Trading zones, interactional expertise and interdisciplinary collaboration

Michael E. Gorman, University of Virginia

***Draft (11/2/05)* description of a workshop to be held May 21-25 at Arizona State University**

Recent NSF initiatives like nanotechnology and convergent technologies emphasize collaboration across not only scientific and engineering disciplines, but also social sciences and humanities (Roco & Bainbridge, 2001, 2002). Science-technology studies (STS) is evolving new theoretical frameworks based on trading zones, shared expertise and moral imagination that show promise for understanding and facilitating these collaborations (Gorman, 2002, 2003a, 2003b).

This proposal involves an interdisciplinary workshop with three goals:

1. Developing a framework for analyzing and facilitating interdisciplinary collaboration in science and technology, based upon linking the concepts of trading zones and interactional expertise;
2. Adding an ethics/values component via the concept of moral imagination;
3. Applying the framework to emerging technological capabilities like the convergence between nanoscience, biotechnology, information technology, and cognitive science ("NBIC") and the possibility of developing new expertises in Earth Systems Engineering Management and Service Science.

Communication across disciplinary cultures

Thomas Kuhn argued that scientific breakthroughs produced new paradigms, or perspectives linked to sets of practices (Kuhn, 1962). Those scientists still in the old paradigm literally could not understand central features of the new one—they were separated by an incommensurable gulf.

Therefore, incommensurability does not always emerge; there are cases, like plate-tectonics, where theoretical groups navigate the change from one view to another (Giere, 1992). But Kuhn has captured an important barrier to interdisciplinary collaboration. Disciplines are cultures, with embedded practices and ways of thinking that have been successful at tackling certain kinds of problems. When a new problem or opportunity arises that does not fall into one of the traditional disciplinary bins—like converging technologies--then practitioners from different fields may find they have fundamentally different perspectives on it, including whether there really is an opportunity. This kind of communications barrier depends, in part, on one's level of inclusion in the disciplinary culture (Law & Bijker, 1992) and on which invisible colleges a particular member of the culture belongs to (Crane, 1972).

An example is the division between chemists and nuclear physicists regarding the possibility of cold fusion; many of the former thought it might be possible, while a member of the latter community, after seeing one of the cold fusion experimenters standing next to his fuel cell, noted that the radiation byproducts should have caused body parts to fall off (Close, 1991) (p. 114).

Trading Zones

Peter Galison used the metaphor of a trading zone to explain how scientists and engineers from different disciplinary cultures manage to collaborate across apparently incommensurable paradigms (Galison, 1997). He studied the development of radar, detectors, and particle accelerators and found that different expertise communities had to develop first jargons, then pidgins, and finally full-scale creoles to get around the problem of incommensurability. The key to Galison's approach is that it is possible for coummunication to take place locally even when they disagree about "global" meanings: "They can come to a consensus about the procedure of exchange, about the mechanisms to determine when goods are 'equal' to one another. They can even both understand that the continuation of the exchange is a prerequisite to the survival of the larger community of which they are part" (p. 803).

As an example, Galison describes the development of 'Police Motu' in what is now Papua, New Guinea.[1] The Motu developed a simplified version of their language to facilitate trade across their extensive network. This reduced version of Motu became a pidgin when the British adapted it to colonial rule, introducing new terms and uses that stabilized. When the pidgin is elaborated sufficiently for children to grow up in it, so to speak, it becomes a creole—like the dominant language in Haiti, which began as a French-based pidgin used both for communication between colonizers and subjects, and also among the different linguistic groups enslaved by the French (Asher, 1994).

According to Galison, "the most effective feature of the huge war laboratories was the imposed orchestration of the practices of theorists, experimenters and instrument makers with those of electronic and mechanical engineers" (Galison, 1997) p. 837. This 'imposed orchestration' resembles the need for the British colonizers to communicate with the Motus, and for slaves from a variety of cultures to understand the French and each other. Pidgins are especially likely to develop and survive to the creole stage when three or more languages intersect (Todd, 1990). The development of particle accelerators, radar and the atomic bomb involved the intersection of multiple scientific and engineering communities, fostering the development of pidgins and creoles.

