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Pacific Northwest National Laboratory
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Guidelines—A Primer for Communicating Effectively with NABIR Stakeholders

October 2000

Prepared for the U.S. Department of Energy
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Summary

This primer is a tool to help prepare scientists for meetings with stakeholders. It was prepared for staff involved with the Natural and Accelerated Bioremediation Research (NABIR) program, sponsored by the U.S. Department of Energy. It discusses why some efforts in science communication may succeed while others fail, provides methods of approaching group interactions about science that may better orient expert participants, and summarizes experience drawn from observations of groups interacting about topics in bioremediation or the NABIR program. The primer also provides brief, useful models for interacting with either expert or non-expert groups. Finally, it identifies topical areas that may help scientists prepare for public meetings, based on the developers' ongoing research in science communication in public forums.

I. Introduction

Engaging the public about establishing Field Research Centers at DOE sites is expected to be an important undertaking of the NABIR program in future years. During those engagements, NABIR scientists will have to communicate with non-scientists and engineers about basic research in bioremediation. Such a dialog would not have occurred 20 or 30 years ago. More than any previous generations, children born after World War II have been taught that they must be active citizens, and that they have an obligation to participate in their government. They have learned this lesson well. As a result, the nature of public dialog about local, regional, national, and global affairs has been broadening to encompass more elements of society, and deepening in content as interest in government activities increases and the education level of the citizens continues to rise. This is certainly true in the sciences, where scientists are increasingly communicating with non-scientists about their work. Communication between scientists and non-scientists fills a variety of needs, such as raising national awareness about the implications of global warming, testifying about scientific data in criminal trials, and defending government funding for scientific programs.

Unfortunately, consistently successful communication between scientists and non-scientists remains elusive. Some efforts, such communicating about the benefits and risks of medical radioisotopes, are relatively successful. Others, such as communicating about the benefits and risks of food irradiation, fail miserably.

Public support and politics are outside of the everyday concerns of most scientists. Yet scientific work often depends on public support. If the project is expensive (e.g., remediating a contaminated aquifer) or controversial (e.g., the use of genetically-engineered, herbicide-resistant crops), public emotions can be easily stirred by irrational arguments. "Vagueness, anxiety, fear or abhorrence often prevail over rational judgment, and incorrect or even hostile (it is absurd, extravagant, useless or diabolical) commentary about certain kinds of research spread quickly." (Science, 8/7/98, pg. 776). It is at this point that good scientific conversation is most important AND very difficult to achieve.

Frequently, there are calls for more informed input or more understandable output in discussions of publicly funded science. Citizens ask, or are invited, to participate, listen, discuss, make decisions about, and provide input into community and global issues that involve scientific research. In this context, however, nonscientists are often assumed to be "blank slates"—completely unfamiliar with scientific processes or terms. This may be true for some scientific areas and not for others. Because they lack the means of visualizing, most nonscientists may not understand technical discussions of cellular biology. However, they may be well able to visualize more in technical discussions of wildlife biology or meteorology.

Regardless of whether discussants are experienced in science, discussions take place among those who do not share a common set of problem-solving skills or conceptual training. In such a context, the primary task of science communicators is not simply to convey information or concepts. Instead, the goal of science communication is to interpret appropriately matters of science in diverse contexts. Science communication should enable everyone, nonscientists and scientists, to interpret information and place it appropriately in health, environmental, and social contexts.

In this primer, we acknowledge that people have different backgrounds, different cultural and habitual ways of reasoning, and different sources that all come into play in making their knowledge bases. What people know, whether emerging from training or personal experiences, guides how they interpret new information. We focus on how people use communication to come to know about science.

Who are the NABIR Stakeholders?

In the broadest sense, NABIR stakeholders are any persons or groups who are interested in or potentially affected by the conduct of NABIR research. By this definition, they include citizens, regulators, technology developers, science and technology users, Congress, Native Americans, local officials, environmental groups, public interest groups—and scientists, too. This list of stakeholders may be broader than those commonly considered stakeholders. That is because stakeholders from a communication perspective include more groups than from a legal perspective. Stakeholders are created through networks of interest and concern. The "stake" can be context-specific—"I'm concerned about jobs in my community"—or context-general—"My concern is with protecting the environment." The stake in any given scientific or policy issue may be politically driven or be stimulated by a particular crisis or flurry or stories in the news media. Moreover, the stake that someone holds may not be apparent, that is, someone may not take a position or express a concern at all. Nevertheless, that person may be a stakeholder simply by living in an environment that will be affected. Stakeholders are thus not limited to advocacy groups; they also include citizens who have not taken a position on scientific or environmental policy issues.

As more voices are added to the stakeholder mix, the challenge for science communicators includes recognizing the multiple interests and viewpoints that enter our conversations about science and public policy.

Why Should We Talk with NABIR Stakeholders?

Experience to date indicates that stakeholders generally regard bioremediation as a promising way to address environmental contamination. They want scientists to succeed in developing breakthrough methods to solve intractable problems, and they look to the talents of scientists to generate the knowledge base to enable these breakthroughs. NABIR scientists can take advantage of this public support and actually benefit from stakeholders' insights.

- Early involvement will help identify performance criteria, some of which if not addressed could be research or program show stoppers. It may also identify opportunities that the scientists have not considered.

- Stakeholders possess valuable information about political, regulatory and community concerns regarding site remediation and the application of NABIR research. It is far better to understand and account for these concerns at the outset of a project than to be hindered or blocked by them later.

- Community leaders are looking for solutions to community environmental problems outside the DOE. The NABIR program will gain community support through constituent involvement and collaboration on related problems.

- In a democratic society, citizens will ultimately decide the nature and direction of publicly funded scientific research. Because science-infused decisions are generally superior to decisions made without the benefit of scientific knowledge, scientists have a responsibility to the citizens to help them understand the science that is involved in the decision they are making.

- Public engagement with scientists creates opportunities for scientists and the public to gain practical knowledge about the limits and possibilities generated by scientific research programs and initiatives.

Purpose of This Primer

With this primer, we have tried to avoid prescription for successful communication. Instead, it is intended to be a flexible approach, introducing you to what you can expect and a fruitful way to look at the interactions you will have. It is certainly not the last word on the subject.

You should feel free to add to and amend the information and approaches contained here. Like a scientific hypothesis, if it doesn't work, change it and test again.

However, several purposes are expressly excluded from this approach. Our goal is neither the management of information to the public or manipulation of public sentiment. We want to break down the "us versus them" sort of mentality that it is so easy to slip into when an expert meets a non-expert group. The operant idea is to combine presentation and mutual exchange in a facilitated setting. Your role in these meetings are unlike teaching in a classroom or presenting at a professional conference or interacting with peers in a business meeting. For participants, you are the expert who is willing to listen, respond, and explain. For them, you appear to be as willing to learn as to offer information. This requires some preparation on your part and considerable flexibility. Some people will find this sort of situation an easier "fit" than others. But we are convinced that many scientists with much to share and a real passion for the work could, with some observation and practice, have much to contribute to meetings with the public.

This primer exists to help you prepare. However, we hope that it can also help you look back at meetings you have already experienced, providing you with a vocabulary and hypotheses to reflect usefully on what happened and what (possibly) could work better in the future.

The following sections introduce you to a way to think about and prepare for meetings with the public. Section II, "Systems of Communication—Why Information May Not Be Enough," explains why science communication is a strategic and participatory endeavor, instead of exclusively informative. That section introduces the roles of relationships, the importance of the context (purposes and structures) of encounters, and the rules of thumb that form assumptions in an organization. Section II then introduces the ecological model of communication systems and concludes by seeing science communication as system-spanning. Section III, "Types and Techniques—Drawing on Communication Strategies," presents the varieties of communication likely available to you as a science communicator. With information forming the basis, the primary features, advantages and common conflicts associated with a range of science communication strategies are listed in a single table. Section IV, "On the Spot—The Role of a Science Communicator during Public Engagements," contains practical experience and advice gained from past interactions with NABIR stakeholders. Section V, "Where Do We Go From Here?," makes recommendations for meeting future multivocal challenges of science communication.

