High Reliability Organizations: Unlikely, Demanding and At Risk

Todd R. La Porte*

The HRO project is cast within a broader socio-political context, by first, reviewing its practical origins, its conceptual/logical framework, and a summary of the project's provisional findings, including a brief observation about the importance of a 'culture of reliability.' Then some socio/political implications for HROs are explored as they assume the status of large technical systems (LTSs) and become quasi-public institutions. This paper ends with a reflection on the challenges of institutional trustworthiness that confront HRO operators, managers, and overseers.

Introduction

There is a growing literature on crisis management and system safety theory of which this journal is an exemplar. It draws those interested in the technical and organizational phenomena associated with the causes and prevention of operating failures in systems of potentially great negative consequences, as well as benefits, to economic well-being, human health and environmental quality (see also Bignell and Fortune, 1984; Covelo, Menkes and Mumpower, 1986; Morone and Woodhouse, 1986; Rasmussen, Duncan and Leplat, 1987; Shrivastava, 1987; Heimann, 1993; Sagan, 1993; and the *Industrial Crisis Quarterly*).[1] Such interests command attention to organizations whose performance and internal processes have degraded well below expected levels of achievement given the degree of intrinsic hazard associated with system operations — such as Three Mile Island, *Challenger* or Chernobyl.

Much of this emphasis is devoted to showing *post facto* the structural and behavioural causes and precursors of operating failure (Perrow, 1984; Heimann, 1993). They are based, in part, on the tacit assumption that our present understanding of operational dynamics is more or less adequate, though not fully explicated. One needs simply to repair this or that inductively discovered characteristic to return the more or less well-functioning system to the desired level of safety. An alternative view holds that nearly accident-free performance is impossible and flawed operations should be considered normal with reasonable likelihood of occurrence (Perrow, 1984; Sagan, 1993). We are skeptical of either view—their concerns are too narrow (Rochlin, 1993).

Another tack has been taken by the High Reliability Organization (HRO) Project. It was initiated to explore the conditions that are associated with large-scale operating systems *already* performing at an extraordinary level of safety and productive capacity in the face of very demanding circumstances (La Porte, 1987; Roberts, 1989). Our tacit assumption was that such systems' performance is quite unusual, very difficult to sustain and theoretically inexplicable (La Porte and Consolini, 1991). There are neither theoretical nor empirical reasons to expect failure-free operations in large organizations that attempt to perform demanding tasks with little margin for error. Indeed, there are sound reasons to reject this as a possibility. Perrow (1984) argues succinctly that knowledge available to regulators, planners, managers and operators declines compared to knowledge requirements as technical complexity and tight coupling increase, increasing errors — especially in the context of rigid, hierarchically structured organizations. Indeed, Perrow claims that safety measures themselves can become sources of error if they serve to further increase complexity and coupling.

Yet, however intrinsically demanding it may be, an increasing number of organizations are committed to utilizing very powerful, costly technical systems that are inherently dangerous, calling for highly hazardous, low-risk performance as a condition of delivering their benefits.[2] Their operational challenges are twofold: to manage complex, hazardous, demanding technologies while avoiding major failures; and, at the same time, to maintain the capacity for meeting intermittent, somewhat unpredictable, periods of very high peak demand and production (Rochlin, 1993). That is, they are pressed to operate continuously at a level

*Todd R. La Porte, Department of Political Science, University of California at Berkeley, 210 Barrows Hall #1950 Berkeley, California 94720-1950

usually understood to be very much above average, often near peak capacity. This is a situation in which any change in circumstances, internal processes or technical innovation is more likely to degrade than to improve existing operations. These are extraordinary expectations for any social collectivity; the presence of any 'high reliability organizations' (HROs) is both remarkable and unexpected.

When HRO phenomena are present, they are likely to be associated with systems of great benefit that are so hazardous in their design that, depending predominately upon management strategies based on trial and error, they are seen as very costly.[3] Corporate managers, public managers and military commanders alike count on very high levels of operating performance and safety when failures lead to severe loss of capacity to project military power; to limit health hazards on the job and in communities; to maintain public safety via safe navigation through congested air space or immediate responses to threats of fire, floods or contagion; or to avoid severe damage to human environments and ecosystems.

The HRO project then sought to explicate phenomena which are surprising and unexpected — as well as skeptically received as incredible within the scope of current social science understanding of complex organization (Sagan, 1993; 1994; Perrow, 1994) — even though the organizations that provided initial research settings were well established and had records of sustained, high performance (La Porte and Consolini, 1991; Roberts, 1993b). These organizations — namely, US air traffic control systems, a large-scale electric power generation and distribution system and two nuclear power aircraft carriers — should not have existed in their present form given what one could infer from current organization and management theory. Yet, they do exist and they continue to exhibit extraordinary patterns of behaviour and system performance across a wide range of varied and turbulent conditions (La Porte and Consolini, 1991; Roberts, 1990b; 1993b; Schulman, 1993b).

As societies come to depend on systems designed and deployed in ways that risk putting their operators, consumers and citizens in harms way, demands for HRO-like performance are insistent (perhaps increasing) (Perrow, 1984; Sagan, 1993). There is an attendant concern that even the systems upon which we now can depend may not, perhaps cannot, continue to perform as well in the future.

Much of the crisis management literature is marbled by expressions of this anxiety, worrying that the conditions necessary to motivate operators and executives to persist in the difficult tasks that make up the so-called safety culture, will not be sufficient to sustain it (IAEA, 1991). Though equally interested in the factors associated with effective performance, similar concerns also animate the growing literature of probing the characteristics and dynamics of large technical systems (LTS) introduced below (La Porte, 1988; Joerges, 1994).

Understanding the structure, operating dynamics and social and economic costs of sustaining HRO patterns becomes increasingly salient not only for our understanding of a wider range of organizational phenomena, but for improving the bases for the design and expectations of technical systems — perhaps dampening our enthusiasm for systems whose benefits are conditional on highly reliable behaviour (La Porte, 1994a). The HRO project tracks organizational responses in their attempts to overcome the intrinsic limits of complex technical operations and, in the process, radically minimizes the number and severity of failures in the face of them. As such, the project was intended neither as a contribution *per se* to studies of safety or risk management as they are now framed (although we hope it will be), nor is it in the spirit of the 'search for excellence' perspective (Deal and Kennedy, 1982; Peters and Waterman, 1982). In a sense, one can see this work as a complement to the large body of work that demonstrates the intrinsic costs and difficulties of seeking continuously to achieve failure-free performance in large organizations and the theoretical impossibility of assuring it under all conditions (Rochlin, 1993; Demchak, 1996).

