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7 Technological Determinism Is Dead; Long Live Technological Determinism

Sally Wyatt

The story of Robert Moses and the bridges between New York and Long Island made a great impression on me as on many generations of STS students. Langdon Winner argues that Moses, city planner, deliberately allowed overpasses built during the 1920s and '30s that were too low to permit buses to go beneath them, thus excluding poor, black, and working-class people from the beaches of Long Island.[1] I first read Winner's "Do Artifacts Have Politics?" in the mid-1980s, in the first edition of *The Social Shaping of Technology* (MacKenzie and Wajcman, [1985]1999), where it is the opening chapter following the editors' introduction.[2] As I have described elsewhere (Wyatt, 2001), I am the daughter of a nuclear engineer, so I grew up knowing that technologies are political. Making nuclear power work and justifying his efforts to do so to both his family and a wider public were the stuff of my father's daily life for many years. Despite the continued political differences between me and my father, we shared an appreciation of the existence and implications of technical choices; reading Langdon Winner provided me with a way of thinking about the politics of artifacts more systematically, and perhaps enabled my father and me to discuss these politics more dispassionately. What I learned from my father was that technology indeed matters and that technical choices have consequences, though perhaps I would not have expressed it in quite such terms when I was six years old and he took me to Niagara Falls, not only to admire the water but also to look at the turbines down river. My father and I did not distinguish between the natural and the technological sublime (Nye, 1996).

In this chapter, I wish to address both the ways in which technology itself and the idea of technological determinism continue to fascinate, even if those of us in the STS community sometimes deny this fascination. In the next section, I discuss technological determinism and then turn to the "principle of symmetry" (see also table 7.1) in order to make two points, one about success and failure and the other about treating actors' and analysts' concepts symmetrically, as a way of allowing technological determinism back into our analyses. I then return to technological determinism, arguing that one way of taking it more seriously is to disentangle the different types and what work they do. I identify four different types: justificatory, descriptive, methodological, and normative (see also table 7.2).

Table 7.1.
Extending the Principle of Symmetry

Bloor (1973, 1976) on Science	Pinch & Bijker (1984) on Technology	Callon (1986) on Socio-technology	Wyatt (1998) on Method in STS
Impartial to a statement being true or false	Impartial to a machine being a success or failure	Impartial to an actor being human or nonhuman	Impartial to an actor being identified by other actors or the analyst
Symmetrical with respect to explaining truth and falsity	Symmetrical with respect to explaining success and failure	Symmetrical with respect to explaining the social world and the technical world	Symmetrical with respect to using concepts from analysts and actors
What we take to be nature is the result and not the cause of a statement becoming a true fact	*"Working" is the result and not the cause of a machine becoming a successful artifact*	Distinction between the "technical" and the "social" is the result and not the cause of the stabilization of socio-technical ensembles	*"Success" is the result and not the cause of a machine becoming a working artifact*

Source: First three columns adapted from Bijker (1995: 275).

Table 7.2
Four Types of Technological Determinism

Justificatory
• EU Information Society Forum (2000)
Descriptive
• Technology developed independently of social forces (Misa, 1988)
• Technology causes social change (Misa, 1988; Smith & Marx, 1994)
• Technology developed independently of social forces and causing social change (MacKenzie and Wajcman, [1985] 1999)
• Limited autonomy of science and technology in determining economic developments (Freeman, 1987)
Methodological
• "Look to the technologies available to societies, organizations, and so on" (Heilbroner, 1994a or b)
• "Momentum" (Hughes, 1983, 1994)
• "Society is determined by technology in use" (Edgerton, 1999)
Normative
• Decoupling of technology from political accountability (Bimber, 1994)
• Triumph of technological rationality (Winner, 1977, 1986)

TECHNOLOGICAL DETERMINISM IS DEAD, OR IS IT?

Technological determinism persists in the actions taken and justifications given by many actors; it persists in analysts' use of it to make sense of the introduction of technology in a variety of social settings; it persists in manifold theoretical and abstract accounts of the relationship between the technical and the social; it persists in the responses of policy makers and politicians to challenges about the need for or appropriateness of new technologies; and it persists in the reactions we all experience when confronted with new machines and new ways of doing things. (Examples of each of these can be found in the Back to Technological Determinism section.)

