SUMMARY OF THE SUBJECT MATTER EXPERT PANEL MEETING: TASK 8.4 LETTER REPORT

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TABLE OF CONTENTS

LIST OF ATTACHMENTS

LIST OF TABLES

LIST OF FIGURES

TASK 8.4 LETTER REPORT
SUMMARY OF THE SUBJECT MATTER EXPERT PANEL MEETING

1.0 Introduction

On May 23 and 24, 1995, a meeting was held at NRC Headquarters in Rockville, Maryland with a panel of experts in the area of communications human factors and practice. This meeting was an element of the technical work conducted under Subtask 4 of the Science and Engineering Associates, Inc. (SEA) Task Order 8, "Technical Assistance for Development of Review Guidelines for Evaluating Corrective Plans for NPP Communications Related to Events." This letter report summarizes the meeting contents and the set of recommendations made by the panel members. In this section, we describe more fully the purpose of the meeting, the panel members, and an overview of the major meeting activities.

1.1 Purpose of the SME Panel Meeting

The purposes of the Subject Matter Expert (SME) panel meeting were to advise the project team in the following ways:

- provide feedback on the technical approach taken by the project team and the interpretation of the main findings
- provide input on key project issues, including
  - the characterization of the communication process within the nuclear power plant context
  - the identification of communication errors
  - the range of appropriate corrective actions for the communication errors
  - the proposed approach to the guidelines document

The SME panel members were given no specific tasks to complete prior to the meeting. However, they were given an overview of the project and its findings to that date, and they were given the following set of questions to guide their thinking:

- Has the project team captured the broad range of possible verbal and written communication errors? If not, what types of errors were missed?
- Has the project team adequately identified the range of possible root and contributory causes for communication errors? What other important causes should be considered?
- Will the corrective action review guidelines, as proposed, be sufficiently comprehensive to address the ranges of errors and possible root causes that NRC staff may encounter?
- If a licensee's corrective action plan incorporates the characteristics presented in the draft outline, is it likely to be effective?
- What other corrective action plan characteristics should be included in the guidelines?
- Will the guidelines be usable by NRC inspection personnel?

1.2 SME Panel Members

The panel was composed of the following SMEs: Dr. Judith Orasanu, Capt. Ted Mallory, and Mr. Victor Peters. The following provides a description of each SME's background as it pertains to communication human factors and practice.

Dr. Judith Orasanu: Dr. Orasanu is an experimental psychologist currently employed at the NASA-Ames Research Center in the Operations Human Factors Branch. Her area of specialization is in distributed decision making and team cognition in naturalistic settings. A significant aspect of her on-going research program in these areas has entailed the identification of communication behaviors that discriminate between well and poorly performing crews in aviation. Her recent publications have addressed such issues as shared mental models and crew decision making, information transfer and crew performance, individual differences in airline captains' personalities, communication strategies and crew performance, and linguistic control of shared problem solving in the cockpit. Dr. Orasanu offers extensive theoretical knowledge of communication problems and effective practices for overcoming them, as well as expertise in the application and evaluation of communication strategies in applied settings.

Captain Ted Mallory: Capt. Mallory is the Director of Flight Training Development for Northwest Airlines and is an internationally recognized expert in human factors issues as they affect pilot performance. As a certified pilot, he is familiar with the practical application of communications protocols in operational settings. In his role as Director of Flight Training Development, he has been personally responsible for the design and implementation of Northwest's Cockpit Resource Management (CRM) training program. Capt. Mallory's expertise in CRM techniques is important to the panel because CRM is the primary tool used in the commercial aviation for addressing communications problems.

Mr. Victor Peters: Mr. Peters is an independent consultant specializing in work control and self-assessment processes within the nuclear power industry. Mr. Peters offers extensive knowledge of alternative models of effective coordination and communication processes for work control in on-going maintenance, surveillance, and outage activities at nuclear power plants. He is highly familiar with the administrative processes required as well as with the documentation necessary to support these activities. He has also played a key role in the development and implementation of corrective action plans at numerous plants.

Others attending the two-day meeting were the following:

From NRC's Control, Instrumentation, and Human Factors Branch, RES:
- Julius Persensky
- Isabelle Schoenfeld

From NRC's Human Factors Assessment Branch, NRR:
- Clare Goodman
- Garmon West

From the Project Team:

Valerie Barnes, PSHA
Joseph DeBor, SEA
Cindy Lauder, PSHA
Randy Mumaw, Westinghouse

1.3 Meeting Activities

Appendix A shows the meeting agenda developed prior to the meeting. The meeting progressed through the following general activities over the two days:

On the morning of Tuesday, May 23, the project team (Valerie Barnes and Randy Mumaw) provided project background to the SME panel. We began with a discussion of the project objectives and the model of communications within the nuclear power plant (NPP) context. From this broad overview, we went on to describe the analyses of Licensee Event Reports (LERs) and Inspection Reports (IRs). We talked about the initial LER reviews, the coding scheme that was developed, the full coding and error analysis completed, and the results of the coding. The coding results were presented through a set of 20 data tables (which are also described in the Subtask 8.3 Letter Report). These discussions, which took up the entire morning, aided the SME panel in understanding the NPP context and the range of roles played by written and verbal communications.

On Tuesday afternoon the SME panel offered their views on communications. They shared descriptions of communication-related events and incidents from aviation and nuclear power settings, and they described the ways in which communication problems are being addressed by others. This aided the group in bringing relevant information to bear on the project's objectives, and provided additional opportunities to characterize the nature of communications within the NPP setting.

During Tuesday evening, after the meeting was adjourned for the day, Valerie Barnes and Randy Mumaw developed a document for the next morning. This document was meant to synthesize the group's discussion from the day and present a strawman back to them to better focus their comments. This document is presented in this report as Tables 1 and 2. It uses the communications model to identify the ways in which communication can fail. For each type of failure, we then identified the set of potential root causes. Finally, we identified the set of corrective actions that could be used to address the root causes. The objective was to present a document that demarcated the boundaries of the problem and then use the SME panel to validate it.

On Wednesday morning, we presented our document to the SME panel, which turned out to be an effective way to focus the SME panel's input. There were significant areas where the SME panel felt that our strawman accurately captured the previous day's discussion, but there were also areas in which we made changes in response to their inputs. The remainder of the meeting was spent on two issues. One issue was the "Outline of Proposed Corrective Action Review Guidelines," which was a proposed outline of the project's final report. The other was a

discussion of what corrective action plans should include to ensure that the problems and root cause are being addressed appropriately.

Section 2 reviews the significant issues from the meeting in more detail. Section 3 summarizes the set of conclusions from the SME panel.