II. Systems of Communication—Why Information May Not Be Enough

Typically, when we think about communication, we think of providing information or persuading. Because scientists play the role of experts in public discussions of science and because they often avoid advocacy (persuasion), preparing to talk about science usually means preparing information.

However, not all stakeholder issues are technical or scientific—that is, informational—in nature. The technical information that the scientist wants to provide actually may lie outside the other participants' realms of concern. They are there to discuss something else. They may be interested in the economics of bioremediation or how the Department of Energy or other agency will handle contracting issues (regional, national, or international). They may want answers to technical questions not related directly site clean-up: Will bioremediation help clean-up nitrates in their well water? Will the clean-up operations be put up for bid and clean-up slowed after a couple years?

In our observations, we have found a paradox when we expected to communicate only by providing information. Certainly, no one who comes to a public meeting wants their time wasted with a lot of peripheral material or overt "public relations" stuff. On the other hand, providing only scientific information to the public also does not lead to communication.

Certainly, access to good, objective scientific information is essential to a successful scientific engagement. However, scientists' intentions are affected by a set of other forces once other people arrive to discuss issues involving science. We have identified at least three forces at play in public arenas:

- the nature of the relationships among participants and the role of interested people who are not present, e.g., policy-makers or legislators
- how the meeting is managed (Does it involve testimony, small group interactions, question-and-answer, lecture, etc.?)
- what participants consider to be acceptable as "communication," that is, what communication looks like or results in.

Relationships—making connections

The process of communication can be pivotal in developing rapport (positive relationships) among scientists, the sponsoring agency, and members of the community. Relationship development is affected by participants' sense of well-being and control (or lack of either one), understanding of science (comprehension-ability), and awareness of others, both those in the room and those not present.

Many of the participants in our meetings may live and work in communities affected by clean-up activities and, therefore, have a stake in scientific discussions. However, they may have limited or minimal formal exposure to science and scientific ideas. For them, bioremediation is complicated new material. It may take time for them to understand the scientific discussions. Although we may use the same body of *facts* that we use with more sophisticated listeners, their concerns, rational or not, must also be addressed. For us as scientists, it is a matter of "fact," but for many community members, emotional or non-rational responses indicate deep personal concerns. One of the respondents in our focus groups said it well:

"People give you back a scientific answer when you're talking about a question that involves you and your sense of well-being. You want to be responded to on an appropriate level."

But how do we know what an appropriate level is? Particularly when it comes to discussions of potential or actual risks, information is less compelling than other factors, such as feelings of control or prudence.

We would be wrong to assume that the opposite of scientific rationality is simply irrational fear or ignorance. In fact, it may be one of many alternative rationales, such as actions based on prudence or on economic viability. Parents may prevent their children from going to school because of the fear of old and "sick" buildings, despite the results of certified tests showing that the buildings are safe. Although we may say that they are driven by irrational fears, their rationale is prudence and their data are personal experiences and notions of plausibility. Motorists continue to buy sports utility vehicles, despite their high initial cost, gas-guzzling cost of operation, and contributions to air pollution. Although evidence of global warming appears convincing, the rationale for owning an SUV (perhaps even among scientists themselves) has more to do with personal convenience and safety than with the health of the planet.

Self-interest and sets of values are primary factors in establishing any relationship. Certainly, when emotions run high and new information is being delivered—as it often is in public communication about science—some time must be spent establishing common ground. It usually means asking questions and listening—establishing that you are interested in who is there. At this stage, scientific information embedded in the responses needs to be delivered in the context of the others' interests and concerns. Over time and as community issues continue to be addressed, common frames of reference can be developed—common vocabularies, common connections in life, a common interest in the science involved.

Public communication of science cannot exclude relationships. Much as scientists would like to avoid the conflicts and adopt the role of having an expert final word in public issues, scientists may find themselves advocating a position for science itself. Science, then, does not have all the chairs at the table—or perhaps even a plurality. Relationships are at the center of science's role in our society.

How communication is done—purposes and structures

Communication about science occurs in a great variety of venues and involves a wide variety of circumstances. By reading articles or listening to presentations, we learn about one writer's or speaker's understanding of a topic. By talking with someone—asking questions or sharing information—we fill in gaps in our understanding, reveal differences, and build a common view. By being guided in a facilitated session, we may be led beyond easy assumptions to encounter our real differences or to overcome divergent positions to cooperate on a mutually beneficial course of action. We experience communication over a newspaper or journal, in front of our computers, one-on-one, and in groups, both small and large. Our communication experiences are guided by writers, lecturers, or facilitators, and also unguided, determined largely by our directions of thought and seizing of opportunities.

Communication structures include

- one-to-many - involving a single speaker presenting information and views to others, as in a lecture or a written work, where the readers are not even seen, often having a set time limit for presentation and constraints upon response

- interpersonal - typically, 2-4 participants, allowing fluid topics and expression of viewpoints, less constrained responses, mutual determination and testing of boundaries, acknowledgment of relationship, searching for group norms and degrees of commonality (degrees of individuals' inclusion in the group)

- small group - typically, 5-8 participants

- large group - typically, more than 15 participants, although often considered a collection of small groups

- other combinations and permutations of the structures - including multiparty, open-ended, facilitated events that encourage dialogue among the participants.

The emergence of new technologies and situations produce new variations in communication structures. As the telephone allowed interpersonal communication without face-to-face interaction, so chat rooms and email have introduced large group interactions of a decidedly contentious nature, perhaps because there is no face-to-face contact among participants.

Goals of communication

When people discuss the context of communication, you may not be surprised to hear discussions about relationships among participants and the communication structure itself. However, it is less common to hear discussions about another factor that is very important: the views that the participants have of what constitutes successful communication. We often communicate according to sets of unspoken rules about what is appropriate or rude, beneficial or tiresome. We also may have rules of thumb about what is adequate or understandable information.

Because there is such a wide range of possible rules of thumb—they may differ from one organization and group to another—we find a primary distinction helpful, between strategic and participatory communication. What is defined as successful outcomes differ for each mode. *Strategic communication*, which functions to inform, direct, and coordinate activities, arises from a distinct motive for communicating. From a strategic perspective, science communication is about planning or achieving tasks. Strategic communication tends to be presentational—one person speaks at a time and negotiates for a group's understanding and adherence. In science communication, the motives are primarily to inform or to convince. *Participatory communication* in contrast to strategic communication emphasizes the adaptive and generative features of communication, which involve entering into a dialogue. Participatory communication is more spontaneous and interactive, allowing viewpoints to emerge and even to merge. Advocacy in participatory frameworks is often from multiple perspectives, rather than a point-counterpoint perspective. Information in this context rarely remains static or neutral; it is integrated into sense-making activities and interpreted through multiple frameworks—drawing from listeners' experiences, questioning, countering with other views or data, and so on.

Communication Systems

In a commonly held view, communication occurs when one person transmits a message to another and the message is received—or not received, depending on the intervening mental or social filters (or, to use the broadcast analogy, the level of "noise"). According to this model, then, interactions between people involve simply reversing the process when the listener gets to speak. Although a picture of this model appears to be one speaker and one listener, the same model is often used for one person speaking to many listeners, as in a presentation, lecture, or broadcast. Often, communication situations are created that reflect this model, with the visual focus trained on the speaker's place, with the assumption that there is one speaker and many listeners. Moreover, the ability of the listeners to respond may be limited, as in a question-answer session after a presentation.

Of course, this model describes a common and useful arrangement that we could probably not do without. Our business and educational processes require one person presenting data, results, or ideas, with an opportunity to present supporting evidence and interesting sidelights. However, it is also clear that this model captures a speaker-centered situation. It seems to encourage speakers to envision audiences as single entities or as combinations of types. Evidence suggests that the speaker-listener model may encourage speakers to make awkward—and probably untrue—assumptions about an audience's degree of sympathy or aversion to their message, the listeners' preparation for understanding the message, and their ability to follow leaps in logic or to visualize what the speaker is saying.

