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How Engineers Should Talk to the Public

So, WHAT should we tell the public? Are we experts that proclaim the correct answer to a scientific question? Are we primarily teachers whose goal is to create scientific literacy? Or, is there another role for us? For that matter, is our real battle for literacy, or is it against apathy?

As engineers entering the world of public communication, many obvious paths beckon us, but to my way of thinking they all culminate in dead ends – in a public that isn't more able to participate in democracy. I consider briefly these tempting paths before outlining a positive path. The unfruitful routes are: Presenting ourselves purely as experts, emphasizing research, using the word "technology" as a "catch-all" for engineering, and focusing on hard scientific literacy. These paths of explanation seem obvious, but on reflection are clearly the wrong approaches for talking to the public.

Being an expert

Being an expert is a legitimate and necessary role for an engineer, and it is especially natural for a professor. But ultimately it's very limiting. A major problem is that "expert mode" distances technology from the listener or viewer. When you use "expert mode," you say that science and engineering are something you cannot understand; you need my help. The

gatekeeper role tends to turn off listeners. When on air I'm always called "Bill;" in fact, "professor" is never mentioned at all. Still, being viewed as an expert is a hard role to shake. Over the years I've gotten e-mails asking me for advice on building a concrete dome - part of someone's home improvement project - I've gotten questions about installing gas lighting, and even one about building a concrete submarine in the desert!

The cult of research: promises, promises

Another temptation that engineers face, especially as academics, is focusing on research and the research mission. Jacques Barzun, in his worthwhile *Science: The Glorious Entertainment*, calls it "The Cult of Research." "Research," he writes,

> *in other words, is no longer simply a vocation; it is an institution.*[31]

Barzun implies that institutional priorities overwhelm all others.

In the 1960s, academics formed a Faustian pact with entities like the National Science Foundation.[32] Essentially we said: Give us public funds for our *research* and we will return *technological* items of great value to the nation. Yet, the outcome of our research mission should not be to validate the technological products of research, but instead to emphasize the *human* product - the students and the

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[31]Barzun, Jacques, *Science: The Glorious Entertainment* (New York: Harper & Row, 1964), p. 122.

[32]To be completely transparent about this: I *am* one of those academics - I'm a product and a producer; the U.S. Department of Energy paid for my M.S. and Ph.D., and my research as a newly-minted professor was funded by them.

knowledge created.[33,34] Think for a moment how impossible it is for a specific piece of research to return value in a regular and recurring way! At the core of research lies the strong possibility, even likelihood, of failure. Einstein famously said, "if we knew what we were doing, it wouldn't be called research, would it?" So, while we can make the argument of research's importance in the aggregate - over many cycles of research, our technological products improve the world - the nature of funding forces us to do this for *every* research proposal. This, in turn, results in overstatement and empty promises to the public. The degree to which we promise *direct* results from *specific* research is inversely proportional to how the public eventually assesses the value of the research *mission*. "We must not promise," wrote Lincoln, "what we ought not, lest we be called on to perform what we cannot." As a cautionary tale, consider the Human Genome Project.

The basis of this $3 billion project was to find the genetic roots of common diseases like cancer and Alzheimer's and

[33]Knowledge itself is different than the utility of the research results.

[34]This is best illustrated by the career of Bill Flygare at the University of Illinois. When I arrived at Illinois in 1984, the eminence of Flygare and his research still echoed through the halls, although he had died three years earlier at age 44. His colleague David Chandler reflected on Flygare's work two decades later: "The results of these experiments seemed important at the time. It was believed that knowledge of molecular dipole and quadrupole moments would significantly contribute to a good understanding of intermolecular forces. In current times, however, it is understood that intermolecular forces and their manifestations, especially in condensed phases, are more complicated than those numbers reveal. Further, experiment is no longer required for these quantities because theoretical quantum chemistry can now provide the information easily and reliably. In retrospect, therefore, the results of Bill's Zeeman effect measurements seem less important than the training provided to the students who helped make the measurements." *Biographical Memoirs,* volume 86, pp. 137-161 (National Academies Press, 2005).

then to generate treatments. Science writer Nicholas Wade concluded that "[t]en years after President Bill Clinton announced that the first draft of the human genome was complete, medicine has yet to see any large part of the promised benefits."[35] Even today, the old-fashioned family history does better than looking at the 101 genetic variants linked to heart disease.