Following a brief discussion of central research perspectives and some provisional findings of the HRO work, this paper situates such systems within the broader perspective of large technical systems (LTSs) studies, suggesting that, 'willy nilly', HRO/LTSs take on at least a quasi-public organizational cast. Thus, they become potentially subjected to the rigors of assuring the conditions that foster a sense of public trust and confidence or political legitimacy (La Porte, 1995).

Study perspectives

What patterns of relationships and organizational dynamics characterize HRO performance, especially in demanding environments? Our work was organized around the following questions.[4]

1. HROs' central day-to-day preoccupation is continuously to operate complex, demanding technologies without major failures while maintaining the capacity for meeting intermittent periods of very high, peak

production, for example, peak traffic, power demand loads or maximum air operations. What patterns of *formal organization structure and rules* have developed in response to these requirements under conditions of constrained resources? Complex technologies tend to increase the interdependencies within and among operating organizations. What are the patterns of *interdependencies* associated with units requiring reliability? What processes have emerged to coordinate and manage them in meeting the demands of reliability and potential peak pressures?

2. Top management seeks to commit the organization to high levels of performance, while senior operating officials are committed to assuring superior reliability (and safety) in the face of often unexpected operating conditions. What *decision-making and communication dynamics* evolve in the processes of day-to-day planning and operation when contingencies are expected but their specifics are unpredictable? How are the operational constraints inevitably imposed by formal structure dealt with, especially when conducting those activities from which unacceptable failures may arise?
3. Formal structure and rules (SOPs), or informal operating rules, rarely provide guides for behaviour sufficient to account for the technical and cooperative skills or motivations necessary for effective organizational performance. These gaps are filled variously in the development of an organization's *culture*, whose substance is likely to be crucial for effective operation of HROs. What group norms are evident within and between units requiring reliability in relations with, and obligations to, group members and to the organization as a whole? How are they created and maintained?

The orienting perspective of the project included these aspects within a framework of familiar functional relationships (see Figure I) and emphasized those elements that are associated with HRO phenomena (in italic print). These elements constitute a complex pattern of factors that, while they are not likely to be sufficient conditions for high reliability operations, are surely necessary.

Provisional findings

What have we come to know more firmly, with more confidence, about HRO phenomena?[5] This summary is arranged in terms of the factors highlighted in Figure 1, moving across the

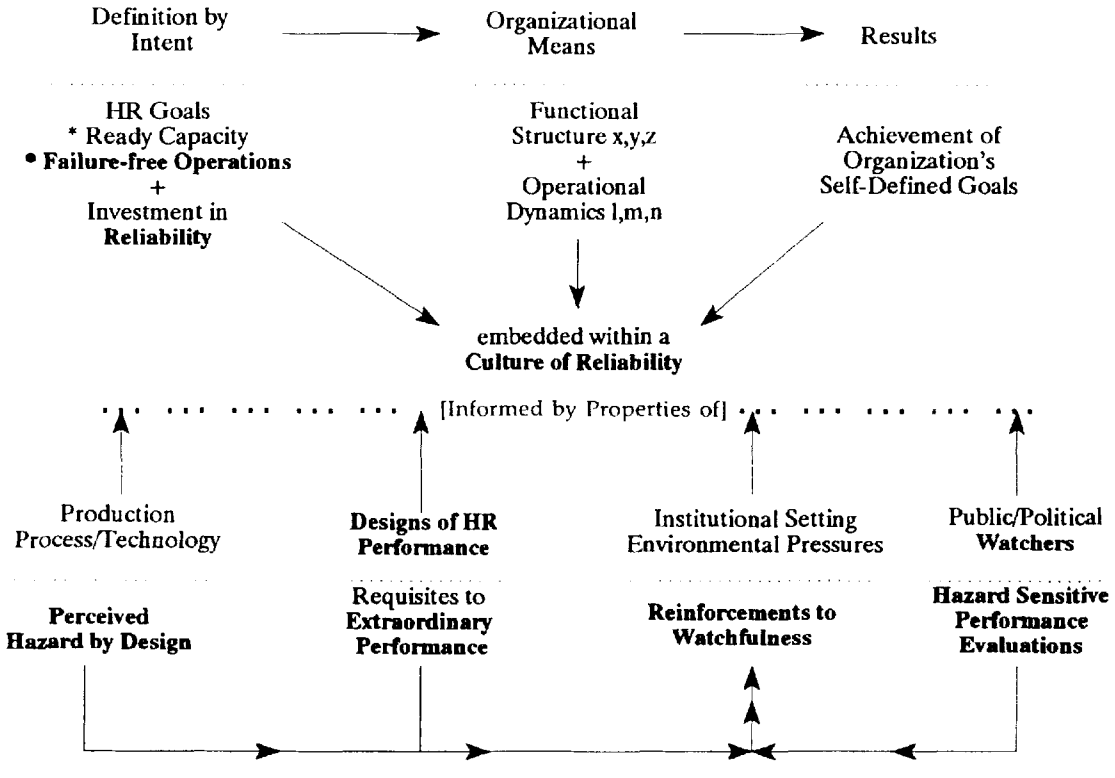

Figure 1: Conceptual logic undergirding HRO studies

schema from left to right, with a distinction between those that are related primarily to internal aspects and those that emphasize external relationships. Due to length constraints, this summary quite cryptically notes some findings that are emphasized for HROs.

Internal processes

Organizationally defined intention

HROs exhibit a strong sense of mission and operational goals stressing not only the objectives of providing ready capacity for production and service but an equal commitment to reliability in operations, and a readiness to assure investment in reliability enhancing technology, processes and personnel resources.