In NSF workshops developing new interdisciplinary initiatives, "One of the most striking features of the workshop process is the amount of reciprocal adjustment required to get all participants, from within NSF and without, talking about the same topics in a mutually comprehensible language" (Hackett, 2000) p. 254. This 'mutually comprehensible language' involves establishing what Bromme calls a group-specific language (Bromme, 2000),or a pidgin.

For example, In a workshop Gorman conducted on scientific and technological thinking (Gorman, Kincannon et al., 2001), spanning disciplines such as psychology, cognitive science, philosophy, history and sociology, the pidgin primarily consisted of agreeing on meaning for certain terms like problem space and mental model, and also the development of metaphors that can " help groups of people from disparate backgrounds think about a problem in the same way" (Palmer, 2001) p. 12. The workshop adopted

---

[1] For this analysis of Police Motu, Galison relies on (Dutton, 1985) and (Foley, 1988). For development of pidgins in general, he cites (Ferguson, 1982).

two: shared toothbrushes and spherical horses. The former referred to the perception that most scholars in this area liked to share frameworks about as much as they liked to share toothbrushes. The latter referred to a joke about a physicist who said he could predict the winner of any horse race to multiple decimal points—provided it was a spherical horse moving through a vacuum. This metaphor reminded the group of the weakness of experiments and models that become too abstract, too distant from the messy world of actual scientific practice. By the end of the meeting, all a participant had to say was 'shared toothbrush' or 'spherical horse' and everyone else in the room knew what was implied.

The term trade is not just a metaphor. It was used by JPL engineers and scientists to reach agreement on where to land a Mars polar lander and later a Rover and what to carry on it (Lambert & Shaw, 2002). Scientists see one kind of location as ideal for exploring water, engineers see another as optimal from the standpoint of fuel, cost and time. The two groups have to trade, not only regarding landing location, but also on issues like what power source to use on the Rover, how much impact is sustainable on landing, and a host of other issues. Unfortunately, Lambert & Shaw's study did not explore whether these JPL engineers and managers had to develop a pidgin to communicate.

The concept of a trading zone has been used to describe interdisciplinary collaborations (Klein, 2000). "The collaborators enter what could be called an academic "trading zone." In this zone, they exchange ideas, learn from one another, and, having traded, return to their disciplines, richer for the experience and bearing tangible rewards in the form of improved research and teaching practices and products" (Morreale & Howery, 2002).

With a small amount of funding from the NSF, Gorman created a trading zone motivated by using nanotechnology to make the world a better place. He shared an engineering graduate student with a materials scientist, and thinking processes were documented by Jeff Shrager, a cognitive scientist (M. E. Gorman et al., 2004). In order to trade, members of this small zone had to develop a pidgin. Instead of developing new terms, we had to find shared meanings for terms used in our respective domains.—like 'directed self-assembly' isoelectric points, lattice structures, mental models and moral imagination. The terms were not reduced, but the meanings were simplified:. Gorman's understanding of a term like 'directed self-assembly' was never as deep or experiential as Groves', and vice-versa with respect to the concept of moral imagination.

The team also had to develop a metaphoric language to talk about its goals. All three participants in this zone liked hiking, which is why this seemed a natural set of metaphors. Groves took the lead in creating the language. Distant mountains are major global problems and opportunities, like human health, climate change, the prevalence of warfare, and so on. Closer foothills represented specific aspects of these problems, like the elimination of heart disease, or cancer, or providing more data on toxins introduced into the environment either as a form of biological warfare or as pollution. The team wanted to build a bridge that could be used by us or others to reach a range of local mountains, or foothills. This bridge would be part of a trail, but could also give access to other trails.

This set of metaphors grows as the team adds collaborators to the trading zone. Patricia Werhane, an expert on business and engineering ethics, suggested thinking about an alternate goal to the mountains—perhaps a village in the developing world, which would direct the project more towards Amartya Sen's emphasis on increasing affluence and education for women, world-wide (Sen, 1999, September 22, 1994).

