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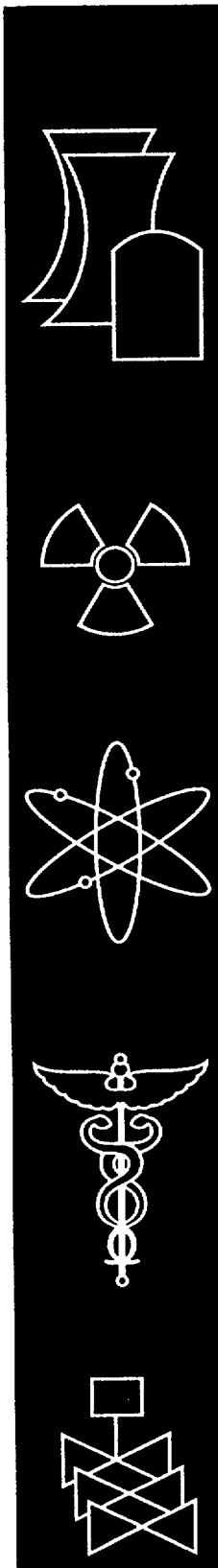

Effects of Deregulation on Safety: Implications Drawn From the Aviation, Rail, and United Kingdom Nuclear Power Industries

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NUREG/CR-6735

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Manuscript Completed: June 2001
Date Published: August 2001

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NRC Job Code K6892

Abstract

Changes associated with economic deregulation of the U.S. electricity supply industry are causing major restructuring, with the potential to affect nuclear power safety. This study was undertaken to identify possible consequences of deregulation for nuclear power safety. A historical case study approach was adopted (using literature reviews and interviews), focusing on the U.S. aviation and rail industries and the United Kingdom nuclear power industry because of their relevance to the U.S. nuclear power industry. Overall, the experience of the case study industries suggests that economic deregulation need not be incompatible with a reasonable safety record, especially in areas where safety is positively related to productivity. However, safety clearly cannot be taken for granted after deregulation, since adverse effects on safety were observed in each of the three case study industries. Among the most notable of those involved financial pressures, safety culture problems associated with mergers and acquisitions, increased use of contractors, and downsizing. The magnitude and speed of such changes can create major challenges to the management of safety. Careful review and study of the problems observed in the case studies may make it possible to identify proactive ways of minimizing similar safety problems in the U.S. nuclear power industry.

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Executive Summary

Changes associated with economic deregulation of the U.S. electricity supply industry are causing major industry restructuring. In particular, the industry is in a state of flux, and the degree of deregulation proposed differs from state to state. The objective of this project was to provide a comprehensive list of those consequences of U.S. electricity deregulation with the potential to affect the risk of nuclear power plants. A historical case study approach was adopted, focusing on the U.S. aviation and rail industries and the United Kingdom (U.K.) electricity industry, because of their relevance to the U.S. nuclear power industry. It is important to note that *safety was not deregulated in any of the three case study industries, nor is the safety of the U.S. nuclear power industry being deregulated.*

The project team collected evidence regarding the effects of deregulation in the case study industries using literature reviews and interviews. We then assessed the relevance of those effects to the U.S. commercial nuclear power industry.

Major Findings of the Case Studies

Adjusting to deregulation is a lengthy process. All three case study industries are still undergoing changes in response to deregulation, even though the air and rail industries were deregulated more than 20 years ago. Thus, the U.S. electric power industry is also likely to undergo a lengthy adaptation.

Overall safety performance

Both the air and rail industries in the U.S. had generally better safety records after deregulation than before. Similarly, the advent of competition in the U.K. prompted nuclear plant managers to focus more intently on regulatory compliance and hardware reliability issues. Thus, deregulation is not incompatible with maintaining safety, especially in areas that are positively correlated with revenue generation. However, the magnitude and speed of the changes associated with deregulation posed substantial challenges to the management of safety in all three case studies. The remainder of this section emphasizes those safety problems that occurred in more than one case study, and could occur in the U.S. nuclear power industry.

Re-prioritization of corporate expenditures

Companies in all three case studies undertook major re-prioritizations of their expenditures. For example, one study of aviation maintenance found that airlines increased the amount of time between engine overhauls after deregulation, but did not experience a higher rate of engine failures. In the rail industry, annual capital expenditures on track maintenance increased by a factor of five, while employment was cut in half. Despite the dramatic labor downsizing, there were improvements in many aspects of rail safety, especially those associated with track condition. The nuclear power sector of the U.K. electricity supply industry also experienced dramatic downsizing after

deregulation, coupled with increased use of contractors. Problems identified in the aftermath of these changes triggered safety regulators to impose a new license condition on reactors in the U.K.

U.S. nuclear power plant owners are already re-prioritizing their expenditures. For example, downsizing has begun, and can be expected to continue. Such changes are not necessarily always adverse to safety, but safety problems could result if organizations make excessive cuts in areas related to safety.

Influences on corporate safety culture

Deregulation was found to create significant challenges to corporate safety culture in our case studies. In the aviation and rail industries, corporate culture problems affected safety after mergers and acquisitions, and at new entrant airlines established after deregulation. There are also concerns about under-reporting of safety problems in the railroad industry since deregulation. In the U.K. nuclear power industry, corporate culture concerns dealt with use of contractors and loss of institutional memory. As a result of such challenges, safety regulators in the U.S. rail and U.K. nuclear power industries have begun requiring prior review of major organizational changes that can affect safety.

The trend toward mergers and acquisitions in the U.S. nuclear power industry seems unequivocal. While not all mergers and acquisitions in other deregulated industries have resulted in safety problems, such problems can be dramatic, and seem to be exacerbated by inadequate planning. Consideration of the potential safety consequences of major organizational changes therefore appears to be critical for nuclear power safety after deregulation.

Association between financial pressures and safety problems

Another key concern is the association between financial difficulties and safety problems in the rail and aviation industries. While the studies to date have not yet clarified the mechanisms underlying that link, the link between poor profitability and safety problems appears strongest for small and unprofitable companies.

Even if the most competitive U.S. nuclear power plants are financially healthy after deregulation, some plants may experience financial difficulties. Companies having financial difficulties may have increased incentives to cut corners. Therefore, financial difficulty may be an indicator of declining safety margins in the nuclear power industry.

Potential safety impacts of downsizing

Significant concerns were raised regarding downsizing and fatigue in the rail and U.K. nuclear power industries. Federal investigations of major railroad accidents in recent years have identified inadequate staffing levels and fatigue as contributing factors. In the U.K., safety regulators raised concerns that excessive downsizing has led to loss of institutional memory and excessive reliance

on contractors. Safety regulators in both industries also raised concerns about increased use of overtime. These issues are likely to be related to the increased cost-cutting pressures associated with competition.

Experiences of safety regulators

The Federal Aviation Administration experienced staff and budget cuts around the time of aviation deregulation, and later found that its staffing levels were insufficient to meet the additional demands that arose from economic deregulation. By contrast, the U.K. Nuclear Installations Inspectorate anticipated that regulatory workloads would increase somewhat with electricity privatization there, and staffed up modestly in preparation for the changes. To the extent that deregulation increases the workload of nuclear safety regulators in the U.S., regulatory staffing levels and other resources may need to be adjusted.

In addition, due to the organizational changes associated with deregulation, safety regulators in both the rail industry and the U.K. electricity industry found it advisable to begin requiring prior regulatory approval of significant corporate changes with the potential to adversely affect safety, such as downsizing or major mergers and acquisitions. The approach has generally not been prescriptive (i.e., requiring a particular approach to safety management), but rather requires that regulated parties demonstrate an adequate plan for maintaining safety.

Conditions Favorable to Safety

In all three case studies, circumstances favorable to safety may have counteracted safety problems due to deregulation. Therefore, even though statistics show that safety improved following deregulation in the aviation and rail industries, it would be a mistake to conclude that similar improvements will necessarily be observed in the U.S. nuclear industry.

In the aviation industry, the decades-long trend toward safety and technology improvements may have masked adverse safety consequences of deregulation. While deregulation may have accelerated the trend towards technology improvement in the aviation industry, many of the observed changes might have occurred even without deregulation.

In the rail industry, the improved financial performance of the industry after deregulation was conducive to safety. This improvement was largely due to easing restrictions on abandoning unprofitable routes. Moreover, rail deregulation took place at a time when the Federal Railroad Administration was becoming more active in safety regulation.

In the U.K., the years immediately following nuclear power privatization were accompanied by extensive subsidies that protected the financial health of the industry. Downsizing and other threats to safety might have been more severe in the absence of these subsidies. The proactive role of the U.K. Nuclear Installations Inspectorate in planning for and monitoring the impacts of privatization may also have reduced or mitigated some safety problems.

The extent to which the U.S. nuclear power industry will benefit from similar changes remains to be seen. In the absence of such favorable conditions, deregulation could have more negative impacts on safety in the U.S. nuclear power industry than in the case study industries.

Overall Conclusions

Based on the case studies, this report has identified a number of issues that have potential safety significance for the U.S. nuclear power industry under deregulation. The experience of the case study industries indicates that economic deregulation need not be incompatible with a reasonable safety record, especially in those aspects of safety that are positively related to productivity. However, safety clearly cannot be taken for granted after deregulation, since safety problems were observed in aspects of each of the three case study industries.

The magnitude and speed of the changes associated with deregulation can be expected to create major challenges to the management of safety by the U.S. nuclear power industry and its safety regulators, as in all three case study industries. Careful review and study of those problems may make it possible to identify proactive ways of minimizing similar safety problems in the U.S. nuclear power industry, where their consequences are potentially severe.

Acknowledgments

The authors want to acknowledge the staff of the U.S. Nuclear Regulatory Commission Human Factors Branch (especially Paul Lewis, the project monitor) for their support of this project. The staff provided not only financial support, but also timely assistance in obtaining needed information and thoughtful review of intermediate work products. In addition, several members of the project team voluntarily donated significant amounts of research time to ensure the highest possible quality of the final product. In particular, the case study of the United Kingdom electricity supply industry draws heavily from the masters thesis of James Joosten (Department of Engineering Physics, University of Wisconsin-Madison), titled *The Impacts of Restructuring the Electricity Market on Nuclear Safety: Lessons Learned from the United Kingdom.*

We would also like to acknowledge the contributions of all the interviewees who generously shared their time and expertise with us to help us understand the effects of deregulation and restructuring on their industries. They include: John Baker, Norman Callaghan, Anne Campbell, Michael Harrison, Peter Haslam, John McNamara, and Jeremy Western of British Energy; Alan Bleeze, Michael Jeal, Craig Reiersen, and J. L. Summers of the United Kingdom Health and Safety Executive; Pearl Marshall (a United Kingdom trade press correspondent); and numerous anonymous representatives of trade unions, safety regulators, and the U.S. aviation and rail industries. Finally, the authors acknowledge Lesley Klein for her support in typing and formatting this report.

1. Introduction

1.1 Background

It is reasonable to believe that the effects of economic deregulation of electricity generation will be seen across a broad spectrum of safety-related areas in the U.S. nuclear power industry. The objective of this project was to provide a comprehensive list of those consequences of electricity deregulation in the U.S. with the potential to affect the risk of nuclear power plants. In particular, we were interested in the effects of deregulation on:

1) Equipment failure rates, and the quantity and quality of maintenance (e.g., the level of expenditures on preventive maintenance, the use of risk-informed maintenance practices and philosophies);

2) Equipment aging;

3) Financial pressures;

4) Factors affecting human error rates and experience levels (e.g., downsizing, use of overtime and contractors, institutional memory, morale, and training);

5) Labor relations;

6) Mergers, acquisitions, and other major management changes; and

7) Levels of investment in support functions such as engineering and industry benchmarking.

For example, while deregulation can increase a company's motivation to avoid costly safety problems, it can also result in reduced spending that may increase safety-related equipment failure and human error. Economic deregulation also reduces the ability of licensees to automatically pass along costs to ratepayers for safety-related activities, thereby potentially influencing decisions on plant upgrades and safety improvements. The impacts of economic deregulation on government safety regulation were also reviewed.

Some of the variables of interest (e.g., reorganization of plant responsibilities after a merger or acquisition) may have only temporary effects on safety. Although temporary, such changes could have significant safety implications. Other effects of deregulation on variables relevant to safety (e.g., reduced staffing levels) are likely to be permanent features of a restructured and more competitive power generation industry.

We recognize that changes in the areas listed above will not necessarily cause increases in safety-related equipment failures or human errors if managed effectively. For example, increased use of risk-informed regulation might help nuclear power plants cut costs while maintaining or enhancing safety by focusing expenditures on the most safety-critical systems,

structures, and components. Similarly, consolidation of existing nuclear power plants into the hands of specialized nuclear operating companies could increase the levels of expertise available to deal with difficult issues at each plant. However, as specified in the scope of work for this project, the issues of greatest interest were those with the potential for negative effects on safety.

1.2 Approach

A historical case study approach was adopted, focusing on the effects of economic deregulation in other deregulated and/or restructured industries that are chronologically ahead of the U.S. nuclear power industry with regard to deregulation. Thus, the project team collected and evaluated evidence regarding the effects of deregulation in several case study industries, using both literature reviews and selected interviews with industry representatives. We then assessed the safety implications of those observed effects for the U.S. nuclear power industry.

We believe that adopting this approach makes it possible to move beyond speculation about the *possible* adverse safety consequences of deregulation, to identify situations in which particular adverse safety consequences actually occurred. The results of this study are intended to make it possible to anticipate adverse effects of deregulation on nuclear power safety, if any, and thereby to develop strategies to detect, monitor, and mitigate those effects. However, because of the study's limited scope, further research on the U.S. nuclear power industry may still be needed in order to clarify the relevance of some study findings.

1.3 Choice of Case Study Industries

The primary criteria for selecting case study industries for inclusion in this study were (1) relevance to the U.S. nuclear power industry, and (2) availability of data (including access to suitable interview subjects). Relevance to the U.S. nuclear power industry was judged based on whether the industry in question has direct safety implications (i.e., the importance of safety-related equipment and human performance in that industry), its organizational and technological characteristics, and the nature of the economic deregulation or restructuring in that particular industry. Thus, the telecommunications industry was excluded from consideration as a case study because safety is only a secondary consideration in that industry. The trucking industry was also excluded from consideration, because it is substantially less centralized and technologically sophisticated than the nuclear power industry.

We included one case study focusing on the nuclear power industry outside the U.S. Although several countries with nuclear power plants have recently undergone changes in the economic regulation and/or ownership of those plants, we chose to study the privatization and restructuring of the United Kingdom (U.K.) nuclear energy sector. This is perhaps one of the most relevant analogues to electricity deregulation in the U.S., and is ahead of the deregulation process in the U.S. In addition, the U.K. is culturally similar to the U.S. (Note, however, that the U.K. began its electricity restructuring process from a position of public ownership, while most nuclear generating companies in the U.S. are already privately owned.)

The other two case studies were drawn from the U.S. transportation industry—in particular, the rail and aviation industries. These provide useful analogues to nuclear power in several respects. These industries have historically been subject to regulation of both economics and safety, went through economic deregulation some time ago, and have obvious safety implications. In particular, there are broad similarities between aviation and nuclear power with respect to issues such as operator training and qualifications, licensing, fitness for duty, hours of service, incident reporting, safety reviews, and maintenance. Thus, these modes of transport are relevant to nuclear power. Finally, academic researchers (primarily economists) have extensively studied both aviation and rail deregulation (including the effects of deregulation on safety, especially in the aviation industry). In addition, the availability of safety statistics (e.g., actual accident rates) facilitates statistical investigation of the effects of deregulation on transportation safety. Therefore, these industries also met our criterion regarding the availability of data.

Each case study consisted of a preliminary literature review phase, to collect data on the effects of deregulation in that particular industry, followed by an interview phase. Due to the limited project scope, the literature review phase did not include independent statistical analysis of available data by the project team; rather, we relied on published statistical analyses, as well as other (more qualitative or anecdotal) published accounts. In the interview phase, initial industry contacts were asked to suggest other candidate interviewees, with the goal of identifying a pool of interviewees that together represented the views of labor, corporate management, and safety regulators. Interviewees occasionally also provided data or references to support their assertions. The relative degree of reliance on published literature versus interviews varied between the three case studies, depending on the extent of information available in the published literature. For example, in the aviation industry, several studies had assessed the safety impacts of deregulation in detail, reducing the need for follow-up interviews with corporate managers and other industry representatives.

Interviews were conducted either by telephone or in person. The topic areas covered in the interviews were generally identified as areas that we wanted to explore further based on the literature review—e.g., topics that were not covered in detail in the published literature, or where the available literature revealed substantial differences of opinion. Interviews with corporate managers generally focused on how each company responded to deregulation and/or restructuring (e.g., downsizing, use of contractor personnel, etc.), as well as the programs and strategies used to guard against detrimental effects of those changes. Impacts on safety-related equipment failure and human performance were also investigated, although in some cases companies were reluctant to share such information. In addition to corporate managers, interviews were also conducted with representatives of other organizations in the case study industries. In particular, we attempted to identify interviewees who represented safety-regulatory agencies and labor unions, to gain greater insight into the human performance and safety impacts of deregulation and/or restructuring in each of the case study industries.

The project team tracked ongoing developments in the U.S. nuclear power industry, so that we would understand the developments currently taking place, and be able to draw insights into the impacts of deregulation in the industry. In this process, the project team relied primarily on published sources (e.g., trade periodicals such as *Electric Utility Week*, *The Electricity Journal*,

Public Utilities Fortnightly, and *Inside N.R.C.*; and refereed academic journals such as *The Energy Journal* and *Journal of Economic Perspectives*). The emphasis was on identifying the general approaches to deregulation being adopted in the U.S. nuclear power industry (e.g., will most utilities choose to divest their nuclear plants, retire them, or keep them operating? are plants experiencing extensive downsizing?), as a basis for assessing the relevance of experiences in the case study industries to the U.S. nuclear power industry.

1.4 Outline of This Report

Section 2 presents the results of our literature review addressing the effects of deregulation on safety in the aviation industry, and Section 3 summarizes our interviews with aviation industry representatives. Similarly, Sections 4 and 5 present the results of our literature review and interviews, respectively, addressing the effects of deregulation in the railroad industry. Section 6 presents the results of a literature review on the U.K. electricity supply industry. Section 7 summarizes our interviews on the effects of electricity deregulation and privatization in the U.K., and also discusses the results of several recent safety audits of U.K. nuclear facilities.