It is notable that for each of the HROs we studied, there is high tacit agreement within the organization and in the society at large regarding the inherent hazard of the technology being operated, the definition and seriousness of error, the value or benefit of whatever economic, social or military outcome is being produced and the cost of failing to provide it. This is an important, perhaps crucial, element of HRO regimes. Until recently, such 'domain consensus' (Thompson, 1967) has provided munificent support for corporate or agency leaders seeking to provide the organizational status and financial and personnel resources required for failure-prevention and quality enhancement.

Reliability enhancing operations

These are related (see Figure 1) to the aspects of structural and operational dynamics that stem from the requisites for extraordinary performance. These properties, to which I now turn, are re-enforced by an organizational culture of reliability, that is, the norms and workways of operations (Ott, 1989; Roberts, 1990a; 1993a).

Perhaps the most dominant quality of HROs' internal operating environments is their palpable technical and social interdependence. This is rooted in the requirement for group differentiation and coordinative hierarchies that characterizes all intensively technological organizations. In HROs, this seems to prompt pervasive patterns of complexly related, tightly-coupled technical and social relationships that shape their social, structural and decisional character (Perrow, 1984; Weick, 1987; Roberts and Gargano, 1989; La Porte and Consolini, 1991; Rochlin, 1993).[6]

HROs' *social character* is typified, not surprisingly, by high technical/professional competence and technical knowledge of the system and demonstrated high performance and awareness of the system's operating state.

1. Extraordinary *technical competence* ultimately shapes authority relations and decision processes among operating personnel who are often consummately skilled at what they do. Continuously attaining this quality entails attention to recruiting, training and staff incentives. It puts a premium on recruiting members with extraordinary skills and/or an organizational capacity to develop them *in situ* via continuous training and an emphasis on reliable knowledge of the fundamentals of the operating system.

   Sustaining very high levels of competence, effectiveness and operator and professional commitment is secured, in part, by a combination of high organizational status and visibility for the activities that enhance reliability, and roles with ready accessibility to senior management. Organizational status is supported by career incentives and the sense of efficacy associated with clear promotional opportunities to senior management positions.
2. HROs achieve rigorously *high operational performance* of the technical systems accompanied by stringent quality assurance (QA) measures in maintenance (Bourrier, 1994; 1996) and procedural acuity (Schulman, 1993a). Extensive performance data bases that track and calibrate technical operations strive to provide an unambiguous description of the systems' operating state. This becomes the information on reliability statistics, quality-control processes and accident-modelling, upon which awareness and interpretations of system readiness from a variety of perspectives are widely available and often nourish competition between groups formally responsible for safety (La Porte and Thomas, 1995).

   HROs' *structural features* are characterized especially by flexibility and redundancy in pursuit of safety and performance and overlapping or nested layers of authority relationships.
3. The HRO operating environment is not only hazardous, it is also often quite contingent. Effective performance calls for considerable flexibility and 'organizational slack' (reserve capacity) to insure safety and protect performance resilience. *Structural flexibility and redundancy* is evident in three ways: First, functional processes are designed so that there are often parallel or overlapping activities that can provide backup in the case of overload or unit breakdown and operational recombination in the face of surprise. Secondly, operators and first-line supervisors are trained for multiple jobs including systematic rotation to assure a wide range of skills and experience

redundancy. Thirdly, jobs and work groups are designed in ways that limit the interdependence of incompatible functions.

4. Predominately hierarchical patterns of authority, typical of large organizations, certainly exist in HROs (although they may be as much adjudicative as directive), most visibly during routine operations. But other, more *collegial*, patterns of authority based on skill and functional authority relationships emerge as the tempo of operations increases, exhibited by the same participants who, during routine times, act out the roles of rank relations and bureaucrats. And 'nested' within, or 'overlaid' upon, these are well practiced, almost scripted, patterns of relationships that are activated during times of acute emergency (Rochlin, La Porte and Roberts, 1987). As these clearly recognized patterns shift, communication patterns and role-relationships are altered to integrate the skills and experience called for by the situation.

   Within the context of HROs' structural properties, their *decision dynamics* are characterized by flexible, dispersed operational decision-making and sustained efforts to improve, including rewards for the discovery of, incipient error.

5. Decision making within shifting authority patterns, especially operating decisions, tend to be decentralized to the level where actions must be taken (Roberts, 1992). Tactical decisions often develop on the basis of intense bargaining and/or collegial interaction among those whose contributions are needed to operate effectively or solve problems (Schulman, 1993a).

6. Once determined, decisions are executed often very quickly with little chance for review, recovery or alteration. HROs therefore put an unusual premium on increasing the likelihood that decisions will be based on the best information available, on the one hand, and, on the other, that internal technical and procedural processes, once put in motion, will not be the source of failure. This lead to more or less formalized efforts, continually to *search for improvement* via systematic gleaning of feedback, and the conduct of program and operational review. These are frequently conducted by internal groups dedicated formally to search out the sources of potential failure as well as improvements or changes in procedures to minimize the likelihood of failure. Such groups are sometimes structured and rewarded in ways that put them in competition with each other to discover potential errors and, due to their attachment to different levels of reporting in the management hierarchy, encourage the quick forwarding of information about potential error to a higher authority (La Porte and Thomas, 1995).

Finally, this kind of activity, due to its intrinsic blame — putting potential, is often sought but rarely conducted with much enthusiasm. In response, HROs exhibit a quite unusual willingness to *reward the discovery and reporting of error*, without at the same time pre-emptorially assigning blame from its commission. This obtains even for the reporting of *one's own error* in operations and procedural adherence. The premise is that it is better and commendable for one to report an error immediately than to ignore or to cover it up.

Organizational culture of reliability

The enactment of both structural support to reliability and the processes that increase it are additional demands in the already intense lives of those who operate and manage large-scale, advanced technical systems. Operating effectiveness calls for a level of personal engagement and attentive behaviour that is unlikely merely on the basis of formal rules and economic contracts. It requires a more fully engaged person responding to norms of individual and group relations that grow out of the particular demands and rewards of the hazardous systems involved. This certainly was evident to the HRO research teams as we came to know the operating groups in each organization (Weick, 1987; Roberts, 1993a). For lack of a better concept to capture these phenomena, we accepted the slippery concept of 'organizational culture' as a rough ordering notion.[7] In our terms, a culture of organizational reliability refers to the norms, shared perceptions, workways and informal traditions that arise within the operating and over-seeing groups closely involved with the systems of hazard (Roberts, 1990b; Rochlin and Von Meier, 1994).