This pilot study shows that it is possible to form an interdisciplinary trading zone in which a scientist and a social scientist jointly explore a cutting edge topic in nanotechnology, sharing a graduate student and expanding their trading zone to include a biomedical engineer. The research topic selected by the first student incorporated nanotechnology, biotechnology and cognitive reflection, three of the four NBIC technologies, and included an explicit ethical component (M. E. Gorman et al., 2004).

Types of Shared Expertise

Two sociologists of science (Collins & Evans, 2002) have described three levels of shared expertise that line-up nicely with the three stages in trading zones (Gorman, 2002).

None: This absence of sharing occurs in Stage 1 networks, where the top gives orders and black-boxes those below into compartmentalized roles. The military wanted to create this kind of network for the development of radar and the atomic bomb. In these situations, experts throw parts of the solution over a wall to one another without really sharing knowledge. Only the top of the organization has the complete picture—and the top is focused on results, not on understanding and facilitating the process by which the results are achieved.

Interactional: This kind of shared expertise is particularly important in Stage 2 networks. The interactional expert corresponds to an agent who understands enough of the languages and norms of the different cultures involved in the zone to facilitate trades. For example, early in the development of MRI, surgeons interpreted as a lesion what an engineer would have recognized as an artifact of the way the device was being used, This breakdown in the creole between these communities was recognized and solved by an interactional expert who had a background in both physics and medecine (Baird & Cohen, 1999).

Contributory: This kind of shared expertise involves experts who learn enough about other disciplines to make original contributions. In the case of radar, a central facilitator was Alfred Loomis, a wealthy banker turned scientists who saw the potential for this technology, created the team that expanded into the Rad Lab, supplied the initial funding himself and served as an advocate for this research in the halls of power in Washington. In addition to serving as an advocate, fund-raiser and network-builder, Loomis made original contributions to the science and engineering involved in radar (Conant, 2002).

At Los Alamos, the director, J. Robert Oppenheimer, served as a cross-disciplinary contributing expert; he "integrated the laboratory by his physical circulation through it, visiting meetings in theoretical physics, experimental physics and metallurgy…Some commentary, indeed, ascribes Oppenheimer's skill at integration to the circumstance that he just knew an enormous amount of the relevant physics and, more generally, that he had a grasp of a greater range of sciences than anyone else at Los Alamos" (Thorpe & Shapin, 2000) p. 573.

Moral Imagination

Both radar and the atomic bomb are examples of goals that are connected to competition with another group—in this case, the Axis powers in World War II. Survival of the Allied nations, and of populations of nations conquered by the Axis powers, was clearly at stake.

Convergent technologies could follow this route—could help one nation or culture gain a military or economic advantage over rivals. Sherif, however, emphasized a kind of goal that did not involve a common enemy, and referred to it as 'superordinate' (Sherif et al., 1961). He set up a simulated intergroup conflict at a summer camp, then brought opposing groups of boys together by posing problems with access to water and food.

Fair distribution of food and water is a chronic problem in the world today. One missing element is the ability to see anothers' suffering as if it were one's own—to see that ensuring no child dies of thirst, or starvation, is a superordinate goal for all. Other potential superordinate goals include increasing affluence and education opportunities for women globally, which would help alleviate population growth (Sen, 1999). The poor represent a potentially huge market for new technologies, because of their sheer numbers (Prahalad & Hammond, 2002).

Trading zones that incorporate these kinds of superordinate goals will require participants to exercise moral imagination (Werhane, 1999). The central tenet of moral imagination is that we learn practical ethics from stories, which become mental models for virtuous behavior (Johnson, 1993). Every culture has mythical tales that illustrate virtues and show the consequences of failing to behave in accordance with them. These stories can be transformed into unquestioned, tacit assumptions that lead myth to be confused with reality. Moral imagination consists of seeing that one's own cultural truths are views, and that alternative views are worthy of attention.

Note that this is not relativism. Moral imagination does not assume that all views should be treated equally, just that each perspective is worth at least listening to—despite all the difficulties involved in understanding another cultural perspective.[2] Each culture has learned valuable lessons over its history.

