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EXPLORING THE "CULTURE OF PROCEDURES"

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ABSTRACT

In this article we present the findings of a field study conducted to explore the influence of *culture* on procedure use in the petrochemical refining industry. We argue that anthropological approaches to the study of sociological culture suggest a methodology through which we can explore the roles played by procedures. We establish five dimensions of culture in process operations settings and give examples of how the dimensions manifest. We discuss the limitations and trade-offs associated with different approaches to procedure strategies and offer some tentative recommendations for putting this knowledge to use.

INTRODUCTION

Modern petrochemical refineries invest large amounts of time, money and manpower in creating, maintaining, training personnel in, and ensuring compliance with, their operating procedures. The Occupational Safety and Health Administration's (USA) standard OHSA 1910.199 imposes strict, detailed, and extensive requirements on U.S. petrochemical operations to document their operational procedures. In many plants, the role of 'procedure writer' is a full-time job for one or more individuals. Yet this effort regularly produces less than desired results. Operators frequently complain that procedures are 'out of date' and acknowledge that they seldom reference written procedures except during start up and shut down. In some quarters, the prevalent opinion seems to be that, 'if we could only get and keep our procedures *right*, and then get operators to follow them, then everything would be fine.' Yet recent research and theoretical developments (Rasmussen, et al., 1994; Suchman, 1987, Vicente, 1996; Miller and Vicente, 1998, 1999) imply that it is, and will always be, impossible to create a complete, correct, and comprehensive set of procedures for any 'open' domain—that is, one in which not all variables and interactions can be known.

Prior attention has been paid to the use of procedures in a variety of operational settings including process control. Both academic and industrial investigators have evaluated various processes for the generation, maintenance, design, use, and style of procedures. In contrast, this study looks specifically at issues of work *culture* and its impact on procedures. The study of 'culture' is properly the domain of anthropologists. Hence the methods we used to both collect and structure our data were based on anthropological techniques (see below).

It is important for us to note that the study of procedure culture *includes* the study of the procedures themselves, processes for generating and revising them, etc. However, procedures are always employed in some socio-organizational (i.e., cultural) setting. Beyond the procedure as artifact that researchers and engineers have typically been concerned with, there is a range of interesting factors affecting how, when, and why procedures get used. More so than with plant equipment or user interfaces, how and why procedures get used appears to be affected by organizational factors such as trust, faith, consent, motivation, enforcement, and ego. These factors, and the social and organizational parameters that control or affect them are what we mean by 'culture'. If engineers want to design improvements or revisions to procedure practices, understanding such cultural factors will provide a more detailed design landscape than more traditional investigations.

METHOD

Data Collection: We conducted field observations and interviews at four petrochemical refineries in the U.S. and Canada. A large proportion of our time at each site was spent with subject matter experts (SMEs) and/or procedure writers. These individuals are generally responsible for the creation, maintenance, and sometimes training of operational procedures. In addition, we spoke with operators at both board positions and lead and/or head

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operator positions. We employed a partially structured interview strategy, using both prepared questions and dynamic queries to direct the dialogue. We also reviewed the procedures of one plant unit extensively, mapping them against detailed knowledge that had previously been gained of the physical and functional operation of that unit (Miller and Vicente, 1999).

Organizing Framework: One of the first things that anthropologists do when beginning the study of a new domain where multiple, varying human cultures exist is to attempt, after multiple observations, to describe the dimensions across which those cultures vary. This is equivalent to creating a hypothetical 'map' for the terrain after having observed a few data points. It attempts to represent the 'space' of possible conditions across which the cultures may vary, even though not all possible points in that space have been observed. Some sample dimensions that characterize naturally occurring human cultures are:

- Matriarchal/Patriarchal
- Matrilinear/Patrilinear
- Primary Industry Class (e.g., Hunter/Gatherer Nomadic, Agricultural, Industrial)
- Social Organization/Political Form (e.g., Tyrannical, Monarchical, Democratic, Representational, etc.)