Recall that, for HROs, high levels of production and safety are held as equally important and inexorably related (Rochlin, 1993; Schulman, 1993b). They face the challenge of being highly reliable, both as producers (many under all manner of demanding conditions) and as safety providers (under conditions of high production demands). This suggests an organizational culture integrating the familiar norms of mission accomplishment and production with those of the so-called 'safety culture' (Weick, 1987).

Examples of cultural norms particularly relevant to HRO operations are operator/member elan; operator autonomy; and incipient tensions between skilled operators and technical experts.

- Operating personnel *evince an intense elan* and strongly held expectations for themselves about the value of skilled performance; it seems to be a kind of prideful wariness. There are often intense, peer group pressures to excel as a highly competitive team and to cooperate with and assist each other in the face of high operating demands. This includes expectations of fulfilling responsibilities that often go well beyond formal role specifications. For example, there is a view that 'whoever spots a problem, owns it' until it is mitigated or solved in the interest of full, safe functioning. This *elan* is re-enforced by clearly recognized peer group incentives that signal high status and respect, pride in one's team, emphasis on peer 'retention' and social discipline and reward for contributing to quality enhancing, failure preventing activities (Rochlin and Von Meier, 1994).
- Hazardous operations are often time critical. A keen situational awareness is required for decisive action to be taken quickly with little opportunity for assistance or approval from others. Partly as a result, HRO operators come to develop and insist upon a *high degree of discretion*, autonomy and responsibility for activities 'on their watch' (Roberts, Rousseau, and La Porte, 1994). Often typified as being 'King of my turf', this is seen as highly appropriate by both other operators and supervisors.
- But operator autonomy has a price. The HROs in our initial studies all operated complex technical systems that put a premium on technical engineering knowledge as well as highly skilled operating knowledge and experience. These two types of skills are usually formally distinguished in the occupational roles designations within HROs. Each has a measure of status, each depends on the other for critical information in the face of potential system breakdown and recovery if problems cannot be contained. But operators also have an almost tactile sense of how the technical systems actually function that is likely to be more situationally refined and intuitively more credible that the more abstract, cognitively-based knowledge possessed by engineers. The result is *tension between operators and technical experts* when considerable stress is placed both on formal specifications and on experienced-based tacit knowledge of system operations (Rochlin and Von Meier, 1994; Von Meier, 1995).

These are dominant workways and attitudes about appropriate behaviour at the operating levels of HROs, that is, the work closest to the hazards, so to speak. They give a sense of the strength of the affective nature of HRO operations and provide the basis for the expressive authority and identitive compliance norms that enable the close cooperation necessary when facing the challenges of unexpected high-tempo/high-surge situations with minimum internal harm to people and capital equipment.

External relationships

HRO performance is centrally associated with extraordinarily dense patterns of cooperative behaviour within the organization. These are extensive, as well as quite intensive; they are unusual in terms both of continuous reliability and costs and would be difficult to sustain in the absence of external re-enforcement. Continuous attention to both achieving organizational missions and avoiding serious failures requires sustained interaction with elements in the external environment, not only to insure resources, but, as importantly, to support internal resolve to maintain internal relations outlined above and to sustain HROs' culture of reliability. The external support for achieving the internal conditions of trustworthiness is perhaps the most important of all the properties of HROs the Berkeley group studies; and without them the rest are difficult to achieve and sustain. In terms of the schema in Figure 1, this refers to the externally situated, independent public bodies and stake-holding interest groups.

Aggressive, knowledgeable 'watchers' increase the likelihood that reliability enhancing operations/investments will be seen as legitimate by corporate and regulatory actors, that is, costs should be incurred and social compression allowed in the interest of safety. This may mean investing, on one hand, in developing and training external review groups and some instruments of behavioural surveillance, for example, random drug tests, and, on the other hand, assuring that HRO leaders will be held quickly accountable for changes that could reduce reliability in service or safety.

These watching groups may be either formal or informal and are found both within the HRO's immediate institutional environment and outside it. It is crucial that there be clear institutional interest in highly reliable performance. This can be seen in strong *superordinate institutional elements of the parent organization* such as Corporate or Command level officers (for example, utility corporate headquarters, higher military command, Washington agency headquarters) and sometimes industrial association watchdogs (for example, the nuclear industry's Institute for Nuclear Power Operators (INPO) (Rees, 1994)).

At the same time, the strong presence of *external stake holding groups* assures attentiveness

(and occasional resentment). These range from quite formal public watchers, such as regulatory overseers, for example, the Nuclear Regulatory Commission (NRC) and user and client groups, for example, pilots or government officials, to a wide sweep of 'public intervenors' ranging from state and local governments to independent public or citizen interest groups. Finally, an important function is played by professional peer bodies and other knowledgeable observers such as HRO alumni, who are respected for their experience as well as their knowledge.

Such external watchers re-enforce and support the culture of reliability by creating 'mechanisms' for *boundary spanning processes* through which encouragement and constraint in the interest of product/safety reliability are exercised or expressed. Two types are evident. First, there are often a number of formally designated positions and/or groups (such as various forms of resident inspectors) who have oversight responsibilities. We found a host of these formalized channels. Sometimes this boundary spanning activity is expressed via the requirement for dual reporting, both to the organization and to an oversight or regulatory agency.

Boundary spanning, and with it increased transparency, also occurs intermittently in the form of formal, periodic visits from 'check' or review groups that often exercise powerful sanctions if the reviews do not measure up. These activities come in a number of forms, such as phased inspections and training checks in aircraft carrier combat preparations, or the NRC mandated, biannual, realistic simulation of activation of nuclear power-plant emergency scenarios in collaboration with all the relevant local and state decision-makers under the watchful eye of outside inspectors (La Porte and Thomas, 1995).

Finally, external watchers, however well provided with avenues of effect, must have credible, current information. This can be a very demanding requirement, often including not only full operating logs but also reports of annual evaluations, hazard indices, statistical summaries and other indicators of incipient harm and the early on-set of danger that become a basis for insightful reviews and public credibility (see below).

