporting, or relieving tension. People working independently simply don't have the breadth of resources to fill all these functions.

- c. **Is There More Than One Decision or Solution?** Groups are best suited to tackling problems that have no single, cut-and-dried answer: What's the best way to boost membership in a professional organization? How can funds be raised for a charity? What topic should the group choose for a class project? Gaining the perspectives of every member boosts the odds of finding high quality answers to questions like these.
By contrast, a problem with only one solution won't take full advantage of a group's talents. For example, phoning merchants to get price quotes or looking up a series of books in a library don't require much creative thinking. One or two people working alone can

handle jobs like these. Of course, it may take a group meeting to decide how to divide the work to get the job done most efficiently.

- d. **Is There Potential for Disagreement?** Tackling problems as a group is essential if you need the support of everyone involved. Consider a group of friends planning a trip. Letting one or two people choose the destination, schedule, and budget would be asking for trouble, since their decisions would almost certainly disappoint at least some the people who weren't consulted. It would be smarter to involve everyone in most important decisions, even if doing so took more time. Once key decisions were settled, it might be fine to delegate relatively minor issues to one or two people.

C. ORGANIZATIONAL CULTURE

For the purpose of this research project, I will give a detailed analysis on why organizational culture should be assessed before undertaking team building and problem-solving groups. When injuries escalate and workers' compensation cost rise, management often initiates new programs, procedures and rewards (the new flavor of the month) to lower costs and personnel injuries. Yet, we wonder why after a few months, the injuries and compensation costs rise again. In many instances employee turnover, new technology, new processes and procedures are contributing factors to an organization returning to past failures. There can be a false assumption that the "employees are maybe out of control" or they are just "careless." What actually happens is that the organization fails to continue to use it's new learning.

The ability to create new organizational forms and processes, to innovate both in technical and organizational arenas, is crucial to remaining competitive in an increasingly turbulent world. But this kind of organizational learning requires not only the invention of new forms, but their adoption and their diffusion to the other relevant parts of the organization. Organizations still have not learned how to manage that process. The examples of successful organizational learning I've seen either tend to be short-run adaptive learning, doing better at what we are already doing, or, if they are genuine innovations, they tend to be isolated and eventually subverted or abandoned.

The history of organizational development, change, innovation and learning shows over and over again that certain lessons seem not to take hold. As early as the Hawthorne studies of the 1920's it was recognized that employee involvement increased both productivity and motivation. Lewin, Argyris, McGregor, Likert, and many others showed managers who treated people as adults, who involved them appropriately in the task they were accountable for, who created conditions that allowed employees to obtain good feedback so that they could monitor their own performance were more effective than those who did not.

On the one hand, one can say that this is just normal life in organizations. It is just politics or just human nature. Or one can say that these projects and programs were mismanaged, either by the project teams or the executive management above them. Or one can say that all of these human relations oriented programs were misguided in the first place. The deeper issue is that we have in most organizations three different major occupational cultures that do not really understand each other very well and that often work at cross-purposes with each other. These cultures cut across organizations and are based on what have been described as "occupational communities"(Van Maanen & Barley, 1984).

(See section on the concept of culture and occupational communities).

1. What is Organizational Culture?

The review of literature to support this project provided for some interesting theories and philosophies in regards to the concept of organizational culture.

The intent of the review of the literature was to gain as much knowledge and insight as possible to assist in my own understanding of the concept of organizational culture. This is necessary in order to determine the methodology for developing a working definition of organizational culture.

The working definition is built on the idea that the two principal types of assumptions that form any culture are shared beliefs and shared values. The content of the culture is ultimately derived from two principal sources; the first being the assumptions that leaders, managers, and employees bring with them to the organization, and the second being from the actual experience from the people within the organization as they adapt to the internal and external environments. The ability to define and label culture is difficult and requires the use of evidence, both historical and current, to infer what the culture is.

Charles Hampden-Turner provides a definition in his book, *Creating Corporate Culture: From Discord to Harmony* (1992), which provides insight to the overall idea and concern of culture, and assists in the building of a working definition for this project.