Section 8 synthesizes the main conclusions of the three case studies, noting any significant similarities or differences between the various case study industries in their responses to deregulation or restructuring. This section also summarizes actual and anticipated developments in the U.S. nuclear power industry, as a basis for assessing which of the observed impacts of deregulation in the case study industries have the potential to increase the risk of nuclear power plants in the U.S. Finally, Section 9 briefly summarizes our most important findings and conclusions, with an emphasis on those developments that were observed in two or more of the case study industries and have the potential to adversely affect safety. Interested readers are therefore encouraged to read Sections 8 and 9 early, and turn back to Sections 2 through 7 as needed to see the detailed background information on which the observations in Sections 8 and 9 were based.

Throughout most of this report, supplementary material (e.g., additional details on the design of cited studies) is provided in footnotes. However, in Section 2 (the literature review on aviation deregulation), this supplementary material is so extensive that it is instead provided in endnotes at the conclusion of the section.

2. Aviation Deregulation Literature Review

2.1 Introduction

Aviation has many parallels to the nuclear power industry, and as a result there are many potential lessons to be learned from an examination of aviation deregulation. In particular, both industries:

1) Rely on advanced technology.
2) Are heavily regulated.
3) Emphasize public safety from low-probability, high-consequence accidents.
4) Require high levels of personnel qualifications and training.

Therefore, the experiences of the aviation industry and the Federal Aviation Administration (FAA) with economic deregulation are potentially of interest to the nuclear power industry and the U.S. Nuclear Regulatory Commission (NRC).

Aviation deregulation has been extensively studied in the past (see for example Graham and Kaplan, 1982; Bailey et al., 1985; Transportation Research Board, 1991; Morrison and Winston, 1986, 1995). A number of studies have focused specifically on aviation safety after deregulation (e.g., Office of Technology Assessment, 1988; Oster et al., 1992), due to a combination of long-standing public concerns about aviation safety in general and concerns that cost-cutting induced by deregulation would adversely affect safety. Books by O'Malley (1993) and Nance (1986) provide first-hand perspectives based on extensive interviews with airline pilots, mechanics, FAA inspectors, accident investigators, and others. These books were written for the general public rather than a technical audience, and were generally critical of deregulation rather than impartial, but nonetheless serve as a useful supplement to the statistical analyses provided by other sources due to the additional detail that they provide. Finally, a survey of Air Line Pilots Association (ALPA) members provides a systematic (although again not impartial) source of information on pilots' views of safety (Fingerhut, 1986). This makes the aviation industry an especially suitable case study from which to learn about possible impacts of deregulation on safety.

2.2 Regulatory History

Prior to 1978, the U.S. airline industry had been subject to economic regulation by the Civil Aeronautics Board (CAB). Under CAB regulation, entry both into the airline industry as a whole and into specific routes was severely restricted. In particular, Dempsey and Goetz (1992, pg. 173; see also endnote 1 on pg. 176) cite the report of a 1976 Senate subcommittee hearing to the effect that "Between 1950 and 1974, the CAB received 79 applications from firms seeking to obtain operating authority to provide scheduled domestic service. None were granted. Moreover, between 1969 and 1974, the CAB [refused] to grant or even hear any applications to serve new routes." Furthermore, "The CAB had not permitted a single bankruptcy" since its creation in 1938 (Dempsey and Goetz, 1992, pg. 174). For example, the CAB helped to ensure the financial stability of the airline industry by giving financially troubled airlines preference for

the most profitable routes, and by facilitating mergers to provide them with an influx of needed capital. The CAB also regulated rates, based on typical industry costs, an assumed load factor of 55 percent, and a 12 percent assumed rate of return (Dempsey and Goetz, 1992, pg. 174). Note that this is different from the economic regulatory regime in the electricity industry, which typically allowed the recovery of any costs that were prudently incurred and used current (i.e., time-varying) rate of returns.

Following some experiments with partial "de facto" deregulation in the 1970s, the airline industry was economically deregulated with the passage of the Airline Deregulation Act of 1978. (The FAA continued to be responsible for ensuring aviation safety through a system of regulation and inspection, although its mission also included promoting aviation.) Proponents of airline deregulation (most notably CAB chairman Alfred Kahn) predicted that "deregulation would bring lower fares...and great improvements in efficiency," with little or no adverse impact on safety (Alfred Kahn, 1988a, pg. 321); see also Alfred Kahn (1988b) for another retrospective summary of these views. In particular, carriers with more favorable cost structures than assumed in CAB regulation (e.g., load factors higher than 55 percent, or lower operating costs than the industry average) were generally not permitted to reduce rates under CAB regulation, but were expected to do so following deregulation (Dempsey and Goetz, 1992). Opponents of deregulation were concerned about issues such as loss of labor earnings, poor safety records, loss of service to small communities, and general instability in the aviation industry; see for example Brenner (1988a, 1988b).

Deregulation resulted in a number of changes to the nature of the airline industry. In particular:

1) Fares dropped sharply after deregulation (especially for leisure travel), greatly increasing the volume of airline transportation.

2) Airlines increased their reliance on hub-and-spoke operations, allowing them to continue providing service to a fair number of "spoke" cities with relatively low travel densities while abandoning unprofitable non-stop service on routes that they had formerly served.

3) Deregulation encouraged a large number of "new entrants" to the aviation industry (e.g., People Express), and triggered a large number of mergers, acquisitions, and eventually bankruptcies.

Perhaps prolonged by the air traffic control strike in 1981 and the recession of the early 1980s, both of which may have delayed the eventual increase in travel volume, the period of adjustment following deregulation continued for over a decade. For example, shortages of experienced labor did not become severe until the mid-1980s, and bankruptcies (affecting both new and established carriers) continued into the 1990s. Also, the Congressional Research Service (CRS; Fischer, 1986, pg. CRS-5) noted that "the process of industry restructuring brought about by deregulation is far from complete."

In fact, the airline industry may still be evolving in response to deregulation. With most new entrant airlines no longer in existence (Mark Kahn, 1988, pg. 3) and a continuing trend of mergers, acquisitions, and code-sharing arrangements, the airline industry is once again largely consolidated in the hands of a few large carriers. Wald (1999) notes that, "of the 1,000 most popular routes in this country, only about half are served by more than one airline." In recent years, lack of competition has been blamed for a return to high fares (Johnston, 1999), and for declines in the quality of customer service. For example, Wald (1999) quotes Berger (editor of the *Consumer Reports Travel Letter*) as saying, "When there's no competition, there's no incentive for airlines to provide better service." As a result, there has even been discussion periodically of whether the government should re-regulate airline fares (Mark Kahn, 1988; Dempsey and Goetz, 1992; Johnston, 1999; Poole and Butler, 1999).

2.3 General Safety Trends

Accident rates have been steadily declining for many years, and that trend continued after deregulation. Oster et al. (1992) find not only that the overall rate of accidents decreased from the pre-deregulation time period to the immediate post-deregulation period (1979-1985), but that accident rates caused by equipment failure, pilot error, and ground crew error also decreased. It is obviously possible that accident rates might have decreased even more sharply without deregulation, but these results suggest that deregulation of the aviation industry had little adverse effect on either equipment reliability or human performance. Moreover, an analysis by Rose (1989) finds no adverse trend in overall accident rates after deregulation; her regression results actually suggest that "accident levels decline *faster* after deregulation, although this effect is not statistically significant" (pg. 100).[1] This generally positive picture is further supported by the observation that both insurance costs (Morrison and Winston, 1988) and rates of occupational injuries (Viscusi, 1989) declined in the aviation industry following deregulation. In fact, the FAA (1992, pg. 14) concluded that there was "a significant decline in the total accident rates...during the 1975 to 1989 period."[2]

However, a great deal can be learned from closer examination of the situation. For example, there is some evidence that safety problems may have begun to emerge in the later post-deregulation period (i.e., the mid-1980s). The rates of both near midair collisions and "runway incursions" (i.e., "near collisions...on the ground"), which may be leading indicators of accident risk, increased during the mid-1980s, perhaps due to the increased travel volume associated with deregulation and the shortage of air traffic controllers (Oster et al., 1992). (However, the interpretation of data on near collisions is problematic, both because they are only weakly correlated with actual accidents, and because reporting is largely voluntary and hence highly variable over time; see for example Oster et al., 1992.) Detailed examination of post-deregulation experience in the aviation industry also reveals a number of other important caveats regarding the safety of the airline industry, including a difference in the safety records of new entrants versus established airlines, and a difference in the safety records of financially strapped versus financially sound airlines. We discuss these and other issues below; in particular:

1) Equipment failure rates and the quality of maintenance, including their relationship to accident rates.

2) The role of human error in aviation, and its relationship to factors such as pilot and ground crew experience levels.

3) Whether financial pressures are associated with higher accident rates for particular airlines, perhaps due to reduced expenditures on maintenance.

4) Aging of the aircraft fleet.

5) The new entrant airlines' experiences and safety records.

6) Possible safety concerns regarding the effects of mergers and acquisitions.

7) The post-deregulation tendency of airlines to reduce their investment in support functions such as engineering and employee assistance.

8) Changes in labor relations after deregulation.

9) Impacts on the FAA's regulation of aviation safety.

Finally, we summarize the impacts of deregulation on aviation safety, and present a preliminary comparison of the U.S. aviation and nuclear power industries.

2.4 Equipment Failure and Maintenance

Did deregulation result in unacceptable cuts in equipment maintenance? Both mechanics and pilots have expressed concern that it did. For example, O'Malley (1993, pg. 98) cites a first officer at Delta Air Lines as saying:

> Deregulation has certainly changed things and maintenance is one of them. I mean you just have to think of the economics of the whole thing. Everybody's trying to cut corners now, and they're going to cut everywhere in order to compete and stay in business. It's expensive to keep all those spare parts around, and it's expensive to keep these maintenance guys all over the place.

Time pressure also affects the quality of maintenance, especially as airport congestion increases—for example, Wallich (1986a, pg. 72) cites a mechanic at a major airline as saying, "Most mechanics are concerned about safety; most production supervisors are concerned about schedule." The ALPA survey (Fingerhut, 1986) documented pilot concern that deferred maintenance had increased after deregulation, and that some airlines were pressuring pilots to accept airplanes in which some systems were not operational. Winpisinger (1988, pg. 365), then president of the International Association of Machinists and Aerospace Workers, similarly noted that "In 1987, there were 30 percent more aircraft to service... The number of flights during the

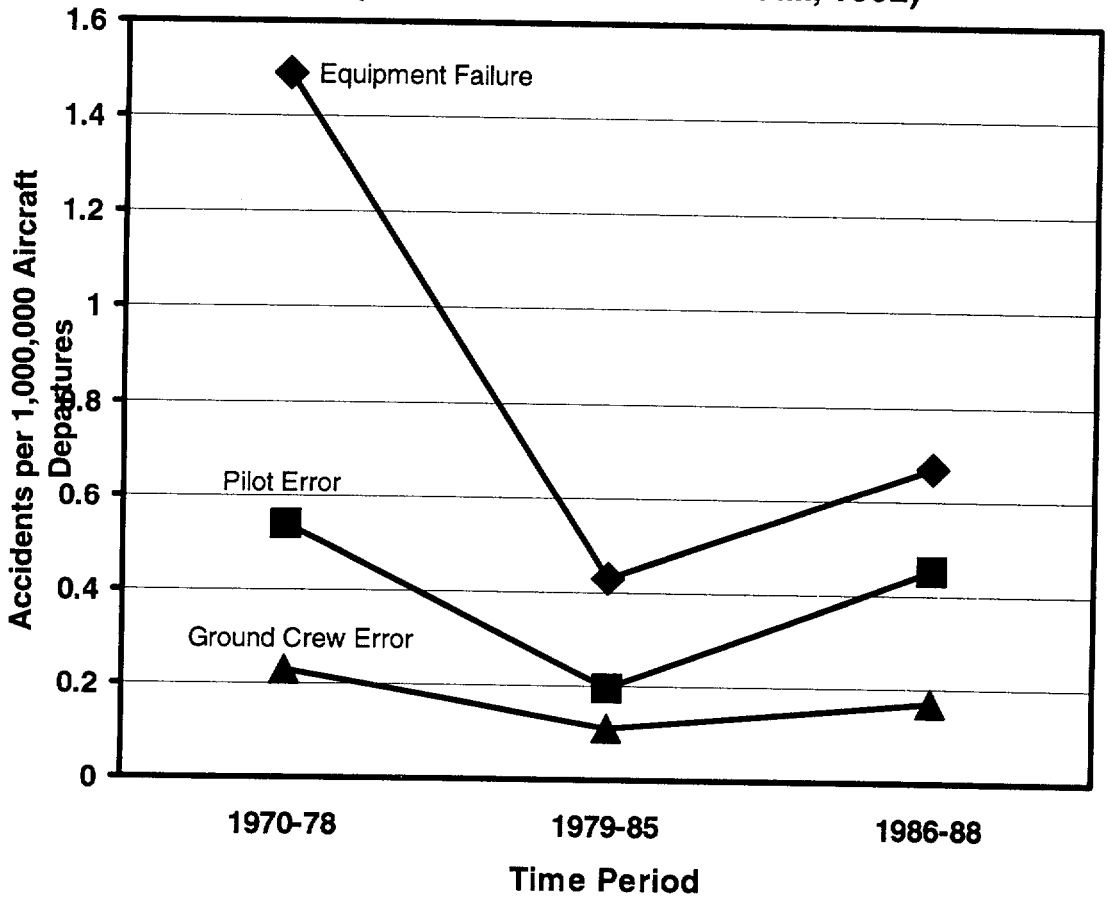
1980-84 heyday of deregulation skyrocketed. Yet money spent by carriers for maintenance in that same period declined from 8.85 percent to 7.6 percent of the carriers' budgets." Voelcker (1986, pg. 79) cites even larger cuts, claiming that "airlines cut the portion of their operating costs devoted to maintenance by 30 percent in the first six years after deregulation."

Perhaps surprisingly, accidents caused by equipment failure actually declined after deregulation (as shown in Figure 2-1). Oster et al. (1992, pg. 30) note that "The rate for equipment failure related accidents in the first six years following deregulation is less than one third of the pre-deregulation rate," although the rate then increased by about 50% in later years. Interestingly, Kennet (1993) finds that airlines did reduce engine maintenance, but did not experience a higher rate of engine failures as a result.[3] "Examination of aircraft engine histories provided by Pratt & Whitney, Inc., indicates a significant increase in the number of engine hours between major overhauls following deregulation... engine 'failures' (as measured by in-flight shutdowns) have not increased as a result of deregulation" (pg. 542). (This analysis controls for "model upgrades in the engines, heterogeneity in airline maintenance practices, unobserved airline heterogeneity, heterogeneity in aircraft types, and the incidence of shutdowns" (pg. 557), but not for engine age. Thus, it is possible that the results could be due to a decrease in the age of engines in service during the period of the study, but this seems unlikely for reasons discussed below, in the section on "Aging Aircraft.") The finding that reduced maintenance did not lead to increased engine failure is also supported by Kanafani et al. (1989), who found that maintenance expenditures were not a strong predictor of the rate of service difficulty reports (SDRs) after controlling for other variables such as aircraft type.[4] These results suggest that airlines may have been doing more maintenance than necessary prior to deregulation, and then optimized their maintenance programs after deregulation—"perhaps by improving the quality of service performed but paying less attention to minor problems between scheduled shop visits" (Kennet, 1993, pg. 542). More recently, Marksteiner (1999) presented results suggesting that reducing the frequency of maintenance can sometimes reduce rather than increase the number of engine failures, simply by reducing the number of opportunities for maintenance errors.

Nevertheless, there were some disturbing signs that deregulation and the resulting competitive environment may have caused airlines to engage in risky maintenance practices. One troubling issue is the $9.5-million fine "assessed against [the former] Eastern Airlines for maintenance violations that occurred between 1985 and 1986" (Transportation Research Board, 1991, pg. 183). Eastern supervisors and employees were subsequently indicted in 1990 "for falsifying maintenance records and allowing improperly maintained aircraft to be used in passenger service" (pg. 183). (Eastern admitted in 1991 that some of these charges had been true.) As noted by the Transportation Research Board (TRB, pg. 184):

> The maintenance violations at Eastern would appear to indicate that deregulation may have contributed to reduced safety at this airline because of Eastern's attempts to cut corners on maintenance... Although no accidents were attributable to Eastern's maintenance violations, evidence that maintenance managers under pressure to dispatch aircraft were falsifying records and impeding the FAA investigation is disquieting.

FIGURE 2-1
JET CARRIER SERVICE, ACCIDENT RATE BY CAUSE
(data taken from Oster et al., 1992)



The TRB report (pg. 184) notes that Eastern was "financially weak" and suffering from "contentious labor-management disputes," both of which had "predated deregulation." Smaller fines ($1.5 to $2 million) were also levied against American Airlines and Pan American (Wallich, 1986a, pg. 70); Pan Am, like Eastern Airlines, had been "financially troubled" (Oster et al., 1992, pg. 122).

Other areas of concern include increases in "the number of aircraft fires" and "the number of accidents caused by metal fatigue and corrosion," which International Association of Machinists and Aerospace Workers president Winpisinger (1988, pg. 365) attributes to reduced maintenance and inspection efforts; however, this observation is not based on a statistical study. Finally, the Office of Technology Assessment (OTA, 1988) raised concerns regarding:

> 1) Rising use of contract maintenance. While there is little or no statistical evidence linking contractor use to higher accident rates in aviation, some anecdotal evidence (such

as the involvement of contractor maintenance workers in the accident at the former Valujet; see for example Langewiesche, 1998) has resulted in increased levels of concern. The OTA (1988, pg. 107) notes that "Contract maintenance, by its nature, is not as easy as in-house work to monitor and manage." Concerns have also been raised about the impact of contract workers on safety in the petrochemical and mining industries (see for example Wells et al., 1991; Kochan et al., 1994; Rebitzer, 1995; Rousseau and Libuser, 1997).

2) Greater reliance on leasing rather than ownership of aircraft. The OTA (1988) found that leasing affects maintenance philosophy, particularly near the end of the lease period. For example, leasing increases the reliance on "periodic inspections ... in lieu of permanent fixes" (pg. 108), and is associated with reduced treatment of corrosion.

3) The larger number of flights and "tighter schedules." The OTA (1988, pg. 108) noted that with tight schedules, "pilots and mechanics feel pressure, implicit and, in some cases explicit, to overlook mechanical problems to prevent delays."

2.5 Human Error

2.5.1 *Pilots*

As with equipment failure, pilots and others expressed concern that the pressures of deregulation would result in higher rates of human error. For example, O'Malley (1993, pg. 106) quoted a first officer at Northwest Airlines as saying:

> We'd all like to think there's never any pilot error, but there is. And I firmly believe that the pressure that's in the cockpit now, the other concerns that we have about things we were never concerned with before are certainly a contributing factor. Because you're not being able to keep your mind one hundred percent on just flying a safe flight. The pressure of trying to be on time, trying to save fuel...