2.0 Issues Raised by the SME Panel

In this section we provide summaries of issues and themes that were introduced during the two-day meeting.

2.1 Review of Coding Data

The review of the coding data led the project team and the SME panel to express several concerns.

First, the coding data showed that written communication errors were much more prevalent than were verbal errors in the reports analyzed. The meeting participants confirmed a concern that the project team identified in the first task--i.e., it is unlikely that all communication errors are identified. This concern led the project team to develop a communication model that would aid in identifying communication errors. The meeting participants concurred that only communication errors that led to a significant problem (violation of Technical Specifications, etc.) and, therefore, the need for an LER were identified by this analysis. It is likely that many other communication errors occur but are either caught and corrected or lead to less significant consequences. Written errors take a more prominent role in reporting because they are more likely to be identified in a post-event analysis. Thus, we probably don't know the true extent of verbal errors or the relative importance of verbal and written errors in communications based primarily on an analysis of LERs.

A similar concern was raised by the finding that the coding data were more likely to implicate communications between functional groups than within functional groups--for example, between operations and maintenance rather than within operations, or across levels of the management hierarchy rather than within levels. While there is reason to believe that the across-group communications are problematic, it is also likely that communication errors will be under-reported for within-group communications. Again, the reason for this may be that errors that occur within a functional group are more likely to be caught and corrected by supervision before serious consequences occur.

The aviation industry representatives noted that a significant concern for them, when talking about communication errors, is authority differences--that is, the Captain does not use or seek information from subordinate officers or the subordinate is reluctant to offer unrequested information to the Captain. However, the LERs did not identify this issue in the NPP setting. This prompted Garmon West to relate such a case from a recent NPP incident. Further

discussion suggested that potential exists in NPPs for cultural and authority differences to lead to communication failures.

2.2 Significant NPP Influences on Communications

The discussion also aided the project team in identifying issues unique to the NPP setting that may push organizations toward communication failures.

First, unlike the aviation industry, the utilities have less pressure to include communications skills in their training. The NRC does not require communications training (such as CRM). Although, it was pointed out that a number of utilities are adopting this type of training on their own. The training being used in NPP settings, however, tends to address communications within functional organizations only. The group believed that training programs that address communication between groups are not common. In this context, it was mentioned that Professor Rhona Flin has been working with off-shore oil rig teams near Scotland to train communication and decision-making skills within large-scale simulations. These exercises tap into large segments of the entire organization.

Other issues were touched on in the discussion that made the group aware of general trends in the NPP setting that may lead to communications errors. Evidence was presented that there are sometimes significant delays in updating critical plant documents. The NPP is dynamic, with equipment changes and upgrades occurring frequently, and it is difficult for plant workers to keep up with the paperwork. As a result modifications are not always documented in a timely fashion and incorrect information can find its way into the work process.

We also discussed that some procedure-development practices (but not those connected to emergency conditions) may be less rigorous than they should be. The procedure developer may work from existing documents when developing a procedure, and then neglect "walking down" the procedure to verify its accuracy. As a result, the procedure may not be accurate or may be difficult to use, leading to written communication errors.

Finally, in the area of planning and scheduling, it is not uncommon for a plant to appoint a more junior person to the difficult task of determining how planning and scheduling of complex work tasks should occur. Ideally, a fairly senior person, who understands the plant and the potential for interactions of seemingly independent work activities, is placed in charge of planning and scheduling (especially, running the pre-job brief).

2.3 Communication Failures and Root Causes

In previous analyses, two representations of the communication process were created. Figure 1, shown on the next page, is a simple portrayal of the communication process between a sender and receiver, but it also provides the broader context of the job setting by including feedback and supervision explicitly. This diagram and a second diagram were presented to the SME panel as part of the Project Status Update package of materials.