The hoped-for result of a serious dialogue among different world views will be an alternative that is better than any of the originals, taken alone. In this sense, moral imagination is like the scientific method. Each of these stories is a hypothesis about how one ought to live in the world, and these hypotheses need to be compared with other hypotheses and evaluated against changing circumstances. This comparison will include imagining "possible future worlds that are disclosed and shaped by new technologies" (Keulartz et al., 2004) p. 20.

Imagining the future of NBIC convergence requires explicit consideration of values—of what kind of world we ought to create. The sacred books and mythologies that date back hundreds of years cannot completely account for the dilemmas created by advances in science and technology that have given us increased ability to modify our

---

[2] "The truth of the doctrine of cultural (or historical—it is the same thing) relativism is that we can never apprehend another period's imagination neatly, as though it were our own. The falsity of it is that we can therefore never genuinely apprehend it at all. We can apprehend it well enough, at least as well as we apprehend anything else not properly ours; but we do so not by looking *behind* the interfering glosses that connect us to it but *through* them" (Geertz, 1983) p. 44.

planet and ourselves (Campbell, 1968). NBIC enhancements in human performance will take us closer to abilities reserved for God(s) in most of our traditional stories. Therefore, decisions about which technological directions deserve public support, both nationally and internationally, will involve the exercise of moral imagination.

Moral Imagination & GMOs

When Monsanto took the lead in developing genetically-modified organisms (GMO) the company's story was that this technology would create a new green revolution and would be much easier on the environment (Kilman & Burton, 1999). Instead of spraying chemicals on plants and soil, why not build this intelligence into the plant? Genes from a bacteria were inserted into crops like corn and cotton to produce a chemical that would reducethe need for spraying pesticides. Resistance to Monsanto's Roundup was added to soybeans and other crops, thereby potentially reducing the need for herbicide spraying (Gorman, Hertz et al., 2000).

The problem was that Monsanto's story about the benefits of GMOs clashed with alternate stories. Consider Monsanto's attempts to protect its intellectual property (Gorman, Simmonds et al., 2001). Monsanto wanted to prevent re-use and unauthorized distribution of any of its seed. Monsanto's effort to guard against re-use included farmer contracts that allowed the company to inspect fields and prosecute farmers, some of whom thought they had a right to re-use seed they had purchased (Hurt, 2004).

So Monsanto's story about the benefits of biotechnology was in conflict with stories that put the farmer's rights to re-use seeds ahead of corporate ownership and profit (Pringle, 2003). In hindsight, Monsanto might have been able to reach out to stakeholders holding these views and similarly those stakeholders could have listened to Monsanto's story. Perhaps it would have been possible to reach agreement on a superordinate goal, like feeding the world's population in a way that increases affluence in developing nations. The Danforth Foundation, working with Monsanto support, is teaching scientists from the developing world how to develop GMO technologies appropriate to their own natural and cultural environments.[3]

Moral imagination in an environmental textile

Susan Lyons, a New York fashion designer, wanted to create a new fabric for the high-end furniture market that embodied environmental principles. She recruited the architect William McDonough because of his reputation for environmental thinking. He believed that industrial design ought to follow the analogy of nature (Gorman & Mehalik, 2002; Mehalik, 2000a). All waste in nature becomes food. Similarly, all industrial waste should become food for other products. This could be done in two ways, by having biodegradeable products or where that was not possible, by re-using all materials. In this way, the industrial lifecycle would be transformed from cradle to grave to cradle to cradle.

---

[3] Tiffany Nichols, *A study of the transfer of genetically modified crops from the United States to Kenya*. Undergraduate Engineering Thesis, April 20, 2004, University of Virginia (available in the library).

McDonough brought his collaborator Michael Braungart, an environmental chemist, into the design network. Susan Lyons added a textile manufacturer, Albin Kaelin, who understood McDonough's philosophy and agreed to implement it.

Therefore, this interdisciplinary team adopted a shared mental model based on waste equals food, and committed to making a furniture fabric via a clean manufacturing process that could be composted at the end of its life.

As long as McDonough's waste equals food served as the source of a dynamic mental model, this network remained in a Stage 3, based on the continuous exercise of moral imagination. Kaelin and Braungart worked particularly hard on alignment,: both were careful to bring in suppliers whose practices could be adapted to fit with the principles, staying in close contact with Lyons and McDonough. But if the principle ever degenerates into an ideology, then this network would become a Stage 1, dependent primarily on McDonough as a guru.