The ALPA survey indicated that pilots were also concerned about the safety impacts of pilot inexperience (Fingerhut, 1986).

Figure 2-1 shows that accidents caused by human error declined immediately after deregulation. Oster et al. (1992, pg. 31) note that "Pilots and cabin attendants are flying more hours per month and ground crews are performing a wider variety of tasks than they were prior to deregulation. Despite these pressures, the rates for pilot error and ground crew error both declined in the 1979-1985 period." Thus, the dramatic change in working environment for airline employees after deregulation does not seem to have had a significant adverse impact on accident rates.

However, the story is more complex than that, because data for the later post-deregulation period (in particular, 1986-1988) show a modest increase in accident rates caused by pilot error; see Figure 2-1. Oster et al. (1992, pg. 31) note that "the rapid growth in air travel...caused some jet

airlines to reach down into the commuter ranks for pilots more frequently than before. Some concern has been raised that less experienced and perhaps less qualified pilots were moving into the jet carrier ranks as a result. It is interesting, therefore, that the pilot error rate is twice as high in 1986-1988 as it was in 1979-1985" (although still lower than before deregulation). Note also that despite the severe shortages of experienced pilots, pilots' wages and earnings do appear to have been adversely affected by deregulation; see for example Johnson (1991, 1995) and Card (1996).

A closer look at actual experience levels of pilots and other crew members suggests that the rapid growth in air travel did adversely affect experience levels among both pilots and ground crews. The CRS (Moore and Humphlett, 1986, pg. CRS-2) and the OTA (1988, pg. 26-27) both estimate roughly a 50 percent increase in the industry by 1986. Gray (1987, pg. 35), a pilot specializing in aviation law and critical of deregulation, cites statistics from *Aviation Daily* as follows: "13 percent of the new pilots hired by major airlines in 1986 had under 2,000 hours of flight time. Two years earlier, virtually no new pilot hired by a major airline had so little experience." Just as major airlines hired less experienced pilots from the commuter airlines, Oster et al. (1992, pg. 36) note that:

> The same growth in travel demand...has caused commuters to reach down into the ranks of pilots in air taxis and cargo operators at a faster rate. In the same way an influx of less-experienced pilots from commuters may have increased pilot error in jet carriers, an influx of replacement commuter pilots from air taxis and cargo operators may have increased commuter pilot error rates.

OTA (1988) statistics certainly support this view. Table 2-1 below (taken from OTA, 1988, pg. 110) shows the dramatic decrease in experience levels of new hires by airline type. Moreover, the OTA notes that airlines also relaxed education, age, eyesight, and physical requirements for new hires.

Anecdotal evidence provides some support for concerns about pilot inexperience. For example, Nance (1986) notes that former intrastate carriers such as Air Florida sometimes lacked formal training programs and standardized procedures,[5] and suggests that such problems (compounded by the hiring of relatively inexperienced pilots) contributed to the airline's 1982 accident in Washington, D.C. This conclusion is supported by the National Transportation Safety Board (1982) report on the accident, which stated that "limited training and low experience in jet transport winter operations in snow and ice conditions were contributing factors" (cited by Nance, 1986, pg. 286). Lauber (1988) cites similar examples in which pilot inexperience was a contributing factor in commuter accidents. Nance (1986) also describes incidents of pilot inexperience that did not result in accidents, but may still be of concern—especially cases in which all members of a flight crew were inexperienced. In one such case, a new entrant airline assigned a three-person flight crew to a Boeing 747, none of whom had ever flown that aircraft before; their 747 experience had been limited exclusively to flight simulators (Nance, 1986, pp. 363-364, footnote 2). After a similar incident at a major airline in which all members of the flight crew were inexperienced for the positions they were flying, the captain wrote an open letter describing the flight as "a quintessential case of the blind leading the blind. How we kept

from having a major accident and killing ourselves from a stupid mistake I will never know!" (Nance, 1986, pg. 365, footnote 3).

Table 2-1
Qualifications of New-Hire Commercial Flight Crews (percent, by year)
Source: OTA (1988)

	Major Airlines		National Airlines		Other Jet Airlines		Regional Airlines	
Pilots with	1983	1986	1983	1986	1983	1986	1983	1986
Less than 2,000 hours total flight time	1	13	0	11	14	12	9	29
No military experience	46	56	18	66	55	70	83	88
No jet or turboprop flight time	1	2	1	6	24	29	32	28
No air transport pilot certificate, no flight engineer certificate	18	26	24	41	42	56	77	76

However, the evidence on whether pilot inexperience was actually responsible for a significant fraction of accidents is ambiguous. A study by Morrison and Winston (1988) found that pilots who had been involved in accidents after deregulation (defined as the years from 1976-86) had just as much flight experience as pilots who had been involved in accidents before deregulation (1965-75).[6] Lauber (1988) found that pilots involved in accidents after deregulation (1982-85) had less total flight experience than pilots involved in pre-deregulation accidents (1975-78), but more experience in the type of airplane actually involved in the accident.[7] Interestingly, the OTA (1988, pg. 110) suggests that "Actual experience in a specific aircraft type and airline might be more predictive of accident risk." The TRB (1991, pg. 180) notes that "it is difficult to be conclusive [about the impact of pilot experience on safety], given the lack of comparative data on pilot age and experience" for pilots who were not involved in accidents. The lack of statistical significance and the different time periods considered in the two analyses also make it difficult to reconcile the somewhat conflicting results obtained by Lauber (1988) and Morrison and Winston (1988) regarding the impact of pilot experience.

Gray (1987, pg. 36) notes that for a variety of reasons (including reduced benefits of seniority and concerns about the financial health of particular airlines), "pilots are changing airlines more often." Economic theory predicts that such turnover will result in loss of firm-specific (and aircraft-specific) human capital or skill levels. This problem appears to have been particularly severe among commuter and regional airlines; for example, both Gray (1987, pg. 36) and OTA (1988, pg. 110) cite pilot turnover rates of over 100 percent per year for some airlines. As Gray

(1987, pg. 36) succinctly observes, "It is difficult to comprehend how a carrier can operate with a 125 percent attrition rate."

2.5.2 *Mechanics*

Similar problems (including labor shortages, inexperience, and "carrier-hopping") were also observed among airline mechanics in the mid-1980s. Such problems may help to explain the data presented by Oster et al. (1992), which show that the rate of ground crew error among jet carriers (although still less than before deregulation) increased by about 50% between the 1979-1985 and 1986-1988 time periods; see Figure 2-1.

Some have attributed maintenance problems in part to low wages for airline mechanics. Gray (1987, pp. 36-37) cites a 1985 article from *Air Transport World* as stating that in the mid-1980s, the wage for an entry-level mechanic was about $6 per hour in the general aviation industry (well below market rates in other industries), and $4.50 per hour at one particular regional carrier. However, Card (1996) and Johnson (1995) present hourly wage data for mechanics at the major carriers that are well above the values cited by Gray for general aviation. Thus, problems with substantially below-market wages appear to have been confined largely to the general aviation industry, small carriers and new entrants (which provided only a modest fraction of all scheduled air transportation), and perhaps a few major carriers with financial difficulties. Wallich (1986b) confirms that at small airlines, "mechanics are generally paid about 40 percent less than those at major airlines."

However, airline mechanics in general did apparently experience both reduced wage premiums (relative to mechanics in other industries) and reduced earnings (relative to pre-deregulation expectations) after deregulation. With respect to wage differences between aviation and other industries, Card (1996, Table 4) finds that mechanics in scheduled air transportation earned on average about $0.47 more per hour than mechanics in other industries in 1979. That wage premium decreased slightly (to $0.35 per hour) in 1989, due largely to a change in the relative composition of the work force in the airlines versus other industries (which would be consistent with hiring of less experienced mechanics in the aviation industry after deregulation than before).[8] With respect to differences in earnings after deregulation, Johnson (1991, Table 4, panel I) estimates that there was roughly a 9% per year decrease in mechanics' earnings at major airlines from 1978-1984, after controlling for a number of factors that would be expected to affect earnings (but not mechanic experience).[9] She therefore concludes: "earnings did significantly decline for mechanics...in the early deregulatory period"; see also Johnson (1995). However, she also notes that reductions were observed only for actual earnings, not for contractual wages, suggesting that "earnings declines...could be attributed to changes in flight schedules and overtime premiums" (Johnson, 1991).

There was also greater variability among wage rates for airline mechanics after deregulation than before (Card, 1986, 1996). In particular, Card (1986) cites "significantly lower wage rates at several of the financially troubled airlines" (pg. 528) and "a small concentration of wage rates some 20-40 percent below the industry mean wage" (pg. 530).[10] Therefore, while hiring of inexperienced, low-wage mechanics does appear to have occurred, at least at some airlines, it is

unclear whether this was sufficiently widespread to explain the increase in ground crew errors cited by Oster et al. (1992). Finally, Card (1986, pg. 537) estimates that there was "a 15-20 percent reduction in maintenance employment at the trunks, or a transfer of 5,000 to 7,000 maintenance jobs from the trunks to the smaller airlines" due to their loss of market share.[11]

2.6 Financial Pressures

As might be expected, airline profitability has been far more variable after deregulation than before. The CRS (Fischer, 1986, pg. CRS-2) notes that "Under regulation, when the industry had a good year, its benefits normally were spread among all carriers. In 1984 and 1985, however, the distribution of profits was dramatically different." Fischer concludes (pg. CRS-3): "Carriers have shown that it is possible to move from the financial brink to profitability, and in some cases, back again, in a relatively short period of time."

Moreover, a significant number of airlines (especially new entrants) went out of business in the post-deregulation period. According to Fischer (1986, pg. CRS-3), "Business failure...is now a fact of life in the airline industry." This also made it difficult for airlines to obtain financing: "Prior to deregulation, financial institutions were willing to lend airlines funds for new aircraft almost irrespective of their financial condition, because the CAB could guarantee the carriers' long-term survival. Airline bankruptcies of the last few years have soured this relationship" (Fischer, 1986, pg. CRS-7). Even strong advocates of deregulation such as former CAB chairman Alfred Kahn (1988b, pg. 248) have acknowledged that "the profit record of the industry since 1978 has been dismal, ...deregulation bears substantial responsibility, and...the proponents of deregulation did not anticipate such financial distress—either so intense or so long-continued."

The greater financial instability of the airline industry has led to concerns that airlines with financial difficulties may engage in excessive cost cutting. For example, the OTA (1988, pp. 54-55) states that "the economic health and management stability of an airline strongly influence its ability and willingness to bear the cost of such safety activities as recurrent cockpit resource management and weather training for pilots, internal safety audits, and standardizing equipment and procedures." Similarly, findings of a survey by the National Transportation Safety Board (1980) indicated that "about 65% of the commuter managers believe that there is a relationship between safety and financial and economic posture." Specific concerns cited included violations of procedures, under-reporting of hardware problems, flying with excess weight, reduced spare parts, and poorer training of pilots. According to the survey conducted by ALPA, problems such as pilot fatigue and pressure to ignore mechanical problems tended to be more severe at small carriers than at major airlines (Fischetti, 1986b).

Empirical evidence on this subject is mixed. Statistical analyses of airline data from 1963 to 1970 (pre-deregulation) by Golbe (1986, pg. 305) found that "safety [measured by accident rates] and profits have no significant relationship. Thus, it does not appear that profit-reducing changes in regulation will lead to less safe airlines."[12] However, note that Golbe evaluated data from only the era before deregulation, when CAB had a strong influence on profits, so it is difficult to draw any conclusions concerning profits from this period. A more extensive analysis

by Rose (1989, 1990, 1992), covering data from 1957-1986, concludes that "lower profitability is correlated with higher accident and incident rates, particularly for smaller carriers" (Rose, 1990, pg. 944).[13] These results were summarized as follows (Rose, 1992, pg. 84):

> A 5 percentage point increase in the operating margin (for example, from 5 percent to 10 percent) implies about a 5 percent reduction in the total accident rate and more than a 15 percent reduction in the fatal accident rate, other things equal... A 5 percentage point increase in the operating margin implies about a 20 percent reduction in reported incidents for the smallest carriers in the sample and a 10 to 12 percent reduction for mid-size carriers.

Rose suggests that "Smaller firms...may be more responsive to fluctuations in the economic environment" (Rose, 1990, pg. 959), and that "more intense scrutiny of the safety practices of financially marginal carriers is desirable" (Rose, 1989, pg. 111). Oster et al. (1992, pg. 124) conclude:

> these research results must be viewed with caution, because...the mechanism by which this profitability-safety link emerges is not clear. For example, if carriers reduced maintenance expense in the wake of poor profits, one might expect accident rates to rise. However, there appears to be little correlation between maintenance expense per available seat mile and changes in profitability.

Moreover, as Rose (1990, pg. 947) points out, "Airline passengers, employees, and insurance companies all have strong incentives to monitor carrier safety." In particular, "most airline executives cite the need to preserve and enhance their reputation as their primary concern in maintaining safety standards" (Rose, 1992, pg. 88). However, it is unclear whether this effect is strong enough to ensure that airlines actually maintain safe operations. For example, Rose (1992, pg. 93) notes that the market may not be effective in controlling airline safety if "consumers are unaware of the aircraft type used on particular flights, have difficulty assessing safety records..., or are slow to respond to differences in perceived accident risks." Thus, despite the somewhat ambiguous nature of the evidence, it would seem prudent to consider financial difficulty as a potential leading indicator of safety problems.

2.7 Aging Aircraft

The TRB (1991, pg. 190) notes that "no studies have been conducted that link the financial conditions of the airlines as a result of deregulation to the aging of the aircraft fleet, nor has any direct link been established between aging aircraft and increased risk." However, it stands to reason that the financial pressures of deregulation, combined with difficulties in obtaining financing for purchases of new aircraft, might result in longer aircraft service lives than would have been experienced in a regulated environment. Dempsey and Goetz (1992, pg. 303) state that "Debt-ridden carriers nearing bankruptcy have little alternative but to defer new aircraft purchases."

Thus, Oster et al. (1992, pg. 126) note that "Aircraft are remaining in service for longer than the engineers who designed them had anticipated" (typically 20 years). Moreover, the Aloha Airlines accident in 1988 raised concerns about whether an aging fleet of aircraft could in fact be operated safely. The fact that "the rate of equipment failure accidents was 50 percent higher in 1986-1988 than it had been in 1979-1985" (although still less than half the rate before deregulation; Oster et al., 1992, pg. 31) has generated increased concern about the safety of older aircraft. An analysis by Morrison and Winston (1988, pg. 11) showed that "airframe hours of planes involved in accidents have increased, but hours have increased even more for the industry fleet."[14] Thus, it does not appear that the use of aging aircraft has in general been associated with a substantial increase in risk. However, International Association of Machinists and Aerospace Workers president Winpisinger (1988, pp. 365-366) notes that the age of "aircraft involved in accidents caused by metal fatigue" increased much more rapidly than the age of aircraft involved in other types of accidents.[15] This suggests that increased aircraft age may contribute to the risk of that specific category of accidents. Moreover, although no study to date has shown conclusive evidence of risk due to aging aircraft, adverse effects may still occur in the future.

2.8 New Entrants

Airline deregulation permitted the establishment of a number of "new entrant" airlines, since they no longer needed to apply to the CAB for permission to fly particular routes. Thus, the OTA (1988, pg. 27) reports that "119 carriers...entered the industry between 1978 and 1986"; Mark Kahn (1988, pg. 3) cites statistics from the *New York Times* indicating 128 new entrants (of which only 37 were still in existence as of November 1987). Gray (1987, pg. 34) states that "Many new carriers have little notion of or experience in how an airline must be run," and the safety performance of new entrants has been a significant concern.

Limited anecdotal evidence supports concerns about the safety of new entrants. For example, following a 1984 accident by Provincetown-Boston Airlines, a former commuter carrier, the airline lost its certification. According to Nance (1986, pg. 355), the results of an FAA investigation found:

> serious violations in maintenance, training, flight following, maintenance monitoring, aircraft inspections, unauthorized personnel performing maintenance, use of untrained and unqualified maintenance inspectors, failure to sign off airworthiness releases, and violations in weight and balance, manifests, and equipment.

A statistical analysis by Barnett and Higgins (1989, pg. 14) found that "new entrants" to jet service had a fatality risk of 1 per 870,000 flights, as compared to 1 per 11.8 million flights for the "trunklines" (roughly "*twelve* times riskier").[16] As a result, they conclude, "the 1979-86 mortality risk of domestic jet travel was perhaps 60% higher" due to deregulation, taking into account the fraction of air travel conducted on new entrant airlines (pg. 17). Oster et al. (1992, pg. 24) also find that "the new entrants did experience more passenger fatalities per 1 million passenger emplanements and more fatal accidents and minor accidents per 1 million aircraft

departures than did either the trunk and local service carriers or the former intrastate and charter carriers." (However, the differences presented by Oster et al. fell short of statistical significance.) Moreover, Oster and Zorn (1987, 1989) found that new entrants and other non-trunkline jet carriers had a higher rate of accidents due to pilot error.[17] Rose (1990) found that accident rates (especially the rate of fatal accidents) were negatively correlated with "cumulative airline operating experience," which is consistent with the hypothesis that new entrant airlines would generally have worse safety performance.[18] However, Kanafani and Keeler (1989) found "no difference in safety performance between the established carriers and new entrants who joined the market after airline deregulation" (pg. 128), and noted that "new-entrant carriers... spend a higher portion of their total expenditures on maintenance" than more established airlines (pg. 119).

Moreover, analyses of new entrants are subject to significant caveats. First, they are based on very few accidents—e.g., three fatal accidents among new entrants in the Barnett and Higgins database, five total accidents among new entrants in the data used by Oster et al. In addition, as noted by Rose (1992, pp. 84-85), the results are "sensitive to the measures of safety performance employed in the study, and also may depend on the definition of entrant carriers and identities of the firms included in the sample." In particular, while new entrants have experienced higher rates of *fatal* accidents, one study found that their *total* accident rates were actually *less* than those of "established carriers," after controlling for other factors.[19] While it is possible that "more experienced carriers [can] limit the severity of otherwise unavoidable accidents, reducing or eliminating fatalities" (Rose, 1992, pg. 86), the small number of accidents involved in these analyses also suggest that the result may be a fluke. Finally, the category of "new entrants" is often defined to include not only newly established companies such as People Express, but also companies that had operated as charter and/or intrastate airlines prior to deregulation (Rose, 1992). Thus, for example, one of the "new entrants" involved in a fatal accident in the database of Barnett and Higgins, World Airlines, was "a former charter carrier with extensive experience in jet operations" (TRB, 1991, pg. 178). Since the number of accidents in that database was so small, re-categorizing even one of the carriers involved in an accident from a "new entrant" to a "trunkline" would have substantially affected the results.