Hannah Arendt (1958: 144) wrote, "[t]ools and instruments are so intensely worldly objects that we can classify whole civilizations using them as criteria." Not only can we, but frequently we do; thus, we speak of the "stone," "iron," "steam," and "computer" ages. We also characterize nations by reference to technologies in which they have played a prominent developmental role and/or which are highly symbolic of their culture: Holland and windmills, the United States and cars, Japan and microelectronics. Robert Heilbroner (1994b) and David Edgerton (1999) argue that it is the availability of different machines that defines what it is like to live in a particular place and time. Lewis Mumford (1961) suggests that the tendency to associate whole millennia or entire nations with a single material artifact has arisen because the first academic disciplines to treat technological change seriously were anthropology and archaeology, which often focus on nonliterate societies for which material artifacts are the sole record.

> [T]he stone or pottery artifact came to be treated as self-existent, almost self-explanatory objects . . . These tools, utensils, and weapons even created strange technological homunculi, called 'Beaker Men', 'Double Axe Men', or 'Glazed Pottery Men' . . . The fact that such durable artifacts could be arranged in an orderly progressive series often made it seem that technological change had no other source than the tendency to manipulate the materials, improve the processes, refine the shapes, make the product efficient. Here the absence of documents and the paucity of specimens resulted in a grotesque overemphasis of the material object, as a link in a self-propelling, self-sustaining technological advance, which required no further illumination from the culture as a whole even when the historic record finally became available. (Mumford, 1961: 231)

Those of us concerned with more contemporary societies have no similarly convenient excuse for such reductionist thinking. Yet the linguistic habit persists of naming whole historical epochs and societies by their dominant technological artifacts. This habit can be witnessed frequently in museums, schoolbooks, and newspapers and on television and radio.[3] Even a few years into the twenty-first century, it is still difficult to predict for which of its many new technologies the twentieth century will be remembered by future generations, yet the habit of thought and language of associating places and time periods with their technologies endures, even if causality is not always explicit. This way of thinking about the relationship between technology and society has been "common sense" for so long that it has hardly needed a label. But its critics have termed it "technological determinism," which has two parts. The first part is that technological developments take place outside society, independently of social, economic, and political forces. New or improved products or ways of making things arise from the activities of inventors, engineers, and designers following an internal, technical logic that has nothing to do with social relationships. The more crucial second part is that technological change causes or determines social change. Misa (1988) suggests that what I have presented here as two parts of a single whole are actually two different versions of technological determinism. Defining it as two different versions enables the scourges of technological determinism to cast their condemnatory net more widely by defining people like Winner and Ellul as technological determinists because they point to the inexorable logic of capitalist rationality. This is to confuse their materialism and realism with determinism. If they are to be accused of any sort of determinism, economic determinism is the more appropriate charge. I follow MacKenzie and Wajcman ([1985]1999) in defining technological determinism as having two parts, both of which are necessary,[4] and I will return to this distinction later. Over the past 25 years, STS has focused primarily on demonstrating how limited the first part of technological determinism is, usually by doing empirically rich historical or ethnographic studies demonstrating how deeply social the processes of technological development are.[5]

Technological determinism is imbued with the notion that technological progress equals social progress. This was the view of Lenin (1920) when he claimed that "Communism is Soviet power plus the electrification of the whole country" and it remains the view of politicians of all political persuasions. For example, George W. Bush, a politician very different from Lenin, is committed to missile defense, and as he stated

in his 2006 State of the Union address, he sees technology as the solution to the looming energy crisis in the United States.[6] There is also a strand of very pessimistic technological determinism, associated with the work of Ellul (1980), Marcuse (1964), and the Frankfurt School generally. Historically, technological determinism means that each generation produces a few inventors whose inventions appear to be both the determinants and stepping stones of human development. Unsuccessful inventions are condemned by their failure to the dust heap of history. Successful ones soon prove their value and are more or less rapidly integrated into society, which they proceed to transform. In this way, a technological breakthrough can be claimed to have important social consequences.

The simplicity of this model is, in large part, the reason for its endurance. It is also the model that makes most sense of many people's experience. For most of us, most of the time, the technologies we use every day are of mysterious origin and design. We have no idea whence they came and possibly even less idea how they actually work. We simply adapt ourselves to their requirements and hope that they continue to function in the predictable and expected ways promised by those who sold them to us. It is because technological determinism conforms with a huge majority of people's experiences that it remains the "common sense" explanation.