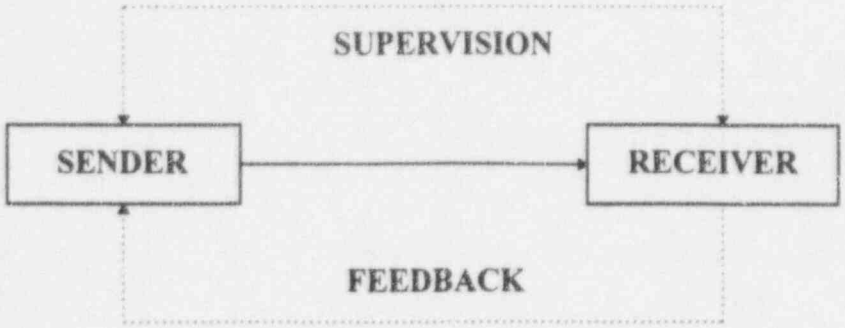

Figure 1: Basic Organizational Communication Process

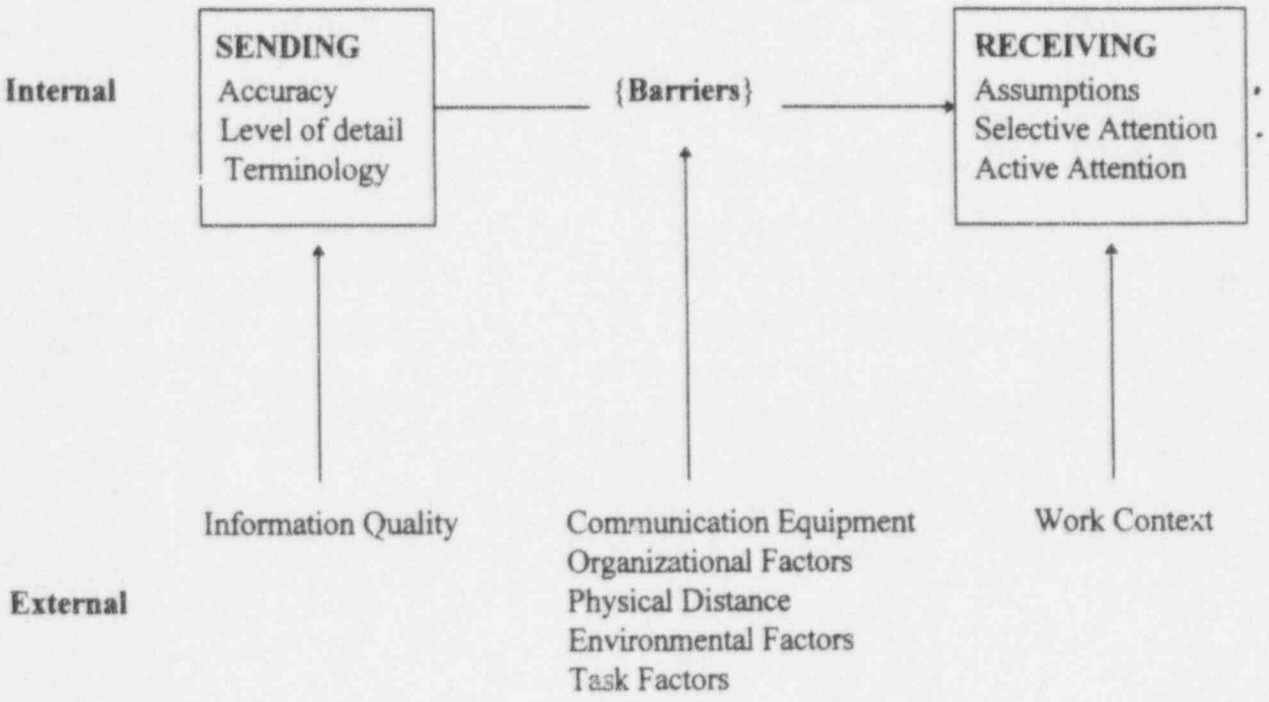

Figure 2: Internal and External Influences on Written and Verbal Communication

Figure 2, shown above, listed the major internal and external influences on the communication process. Between the first and second days of the meeting, Barnes and Mumaw used these figures to synthesize SME inputs from the first day's discussion and identify important corrective actions. Tables 1a and 1b show the results of this exercise. These tables were provided as an input to the SME panel to confirm their accuracy and completeness.

TABLE 1a: COMMUNICATION ERRORS AND POSSIBLE ROOT CAUSES	
Sending a message can fail in the following ways:	Possible Root Causes of Error
1. Message content is Wrong (I)	Information provided to sender is inaccurate: Incorrect documentation; poor technical training.
2. Message is inconsistent with other information (I)	Information available to receiver is not consistent with message: Incorrect documentation; poor technical training; incomplete information.
3. Message content is inappropriate for receiver (I)	Information is not tailored to receiver: Poor assumptions about receiver's knowledge or job role; poor understanding of job context.
4. Message production is inadequate (P)	The verbal or written production process fails: Verbal slips; typographical errors; communication equipment failures; interference from noise.
5. Message does not get sent (T;P)	Transmission does not occur: planning and scheduling weaknesses; high workload; distractions; slips; equipment failures.
6. Message is sent to wrong place/person (T)	Transmission is misdirected: planning and scheduling weaknesses; slips; equipment failures.
7. Message was sent at wrong time (T)	Transmission occurs too early or too late: planning and scheduling weaknesses; high workload; distractions; equipment failures.
8. Sender fails to verify/test receiver's understanding of message (V)	The success of the communication is not managed: Lack of awareness of effective communication skills; no way to get direct feedback.

The process used to create these tables was as follows: Initially, we identified the ways in which the direct communication process could fail, first in the sending process and then in the receiving process. The first column of Tables 1a and 1b shows the different types of potential errors. Next, for each type of error, we generated a set of possible root causes, which are shown in the second column of Tables 1a and 1b. Using the second column as an input, we then identified the set of corrective actions at a general level of description. The corrective actions are shown in Table 2 (see Section 2.4).

TABLE 1b: COMMUNICATION ERRORS AND POSSIBLE ROOT CAUSES	
Receiving a message can fail in the following ways:	Possible Root Causes of Error
1. Message is not sought (I)	Receiver fails to seek needed information: poor technical understanding, workload; distractions; cultural factors.
2. Message is not found or not used (R;Pc)	Receiver does not employ information in message: poor technical understanding; workload; distractions; organizational factors; equipment failures.
3. Message is misunderstood (Pc)	Receiver does not understand message and its implications fully: poor technical understanding.
4. Receiver does not apply a questioning attitude (V)	The success of the communication is not managed: lack of awareness of effective communication skills; no way to use direct feedback.

The following provides a more detailed description of the entries in Tables 1a and 1b:

Sender Failure - Message content is wrong. In this case, the communication fails because the information (message content) is incorrect. The primary concern, as reflected by the root cause column, is that the source of information for the message is incorrect, and the sender is not aware of the inaccuracy. We are thinking of cases in which incorrect information is taken from a source that is assumed to be authoritative (plant document, implementing procedure, etc.). Or, the information could be taken from another person and reflect gaps in that person's knowledge; therefore, incorrect technical training could be the root cause. Because of the constant stream of changes in a plant, the information in source documents eventually becomes inaccurate, and too often, updates to these documents fall behind.

Sender Failure - Message is inconsistent with other information. In this case, the information in the message sent is accurate, but it is not totally consistent with other information available to the receiver. The other information may be incorrect, or it may just be difficult to find the consistency between the two sets of information. For example, the message sent could be incomplete within the larger context of the task at hand, and the receiver could have trouble integrating the message with the other information. Therefore, possible root causes are similar to those of the previous failure.

Sender Failure - Message content is inappropriate for receiver. The role of the sender is to understand the task at hand, determine what information should be sent to another person, and then tailor that information so that communication is clear and effective. One form of tailoring the message is to ensure that the information is put into the proper work context. This might

mean pointing out links to other relevant work activities, identifying necessary modifications to standard practice, etc. Establishing the work context in the communication also means understanding the role the receiver will play in the job. In addition, tailoring the message content has implications for general language use--for example, removing ambiguous or vague references, using appropriate terminology, taking into account the receiver's technical understanding. Thus, there are a number of ways the sender can fail to make the content appropriate. The root causes here focus on the sender's inability to understand what is appropriate for the receiver: not understanding the work context fully, not understanding the receiver's role, not understanding how separate organizations (e.g., operations and maintenance) function together for the task at hand.

Sender Failure - Message production is inadequate. After an accurate and complete message has been composed and tailored to the needs of the receiver, the sender can create barriers to effective communication by failing to produce the message well. In verbal communication, poor production can lead to a garbled transmission or fail to make the signal stand out from the background noise. Poor use of the language, such the use of ambiguous or vague references, can impair verbal communication. The communication equipment (e.g., transmitter, public address) can also become a barrier to effective production. In written communication, production failures can take the form of poorly prepared materials (e.g., typographical errors, poor legibility). Possible root causes for these production errors are many; a few examples are provided in the table.

Sender Failure - Message does not get sent. A straightforward type of failure is that the sender fails to transmit the message. As we have said elsewhere, a significant contributor to effective work is planning and coordination. The job planning process should identify what information goes to which people and at what time. The simplest failure is that the message is not sent. The other potential failures are that the message is sent but to the wrong place or at the wrong time (see next two items). A failure to transmit might be due to lapses in the planning and scheduling process (e.g., it fails to identify the need to communicate). A second significant root cause for this failure is likely to be workload. A high workload (or some peripheral distraction) can prevent the sender from sending the message. Finally, a failure of the communications equipment might prevent the message from being sent. As computer-based communications (e.g., e-mail) take a larger role in nuclear power plants, transmission failures are likely to increase. The sender is likely to have less control over the transmission of messages sent in this way.