A chemist, Tom, speaking to his professional peers at a conference, was fairly certain that they would understand his presentation, perhaps even praise his work. To his surprise, his listeners were confused and distracted shortly after he began. Uncertain at the tone of his reception, he asked a friend for a critique and heard, "That's already been done—long ago. What's the news?" He then realized what he had omitted in the presentation—by emphasizing his experimental process, he had omitted essential background information about the problem that his work addressed. His innovation was in applying a familiar process to a class of problems previously not addressed. He had relied on his audience to make the connection. The factors affecting communication for Tom were broader than a simple message and counter-message. Our miscommunications often point out to us that the context for communication is as important as the messages themselves.

In fact, the message-receiver model of communication is a simplified version of a model that accounts for communication contexts: for the information that listeners bring with them, for the responses that listeners have, whether expressed or unexpressed, for the alliances that listeners may make in response to a speaker's message, and so on. The broader model of communication describes communication as a system, that is, as a process with many potential or actual voices, viewpoints, values, and professional and personal experiences brought into the set of phenomena that we call communication.

Communication as an Ecological System

The concept of communication as an ecological system begins to capture the complexity and inter-relationships that exist in a public dialog about science.

Communicating in a public setting possesses the analogs of all three key attributes of ecological systems: structure, energy, and "nutrient" flow. Together, they allow the system to evolve over time. When scientists engage in public dialog about science and basic research, they are attempting to help non-scientists understand how the basic or applied research that they are conducting has the potential to affect how their world evolves.

In this system, the groups to which people belong provide *the structure*. People may belong to these groups intentionally, unintentionally, through their employment, or simply because of where they live and work. Singly or as groups, they possess different frames of reference with respect to science as a whole and sometimes specific scientific topics (e.g., radioactive contamination of soil).

The energy that drives this "ecological system" is the desire or need to communicate. The desires or needs may originate in personal health concerns, concerns for environmental quality, or the need to keep an activist organization funded by a citizen constituency. Communication occurs among individuals and groups because these desires and needs exist.

The nutrients that feed the system are both the information that is communicated, and the way in which that information is communicated among various individuals and organizations. The information and process of communication itself have the potential for each party in the dialog to benefit from any other, albeit not always equally.

The behavior of any particular part of an ecological system depends not only on its own traits but on the subsystem that it forms with other organisms, that is, on its relationships. Thus, the immediate subsystem of which any single member is a piece may be more immediately important to that organism than the system as a whole. However, the whole system sustains its subsystems in complicated and varied ways, by providing structure, energy, or nutrients either directly or indirectly.

To turn to a social analogy: A small group of participants in a public meeting on relicensing a nuclear plant, for instance, who share a common political stand on the issue, gain from their similarities, their common energy, and their adaptation to available information. As a subsystem within the public meeting, they also draw from the frame of reference provided by the structure of the meeting, by the various viewpoints expressed there, and by the range of information and interpretations placed on that information by various individuals and other subsystems. Subsystems may overlap, as well. A member of a group opposed to the plant's relicensing, for instance, may nevertheless be a neighbor of someone who supports it, so that both are part of a subsystem with roots in the community.

Indeed, in your own experience, you can probably identify four domains of communication ecology:

- Microsystems - including you and others and in your immediate work or home environments, such as your family

- Mesosystems - the relationships among various microsystems, such as you may encounter as families gather for religious observances or get together during Little League games

- Macrosystems - the relationships among mesosystems, involving the crossing of immediate boundaries to include subsystems that may not usually be gathered together, such as with ecumenical religious observances or school-district sports banquets

- Exosystems - gathering the subsystems into cultural belief patterns, and social, technological, or political groups that may form the content of other subsystems.

All of us are members of such systems and all the systems exhibit topics, terminology, shared beliefs, and communication behaviors that reflect their component subsystems.

Of course, this analogy between physical and communication ecology is not perfect. Notably, energy can be received and harnessed by anyone in the communication system. This is not true of ecological systems, where plants harness the sun's energy, and all higher trophic levels are dependent on plants.

More important, though, the broader harnessing of energy and the nature of communication itself result in a system that is even more complex than an ecological system:

- Communication can occur anywhere in the system, and among any of the individuals or organizations. Hence, there are more potential interactions in a communication system than an ecological system.

- In addition, communication has the potential to change both the sender and receiver, and in the process, what is conveyed changes to a greater or lesser degree. These changes drive the evolution of the social system in which science operates.

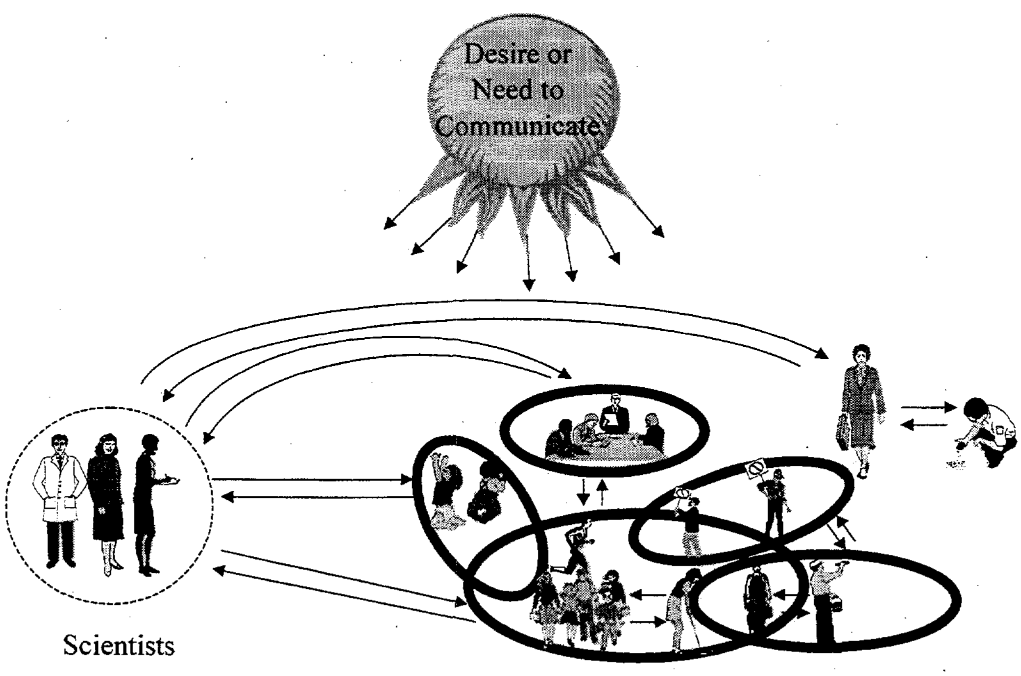

Figure 1. Communication as a Social Ecosystem

Science Communication as System-Spanning

An ecological model of communication acknowledges the complexity introduced when science experts are recruited to communicate about basic science to members of the public not familiar with their work. Public involvement work asks scientists to discuss their work in social, cultural or political contexts not typically required for scientific or technical work. The need is for communication competencies that are sensitive to the communication ecology of the public engagement process.

The ecology of science communication suggests that science is conducted by communities of individuals, who through their specialized (expert) language use, come to understand their area of expertise in ways that align them with some, while making them distinctly different from others in the same field of study. Scientists share in domains that are both professional and personal and, thus, can relate to communication subsystems that make either role dominant in their public perspectives. It must be acknowledged that science, indeed, all understanding, is guided by the inquirer's perspective. Whereas our point of view allows us to frame the world in a way that makes it understandable and predictable, our point of view can also narrow our vision by blocking out competing visions (see the model in the Appendix). Our most evident communication subsystems may prevent our seeing commonalities with others in adjoining or overlapping subsystems.