Once a candidate set of dimensions is understood, it becomes possible to begin to make correlational hypotheses about relationships within the dimensions which comprise the space, and between positions within the space and observed behaviors. For example, the belief that matriarchal societies tend to be agricultural is a statement about correlation between two dimensions of culture—and is moderately true with regards to observed data. Similarly, the claim that democratic cultures do not make war on one another is a claim about the correlation between a class of cultures that fall into a common region in the space and their behaviors. To date, this claim has proven true, although developing causal theories about why it is or must be true is far more difficult.

As one of the primary outcomes of this study, we have attempted to identify an initial set of 'dimensions of culture' for the ways in which refineries use and think about their procedures. As for the dimensions of naturalistic human cultures above, the purpose of this set is to 'map out the space' of potential cultures as a forerunner to describing and developing theories about how aspects of culture affect procedure use.

RESULTS

We identified five dimensions of organizational culture affecting procedure use. For each of these dimensions we provide a brief description, a definition, and a set of example alternative positions along that dimension.

Dimension 1: Purpose and Motivation

A procedure is capable of accomplishing multiple goals for an organization and different organizations use procedures to achieve different ends. In any event, the specific purpose(s) to which the organization (or parts of the organization) put the procedure colors not only the type of activities that are captured as procedures, but also the way in which procedures are regarded.

Definition: The various roles (both perceived and actual) that procedures fulfil in the organization.

Example Alternatives:

- Procedures as guidelines
- Procedures to meet regulatory requirements
- Procedures as a training tool
- Procedures as a means of enforcing culture or practice
- Procedures to capture operational expertise
- Procedures as records of historical information

Dimension 2: Comprehensiveness of Procedure Set

There is a broad three-dimensional continuum in which we can categorize the comprehensiveness of procedure coverage. Together, these dimensions convey how much of the full set of knowledge required to run the plant has been captured in the set of procedures. They interact to affect the kind of procedures the plant uses.

Definition: The comprehensiveness of a procedure set as a function of the number (many/few), breadth of coverage (narrow/broad) and level of detail (finer/coarser).

Example Alternatives:

- Generate procedures for every contingency (increased number and/or breadth)
- Generate procedures for only the most difficult contingencies (reduced number and breadth)
- Supplement procedures with other behavior-regulating practices (increased breadth)
- Create procedures that act as a guideline for operator behavior (less detail)
- Create procedures that denote as many details as can be pre-specified (increased detail)
- Create general procedures or operational rules (reduced number and detail)

- Aggregate procedures (increase detail or coverage or both while reducing number)
- Split procedures (increase number by splitting along either detail or coverage dimensions)

Dimension 3: Attitude Towards Deviation

We frequently come across incident reports or accounts of accidents that, explicitly or implicitly, implicate operators in failing to follow procedures. Yet there is a clear recognition in the industry that there are times when following the procedure is not the best course of action. This dimension addresses how organizations view deviations from established procedures.

Definition: The manner in which the various organizational bodies (e.g., management, operations teams) respond to operators deviating from procedures.

Example Alternatives:
- Deviating from a written procedure seen to be inherently wrong
- Attitude towards a deviation depends on the outcome
- Operator judgement is respected
- Procedures are regularly ignored

Dimension 4: Degree of Support Provided

Refineries are businesses and, like most enterprises, the issues that they see as being important receive a disproportionate quantity of resources. Procedures are no exception to this rule. Companies that value procedures will be more inclined to invest in their development and maintenance. Yet tradeoffs must always be made and the amount of resources provided may not be fully correlated with either need or with perceived importance.

Definition: The quantity of resources (human, financial, technological) that the organization devotes to procedure generation, use, and maintenance.