Sender Failure - Message is sent to wrong place/person. Even when the message is transmitted, failures can occur. For example, the sender could compose and transmit the correct message but send it to the wrong person or the wrong place (which also implies a wrong person). Similar to the last item, this failure may be due to lapses in the planning and scheduling process. Or, it might be the result of a slip, such as dialing a wrong number to send a message. Similarly, in the e-mail context, the wrong address could be used. These potential causes are represented in the root cause column.

Sender Failure - Message is sent at wrong time. Another aspect of coordinated work efforts is the timing of communications. Communication fails if the sender transmits the message either too soon or too late for the receiver to use the information appropriately. Sending the message too soon can be a problem because the receiver is then required to maintain the information somehow until it is needed. Memory can fail, or information recorded in some other way can be lost before it is needed for the task at hand. A significant root cause for this failure is likely to be workload. Both sender and receiver are likely to have multiple demands on them. A high workload (or some peripheral distraction) can prevent the sender from sending the message at the appropriate time. Weaknesses in the planning and scheduling process can also be a root cause of a communication timing failure. Finally, as the Table shows, failures in communication equipment may contribute to a timing failure.

Sender Failure - Sender fails to verify/test receiver's understanding of message. Implicit in our model of effective communication are burdens on both the sender and receiver to ensure that a communication act was effective. Thus, for the sender, the burden is to ensure that the receiver accepted and understood the message. This burden requires that the interaction extend beyond the initial communication act. The sender should take some action to verify or test the receiver's understanding of the message and its implications. When the sender fails to follow-up the message transmission, a communication failure has occurred. A likely root cause is that the sender is not aware of this role; communication skills have not been extensively trained in the nuclear power industry. Also, note that this type of failure makes most sense to discuss in the context of direct verbal communications. When communication is written or transmitted through a computer-based medium, such as e-mail, the sender cannot directly seek a verification. Instead, written communications must be tested more broadly at the time they are developed. For example, a procedure walk-through would be a way to test the user's ability to understand the procedure-writer's intent.

Receiver Failure - Message is not sought. The receiver's role in establishing the intention of a communication is to understand that information is needed for the task at hand and that that information should come from some communication (verbal or written). In the case of verbal communication, the receiver needs to seek information from the appropriate sender, or at least be prepared for a communication from someone. In the case of written communication, the receiver needs to know the set of documents or procedures that should be used for completing the task at hand. The primary root cause of failures is likely to be poor technical understanding--that is, the worker does not realize information is needed or, perhaps, relevant. For example, the worker may not understand that a procedure should be consulted or that coordination with a separate crew is required. A second source of this failure could be that the worker is overwhelmed. Workload is so high that it is not possible to seek the information needed. Finally, nuclear power workers may not have the appropriate mindset about the communications process and may not understand that receivers cannot be passive participants in communication.

Receiver Failure - Message is not found or is not used. The most straightforward failure on the part of the receiver is to not use the message transmitted by the sender. That is, we assume that a correct message has been successfully transmitted to the appropriate person at the appropriate time, but the communication fails because the receiver, intentionally or unintentionally, does not

employ the information in the message. One possibility is that the message is not found--for example, computer e-mail is not checked. A second possibility is that the message is "ignored" or not used, which might mean the receiver intentionally elects to not process the message or that the receiver is too overwhelmed by other events to process the message. For the case of the message being ignored intentionally, a root cause might be the receiver's poor lack of understanding of the message's relevance. When the failure is unintentional, high workload and distractions are possible root causes. Another potential contributor to this failure are organizational factors. As one moves from one organization to another, or across levels of the hierarchy, there is less understanding of the information available from the sender.

Receiver Failure - Message is misunderstood. When the receiver identifies and processes a message, communication can fail because the receiver misunderstands the message. One possible source of misunderstanding is that the message was not clearly produced and transmitted. There could be a significant physical distance between sender and receiver, or problems with communication equipment or noise could make processing difficult. However, we would prefer to place these root causes with the sender (under message production failures). The primary issue for the receiver, then, is one of technical understanding. For example, the receiver could have insufficient technical understanding (training) to do a job well and not understand how to interpret a message, even though that same message would be ideal for the person with the appropriate training. Thus, this type of failure places some burden on the receiver to be technically proficient. Although a role of the sender is to tailor the message to the receiver, there have to be practical limits on the modifications needed, especially for written communications.

Receiver Failure - Receiver does not apply a questioning attitude. As we said above, implicit in our model of effective communication are burdens on both the sender and receiver to ensure that the communication was effective. We noted that, for the sender, the burden is to ensure that the receiver accepted and understood the message. For the receiver, the burden is to go beyond the initial communication act to test his own understanding. This may mean repeating back or paraphrasing the message to the sender to check concurrence. By adopting a questioning attitude, the receiver can identify gaps in the message or in his understanding. The receiver needs to ensure that the message and its full implications are understood. When the message does not seem to fit with other information, the receiver needs to continue the interaction with the sender to remove uncertainty. As before, the likely root cause of a failure to do this is that the receiver is not aware of this responsibility. For written communications, the receiver may have to work harder to apply a questioning attitude--for example, seek the supervisor or the developer of the original procedure--since the original sender may not be available.

Discussion of failure types. Two larger issues should be noted regarding this exercise and the resulting Table 1. First, there are strong assumptions (taken from the Cockpit Resource Management model of communication) in these failure types regarding the appropriate responsibilities of the sender and receiver roles. We took the position that the two individuals involved in the communication act need to take an active role in communication. The sender needs to try to understand the role of the receiver in the work context, tailor the message to that receiver (within reasonable limits), and verify that the message was understood. The receiver, in

his role, must understand the need for communications from others in the work context and ensure that the information received is understood in that context.

Note that these responsibilities have the most meaning in direct verbal communication. However, they should be applied as well to written communications. In this case, the responsibility of the sender is to conduct more general tests of the message's effectiveness. The responsibility of the receiver becomes one of seeking other sources to confirm an understanding of the message.

Some discussion took place on the second day of the meeting on the impact of computer-based communications, which are becoming more prevalent in power plants. This medium, like any written medium, can remove the opportunity for direct feedback between sender and receiver. Unlike many more-formal written communications (such as operating procedures), however, there are less likely to be tests of the message's effectiveness.