The focus on an ecological model of communication can force us to factor in the possibility that differing assumptions, beliefs, expectations, and language usage are not insurmountable. Such a model can stimulate us to look for the overlapping subsystems and commonalities. As a scientist communicating with the public, you do not necessarily have to know about the assumptions, beliefs, or expectations of everyone who participates, but you do have to know and expect that there is a good chance that unless the participants have a lot of experience with your area of expertise, that their perspective is different from your own. Instead of being a liability, this puts you in the potentially powerful position of boundary-spanning.

III. Types and Techniques—Drawing on Communication Strategies

Table 1 explains various types of communication formats that are common in DOE science communication by some of their essential features: in what situations they are most appropriate, which communication models they may draw from, the opportunities and constraints on responses, the conflicts that each brings out, and the communication products that often accompany them. Although the types of communication formats listed may not be exhaustive, the list does contain the most commonly used formats: presentations (perhaps the most commonly used), interpersonal forms of communication, small and large group interactions, panel or roundtable discussions, networks (either open or closed), and facilitated or unfacilitated groups. No format listed is entirely exclusive of other formats: interpersonal communication may include a presentation of a viewpoint; networks may include small group interactions as participants seek out like-minded colleagues; panels may involve interpersonal and facilitated communication behaviors. However, Table 1 points out that a communication format may very well create the character or tone of a communication activity. For a meeting that promises to be contentious, open-network event, for instance, a format that emphasizes presentations would probably be a dangerous choice. Participants would not be content to listen with little opportunity for response. In fact, such a setting might invite interruptions and heckling.

Information as the Basis—Tools for Interpretation as the Strategy

Science communication depends on the providing of information. However, the primary task of science communication is not just to convey information but to provide tools to allow non-specialists to interpret correctly the information they receive on a scientific topic. This is true because you, as the science communicator, may very well not be the only source of information for the non-specialist. News media, which often showcases scientific experts only in sound-bytes, may transmit ready-made interpretational frames provided by interest groups. As the most visible framework for interpretation, the most extreme of such groups may seize the moment by placing scientific information into their preferred context.

Scientists have historically depended on their work to speak for itself. However, just as important as the content of scientific information is the use to which the information is put. As scientists, we need to suggest the meaning of the information we report. We may also need to identify interpretations that may be easy but false.

Table 1. Types of Common Communication Strategies and Their Features

	When Most Appropriate to Use	**Applicable Communication Model**	**Opportunities for Responses**	**Constraints on Responses**	**Common Conflicts**	**Associated Communication Products**
Presentations	When information is critical to decision-making and problem-solving. Full views can be aired and supported. Mini-presentations can also take place in small and large group discussions, panel discussions, poster sessions, etc. Success depends on credibility, currency, relevance, representativeness, appropriateness of speaker and content.	Transmission - primarily one-way delivery, with emphasis on conveying information and/or influencing	Determined by format. Audience response pivots on gaining the attentive ear of the audience (gaining and maintaining attention). Interpersonal response limited. Individuals responses to presenter can vary widely.	Often, limited chance for feedback, e.g., constraints on time for questions, comments, counterviews. Questions and counterviews may remain unsupported. Often, lack of immediate feedback for both speaker and listener. Appropriateness of response depends on relevance of topic to listener. Speaker may be unaware of listener predispositions. Adverse affects on listeners of excessive or insufficient information.	Lack of access to listeners' viewpoints may create conflicts via differing frames of reference or orientations. Can result in listeners' sense of isolation or polarization, resistance, or covert non-compliance. Also, a confirmation bias is common: listening only for information that supports our perspective.	Speeches, texts of presentations, visual aids such as viewgraphs or computer slides

Table 1. (contd)

	When Most Appropriate to Use	Applicable Communication Model	Opportunities for Responses	Constraints on Responses	Common Conflicts	Associated Communication Products
Interpersonal	When two or more individuals are engaged in direct communication.	Interpersonal - Information delivery (to be useful) is a connected with critical thinking models in interpersonal communication. Critical thinking requires the ability to analyze and evaluate ideas and information.	Occur in listening, interpreting and responding. Speaking and interpreting occur simultaneously. Responses include explanation of viewpoints and attempts at common understanding. Support for participants' viewpoints available.	Limited range of viewpoints. Also, words have different meanings for different people. Hidden agendas may be at work.	Differences in values, beliefs, uses of language, or goals for communicating. Defensive communication patterns. Conflicts of interest, power imbalances, or differences in interpretation of information may stand in way of understanding or agreement.	Includes the means of interaction and the outcomes of interactions. May be emails, letters or memos, plans (spoken or written), telephone calls, as well as the wide variety of possible outcomes.

Table 1. (contd)

	When Most Appropriate to Use	Applicable Communication Model	Opportunities for Responses	Constraints on Responses	Common Conflicts	Associated Communication Products
Small Groups	Groups outperform individuals • in broad-range tasks; • when no members of group have needed expertise (as in currently unresolvable problems); • when experts face a complex task; • when group is composed of an individual expert and an informed group.	Interpersonal + dialogue + facilitated interaction	Questioning allowed. Speakers accessible. Common work and under-standing possible. Collaboration possible. Allows collective recall of information and pooling of knowledge.	Letting others speak. Some may dominate group. Limited range of views (i.e., the system is too closed, resulting in analysis paralysis). Danger of negative synergy (group members working together produce worse result). Possibility of competing goals, sharing ignorance, or establishing negative norms (e.g., mediocrity, groupthink).	Competitive group environ-ment. A pressure to conform. Differing goals among group members, whether expressed or not (hidden agendas).	Notes, flip chart notes, transcripts, video or audio tapes, storyboards, hand-outs

Table 1. (contd)

	When Most Appropriate to Use	Applicable Communication Model	Opportunities for Responses	Constraints on Responses	Common Conflicts	Associated Communication Products
Large Groups	Useful in accomplishing cooperative goals through interdependent division of labor and resources with the group. Success not defined individually but in terms of group. Large groups become more effective when managed through small groups activity or networking. Then the group advantages are increased while allowing for greater participation and diversity.	Interpersonal + dialogue + facilitated interaction	Can form subgroups - individuals' viewpoints may be supported by others. Range of views may be available. Ability to divide labor.	Illusions of agreement. Complexity increases with size. Information distortion may be a larger problem. Factionalism may arise. Difficulty in achieving agreement or consensus. Very large groups decrease possibility for participation and increase pressures to conform. Coalitions may form in opposition to group norms. Group size may decrease access to information. Group size decreases speed of decision-making. Problems of coordination and efficiency increase.	Social loafing (Gerow 1995), i.e., the tendency of individual group members to reduce their work efforts as groups increase in size. Conflicts increase as coalitions form, increasing likelihood of interest-identification and insulation from other groups.	Hand-outs, flip charts, transcripts, video and audio tapes, storyboards, notes, collaborative reports, web sites.

Table 1. (contd)

	When Most Appropriate to Use	Applicable Communication Model	Opportunities for Responses	Constraints on Responses	Common Conflicts	Associated Communication Products
Panel/roundtable discussion	Small group of participants engage in information exchange on a specific issue or problem in front of listeners or viewers. Working on solving a difficult problem; informing listeners about a problem or topic of interest; stimulating an audience to think about the pros and cons of an issue.	Small group + transmission.	Moderate range of viewpoints available. Balanced perspective possible.	Views limited to choice of speakers. Posing and positioning possible. Facilitation (moderator) likely to be needed. Process limited by physical environment and time allowed.	Pre-existing agendas. May be considered as opportunity for gaining public visibility, positioning, soliciting or support.	Transcripts, video and audio tapes, topic notes.