So, to build a public outreach effort based on explaining research easily falls into the trap of reflecting the institutional priorities of the research mission – of getting that next grant, or proving to the funding agency the utility of the work.

Technology: a hazardous concept

If we use the word "technology," we defeat our outreach mission as engineers. On the surface what could be more odd? What more ridiculous claim could an engineer make? After all, "technology" nearly envelopes us: it fills our pockets with cell phones, it flies overhead as highly sophisticated jets, zooms by in the computer-controlled engine of a car, and flows through our veins as carefully designed drugs. In describing these items we use the word "technology" to lump together many separate, and even disparate, things.

For example, we might toss off a comment about how "railroad technology" has changed our world. Yet, what in the world do we mean by "railroad technology"? Well, we mean everything from drilling tunnels and laying tracks, to business organization, to telegraphy, to specially trained workers. Just to fully define the loaded phrase "railroad technology" takes a 700 plus-page book: *Empire Express:*

[35] Wade, Nicholas, "A Decade Later, Genetic Map Yields Few New Cures," *New York Times,* June 12, 2010.

Building the First Transcontinental Railroad.[36] We use "technology" as a catch-all which, while useful, lies at the heart of many myths about technology.

When we talk about technology as a single thing we give the sense that it has a mind and agenda all its own. Yet "technology" certainly isn't a thing; it is a human-made construct that reflects all aspects of humanity. Using the word technology buries the creativity of engineers: it camouflages the genius of engineers like George Stephenson or Isambard Kingdom Brunel.

Engineering creativity becomes buried because most people gauge the success of a technology by its degree of invisibility: the more concealed it is, the better! Think for a moment of heating your home in the 18th century. A typical house had an open hearth, which required *action* by the homeowner. It had to be filled with coal or wood, lit, and then constantly tended. Even so, much of this heat escaped through poorly insulated walls, prompting Theodore Roosevelt's wife to compare heating a home to "trying to heat a birdcage." Today, of course, we warm our well-insulated homes using a furnace hidden in the basement, pumping away with little assistance from its owner, and even less thought. Home heating has reached the pinnacle of technology: invisibility.

But this "out of sight, out of mind" means that the public no longer has visceral contact with technological objects, and so now believes myths about how this foreign "thing" called technology behaves. What we need to do in our outreach is make the work – the creativity, the inventiveness – of

[36] Bain, David Howard *Empire Express: Building the First Transcontinental Railroad* (New York: Penguin, 1999).

engineers visible.

Hard scientific literacy

The final temptation is to engage in what's called "hard scientific literacy." What I mean by this is having a basic toolbox of skills - in mathematics, physics, chemistry, mechanics - that allows a person to delve into almost any technological area. Most readers of this book have such a toolbox. The goal of those who promote hard literacy is to create a public that is as capable as an engineer of making independent, scientific decisions. This has been the scientific literacy goal for the last thirty years or so. There is now a fair amount of evidence, though, that this effort has failed to penetrate the consciousness of the American public. In spite of all our efforts, by any reasonable measure we are a nation of scientific illiterates. If you just looked at the huge amount of work done to ingrain hard scientific literacy on a pragmatic cost/benefit basis, the effort would surely be abandoned.

Also, it isn't even clear that hard scientific literacy is desired. Morris Shamos, a physicist who's worked for thirty years to improve scientific literacy, reports:

> *To make matters worse, we keep insisting that public understanding of science means understanding some basic science rather than the technology that the public finds more palatable. All this despite the fact that ever since the Enlightenment, society has been sending back the message: give us the useful end products of science, as long as they cause us no real harm; but while we can relate to their technology, we don't require that we understand their underlying science.*[37]

So, if it isn't hard literacy we want - or can get - what do we

[37] Morris Shamos, *Myth of Scientific Literacy* (Rutgers University Press: Rutgers, New Jersey, 1997), p. 238.

aim for?

