Social Responses to Large Technical Systems

Control or Anticipation

edited by

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PREFACE

This volume stems from the efforts of scholars who seek to understand the social dynamics of large technical systems. The purpose is to develop concepts and empirical knowledge concerning the dynamics of such systems, with particular emphasis on the processes of control and/or management in a variety of national settings, and to improve the basis of public policy so that future developments might be less distressing in consequence and more shaped to the desires of their "host" societies.

One vehicle for this enterprise is a series of international conferences on the Evolution and Dynamics of Large Technical Systems (LTSs). This series was instituted to encourage the coalescence of the multidisciplinary group of scholars who are actively engaging in the empirical study of these phenomena. Their disciplines span history, sociology, political science, and economics studies. They come Australia, France, the Netherlands, Norway, Sweden, the United Kingdom, the United States, and West Germany. And they possess strong backgrounds in the empirical study of specific technical areas and a taste for conceptual and theoretical integration.

The first conference, "The Development of Large Technical Systems—Theoretical Approaches, Empirical Cases, and International Comparison," was sponsored by and held at the Max Planck Institute for Social Research, Cologne, West Germany, in November 1987. Its papers appear in *The Development of Large Technical Systems*, edited by Renate Mayntz and Thomas P. Hughes. The present volume includes revisions of papers presented at the the second conference, "Societal Responses to the Development of Large Technical Systems: Control, Adjustment or Adaptation," held 17–21 October 1989 at the University of California at Berkeley, U.S.A. (The conference agenda and a list of participants appear in the Appendix).

The Berkeley conference was intense, yeasty, often dramatic, and a bit harrowing, with considerable warmth of feeling among the participants—a necessary glue in holding together a group of disparate perspectives. Our welcoming dinner began about twenty minutes after a major earthquake struck nearby. As the dinner progressed on the more or less unaffected university campus, news slowly filtered in about the full effects of the quake. Several of our number were absent. Two were unaccounted for; later, it turned out that they narrowly escaped the collapse of a major freeway as they were returning their auto to the airport. Conferees, staying in a slightly damaged hotel nearby, faced the next day without hot water. Two U.S. participants could not join us the next day due to disrupted air transport.

The earthquake and the startling effectiveness of public agencies' emergency responses and remarkable citizen outpouring of aid gave an extraordinary cast to our discussions. One session the next day was spent comparing videotapes of the media response immediately after the quake with reporting a day later. It was an occasion to reflect on comparative perceptions of events and organizational responses. Overall the discussions were vigorous, lively, and fruitful, especially given the circumstances.

A conference of this scale needs a good deal of support and skillful assistance to facilitate keen interchange. Gratefully, we acknowledge the financial support of the NATO Advanced Research Workshop Program. Craig Sinclair, the program's director, was encouraging from the outset. The NATO program provided the resources for foreign travel. The U.S. Congress Office of Technology Assessment, through the good offices of John Andelin, its assistant director, supported the travel of U.S. participants. The Institute of International Studies, University of California, Berkeley, provided admirable local support. They gave superb assistance in administrative matters, local hospitality, and editorial help in getting the papers in shape for publication. Karin Beros, Katherine Merrill, Nadine Zelinsky, and Stephen Pitcher were particularly effective.

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Berkeley, California
September 1990

nary situation; they exert very strong demands for remarkable performance at a time when there is scant understanding of the conditions relevant to such operations. Yet we are becoming increasingly dependent on systems with just such characteristics.

Large technical systems excite—and confound—all advanced industrial societies. The policy challenges they provide are a regular concern of all nations striving to take on the mantle of advanced industrialism. Yet there is scant systematic knowledge about their patterns of evolution or internal dynamics, and limited systematic knowledge about their effects upon different political systems. Building on earlier primarily historically oriented work,[1] the authors in this volume turned to the problem of controlling, managing, or adjusting large technical systems during the deployment process.

When Societies Respond to the Deployment of Large Technical Systems[2]

When technical systems promise substantial benefits, they frequently are developed to large scale. Some LTSs (e.g., the air transport industry) produce enormous benefits as they approach mid-stages of deployment and continue to do so as they reach full market maturity. A few LTSs develop in the midst of controversy and are still in question as they become mature, e.g., the U.S. nuclear industry. Other LTSs (e.g., the chemical industry) produce substantial benefits in the early and mid-stages of deployment only to become seen as the source of considerable distress as they grow to very large, mature scale and produce substantial environmental and social disruptions.

Nation-states struggle simultaneously to maintain technologically based benefits and to redirect the character of LTSs as they advance toward fully deployed systems in order to mitigate surprising, negative consequences mature technical systems can have. How have the leading institutions of advanced industrial societies responded to the successes, surprises, and negative effects of technical systems as they have flowered and grown toward large scale? These responses vary significantly from one advanced industrial country to another. What explains these differences? Do different technical systems provoke different institutional responses? To what degree have such responses produced the hoped-for results?