Table 1. (contd)

	When Most Appropriate to Use	Applicable Communication Model	Opportunities for Responses	Constraints on Responses	Common Conflicts	Associated Communication Products
Networks	Structured opportunities for information exchange and personal contact. May be in person or via interactive television, internet or other interactive media. Systems may be open (broadly available) or closed (limited participation, e.g., by invitation).	Transmission + interpersonal + small group + large group +	Open network information accessible to broad range of individuals. Encourages examination of assumptions and change. Closed network range is bounded, encouraging stability of group and goals and accomplishment of agreed-upon tasks.	Set roles create boundaries in group functioning. May regulate degree of openness and exposure to change. Physical or technological barriers may limit possibilities. May be psychological or group barriers to connecting outsiders into closed system or closing an open system (e.g., creating interest or task-specific groups).	Control or appropriate interpretation boundaries on information. Physical isolation of individuals (e.g., in cyber networking). Use of specialized vocabulary. In-group/out-group dynamics (us vs. them). In open network, difficulty of establishing and pursuing goals.	-

Table 1. (contd)

	When Most Appropriate to Use	Applicable Communication Model	Opportunities for Responses	Constraints on Responses	Common Conflicts	Associated Communication Products
Facilitated groups	When participants come from more than one domain of expertise or social group or when domains or social groups are unknown. When there is a history of conflicts among participants. Facilitator should have time to prepare with participants the strategy, process, sequence of events, and desired outcomes.	Interpersonal + small group + large group, with emphasis on crossing domains of knowledge and experience.	Overall control over process is given to a facilitator. However, often input is encouraged on strategy selection, process, goals, sequence. Facilitation can encourage viewpoints to be heard and considered, without a single viewpoint dominating.	Meeting objective and/or design may constrain facilitator from pursuing "off-task" or divergent input. Also, group composition may exclude discussion of some ideas. Some participants may resist facilitator.	Participants' goals and/or expectations for outcomes may not be harmonious. Skepticism of process or of facilitator. Inappropriate facilitation - in process, listening ability, assumptions, etc. Differences in domain-specific expertise or in communication skills among participants.	Flip charts, audio or video recordings, output designated as goal of facilitated meeting (e.g., report).

Table 1. (contd)

	When Most Appropriate to Use	Applicable Communication Model	Opportunities for Responses	Constraints on Responses	Common Conflicts	Associated Communication Products
Unfacilitated groups	When domain-specific expertise is shared. When tasks are clearly defined. When group members are known to be compatible.	Interpersonal + small group + large group, with emphasis on sharing domains of knowledge.	Can achieve goal quickly, given clear common goals and processes. Easily formed. Tendency to call together groups of like-minded participants.	Group depends heavily on individuals' communication skills (e.g., listening, cooperation, rephrasing, etc.). Unequal participation (e.g., dominance of one or a few group members). Uncertainty over process. Possibility of one or a few participants setting agendas and/or processes. Tendency to call together groups of like-minded participants - few divergent assumptions and/or pressure for conformity.	Uncertainty in determining goals. Coercion of group by one or a few participants. Disagreement about who decides rules and/or assigned actions. Struggles over status. Clash of unexamined assumptions and/or unstated agendas. Confusion and/or suspicion over motives.	Flip charts, audio or video recordings, output designated as goal of facilitated meeting (e.g., report).

Our NABIR research shows that the public often wants to know the answers to several *why* and *what* questions:

- Why are you providing this information?
- Why are you doing this?
- Why are you seeking approval?
- What is your mission?
- What do you want to get out of this?
- What do you want from us? (And in the case of a public meeting, Why are we here?)

Thus, information in science communication is functional. It does work beyond what we may intend because we may not be in control of how others use it. So, when we provide information, we need to provide an explicit context, as well. The need to provide context and interpretational tools suggests that we must be ready to do more than simply inform our listeners or readers.

IV. On the Spot—The Role of a Science Communicator During Public Engagement

Like other professionals, scientists are able to communicate effectively with each other using a limited set of communication tools. As scientists, we are trained to present our work to other scientists, primarily in the form of journal articles, books, or live presentations. Discussions and debates about scientific work are conducted in a "scholarly" manner, for example by questioning assumptions, inquiring about the study design and data collection methods, criticizing the analytical methods, and debating whether or not the data support the conclusions drawn by the author or presenter. Questions are answered and criticisms rebutted using appropriate scientific terminology (e.g., endocrine disrupter). In fact, in dealing with other scientists, *not* using the shortcuts, implicit references, and special vocabulary would be damaging to our reputations.

Among scientists, certain beliefs affecting our use of language and views of communication have been conditioned by professional values and practices:

- the importance of the scientific method in reaching conclusions—if not tested and retested, then not certain
- division of science into disciplines, each with its own special vocabulary and procedures
- knowledge derived from science as, in itself, morally neutral
- belief in scientifically acquired knowledge as a foundation to improve the human health and welfare and the environment
- separation of information (factual and testable knowledge) from persuasion
- view that complex information is essentially non-convertible—that is, it must be "dumbed up" to be paraphrased or explained
- belief that scientific information is the most important thing that a scientist can communicate.

However, non-scientists, or even other scientists, may or may not share the above beliefs. As a result, they understand science to varying degrees and have a multitude of different frames of reference about the communicability or even the worth of scientific information. Their questions will come from their respective frames of reference. Those frames of reference may be incongruent with those of scientists who are trying to talk about a kind of basic research.

Questions may seem trivial or may not be answerable given the present level of scientific understanding. Or the questions may be superficially simple but difficult to answer in terms that can be understood by non-experts. For example: "How safe is it to live next to this abandoned manufacturing plant?" or "Can you prove to me that this genetically engineered organism will not mutate after it destroys the contaminants in the soil?"

The presentation and questioning techniques that scientists have been taught, and that work so well when communicating with other scientists, are simply not adequate to address this larger arena of public dialog. When scientists rely *only* on familiar professional techniques to communicate science and basic research to the public, two outcomes often result that open up a chasm between the scientist and other meeting participants. First, the scientists feel "besieged" by a barrage of questions that appear to be trivial, irrelevant, or unanswerable. Believing that they are helpless victims of a mismanaged process, they avoid further public interactions, particularly with non-scientists. Second, other meeting participants feel that the scientists have not adequately answered their questions, which, after all, were asked in good faith. Believing that the scientists have not been responsive, they begin to question the scientist's motives and integrity.

These outcomes are far less likely to happen when some attention is paid to the frames of reference of meeting participants. Analyses of taped dialogs between NABIR scientists and non-scientists revealed that the more effective communicators of science already possessed and used a relatively large repertoire of communication skills that help them bridge the chasm. These tools are known to students and practitioners of communication, but are usually not taught to scientists, and the scientists themselves often do not recognize them as *bona fide* communication tools. Their utility begins to surface when we think of communication with the public as more than simply an exchange of information—in fact, as a kind of ecological system in itself.

What can you expect to do when you (as a scientist-participant) engage other participants in the communication ecosystem? The scientists we observed in meetings:

- Provided information
- Responded to inquires
- Asked helpful questions
- Summarized comments
- Helped to organize the discussion
- Helped to clarify group goals
- Encouraged participation
- Acknowledged contributions
- Provided focus
- Dealt with skepticism
- Developed trust
- Helped participants communicate
- Summarized what has been said
- Provided encouragement and acknowledgment
- Were good listeners and clear speakers.

In short, the scientist communicators engaged in normal, everyday communications activities.

This support was clearly evident in our focus group discussions that began with a highly-charged and potentially negative interaction. Not five minutes into the discussion, distrust of DOE became a hot topic. By the end of the discussion, scientists and community members were discussing the use of "bugs to solve problems." Through a series of small steps, with intuitive use of communication tools (e.g., listening, acknowledging, reframing, and providing scientific information) by the team scientist, a significant turn in the conversation materialized. Participants, scientists and community members, realized that they share a common goal – to solve previously irresolvable problems. And the vision shared by all participants is related to efforts to "Achieve a cost effective cleanup." The more the links that the NABIR Program can establish to link with this and other relevant visions, the easier it will be to maintain community interest and support in discussions and the development of the NABIR program.

When talking about bioremediation research, the science team and community members share a common goal – to solve previously unsolvable problems. But they may, or may not share a common context for discussion or collaboration. "Bridgework" is needed between scientists and non-scientists, and among scientists trained in different disciplines.