This compressed review of provisional findings is concluded with an important caveat. The organizations we chose are certainly excellent, indeed extraordinary, in many respects. But it is not warranted simply to apply these findings from three 'top performers' to other organizations that aspire to become HROs. Whilst these conditions may be necessary, they are not sufficient. Indeed, one of our work's most striking lessons is that these conditions are so demanding that they may not be attainable in other areas without great hazard, travail and social costs along the way.

Current conditions and challenges for HROs

While HROs may be interesting in their own right, both in operational and conceptual terms, they are also a special case of what have been termed large technical systems (LTS), which have steadily increased in number and range over the past 100 years (Hughes, 1983; 1987). The most significant properties of LTS, in addition to their undeniable importance as they grow to scale, are increasingly intensive knowledge requirements, tightening patterns of functional interdependence within major productive or service segments and expanding networks of cooperation and control (Joerges, 1988; La Porte, 1991a).

These properties are prompted by some of the characteristics we see in HROs and their supporting networks: the physical, engineering and architectural design requirements of production and distribution; the energy, communication and transport systems that support them; as well as the complex operational, financial and regulatory functions involved in large-scale delivery of benefits. LTS phenomena are not yet well understood, with only limited systematic knowledge about the patterns of evolution or internal dynamics of LTSs and their effects upon different political systems. But what has been developed (see Mayntz and Hughes, 1988; La Porte, 1991b; Summerton, 1994) provides a wider perspective with regard to the operation of HROs that raises other political or social issues, especially when HROs occupy important positions within extensive support and oversight networks.

When technical systems promise substantial benefits, they frequently are developed to large scale. Some produce enormous benefits, for example, air transport or electrical power systems, as they approach mid-stages of deployment and continue to do so as they reach full market maturity. A few develop in the midst of controversy and are still in question as they become mature, for example, the US nuclear industry. Other LTS, for example, 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.

What can be said about LTS thus far derives significantly from their properties as *networked* systems, whose benefits depend, in part, on the qualities of dispersed facilities and connectors that are relatively tightly coupled. Their properties intensify over time — as a function

of the scale and complexity of the system.

Networked large technical systems, and HRO as a crucial sub-set, are likely to be (La Porte, 1988):

- Tightly coupled technically, with complex organizational and management 'imperatives' prompted by operating requirements designed into the system, that is, unless operations are carried out in specific ways, there are no benefits and perhaps great harm can be imagined;
- prone to the operational tendencies or logic of network systems, that is, exhibit a drive to achieve maximum coverage of infrastructure and internal activity or traffic within the network (Thompson, 1967);
- non-substitutable services to the public, with few competing networks delivering the same service (the more effective the system, the more likely its monopoly);
- the objects of public anxiety about the possible wide-spread loss of capacity and interrupted service (the more effective it is, the more likely the anxiety); and
- especially for HROs, the source of alarm about the consequences of serious operating failures to users and outsiders, for example, mid-air collisions, nuclear power station disruptions, and subsequent public expressions of fear and demands for assurances of reliable operations.

In most cases then, LTS provide important, sometimes crucial, services or production for major regions or whole societies. Indeed, this characteristic draws aspiring organizational leaders to them, for this surely is the basis for exercising extraordinary institutional and social power. At the same time, many LTS — as they reach maturity — are discovered either to have substantially greater benefits or negative social, economic or environmental surprises than were expected. Societies often respond to unusual benefits with unrestrained enthusiasm and pell-mell, unregulated deployment to full-scale. Negative surprises raise different problems and elicit varied responses.

LTS, and especially their HRO elements, have been subjected to political efforts at standard-setting and regulation. There have been attempts to shape technology to particular political ends, military capabilities and social values; to control or protect domestic markets; and to mitigate consequences of mature systems. When hazards remain high and benefits crucial and citizens feel increasingly vulnerable, LTS, and HROs especially, come to be subject to political as well as economic and market constraints. This suggests that HRO leadership must be cognizant of the challenges of maintaining both economic and political legitimacy, and the need for heightened executive awareness regarding citizens and the political culture of the society.

HROs, networks and the problem of trustworthiness

When considered from the vantage of outsiders (those citizens and watchers noted above who play a vital role in assuring the persistence of high reliability), HROs are at once a source of benefit and worry. As the benefits become crucial and the potential damage from mis-steps becomes grave, the difficulties of maintaining public trust and confidence grow.[8] The degree of difficulty will, in large part, be a function of the following conditions, many associated with HROs (USDOE, 1993; La Porte and Metlay, 1996):

- Operations are beneficial but hazardous in their design, that is, the work is intrinsically dangerous;
- hazards are evident and likely to extend well after benefits have been gained;
- the benefits of the production system have already accrued to past and present generations with high costs still to be borne by future ones;
- overall success or failure of the operations is hard to determine for several work generations;
- there is reasonably rapid change in the technical aspects of the work, the core technologies, or information about the environment where it is deployed; and
- there is hostility to current or future operations based on learning from past corporate or agency practices.

These conditions, along with the ever present competition for resources generally, combine to re-enforce the sense of public dependence on the skills and integrity of managers and operational leaders. This, in effect, intensifies the public's perceived vulnerability and their hope — perhaps against hope — that organization leaders are worthy of the public's trust and confidence. [9] Along with the other demands of assuring HRO operations, this suggests an additional demanding management challenge. It is exacerbated by HROs/LTS network embeddedness, hazardousness and expected duration. If not taken into account in the operation of HROs, they put their sponsors and operators at risk with regard to their political legitimacy.

Responding to the requisites of institutional trustworthiness

When HROs' managers take seriously the obligations of being worthy of the public trust

— and they surely must — attending to both internal operations and external relations levies a demanding burden. It re-enforces the importance of the quality of technical knowledge, operations and management.

A key premise in the development of trust, enhancing internal operations, is that: 'tasks should be carried out in ways that, as the public become aware of internal processes, they discover activities that increases institutional trustworthiness rather than decreases it' (USDOE, 1993: 55).

The higher the potential hazard associated with HRO operations, the more critical is the organization's proper conduct. Put another way, trust is sustained (or in the more demanding case, recovered) when the more one knows about the agency or firm, the more confident one is that hazardous processes are, and will continue to be, done very well. When this is in fact the case, it reverses the effect most observers expect when they become fully familiar with large institutions, that is, 'the more you know, the worse it gets'.