Culture comes from within people and is put together by them to reward the capacities that they have in common. Culture gives continuity and identity to the group. It balances contrasting contributions and operates as a self-steering system that learns from feedback. It works as a pattern of information and can greatly facilitate the exchange of understanding. The values within a culture are more or less harmonious (Hampden-Turner, 1992).

Edgar H. Schein, MIT Sloan School of Management, provides another definition in the periodical titled, *The Key to Organizational Learning in the 21st Century* (1997).

A culture is a set of basic tacit assumptions about how the world is and ought to be that is shared by a set of people and determines their perceptions, thoughts, feelings and, to some degree, their overt behavior of people and determines their perceptions, thoughts, feelings and, to some degree, their overt behavior. Culture manifests itself at three levels, the level of the deep tacit assumption that are

the essence of the culture, the level of espoused values which often reflect what a group wishes to be ideally and the way it wants to present itself publicly, and the day to day behavior which represents a complex compromise between the espoused values, the deeper assumptions and the immediate requirements of the situation. Overt behavior alone cannot be used to decipher culture because situational contingencies often make us behave in a manner inconsistent with our deeper values and assumptions. It is for this reason that one often sees "inconsistencies" or "conflicts" in overt behavior or between and espoused values. To get at the basic elements of culture one must either observe behavior over a long period of time or get directly at the underlying values and assumptions that drive the perceptions and thoughts of the group members.

For example, many organizations espouse "team work" and "cooperation," but the behavior that is rewarded and encouraged by the incentive and control systems of the organization is based more on a shared tacit assumption that only individuals can be accountable and that the best results will come from a system of individual competition and rewards. If the external situation demands teamwork the group will develop some behavior that looks on the surface like teamwork by conducting meetings and seeking consensus, but members will continue to share the belief that one gets ahead by individual effort and will act accordingly when rewards are given out.

Many executives tell their subordinates that they expect them to act as a team but remind them in the same sentence that they are competing for the boss's job!

2. Procedures to Analyze Organizational Culture

Review of the above-mentioned books pointed out that organizational culture couldn't be easily measured, observed, and defined. Therefore, it is my suggestion to utilize both historical and descriptive methodologies of research in order to obtain both qualitative and quantitative aggregate data.

Historical research involves the studying, understanding, and explaining of past events in order to arrive at conclusions about causes, effects, and trends of past events. This can help researchers in understanding and explaining present events and to also anticipate future events. Two of the principal types of assumptions, which form a culture, are shared beliefs and shared values. What has to be measured is not what the person says his/her beliefs and values are, but what his/her actions exhibit.

Culture is subject to development and change over a period of time because of the learning going on within the organization. This change is normally incremental and evolutionary and is affected by both external and internal environmental factors. The importance is in understanding the assumptions that leaders, managers, employees have brought with them and determining how these assumptions have had an impact on the development of the present culture. It is also important to determine the actual experience from people within the organization in their adapting to the internal and external environments.

In conducting the historical research, the main emphasis is determining how the culture is embedded in the organization and what significant events may have led to significant changes in the organizational culture. The evolution of the organization to how it exist now may give insight to the culture. Conflicts between leaders, union, and management as well as changes in organizational philosophy will all have an effect on the people within the organization. The researcher must determine how the organization is designed and structured for its decision making and communication flow. It is also important to determine how the organization response to crisis and other critical events and what has been learned from these experiences. This historical research will provide a basis upon which to build an understanding of the culture, and why it exists as it does today.

The descriptive research method is used to gather information on determining and reporting on the present status of the culture. The purpose is to clarify and report on the way things are now. This process can involve assessing attitudes and/or opinions. The problem with measuring feelings and attitudes is that they are highly changeable. In reacting to day-to-day events a person may be content one day and highly agitated and disagreeable the next.