Example Alternatives:
- None; procedures are operators' notes if they're captured at all; no formal style, tools for use, or practice for maintaining
- Some; agreed format and storage location; designated procedure writer; basic software tools
- Lots; full time procedure writer(s); templates; dedicated software tools for writing and revision

Dimension 5: Degree of Participation

In any work environment, workers are more likely to be aware of and follow organizational practices when they have a say in establishing those practices. However, we also know that establishing policy by committee can be slow and expensive. Processing plants must decide to what extent each of the potential stakeholders in operating procedures will be granted writing, editing, or review authority.

Definition: The degree to which the generation, use, and maintenance of procedures is distributed through an organization.

Example Alternatives:
- Control isolated to one group of people; e.g., SME's or engineers
- Control shared
  - SMEs write; Operators review and modify procedures
  - SMEs draft with board and field operator input
  - Each team drafts its own procedures according to organizational standards and/or with SME review

DISCUSSIONS

The Troubles With Procedures

Through our observations and interviews we have noted a number of issues related to the role of procedures in social-organizational settings. Most of these stem either from tradeoffs which organizations must make in deciding how to use procedures or from discrepant pressures from various groups or subcultures within the organization as to where the organization should be on the various dimensions listed above.

High Cost of Maintenance. Organizations invest substantial time and resources in their procedures. This cost increases with the comprehensiveness (number, detail and/or coverage) of the procedure set and probably does so more than linearly, since procedures interact and multiple procedures will need to be reviewed whenever a change is made in one. Further, it is possible that procedure-intense cultures are self-reinforcing; organizations with a large number of procedures invest more money in procedures, which can lead to the generation of more procedures.

Accessibility. Making the procedures available to the intended users becomes a substantial challenge when the number of procedures becomes large. We witnessed a number of facilities where procedures are contained in multi-volume binders organized in such a way that the operators expressed frustration when trying to find a specific procedure. To some extent this problem is a function of poor organization of those particular documents but there is a degree to which the problem cannot be avoided. The more procedures there are, the

more difficult it will be to find the right one for the context at hand. Further, as more procedures are developed to cover more operator activity, access will become a more salient problem.

Infrequent Use Belies Investment. Despite the substantial investment made in procedures, we very rarely saw procedures in use in process facilities. Operators reported checking procedures during task execution only for particularly complex and infrequent tasks such as start up and shut down. It is clear that a very small proportion of operator activity is overtly done with procedures in hand. Operators either know the procedures well enough to ignore them, ignore them regardless of whether they know them, or think they know them well enough not to need them. Of course, this interacts with the accessibility of procedures—the higher the cost required to obtain, understand and use a procedure, the more likely it is that operators will make the cost-benefit tradeoff in favor of ignoring the procedure, assuming (whether or not it is true) that they know the procedure well enough to avoid the cost of having to explicitly acquire and use it. There are many points along this line of reasoning that are subject to misjudgment.

Perception of Out-Datedness. Every facility that we visited was able to state clearly their practice for periodically reviewing and revising procedures. In many cases it appears that these practices are followed dutifully. However, there is an unmistakable perception, often repeated, amongst operations personnel that some of the procedures that they are expected to use are out of date. In some cases this perception is justified, in others it is inaccurate. However, the perception itself is sufficient to impact the confidence that operators have in procedures and the practices that are associated with them.

Specter of Regulatory Compliance. OSHA has established requirements specifying modes of operation for which plants must establish procedures. However, these guidelines leave a great deal of room for interpretation of what a procedure should look like. The mere existence of a requirement, however, is a clear message to companies that procedures must be established and that they can be held responsible for failing to create, maintain, and execute those procedures. The potential problem with regulatory compliance is that it can lead to procedures that are designed to meet the legal requirements as opposed to support the operator. The simple fact is that design for multiple purposes is more difficult, and therefore more expensive, than design for a single purpose. Also, because OSHA has not (and cannot) explicitly state what set of procedures should exist for each plant and unit, there is perhaps some pressure to create and maintain more procedures than even OSHA would demand 'just to be on the safe side' of the legal requirement—though financial pressures would weigh against this.