There are six conditions of trustworthy internal operations which can be used to develop specific measures tailored to the context of particular HROs. These conditions are closely parallel to some of the properties already noted regarding HRO performance. The last four of these are relevant when the challenge is to *recover* public trust and confidence. These are (USDOE, 1993: 56):

- High professional and managerial competence and discipline in meeting technically realistic schedules;
- pursuing technical options whose consequences can be most clearly demonstrated to broad segments of the public;
- processes of self-assessment that re-enforce activities permitting the agency to 'get ahead of problems ... before they are discovered by outsiders';
- tough internal processes of reviewing and discovering actual operating activity that includes stakeholders; and
- clear, institutionalized assignment of responsibility for protecting the internal viability of efforts to sustain public trust and confidence throughout the organization.

This suggests that in effecting conditions that nurture public trust and confidence, HROs develop patterns of internal structure and dynamics with an unusual increment of public 'value added'. And, in a sense, they are involved in efforts to avoid the high *transaction costs of suspicion* (La Porte, 1994b). These emphases on public transparency and rigorously applied processes of discovery, evident in the HROs we studied, are different from the familiar skills of technical development, coordination and execution — all carried out far from public view. They are costly in time and other resources, and call for different managerial skills and attitudes of technical professionals *vis-a-vis* the public.

But attending to internal matters alone is not enough. To carry the effort fully through, either rescuing oneself from the edge of the 'slippery slope' of declining trust, or assuring the maintenance the organization's 'trust quotient', requires attending to *external relations* as well. Many of these are familiar, though they often seem an unnecessary and irksome burden to HRO operators. The central premise that informs the development of external trust evoking measures is:

> When agencies (or firms) manage programs that could be seen as levying more potential harm than benefits upon citizens and communities, agency (or industry) leaders must give all groups of citizens and their representatives opportunities for involvement and must demonstrate fairness in negotiating the terms of their immediate relationship' (USDOE, 1993: 50).

Insofar as this is not accomplished, nutrients for suspicion and grounds for distrust remain. To avoid this, HROs and other organizations should meet the following six conditions. Note that only the first one is needed if there has been a history of public trust and confidence in the organization. The other five are necessary for the *recovery* of trust and confidence. They are much more demanding with high transaction costs of reducing/overcoming suspicion. The six conditions are:

- Early and continuous involvement of stakeholders advisory groups, characterized by frequent contact, complete candor and rapid, full response to questions.
- Timely carrying out of agreements unless modified through an open process established in advance.
- Consistent and respectful reaching out to state and community leaders and the general public to inform, consult and collaborate with them about technical and operational aspects of agency (or firm) activities.
- Active, periodic presence of highly-placed leaders, visible and accessible to citizens at important agency field sites.
- Unmistakable agency (or firm) and program presence in the locality that contributes to community affairs and pays through appropriate mechanisms its fair share of the tax burden.
- Assuring the availability of negotiated benefits to the community along with the resources to the affected host communities

that might be needed to detect and respond to unexpected costs.

Concluding comments

One of the curious things about HRO operations in our society is that when either the consensus about their value declines or economic resources in general become more dear, reliability regimes are more difficult to sustain, especially after *conspicuous success* and/or as system *resources become relatively more scarce*. Supporting bodies, such as the corporate headquarters, budget offices and legislatures, usually do not understand the costs of reliability and safety. The better an HRO is in achieving safe, productive performance, the more difficult public resource overseers are to convince that resources applied to reliability enhancing activities should remain stable.

The HROs studied in the Berkeley Project have all operated in a climate of legitimacy, although the nuclear utility's 'margin of trust' was slim (Rees, 1994). Each HRO had also gone to considerable effort to develop the internal properties that nurture an expectation of trustworthiness. But now each faces increasingly stringent financial limitations. It remains to be seen if they will be able to continue the investment in the processes and personnel to avoid increasing their risk of losing political legitimacy. This will depend in part on the effectiveness of external watchers in their role, not only in scrutinizing HRO operations, but in taking up the role of interpreting HRO needs to society's corporate and political leaders.

Notes

1. There is less attention to failures that result merely in loss of profit, disappointment in attaining public objectives or the displacement of highly placed corporate leaders, unless of course bankruptcy follows.
2. The terms 'hazard' and 'risk', often used interchangeably, must be carefully distinguished. Hazard is the intrinsic capacity for harm, risk the probability of its occurrence. HROs (intrinsically high-hazard, managed low risk) must be distinguished from systems with low hazard as well as from those where risk is high.
3. See especially Rochlin (1993) for an extended discussion of the definitional challenges involved in the HRO project.
4. Three of the four research questions that informed our work are discussed here. The fourth, on the effects of new, often computer-based, technologies is discussed in more detail by Demchak (1996) and Rochlin (1996).
5. Caution should be taken in drawing generalized inferences from this discussion. These 'findings' are based mainly on three types of organizations, each with a limited number of cases, with bits from others (Roberts, 1993b). Though they operate in quite different institutional *milieux*, we cannot say they represent a systematic sample. No one now knows what the population of HROs might be.
6. While it is rarely done, it is useful to make a distinction between physical, functional, tight-coupling, that is, the degree to which the system is technically 'hard-wired' and the degree to which its working groups are tightly coupled in coordinative relationships. Both technical and social coupling can be structured in a vertical, hierarchical fashion and/or in horizontal tightly-coupled ways (See Figure 2).
7. The concept of organizational culture is attractive, for it captures the sense that there are norms,

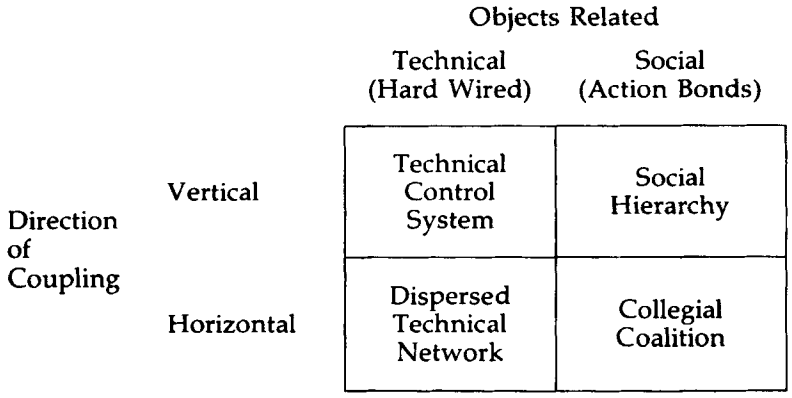

Figure 2: Dimensions of tightly-coupled units

values and 'taken for granted' modes of behaviour and perceptions that shape interpersonal and group relations. At the same time, the concept retains a reasonably high degree of operational ambiguity, its use subject to stiff criticism (Ott, 1989; Roberts, 1993b; Rochlin, 1996).