An excellent instrument to measure how much of something is present and not feelings, or likes and dislikes, is the Survey of Organizations (SOO-2000). It is developed and provided by Renis Likert Associates, Inc. The main purpose of the instrument is to measure characteristics of the organizational climate, managerial leadership, peer behavior, satisfaction, and group process. This provides a descriptive measure of the prevailing conditions as perceived by the members of the organization.

The survey examines four categories of the organization. It measures the overall Organizational Culture, which deals with the organization-wide conditions, policies, and practices. The second category is Supervisory-

leadership, which relates to the interpersonal and task-related behaviors displayed by superiors towards their subordinates. The Peer Relationships are a measure of the interpersonal and task-related behaviors of the work group. The final category is a measure of the way the group works together as a team. This becomes an overall measure of the organization as summarized in the end results.

There is substantiating evidence that every organization has some type of culture. That culture represents a set of shared values and beliefs, which form a set of customs and typical patterns. It is assumed that an organization that has any history at all has developed some sort of culture and that this will have a vital impact on the degree of success of any efforts to alter or improve the organization.

The study of organizational culture provides a definition of a pattern of basic assumptions--invested, discovered, or developed by a given group as it learns to cope with its problems of external adaptation and internal integration--that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to these problems. The culture then becomes a major factor in determining the behaviors or actions by letting people know what is acceptable and what is not acceptable. These patterns of basic assumptions then become viewed as a set of understandings or meanings shared by that group of people. This definition then lends validity to the fact that many other organizational components, other than just employee attitudes, must also be considered in any assessment of the organization as whole.

To get a truly comprehensive picture of a department's culture, the following organizational components must be assessed.

1. The basic organizational beliefs, expectations, and shared values that set the environment for quality of service provided.
2. The group relations in regards to openness and trust among department members.
3. The history of the organization's growth and development, with emphasis on folklore, and stories of past events.
4. The leadership styles throughout the organization, and how

leadership is shared and promoted.

5. The lines of communication through the organization, with emphasis on free, creative, and effective communication of ideas.
6. The task of commitment, with goals and objectives clearly defined, with evidence of commitment to support and achieve them.
7. The reward system that recognizes challenging work combined with a system that adequately rewards persons for their efforts and achievements.
8. The spirit of cooperation which may exist between individuals and among the various parts of the department, with special emphasis on teamwork.

3. Cultures and Sub-Cultures

Cultures in this sense arise within *organizations* based on their own histories and experiences. Starting with the founders, those members of the organization who have shared in the successful growth of an organization will have developed a set of assumptions about the world and how to succeed in it, and will have taught those assumptions to new members of the organization.

Shared assumptions also typically form around the functional units of the organization. They are often based on similarity of educational background in the members or a similarity of organizational experience. What we often end up calling "stove pipes" or "silos." We all know that getting cross-functional project teams to work well together is difficult because the members bring their functional cultures into the project and, as a consequence, have difficulty communicating with each other, reaching consensus, and implementing decisions in an effective manner. The difficulties of communication across boundaries arise not only from the fact that the functional groups have different goals, but also from the more fundamental issue that the very meaning of the words they use will differ. The word "marketing" will mean product development to the engineer, studying customers through market research to the product manager, merchandising to the salesman, and constant change in the design to the manufacturing manager. When they try to work together they will often

attribute disagreement to personalities and fail to notice the deeper shared assumptions that color how each function thinks.

Another kind of sub-culture, less often acknowledged, reflects the common experiences of given levels within a hierarchy. Culture arises through shared experiences of success. If first line supervisors discover ways of managing their subordinates that are consistently successful, they will gradually build up a set of shared assumptions about how to do their job that can be thought of as the "culture of first line supervision." In the same way middle management and higher levels will develop their own shared assumptions, and, at each level, those assumptions will be taught to newcomers as they get promoted into that level. It is these hierarchically based cultures that create the communication problems associated with "selling senior management on a new way of doing things," or "getting budget approval for a new piece of equipment." As each cultural boundary is crossed, the proposal has to be put into the appropriate language for the next higher level, and has to reflect the values and assumptions of that higher level. Or, from the point of view of the higher levels, decisions have to be put into a form that lower levels can understand, often resulting in "translations" that actually distort and sometimes even subvert what the higher levels wanted.