Effective bridgework:

- Recognizes that information and relationship networks are the same networks. Scientific information appears to be most successfully integrated into a community through relationships among people, not just through information available through the mass media. Despite the visibility of mass media, information networks in many communities remain interpersonal. During the two years of NABIR public meetings that we have analyzed, participants regularly expressed their enthusiasm for direct, rather than indirect access, to information about science. As one participant put it, "I think what we need is if there were technical people who were responsible for sharing information. Not just in press, but actual scientists who've had established research or this research in the lab or in the field." Participants also expressed support for scientists being rewarded in their jobs for communicating with the public.

We know from the collaboration literature (Chrislip and Larson 1994) that "In order for collaboration to occur in the first place, the participants must believe that the collaboration will serve their own interests. But as the process evolves, and as the emotional energy that helps sustain the initiation through the difficult times develops, there is a shift from narrow parochial concerns to broader communal concerns. This shift is often described as occurring at a specific time or around a particular event. Once it occurs, it is actively promoted and reinforced by the group. This shift is a profound one, and it marks the turning point in a collaborative initiative (ibid., pg. 10)."

To effectively enhance public understanding of bioremediation research, NABIR scientists must facilitate a collaborative shift not only by conveying the content (substantive ideas, facts, etc.) of the NABIR Program and related issues, but also by developing relationships between people, institutions and ideas. It is within and through these relationships that public understanding of bioremediation is developed.

- Establishes common ground, thereby developing area for initial connections to take place. Common ground allows different social worlds to be bridged and common forms of communication to be developed.

- Honors the different motivations that exist among the stakeholders who participate. Honoring their motivations will enable their self-interests to be valued through the process. Self-interests are always part of why people participate in public informational or engagement events. We all know about those events where a FEW participants seem convinced that their primary job is to advocate for the narrow self-interests of their own group. One of the outcomes of effective communication is to provide a context for collaboration where self-interests can be aligned with common goals.

What Can You Assume About Participants?

Even if you are not familiar with participants in a meeting, there are probably some assumptions you can make about them:

- People will probably need to talk about issues that concern them, whether directly related to bioremediation or not. If people feel their interests or concerns are not being addressed, they cannot hear the science you are presenting. Listen and provide information, if possible. Acknowledge their interests and concerns.

- Many members of the public would like to find positive elements in the project that they can relate to, e.g., demonstrating good stewardship of federal funds or that the project is effectively accomplishing what it is supposed to do.

- When introducing basic science or a new technology, expect some degree of suspicion. Community members are requesting perspective in terms they can understand. "What happens if nothing is done? What are the important issues that I should be concerned about?" They are trying to develop a frame of reference for how the science you are talking about affects them as they live in this community.

- In the quest to establish personal credibility, questions like "would you raise you children here?" are often significant. The motive is to establish common ground through personal connection. Are you like them? Why are you an expert in this area? What personal experiences or insights do you have that make you an expert?

- Community members see themselves as good people. They see themselves as reasonably intelligent people. No matter how strange, unlikely, impractical or crazy their positions or ideas seem to you, you must assume that their perspective is logical, consistent and reasonable to them.

- The timing of information releases affects the perception of issues. Some participants may come prepared to respond to recent information from the news media about the science, the agency, or the region.

- There may be alternatives to bioremediation. What are they? The public will want to place your comments about bioremediation into a broader or narrower context.

- Long timetables for scientific/technical projects raise issues of concern (red flags) that must be addressed. This does not mean that public will not support the long time-lines, but they need to be explained in terms that people believe are significant.

- When there is discussion about risks, participants may want reference points for thresholds of risk (i.e., the degree of danger, the longevity of the risk) in terms they can understand. They want to understand the consequences for the deployment of science.

Topics from Our Meetings

During the public meetings we have studied thus far, participants' concerns and questions about bioremediation touched on many ideas of which facts were significant or interesting, what policies should be in place, and which values (social, economic, personal) might be affected by bioremediation research. Specific advice about what to communicate may lend a false sense of confidence. You *will* encounter new ideas, probably as soon as you show up. However, from the list below, you may note that two kinds of preparation, besides your expertise in basic research, may serve you well: (a) your familiarity with applied research and similar kinds of programs and (b) speculation about what would happen *if*.... Our observations tell us that *what* to communicate varies over time and is affected by the process of the meeting—whether participants feel free to ask questions, for instance.

So, despite the fact that the following list is incomplete, feel free to modify or add to what we have observed. *Your* list is the one that will work for you.

- *The links between bioremediation research, science, and technology to practical applications*. How does bioremediation research answer questions (currently unanswerable) that can enhance clean-up concerns? That could be applied to other kinds of contamination or environmental concerns?

- *Your role and level of responsibility in the bigger picture.* Programmatic responsibility is diffuse. Scientists, program managers, funding agencies, all have different responsibilities that are worth talking about. Participants in our meetings wanted information both about the science and about the programmatic issues, schedules, and rationales. They wanted to see how the science is being integrated into current concerns and future planning.

- *How basic science presents a clear alternative to no-action.* That is, unless we can answer critical questions, certain problems will remain unsolvable or highly expensive. Give examples, as closely linked to bioremediation research as possible.

- *How research is directly related to site or local community conditions, issues and needs.* Do homework up front to be able to answer such questions as, What need will this basic research fulfill? How does this research fit into the larger picture of site clean-up? How does this research integrate or differ with other activities? Will the results of this research have applications outside DOE's needs that are important to the community? To prepare for groups near DOE sites, learn from Site Technology Coordination Groups how research correlates with site cleanup needs.

- *Your personal credibility.* Provide information about what you know about the research, and how you came to know it. For instance, you may be familiar with bioremediation through work in the petroleum industry. Credibility will be enhanced if you can respond in terms of participant's interests.

- *Related technologies as outcome of basic science.* Participants seem to ask, Why are you asking about basic science when you can't tell us about the technology part of it? For scientists, this means they could be asked to talk out of their research domain. For example, NABIR scientists must be willing to discuss activities in EM-50 and ER, even if they are different programs.

- *Scientists as de facto advocates for specific programs and agencies.* Scientists may sometimes be seen as representatives of the interests of DOE or other government agencies or of particular programs. Thus, their words may be interpreted as more persuasive in intent than informative, in spite of the actual language used by the scientist.

- *Historical links to topics under discussion.* Participants may want information about how bioremediation was used in past and what happened in those instances—both successes and failures—so as to provide a context for the science.

- *Usefulness of bioremediation in regaining use of contaminated lands.* Be able to explain of how bioremediation may lead to immobilization of contamination, and the possible steps to be taken after immobilization to remove or neutralize contamination. Be prepared to address the concern that "immobilization is not remediation," and the concern that substances may be injected into the land.

- *Reversibility of bioremediation's effects.* If bioremediation changes subsurface conditions, will they eventually revert to their original state, an unexpected state, or a less healthy state?

- *Satisfaction of regulatory requirements.* To what extent do bioremediation program activities satisfy regulatory requirements? This may be a good opportunity to gauge public and political expectations for regulatory protection.

- *Time tables for deployment.* Know the clean-up timelines and the decision-making schedules for which remedial methods will be deployed. Although participants will realize that in order to get answers, research is needed, many are also prepared to apply pressure to show results. Be prepared with success stories and clear reasons for "more research before application," if possible.

- *Safety issues.* Explicitly and directly address how microbial processes will be monitored and controlled. It will be hard to pass "Go" if you do not address this concern. Explain the consequences of simulated microbial processes. Address the NABIR program's position in regard to genetically engineered microorganisms.

Managing Your Own Responses—The Listening, Acknowledgement, Feedback, and Facilitation (LAFF)Model

The LAFF model identifies three sets of communication competencies (i.e., listening, acknowledgment, feedback) and a mechanism for enhancing the communication process (i.e., facilitation) when necessary.

- *Listening (including questioning).*
  We must listen for more than what we want to hear. People generally try to acknowledge only those topics they are prepared to talk about. But in public discussions, other topics raised by the participants must also be acknowledged if the discussion is to remain fruitful.