One of the problems with technological determinism is that it leaves no space for human choice or intervention and, moreover, absolves us from responsibility for the technologies we make and use. If technologies are developed outside of social interests, then workers, citizens, and others have very few options about the use and effects of these technologies. This serves the interests of those responsible for developing new technologies, regardless of whether they are consumer products or power stations. If technology does indeed follow an inexorable path, then technological determinism does allow all of us to deny responsibility for the technological choices we individually and collectively make and to ridicule those people who do challenge the pace and direction of technological change.

This chapter demonstrates that we cannot ignore technological determinism in the hope that it will disappear and that the world will embrace the indeterminancy and complexity of other types of accounts of the technology-society relationship. I argue that we in the STS community cannot simply despair of the endurance of technological determinism and carry on with our more subtle analyses. We must take technological determinism more seriously, disentangle the different types, clarify the purposes for which it is used by social actors in specific circumstances. Moreover, I argue that in order to do this we have to recognize the technological determinists within ourselves.

A BRIEF AND SYMMETRICAL DETOUR

Before returning to the discussion of technological determinism, I want to digress slightly and discuss the principle of symmetry (table 7.1) in order to demonstrate two points. The first is the more conventional application of the principle of symmetry

related to working and success versus nonworking and failure. The second relates to the symmetrical treatment of actors' and analysts' concepts.

First, the principle of symmetry was initially articulated by David Bloor (1973, 1976) in relation to the sociology of science. He argues that knowledge claims that are accepted as true and those that are regarded as false are both amenable to sociological explanation, an explanation that must be given in the same terms. Nature itself must not be used to justify one claim and not another: what we take to be nature is the result of something being accepted as true, not the cause. In the case of technology, the principle of symmetry suggests that successful and failed machines or artifacts need to be explained in the same, social terms. However, unequivocally successful systems do not provide such a rigorous test for Pinch and Bijker's (1984) claim that working is the result and not the cause of a machine becoming a successful artifact. For successful systems, such a claim is tautological. However, there are other, more ambiguous systems,[7] in terms of success and failure, working and nonworking, which are a better illustration of how right Pinch and Bijker are, especially if an iterative loop is added to the statement. In previous work about ICT-network systems in the U.S. and U.K. central government administrations (Wyatt, 1998, 2000), I demonstrated how such systems worked, were not successful, and no longer work. Playing the postmodern trick[8] of reversing the wording of the claim so that it becomes, "success is the result and not the cause of a machine becoming a working artifact" illustrates the significance of Callon's contribution to table 7.1, namely, his exhortation to treat the sociotechnical divide as a consequence of the stabilization of sociotechnical ensembles and not as a prior cause. One of the difficulties with the Pinch and Bijker claim about working being the result rather than the cause of a machine becoming a successful artifact is that they presume the existence of that divide in their association of success with the social world and of working with the technical world, thus presuming a binary divide between the social and the technical, whereas much of STS is concerned with demonstrating how interwoven the social and technical are with one another. Moreover, one cannot privilege the social as they do by placing "success" prior to "working." It has to be possible to reverse the claim as I have done here in order to make visible the mutual constitution of the social and the technical, but that means that successive extensions of the principle of symmetry have led us back to a position of classical realism. This should not come as a surprise. The claims of "success" and "working" have to be interchangeable to enable us to treat the social and the technical symmetrically. Rather than seeing the bottom items in the columns in table 7.1 attributed to Pinch and Bijker and Wyatt as alternatives, they need to be understood as two sides of the same coin. Neither is adequate on its own.

The second point is that actors' and analysts' concepts need to be treated symmetrically, the middle claim by Wyatt in table 7.1. Others (Bijsterveld, 1991; Martin and Scott, 1992; Russell, 1986; Winner, 1993) have pointed to the limits of "following the actors" (Latour, 1987), in particular that by doing so analysts may miss important social groups that are invisible to the actors but nonetheless important. Users are often overlooked by developers (Oudshoorn and Pinch, chapter 22 in this volume). Often

it is possible to define clearly who the users are or will be. But with information networks, for example, there can be at least two sets of users. The first group is those people who are conventionally considered to be the users; employees who use the system to access information in order to perform their job tasks. In many cases, there is also a second group of users: clients or customers whom the more direct users ultimately serve with the help of the system and who have different interests.