This team produced a fabric called Climatex Lifecycle that won numerous awards for environmental design. If this product is to achieve one of McDonough's goals and become a model for a sustainable industrial revolution, the waste equals food framework and associated procedures will have to adapt to a complex global system that includes different economic, natural and technological sub-systems (B. R. Allenby, 2000/2001).

Using a workshop to improve the framework

Trading zone, shared expertise and moral imagination have only been combined in one small pilot project on nanotechnology. This framework needs to be tested and modified in a variety of other interdisciplinary contexts. Furthermore, aside from the e-mail reflections used in the pilot study, there are no tools or methods for facilitating development of appropriate trading zones for collaboration.

As a first step towards addressing these limitations, this proposal calls for funding a workshop that would bring STS scholars with expertise in trading zones and shared expertise together with those developing aspects of converging technologies, in hopes that new understandings and collaborations will emerge. Questions confronting workshop participants will include:

- Should there be a taxonomy of types of trading zones?

Gorman and Mehalik have proposed at least three types (Gorman & Mehalik, 2002):

1: A top-down trading zone, in which the goal is dictated by the dominant group or individual. Centralized agricultural plans promoted by Communist governments serve as examples. These schemes were effective controlling the behavior of the population, but were terrible at producing crops (Scott, 1998). In this kind of trading zone, there is little or no shared expertise—local knowledge and initiative are suppressed.

2: A relatively equal trading zone, which may include a boundary object (Bowker & Star, 1999) or system that participants are trying to work together to create, and that sits on the boundaries of their various expertises. Early in the development of MRI, surgeons and physicists perceived the system differently, making it a

boundary object; an interactional expert with background in both physics and surgery had to align the practices of the two communities (Baird & Cohen, 1999).
3: A shared mental model zone, in which participants share a dynamic, evolving representation of the superordinate goal and the boundary system. The team that developed the Arpanet had this kind of free exchange, in which experts from different backgrounds jointly contributed to the eventual result.
These three stages are very general, and do not describe all possible types of trading zones. What is needed is a more comprehensive taxonomy of types of trading zones. There will also be a wide range of hierarchies and organizational constraints on trading zones—these need to be developed more fully (Hughes, 1998).

- The trading zone metaphor needs to be complemented by other metaphors that cover aspects of collaboration and negotiation (Geertz, 1983). Workshop discussion will help us find the strengths and limitations of the trading zone metaphor.

  For example, Davis Baird has proposed that gift zones are more stable than trading zones (Baird & Cohen, 1999). Among the Trobriand islanders, for example, economic bargaining at the market is distinct from the exchange of gifts; the complex network of gift exchanges serve to bind the society together. In this and other cultures, gifts are linked to honor and prestige (Mauss, 1990). In science, credit for discovery is more important than any financial gains, and is linked with prestige (Merton, 1973). The complex patterns of citations and credit, reinforced by the community, might serve a function similar to gifts. The kind of interdisciplinary knowledge exchange prevalent at the Rockefeller Institute and Caltech might also be described as a gift zone (Hollingsworth & Hollingsworth, 2000).

  Stephen Turner uses the metaphor of cartels to describe disciplines; they "organize markets for the production and employment of students by excluding those job-seekers who are not products of the cartel" (Turner, 2000) p. 51. Most disciplines are preceded by an interdisciplinary focus on a problem or goal, which in certain cases leads to the foundation of a cartel that can 'corner' that market.

  How does the discipline as cartel metaphor relate to the trading zone? Perhaps disciplines turn fluid trading zones into stable markets for their expertise—and can therefore be threatened by interdisciplinary enterprises, unless they increase the market for their graduates.

  For the workshop, these and other metaphors[4] represent alternatives that can supplement, embellish, alter and even replace the trading zone metaphor in certain situation.

- What other mechanisms for communicating trades can complement or even replace pidgins and creoles? Interactional experts can play a role similar to agents at trading posts, facilitating exchanges between cultures (O'Leary et al., 2002). Forms of visual or tactile representation can play a role similar to pidgins or creoles, gradually becoming standardized (Gooding, 2005). Metaphors and analogies can also play a role in knowledge exchanges, as the pilot nanotechnology project showed.