However, a more recent study by the General Accounting Office (GAO, 1996b) confirms that new entrant airlines (those with no more than five years of experience) continue to be associated with safety problems, regardless of airline size.[20] For example, the report notes that "from 1990 through 1994, new airlines had an average accident rate of 0.60 per 100,000 departures compared with the established airlines' average rate of 0.36 per 100,000 departures" (pg. 7). Incident rates were similarly elevated; perhaps surprisingly, this increase affected large airlines even more than commuter airlines. The report does note, however, that "one adverse event for a new airline with a limited number of departures can significantly affect accident, incident, or enforcement rates" (pg. 10). Interestingly, the increased rates of accidents and incidents appear not in an airline's first year of operation, but in subsequent years. The report speculates that "new airlines may encounter more incidents because their fleets expanded faster than their organizational ability to absorb the growth" (pg. 13). Other possible reasons cited include the use of contractors and the development of financial difficulties during an airline's first few years of operation. Although not explicitly mentioned in the GAO report, yet another explanation

might be the onset of complacency after a period of heightened vigilance associated with airline startup. As a result of their findings, the GAO recommended "closely monitoring the performance of new airlines during their first several years of operations" (pg. 27).

2.9 Mergers and Acquisitions

As noted by the CRS (Fischer, 1986, pg. CRS-6), "An early reaction to deregulation was a succession of mergers and buyouts of existing carriers by several others." Moreover, many new entrants went bankrupt. Cappelli (1987, pg. 142) notes, "the new carriers appeared particularly vulnerable to the vagaries of competitive markets; of the 60 airline bankruptcies since deregulation, only two, Braniff and Continental, have been at the trunk carriers." As a result, despite the large number of new entrants to the aviation market in the early 1980s, Easterbrook (1987, pg. 21) noted that "nearly 94 percent of the U.S. air market [is] in the hands of eight companies."

Oster et al. (1992, pp. 125-126) list three reasons that mergers and acquisitions could have undesirable consequences for safety: "First, the merging of maintenance operations and procedures is required..." "A second potential safety issue involves the lack of standardization of cockpit design and operating procedures across carriers. As newly merged flight crews adjust to new cockpit designs and different operating procedures, there is the potential for increased mistakes and errors." "A third potential factor involves the merging of seniority lists among airline personnel."

For example, as the result of a merger, relatively inexperienced pilots (or pilots inexperienced with particular routes or types of equipment) sometimes obtained senior positions such as captain earlier than they would have otherwise. Nance (1986) echoes the concern of Oster et al. about consistency of procedures, noting that after the merger of the former Republic and Airwest, "On a single day, all Airwest [DC-9] pilots were required to change to Republic procedures. The result was often confusion" (pg. 321, footnote 1). He suggests that confusion regarding procedures for the use of the fuel boost pumps could have contributed to a 1983 incident in which a Republic flight descended from 35,000 feet to 13,000 feet without power before successfully reestablishing fuel supply and restarting the engines (pg. 319).

Similar concerns also surfaced after the merger of USAir with the former Pacific Southwest Airlines and Piedmont Airlines. Westrum (1996, pg. 8; see also Figure 2 on pg. 7) cites *New York Times* data indicating that the rate of "pilot deviations (actions which might violate regulations)" at USAir roughly doubled after the merger, and "only gradually decreased as integration proceeded over the next five years." In fact, Westrum (pp. 7-8) comments that "A changing organization is an organization at risk since change increases mental workload... Rapid change overloads the mind and clogs the desk of the busy executive," and observes that "Mergers and rapid growth often cause such overloading."

The OTA (1988, pg. 39) notes that mergers also generate stress:

> employees become absorbed and preoccupied with the reorganization... Once the merger begins, the problems become more complex, and the most important contributor to company discord and stress is the clash in corporate cultures... Competition develops over whose practices will become the new company policy.

This pattern of behavior is prevalent enough across industries that it was even given a name—"merger syndrome" (Marks and Mirvis, 1986). Based on an eight-year study of mergers and acquisitions, Marks and Mirvis note that "the most important contributor to discord is a clash in corporate cultures," and suggest that "the merger syndrome often plays a major role in turning potentially good alliances into disasters."

The merger of Northwest Airlines with the former Republic Airlines provides some dramatic illustrations of such problems (Halliday, 1987). In particular, many Republic employees had been less well paid than their Northwest counterparts, because their union had agreed to concessions "to help keep Republic afloat"—pay differences that persisted after the merger. These wage disparities were exacerbated by the inability of the Machinists union, which was temporarily representing former Republic employees, to come to a satisfactory transitional agreement with Northwest (Halliday and Wernle, 1987). In addition, former Republic employees felt that the merger had been conducted in a way that did not adequately respect their abilities and ways of doing business, and found it frustrating to adapt to the new corporate culture. For example, one flight attendant formerly employed by Republic stated that "Northwest management is management by intimidation. Northwest employees are not allowed to question, to criticize, or to comment on the company." Another former Republic employee stated that Northwest "imposed a lot of narrow-minded procedures on us, without even stopping to analyze whether the way Republic did it before was better" (Halliday, 1987, pg. 29).

The net result of these dissatisfactions was sabotage against Northwest by former Republic employees. Sabotage activities included removing luggage tags, disabling baggage transport carts and ground service computer equipment, stealing radios used by ground service crews, and even fighting between Republic and Northwest employees. While Halliday (1987, pg. 1) notes that "There is no suggestion that any employee has done anything to endanger safety," such extreme strife can clearly be problematic in running a complex and safety-critical business.

2.10 Reduction of Support Services

A number of airlines have cut support departments, such as engineering, to focus scarce resources on the necessities of operations and maintenance. There has been little or no systematic study of how such cuts have affected safety. However, some airline industry observers and critics of deregulation have raised concerns that such cuts leave the airlines more dependent on aircraft vendor input on decisions regarding new aircraft designs, as well as maintenance and other areas. Thus, for example, O'Malley (1993, pp. 80-81) cites a United Airlines captain as saying:

> The U.S. carriers are throwing away their engineering departments, their maintenance expertise, their display flight-following functions, their meteorology

> departments, their piloting departments... All of this is very much a function of deregulation and the Wall Street orientation toward the short-term bottom line...of the bean counters.

He also notes, "You don't see our European counterparts or our Asian counterparts racing toward this precipice. This is uniquely American." Lauber (1988, pg. 227) echoes the concern that "company divisions that are not direct revenue producers may not be receiving sufficient support," and cites "safety and medical departments" as specific examples. Nance (1986) also notes that competition and financial pressures have reduced the resources available for inter-airline bench-marking.[21]

Other support services have also been vulnerable to cuts after deregulation. For example, O'Malley (1993, pg. 193) notes that "In January 1993, as part of an action to reduce its work force by twenty-eight hundred people, United Airlines terminated its nine full-time employee assistance representatives and their immediate staffs." The employee assistance program had focused extensively on identifying and developing treatment recommendations for pilots with drinking problems.

2.11 Labor Relations

As noted by the TRB (1991), "Many new-entrant carriers offered services with non-union labor and were encumbered by few of the work rules that had developed in the unionized firms." For example, a CRS report (Belous, 1986) cites salary differentials equal to a factor of 2 or 3 between an established airline and a new entrant serving the same market in the early 1980s. Moreover, both the recession of the early 1980s and the fare wars between established carriers created sharp downward pressures on wages (Cappelli, 1988).[22]

In order to compete, the established carriers had to reduce labor costs, and "virtually all labor groups ultimately agreed to compensation or work-rule changes or both" (TRB, 1991). In fact, both Braniff and Continental became "nonunion operators" in post-bankruptcy restructuring (Meyer and Oster, 1987). For example, after filing for bankruptcy, Continental cut labor costs about 50 percent by unilaterally imposing new wage rates and work rules (Cappelli, 1987, pg. 156), although "pilots and flight attendants at Continental...re-established union coverage" in the 1990s (Card, 1996, pg. 23). Similarly, Derthick and Quirk (1985, pg. 3) note that "Between 1980 and 1984 locals of the Air Line Pilots Association accepted wage deferrals or freezes more than forty times."

A study by the CRS (Fischer, 1986, CRS-4) confirms that deregulation was unfavorable for organized labor: "Airline labor has suffered some serious reverses under deregulation, compared to the regulated era." In particular, "Airlines facing competition with new entrant carriers using less expensive labor have sought to stabilize and/or reduce their own operating costs through new labor accords with provisions for two-tier wage structures, employee stock ownership, and other mechanisms" (pg. CRS-5).

As discussed above, reduced wages may affect safety by increasing turnover and thus lowering pilot and ground crew experience. In addition, de-unionization may increase turnover rates at firms, even after controlling for any reduction in wages. For example, Freeman and Medoff (1984) note that "unionism reduces turnover, first by creating desirable work conditions, and second by providing discontented workers with a voice alternative to quitting." Concerns have also been raised that de-unionization could have more direct effects on safety—for example, by reducing the protection available to employees who report safety problems or refuse to comply with what they consider to be unsafe management decisions (Nance, 1986).[23] Thus, O'Malley (1993, pg. 96) quotes a United Airlines captain as saying, "What does the protection of a union contract do for you? I'll tell you what it does for you." He elaborates, "if I do something as a union representative [e.g., cancel or delay a flight due to bad weather], they cannot come back at me and take personal punitive action against me. There's an insulating layer."

The OTA (1988, pg. 131) points out that "union contracts or initiatives often address issues not covered by Federal policy," or impose more stringent requirements (e.g., more restrictive "duty-time limits" for pilots, better training). Thus, Nance (1986, pg. 80, footnote 3) notes that "restrictions on the amount of time a pilot can be allowed to fly...became part of the general airline system only because they became federal regulations, or were incorporated into union contracts negotiated for the pilots by ALPA." Similarly, Hopkins (1982) notes that "ALPA took the lead that management should have taken and insisted that if pilots were to be vulnerable during recurrent FAA line checks, then they should at least have adequate training to prepare them." Aviation unions have historically also provided a number of safety-related services to their members—e.g., training and informational materials (OTA, 1988, pg. 131), and employee assistance programs for addressing alcohol abuse (Cooper, 1988).

There was a dramatic increase in labor strife after restructuring. In aviation, mergers created a great deal of labor unrest because of the need to merge seniority lists between two formerly separate carriers (Nichols and Kennedy, 1988). However, the impact of labor unrest on safety is not always negative. Although in general under-reporting of safety violations and injuries may be more likely than aggressive reporting in a competitive environment, Conway (1988, pg. 214) notes that flight attendants at American Airlines used aggressive reporting of safety violations to the FAA to create pressure on management without going on strike. Similarly, during the contentious merger of Republic and Northwest discussed above, baggage handlers resorted to a "Work Safe Program" of carrying only one bag at a time as a means of slowing down airline operations (Halliday, pg. 28).

2.12 Implications for the Federal Aviation Administration

The general consensus seems to be that deregulation greatly increased the workload of the FAA, without any concomitant increases in budget and/or staff (at least initially). Although we have already noted that overall accident rates did not increase, "inadequate FAA surveillance of pilot certification procedures" was cited as a factor contributing to the large Air Florida crash in Washington, D.C., in 1982, and several commuter airline accidents in the mid-1980s (Moses and

Savage, 1990, pg. 183). Inadequate FAA oversight was also cited more recently as a contributing cause of the ValuJet accident (Langewiesche, 1998).

The dramatic increase in both travel volume and number of airlines after deregulation (Moses and Savage, 1990), coupled with increased reliance on contractor maintenance (OTA, 1988)[24] and an aging fleet of aircraft (Nance, 1986),[25] greatly increased the burden on FAA inspectors. Former FAA Administrator Donald Engen noted that the FAA initially "didn't realize the effect deregulation would have on the agency," and commented that the effort required to certify new entrant airlines interfered with providing adequate oversight of existing airlines (Fischetti, 1986a, pg. 67). This was confirmed by a study performed by the GAO, which estimated that in the mid-1980s, FAA inspectors spent more than three quarters of their time on new certifications (Fischetti, 1986a, pg. 67). Nance (1986, pg. 345) also notes that "pilots...after 1978 began moving from carrier to carrier, airplane to airplane, position to position with frightening speed, generating the need for new FAA check rides [test flights] with almost every move." As a result, FAA began designating pilots to administer check rides for other pilots in their own airlines, a situation that sometimes led to abuse (e.g., "pilots...issuing each other check-ride approvals when no check rides had been flown"; Nance, 1986, pg. 356).

At the same time, FAA staffing levels were being cut. In particular, the OTA (1988, pg. 58) notes that the number of FAA Flight Standards field office inspector positions decreased by 18 percent between 1981 and 1984; the number of "air carrier" inspector positions underwent a similar decrease in the early 1980s, both as a result of budget cuts. As a result, the OTA observed, "FAA became adequately staffed to handle new industry entrants only in 1984, the year that new airlines began to go bankrupt or merge with established carriers" (pg. 17). Similarly, O'Brien (1988, pg. 379, Figure 5), a safety official at ALPA, cited FAA data showing that the number of FAA inspectors per airline had decreased by about a factor of three between 1976 and 1985 (from 4.5 to only 1.5 per airline). This is especially problematic since prior to deregulation, many airlines had internal rules and procedures (e.g., duty-time limits, spare parts inventories) that were more stringent than FAA requirements (Nance, 1986, pg. 339; see also Nance, 1989, O'Brien, 1988, and Westrum, 1996). As such extra margins of safety were reduced or eliminated, the role of FAA inspectors became more critical. In addition, the TRB (1991, pg. 184) noted: "The FAA's focus on maintenance records in its routine inspections makes it difficult to detect maintenance violations if such records are systematically falsified. The limits of FAA staffing resources more or less force the agency to rely on the carriers to report maintenance practices faithfully."

Thus, Moses and Savage (1990) conclude that "If there had been increases in accident rates caused by inadequate oversight of airlines..., then the Congress as well as the US Department of Transportation would have had to bear a heavy measure of blame because they adopted a set of contradictory policies." Alfred Kahn (1988c, pg. 345) echoes this concern, noting that "It is the responsibility of the federal government to ensure that staffing of the FAA is adequate to monitor airline safety practices." Nance (1986, pg. 342) similarly remarks: "To meet the challenges thrown at it by deregulation, the FAA would have required a massive infusion of funds, significant alteration of its surveillance and monitoring authority, and a significant

alteration of its philosophical approach to airline safety. Congress, however, gave it only the additional work load."

More recently, in a study of new entrant airlines, the GAO (1996b) noted that the FAA apparently had not targeted its resources effectively. In particular, the GAO report observes that the FAA has not singled out new airlines for increased inspection effort, despite their apparently higher risk. In general, levels of FAA inspection effort appear to have been largely unrelated to leading indicators of risk (such as incident rates) at particular airlines (GAO, 1996b, pg. 18):

> some airlines that had had no accidents, incidents, or enforcement actions initiated against them were inspected by FAA once every several hundred departures. One other, however, was inspected every two departures... [The former] ValuJet—had an incident rate that was 40 percent higher than average, but it was inspected only about one-third as frequently as all new large airlines through calendar year 1994.

In other observations regarding FAA practices, the GAO noted that effective targeting of inspection and monitoring efforts requires the availability of high-quality data. Moreover, the report cites problems with uneven or inadequate training of FAA inspectors. For example, sixteen of the 37 inspectors interviewed by the GAO reported "gaps in training that affected their effectiveness in doing their jobs" (pg. 22), such as lack of training on the specific types of equipment that they are required to inspect. These problems may have arisen in part because the budget available for training had been cut during the same time period when significant numbers of new staff members were being hired.

2.13 Summary—Impacts of Deregulation on Aviation Safety

As noted above, aviation has many interesting parallels to the nuclear power industry. In particular, both industries rely on advanced technology, are heavily regulated, have the potential for low-probability, high-consequence accidents, and employ personnel with high levels of qualifications and training. Therefore, the experiences of the aviation industry with economic deregulation are potentially of interest to the nuclear power industry. To summarize those experiences briefly, deregulation appears to have adversely affected many of the inputs that are believed to be important to aviation safety. For example, deregulation apparently resulted in:

1) Decreased maintenance.
2) Less experienced personnel.
3) Increased pressures for cost cutting.
4) Increased reliance on older aircraft.
5) New entrant airlines unfamiliar with the FAA requirements for interstate carriers.
6) Reduced investment in support services such as engineering and employee assistance.
7) Poor labor relations.

Some of these changes (e.g., use of less experienced personnel) resulted from the rapid increase in air transport volume observed after deregulation, while others were a direct result of

competition. Moreover, these changes took place during a time when the FAA work force was being substantially reduced. Perhaps surprisingly, although such problems contributed to some individual accidents (see for example Nance, 1986), they appear to have had little adverse impact on overall safety records, which generally continued their pre-deregulation trend of improvement.

There are several possible reasons for the favorable safety performance of the aviation industry after deregulation:

- The margin of safety prior to deregulation may have been large enough that some decreases in safety margin could be sustained without a significantly increased rate of accidents. For example, the inherent safety of modern aircraft (especially the high level of redundancy in many key systems) may be one reason that "accidents caused by poor maintenance are rare" (Wallich, 1986a, pg. 70).

- The overall trend toward improving safety records (due to improvements in both equipment and training) may have been sufficiently large to compensate for some adverse impacts due to deregulation. For example, data from Boeing (1998) show that the rate of severe accidents due to all causes decreased sharply from 1959 to 1979, presumably due to a variety of technological and operational improvements.[26]

- The adverse effects of deregulation could have been delayed. In particular, Figure 2-1 shows that the rates of several important accident causes increased in the 1986-1988 time frame. This is consistent with a delayed impact of deregulation, since travel volume did not increase until some time after deregulation because of the air traffic control strike in 1981 and the recession of the early 1980s.

- Pilots may have exerted an exceptionally "keen level of vigilance in the cockpit" to compensate for the effects of deregulation, such as reduced maintenance (Dempsey and Goetz, 1992, pg. 305).

It is also possible that we have simply not yet seen the full safety impact of deregulation. Reduced safety margins (indicated, for example, by increased rates of near midair collisions and runway incursions; Oster et al., 1992), in combination with an aging aircraft fleet, may still lead to more significant safety problems at some point in the future. However, this seems unlikely based on the recent accident record, since data from Boeing (1998) indicates that total rate of severe accidents ("hull loss and/or fatal accidents") for the U.S. and Canada combined remained roughly constant (and generally lower than comparable pre-deregulation accident rates) from 1979 through 1997.