To understand the role of users, it is important to distinguish between "real" users in the "real" world and the images of those users and their relationships held by designers, engineers, and other sorts of system builders. It is also important to be aware of "implicated users" (Clarke, 1998), those who are served by the system but who do not have any physical contact with it. Again, distinctions need to be made about their actual social relations and the images held of them. Sometimes both sorts of users are ignored during systems development, in other words, serious attempts are not always made to configure the users (cf. Woolgar, 1991), raising both methodological and normative issues.

There are problems with following the actors. Identifying all the relevant social groups as mentioned above and defining scale[9] and success can become messy or impossible if analysts are over-reliant on actors' accounts. As analysts, we have to rely on ourselves and on the research done by others to help us define our concepts and identify relevant groups. Let us continue to take seriously the principle of symmetry. If, as analysts, we allow our own categories and interpretations into the constructions of our stories, we also need to allow actors' concepts and theories to inform our accounts. Actors and analysts all have access to both the abstract and the material.

Anthony Giddens (1984) has a particular view of the double hermeneutic in social science[10]: Not only do social scientists need to find ways of understanding the world of social actors, they also need to understand the ways in which their theories of the social world are interpreted by those social actors. In other words, the ideas, concepts, theories of both social actors and social scientists need to be given space. "Follow the actors" can be rescued by recourse to the higher principle of symmetry. Actors' and analysts' identification of other actors and their interests should be treated symmetrically. But I certainly do not wish to grant the analyst the status of an omniscient, superior being. In the next and final section, I will return to the persistence of technological determinism and argue that its continued use by actors necessitates that as analysts we take it more seriously than we have done in recent years. Following Giddens (1984) means that actors' theoretical ideas need to be treated symmetrically with our own, even if they are antithetical to our deeply held views.

BACK TO TECHNOLOGICAL DETERMINISM

Within the humanities and social sciences[11] we frequently ignore the equivalent of a thundering herd of elephants when we dismiss the role of technological determinism in shaping the views and actions of actors.[12] Michael L. Smith eloquently expresses a similar view,

> We scholars of technology and culture lament the stubborn tenacity of technological determinism, but we rarely try to identify the needs it identifies and attempts to address. On the face of it, our brief against this variety of superstition resembles the academy's response to creationism: How can something so demonstrably wrong-headed continue to sway adherents? (1994: 38–39)

Smith is correct to point to the importance of understanding the needs and interests served by a continued adherence to technological determinism, and I will return to that below. He is wrong, however, to dismiss technological determinism (and creationism) as wrong-headed superstition or as a form of false consciousness. Recall Bloor's (1973, 1976) original formulation of the principle of symmetry, namely, that both true and false beliefs stand in need of explanation. We need to remain impartial in our attempt to explain the persistence of technological determinism in order to understand why it continues to be regarded as true by so many people. In the previous section, I argued that the categories deployed by both actors and analysts need to be pursued in order to justify paying attention to users who might never be noticed if analysts naïvely follow the actors. Now it is time to follow the actors in their continued commitment to technological determinism.

One of the most misleading and dangerous aspects of technological determinism is its equation of technological change with progress.[13] From the many histories and contemporary case studies of technological change we know how messy and ambiguous the processes of developing technologies can be. But this is not always the perspective of actors. Some actors, some of the time, present projects as simple and straightforward. It is necessary for them to do so in order to make things happen and to justify their actions. Sometimes sociotechnical ensembles work; sometimes they do not. Including stories of systems that do not work or were not used or were not successful provides further armory in the arsenal to be used against technological determinism because such stories challenge the equation of technology with progress, though not, of course, if we have an evolutionary perspective on progress. But we should not be under any illusions that technological determinism will disappear, and we should recognize that it has a useful function for system builders.

In this section, I return to an exploration of the endurance of technological determinism—endurance in the accounts of some analysts, in the actions of system builders, as well as the justifications proffered by policy makers and other social groups. Despite all the detailed empirical work in STS about both historical and contemporary examples of the contingency of technological change and despite the nuanced and sophisticated theoretical alternatives that have been proposed, technological determinism persists. One of the dangers of simply ignoring it in the hope it will disappear is that we do not pay sufficient attention to its subtlety and variety. Sometimes it is a table upon which to thump our realist credentials; occasionally it can be a rapier to pierce the pretensions of pompous pedants. In whatever way it is used, my argument here is that we need to take it more seriously.