[4] For example, the metaphor of an enclave has been applied to interdisciplinary research centers (Klein, 2000).

- What kinds of organizations can facilitate the development of interactional expertise and trading zones? To work effectively between disciplines and cultures, interactional experts may need to belong to boundary organizations that have experience creating trading zones. "Where effective, **boundary organization**s are the sites of co-production of knowledge--the act of producing information or technology through the collaboration of scientists/engineers and nonscientists who incorporate values and criteria from both communities." (Cash & Buizer, 2005) p. 14

The workshop will also explore methods for making the application and assessment of the framework more rigorous. Potential tools include:

- The Arizona State University Decision Theater, where the workshop will be conducted, will allow participants in a trading zone to visualize alternatives. For example, multiple stakeholders concerned about the future of Phoenix could develop visual representations of their imagined future city, and project them for others to see and discuss. This tool could be particularly useful for promoting moral imagination.
- Methods for visualizing shifts in the network over time, and complementary quantitative metrics (Mehalik, 2000a, 2000b)
- Reflective diaries kept by participants (Shrager, 2004) that include societal as well as technical dimensions. These diaries can be coded, triangulated against selected transcripts of trading zone meetings, and turned into problem-behavior graphs which are presented to participants in a trading zone to facilitate the process—even if they disagree with the diagram and modify it, reflection is encouraged.

One hoped-for outcome of the workshop will be specific collaborations among the participants, directed towards opportunities that require convergent technologies.

Service Science

One of these is the effort by workshop participant Jim Spohrer to create a new, interdisciplinary service science (http://www.almaden.ibm.com/asr/events/serviceinnovation/). IBM played an important role in creating the discipline of computer science. Now IBM is shifting from a manufacturer of computers to a provider of services, rapidly adapting to user needs. These services include not only the specific needs of a user at a given time, but also the basic needs of human beings everywhere. Amartya Sen emphasizes that economic development is critical to human freedom; those who are poor have less options (Sen, 1999). But this economic development must include health care, education and a sensitivity to human rights. Service science should focus on the evolution of the socio-technical system in a way that enhances human capabilities.

Earth Systems Engineering Management

Another is the effort by workshop participant Brad Allenby to create a new expertise in Earth Systems Engineering Management (B. R. Allenby, 2000/2001). There is no part of the global ecosystem that has not been affected in one way or another by human activity, going back to prehistory (Mann, 2002). The concept of a pristine ecosystem, untouched by human activity, "is collapsing in the wake of scientists' realization that there are *no places left on Earth that don't fall under humanity's shadow*." ("Science special report: Human-dominated Ecosystems," 1997).

Of course, there are some systems – plate tectonics, for example – that at this point do not appear to be influenced by humans (but could be in the future). These systems correspond to what Collins and Evans (2002) call historical science, as distinct from reflexive, historical science, which refers to systems whose dominant dimensions are anthropogenic, such as industrial or economic systems. These systems can learn about themselves, and future states are affected by this knowledge. ESEM is primarily concerned with these reflexive, historical systems involving a tight coupling between nature and society.

ESEM can accordingly be defined as the capability to engineer and manage socio-technical systems in such a way as to provide the requisite functionality while facilitating the active management of strongly coupled natural systems. As an obvious corollary, ESEM should aim to minimize the risk and scale of unplanned or undesirable perturbations in coupled human or natural systems. Moreover, it is apparent that such complex systems cannot be "controlled" in any usual sense: accordingly, ESEM is a design and engineering activity predicated on continued learning and dialog with the systems of which the engineer is an integral part, rather than the traditional engineering approach, predicated on a predictable, controllable system which is external to the engineer and her actions. ESEM will require a sophisticated, adaptive trading zone that includes not only multiple human stakeholders but also a close dialogue with nature and the development of new technologies (B. Allenby, 2005).

Workshop participants[5]

Scholars, practitioners involved in convergent technologies and those with methodological expertise regarding trading zones will be brought at Arizona State University's Decision Theater. All participants will have had previous exposure to this framework, as part of presentations and discussions with the PI, and will be interested in collaborative work.