Occupational communities also generate cultures that cut across organizations (Van Maanen & Barley, 1984). For example, fishermen around the world develop similar worldviews, as do miners, and, as do the members of a particular industry based on a particular technology. In these cases the shared assumptions derive from a common educational background, the requirements of a given occupation such as the licenses that have to be obtained to practice, and shared contact with others in the occupation.

The learning problems that are identified above can be directly related to the lack of alignment between three cultures, two of which are based on occupational communities. 1). *The culture of engineering.* 2). *The culture of CEO's.* 3). *The culture of operators.* The shared assumptions that arise in the "line units" of a given organization as it attempt to operate efficiently and safely. In order to understand how these cultures interact, let's examine their shared assumptions.

D. Three Cultures of Management

The Operator Culture. This culture is most difficult to describe because it evolves locally in organizations and within operational units. Thus one can identify and operator culture in the office, in the auto plant, in the cockpit, in the chemical complex, but it is not clear what elements make this culture broader than the local unit. To get at this issue we must consider that the operations in different industries reflect the broad technological trends in those industries. At some fundamental level, how one do things in a given industry reflects the core technologies that created that industry. And as those technologies themselves evolve, the nature of operations changes. For example, as Zuboff (1988) has persuasively argued, information technology has made manual labor obsolete in many industries and replaced it with conceptual tasks. In a chemical plant the worker no longer walks around observing, smelling, touching and manipulating. Instead he or she sits in a control room and infers the conditions in the plant from the various indexes that come up on the computer screen.

The operator culture is based on human interaction and most line units learn that high level of communication, trust and teamwork are essential to getting the work done efficiently. Operators also learn that no matter how clearly the rules are specified of what is supposed to be done under different operational conditions, the world is to some degree unpredictable and one must be prepared to use one's own's innovative skills to deal with them. Rules and hierarchy often get in the way under unpredicted conditions. Operators become highly sensitive to the degree to which the production process is a system of interdependent functions all of which must work together in order to be efficient and effective. These points apply to all kinds of "production processes" whether we are talking about a sales function, a clerical group or a service unit.

The tragedy of most organizations is that the operators know that to get the job done effectively they must adhere to the assumptions stated above, but the incentive system nor the day to day management system may support those assumptions. Operators thus learn to subvert what they know to be true and "work to rule," or use their learning ability to thwart management's efforts to improve productivity. In order to understand why this happens we must examine how two other major cultures operate in organizations.

The Engineering Culture. In all organizations there is a group that represents the basic design elements of the technology underlying the work of the organization and has the knowledge of how that technology is to be utilized. This occupational community cuts across nations and industries and can best be labeled the "engineering culture" (Kunda, 1992). Though this culture is most visible in traditional engineering functions one can see it in operation equally in the designers

and implementers of all kinds of technologies, information technology, market research, financial systems, and so on. The shared assumptions of this community are based on common education, work experience and the requirements of their job.

Engineers and technocrats of all persuasions are attracted to engineering in the first place because it is abstract and impersonal. Their education reinforces the view that problems have abstract solutions and those solutions can, in principle, be implemented in the real world with products and systems that are free of human errors. Engineers, and I am using this term in the broadest sense, are designers of products and systems that have utility, elegance, efficiency, safety, and maybe, as in the case of architecture, even aesthetic appeal, but they are basically designed to required standard responses from their human operators, or, ideally, to have no human operators at all.

In the design of complex systems, the engineer prefers a technical routine to insure safety rather than relying on a human team to manage the contingencies that might arise. Engineers recognize the human factor and design for it, but their preference is to make things as automatic as possible. Safety is built into the designs themselves. In other words, one of the key themes in the culture of engineering is the pre-occupation with designing humans out of the systems rather than into them.

Both the operators and the engineers often find themselves out of alignment with a third critical culture, the culture of the executives.