A second issue, raised by Dr. Orasanu, is that the failures in Table 1 can be classified into a higher-level description of communication. The failures on the sender side represent the following:

- Intention - the sender's intention to develop an effective message. The first three failures (marked in Table 1 with an I), represent failures in the intention to develop an effective message.
- Production - the sender's ability to effectively produce the message for transmission. Failures 4 and 5 in Table 1 can represent production failures.
- Transmission - the sender may fail to transmit a message effectively, as represented by failure types 5, 6, and 7.
- Verification - the sender may fail to verify that the message was received and understood. The last failure type is in this category.

Thus, one might use these processes--intention, production, transmission, and verification--to describe the sender's communication. On the receiver's side, the following processes are used:

- Intention - the receiver's intention to seek a communication, as represented by failure 1.
- Reception - the receiver's ability to receive the transmission.
- Processing - the receiver's ability to comprehend the message and its implications for the task at hand.
- Verification - the receiver may fail to conduct a thorough verification of the intent of the message.

The receiver processes in communication, then, are intention, reception, processing, and verification. These process classes for senders and receivers provide some structure for identifying the failures in the communication process.

2.4 Corrective Actions

Table 2 shows the corrective actions we derived from the set of root causes in Table 1. These items are described here and linked to the most relevant root causes.

Table 2: CORRECTIVE ACTIONS

- **Document Management Program**
- **Work Control Program**
- **CRM (requires culture change)**
  - **Communication practices**
  - **Team building/cross-training**
  - **Workload management**
  - **Technical proficiency**
- **Engineering/technology improvements**
- **Administrative Controls**
  - **Increased staffing**
  - **Checklists**

Document Management Program. A concern for the sender in our analysis of failures, and a nontrivial source of errors in the coded reports, was the existence of inadequate information among plant documents. The root causes for sender failures 1 and 2 in Table 1a reflect this situation. In addition, Mr. Peters, during the SME panel meeting, emphasized how difficult it is for nuclear power plants to maintain accurate documents. Often, the necessary changes are made in the plant hardware, procedures, etc., but those changes are not documented in a timely manner. Therefore, the documents that plant staff rely on contain a substantial number of inaccuracies. Examples are equipment diagrams that don't show modifications, procedures that are not updated to account for new equipment, and surveillance and test schedules that are out of sync with other documents. These flawed documents are the source of much of the information that is communicated during plant operations and maintenance. Therefore, on occasion, someone will send inaccurate information and a significant problem will result. In many cases, the error is significant enough to create an awareness of the problem, and the immediate inaccuracy is corrected.

There seem to be two issues behind this problem. First, the effort required to keep up with changes is monumental. Second, it may be difficult to determine exactly which sections of which documents are affected by a modification. A more enduring corrective action would be to establish a program for better maintaining the integrity of the documents that plant staff rely on. Ideally, a computer-based system could keep track of the links between documents so that when changes are made, all relevant documents can be identified and modified appropriately. Many utilities have instituted some type of program for this purpose. However, problems with the systems remain, and errors continue to occur.

Work Control Program. There were several potential failures linked to the sender's transmission of messages (see failures 5, 6, and 7 in Table 1a). A root cause identified with these failures was the existence of weaknesses or gaps in the planning and scheduling of tasks. Namely, there was a concern that a poor planning and scheduling process may lead to failures of relevant workers being made aware of job information. Recall that the second phase of our broader model of NPP communications identified the importance of the planning and scheduling in ensuring effective communications and reducing error. A large class of corrective actions can be directed at establishing effective work control practices.

An important element of a work control program is establishing the appropriate policies or processes to ensure that complete and thorough planning and scheduling are done. These processes should indicate the types of situations that demand activities such as pre-job briefings, and they should identify the groups that should be represented at these briefings. A critical element of managing communications in a work control program is a set of guidelines for conducting effective pre-job briefings. The guidelines can specify the types of information to be presented, the types of feedback that should be obtained before the briefing is completed, etc.

Cockpit Resource Management. Over the last 10 years, commercial aviation has developed and adopted a Cockpit (or Crew) Resource Management (CRM) approach to training cockpit crews. In developing CRM, the aviation industry was responding to strong evidence that effective communications were being impaired during flight operations. Specifically, there was mounting evidence that cockpit communication was being stifled by rigid adherence to a strong, single decision maker. Flight Captains were reluctant to seek information from junior officers, and the junior officers were discouraged in both subtle and explicit ways from questioning the Captain's authority. In addition, there were problems in workload management. Captains were reluctant to hand over flight tasks even when they were too overwhelmed to complete these tasks. Thus, too often flight tasks were not conducted efficiently, and in some cases, accidents resulted.

The aviation industry began instituting training that focused on three issues: communication skills, team building, and workload management (Note that the Northwest Airlines CRM program also includes technical skill training, but we have placed this type of training in a separate Corrective Action). According to the description of Northwest Airlines' CRM program (supplied by Captain Mallory of the SME Panel), the following skills are addressed by the CRM program:

- Communication
  - briefs crew thoroughly
  - clearly communicates decisions about operation of the flight
  - explicitly encourages participation from crew
  - seeks information and direction from others when necessary
  - asserts appropriate level of persistence to maintain a safe operation
  - critiques self and other crewmembers when appropriate
- Team Building
  - act with confidence
  - involves entire crew in decision-making process
  - uses appropriate techniques to manage interpersonal and operational conflict
  - adapts to crew interpersonal differences
  - crewmembers cope effectively with operational stress
- Workload Management
  - distributes task to maximize efficiency
  - prioritizes tasks for effective accomplishment
  - manages time for accomplishing tasks
  - monitors and analyzes all relevant operational factors to remain situationally aware

The skills addressed by the CRM program are strongly relevant to several of the communication failures identified in our analysis. First, training effective communication skills can have a significant impact on sender failure 8 and receiver failure 4. And, the training provided by CRM has been shown to be an effective means for training communications skills. This training approach provides a model of communication that assigns clear roles to both sender and receiver, and then it provides directed training that moves trainees from awareness of these roles to detailed operational scenarios in which they can practice communication skills.

Second, team building directly addresses concerns with the coordination among work groups. Especially when the notion of cross-training is added to team building, this type of training helps ensure that senders have a deeper understanding of the receivers' roles in the work context. Sender failure 3 is linked to having a poor understanding of what other workers are doing and its relevance to the communications. Cross-training is a way to familiarize a worker with the tasks and roles of other workers who have a direct link to a shared task.

Third, workload management training is relevant to all the failure types in which high workload was cited as a possible root cause: sender failures 5 and 7 and receiver failures 1 and 2. This type of training aids pilots in assigning priorities to tasks and provides effective strategies for re-allocating workload when demands become too great.