In effect, the workshop is reflexive: we develop techniques for encouraging collaboration by collaborating, and therefore we will, in this workshop, also reflect on our emerging trading zone.

Organizers:

- Michael E. Gorman (Science, Technology & Society, UVA)

[5] The PI has has received telephone or e-mail commitments to attend the workshop from all of the participants listed in this proposal—depending, obviously, on the timing of the workshop. We are tentatively targeting late spring of 2005.

- James L. Buizer (Special Advisor to the President and Director for Science Applications, Center for Environmental Studies, ASU)
- David Rejeski (Director, Foresight and Governance project, Woodrow Wilson International Center for Scholars, http://wwics.si.edu/)--Has conducted workshops on nanotechnology and the environment (Rejeski, 2004), nanotechnology and intellectual property, and also on convergent technologies.

STS scholars and working on trading zones and shared expertise.

- Peter Galison (Harvard)—Used trading zones as a central metaphor in his *Image and Logic*.
- Harry Collins & Rob Evans (Cardiff University)—Are doing cutting-edge work on the nature of shared expertise.
- Davis Baird (Chair of Philosophy Department and Director of Nanotechnology NIRT, University of South Carolina)—Has written about the kind of trading zone that grew up around MRI, and is himself engaged in creating a trading zone around societal dimensions of nanotechnology.
- Monique Lambert (Stanford)—A doctoral candidate in Engineering Managment doing research on how engineers at JPL form trading zones to develop devices like the Mars polar lander and the Mars Rover.
- Ed Hackett (Arizona State University)—Extensive experience with interdisciplinary collaborations at the National Science Foundation, and has done cutting-edge work in this area.
- Dan Sarewitz and Dave Guston (Consortium for Science & Policy Outcomes at ASU)—both have experience working on interdisciplinary boundaries and real-time technology assessment (Guston & Sarewitz, 2002).
- Martin Rosenberg (Penn State)— organized a Modern Language Association panel on “Metaphor, Science and the Trans-Disciplinary 'Trading Zone”, focusing particularly on semiotics.

Development of tools:

- Jeff Shrager (Xerox PARC and Stanford)—Has developed a reflection diary methodology and also a coding scheme for trading zones which has been applied in pilot form in the domain of nanotechnology. Is working on methodological refinements that would prompt members of a trading zone for reflections, and also code more effectively for evidence of moral imagination.
- James Buizer (ASU)—Has experience developing interdisciplinary collaborations (Cash & Buizer, 2005), and played a central role in developing the Decision Theater at ASU that will host the workshop.
- Michael Hertz (Progeny Systems)—Has created a ‘provocative decision aid’ that helps managers visualize the network of stakeholders who ought to be involved in a trading zone.
- Matt Mehalik (University of Pittsburgh)—A postdoctoral fellow at the University of Pittsburgh who has developed tools for visualizing the development of trading zones and is documenting parameters of trading zones in order to specify their boundaries quantitatively.

Practitioners trying to develop trading zones:

- Michael Huff (MEMS exchange, http://www.mems-exchange.org)—Has to facilitate development of a creole in microelectronics manufacturing so that participants can trade information.
- Brad Allenby (Arizona State University)—Is working with scholars, policy leaders and industry to establish Earth Systems Engineering Management, an approach to global environment that will require development of new kinds of interactional expertise (B. Allenby, 2004).
- Mary Ann Leeper (President and CEO of the Female Health Company, http://www.femalehealth.com/)—Is involved in marketing the female condom world-wide, requiring her to link NGOs, governments, shareholders and others in trading zones that prevent AIDs and other sexually transmitted diseases.
- Nora Savage (Environmental Protection Agency)—Is funding research and anticipating the kind of environmental regulations that will be required for converging technologies.

Leaders in converging technologies:

- Jim Spohrer (IBM Almaden)—Sponsored a major symposium on the co-evolution of technology-business innovations and calls for expansion of NBIC to NBCST (nano-bio-cogno-socio-techno) (Spohrer & Engelbart, 2004).
- Carlo Montemagno (UCLA)--Has developed bio-molecular motors and technologies that emulate neurons (Montemagno, 2004).