Our interest is in the ways societies attempt to manage or shape deployed LTSs; that is, those LTSs that have reached mid or mature stages of deployment and are discovered either to have substantially greater benefits or negative social, economic, or environmental consequences than were expected.[3] Societies often respond to unusual benefits with unrestrained enthusiasm and pell-mell, unregulated deployment to full scale. Negative surprises raise different problems. Responses range from "after the fact" mitigation of environmental damage, to attempts to anticipate and "design out" problems "before the fact." In more detail, societies respond variously by attempting to:

- Prevent any regulation or deregulate a technical area if there had been regulations;
- Provide governmental subsidies and legal protection for the deployment of a particularly attractive technical system, (e.g., military and governmental

Foreword

THE CHALLENGE OF UNDERSTANDING LARGE TECHNICAL SYSTEMS

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The number, scale, complexity, and range of large technical systems (LTSs) has increased steadily over the past hundred years. Their importance for social development and public policy matters is unquestioned. The most significant properties of such systems are their growing scale, increasingly intensive knowledge requirements, tightening patterns of functional interdependence within major productive or service segments, and expanding networks of cooperation and control. Yet these phenomena are not well understood. They confound engineers, social scientists, historians, economists, policy planners, and political leaders. Social and organizational theories falter in the face of complex, interdependent relationships. Nor do historical or economics-based models of technological change give policymakers a firm theoretical basis for their decisions.

Governments make technological policy with little help from historical experience or systematic social or economic theory. Policymakers need to know more about the ways in which complex technologies evolve, and the effectiveness of various policy instruments in shaping that process. The characteristics and behavior of technical systems may differ over time, or display similar patterns over their life histories, such as those of the telephone or electrical power systems, ballistic missiles, air traffic control, and computer systems. Many of the policy effects of technological systems appear well after the first years of deployment. More certain knowledge of both the evolution and dynamics of such systems would make policy more effective and less fraught with surprise. Likewise, legislators should expect to craft different types of regulatory instruments when dealing with technological systems in different stages of innovation and development. Such instruments are strongly shaped by their particular political and institutional histories and appear to vary significantly among advanced and less developed nations.

Conceptual inadequacy and a meager sense of history would be mainly a matter of academic interest and "politics as usual"—if the benefits of such systems were modest, and the consequences of their failures limited. But in a growing number of areas neither of these conditions hold: benefits are not piecemeal, nor breakdowns mainly instructive. Rather, benefits of many large-scale systems are themselves large-scale, dispersed, and often quite generous. And significant failures (or even the prospect of them) evoke widespread concern, sometimes great fear. Indeed, for an increasing number of LTSs, benefits are conditioned on continuously reliable operations, and, in some cases—such as nuclear power—nearly failure-free operations. These requirements pose an extraordi-

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nary situation; they exert very strong demands for remarkable performance at a time when there is scant understanding of the conditions relevant to such operations. Yet we are becoming increasingly dependent on systems with just such characteristics.

Large technical systems excite—and confound—all advanced industrial societies. The policy challenges they provide are a regular concern of all nations striving to take on the mantle of advanced industrialism. Yet there is scant systematic knowledge about their patterns of evolution or internal dynamics, and limited systematic knowledge about their effects upon different political systems. Building on earlier primarily historically oriented work,[1] the authors in this volume turned to the problem of controlling, managing, or adjusting large technical systems during the deployment process.

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- Prevent any regulation or deregulate a technical area if there had been regulations;
- Provide governmental subsidies and legal protection for the deployment of a particularly attractive technical system, (e.g., military and governmental

procurement processes);

- Develop an analytical capacity, (e.g., policy analysis or technology assessment), to forecast or anticipate potential effects of a LTS during and after the deployment process so as to "design away" effects that are not politically desirable;
- Legislate regulations directed toward moderating the behavior of deployers in the early deployment stages (e.g., environmental impact analysis process, and/or demands for failure-free technical and organizational performance), so that the potentials for subsequent undesirable effects is diminished;
- Enforce punitive economic and legal regulations after the damage or surprising consequence of an LTS becomes evident (e.g., liability litigation processes).

These responses lead to particular knowledge requirements and institutional imperatives. They are likely to vary as a function of the properties of the technical system and/or the society within which it is being deployed. Conference papers ventilate the intellectual and policy issues involved in some of these responses. The intent is to develop more systematic understanding of their dynamics and the limits of their effectiveness. Approaches made use of both history and contemporary social science, and the comparison of technologies both within and among a variety of advanced industrial societies. Particular emphases included the problems of system failures and their external effects, the side-effects of full deployment, momentum/autonomy/uncontrolled developments and liability, types of system controls (e.g., bureaucratic and computer-aided controls, interactions with organization cultures, and regulatory legislation.

Finally, there is an emphasis on the need for: 1) increasing precision in specifying the phenomenon—technical systems—in social scientific, as well as engineering, terms; 2) examining models of technological and political change or evolution in order to explicate concepts used in them, including models of how political decisions play a role in the development of technological systems and the uses of case histories to define the models and concepts; 3) explaining similarities and/or differences in the dynamics and social properties of apparently quite different technical systems developed in different political settings during various historical periods; and 4) exploring the reciprocal contributions of history and social science, especially the conceptual and methodological conditions conducive to effective contributions of historians and social scientists to the understanding of technological systems.

NOTES

1. See *The Development of Large Technical Systems*, ed. R. Mayntz and T. P. Hughes (Frankfurt: Campus Verlag, and Boulder: Westview Press, 1988). Cf. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, ed. W. E. Bijker, T.

P. Hughes, and T. Pinch (Cambridge, Mass.: MIT Press, 1987).

2. From the conference call for papers, January 1988.

3. This contrasts to interests in the full train of steps from invention of technical possibilities to the fully matured large scale producing benefits and/or distress. These steps include 1) invention, 2) feasibility, 3) initial start-up, 4) mid-stage deployment, 5) mature technical systems at scale, and 6) possibly the discovery of unanticipated effects.

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