One of the few sustained engagements with technological determinism to be published is the collection, *Does Technology Drive History? The Dilemma of Technological Determinism*, edited by Merritt Roe Smith and Leo Marx (1994). All the contributors

are professors of history at U.S. universities, and the concerns they express are largely those of historians of technology, in their relationship with other historians, and of Americans, with their historic paradigmatic equation of technology with progress and their collective but partial loss of faith with that equation. The contributors provide a valuable mapping of the terrain of meanings associated with the concept of technological determinism.

In their introduction, Smith and Marx (1994: ix–xv) suggest that technological determinism can take several forms, along a spectrum between hard and soft poles.

> At the "hard" end of the spectrum, agency (the power to effect change) is imputed to technology itself, or to some of its intrinsic attributes; thus the advance of technology leads to a situation of inescapable necessity . . . To optimists, such a future is the outcome of many free choices and the realization of the dream of progress; to pessimists, it is a product of necessity's iron hand, and it points to a totalitarian nightmare. (Smith & Marx, 1994: xii)

At the pole of "soft" determinism, technology is located, "in a far more various and complex social, economic, political, and cultural matrix." (Smith & Marx, 1994: xiii) In my view, this soft determinism is vague and is not really determinism at all, as it returns us to the stuff of history, albeit a history in which technology is taken seriously.

Robert Heilbroner's famous article, "Do Machines Make History?," originally published in *Technology and Culture* in 1967, is reproduced in the collection, together with his own recent reflections on the question. He is the most avowedly technologically determinist of the contributors, in both an ontological and methodological sense. He suggests that a good place to start in the study of an unfamiliar society is to examine the availability of different machines, since this will define what it is like to live in a particular place and time (1994a: 69–70). He proposes this as a heuristic for investigation, not as a normative prescription. "[T]echnological determinism does not imply that human behaviour must be deprived of its core of consciousness and responsibility" (1994a: 74). David Edgerton makes a similar point when he argues that technological determinism must be seen as the "the thesis that society is determined by technology in use" (1999: 120), which, as he points out, allows inclusion of societies with technology but not necessarily with high rates of technological change.

Bruce Bimber picks up the theme of normative prescription. He distinguishes between three interpretations of technological determinism, what he terms "normative," "nomological," and "unintended consequences" accounts.[14] The first he associates with the work of Winner (1977), Ellul (1980), and Habermas (1971), among others, who suggest that technology can be considered autonomous and determining when the norms by which it is developed have become removed from political and ethical debates. For all the authors Bimber mentions, the decoupling of technology from political accountability is a matter of great concern. Nomological technological determinism is Bimber's very hard version: "in light of the past (and current) state of technological development and the laws of nature, there is only one possible future course of social change" (1994: 83). To make this even harder, Bimber imposes a very

narrow definition of technology: artifacts only. No knowledge of production or use can be incorporated because that would allow social factors to enter this otherwise asocial world. His final category arises from the observation that social actors are unable to anticipate all the effects of technological change. However, since this is true for many other activities and does not arise from some intrinsic property of technology, Bimber dismisses this as a form of technological determinism. Bimber is concerned to rescue Karl Marx from the accusation of technological determinism. This he does by setting up these three accounts, suggesting that the nomological is the only true technological determinism and that Marx does not meet the strict criteria.[15]

Thomas Hughes returns to the spirit of the distinctions made by Smith and Marx between hard and soft determinism, albeit in different terms and with the explicit objective of establishing "technological momentum" as "a concept that can be located somewhere between the poles of technical determinism and social constructivism." For Hughes, "[a] technological system can be both a cause and an effect; it can shape or be shaped by society. As they grow larger and more complex, systems tend to be more shaping of society and less shaped by it" (Hughes, 1994: 112). On a methodological level, he suggests that social constructivist accounts are useful for understanding the emergence and development of technological systems, but momentum is more useful for understanding their subsequent growth and the acquisition of at least the appearance of autonomy.