Moral imagination

- Patricia Werhane (DePaul University)—Has done seminal work on the importance of moral imagination in the kinds of trading zones set up by companies, especially in developing nations.

NSF program officers with an interest in the workshop will be welcome, and the PI will prepare a report for NSF, in addition to other deliverables listed below. The Boston Consulting Group has agreed to support part of the costs of the workshop, and will send several representatives, including Tiha von Ghyczy, from UVA's Darden business school.

Workshop structure

Participants will each be invited to submit one paper, or excerpt, or powerpoint presentation, or URL in advance of the workshop. These materials will be put on a web page at the WWIC for participants to study in advance.

The workshop will follow the list of participants and topics above, opening with presentations from those involved in research using the trading zones metaphor (Galison, Baird, Lambert), followed by those involved with interactional and other forms of shared expertise (Collins, Evans), followed by a synthesis and suggestions on how it could be applied to convergent technologies (Gorman). Then those who have or are developing tools to facilitate collaboration across trading zones will present (Shrager, Buizer, Hertz, Mehalik). Then practictioners engaged in developing trading zones will give background on what they are doing (Huff, Allenby, Leeper, Hackett). Next, those who are pursuing NBIC trading zones will speak (Spohrer, Allenby, Montemagno). Finally, there will be presentation and discussion of moral imagination (Werhane, Gorman).

These presentations will take the first day, and will be punctuated by questions and discussions, monitored by David Rejeski. At the beginning of the second day, Gorman and Rejeski will attempt an overview of what was learned about the framework from the first day. Then the discussion will turn to future research and applications—in NBIC, but also in other areas. The goal will be to plan specific research collaborations among participants, and begin to think about the means to achieve them.

The workshop will be held at Arizona State University's Decision Theater, in winter 2004 or spring 2005, depending on participants' schedules. ASU will permit facility use for free, and will record the workshop. These digital recordings will be made available to participants and distributed outside the workshop group only with their express permissions.

Deliverables

The entire workshop will be recorded; no materials will be released outside of the small group without specific permission from participants. In addition to a report for NSF, the PI will edit a volume including comments and conclusions from the workshop; participants who wish will be invited to submit chapters to the volume.[6] The PI is in conversation with Erlbaum over publishing such a volume, but the structure of the work will not be known until after the workshop. The PI will also be the lead author on an article for *Social Studies of Science* or *Science Technology & Human Values* and will give a presentation at future Converging Technology meeting. A web site describing the workshop and documenting research collaborations among participants will be maintained by the WWIC.

One hoped-for end result will be establishing the value of STS, coupled with ethics, for promoting the kinds of interdisciplinary collaboration that will yield scientific, technological and social benefits.

Results from Prior NSF (M. Gorman)

In an STS grant **Workshop on Cognitive Studies of Science & Technology (SES-0000573)** Gorman designed a workshop similar in structure to the one proposed above, but on a different topic. Results from this workshop will be available in a volume published this summer (Michael E. Gorman et al., 2004).

In an STS grant, **Inventing for a Better Global Environment: A Comparative Analysis of Two Networks (SBR-9810200)** Gorman and Mehalik developed portions of the theoretical framework that is used in this proposal and applied it to the team that created environmentally sustainable products (Gorman & Mehalik, 2002).

In three previous SDEST grants, **Environmental Ethics and Invention: A Case Study (GBR 9319983) and Putting Ethics at the Heart of Design (SBR-9618851)** and **Moral Imagination, Invention & Design (SES-0080400)**, Gorman, Werhane, and

---

[6] The potential, as one reviewer of an earlier version of this proposal put it, is "a volume with the impact of the Pinch and Bijker "Social Construction of Technology" book."

graduate students from systems engineering and the Darden Business School wrote a series of engineering ethics cases and notes on ethical reasoning that were published in the University of Virginia Darden School Case Bibliography, are available on the World Wide Web (http://repo-nt.tcc.virginia.edu/ethics/home.html) and in a volume (Gorman, Mehalik et al., 2000).