Technical Training. As our analysis of failures and root causes showed, and the error report coding data confirmed, in a significant number of cases communication fails because the sender or receiver has weak technical skills. The sender and receiver both need to understand the task at hand and the types of information that should be transmitted to support task performance. For example, the sender needs to be able to know how to couch a message in the appropriate work

context. Similarly, the receiver needs to understand what information is relevant so that information can be sought out. We identified poor technical training as a potential root cause of communication failures in sender failures 1, 2, and 3 and in receiver failures 1, 2, and 3.

Technical training is already a significant element of nuclear power plant operations. We believe that strengthening crew technical skills can be a valid approach for addressing communication errors.

Engineering and Technology Improvements to Communications Equipment. A number of communication failures were tied to root causes that implicated communications equipment. A simple example was a failure of a radio device. Especially as new communication media are introduced to the work setting (e.g., computer-based message transmission), it is important to ensure that communication equipment supports the elements of effective communication. For example, it is important that the sender be able to determine that the message was received by the appropriate person at the appropriate time. Or, it is important that the receiver has a means to test his understanding of the message with the sender.

The possibility of communication equipment contributing to communication failures occurred in sender failures 4, 5, 6, and 7 and in receiver failure 2. There is a general class of corrective actions that improve communications equipment to aid effective communications.

Management and Supervision Controls. Finally, we identified the possibility that communication failures could be caused by simple slips (see sender failures 4, 5, and 6). That is, human error is unavoidable no matter how effective an organization. The last line of defense is to catch errors that occur and correct them before any real damage is done. A general approach to preventing and mitigating serious errors is to establish an effective method for management and supervision.

In some cases, part of the effective solution is increased or more competent staffing. Increasing staffing can provide an additional pair of eyes and ears, which can be sufficient in some cases to catch errors. Often the primary role of supervision is to provide the extra check that performance is correct. The supervisor is less likely to get lost in the details of performance and more likely to monitor appropriate outcomes of the work. In other cases, increases in staffing are less important than having the right person with the right skills in the job. For example, because technical proficiency is often critical to effective communications, placing highly skilled people in charge of planning and scheduling can help to reduce error opportunities.

Another management technique is building in sufficient checks on performance. The aviation industry has been very good about providing formal checklists even when detailed procedures are not needed. The checklists, or even automated checks on accurate and complete performance, aid pilots in catching errors before significant consequences occur.

2.5 Corrective Action Plans

On the second day, we discussed general guidance for evaluating Corrective Action Plans. The purpose of this exercise was to identify important characteristics of a Corrective Action Plan so that the NRC reviewer can evaluate whether the Corrective Action Plan includes them. Mr. Peters indicated that there is often no formal effectiveness evaluation in a Corrective Action Plan. Thus, as soon as the Plan is put into place, it is considered to be completed and successful. Too often, no one takes responsibility for determining if errors are reduced (or performance is improved). This is especially true for Corrective Actions that use training: the implementation of the training is considered the endpoint of the Plan.

Mr. Peters led the group through general guidance for evaluating the effectiveness of Corrective Action Plans. Appendix C is a document he provided after the SME Panel meeting. Important points within this guidance are the following.

First, it is important to ensure that an adequate root cause analysis was conducted. Second, it is critical to determine that the goals of the corrective action(s) are tied to the root cause(s) of the problem. Mr. Peters related a story in which a maintenance report described a pump problem as "the pump don't pump." Taken at face value, the maintenance crew may have requested a complete overhaul of the pump, which would have been extremely expensive. A more detailed look at the problem uncovered a bad fuse, which could be replaced at virtually no cost. The point of the story is that a Corrective Action Plan should ensure a thorough analysis of the problem is conducted so that the root cause can be addressed.

Third, it is important to identify measurable objectives for determining the success of the Corrective Action Plan. This allows one to determine that the implementation of the action plan is having the desired effect. Fourth, the Corrective Action Plan should identify steps or actions to achieve each objective, including an implementation schedule and the assignment of a manager to be responsible for carrying out activities.

Lastly, an important element of an effective Corrective Action Plan is the Closure Criteria. The Closure Criteria include a description of how to determine whether objectives have been met, a designation of a person or persons responsible for monitoring system performance to determine that the problem has been resolved, and a plan for on-going performance measurement (not just a one-time measurement).

3.0 Summary of SME Panel Recommendations

Through the two-day meeting, the SME panel offered a number of recommendations. This was not a formal process of consensus development in which we documented specific recommendations. Instead, we identified the larger issues for which there was strong agreement among group members. Each recommendation is described here:

1. Characterization of the Communications Process. In general, the SME panel was in strong agreement that our characterization of communications in the NPP setting was comprehensive and provided a useful framework for discussing errors. More specifically, the initial communications model presented in a Letter Report was accepted as a useful framework for describing the errors from the coding. Also, the analysis of communication failures and root causes (presented here in Table 1) was accepted with only minor revisions. It was seen as a comprehensive account that provided a useful link to the root cause analysis. The most discussion came from the proposed set of corrective actions (Table 2 above). There were a number of revisions to the initial version of this set, but by the conclusion of the meeting, there was strong agreement that this set was complete for our purposes.

2. Interpretation of the Coding Data. The group was in strong agreement that, while the data from the coded LERs and IRs were valuable for developing insights into NPP communications, those data should not be given too much weight. As a group we found potential biases in the data (see Section 2.1), and that these data may not be totally representative of the types of communications errors that occur. Certain error types are over-represented and certain types are omitted completely. However, put in the proper perspective, these data can supplement the more theoretical model development.

3. The Scope of the Corrective Action Review Guidelines. The exercise that led us to develop Table 2 greatly expanded the scope of the corrective actions that are relevant to communications issues. Early in this project, we maintained a focus on corrective actions linked narrowly to verbal communications skills. However, as we revealed more of the complexity of the communications process, including written communications as well, we expanded the set of root causes that should be addressed through corrective actions. Table 2 includes corrective actions linked to information management systems, plant management approaches, communication technology issues, and technical training. The SME panel saw value in considering all of these as legitimate responses to communications issues.

However, there was also the acknowledgment that guidance already exists that addresses some of these other issues. Certainly, within the nuclear power industry and its regulatory agencies there are extensive guidance documents in place for technical training, development of procedures and other formal written documents, and organizational/management issues. In addition, as communication technology advances, guidelines will be added by appropriate groups to address communications functions. Therefore, although the scope of corrective actions has been expanded, there was agreement that the document developed for this project should concern itself

primarily with verbal communications skills, which are not addressed by other sources. It is important that the review guidelines reference other relevant guidance documents.