8. This challenge will differ depending on whether the stage of the organization's development and history presents it with the requirement of achieving the properties resulting in HRO performance for the first time; the happy condition of continuing to warrant substantial public trust in the face of changing conditions; or, in the bedeviling situation in which there is a steep deficit of trust, recovering trust (USDOE, 1993).
9. There have been few attempts systematically to explicate concepts of 'public trust and confidence' (Thomas, 1993). The following definitions are the conceptual touchstones for my treatment (see USDOE, 1993; La Porte, 1994a).

   1. Trust is the belief that those with whom one interacts will take your interests into account, even in situations where you are not in a position to recognize, evaluate and/or thwart a potentially negative course of action by those trusted.

   2. Confidence exits when the party trusted is seen to be able to empathize with (know of) your interests, is competent to act on that knowledge, and will go to considerable lengths to keep her/his word.

   3. Trustworthiness is a combination of trust and confidence. 'Trust and confidence' in this sense, is more akin to professional or 'institutional' trust and confidence.

References

Bignell, V. and Fortune, J. (1984), *Understanding Systems Failures*, Manchester University Press, Dover.

Bourrier, M. (1994), 'Compliance as a Strategy', Institute of Governmental Studies Working Paper Number 94–11, University of California, Berkeley.

Bourrier, M. (1996), 'Organizing Maintenance Work At Two American Nuclear Power Plants', *Journal of Contingencies and Crisis Management*, Volume 4, Number 2, June, pp. 104–112

Covelo, V., Menkes J. and Mumpower, J. (Eds),(1986), *Risk Evaluation and Management*, Plenum Press, New York.

Deal, T.E. and Kennedy, A.A. (1982), *Corporate Culture: The Rites and Rituals of Corporate Life*, Addision-Wesley, Reading.

Demchak, C.C. (1996), 'Tailored Precision Armies in Fully Networked Battlespace: High Reliability Organizational Dilemmas in the "Information Age"', *Journal of Contingencies and Crisis Management*, Volume 4, Number 2, June, pp. 93–103

Heimann, C.F.L. (1993), 'Understanding the Challenger Disaster: Organizational Structure and the Design of Reliable Systems', *American Political Science Review*, Volume 87, Number 2, June, pp. 421–438.

Hughes, T. P. (1983), *Networks of Power: Electrification in Western Society, 1880–1930*, Johns Hopkins University Press, Baltimore.

Hughes, T. P. (1987), 'The Evolution of Large Technical Systems', in Bijker, W., Hughes, T. H. and Pinch, T. (Eds), *The Social Construction of Technical Systems: New Directions in the History and Sociology of Technology*, MIT Press, Cambridge, pp.1–82.

International Atomic Energy Agency (IAEA) (1991), *Safety Culture: A Report by the International Nuclear Safety Advisory Group*, IAEA Number 75-INSAG-4, Vienna.

Joerges, B. (1988), 'Large Technical Systems: Concepts and Issues', in Mayntz, R.M. and Hughes, T.P. (Eds), *The Development of Large Technical Systems*, Westview Press, Boulder, pp. 9–36.

Joerges, B. (1994), 'On the Large Technical System Discourse in the History and Sociology of Technology', (translated from) Derlien, H., Gerhardt, U. and Scharpf, F. (Eds), *Systemrationalitat und Partialinteresse (Systems Rationality and Partial Interests)*, Festschrift für Renate Mayntz, Nomos Verlagsgesellschaft, Baden-Baden, pp. 453–490.

La Porte, T.R. (1987), 'High Reliability Organizations: The Research Challenge', HRO Project Paper, Institute of Governmental Studies, University of California, Berkeley.

La Porte, T.R. (1988), 'The United States Air Traffic System: Increasing Reliability in the Midst of Rapid Growth', in Mayntz, R.M and Hughes, T.P. (Eds), *The Development of Large Scale Technical Systems*, Westview Press, Boulder, pp. 215–244.

La Porte, T.R. (1991a), 'The Challenge of Understanding Large Technical Systems', in La Porte, T.R. (Ed.), *Social Responses to Large Technical Systems*, Kluwer, Dordrecht, pp. 1–4.

La Porte, T.R. (Ed.) (1991b), *Social Responses to Large Technical Systems*, Kluwer, Dordrecht.

La Porte, T.R. (1994a), 'A Strawman Speaks Up: Comments on Limits of Safety', *Journal of Contingencies and Crisis Management*, Volume 2, Number 4, December, pp. 207–211.

La Porte, T.R. (1994b), 'Large Technical Systems, Institutional Surprise and Challenges to Political Legitimacy', in Derlien, H., Gerhardt, U. and Scharpf, F. (Eds), *Systemrationalitat und Partialinteresse (Systems Rationality and Partial Interests)*, Festschrift für Renate Mayntz, Nomos Verlagsgesellschaft, Baden-Baden, pp. 433–452. (Slightly revised version published in *Technology in Society*, Volume 16, Number 3, December, pp. 269–288).

La Porte, T.R. (1995), 'Technologies as Systems and Networks: Issues of Dependence, Public Confidence and Constancy', *Flux: International Scientific Quarterly of Networks and Territory*, Number 21, July-September, pp. 37–46.

La Porte, T. R. and Consolini, P.M. (1991), 'Working in Practice But Not in Theory: Theoretical Challenges of High Reliability Organizations', *Journal of Public Administration Research and Theory*, Volume 1, Number 1, Winter, pp. 19–47.