Procedure Trade-offs

One of the difficult challenges posed by procedures is the trade-offs that they impose. We will discuss four of them.

Context Sensitivity vs. Completeness. It is clearly desirable to specify appropriate actions for operators to take when faced with foreseeable situations. However, no amount of investment will ever yield a truly complete set of procedures for an open system. Operators will inevitably face situations for which the available procedures are either not intended or provide incomplete guidance. One response to this is to write procedures that are context insensitive, or "open" to the variability that is inherent to complex systems. Another approach is simply to write lots of highly detailed procedures. Both approaches have advantages and drawbacks that are difficult to resolve.

Autonomy vs. Reliability. Writing context insensitive or "open" procedures places more responsibility for decision making and action on the operator. The organization must be willing to support a higher level of operator autonomy. The problem with greater autonomy is that it opens the unit up to greater variability in operator behavior. The motivation to grant operators greater autonomy to deal with varying contexts competes with the desire to know how operators will respond to a situation.

Autonomy vs. Co-operation. Autonomy can lead to problems with team cooperation. In an organization with low individual autonomy, an operator's teammates can predict with some confidence the actions he will take. This can be very valuable in terms of improving the efficiency of communication and co-operation.

Autonomy vs. Optimization. Autonomy can lead to a reduced ability to optimize a process. If procedures are employed to direct operators toward optimal performance, individual variability will likely reduce the degree of optimization. Even if operator actions by themselves are not particularly 'optimized', simply knowing reliably how operators will perform may be an aid to optimizing the plant as a whole. Operator creativity, while highly desirable in unanticipated fault situations, might be highly undesirable in most normal situations.

Recommendations

We conclude with a list of cautious recommendations for using this newfound knowledge about the socio-cultural aspects of procedure use.

Understand How Procedures Fit Into Control Room Activity. Procedures account for only a small fraction of the normal activity in a control room. The remaining 'normal operations' activity that takes place is both varied and critical to operational safety and productivity. Trying to document and 'proceduralize' it will be both difficult, time consuming, and very difficult to achieve with the richness and accuracy required. Instead, we think that it is important to develop an understanding of how procedure use fits into the broader scope of operator activity. That is, work design should consider how procedures interact with other activities such as routine monitoring, communication between control and field operators, and shift transitions among many others.

Acknowledge Multiple Roles. Not all stakeholders acknowledge the plurality of functions that procedures serve. Individuals tend to view procedures as serving a single purpose and may not recognize that they serve competing goals. To the extent that the designers and users are aware of the trade-offs inherent in procedure design they can more effectively evaluate the product.

Leverage Effort Devoted to Procedures. It is questionable whether organizations would invest in maintaining a large number of procedures if it were not for regulatory requirements. A greater return on this investment could come from leveraging the effort that goes into procedures by applying the process or product to other uses. One of the companies we observed does this particularly well with their integration of procedure generation and operator training.

Distinguish Levels of Constraint. A possible response to the trade-offs between the competing interests of autonomy, reliability, optimization, and team co-ordination may rest in specifying two levels of constraint on operator activity. These levels would reflect a distinction between hard requirements and educated suggestions. The hard requirements identify functional or operational constraints that, if violated, will likely place the process in a compromised state. The educated suggestions present the operator with an appropriate action that, if followed should lead to an improved process state. Other actions might well produce the same or better states. The operator can choose the suggested path or make an alternative if s/he believes it will be better. We would advocate making this distinction clear to operators to help them identify opportunities to exercise their autonomy within realistic hard constraints established to protect the process.

CONCLUSION

We have employed an anthropological approach to identify five 'dimensions of culture' to describe procedure use in refineries. Drawing from our field observations we provided examples of a number of points along each of those dimensions. These dimensions then served to promote a discussion of some difficulties and trade-offs with procedures. Finally, we offered some preliminary recommendations for improving procedure use.

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