4. The Corrective Action Plan Scope. There was strong agreement that the Review Guidelines should provide a model of a Corrective Action Plan. The model should include appropriate treatment of root causes, establishment of objectives, and complete closure criteria. Appendix B provides some guidance for this element. This document was provided by Mr. Victor Peters as an input to the requirements for Corrective Action Plan guidance.

5. The Guidelines Document. Discussion of the Corrective Action Review Guidelines document led to two recommendations on format and content. First, several panel members felt that the body of the guidelines document should have more of a "checklist" appearance, with the details stored in an Appendix. This assumes that the reviewers are trained on the guidelines and primarily need retrieval cues and reminders in conducting a review. Second, the panel recommended that the reviewers receive training on the review process and that the guidelines document include a substantial "preamble" to introduce the purpose and scope of the document.

This set of recommendations has been taken as input to the guidelines document, which is now being developed.

ATTACHMENT A

Meeting Agenda

Wednesday, May 24

9:00 a.m.	Assess Feasibility of Corrective Actions in NPP Context · Identify Potential Barriers to Implementation · Develop Strategies for Implementation Despite Barriers
10:30 a.m.	Break
10:45 a.m.	Identify Set of Corrective Actions Appropriate for NPP Context
11:15 a.m.	Propose General Guidelines for Each Corrective Action
12:30 p.m.	Adjourn Meeting

Meeting Attendees:

Valerie Barnes, PSHA
Joseph DeBor, SEA
Clare Goodman, NRC
Ted Mallory, Northwest Airlines
Randy Mumaw, Westinghouse STC
Judith Orasanu, NASA-Ames
Julius Persensky, NRC
Victor Peters, AMS
Isabelle Schoenfeld, NRC
Garmon West, NRC
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ATTACHMENT B

General Guidance for a Corrective Action

CORRECTIVE ACTION PLANS IN NUCLEAR POWER PLANTS

I. TYPES OF CORRECTIVE ACTION PLANS

A. GENERAL PLANT IMPROVEMENT PLAN

- Usually involves all site organizations

- Originates due to one or a combination of:
  - Internal Self Assessment reports
  - Self-initiated Site Evaluation Team (SET) or Operational Readiness Assessment Team (ORAT) report
  - INPO evaluation team report or assist visit report
  - Regulatory requirements expressed in a Confirmatory Action Letter
  - Declining performance trends identified in Systematic Assessment of Licensee Performance (SALP) report
  - Findings identified in performance-driven Site Inspection Team (SIT) reports

- Purpose is to effect significant change in work and management processes to bring about improvement in operational performance including a reversal in declining performance trends.

- Actions can address specifically identified problems and weaknesses and any and all aspects of the plant including: Organizational structure; management span of control; reporting relationships; manager capability and competence; training and qualification programs; performance indicators; and the hierarchical family of vision; goals, objectives, policies, programs, processes, procedures, and practices.

  Note: In this context, a "policy" is constraint or limitation on the latitude which may be taken in developing and implementing programs, processes, procedures and practices to meeting established goals and objectives (e.g., use of overtime, use of contractors, budget variance limits, dress codes, meeting durations, planning deadlines, material ordering deadlines, scope freeze dates, etc.)

B. CORRECTIVE ACTION PLAN

- Usually involves a single problem or type of problem

- Can be subset of a General Plant Improvement Plan

- Originates from:
  - The NPP's own Corrective Action Program (CAP) including RCA and trend analysis
  - Commitments made in Licensee Event Reports (LER) and other written and oral reports to the NRC
  - Internal Departmental Self Assessments

- Purpose is to correct the root causes(s) of a specific problem or type of problem or to correct specific personnel errors or errors in technical documentation and procedures. Actions are usually performance-related, either to improve personnel performance, or to improve the performance (reliability) of plant components, systems and structures.

- Actions can be directed at changing a procedure or a process to establish additional safety barriers or to improve actual practice; upgrading personnel knowledge and skills through training; changing management styles and focus; establishing additional performance indicators; or developing and implementing plant modifications.

  Note: An effective NPP Corrective Action Program includes maintenance monitoring, trend analysis, and root cause determination of component failures.

II. ACTION PLAN DEVELOPMENT

A. SYMPTOMS (Symptoms are evidence of Problems)

The first step in developing an effective Action Plan is to identify real causes, to move from symptoms to problems. A situation in need of attention or corrective action is manifest in one or more symptoms. The symptoms themselves are very often mistaken as the problems or situations in need of attention. Weaknesses in the problem identification process can lead to inappropriate or ineffective corrective actions.

Peters' Law of Opposites: **"The truth usually lies in the direction opposite of where it appears."**

First Corollary of the Law of Opposites: **"Any action taken to correct a problem will make it worse."**

For performance-related situations on a broad scale (plant performance), problem symptoms are usually identified subjectively. Subjective symptom descriptions are more easily biased (albeit unintentionally) by the reporting person because the descriptions originate from one-time or short-term (partial) observations, analyses of inaccurate or incomplete data, comparisons with personal experience, perceptions of others, opinions (of both interviewer and interviewee), comparisons of portions of processes with a home plant (or favored plant, or previous plant) methodology, or other "soft" sources. Corrective actions based on this kind of source information can be aimed at changing perceptions, or opinions, or altering (fouling) a critical part of a process to make that portion similar to a process at another plant, etc. The resultant action plan can easily become an exercise in futility. Implementation can exacerbate the existing conditions rather than "fix" them. Such a plan also communicates the wrong message, i.e., "management is clueless."

It is often difficult to accurately identify real problems from subjective source information. Therefore, it is important to "Validate" each data element (to the maximum extent possible) and then make a best effort to identify the underlying causes of the observed symptoms. Related causes or valid problems should then be grouped for the second step in developing an action plan. Subjective source information which cannot be validated or for which an underlying cause cannot easily be identified, should be grouped and treated the same as validated input data. Some of this information will fall out during implementation plan development or implantation.

For performance-related situations involving singular events or conditions (equipment failure, personnel error, etc.) problem symptoms derive from the result of the event or condition. Although it is usually easier to identify root causes for singular events or "hard" sources, the symptoms can be mistakenly used as the problem description. Unless the root cause(s) is correctly identified, the action plan is not likely to effect an improvement in performance. Again, the real problem could be exacerbated by the action steps in the plan or, more likely, the actions could have no lasting effect on performance at all.