Overall, therefore, the experience of the aviation industry suggests that economic deregulation did not have a negative impact on the overall safety record, but that safety cannot be taken for granted after deregulation. The situation is well summarized by Lauber (1988, pg. 228), who notes that "the accident statistics do not demonstrate that safety has suffered under airline

deregulation—but neither do they prove that there has been no impact... Vigilance, therefore, must be continuous."

2.14 Endnotes

[1] The database used by Rose (1989) as the basis for this analysis covers all accidents in both "scheduled passenger and cargo operations, from 1955 through 1986" (pg. 97). Her measures of accident risk include "the total number of accidents in a given year..., the total number of accidents per 100,000 departures..., and the number of fatal accidents in a given year" (pg. 99). The results show roughly a 4.5% average annual decline in the absolute *number* of accidents per year, and a 6.5% annual decline in the accident rate (pg. 99). These trends are statistically significant (pg. 99), and remain roughly the same when the analysis controls "the industry's average operating margin" in each year (pg. 100). In all six analyses (i.e., three different measures of accident risk, and formulations that do or do not control for operating margin), the decrease in accident risk is steeper after deregulation than before, although this relationship is not statistically significant in any of the analyses. However, Rose does not control for some factors that could have affected the accident rate, such as the travel volume in each year.

[2] The data used for this study was obtained from the National Transportation Safety Board for the years from 1975-89. Among major carriers, the accident rate was 0.53 per 100,000 departures before deregulation (1975-78), and 0.39 per 100,000 departures after deregulation (1979-89). This difference was found to be "significant at the 95 percent confidence level" (Exhibit 8, pg. 15). The rate of fatal accidents among major carriers also declined, from 0.08 per 100,000 departures before deregulation to 0.06 after deregulation, but this difference was not found to be statistically significant.

[3] Kennet (1993, pg. 543) states that "The data take the form of 42 complete engine histories covering the years 1964 to 1988 provided by Pratt & Whitney, Inc. A major advantage of this data set is the relatively large number of events to be analyzed"—hundreds of shop visits, and on the order of 100 engine shutdowns. Kennet also notes that "the sample was drawn from engines whose service lives covered a substantial period both before and after deregulation" (pg. 542, footnote 2). The results suggest that deregulation had little or no effect on the probability of an engine shutdown for the stronger JT9D engines used on Boeing 747 aircraft, and actually "led to a significant decline in the likelihood of engine shutdown for JT8D engines" (pg. 554). Thus, the results do not appear to reflect a lack of statistical power, since for at least one type of engine, statistically significant effects of deregulation on the probability of engine shutdown were detected despite the relatively large number of control variables.

[4] The study by Kanafani et al. (1989) is not as strong as the one by Kennet (1993). First, the study period is much shorter (1980-1984), and does not include any pre-deregulation experience. Thus, the study investigates the effects of maintenance practices on aircraft safety, but does not explicitly include deregulation as a variable. Second, the measure of safety is the number of severe SDRs, which the authors note can suffer from "potentially poor reporting" (pg. 43). The data set contains 274 observations, where an observation consists of the number of severe SDRs experienced by a particular air carrier and aircraft type in a single calendar year; thus, the data set does not track the experience of individual aircraft. Finally, there may be co-linearity between maintenance expenditures and other independent variables; in addition, the authors note that maintenance expenditures from previous years may have more power in predicting the number of severe SDRs than maintenance expenditures in the year where the SDRs were experienced.

[5] On pg. 153, for example, Nance notes that at Air Florida in 1979, "no one had been specifically assigned to any aspect of training, including the scheduling of training courses or the tracking of training requirements." He also notes on pg. 158 that "Air Florida didn't have any standard operations manuals... Air Florida's airplanes had been purchased and leased from so many different operators that no two airplanes seemed to have exactly the same instrumentation, and the operations manuals that came with each airplane were slightly different."

[6] The data for this analysis were taken from National Transportation Safety Board accident reports from 1965-1986, and are summarized in Table 3 of Morrison and Winston (1988, pg. 12). Pilots involved in accidents during the 1965-1975 time period had an average age of 45, an average of roughly 15,000 flight hours, and an average of 2,500 flight hours in the particular type of aircraft involved in the accident. By the 1976-1986 time period (which includes both deregulation and a period of "de facto" deregulation prior to passage of the Airline Deregulation Act), those numbers

had increased to 47 years of age, 17,000 flight hours, and 4,300 flight hours in the aircraft type involved in the accident, respectively. However, the authors note that "the averages are not statistically different across periods" (pg. 11), even at the 25 percent significance level (pg. 15, endnote 4). The authors also observe that their results could be explained by "an increase in the average age and experience of pilots throughout the industry" (pg. 15, endnote 4), a possibility that they consider unlikely but do not explicitly test or exclude.

[7] The data used by Lauber (1988) were compiled from National Transportation Safety Board accident reports from 1975-78 (representing the pre-deregulation period) and 1982-85 (post-deregulation). For major carriers, he found that "the post-deregulation pilots [who were involved in accidents] had fewer total flight hours than did those before deregulation: for example, a median of approximately 13,000 hours compared to approximately 16,500. However, ...the post-deregulation pilots had more time in type [i.e., the type of aircraft involved in the accident] than did the earlier group" (pp. 225-6; see also Figure 9 on pg. 233). According to Figure 10 (pg. 233), the median experience of accident-involved pilots in the particular type of aircraft they were flying at the time was somewhat less than 3,000 hours before deregulation, but nearly 3,500 hours after deregulation. No tests of statistical significance were performed, perhaps because the data reflect all accidents in the relevant time periods, rather than a random sample. Lauber also notes that "There is information on pilot experience in the Safety Board data, but only on...those who have been involved in accidents" (pg. 225). Therefore, he was unable to determine whether the experience levels of pilots involved in accidents were typical of pilots in the industry as a whole, or whether inexperienced pilots appeared to be more at risk. In addition, the TRB (1991, pg. 180) states that "Lauber's (1988) findings are also limited because his analysis includes all accidents instead of those in which pilot error played a major role" (pg. 180).

[8] The data for this study come from the 1980 and 1990 U.S. Censuses, and the 1994-95 Current Population Survey (which surveys roughly 400 airline workers, among others). The difference between the 1979 and 1989 wage premiums is statistically significant. However, that difference vanishes when control variables (education, experience, gender, race or ethnicity, marital status, "veteran status," and region of residence) are taken into account.

[9] The data used by Johnson (1991) reflect annual wages for mechanics at 13 major airlines from 1978 to 1984, with a total of 70 data points. The effects of deregulation were assumed to begin in 1978, and to grow throughout the remainder of the study period. The analysis also controlled for the effects of unemployment levels, total sales by each airline, the airline's return on assets, and debt-to-equity ratio, and load factor (i.e., what fraction of time planes were in service). Of those, deregulation, unemployment, return on assets, and load factor all had statistically significant effects on mechanics' earnings. The statistical significance of the deregulation variable reflects not a decline in earnings from the pre-deregulation period, but rather a continuing decline in earnings during the period of deregulation.

[10] The data used by Card (1986, pg. 528) "consist of annual observations on employment, wages, and output" at 11 major airlines. Card notes that "Wage rates at the financially sound airlines have maintained the pattern of equality established in the industry before deregulation" (pg. 528), suggesting that below-market wages affected only airlines in financial difficulty.

[11] This estimate was based on a statistical analysis that controls for factors such as the reduction in employment that would have been expected even in the absence of deregulation due to productivity improvements, as well as changes in market share, flight length, aircraft size, and ton miles per departure.

[12] The data used by Golbe (1986) consist of the total number of accidents (obtained from CAB and National Transportation Safety Board reports) for 11 major airlines from 1963 to 1970. This time period was specifically chosen to "reduce problems caused by structural shifts in the profit function such as...the advent of deregulation" (pp. 310-311). Thus, the study investigated the effects of financial difficulties on safety only in the pre-deregulation period. The independent variables were net income after taxes, return on investment, number of departures, and stage length (i.e., number of miles per flight). Neither net income after taxes nor return on investment was significantly related to the number of accidents, and in seven of the eight analyses reported (four covering the period from 1963-66, and four from 1967-1970), the coefficient was positive, suggesting that "more profitable firms have more accidents" (pg. 315). A time series analysis was also conducted, including data from 1952 to 1972. Here, the explanatory variables were net income after taxes, return on investment, number of departures, Gross National Product (GNP), and another indicator of business cycles. (Stage length was highly correlated with GNP, and hence was dropped from the analysis.) Once again, the

relationship between profitability and number of accidents was generally not statistically significant, but consistently positive, suggesting that profitability and safety vary inversely with each other.

[13] The database used by Rose (1990) covers both accidents (which are more relevant to safety) and incidents (which are more numerous) at "35 large U.S. scheduled passenger air carriers for 1957-86" (pg. 948), for a total sample size of more than 700 carrier-years. Thus, she analyzes a larger number of airlines than Golbe, and over a longer period of time that spans the effects of deregulation. This larger heterogeneity reduces the power of the analysis, but makes any significant results more compelling. Her primary measure of financial health is operating margin (i.e., "profitability before capital expenses and taxes"; pg. 949) in the previous year. She also controls for average stage length, number of miles of operating experience to date by each airline, fraction of international flights, Alaskan carriers (due to "adverse climate and operating conditions"), and a time trend to capture the effects of changes such as technology improvements (pp. 948-949). The aggregate results show that operating margin is negatively associated with safety, "implying that higher operating profits are associated with lower accident rates" (pg. 953). The relationship is not statistically significant, but is described as "strikingly robust to changes in the specification" (pg. 953); e.g., whether one considers all accidents or only fatal accidents, whether the analysis controls for the average accident rate at each carrier, etc. An analysis that controls for carrier size (pg. 955) finds that "profitability effects may be most pronounced for smaller carriers"; this relationship is "statistically significant at the 10 percent level or better," depending on the particular model specification. The relationship is in the same direction, but more highly significant, in analyses of incident data rather than accident data; the analyses of incident data cover only the period from 1981-86 (rather than 1957-86). The effect of operating margin on incident rates remains significant even after controlling for other measures of financial condition, such as interest coverage (a measure of debt leverage) and working capital (a measure of liquidity). Rose (1990, pg. 957) notes, however, that the direction of the relationship between operating margin and incident rate is reversed for large carriers, and speculates that "For larger carriers...higher profitability seems to be correlated with higher incident reporting rates."

[14] The accident data for this analysis were taken from National Transportation Safety Board accident reports from 1965-1986. Aircraft age data were provided by Boeing, and reflect the average age of all Boeing aircraft. The results are summarized in Table 3 of Morrison and Winston (1988, pg. 12). Aircraft involved in accidents during the 1965-1975 time period had an average age of 16,000 hours, compared to 20,000 hours for the industry as a whole. By the 1976-1986 time period (which includes both deregulation and a period of "de facto" deregulation prior to passage of the Airline Deregulation Act), the average age of aircraft involved in accidents had increased to 24,000 hours, compared to 28,000 hours for the fleet as a whole. The authors note that the general result was the same when they considered only "accidents where defective planes were a contributor" (pg. 11).

[15] In particular, Winpisinger states: "Between 1974 and 1978, only 16.6 percent of aircraft involved in accidents caused by metal fatigue had more than thirty thousand hours flying time. In the five years that followed, after deregulation, 66.7 percent had more than thirty thousand hours flying time" (pp. 365-366). He also notes that this trend applies to all accidents, not only those involving fatigue: "25 percent of the prederegulation accidents...involved aircraft with more than thirty thousand hours flying time, whereas five years after deregulation 41.9 percent of the aircraft involved in accidents had more than thirty thousand hours."

[16] Barnett and Higgins (1989) compiled data for 12 trunkline carriers between 1977-86, and 19 new entrants between 1976-86. These data included four "disasters, which kill the overwhelming majority on board," at the trunklines, and two disasters and one other fatal incident at the new entrants. Their actual measure of safety was the probability that a passenger on a randomly selected flight would be killed. This measure was chosen because it focuses on flights rather than passenger-miles (which is appropriate since most accidents occur during takeoff or landing), and gives greater weight to accidents that kill a large fraction of the passengers on board (regardless of how full the flight actually was). Despite the small number of events observed during the study period, the discrepancy in accident risk was large enough to be statistically significant at the 5% level.

[17] Accident data for this study were obtained from National Transportation Safety Board records for 1970 to 1985 (Oster and Zorn, 1987). Operational data (e.g., number of flights and number of passengers) were obtained from the CAB, the U.S. Department of Transportation, and the Regional Airline Association. According to these data, the trunk carriers had an average of 0.16 accidents due to pilot error per million departures in the post-deregulation period (between 1979 and 1985). Other jet carriers (including both new entrants such as Air Florida and People Express, but also more experienced carriers such as World Airways that were "new to scheduled passenger service") had an average of 0.60

accidents due to pilot error per million departures (Oster and Zorn, 1987, Table 2). This difference was significant "at the 90 percent confidence level." The overall accident rate was also different between the two groups of carriers (2.38 per million departures for the trunklines, 3.31 for new entrants and other jet carriers), but this difference was not statistically significant.

[18] As summarized by Rose (1992), "For total accident rates, airline operating experience has at most a weak negative effect, which vanishes in specifications that control for a carrier's average accident rate. For both fatal accidents and total incidents, however, experience exerts a strong, statistically significant negative effect: more experienced airlines have fewer fatal accidents and fewer incidents, other things equal."

[19] William N. Evans (1989), "Deregulation and Airline Safety: Evidence from Count Data Models," mimeo, University of Maryland-College Park, cited in Rose (1992, pg. 85).

[20] The database for this study included all accidents reported to the National Transportation Safety Board from 1990 through 1994. This database represented "29 new large airlines, 60 large established airlines, 50 new commuters, and 123 established commuters" (pg. 7, footnote 8), and included roughly 200 accidents, nearly 3,000 incidents, and nearly 4,000 FAA enforcement actions. No tests of statistical significance were performed, perhaps because the database included "the entire data sets of departures, accidents, incidents, and enforcement actions" during the study period, rather than a random sample. Nonetheless, if the data for 1990-94 are viewed as a random sample from a larger population of hypothetical flights, then a chi-square test for the equality of two binomial distributions finds that the accident rate for new entrants is significantly different than that of established airlines at a 10% level.

[21] On pg. 370, for example, Nance states: "No matter how bitter the competition between carriers, they could always (before deregulation) converse on matters contributing to air safety—and they did... [T]hat cooperation, if not dead, has been severely strained. Who has the time or money to spend on such meetings...?"

[22] In fact, Cappelli argues against the widespread view that "competitive pressures from new, low-cost airlines had forced the trunk carriers to cut costs," stating (pp. 50-51):

> Despite the popularity of this view, there is little evidence to support it. Upstart carriers such as People Express had an important influence on fares in many regional markets, but all told they never held more than about 4 percent of the market for passenger traffic. The unions began making concessions not because the carriers were forced to cut costs to compete with low fares but because they needed to cut wages to generate cash flow to help stave off bankruptcy. The main financial pressures on the carriers were the industry recession...and the bloody fare wars, not with the upstart carriers but with other trunk airlines.

[23] For example, on pg. 275, Nance (1986) notes: "any U.S. pilot who alighted at his destination (...after a near-disaster with a severe pitch-up in his 737) and picked up the phone to report the incident in detail would be taking an enormous risk. Even in the major, established airlines, his career could be imperiled. In the new-entry carriers or rapidly expanding ones with no time or money for FAA battles, and no union protection, such a phone call could be professional suicide."

[24] On pg. 58, the OTA notes that "FAA inspector training programs cannot keep up with new industry procedures and equipment, such as contract maintenance."

[25] For example, on pg. 371, Nance notes that "many of the new-entry carriers and newly expanded carriers are recyclers of old (sometimes tired) airplanes."

[26] Although not specifically focused on the post-deregulation period, Rose (1989, pg. 97) cites improvements introduced over the preceding 40 years as including "the diffusion of radar technology, development of the jet aircraft..., metallurgical and materials advances, the introduction and continued improvement of navigational and landing aids..., more sophisticated simulators for pilot training, and the like."

3. Aviation Industry Interviews

3.1 Background

In order to examine the impact of economic deregulation on safety in the aviation industry, the existing literature provides an excellent starting point. In particular, two books based on interviews with airline pilots, mechanics, FAA inspectors, accident investigators, and others (O'Malley, 1993; Nance, 1986) provide extensive first-hand perspectives on experiences in the aviation industry in the years after deregulation. These books serve as a useful supplement to the statistical analyses and other empirical data summarized in the literature review, and provide detailed information from interviews.

Nevertheless, both these references and the remainder of the literature leave several questions unanswered. The available literature on the effects of deregulation does not clearly summarize the other technological changes that were taking place in the industry at the same time. In addition, the literature is ambiguous about the causes of some observed phenomena. For example, Oster et al. (1992) found that the rates of pilot error, ground crew error, and equipment failure all increased in the mid-1980s. It is unclear from the literature whether this deterioration in performance is attributable to reductions in expenditures on maintenance and reduced pilot and ground crew qualifications after airlines were deregulated, or simply to the effects of increased travel volume. The main goal of the interview phase of this project was to shed additional light on these and other remaining questions. We also sought to gain additional insight into the human performance and safety impacts of deregulation, and to learn more about the programs and strategies that airlines used to guard against potentially detrimental impacts of deregulation.

The five interviewees included two individuals who had at least 20 years of experience in the aviation industry, and three of them had close to 30 years of experience. Although relatively few interviews were conducted, the interview candidates were chosen for their extensive experience, and in some cases their role as opinion leaders within the industry. Therefore, they can perhaps more appropriately be viewed as senior advisors to the project, rather than as a representative sample from within the industry.

All of them have held positions directly related to safety, such as director of flight safety, general manager of safety, vice president of flight operations, or vice president of regulatory affairs. Four of the five interviewees had significant experience at one or more major airlines in flight operations, safety, and/or maintenance, and one also had experience at a major aircraft manufacturer. In addition, at various times during their careers, two of the five had been involved in aviation safety research at the National Aeronautics and Space Administration (NASA), one had been a member of the National Transportation Safety Board, and one had worked in the Federal Aviation Administration (FAA). In addition to the union representative that we interviewed, one other interviewee had also been involved in union safety work through the Air Line Pilots Association. We were unable to identify an interviewee who was currently at

the FAA whose tenure at the agency spanned the period of deregulation, due to extensive turnover since that time.