La Porte, T.R. and Metlay, D. (1996), 'Facing a Deficit of Trust: Hazards and Institutional

Trustworthiness' (Revision of a paper presented at the Conference on Resource, Risk and Responsibility, Colorado School of Mines, Sonoma Mission Inn, Sonoma, 4 December 1994 and the Conference on Trust, Institute of Cognitive and Decision Sciences, University of Oregon, Eugene, 5 November 1994).

La Porte, T.R. and Thomas, C.W. (1995), 'Regulatory Compliance and the Ethos of Quality Enhancement: Surprises in Nuclear Plant Operations', *Journal of Public Administration Research and Theory*, Volume 5, Number 1, Winter, pp. 109–138.

Mayntz, R. and Hughes, T.P. (1988), (Eds), *The Development of Large Technical Systems*, Westview Press, Boulder.

Morone, J.G. and Woodhouse, E.J. (1986), *Averting Catastrophe: Strategies for Regulating Risky Technologies*, University of California Press, Berkeley.

Ott, J.S. (1989), *The Organizational Culture Perspective*, Brooks-Cole, Pacific Grove.

Perrow, C. (1984), *Normal Accidents: Living with High Risk Technologies*, Basic Books, New York.

Perrow, C. (1994), 'A Review of Sagan's Limits of Safety,' *Journal of Contingencies and Crisis Management*, Volume 2, Number 4, December, pp. 212–220.

Peters, T.J. and Waterman, R.H. (1982), *In Search of Excellence: Lessons from America's Best-Run Companies*, Harper and Row, New York.

Rasmussen, L., Duncan, K. and Leplat, J. (1987), (Eds), *New Technology and Human Error*, John Wiley and Sons, New York.

Rees, J. (1994), *Hostages to Each Other: The Transformation of Nuclear Safety Since Three Mile Island*, University of Chicago Press, Chicago.

Roberts, K.H. (1989), 'New Challenges to Organizational Research: High Reliability Organizations', *Industrial Crisis Quarterly*, Volume 3, Number 2, pp. 111–125.

Roberts, K.H. (1990a), 'Managing Hazardous Organizations', *California Management Review*, Volume 32, Number 2, Summer, pp. 101–113.

Roberts, K.H. (1990b), 'Some Characteristics of High Reliability Organizations,' *Organization Science*, Volume 1, Number 2, pp. 160–177.

Roberts, K.H. (1992), 'Structuring to Facilitate Migrating Decisions in Reliability Enhancing Organizations', in Gomez-Mejia, L. and Lawless, M.W. (Eds), *Advances in Global High Technology Management: Top Management and Effective Leadership in High Technology Firms*, JAI Press, Greenwich, pp. 171–192.

Roberts, K.H. (1993a), 'Some Aspects of Organizational Cultures and Strategies to Manage Them in Reliability Enhancing Organizations', *Journal of Managerial Issues*, Volume 5, Number 2, pp. 165–181.

Roberts, K.H. (Ed.), (1993b), *New Challenges to Understanding Organizations*, Macmillan, New York.

Roberts, K.H. and Gargano, G. (1989), 'Managing a High Reliability Organization: A Case for Interdependence', in Von Glinow M.A. and Mohrmon, S. (Eds), *Managing Complexity in High Technology Industries: Systems and People*, Oxford University Press, New York, pp. 147–159.

Roberts, K.H., Rousseau, D.M. and La Porte, T.R. (1994), 'The Culture of High Reliability: Quantitative and Qualitative Assessment Aboard Nuclear Powered Aircraft Carriers' *Journal of High Technology Management Research*, Volume 5, Number 1, Spring, pp. 141–161.

Rochlin, G.I. (1993), 'Defining "High Reliability" Organizations in Practice: A Taxonomic Prologue', in Roberts, K.H. (Ed.), *New Challenges to understanding Organizations*, Macmillan, New York, pp. 11–32.

Rochlin, G.I. (1996), *The Computer Trap*, Princeton University Press, Princeton.

Rochlin, G.I., La Porte, T.R. and Roberts, K.H. (1987), 'The Self-Designing High-reliability Organization: Aircraft Carrier Flight Operations at Sea', *Naval War College Review*, Volume 40, Number 4, pp. 76–90.

Rochlin, G.I. and Von Meier, A. (1994), ' Nuclear Power Operations: A Cross-Cultural Perspective', *Annual Review of Energy and the Environment*, Volume 19, pp. 153–187.

Sagan, S. D. (1993), *Limits of Safety: Organizations, Accidents and Nuclear Weapons*, Princeton University Press, Princeton.

Sagan, S.D. (1994), 'Toward a Political Theory of Organizational Safety', *Journal of Contengencies and Crisis Management*, Volume 2, Number 4, December, pp. 228–240.

Schulman, P.R. (1993a), 'Negotiated Order of Organizational Reliability', *Administration and Society*, Volume 25, Number 3, November, pp. 356–372.

Schulman, P.R. (1993b), 'The Analysis of High Reliability Organizations: A Comparative Framework', in Roberts, K.H. (Ed.), *New Challenges to Organization Research: High Reliability Organizations*, Macmillan, New York, pp. 33–53.

Shrivastava, P. (1987), *Bhopal: Anatomy of a Crisis*, Ballinger, Cambridge.

Summerton, J. (1994), 'The Systems Approach to Technological Change', in Summerton, J. (Ed.), *Changing Large Technical Systems*, Westview Press, Boulder/Oxford, pp. 1–21.

Thomas, C. (1993), 'Public Trust in Organizations and Institutions: A Sociological Perspective', *Earning Public Trust and Confidence: Requisites for Managing Radioactive Waste*, Task Force on Radioactive Waste Management, Secretary of Energy Advisory Board, Washington, Volume 2.

Thompson, J.D. (1967), *Organizations in Action: Social Science Bases of Administrative Theory*, McGraw-Hill, New York.

US Department of Energy (DoE) (1993), *Earning Public Trust and Confidence: Requisites for Management Radioactive Waste* (Report of the Task Force on Radioactive Waste), Secretary of the Energy Advisory Board, Washington, November.

Von Meier, A. (1995), *Cultural Factors in Technology Adoption: A Case Study of Electric Utilities and Distribution Automation*, Unpublished Dissertation, University of California, Berkeley.

Weick, K.E. (1987), 'Organizational Culture as a Source of High Reliability', *California Management Review*, Volume 29, Number 2, pp.112–127.