This discussion leads me to distinguish between four types of technological determinism, which I term justificatory, descriptive, methodological, and normative (table 7.2). Justificatory technological determinism is deployed largely by actors. It is all around us. It is the type of technological determinism used by employers to justify downsizing and reorganization. It is the technological determinism we are all susceptible to when we consider how people's lives have changed in the past 200 years. It is the technological determinism (and frustration) we feel when confronted with an automated call response system. It can be found in policy documents, including the EU Information Society Forum report, which claims, "[t]he tremendous achievement of the ICT sector in the last few years, and particularly of the Internet, have practically cancelled the concept of time and distance . . . The emerging digital economy is radically changing the way we live, work and communicate, and there is no doubt about the benefits that will lead us to a better quality of life" (2000: 3). It is similar to what Paul Edwards has called the "ideology of technological determinism" (1995: 268) when he reflects on "managers' frequent belief that productivity gains and social transformation will be automatic results of computerization." (1995: 268)

Second is the descriptive technological determinism identified by MacKenzie and Wajcman ([1985]1999), Misa (1988), and Smith and Marx (1994: ix–xv). These authors eschew technological determinism as modes of explanation for themselves but certainly recognize it when they see it in others. Having recognized it, they rarely attempt to understand the reasons for it and instead focus on developing richer, more situated explanations of sociotechnical change. They simply reject technological determinism because of its inadequate explanatory power. Christopher Freeman (1987) is more

assertive in his defense of this type of technological determinism, arguing that in some cases at least, technological determinism is quite a good description of the historical record.

Third is the methodological technological determinism of Heilbroner, Edgerton, and Hughes. Heilbroner reminds us to start our analyses of societies, and of smaller scale social organizations, by examining the technologies available to them. Hughes' methodological technological determinism is more analytical. But, like Heilbroner, he too is attempting to develop a tool for helping us understand the place of technology in history. In STS, that is what we are all doing—attempting to understand the role of technology in history and in contemporary social life; actor-network theory, social constructivism, history of technology, and innovation theory all take technology seriously. All of these approaches are regarded as deviant by their parent disciplines because they include technologies in their analyses of the social world. My provocation here is that our guilty secret in STS is that really we are all technological determinists. If we were not, we would have no object of analysis; our *raison d'être* would disappear. Winner hints at this obliquely at the end of the preface of *Autonomous Technology* (1977) when he writes, "there are institutions [machines] one must oppose and struggle to modify even though one also has considerable affection for them" (1977: x).

Finally, there is the normative technological determinism identified by Bimber, by Misa in his second version, and implicit in Hughes' concept of momentum. This is the autonomous technology of Langdon Winner, technology that has grown so big and so complex that it is no longer amenable to social control. It is this version of technological determinism that has resulted in the intra-STS skirmishes, in which Winner (1993) accuses constructivists of abandoning the need to render technology and technological change more accountable, and it is with this accusation in mind that I conclude.

CONCLUSION

Does Technology Drive History? ends with a moving plea from John Staudenmaier to continue to take the history of technology seriously, to treat artifacts, "as crystallized moments of past human vision . . . each one buffeted by the swirl of passion, contention, celebration, grief and violence that makes up the human condition" (1994: 273). Scholars concerned with understanding the relationship between technology and society share that commitment.

In STS we study people and things, and we study images of people and things. We also need to study explanations of people and things. Just as we treat technology seriously, we must treat technological determinism seriously. It is no longer sufficient to dismiss it for its conceptual crudeness, nor is it enough to dismiss it as false consciousness on the part of actors or as a bleak, Nietzschean outlook for the future of humanity. Technological determinism is still here and unlikely to disappear. It remains in the justifications of actors who are keen to promote a particular direction of change,

it remains as a heuristic for organizing accounts of technological change, and it remains as part of a broader public discourse which seeks to render technology opaque and beyond political intervention and control.

What I have done here is to delineate different types of technological determinism, not because I believe it to be an adequate framework for understanding the relationship between the social and technical worlds but because lots of other actors do, and therefore we need to understand its different manifestations and functions. Within STS, we have always treated technology seriously; we have always been concerned with the risks and dangers of autonomous technology. We are not innocent in the ways of methodological and normative technological determinism. But we can no longer afford to be so obtuse in ignoring the justificatory technological determinism of so many actors. Only by taking that type of technological determinism seriously will we be able to deepen our understanding of the dynamics of sociotechnical systems and the rhetorical devices of some decision makers.