The interviews were conducted by telephone between August and December 1999, and took approximately forty-five minutes to an hour to complete. In order to make the respondents comfortable, the interviews were not tape recorded. In addition, in order to gather as much information as possible, the questions asked during the interviews were open-ended in nature. We did not use a traditional survey instrument; rather, Appendix A contains the interview discussion guide that was used. The discussion guide addressed areas identified from the literature review as requiring further investigation, but also included confirmatory questions on topics that were extensively discussed in the literature review. It is important to stress that the resulting survey questions were used only as a guide; depending on their backgrounds, not all respondents were asked all of the questions listed, and conversation frequently strayed into areas not listed in the guide.

3.2 Summary of Interviews

3.2.1 The most important safety issues in the aviation industry

As the aviation industry continues to adjust to the impacts of deregulation, many of the important safety issues seem to be related to human performance. Three interviewees cited human performance issues as being critical, where human performance is taken to include both traditional ergonomics issues (e.g., fatigue and duty time limits; the design of tools, equipment, cockpits, work stations, and job aids), and also management and organizational issues (i.e., how to manage a large organization that must simultaneously make a profit and operate at high safety levels). The labor representative that we interviewed specifically raised concerns that the airlines and aircraft manufacturers are "dragging their heels and taking a backward stance" with respect to the issue of pilot fatigue. A fourth respondent cited specific safety problems (for example, altitude deviations, runway incursions, and controlled flight into terrain), all of which involve significant human performance aspects.

Another safety issue cited by one respondent was the need to gather and disseminate real-time weather information. A respondent whose primary area of responsibility is in maintenance cited the problems of aging aircraft as the biggest issue. Finally, the union representative mentioned air space modernization (including not only modernization of the air traffic control system, but also expanding the number of takeoff and landing slots) as the most important safety issue affecting the industry.

Overall, however, despite their serious concern about the safety problems discussed above, most respondents seemed generally comfortable with the safety performance of the aviation industry, at least at the major carriers (although not necessarily at start-up carriers and small-time operators, with which the respondents were not as familiar). Two respondents specifically noted that the industry is getting safer all the time, and referred to statistical data on accident rates to support that claim.

3.2.2 *Did deregulation affect safety?*

When asked how deregulation has affected safety overall, two respondents argued that it had not had a major effect. In one case, this was because the interviewee viewed the most serious safety problems in the aviation industry as being primarily international rather than U.S. problems; this interviewee noted that deregulation of the airline industry is not yet widespread around the world. Another respondent attributed the lack of effect to the fact that the airline industry has always been under a microscope with respect to safety; this individual argued that regulatory and public scrutiny of the industry has resulted in a continuous improvement in the industry's capabilities to identify and manage risk. A third respondent noted that the industry is far safer today than it was before deregulation, but did not believe that this reflected a cause-and-effect relationship.

However, some respondents did identify deregulation-related safety problems in particular areas. One respondent (the same individual who had identified aging aircraft as a significant safety issue in the industry) argued that deregulation may have been associated with increased aging of aircraft, since in the deregulated environment, every company is trying to grow and expand, which encourages keeping airplanes in service longer. Another respondent noted that the competitive pressures associated with deregulation may have induced some airlines (especially smaller regional carriers) to adopt "creative" flight schedules that exploit loopholes in the duty time regulations.

Two individuals noted that deregulation had increased the numbers of airplanes in the air, and hence the amounts of traffic being handled by the air traffic control system. One of these specifically suggested that this might be a factor in altitude deviations and runway incursions, and emphasized that communications is one of the two biggest accident causes in the industry. This individual also noted that in the first 10 years after deregulation, neither the new airlines nor the FAA were fully prepared to deal with the safety problems that they were confronting. He commented that some accidents had exposed the "underbelly" of how some carriers were operating. However, he viewed these problems as being largely transitory in nature, since today the FAA has recognized the problems posed by deregulation, and the new airlines are better structured and held to more stringent requirements.

3.2.3 *What explains the safety improvement observed shortly after deregulation?*

When asked to identify which changes in the industry could explain the improvement in safety observed during the early 1980s, most respondents emphasized technological improvements in the areas of equipment reliability and human performance. In the area of equipment reliability, one respondent noted that engines have become much more reliable over the years, so that engine failures, which used to be a fact of life, are now extremely rare. In addition, respondents commented that preventive maintenance has become much more sophisticated. Thus, in addition to better diagnostic tools, the aviation industry today also has a better understanding of optimum maintenance cycles and how to ensure that maintenance is used as cost-effectively as possible to prevent failure.

With respect to factors affecting human performance, two respondents noted that modern aircraft provide better information to pilots, and greater automation reduces the manual requirements for flight crews. One respondent also credited the development of high speed, high fidelity, and low cost flight simulators with significantly improving both the quality and the quantity of pilot training. The low cost of flight simulators enables airlines to provide more extensive training to their flight crews. In addition, flight simulators make it possible for airlines to take fewer chances in training and practice truly catastrophic situations that couldn't be done in real airplanes. (To illustrate the effectiveness of flight simulators in reducing risk, this person noted that one of the leading causes of hull losses before the advent of flight simulation was training accidents.) Yet another factor affecting the quality of training during the post-deregulation time frame was the adoption of crew resource management techniques to improve communications and teamwork.

The labor representative that we interviewed did not dispute the improvement in safety after deregulation, but stated that many members of his union believe that "the improvements would have been even greater without deregulation." This individual argued that statistics don't always tell the complete story, since there can be erosions of safety margin that are not reflected in actual accident statistics, but are clearly revealed in anecdotal experiences. He referred to the types of maintenance violations observed at Eastern Airlines as being "virtually unheard of in the airline industry" prior to deregulation, and noted that the actions of some airlines in cutting back safety standards to "FAA minimums" were also a product of deregulation.

3.2.4 What explains the deterioration in safety performance observed in the mid-1980s?

One respondent did not specifically recall that safety performance had deteriorated in the mid-1980s, and therefore did not address this question, and two others (including the labor union representative that we interviewed) felt that the apparent deterioration was probably just a statistical fluke due to the small number of accidents in each year. Both of the interviewees who did choose to discuss possible causes for the observed deterioration in performance cited the explosive growth in the number of new airlines starting up without historical experience in the years after deregulation. In addition, one respondent noted that the existing airlines were being "beaten to death" by lower fares at the same time. He stated that the pressure to reduce costs was very real, and did not find it surprising that there may have been a delayed reaction to these pressures.

With regard to concern about possible declines in employee qualifications during this period, one interviewee noted that his own airline did *not* reduce qualifications during the post-deregulation time period. If anything, he argued that employee qualifications *increased* during this time period, since new avionics technology increased the skill levels and training required of new hires, at least in the maintenance area. However, he also observed that while the best airlines get to pick and choose which people to hire, the lower-tier carriers can't afford to be as selective, so that problems with experience levels may have existed at other carriers.

3.2.5 *How has the Federal Aviation Administration performed since deregulation?*

When asked how effective the FAA has been at promoting safety, respondents gave highly variable answers. One respondent stated definitively that the FAA is a model regulatory agency, not only among aviation safety regulators around the world, but in virtually any industry.

Three respondents noted that the FAA is facing a monumental task in ensuring aviation safety, and is still playing catch-up and struggling with scarce resources, funding cuts, and scale-backs. Two of these individuals noted that the FAA has recently developed a new scheme for surveying air carriers (the Air Transportation Oversight System), which was intended to foster a systems approach to air safety and encourage stronger working relationships between the FAA and air carriers in meeting safety goals. While they felt that this system has good potential, both commented that it had been implemented too quickly and with inadequate resources. All three of these respondents seemed to feel that the FAA is doing a good job given the tasks it is facing and the resource constraints under which it is operating, but could do substantially better if given additional resources. Two of them also noted that the air traffic control system requires extensive equipment upgrades and additional resources in order to bring it up to speed. The labor representative that we interviewed specifically stated that the FAA has been chronically short of funding, and that air space modernization will require a more stable long-term base of funding that is not subject to political manipulation from one year to the next.

Finally, our fifth respondent felt that the FAA was doing worse and worse over time. This individual noted that historically, the U.S. aviation industry had one of the best safety records in the world, in part because of FAA oversight. However, he felt that recently the agency "has lost its edge," and noted that the agency seems to be floundering with respect to a number of issues, including training, aircraft certification, and the specification and procurement of air traffic control systems.

3.2.6 *Corporate culture and the environment for reporting safety violations*

Most of the responses to our question regarding the environment for reporting of safety violations were quite positive. One individual felt that there had not been any significant changes in the reporting climate since the introduction of the NASA Aviation Safety Reporting System in 1975. Another stated that the industry had gone through phases of underreporting after deregulation, and that airlines without a strong commitment to safety can make reporting of violations more difficult. Overall, however, most respondents felt that there had been a natural evolution of thinking in the industry to favor increased reporting, but did not attribute this improved reporting climate to deregulation.

The reasons for the observed improvement in the reporting climate were attributed to greater sophistication in the human factors area, changed management attitudes (e.g., greater appreciation for the value of reporting), and the existence of FAA hotlines and other systems to encourage reporting. One individual also noted that today there is more in-depth scrutiny by FAA inspectors than was typical in the pre-deregulation environment, which he perceived as being less stringent and characterized by a more "collegial" relationship between the FAA and

the carriers. Those respondents who did observe an improved reporting climate stated that it had unquestionably improved the safety of U.S. aviation, especially the quality of training programs. As one individual remarked, "If you don't know what's happening, you can't fix it. If you recognize a trend, then you can manage it."

Despite this trend toward improved reporting, respondents recognized that not all mistakes are reported, especially if they are not safety significant. However, the consensus was that under-reporting had diminished over time, and that the reporting systems were not missing many serious or safety-critical events. Some respondents also commented that there are sometimes pressures to maintain production, even if it means noncompliance with safety regulations, but this was viewed as being an exceptional situation rather than a trend across the industry as a whole. According to one respondent, companies have realized that "a single accident is literally a life-threatening event for a corporation," so saving a few cents here and there is viewed as not being worth the risk. This individual stated that managers at the top 10 airlines wouldn't dream of questioning expenditures related to safety. However, since he had not worked at startup carriers, he was unable to say whether the same commitment to safety was in effect at smaller carriers as well.

3.2.7 How do safety issues differ for the smaller carriers?

None of our interview respondents had first-hand experience working at smaller carriers, but some had interacted with smaller carriers as part of their jobs; e.g., with their airlines' connection partners. In general, there was a consensus that safety performance was probably not vastly different among smaller carriers, but that the smaller operators are probably not as safe on average as the major carriers, because fewer resources are available. However, two respondents noted that some small airlines have safety records just as good as those of the major carriers. One respondent specifically pointed out that different challenges require different management approaches, but that with suitable management, small airlines can still achieve top performance.

One individual cited the operation of used aircraft from a number of different sources, with different cockpit configurations, as a challenge to safety at a number of small airlines, since lack of standardization is a potential problem from a human performance standpoint. This individual noted that at a major carrier, used aircraft would generally be modified to be equivalent to similar aircraft in that airline's fleet, even though this is not required by safety regulations. Such modifications, which smaller operators may not have the resources to undertake, contribute to a higher level of safety, in his opinion. The union representative that we interviewed specifically argued that the distinction between commuter airlines and larger airlines had been artificial and that similar standards are now applied to all airlines.

One respondent believed that poor financial health was probably a better predictor of a poor safety record than small size. This individual commented that pressure for low fares and a need to keep resource expenditures under control could interfere with safety investments.

3.2.8 The impact of mergers on safety

Four of our five respondents had first-hand experience with at least one merger, and all had witnessed the effects of other mergers in the airline industry. Most respondents agreed that mergers are bound to have an adverse impact on safety in the short term, since they cause upheaval in organizations—"people not knowing exactly what to do or who to talk to, the flow of communication was interrupted."

The biggest safety problem cited with mergers was the merging of two corporate cultures. Different organizations have different ways of doing things, different manuals, paperwork, training programs, management and employee attitudes, etc., and merging two different cultures has proven to be very difficult. For example, one respondent noted that he can still identify "pockets" of people from the smaller airlines that were merged into his airline, and that they still have some gripes. Another airline had felt the need to recruit an "outsider" who was not affiliated with either side in the merger, to assist in integrating the two cultures.

Hand in hand with corporate culture problems, another serious problem associated with mergers was the morale of company employees. Morale suffered after mergers for a variety of reasons, of which the most important (cited by three of the five respondents) was integration of seniority lists. However, other morale problems were also noted. Two interviewees commented that when a dominant partner absorbs a smaller airline, the employees of the smaller company typically have morale problems, since they are likely to feel that the dominant group is in control and their concerns or suggestions are not being listened to. In addition, people were often concerned about whether they would have to relocate after a merger in order to keep their jobs, or whether they would become superfluous and be replaced by someone from the other merger partner. Opinions on whether such downsizing was actually common after mergers was mixed, with one respondent noting that his company didn't furlough anyone after its mergers, while another noted that mergers seem to occur during downturns, which create pressures to reduce resources.

Some respondents also noted training as a potential safety problem after mergers. One individual noted that some mergers have had serious problems with standardization (sometimes even maintaining two different training programs), and that these problems were sometimes not resolved until after an accident. However, another respondent stated that in his experience, training was enhanced after every merger. This appeared to be largely because the company picked up additional types of aircraft with each merger, so employees (especially in maintenance) had the opportunity to be trained for a wider variety of equipment and enhance their skills.

Despite the problems noted above, however, one interviewee argued that the longer-term effects of mergers have generally been beneficial for safety, since "consolidation has led to the creation of stronger companies with more resources at their disposal" for safety investments. This individual noted that economies of scale are critical. For example, a larger airline can invest in its own training facility, whereas a smaller airline must buy simulator time from another organization in order to conduct its training, and the simulators are then not always available at

convenient times. Similarly, a smaller airline can't afford to do its own maintenance, so contractors must do most of the maintenance, which creates tension and lack of control. By contrast, at a larger airline, the mechanics are likely to think, "my family is going to be riding on this airplane"; there is a greater sense of ownership. Thus, the short-term and long-term safety implications of mergers appear to be quite different.

Another area that was cited as a relatively favorable experience after mergers was the process of integrating safety programs at two different companies. While some mergers did lead to friction among safety personnel, in other cases, the safety people from different companies appear to have worked well together after mergers, and were able to put aside political and financial issues to focus on the critical safety issues at hand. Two interviewees specifically noted that mergers make it possible to take the best practices from both organizations, and can create a positive learning experience for safety professionals by exposing them to different ideas.

3.2.9 Employment and experience levels

As noted in the literature review, there was a large increase in employment in the aviation industry as travel volumes increased. On the question of whether this increase in employment levels had any effect on safety levels, our respondents were of mixed minds. Two respondents indicated that they did not observe any negative impacts on safety; in particular, one of these individuals noted that his airline did a lot of hiring after deregulation, but generally was able to hire well trained employees, often with bachelor of science degrees from the best aviation schools. Three individuals noted that rapid employment increases did pose challenges, for two reasons: (1) by bringing in inexperienced people and thereby diluting the average experience level in the company; and (2) by putting a strain on training programs. The combination of these factors did lead to less experienced employees at some airlines, according to these respondents, but one of them specifically indicated that the system was generally robust enough to absorb these changes without serious safety problems.

Two respondents also indicated that experience levels for pilots (at least at the major airlines) were often higher than in other areas, such as maintenance or passenger service. This was in part because of the widespread availability of pilots with commuter and general aviation experience to be hired by the major carriers. The availability of a pool of relatively experienced pilots available for hire may help to explain why safety problems associated with inexperience were relatively modest. The union representative that we interviewed noted that problems with inexperience were relatively minor at the large carriers, since they were able to hire people away from the smaller carriers, but that the small carriers often had tremendous problems with high turnover, and generally had to adapt their admissions standards to the conditions in the labor market at any point in time. This individual also noted that FAA minimum pilot experience levels are not always adequate. For example, he pointed out that a commercial pilot's license does not require nearly as much flying experience as the hiring standards at most major airlines, and that increased training may be needed when significantly lower hiring standards are applied (as at smaller carriers after deregulation).

One individual also commented specifically on the adequacy of current staffing levels with regard to safety issues. He indicated that staffing levels were actually quite variable from one job description to another, and from one organization to another. In particular, he noted a tendency in the last few years to keep costs at a minimum, with the result that fewer people were often doing more work, and that staffing levels were not necessarily adequate in all cases.

3.2.10 Changes in maintenance practices

In the literature review, reduced maintenance of airplanes was identified as a safety concern in the aviation industry in the 1980s. However, our respondents differed on the extent to which this had actually occurred. One individual mentioned that there had been a great deal of pressure to reduce maintenance costs in the years immediately after deregulation, but that the importance of maintenance is now more widely recognized, so that those problems were largely transitory. The labor representative that we interviewed specifically mentioned the federal indictment of Eastern Airlines for maintenance violations as an example of a deregulation-induced problem; he pointed out that pilots had been notifying their union representatives of pressure to accept airplanes with mechanical problems long before the eventual indictment. By contrast, another respondent argued that it makes no sense economically to skimp on maintenance, since maintenance translates into operational reliability. He speculated that any apparent reduction in maintenance might be due to newer fleets with inherently more reliable equipment (especially engines).

One individual (who had formerly worked at the FAA) argued that maintenance practices had actually improved after deregulation, but that this improvement was in part regulatory driven. He described a cycle in which the airlines develop new maintenance practices as a result of operational experience, and those improved practices are eventually encoded in regulations. Thus, an innovation that may have begun at one or a few airlines is eventually mandated for all airlines. This respondent believed that the greater sophistication of preventive maintenance practices today had unquestionably helped the safety performance of the aviation industry. He cited corrosion as an area where such improvements had a significant impact. As a result of extensive effort to understand the causes and effects of corrosion, the skins of a number of aircraft had been replaced for preventive maintenance purposes.

This same individual also noted that preventive maintenance resources have been significantly reallocated and optimized over the last 10-20 years. In particular, some types of equipment (such as engines) have become substantially more reliable over the years, so much less maintenance of those items is done today than prior to deregulation. In other cases, however, intervals between maintenance visits have been tightened, since older aircraft are now known to require more frequent inspections in certain areas.

3.2.11 Workload and morale

Most respondents agreed that workloads in the aviation industry have increased significantly since deregulation, due to pressures to increase productivity. For example, pilot flight hours have been increased, with the result that the airlines can accomplish more work with fewer

people. One respondent specifically commented that the increased travel volume has been largely responsible for the increase in workloads; he commented that with high demand, if the level of resources available to satisfy that demand is not increased, the quality and safety of flight operations would inevitably suffer. He believed that the increase in workloads has in fact affected safety performance, but that the overall accident rate may not a sufficiently sensitive measure to capture the effects of this change.