- *Acknowledgment (including perception-checking).*
  When you acknowledge someone, you make sure that you understand their point of view. Acknowledgement may involve asking questions or restating ones understanding.

- *Feedback.*
  Feedback includes a variety of responses: responding with a new idea, responding with a similar, supporting idea, nodding, writing a note, etc.

- *Facilitation through a third party.*
  Sometimes help is needed to manage the communication process. In such cases, the assistance of a third-party facilitator (process expert) is useful.

The LAFF model outlines specific communication strategies that are based on practical communication skills used in everyday activity. The challenge for the scientist is to transfer these skills to the public engagement setting. How successful you will be at communicating science at a public event depends on many factors, including communication skills that may or may not be used in your standard work routine. In addition, individuals vary greatly in their abilities to deal with hostile community members or individuals who do not understand basic scientific principles.

The LAFF model is based on individual communication competencies. A high degree of variability exists among individual communication training and skills. Some public events challenge even the most highly trained communication specialists. For many scientists, public involvement is a novel and uncomfortable experience. Their communication training may be taxed to its limit, or even overrun. Behaviors performed in the presence of others are facilitated, augmented, or exaggerated to the extent that they are well learned; they are debilitated to the extent that they are not well learned (Zajonc 1960). The LAFF tool helps ensure the success of the science engagement process by allowing for the services of a trained facilitator, someone who is a communication process expert.

Step 1 - Listening (and questioning)

- Do not assume that you and others at the event share the same expectation for the outcomes.
- Delay judgment.
- Learn about group resources. Check perceptions to develop your own frame of reference and adjust for other frames of reference.
- Attend to as much of the message as possible.
- Turn each speaker's ideas and perspectives into productive activity through good questions.

Step 2 - Acknowledgement (and perception-checking)

- Restate the content of what others say.
- Reflect concerns demonstrated by others.
- Identify goals, interests, values and needs.
- Comment on positive contributions.
- Reframe comments in constructive ways.
- Summarize what has been achieved.

Step 3 - Feedback (response options)

- State your own content.
- Explore common ground, or different interests goals, needs.
- Frame issues and options.
- Suggest positive resources.
- Discuss implications.
- Create a positive environment for discussion.
- Explore the problem further.
- Solve a problem collaboratively.

Step 4 - Facilitation

- Engage a trained facilitator wherever any doubt exists as to whether the scientist's communication skills are adequate to meet the challenges posed by the persons and groups being engaged.

Acknowledging the concerns and interests of others has powerful communicative impact. In one of our focus groups, distrust of DOE among non-expert participants was a dominant theme. In responding to participants' concerns about the trustworthiness of DOE, the team scientist used many of the elements in the LAFF model. At the end of the session, when the facilitator asked community members what scientists needed to do to communicate better with the public, one of the responses said, "Do just what you did here. Develop trust." The scientist at this event was not specially trained to acknowledge or to use communication tools strategically to garner trust, but he used those tools intuitively. Trust was not established through use of a single strategy nor all at once. Instead, it was gained through a series of small steps, using communication strategies that felt and looked natural.

V. Where Do We Go From Here?

This primer explores the underlying reasons for the difficulties that scientists often face when talking about their work with the general public and even relatively well-informed stakeholders. But it does not and cannot instill in scientists the process skills necessary to enhance HOW they communicate. Reading about those process skills is only a marginal improvement. What anyone need who needs to communicate more effectively is hands-on experience developing process skills in an interactive setting.

Communication involves more than learning a few skills. Attention to skill development in isolation from knowledge of complex relationship patterns or without understanding the complexity of the process may be potentially harmful. Indeed, most people can think of an instance in which more communication or the wrong sort of communication has made matters worse, stimulating divisiveness among people that has led to more problems. Sometimes, conversation is simply inadequate. Negotiating with your auto mechanic over a bill may result in an impasse that no amount of communication can resolve. In communicating over issues and developments in science, it is important to identify and acknowledge differences in interests and goals, rather than dismissing them as failures to communicate. In the workplace, too, teams may fall apart or resist formation, not so much because communication is poor, but because of competing goals, or differences in work style. Communication behavior may simply be the litmus test that reveals the pH of an underlying situation.

You will not solve every conceivable problem by learning to communicate more effectively because not all problems are communication-based. However, no process tool can be ignored, much less a powerful one. We urge that future science communicators be conscious of the strategic and participatory features of communication, as well as its informative ones. To this end, using communication teams and plans can keep the process fresh and responsive while meeting your needs for information exchange.

Establishing a Science Communication Team

NABIR stakeholders are extremely diverse with respect to their basic values, interests, science and technology training, and expectations for the future. One key finding of our initial engagements with Hanford stakeholders is that the less technically trained the stakeholders are, the more important is HOW communication is established and the less important is WHAT is communicated. This appears to be particularly true at the initial stages of engagement, when first impressions are extremely important. As a result, before NABIR scientists engage stakeholders about the program, it is very important that they team with communication specialists who understand the broader functions of communication and the process tools associated with them. These specialists can help scientists use different tools to broaden their communication efforts and enhance their listening, acknowledging, and feedback skills.

Another key finding of the initial Hanford stakeholder engagement effort is that stakeholders within and outside "official" DOE engagement processes will have issues, concerns, and interests that are both directly and indirectly related to basic research. In many cases, they will extend beyond typical scientific concerns and into the larger social infrastructure in which NABIR scientists are working. For example, they may ask questions about:

- the knowledge your research may yield
- the level of trust (or distrust) engendered by the DOE
- the history of the site at which you are working
- the technologies that are expected to be produced as a result of your basic research, and
- the policies and politics associated with the funding of your project and the NABIR program.

These findings argue for two actions. First, it is important to have as diverse a communication team as possible, including, to the extent practical, spokespersons for science, policy, and funding decisions who can speak to various related and sometimes unrelated issues. Given the practical limitations of assembling such a team, it will usually be necessary to establish communication mechanisms *a priori* to answer questions that cannot be responded to in the immediate engagement process. And second, it is important that the team define the scope of the meeting at the outset. The team should, for example, anticipate and discuss at the beginning what they would like to learn from the meeting, what they can and cannot respond to, and the degree of influence that they have or do not have over elements of the project and program. These actions will help focus discussions.

We recommend that if you are interested in expanding your communication skills, you obtain guidance from one or more process communication experts and participate in an interactive dialog with stakeholders. Together, you can form a communication team for facilitated events. Such events meet three essential needs. First, the science communication team interacts with stakeholders about some aspect of the scientific program, for example, the designation of potential field research centers or involvement of local schools and community groups in basic education about bioremediation. Second, following some preparatory instruction, scientists and the facilitator interact with stakeholders using process tools that enhance listening, acknowledgement, and feedback during the interactions. Third, the communication team can identify ways of improving the engagement process, by refining the communication tools or reflecting on the interactions. Such an approach would serve to further NABIR goals, train scientists to be better communicators, and improve the communication process through a series of engagements.

Developing Communication Plans

Moreover, envisioning communication situations as ecosystems points out the importance of developing communication plans for teams to use. Such plans take into account the full context of communication activities. Communication plans make it easier to strategize and assess the results of interactions, as well as the effectiveness and appropriateness of communication products and other project outcomes.

Communication plans can be built from any of three elements: environmental scanning, questionnaires, interviews, and engagements (events). *Environmental scanning* is the detection of environmental turbulence or change likely to affect the homeostasis of a system. As practiced by communication professionals, environmental scanning involves monitoring internal and external communication artifacts, such as memos or emails, for key themes or terms. A cluster of terms and sources can be identified for initial tracking, e.g., "bioremediation," "biotransformation," and related terms. In addition, methods of data collection, such as public meetings, focus groups, or interpersonal contacts, can then be identified. The analysis of such data focuses on communication complexity (the degree to which terms or concepts are perceived as difficult to understand or use) and communication compatibility (the degree to which terms are perceived to be consistent with existing values and past experiences). *Questionnaires* can allow respondents to indicate their perceptions of the current status of an aspect of NABIR communication and a desired or ideal goal. They help identify future directions. For *interviews*, participants may be selected either randomly or purposively to corroborate or expand upon the concerns reported in the planning tools. Interviews will be conducted confidentially, sometimes using tape recorders to facilitate data analysis. Following up on prior successful events, future *public engagement events* may also be used, including poster sessions, dialogue events, web-based interactions.