The challenges for STS remain: to understand how machines make history in concert with current generations of people; to conceptualize the dialectical relationship between the social shaping of technology and the technical shaping of society; and to treat symmetrically the categories of analysts and those of actors even if the latter includes technological determinism, anathema to so much contemporary scholarship in the humanities and social sciences. These dialectics are unresolvable one way or another, but that is as it should be. What is important is to continue to wrestle with them. We need to take seriously the efforts to stabilize and extend the messy and heterogeneous collections of individuals, groups, artifacts, rules, and knowledges that make up our sociotechnical world. We need to continue to grapple with understanding why sometimes such efforts succeed and sometimes they do not. Only then will people have the tools to participate in creating a more democratic sociotechnical order.

Notes

I am very grateful to the editors and three anonymous reviewers for their thoughtful and provocative comments, which helped improve this chapter considerably. I am also grateful to the editors for their patience in waiting for this chapter. My father died at the end of 2005, when I should have been preparing the final version. As the reader will learn from the first paragraph, my father had an enormous influence on my own views about technology. The most difficult revisions I had to make were to the verb tenses in that paragraph. This chapter is dedicated to the memory of my father, Alan Wyatt.

1. See discussion by Joerges (1999) and Woolgar and Cooper (1999) regarding the mythic status of the Moses/Winner story. For my purposes here, it is precisely the mythic quality of the story that counts.

2. The foundational status of this piece is confirmed by its inclusion in the second edition (MacKenzie & Wajcman, [1985]1999), still in the number one spot.

3. For example, the 2005 BBC Reith lectures were given by Lord Broers, Chairman of the British House of Lords Science and Technology Committee and President of the Royal Academy of Engineers. The title of his first lecture was "Technology will determine the future of the human race." The title for the series of five lectures was "The Triumph of Technology" (see www.bbc.co.uk/radio4/reith2005).

4. Feenberg also identifies two premises on which technological determinism is based, what he calls "unilinear progress" and "determination by the base" (1999: 77). This is much the same as the two parts of MacKenzie and Wajcman, since unilinear progress refers to the internal logic of technological development and determination by the base refers to the ways in which social institutions are required to adapt to the technological "base."

5. Two early examples are Latour and Woolgar (1986) and Traweek (1988). However, the pages of *Social Studies of Science* and of *Science, Technology & Human Values* are filled with such case studies.

6. For the full text of Bush's speech, see http://www.whitehouse.gov/stateoftheunion/2006/index.html.

7. For example, it is often very difficult to evaluate clearly the success and failure of many information technology-based systems in terms of their success and failure, working and nonworking.

8. See Derrida (1976): The signified is always already in the position of the signifier, often paraphrased as X is always already Y.

9. Defining scale is not only an analytical problem facing the researcher (Joerges, 1988), it is also a practical one for the actors. The resolution of this problem is necessary for the researcher to circumscribe the object of study, but it is also a problem experienced by the actors.

10. Within philosophy, the "double hermeneutic" is used more generally to refer to the problem that social scientists have in dealing with the interpretations of social life produced by social actors themselves as well as the interpretations of social life produced by analysts.

11. I exempt historians from this criticism, especially in light of the publication of Smith and Marx (1994) and, more recently, of Oldenziel (1999), in which she carefully traces the shifting meaning of technology and the rise of technocracy in the United States.

12. Equally peculiar is the way in which technology itself is ignored. As Brey (2003) points out in his comprehensive review of literature pertaining to technology and modernity, much of the modernity literature makes, at best, only passing reference to technology. Brey argues that this is not because modernity authors do not recognize the importance of technology but rather because they see it as the means by which regulative frameworks such as capitalism, the nation state, or the family are governed and not as an institution itself. Another reason may be that social science and humanities scholars may not have the tools or the confidence to analyze technology as such, and at most are only able to critique discourses around technology.

13. See Leo Marx (1994) for a detailed historical account of the emergence of technology and its relationship to ideas of progress.

14. These are not dissimilar to Radder's (1992) distinctions between methodological, epistemological, and ontological relativism.

15. I agree with Bimber that Karl Marx was not a technological determinist, but this point has already been more than adequately made by MacKenzie (1984) in his detailed review of this literature.

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