Hard literacy vs. awareness

We would like adults to understand how the scientific enterprise works in our particular political and economic climate. We want to encourage an appreciative public, one that at least understands how much needs to be spent on science and technology. The science and engineering community would be well served by a society that, while perhaps illiterate in science in the formal academic sense, is at least aware of what science is, of how it works, and of its horizons and limitations. You might call this approach "science awareness," rather than literacy.

The objectives of this approach are to help students, and society in general, feel more comfortable with new developments in science and technology. They need not understand the details but rather recognize the benefits and the possible risks of technology.

The real battle: technological determinism

The argument over hard literacy versus awareness distracts from the main problem. Our battle is not so much with literacy, as with technological determinism: the belief that technology shapes our lives with a ruthless logic all its own. In fact, which of us doesn't carry in their head an image of a great whirlwind of innovation that sweeps through our world, creating blessings and havoc? This view is only half true and, because of this, dangerous.

Its truth lies in the degree to which science affects our lives. Never before has such a complex web of technology permeated a culture. For sure, in every century some marvel has reshaped the world - the printing press, gunpowder, the

cotton gin - but only in the twentieth century have these wonders united into a comprehensive system that seems poised to overtake us.

Technological determinism makes people passive and in doing so promotes a dangerous apathy. People become focused on how to adapt to technology, not on how to shape it. Thus, technological determinism removes a vital aspect of how we live from our public discourse, creating a pressing need for citizens who understand technological systems not just to grasp the impressive world of technology, but to exercise the civic duty of shaping those forces that shape our lives so intimately, deeply, and lastingly.

Lewis Mumford,[38] a pioneering historian of technology, pointed out that the products of engineering have meaning "only in relation to a human and social scheme of values." The key here is that the technical aspects of any technology cannot be construed apart from their social context. The values and world views, the intelligence and stupidity, the biases and vested interests of those who design a technology are embedded in the technology itself.

In my work, I look at the entire context of the things that surround us, which includes the people who make technology happen. In reaching out to the public, we must present the entire technical, social, political, economic, and cultural context of the things that surround us. This includes the innovators, inventors, engineers, entrepreneurs, and business people who make technology happen. And, more importantly, we must present this message in a way that

[38]In 1938, *Time* magazine featured Mumford on their cover. This is likely the one and only historian of technology to ever make the cover of a national news magazine!

resonates with the public.

The key aspect of how to do that comes from a G.K. Chesterton quote, which is posted in my office. Over the years I've collected quotations about writing and reaching readers, listeners, and viewers. I've laminated them and rotate them on and off a filing cabinet by my desk where I write. This is one of my favorites, and in fact is up there most of the time. Chesterton writes:

> *The only two things that can satisfy the soul are a person and a story; and even a story must be about a person.*

Look at very successful news shows like CBS's *60 Minutes* or NBC's *Dateline*. They always tell a story using, to my taste, too much suspense. They usually have a strong narrative, or at least a strong human interest angle. Look, also, for a moment at the scientific disciplines that are extremely popular: astronomy and evolution. They both had superb popularizers - Carl Sagan and Stephen J. Gould - but the public also sees them as situating us in our world. They answer questions like: Who are we? What is the purpose of life? The message to any technologist who wants to reach out is to place technology in context. As engineers we often neglect context, focusing instead on the mechanical details.

When I'm tempted to just explain how something works, I recall another quote that often rotates on and off my filing cabinet. Ambrose Bierce, in his 19th century *Devil's Dictionary,* essentially a list of literary barbs, defined "inventor" as,

> Inventor, *n. A person who makes an ingenious arrangement of wheels, levers and springs, and believes it civilization.*

This is what we must avoid when talking to the public.

