The trouble with technology

David L. Sills

Normal Accidents: Living with High-Risk Technologies. By Charles Perrow.
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KARL POPPER once noted that people can be divided between those who see the world as analogous to clocks, in which cause and effect are always mechanically related, and those who see the world as clouds, each particle acting erratically with only the broad shape of things moving in understandable ways. Appealing as this imagery is, however, it will not do to explain the large-scale accidents that occur in a high-technology society: the nuclear accident at Three Mile Island; the dioxin contamination of Seveso; the crash of a large aircraft; the collision of two ships at sea; the failure of a large dam. These accidents are the products of neither clockwork-like processes nor random events. What they *are* the product of is the theme of this book.

A place to begin is the famous 1966 accident at the Fermi nuclear power plant near Detroit, Michigan — so near, that a popular account of the accident by John Fuller is entitled *We Almost Lost Detroit*. In *Normal Accidents*, Charles Perrow, a professor of sociology at Yale University, gives a technical account of the Fermi accident, an account that points out how instructive the accident was to the designers of nuclear power plants. Perrow remarks that "In our accident is our salvation".

There is a hint of sarcasm in this comment, but there is a larger dose of truth. Accidents have become the X-rays, the litmus paper, the illness, the diagnostic test — whatever metaphor you like — of high-technology systems. Engineers describe how complex machines and machine systems are supposed to work; we find out how they actually work (or fail to work) when there is a serious accident.

It was a major nuclear accident, the one at Three Mile Island in 1979, that turned Perrow's attention to accidents in general. A specialist in the sociology of organizations, he soon learned that events at TMI were not simply the result of an engineering failure or the result of operator error; rather, they were a consequence of systems failure. All of us who pored over the volumes of investigative reports on TMI know how irrelevant it is to blame the accident upon the failure of a relief valve. But what was to blame? In a sense, TMI was a real-life *Rashomon*, each of us seeing in it what our training and predisposition caused us to see. The electrical engineering journal *Spectrum* featured, in its special issue on TMI, a full-page, four-colour diagram of the relief valve; political scientists saw the accident as a regulatory failure; human-factors engineers focused upon the confusion in the control room; lawyers saw liability; and sociologists concluded that it was a social system that had failed.

What Perrow learned from his research into the accident at TMI is that there was no coherent theory of accidents in either the engineering or the social science literature, so he set out to create one. The result is a well-written, wide-ranging book, full of insight, that may mark the beginning of a science of accident research. Since Perrow is an outsider to all of the many technical fields reviewed in the book, ranging from nuclear power to marine transport to DNA research, experts may challenge his sources and point out his errors. But they will read his book and they will learn from it.

Perrow's central thesis is that accidents are inevitable — that is, they are "normal" — in technologies that have two system characteristics that he terms "interactive complexity" and "tight coupling". Using these concepts, Perrow constructs a theory of systems which he believes to be unique in the literature on accidents and the literature on organizations. His theory concentrates upon the properties of systems themselves, rather than on the errors that owners, designers and operators make in running them. He seeks a more basic explanation than operator error; faulty design or equipment; inadequately trained personnel; or the system is too big, underfinanced or mismanaged.

"Linear interactions", according to Perrow, are those interactions of one component in the system with one or more components that precede or follow it in the sequence of production. "Complex interactions" are those in which one component can interact with one or more other components outside the normal production sequence, whether intentional or not; they involve unfamiliar sequences, or unplanned and unexpected sequences, and they are either invisible or not immediately comprehensible.

"Tight coupling" is a term borrowed from mechanical engineering. It means that two elements are joined in a way in which there is no slack or buffer or give between them; what happens in one element directly affects what happens in the other. "Loose coupling" is of course the opposite. These dimensions can be cross-tabulated, giving four cells. A simplified version of Perrow's basic scheme is shown at the foot of the preceding column.

Type of coupling	Type of interaction	
	Linear	*Complex*
Tight	Dams Marine and rail transport (1)	Nuclear power Nuclear weapons accidents DNA research (2)
Loose	(3) Assembly-line production Most manufacturing	(4) Mining

Building upon this scheme, Perrow introduces such concepts as catastrophic potential and the costs of alternatives. This makes it possible for him to draw conclusions and make policy recommendations based upon how a technology scores on all of these ratings.

His basic finding is that nuclear weapons and nuclear power have the worst scores of all; his recommendation is to abandon them. Marine transport and DNA research score in the middle; he recommends that their use should be restricted. Space travel, dams, mining, chemical plants and air travel are left to be tolerated and improved.

I have tried to convey something of the impressive theory that leads to these conclusions, and have hardly noted the wealth of fascinating sociotechnical detail that constitutes the bulk of the book. The chapter on marine transport is particularly well done; it will certainly frighten all weekend sailors who venture out to the edges of a watery chaos where currently more than one large ship a day is lost at sea. "Elites", Perrow notes, "do not sail on Liberian tankers" (p.173).

As a sociologist, I applaud Perrow's ideas of complex interaction and tight coupling; these are new social concepts that are clearly essential for the analysis of technological systems. But in going so far down the policy road as to recommend that nuclear power should be abandoned, doesn't Perrow become a latter-day Luddite, using the tools of science to smash a technology he does not trust?

Nuclear power in the United States may not survive its current economic and regulatory troubles, but discussion continues. Only a small part of the debate concerns plant safety: economic competitiveness, nuclear arms proliferation and nuclear waste disposal are the salient themes. Outside the United States nuclear power is doing rather better, and the *New York Times* reports that General Electric, Westinghouse and Combustion Engineering are currently seeking to sell China some $4 to $5 billion dollars worth of equipment that they cannot sell domestically. There seems to be life in the old dog yet.

The difficulty may be in Perrow's yearning for significance, his dissatisfaction with merely creating a new science of accident research. His book will markedly improve discourse on the nuclear power debate; it should not have attempted to decide it. □

David L. Sills is the Executive Associate of the Social Science Research Council, New York.