Another respondent cited burnout in the supervision and management ranks as being especially problematic. In particular, he observed that one major airline used to have supervisors assigned to roughly 6-12 pilots, an arrangement that is conducive to close supervision. Today, the number of individuals in such supervisory positions has been significantly cut back, so that the remaining supervisors may now each manage dozens of pilots. As a result, there has been increasing burnout among flight supervisors, some of whom have gotten tired of the management aspects of their jobs and have gone back to being pilots.

In the maintenance area, one respondent indicated that the level of routine maintenance and inspection has increased, both because airplanes get more use in today's environment, and also because preventive maintenance has increased, to protect safety and the airline's investment in increasingly expensive and sophisticated pieces of equipment. He realized that this increased workload could pose a potential safety concern, but stated that at his airline, management recognizes that people will make mistakes if they are pushed, and therefore is conscientious about not putting people under time pressure. With respect to morale in particular, he felt that the airlines today give mechanics the opportunity to use a wider variety of skills, so that highly trained mechanics are likely to be happier with their jobs and take more pride in their skills than prior to deregulation.

3.2.12 Use of contractors

Our respondents were generally in agreement that the use of contractors has increased in the years since deregulation. Two reasons were cited: (1) attempts to control cost; and (2) the increasing travel volumes in the industry, which have meant that some airlines cannot keep up with their own work internally. The impact of such outsourcing appears to have been mixed. One respondent noted that given the generally improving safety record of the aviation industry in the years since deregulation, outsourcing could not have had much of an adverse impact on safety. On the other hand, other respondents specifically stated that in some segments of the industry, safety has in fact suffered as a result of outsourcing. In particular, some low-cost, non-union carriers were cited as minimizing the use of in-house services and facilities, contracting them out to the lowest bidder instead. According to one individual, due to the complexity of requirements in the aviation industry, the use of contractors can lead to discontinuities and errors that would not have happened with all services integrated under a single operation.

Management of outsourcing was generally believed to be a critical factor in determining its safety impact. In particular, one individual noted that if managed properly, use of contractor services need not affect safety, and observed that at his own airline, contractors were required to meet the same standards as airline personnel. Another individual remarked that at his airline, use

of contractors in the maintenance field is quite limited. He pointed out that scheduled heavy maintenance is not contracted out at his airline, and that they have their own maintenance people wherever there is sufficient workload to justify that. Where they are unable to have their own maintenance people, and instead have contractors on call in case of problems, those contractors are trained for familiarity with the types of aircraft that they will be expected to service, and are held to a basic level of qualifications.

On a related issue, one respondent pointed out that before deregulation, many airlines had their own weather departments, but that now virtually all airlines rely on public weather services. While he felt that these services were generally adequate, he also argued that there is added value in "having your own weather experts, who could focus on the routes that you regularly fly, [and] become familiar with those weather patterns." Thus, as with the use of contractors versus in-house maintenance, there appears to be a greater sense of ownership when services are performed in-house rather than by other organizations.

3.2.13 Turnover

Turnover among the labor ranks does not appear to have been a major problem after deregulation at the major carriers. However, some individuals felt that labor turnover had increased, both because of deregulation, and simply due to economic downturns. Deregulation-related factors that contributed to increased turnover included bankruptcies, corporate incentives for early retirements as part of downsizing efforts, and the "B scale" (dramatically lower salaries for new hires than for employees hired under earlier contracts). However, there was no consensus that this increase in turnover had dramatically affected safety (at least among pilots), due to training programs, quality assurance programs, and the continuing vigilance of the FAA.

Two individuals noted that turnover has increased much more dramatically in the management ranks than in labor. In particular, management was viewed as being more "fragile," because of the cutthroat competition created by deregulation. One respondent particularly noted that before deregulation, each carrier was so highly regulated that there were not a lot of opportunities or needs for managers to relocate. Management was well compensated and stable, with people starting as front-line employees, working their way up through the management ranks, and spending their entire careers at a single airline. Since deregulation, and especially with the rapid growth of the industry, this individual noted that startup airlines would recruit managers from the established airlines. As a result, the whole working environment in the industry has changed. However, these management changes apparently did not cause a great deal of disruption on the work floor, since they were not reported to have had any significant adverse safety impacts.

3.2.14 Quality of training

Our respondents generally were in agreement that the quality of training in the airline industry had improved dramatically in the time since deregulation. However, these improvements were not attributed to deregulation itself, but rather to technology advances (e.g., the availability of high fidelity flight simulators) and specialization (with entire companies now specialized in aviation training). One interviewee noted that methods of training had improved, with greater

computer-based training, more hands-on aids in the classroom, and more sophisticated training programs designed and run by professional educators. Thus, the cutbacks in training that had been predicted in the immediate post-deregulation environment appear to have been short-lived. The increased quantity and quality of training that have been observed were generally believed to have had a positive effect on safety in the industry.

3.2.15 Labor/management relations since deregulation

All of our respondents were in agreement that deregulation had a major effect on labor/ management relations. Among the reasons cited for increased labor/management strife were an increased emphasis on the bottom line, a need to satisfy stockholders, rapid growth, and mergers. Our labor respondent described the resulting effects on morale as "horrendous." However, most respondents felt that this increased strife had not adversely affected safety. In particular, one individual noted that when pilots or mechanics are doing their jobs, they are not thinking about labor/management relations. Aviation professionals were described as dedicated people who know how to do their jobs, do them well, focus on what they're doing, and do not allow their personal dissatisfactions to spill over into their work. One individual argued that management also recognizes the importance of safety to the industry, and thus tries to put safety first even in the face of labor/management problems.

The union representative that we interviewed noted that airlines had abandoned "the public utility model" and adopted "the widget manufacturer model," so that they now operated like any other business. According to him, this change in paradigm was disastrous for labor relations, resulting in "horrible blood-letting...a terrible and bitter history of labor confrontations." In addition to wage concessions, this respondent also noted a number of work rule changes, some of which could be adverse to safety, such as more demanding and "creative" flight scheduling practices. He also attributed some of the demands for union concessions to losses caused or exacerbated by poor airline management, rather than by competition per se. According to this individual, the established carriers didn't know how to compete intelligently in the early years of deregulation, often drastically under-pricing seats in brutal fare wars, and then expected labor to bear the brunt of these mistakes.

Interestingly, despite the general perception in the literature that deregulation has always been bad for labor, one respondent who is currently in airline management felt that the unions are actually stronger today than prior to deregulation. In particular, he pointed out that under the regulated environment, there had been a mutual aid pact between the airlines (see for example Peoples, 1998, pg. 119), so that if one airline took a strike, the other airlines would pay them during that non-revenue period. In that environment, management did not feel terribly worried about labor relations, since a strike was not a company-threatening event. According to this particular respondent, airline management today has much less leverage against labor, because even a two- or three-week strike can be catastrophic.

3.2.16 Management and labor approaches to safety since deregulation

Most respondents believed that management pays more attention to safety today than prior to deregulation, because of the repercussions of accidents. They felt that management has moved beyond mere lip service to safety and compliance with regulations, and is actively working on developing a strong safety culture. However, two individuals noted that the trend toward senior managers with little or no aviation background was worrisome, since people who grew up in the aviation industry are likely to have a better appreciation of safety issues than managers who view the company primarily in financial terms: "When the top guy flies, he understands the need for safety." One of these individuals also noted that historically there had been no regulatory requirement for airlines to have a safety department or safety manager, and that new entrant carriers sometimes had no full-time safety director. Observing that "management is not monolithic," he pointed out that management at some airlines has been less conscientious about safety than at others. This individual also argued that the first decade after deregulation showed "a dip in the curve" in terms of management's approach to safety issues, but that "the curve has trended back upwards" over the last few years. Senior management's willingness to provide adequate resources to address safety problems was also cited as a challenge by one respondent.

On the labor side, one individual felt that labor had always been proactive on the safety front, and that labor's approach to safety had not changed dramatically since deregulation. However, other respondents stated that labor's awareness of safety had undergone much the same type of improvement as was observed in management. One individual specifically noted that examples like Air Florida, which went out of business because of safety problems, provide a great motivation for *both* management and labor to achieve improved safety performance. More generally, it was pointed out that all major aviation unions recognize safety as being critical to their membership and their livelihoods, so the unions have generally taken an active and constructive role on safety issues.

The labor representative that we interviewed felt that unionization was critical for safety, stating that "The only friend that a pilot has is his union, if he wants to stand up for safety issues." Without a union, he felt that significant erosion of safety could take place. He stated that provision of safety resources and expertise had always been a significant way for the aviation unions to attract membership, particularly among pilots, but that even so, the aviation unions had to become "even more vigilant and proactive" about safety after deregulation. According to this individual, the unions hadn't foreseen the extent of erosion in safety margins that deregulation would bring about, particularly at airlines that were facing impending bankruptcy or continuing to operate through a bankruptcy. After deregulation, the unions began to recognize that they did not have adequate protection against predatory management, and had to become more conversant with issues such as corporate finance in order to "beat them at their own game" and protect the interests of their membership. As a result, this respondent felt that the unions are now better able to stand up for themselves in negotiations, which he felt had strengthened their ability to deal with safety issues.

3.2.17 Thinking forward

A number of safety issues were identified as being crucial for the aviation industry over the next five years. Four of our five respondents mentioned the infrastructure of the air traffic control system and its ability to handle an increasing number of flights as a critical challenge, and two people pointed out that this increased demand for air travel is a direct result of deregulation. Two of these individuals also mentioned human performance issues, especially communications, as a continuing problem. Yet another respondent cited the challenge of bringing the global community (in particular, developing countries) into compliance with U.S. standards.

Two individuals also cited aging aircraft as a serious concern. They noted that there are a tremendous number of older airplanes flying today, and pointed out that this number is only going to grow, since companies are trying to maximize the productive lifetimes of their aircraft in order to get the most out of their investments. By contrast, one respondent stated that before deregulation, when an airplane got to be six to eight years old, the major U.S. airlines "traded it in" and sold it in secondary markets (e.g., overseas or for freight service). As airlines began keeping airplanes longer, new problems began to appear that had not been fully addressed in the original designs. As a result, a new safety sub-specialty was established to deal with aging aircraft issues, along with new FAA requirements. One individual felt that maintenance of aging aircraft would not pose a safety problem at the major carriers, who have both the resources and the commitment to do the right thing, but that this might not be true at some of the smaller carriers.

3.2.18 Advice for the U.S. Nuclear Regulatory Commission and the nuclear industry

The biggest safety concern about nuclear power deregulation that our respondents raised was how the nuclear generating companies will balance the competing goals of improving productivity, cutting costs, and maintaining safety. They noted that safety must remain the top priority even when competition creates cost pressures, and advised the industry not to "cut corners to meet production goals." One individual specifically cited mergers and acquisitions in the nuclear industry as a potential safety problem, due to the difficulties in planning and understanding all the factors that are involved in merging two corporate cultures.

Finally, two respondents recommended that the U.S. Nuclear Regulatory Commission (NRC) learn from the FAA's experiences after deregulation, and strive to keep a highly trained and skilled regulatory workforce in place. The respondent who had worked for the FAA noted that the FAA today has a significantly larger oversight infrastructure than either before deregulation or in the early days after deregulation, and suggested that the NRC may have to strengthen its staffing as well. Areas that he cited as crucial were overseeing facility operations, monitoring compliance with regulations, and working in partnership with the nuclear generating companies to solve safety problems.

3.3 Summary and Conclusions

Almost twenty years after passage of the Airline Deregulation Act, the aviation industry is still evolving in response to deregulation. Economic deregulation has led to considerable consolidation through mergers and acquisitions among the largest airlines, after an initial period of proliferation of smaller startup airlines. Deregulation has also been responsible for substantial growth in travel volume, which created safety challenges in the years immediately following deregulation, and will continue to do so in the years ahead.

The interviews were successful at identifying possible causes for the significant safety improvements observed in the airline industry after deregulation. Causes cited by respondents included improved engine reliability, more sophisticated preventive maintenance practices, improved automation and information systems, improved and increased training (due to greater reliance on flight simulators), and the adoption of crew resource management techniques. Respondents were not in agreement as to whether there was a significant deterioration in performance in the mid-1980s, but some interviewees did cite the explosive growth in new startup airlines and the resulting competitive pressures on the existing airlines as possible explanatory factors.

Interview respondents identified human performance issues and aging aircraft as significant remaining safety challenges in the airline industry. Two issues that emerged as particularly relevant to the nuclear power industry after electricity deregulation were the difficulties of merging corporate cultures after mergers and acquisitions, and the need to maintain adequate regulatory staffing levels to cope with deregulation-induced challenges.

4. Rail Deregulation Literature Review

4.1 Introduction

The railroad industry has long been a critical component of the national economy. It has also long been subject to both economic and safety regulation. A push for economic deregulation began in the 1970s and culminated in the passage of the Staggers Act of 1980. This act, which provided a significant degree of economic deregulation, is generally believed to be responsible for substantial improvements in the financial performance of the railroad industry.

Several similarities between the railroad industry and the nuclear power industry are important to keep in mind when examining the impact of economic deregulation on safety in the railroad industry. First, both industries are based on technologies requiring large fixed capital expenditures. Difficulties in quickly adjusting capital levels may produce pressure to enhance short-run financial performance by skimping on expenditures that are more easily adjusted in the short run (such as maintenance) and that may have long-term safety consequences.

In addition, the railroad industry has faced changes in technology and institutional frameworks that have affected its competitive position. For example, competition from both the trucking and the aviation industries had a significant impact on railroads' ability to compete for high-value freight traffic and inter-city passenger traffic. The public investment in highways and airport infrastructure and the lack of public investment in rails, ties, and right-of-way in the railroad industry are also important institutional factors affecting the competitive position of the railroads. The nuclear power industry may face similar issues in the future. For example, the recovery of "stranded costs" and the treatment of decommissioning costs may affect the competitive position of the nuclear power industry. Likewise, competition from other energy technologies is likely to affect the financial strength of the nuclear industry.

In the remainder of this review, we first look at the regulatory history of the railroad industry. We then explore the relationship between economic deregulation and safety. Finally, we conclude with an overview and draw some possible implications for safety in the nuclear power industry.

4.2 Regulatory Environment

Almost from its beginning, the railroad industry has been subject to regulation. Regulation of common carriers has long been a tradition in the common law (Peyton, 1981; Keeler, 1983). Under the common law, railroads were required to serve all shippers desiring service, charge reasonable rates, and provide safe transportation for goods and people.

Formal regulation of railroads in the United States (as opposed to regulation under common law) arrived first at the state level (Harper, 1959). While many of these regulations dealt with pricing and rates, safety practices were also a topic of regulation (Teske et al., 1995).

Concerns over differences in regulations between states, the growing importance of railroads in the national economy, and the increasing use of the federal courts to address railroad issues resulted in pressure to establish federal regulatory oversight of railroads. Eventually, railroads also came to favor regulation as a way to stabilize their markets and enhance their profitability (Teske et al., 1995; Peltzman, 1976). In 1887, these pressures resulted in passage of the Interstate Commerce Act, which established federal regulatory oversight of railroads.

Federal regulation initially focused on issues of rates and shipper discrimination. Establishment of this new regulatory structure led to inevitable conflicts over the scope and jurisdiction of the newly formed Interstate Commerce Commission (ICC). By 1910, both shippers and railroads were generally content with federal regulation (Teske et al., 1995). However, controversy continued with regard to the extent to which the ICC could make rules that would affect intrastate commerce. The Shreveport decisions resolved these issues in favor of the ICC—namely, by specifying that the ICC could regulate intrastate railroads rates, since these rates had the potential to affect interstate commerce.

During World War I, control of railroads was transferred to the federal government to facilitate war efforts. The passage of the Transportation Act of 1920 returned control of railroads to private interests. This legislation incorporated the judicial results obtained from the Shreveport decisions, giving the ICC wide latitude over both interstate and intrastate railroad rates. The 1920 Act also transferred control of route service and route abandonment from the states to the ICC. As will be seen, restrictions on the ability to abandon routes seem to have played a critical role in the financial health and, consequently, the safety performance of railroads. The 1920 Act also allowed the ICC to promote railroad mergers and provided for subsidies to financially weak railroads. During the 1920s and 1930s, at the request of Congress, the ICC developed railroad merger plans. The railroad industry ignored the proposed mergers because they required profitable railroads to purchase unprofitable railroads (Daggett, 1928; Keeler, 1983).

Growing competition from the trucking industry (and to a smaller extent the barge industry) characterized the period after the 1920 Act. While the trucking industry was also regulated, beginning with the Motor Carrier Act of 1935, it proved to be a formidable competitor to the railroads for the transportation of high-value commodities. Rate regulations enforced by the ICC prevented railroads from lowering rates to compete with trucks. In addition, after World War II, the automobile and the aviation industry began to reduce the demand for rail passenger service.

Faced with inter-modal competition and an inability to reduce rates, railroads began to lobby for the deregulation of rates (Keeler, 1983). The results of this effort were reflected in the Transportation Act of 1958, which was designed to help railroads in several respects. First, it provided financial assistance to help financially strapped railroads rebuild physical assets. Second, the Act was designed to promote healthy economic conditions in all modes of transportation. Third, it provided for easier abandonment of passenger rail service. This allowed railroads to relieve themselves of at least some high-cost/low-revenue operations. Further relief

was obtained when railroads were relieved of all passenger obligations by the formation of Amtrak in 1971.

While the 1958 Transportation Act provided some relief to the rail industry, "large portions of the rail industry [still] faced serious problems..." (Teske et al., 1995, pg. 41). By 1973, several railroads in the northeast United States faced bankruptcy. Because of these financial strains, these railroads had spent less on maintenance (Keeler, 1983). (As will be seen later, this period also corresponded with an increase in the number of accidents.) The financial difficulties of railroads during this period resulted in the Regional Rail Reorganization Act of 1973 (the 3-R Act). The 3-R Act focused on reorganization of the northeastern railroads under federal control. This reorganization resulted in the formation of Conrail, as well as the abandonment of about 3000 miles of track.

The continued financial deterioration of railroads outside the northeast resulted in the Railroad Revitalization and Regulatory Reform Act of 1976 (the 4-R Act). The 4-R Act allowed railroads more latitude regarding the setting of rates. In particular, it set the stage for deregulation by allowing railroads complete freedom of rate setting for types of traffic with sufficient competition among shippers. The 4-R Act also streamlined the process for railroad mergers, and again eased the regulations on abandonment of unprofitable lines. Finally, the 4-R Act provided more than $4 billion in subsidies and loan guarantees over a four-year period.