The Executive Culture. The third culture to be explored is the "executive culture," the set of shared tacit assumptions that CEO's and their immediate subordinates share worldwide. This executive worldview is built around the necessity to maintain the financial health of the organization and is fed by the pre-occupations of boards, of investors, and of the capital markets. Whatever other pre-occupations executives may have, they cannot get away from having to worry about and manage financial issues of the survival and growth of their organization (Donaldson & Lorsch, 1983).

What's being identified as the executive culture applies particularly to CEO's who have risen through the ranks and have been promoted to their jobs. Founders of organizations or family members who have been appointed to these levels exhibit different kinds of assumptions and often can maintain a broader focus (Schein, 1983). It is especially the promoted CEO who adapts the exclusively financial point of view because of the nature of the executive career. As managers rise higher and higher in the hierarchy, as their level of responsibility and accountability grows, they not only have to become more pre-occupied with financial matters, but they also

discover that it becomes harder and harder to manage to observe and influence the basic work of the organization. They discover that they have to manage at a distance and that discovery inevitably forces them to think in terms of control systems and routines which become increasingly impersonal. Because accountability is always centralized and flows to the tops of organizations, executives feel an increasing need to know what is going on while recognizing that it is harder and harder to get reliable information. That need for information and control drives them to develop elaborated information systems alongside the control systems and to feel increasingly alone in their position atop the hierarchy.

Paradoxically, throughout their career managers have to deal with people and surely recognize intellectually that it is people who ultimately make the organization run. First line supervisors, especially, know very well how dependent they are on people. However, as managers rise in the hierarchy, two factors cause them to become more "impersonal." First, they become increasingly aware that they are no longer managing operators, but other managers who think like they do, thus making it not only possible but likely that their thought patterns and world view will increasingly diverge from the world view of the operators. Second, as they rise, the units they manage grow larger and larger until it becomes impossible to know everyone personally who works for them. At some point they recognize that they cannot manage all the people directly and, therefore, have to develop systems, routines, and rules to manage "the organization." People increasingly come to be viewed as "human resources" and are treated as a cost rather than a capital investment.

The executive culture thus has in common with the engineering culture a predilection to see people as an impersonal resource that generate problems rather than solutions. Or, another way to put this point is to note that both executive culture and engineering culture view people and relationships as means to the end of efficiency and productivity, not as ends in themselves. If one must have human operators, so be it, but let's minimize their possible impact on the operations and their cost to the enterprise.

1. Interactions Among the Three Cultures

In many industries there is enough initial alignment between the needs of the task as defined by the operators, the needs of the engineers for reliable and efficient operations, and the needs of the executives for minimizing costs and maximizing profits so we do not observe any problems. It is when organizations learn generationally, when they attempt to reinvent themselves because the technologies and environmental conditions have changed drastically that these three cultures collide and we observe frustration, low productivity, and the failure of innovations to survive, therefore they diffuse.

The lack of alignment between the executive, the engineering and the operator culture can be seen in other industries such as health care where the needs of the primary care physicians (the operators) to do health maintenance and illness prevention runs both into the engineering desire to save life at all costs and the executive desire to minimize costs no matter how this might constrain either the engineers or the operators.

In the educational world we see the same conflict between teachers who value the human interaction with students and the proponents of sophisticated computerized educational systems on the one hand and the cost constraints imposed by school administrators on the other. If the engineers win, money is spent on computers and technologically sophisticated classrooms. If the administrators win, classes become larger and undermine the classroom climate. In either case, the operators, the teachers lose out and human innovations in learning are lost.

It is important to note that each of the three cultures is from its point of view "valid", in the sense of doing what it is suppose to do. Executives are supposed to worry about the financial health of their organization and engineers are supposed to innovate toward the most creative people free solutions. To create alignment between these three cultures, then, is not a case of deciding which one has the right point of view, but of crating enough mutual understanding between them to evolve solutions that will be understood and implemented. Too often in today's organizational world either the operators assume that the executives and engineers don't understand so they resist and covertly do things their own way, or executives and /or engineers assume that the operators need to be controlled more tightly and be forced to follow policies and manuals of procedure. In either case effectiveness or efficiency will suffer because there is no common plan that everyone can understand and commit to.