However, communication planning is best done by all those who may be affected by the science and discussions about it working together to provide information and perspectives. Planning is an iterative process of scanning, engaging, reflecting, and replanning.

VI. References

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Appendix – At the "Organism" Level—Multiple Perspectives

As an expert, you are one element in the meeting ecology. However, when you see an ecosystem, the other participants (the "organisms") probably see only their share of the ecosystem, that is, they have their own frame of reference. Often, the most significant challenge for a scientist may be not in the conveyance of information, but in establishing working relationships with other meeting participants. This challenge is heightened when it is necessary to respond to meeting participants who have different levels of scientific expertise, who are distrustful, or who raise issues based on emotional self-interest. The primary conclusion to be drawn here is that *how* you talk about science and substantive issues and *what* you say depends on *whom* you are talking with, the backgrounds and experiences they bring, and their goals for the engagement.

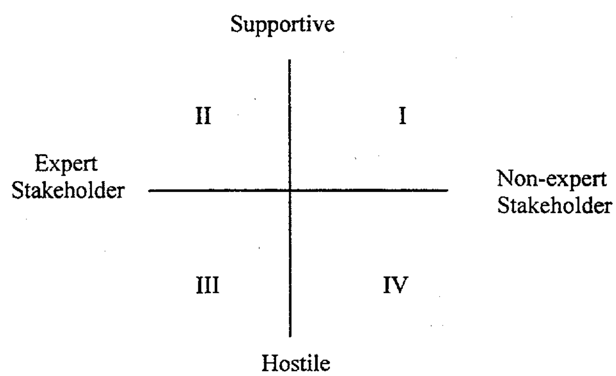
During the process, different people will want to talk about different things. Individuals participate in communication events for different reasons. Each event has its own context, participant interests, representation and outcomes. At the same time, we know from our research and the literature that the *process of information exchange*, that is, how and what information is communicated, influences public perceptions of science. When the public is scientifically naive, disinterested, or hostile, the challenges to communicating science seem immense. It hardly seems worth the effort of getting involved when the participants resist the process of creating a common frame of reference for discussion or collaboration. This is evident at public events where it is clear that many participants come only to advocate their particular (sometimes narrow) interests or views. Acquiring information, while important, is not participants' only—or perhaps not even their primary—concern.

Scoping Out the Situation—The Science Challenge Interaction Model (SCIM)

The Science Challenge Interaction Model (SCIM) demonstrates the challenges faced in conveying information or offering viewpoints to groups. It also illustrates facilitation may help reveal perspectives and achieve understanding. In general, people participate constructively when they feel that their ideas and concerns are taken seriously. This is true for all participants in the process – scientists and community members. However, the challenges that people face to be heard and understood differ depending on their frame of reference. In the ideal group event, everyone can make important contributions in their own way. The challenge is how to communicate in a way that enables productive interaction given all of the different frames of reference that are present. The SCIM model provides insight into the collective interactions of the scientist and/or presenter and the community member. The interactions among self-interests and limited perspectives, the interactions common in an ecosystem, are reflected in the LAFF model as features of the science communication process.

We often blame conflict or hostility on another person's ill will, political or personal, or even bad intentions. We fail to realize that we may have done the same thing if we were in the other's shoes. Why? We interpret events differently for ourselves than we do for them. Our behaviors seem to us be defensive responses to the other. We may even see other persons engaging in unprovoked acts of aggression. What happens if we see the behavior of the other as a response to our own actions?

From the point of view of the scientist, others are seen as:



As a scientist, you are expected to provide objective information. Unfortunately, chances are that the public engagement event will have emotional undertones. In addition, the sophistication of the *public* participants will influence the scientific content of the discussion. These dynamics will affect the communication process and your ability to provide useful substantive information.

Our interviews and focus groups results suggest (but we should generalize cautiously) that the greater the technical sophistication of the participants, the more the discussion can focus on scientific content. The lesser their sophistication, the greater the need for the scientist to adapt scientific information to the communication environment. In addition, from the literature we know that hostility or high degrees of emotion affect a presenter's ability to respond to information.

Understanding this perspective

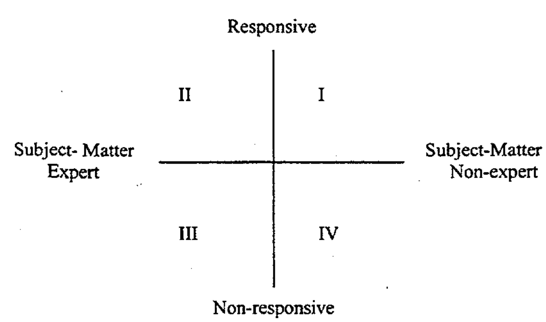
Quadrant II: If you have an expert group that expresses a lot of support, your challenge is to organize and channel their energy toward a positive result. Focus on listening and feedback response options. Your scientific expertise adds substantive foundation to the discussion.

Quadrant III: If you have an expert group that expresses a lot of disagreement, your challenge is to control the process and help build credibility and trust. Focus on listening and acknowledging. Your scientific expertise is essential. When dealing with an informed hostile group, objective information is essential to establish credibility. It is during emotional events that your knowledge is the most necessary. However, it must be provided while acknowledging the frames of reference of the other participants.

Quadrant IV: If you have a non-expert group that seems to be in hostile, your challenge is to develop credibility. Focus on listening and acknowledging. Identify goals, interests, values, and needs. Restate comments in constructive ways.

Quadrant I: If you have a non-expert group that seems to be supportive, your challenge is to build a feeling of safety and invite participation. Focus on listening, questioning, and establishing common ground. Create a positive environment for discussion of substantive issues. Explore the issues together in terms they can understand.

From the point of view of other meeting participants, the NABIR team can look like this:



People are empowered to contribute constructively when their ideas and concerns are taken seriously. Our focus groups and interviews indicate that stakeholders want something more from the communication process than a series of facts. They have questions that they want answered. They want to be listened to and they want their contributions understood. Members of the public generally do not want to be passive receivers of information, but to be included in a communication dialogue in real and significant ways.

This model reflects meeting participants' views of the engagement process. Public engagement processes often include both subject-matter experts (typically, scientists and engineers) and non-experts (typically, facilitators who are not scientifically or technically trained). The responsiveness axis (responsive to non-responsive) reflects a participant's perception of the communication team's receptiveness to their ideas and concerns.

Understanding participants' perspective of members of the NABIR team

Quadrant II: Responsive expert – The scientist-participants are perceived by other participants as interested in their concerns and still able to answer a wide range of scientific and technical questions. They are willing to restate questions, "translate" discipline-specific concepts or terms, and listen to participants' restatements and translations.

Quadrant III: Non-responsive expert—The scientist-experts are perceived as knowledgeable about the scientific matters and probably well prepared. However, participants note an "expert witness" attitude, removed from the concerns of other participants in the meeting or willing to answer questions. A false responsiveness may actually be perceived as non-responsive, as well—as when participants suspect an expert of waffling or turning uncomfortable questions aside.

Quadrant IV: Non-responsive non-expert—Participants note that the team member may not be a scientist or a lay-person who is informed about bioremediation, the site being discussed, or current concerns of the community. This participant may be present to answer programmatic or legal questions only. To other participants, the non-responsive non-expert may convey a tone of bureaucratic judgment or of disapproval of questions that seem too simple.

Quadrant I: Responsive non-expert—This may be a non-scientist staff member or facilitator, who is nonetheless interested in other participants' concerns and adept at linking scientists' concerns with those of other participants. Regardless of the affiliation of the responsive non-expert, he or she can be invaluable in establishing rapport with non-expert participants because they share questions and concerns.

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