B. ISSUES (Problems define Issues)

The second step in the process leading to an effective Action Plan involves identifying Issues from related sets of problems. It is the same regardless of the kind of action plan involved. Issues are defined as undesirable existing conditions that spawn, produce or nurture problems and errors. Issues are identified by grouping related, valid problems with related, alleged problems and then describing an existing condition, with the problem groups being the supporting evidence that the condition exists. It is not necessary to identify all the problems caused by the undesirable existing condition, only enough to recognize what it is. These undesirable conditions are actually more deeply imbedded in the organization than the typical "root cause". ("Root" is an appropriate word to use in this context. A root is a capillary that draws nutrients from its environment into the body of its parent. The more hostile the environment, the more extensive the root structure. The more extensive the root structure, the broader the range of nutrients absorbed, and the more complex becomes the Issue.) Issues can include such things as:

- unwise or poorly implemented policies
- complex, overlapping, redundant and ineffective processes
- incomprehensible, convoluted, and conflicting procedures
- counter-productive attitudes
- unchallenging, confusing (and ineffective) training
- oppressive, overly-passive, chameleon, or unpredictable management styles
- management by group consensus (no direction)
- over-taxed capabilities or lack of experienced personnel (including managers)
- perceived personnel incompetence (including managers)
- isolation of organizational units or elements from the mainstream
- ineffective communications (vertically, laterally and within process-flows)
- increasing work backlogs (both valid and invalid indications)
- failure to invoke schedule adherence requirements

- failure to require the use of schedules across the organization
- inadequate staffing or misdirected utilization of available staff
- non-contributing organizational units
- inverted pay scales (e.g. Planners at grade levels below mechanics)
- implementing change at a rate that throws the organizational balance out of synch
- failure to maintain plant configuration control at all levels of data affected
- the list of Issues is endless

An Issue can be very serious and generate many more problems that those identified as the source information for the action plan. The source data must be considered as only a sampling or representative set of the total set of problems. To be effective, the corrective action plan must convert the Issue to a Desired Condition, eliminating the source of the unidentified problems as well. When an action plan takes on a narrow focus, to correct only identified symptoms and validated problems, it will usually not produce any lasting improvement.

It is a major challenge for any organization to effectively diagnose its own ills, define a cure, and swallow its own medicine while still maintaining an ongoing operation that maintains nuclear safety and meets bottom line business objectives. Nonetheless, it is the only way to be successful in achieving progressive and sustained improvement objectives in this business.

C. DESIRED CONDITIONS (Objectives quantify Desired Conditions)

The third step in developing an effective Action Plan is to examine the identified Issues and develop Desired Conditions. A Desired Condition is a clear statement of how things ought to be instead of the way things are. A good description of the Desired Condition helps in understanding why the existing condition or Issue is not acceptable. It helps conceptualize rising performance standards. It provides the means to communicate to others why the action plan exists, or why current practice is in need of change. The term often applied to this developmental step is to define "goals". Regardless of the terminology applied, the goal or Desired Condition must be directly related to, or be the mirror image of, the Issue that is being addressed. There is usually one Desired Condition for each identified Issue.

This developmental step applies to both broad scope and narrow scope action plans. However, in the correction of hardware problems, the Desired Condition is usually implied rather than being described in an Action Plan. Failure to state the Desired condition can contribute to communications breakdowns, especially when the corrective action is directed at achieving rising standards of performance for either personnel or material condition.

D. OBJECTIVES (Objectives quantify Desired Conditions)

The fourth step in developing an effective Action Plan is to set fourth measurable Objectives that, when achieved, provide the means to "declare operability" of the Desired Condition. There are usually multiple Objectives for each Issue in a General Plant

Improvement Plan, and a limited number for each Issue in a limited-scope Corrective Action Plan.

There is a tendency to become political in defining Action Plan Objectives. Objectives can echo the right words, add apparent substance, and produce the image of a comprehensive corrective Action Plan. This is a common weakness and can lead to failure of the plan to achieve its lofty objectives and goals.

The defining characteristic of an Objective is that it represents a specific condition or change in performance that can be quantified and measured. The set of Objectives defined for measuring the transition from an Existing Condition to a Desired Condition must be complementary, inter-related, and constitute realistic change that permanently moves the organization toward achieving the Desired Condition.

E. ACTION PLAN STEPS (Action Steps achieve Objectives)

The fifth step is to identify the sequential actions that must be completed in order to achieve each defined objective. Action steps are basic activities such as changing an organization to reduce span of control, changing staffing levels, developing training materials, accomplishing training, defining and implementing management information system changes, redefining policies, changing procedures, establishing ad hoc groups to perform specific tasks, etc.

Each action plan step must be an activity that can be scheduled, assigned to a responsible manager, and progressed to a logical conclusion. A characteristic weakness of an Action Plan is that it does not lead to achievement of the defined Objectives. Moreover, when Objectives are not even defined, it can be difficult to understand how the action plan steps can lead to the desired change in performance represented by the Desired Condition. Action Plan steps can sometimes represent superficial actions that give the appearance of making change when, in reality, actual practice (down in the dirt-sucking roots) does not change at all.

F. CLOSURE CRITERIA (Closure Criteria define Completion)

The sixth step in developing an effective Action Plan is to define the Closure Criteria for each step in the plan (or for groups of sequential, related steps leading to single achievements.) What this means is that there must be some evidence that the action step or group of steps effected a positive change in actual practice in the target organizational unit.

Performance Indicators are often relied on to provide evidence of reaching closure. Meaningful performance indicators are sometimes very difficult to structure. There are two rules to follow in establishing these indicators:

- The indicator must be immune from "gaming". (Changing the measurement bases, etc.)
- The indicator must be produced from normal process data without a noticeable labor effort.

The rules for Performance Indicators are based on common sense. If the indicator bases (data sources) can be manipulated to make things look better, the bases will be so manipulated. If production of an indicator requires substantial labor effort, other priorities will shortly lead to termination of the indicator, allowing performance levels to return to their previous "comfort zone."

A typical weakness in Action Plan implementation and follow-through is found in this final area. It may be because the hard part seems to be over and management focus has moved on to other, more current concerns. It may be because the authors of the plan failed to anticipate how difficult it is to implement change. An example of an effective closure process is as follows:

ACTION: Develop materials and train maintenance personnel in the revised Foreign Material Exclusion (FME) program.

Closure Criteria:
1. Provide a copy of the training materials (outline, curricula, examinations).
2. Provide a list of personnel attending the training.
3. Provide a listing of examination scores.

Evaluation:
1. Do the training materials address the Issues involved, the changes being made, and are they geared for the target audience?
2. Did the entire target audience attend a training session?
3. Was the training exam cursory or objective? Did the target audience show an understanding of the issue and the revised process based on satisfactory examination scores?
4. Based on field observation over a period of time, does actual practice now comply with the requirements of the revised FME program?