Another point to note is that both executive and engineering culture are

primarily task focused and operate on the implicit assumption that people are the problem, either as costs or as sources of error. In the case of the engineering culture the assumption is already in their education and training. The ultimately elegant solution is one that always works and works automatically, in other words, with out human intervention. In the case of the executive culture the situation is more complex. Executives either have come from the engineering culture where people were not important in the first place or learned as they rose and began to feel responsible for hundreds and thousands of people that they had to think in terms of systems, routines, rules, and abstract processes for organizing, motivating, and controlling. And as they become chief executives accountable to the financial markets and their stockholders they learn to focus more and more on the financial aspects of the organization. The gradual depersonalization of the organization and the perception that employees are mostly a cost instead of a capital investment is thus a learned occupational response.

The engineering and executive cultures may agree on the assumption that people are a problem, but they disagree completely on how to make organizations work more effectively. Executives recognize that their world is one of imperfect information, of constant change, and of short-run coping while attempting to maintain strategic focus. Engineers seek elegant permanent solution that are guaranteed to work and be safe under all circumstances, and, therefore, typically produce solutions that cost much more than the executives believe they can afford. So the executives and the engineers are in a constant battle of how good is good enough and how to keep costs down enough to remain competitive.

What is most problematic in this kind of scenario is that we have come to accept the conflict between engineering and management as normal, leading members of each culture to devalue the concerns of the other culture rather than looking for integrative solutions that will benefit both. And those executives who realize this dilemma tend to involve themselves from time to time in operations and in product development so that they do not lose touch with realities and strengths of the other cultures.

2. LEARNING IN THE TWENTY-FIRST CENTURY

It is of my belief that, organizations will not learn effectively until we recognize and confront the implications of the three cultures emphasized.

Until executives, engineers, and operators discover that they use different languages, make different assumptions about what is important and until they learn to treat the other cultures as valid and normal, we will continue to

see failures in organizational learning efforts. We will see powerful innovations at the operator level that are ignored, subverted or actually punished, we will see technologies that are grossly under-utilized, we will see angry employees railing against the impersonal programs of re-engineering and down-sizing, we will see frustrated executives who know what they want to accomplish but feel impotent in pushing their ideas through complex human systems, and we will see frustrated academics wondering why certain ideas like employee involvement, socio-technical systems analyses, high commitment organizations, and concepts of social responsibility continue to be ignored, only to be reinvented under some other label a few decades later.

First, we must take the concept of culture more seriously than we have. Instead of fooling around with superficial notions of manipulating a few priorities and calling that "culture change," we must recognize and accept how deeply embedded the shared tacit assumptions of executives, engineers, and employees really are. After all, we live in this industrial system for a century or more and have evolved these assumptions as an effective way for dealing with our problems. Each of these cultures can justify itself historically, and each has contributed to the success of the industrial system we have evolved.

Second, we must acknowledge that one of the main consequences of technological complexity, globalism, and universal transparency is that some of the old assumptions no longer work. Neither the executives, nor the engineers alone can solve the problems that a complex socio-technical system. We will have to find ways of communication that stimulates mutual understanding rather than mutual blame.

Third, we must learn how to create such communication by learning how to conduct cross-cultural "dialogues." The concept of "dialogue" has in recent years substantially improved our understanding of human thought and communication, and promises to make it possible to gain some understanding across cultural boundaries (Isaacs, 1993; Schein, 1993). If we can get people from the different culture into the room together, which is hard enough, we must get them to reflectively listen to themselves and to each other which is even harder.

Fortunately, the understanding of what it takes to create effective dialogues is itself coming to be better understood.

We are a long way from having solved the problems of organizational learning, but I am convinced that thinking about occupational communities and the cultures of management will help the process of structuring solutions to these problems in a way that will become visible in the 21st century.

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