To overcome the temptation to overhype my work, I often tell the story of an inventor or innovator who created some everyday object. I've talked about the invention of the microchip, Scotch tape, the Ping golf putter, and nylon. I'll use a story that reveals how technology is changing the listener's life or has dramatically changed our society. I've discussed the impact of the typewriter, the match, and how color film is embedded with cultural bias. Whenever possible, I like to link up technology with art, music, and especially literature. I've shared how J.R.R. Tolkien felt about technology and what his *Lord of the Rings* might mean for us today. I've delineated how the creative process of an engineer is closely linked to that of a painter. And, at times, I help listeners understand the news of the day. It isn't a mode I use often, but after the September 11th attacks, I tried to put technology and terrorism in perspective, and after the anthrax attacks I described anthrax and its toxicity in detail.

We can envision the general message we want to deliver, or rather the kinds of actions we want to see from the public. Let's take a more sophisticated look at the form of our message.

Framing

Journalism professors Matthew Nisbet and Dietram Scheufele have written engagingly and insightfully about how scientists and engineers should talk to the public.[39] Scientists and engineers, they note, tend to believe that facts will win out -- they call this the popular science model, which is a version of the hard scientific literacy I mentioned earlier. The authors cite ample evidence that this doesn't work. They review sixty years of

[39]Nisbet, Matthew C. and Dietram A. Scheufele, "The Future of Public Engagement," *The Scientist,* vol. 21, issue 10, p. 38, (2007).

research that suggests citizens prefer to rely on their social values. So, these authors argue for what they call “framing.” In the abstract this means tailoring messages in ways that make them personally relevant and meaningful to different publics. Its best to look at some examples.

Let's start with the negative - the ways framing has been used against science. Greenpeace's idea of “Frankenfood” has been effective in opposing all manner of genetic modifications. This organization published a repulsive manipulated image of a frog’s head on a rotting apple core. The image resonates deeply with some fear or social value that people have. What this means for technologists is that to reach out effectively is also to frame using what a group values. For example, when scientists talk to a group of people who think in primarily economic terms, that they should emphasize the economic relevance of science. An example might be embryonic stem cell research, pointing out how expanded government funding would make the U.S., or a particular state, more economically competitive. Nisbet and Scheufele praise E.O. Wilson's book *Creation: An Appeal to Save Life on Earth* for recasting environmental stewardship not only as a scientific matter, but also one of personal and moral duty, noting that this book has generated a discussion among a religious audience that might not otherwise pay attention to popular science books.

As a final example, consider the banner headline on the cover of a recent issue of Brown University's alumni magazine: “Could Today's Wonder Fiber Be the Next Asbestos?” This linking of ideas – nano and asbestos - echos something that buzzed across Europe. On the Continent the opponents of nano push it as the “the asbestos of tomorrow”

or the "new asbestos." This is, of course, framing in action. The public has placed asbestos in context - they have situated it in their political, cultural, and social landscape. This framing of nano ties it into their social judgment. European companies have responded with their own framing of "nano is nature" to try and tie into something else that citizens have already made a social judgment about.

Nisbet and Scheufele stress that they aren't talking about framing as "false spin;" rather they insist that the content be true. They argue, convincingly to me, that scientists engage in framing all the time. When writing a grant proposal, or a journal article, or providing expert testimony, scientists and engineers often emphasize certain technical details over others, with the goal of maximizing persuasion.

All that said, I find their approach too often focuses on only the value-laden scientific questions. Whenever I read their work, I cannot help but think of this quote from Justice Oliver Wendell Holmes from his great dissent in a case before the Supreme Court where he coined the phrase, "Great cases, like hard cases, make bad law." He spells out the reasons:

> *For great cases are called great not by reason of their real importance in shaping the law of the future, but because of some accident of immediate overwhelming interest which appeals to the feelings and distorts the judgment.*[40]

He continues by citing the "hydraulic pressure" - his metaphor for growing peer pressure - applied by these interests. So, to my way of thinking we need to apply framing to less controversial and more everyday things.

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[40]*Northern Securities Co. v.* U.S., 1904.