The final and most significant step in the economic deregulation of the railroad industry was taken with the passage of the Staggers Act of 1980. While the 3-R and 4-R Acts provided some federal regulatory relief, railroads were still constrained by state regulations. The Staggers Act gave railroads a high degree of freedom to set rates, the right to execute private shipping contracts, and significantly reduced the authority of state regulatory agencies. The reduction in state authority enhanced the railroads' ability to abandon unprofitable lines. While railroads are still subject to both federal and state regulation, with the passage of the Staggers Act the degree and scope of this regulation has dramatically decreased.

After the Staggers Act, the railroad industry was dramatically transformed by significantly increased merger activity: "the number of independent Class I railroad systems has been reduced from 30 in 1976 to 9 in 1999, with the 5 largest Class I railroads accounting for 94 percent of industry operating revenue" (General Accounting Office, 1999). In addition, during this same period, the number of small railroads grew dramatically, from 212 in 1980 to 550 in 1994. Most of these new railroads represented "spin-offs" that were created as larger railroads abandoned unprofitable lines.

After the Staggers Act was passed, the financial performance of the railroad industry improved significantly. Productivity, as measured by revenue ton-miles per employee, improved dramatically (U.S. Department of Commerce, 1994). The share of interstate freight traffic carried by railroads ended its downward trend and stabilized soon after Staggers (Braeutigam, 1993). Railroads also introduced technologies to effectively compete with trucks by offering inter-modal operations for containerized freight.

4.3 General Safety Trends

Like most heavy industry, the normal day-to-day operations of railroads poses risks of injury and death to those working on the railroads. In addition, major accidents such as derailments and collisions can also pose safety risks. These risks are imposed on employees as well as passengers, pedestrians, and automobile drivers. Derailments and collisions are probably the clearest risks in the mind of the public at large. However, the highest risk exposure are for employee injuries while engaged in routine support operations required when trains are not in motion—for example, maintenance of equipment and right-of-way. In 1996, injury risks ranged from 1,100 per 100,000 employees (falls incurred by members of train crews) to 3,800 per 100,000 employees (workers performing maintenance on way and structures). Risk of fatality for railroad employees is much lower, and tends to be associated with the movement of trains—ranging from 14.0 fatalities per 100,000 employees (train crews) to 10.3 fatalities per 100,000 employees (maintenance workers on way and structure). Risks to the public include injuries and fatalities:

1) At rail grade crossings.
2) To "trespassers" (members of the public present without authorization on rail property or right-of-way).
3) To "non-trespassers" (non-employees of the railroad who are injured or killed when legally on railroad property or on property adjacent to railroad property).
4) To passengers on trains.

Data on accidents have been collected by the ICC for the railroad industry dating back to about 1890. "Accidents" are defined as railroad activities resulting in damages higher than a specified dollar amount. Changes in the threshold defining an accident over the years make interpretation of the number of accidents very difficult. However, the ICC also keeps statistics on injuries and deaths. A major change in the definition of an employee injury in 1975 resulted in an apparent tripling of the annual number of injuries. Thus, a comparison of employee injury rates before and after the definition change is very difficult, which affects comparisons of the pre-4-R and the post-Staggers periods.

As illustrated in Figure 4-1, aggregate deaths attributed to railroad accidents peaked in 1910 at nearly 10,000 deaths (data used to construct Figures 4-1 through 4-5 were taken from Savage, 1998, pp. 14-16, 217, and 218). The annual number of deaths decreased dramatically until the 1960s, when it leveled out. Since the 1970s, deaths have continued to decrease, but at a slower rate. Annual numbers of injuries (excluding railroad employees) are shown in Figure 4-2. Similarly, annual numbers of injuries to railroad employees are shown in Figure 4-3. These figures follow a similar pattern, with injuries peaking in 1910, followed by dramatic reductions between 1910 and 1960 and smaller reductions afterwards. Injury and death rates, depicted in Figures 4-4 and 4-5, show a general downward trend, with the greatest decreases in the period from 1890 through 1960, and smaller decreases subsequently.

Because of issues associated with indexing the dollar threshold for reporting accidents, consistent data on derailments and collisions is only available since 1975. The number of collisions and derailments was 50% higher in 1979 than in 1975. However, by the mid-1990s, the number of collisions and derailments had decreased to about 40% of the number in 1975. Much of this improvement occurred in period between 1980 and 1985.

Overall, the safety statistics from the railroad industry suggest that, with the exception of the early 1900s and the period from 1960 through the 1970s, the safety performance of the railroad industry has dramatically improved. To what factors can this trend be attributed?

Early in the development of the railroad industry, there were few uniform equipment standards. The first significant federal safety regulation was the Safety Appliance Act of 1893, which required the use of the Westinghouse Brake and Janney Couplers. Other federal legislation was passed in the early 1900s. Among the contributions of those laws were to:

1) Require specific safety hardware and equipment.
2) Specify procedures for handling and storing explosives and other hazardous substances.
3) Sponsor research, development, and implementation of automatic signaling devices.
4) Require inspection of boilers.
5) Regulate the hours that could be worked by railroad employees.

Railroads are held responsible for damage to goods being transported. Furthermore, beginning in 1908, railroad employees were granted the right to file claims against their employers for job-related injuries. Thus, railroads have a stake in promoting safety, particularly with respect to derailments and collisions. This interest was manifested by the Chicago and North Western Railroad when it implemented its "Safety First" program in 1910. This program was designed to train employees, and thereby improve employee safety. By 1918, every Class I railroad in the U.S. was required to implement such a program.

This system of government-specified standards and railroad-sponsored safety programs resulted in significant improvements in safety performance from 1920 through 1960. However, beginning in 1960, safety performance began to deteriorate. As discussed above, during the 1960s many railroads began to experience financial difficulties that eventually resulted in the bankruptcy or near-bankruptcy of several railroads in the Northeast and Midwest. During this period of financial distress, many railroads deferred expenditures on track maintenance. Therefore, the number of accidents attributed to track defects increased dramatically (U.S. Office of Technology Assessment, 1978). These derailments included a number of cases involving tanks cars carrying hazardous and/or toxic materials that created risks for individuals living near the derailment sites.

In 1967, during this period of increasing safety problems, the Federal Railroad Administration (FRA) was established. In 1970, the Federal Railroad Safety Act gave the FRA authority to

regulate all aspects of railroad safety. The FRA immediately established rules designed to detect and rectify problems with rails and rolling stock. These rules were enforced by the FRA, which was given the authority to inspect railroads and assess fines if violations were found. In addition to the efforts of the FRA, Congress passed several pieces of legislation designed to improve the safety performance of railroads. Among other issues, these laws addressed training requirements for railroad engineers, highway grade crossings, and the handling and labeling of hazardous materials.

Thus, the accident problems of the 1960s caused a change in the safety regulation paradigm in the railroad industry. Prior to 1960, railroads sponsored internal safety programs and relied on self-enforcement to meet federally mandated safety requirements. Starting in the 1970s, additional safety requirements were promulgated, and enforcement responsibilities (backed up by the ability to assess fines) were vested in the FRA.

4.4 Financial Pressures and Equipment Maintenance

The poor safety performance of the railroads in the 1960s is generally believed to be associated with the poor financial health of railroads during this period. Economic theory predicts that firms facing financial difficulties are more likely to engage in risky behavior (Golbe, 1988, pg. 79).[1] In the context of railroads, this theoretical result translated into the empirical observation of lower expenditures on maintenance of rails and rolling stock. At the same time that track maintenance was reduced, railroads were also switching to the use of larger rail cars. The combination of larger cars and lower-quality track resulted in more derailments. According to statistics from the FRA, track-caused derailments and collisions on Class I railroads increased by about 80% between 1975 and 1978. After passage of the Staggers Act, expenditures on track increased dramatically. Annual capital expenditures on track were approximately 4.5 times higher in 1985 than in 1975 (Savage, 1998).

Studies of accident rates in the railroad industry during the 1960s documented a correlation between financial health and accident rates, with better financial health generally associated with lower accident rates (Golbe, 1983). This relationship was strongest for those railroads that were unprofitable. Statistical analysis of unprofitable railroads found that as financial losses decreased, so did accident rates; for profitable railroads, the relationship between profits and accident rates was generally insignificant.[2]

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[1] Golbe's arguments are based on an asymmetry between the distributions of returns to bond holders and equity holders. By expanding on a traditional model of bankruptcy, Golbe shows that increasing risk increases the expected gain from continuing operations. Thus, a higher level of risk will reduce the probability of a forced bankruptcy. Consequently, Golbe concludes that firms near bankruptcy may have incentives to take more risks.

[2] Golbe's analysis is based on annual safety statistics and annual financial performance for the period 1964 through 1967. The sample was restricted to Class I railroads resulting in a sample of "about 90 firms for 1963 and 1964 and about 70 firms for 1965 through 1967." Of the total sample, the number of unprofitable firms ranged from nine to sixteen. Analysis of the data indicated that the relationship between financial performance and accidents differed between profitable and unprofitable railroads. Therefore, separate models were estimated for profitable and unprofitable railroads. When conducting regression analysis of the unprofitable railroads, Golbe increased the sample size by estimating one regression model for the period 1963 through 1964 and a separate regression model for 1965 through 1967.

Some would argue that the relation between decreased track maintenance and increases in accident rates was particularly troubling in that the risky behavior (decreased track maintenance) is not easily knowable to the shippers, so the increased risk is not immediately apparent to the shippers. Only through the experience of loss and/or delay of shipments do shippers become aware of the problem (Savage, 1998).

Note, however, that the interpretation of the observed safety trends since deregulation is open to some speculation. It seems clear that poor financial health of railroads in the 1960s and 1970s resulted in reductions in expenditures on track maintenance and possibly other safety-related maintenance. This eventually resulted in higher rates of accidents. The governmental response to these problems was twofold. First, the establishment of the FRA increased regulatory pressure on the railroads through the imposition of track standards, which were enforced by FRA inspections and backed by fines for violations. Second, concern about the financial health of the railroads led to substantial (but not complete) economic deregulation of the railroad industry. Since these changes occurred at roughly the same time, it is difficult to determine whether increased safety regulation or the improved financial health of railroads was primarily responsible for the improvements in safety observed after passage of the Staggers Act.[3]

It is interesting to note that, while problems associated with poor track maintenance have been greatly reduced, they have not disappeared. In a review of accidents that occurred at the CSX railroad in 1997, the General Accounting Office (GAO, 1998a) concluded that inadequate track maintenance was a contributing factor.

4.5 New Entrants

The overall safety performance of the railroad industry tends to be dominated by the performance of the largest railroads. Therefore, investigating the relative safety performance of the smaller railroads may shed further light on the relationship between economic deregulation and safety performance. In particular, some of the financial distress in the railroad industry was attributed to the requirement to continue service on unprofitable lines. Once railroads could abandon these unprofitable lines, financial conditions improved and so did safety performance. However, abandonment of small lines resulted in a proliferation of small railroads that provided service on lines abandoned by the larger Class I railroads. Many of these smaller railroads are non-union and are able to operate at a profit because of lower labor costs (Savage, 1998).

The proliferation of smaller lines raises the question of whether these smaller lines are likely to have a significant difference in safety performance relative to the larger Class I railroads. For example, in 1997, the Association of American Railroads (AAR) estimated that there were about 550 railroads in the United States, owned by 319 economic entities. Of these 319 entities, about

[3] According to Savage (1998, pp. 153-154), it is clear that track related accidents peaked in 1978, and had dropped dramatically until about 1982. Beginning in 1978, FRA inspections of track began to increase substantially, coincident with the drop in track-related accidents. Expenditures on track trended upward between 1976 and 1982, and increased dramatically after 1982. The FRA would claim that the dramatic decrease in track related accidents prior to 1982 can be attributed to its safety-related activities. Others point out that the track standards were developed by the FRA in the early 1970s, and thus are not likely to be the source of reduced track-related accidents given the dramatic increase in track-related accidents between 1975 and 1979.

76% were common carriers (i.e., not port railroads or railroads owned by shippers). Among the common carriers, five railroads accounted for approximately 80% of carloads shipped in the United States (Savage, 1998). Thus, the railroad industry is now characterized by a small number of large Class I railroads specialized in moving large trains for long distances, and a larger number of smaller railroads that do more short-haul and switching business.

An analysis of accident rates suggests that smaller railroads experience a somewhat higher rate of safety problems than the larger railroads. For example, for the period from 1994 through 1996, statistics from the FRA indicate that the smallest railroads (Class III) had:

1) An employee fatality rate about 30% higher than larger railroads (measured in fatalities per billion employee hours).
2) A rate of collisions that is about twice that of larger railroads (measured in collisions per million train miles).
3) A rate of derailments about four times that of larger railroads (measured in derailments per million train miles).

Class II railroads have 70% higher rates of trespasser fatalities (per billion train miles) and collisions (per million train miles) than Class I railroads, and about a 50% higher rate of derailments per million train miles (Savage, 1998, pg. 119).

While these statistics are illustrative, they must be viewed with some caution. The risk exposure for small railroads is much smaller than that for the larger railroads, and some types of accidents (for example, fatalities) are very rare. Therefore, the expected number of fatalities in any year is very small for the smallest railroads. The employee fatality rate for Class III railroads as reported above reflects a single severe accident by a Class III railroad that resulted in multiple fatalities. Thus, the reported employee fatality rate for Class III railroads for the period 1994-1996 may well be overstated. Likewise, the risk of collisions and derailments is larger during switching operations than during long-haul operations. Thus, the smaller short-haul railroads might be expected to have a higher observed rate of such accidents than Class I railroads whose operations focus more on long hauls across main lines in open country. Finally, the lines acquired by the small new entrants were the lines that had been found unprofitable by the Class I railroads. It seems reasonable to expect that these unprofitable lines were subject to higher levels of deferred track maintenance. Thus, the small railroads might have been starting operations with tracks that were at higher risk for derailments than the tracks retained by the Class I railroads.

Taken together, these facts suggest that the safety performance of the small new entrants may not be substantially worse than the performance that would have been experienced by Class I railroads had these railroads maintained short-haul operations. This supposition raises the question of why the smaller firms, with presumably lower financial resources, have been able to maintain a reasonable safety record. A part of the answer (Savage, 1998, pg. 119) is that the substantial reduction in employment by Class I railroads created a pool of experienced railroad personnel. These employees were then available for hiring by the new entrants. A second factor is the structure of interchange agreements between railroads. These interchange agreements

govern the use of rail cars. For example, railroad A can seek damages against railroad B if railroad A's cars are damaged while on railroad B's track. Likewise, if railroad A determines that railroad B's cars are not safe, it can withdraw railroads B's cars from service and repair them at railroads B's expense while those cars are under railroad A's control. Typically, repair in a Class I railroad repair facility is more expensive than in facilities owned by smaller (and typically non-union) railroads. Thus, it is in the interest of small railroads to ensure that their rolling stock meets the safety specifications of the railroads with which it interconnects. Finally, larger railroads may exert pressure on smaller railroads to provide safe service. This pressure comes from the fact that damages to shipments are apportioned among railroads handling the shipment in proportion to the number of miles that the shipment moved on a particular railroad's tracks. As a result, the long-haul Class I railroads tend to bear a larger percentage of the financial cost of damage to shipments as a result of collisions and derailments than the smaller short-haul railroads, regardless of where the accidents occurred.

Evaluating all of these factors Savage concludes that while these are reasons to be concerned about the safety performance of smaller railroads, "... there is little empirical evidence that they pose a serious safety threat" (Savage, 1998, pg. 121).

4.6 Mergers and Acquisitions

Economic deregulation has led to substantial consolidation through mergers and acquisitions among the largest railroads. In 1960, there were more than 100 Class I railroads (Savage, 1998, pg. 102). The number of Class I railroads decreased to 30 in 1976, and to nine in early 1999 (GAO, 1999). This consolidation has significantly changed the operations of the railroad industry. The creation of larger railroad systems has increased the use of unit trains and decreased the amount of switching activity. According to Savage (1998, pg. 18), in the mid-1970s switching accounted for about 30% of all train miles, while by the 1990s, it accounted for only about 13% of train miles.

Since switching is inherently riskier than long-haul operations, the reduced emphasis on switching (all else being equal) should improve the safety performance of the railroad industry, particularly with respect to derailments and collisions. This hypothesized trend has actually been observed. However, it is also clear that the reduction in derailments and collisions can not be attributed solely to the reduced emphasis on switching. In particular, derailments and collisions increased by nearly 50% from 1975 through 1978, a period in which switching activity was nearly constant. By contrast, between 1978 and 1981, the number of accidents had decreased to a level lower than that in 1975, while the rate of switching declined only slightly. According to Savage (1998, pg. 18), this suggests that factors other than the reduced emphasis on switching (presumably the improved financial performance of the industry) must also have played an important role in the observed reduction in derailments and collisions.

The overall safety performance of the railroad industry has apparently not been negatively affected by mergers and acquisitions, since the recent mergers have occurred during a period of generally improving safety. However, in at least one merger case the results were not so favorable. In the mid-1990s, the Southern Pacific and the Chicago and North Western railroads

were acquired by Union Pacific (UP). Problems developed, particularly in Texas, and the merger was described as "the most spectacular merger fiasco of modern times" (Passell, 1998). Passell identified a clash of corporate cultures as a major issue in the post-merger problems: "Union Pacific's by-the-book culture clashed badly with Southern Pacific's, where managers had long been accustomed to making do with chewing gum and bailing wire." In addition to problems with corporate culture, the merged firm also experienced problems with staffing and scheduling. Additional details are provided below, in the section on labor relations and human performance.

During the first seven months after UP acquired Southern Pacific, the company experienced three fatal accidents (Passell, 1998) that resulted in the deaths of seven railroad employees (Boisseau, 1997). These accidents ultimately resulted in a special nation-wide FRA investigation of UP and its safety practices. According to FRA Administrator Molitoris, the FRA concluded that "there are critical safety deficiencies present at some locations and immediate action across the entire UP systems is necessary" (Boisseau, 1997).

After the FRA investigation had been completed, Molitoris attributed the safety problems to four main areas, including under-staffing, fatigue, insufficient levels of supervision, and dispatching deficiencies (FRA, 1998). Furthermore, Molitoris concluded that the problems at UP occurred while overall safety performance in the railroad industry was improving, and that there were no apparent advance indicators that safety problems were on the horizon for UP.

Concern about the negative aspects of the UP/Southern Pacific merger has resulted in heightened attention on railroad mergers. For example, FRA and the Surface Transportation Board (STB) joined forces in developing proposed regulations governing mergers, consolidations, and acquisitions of control (U.S. Department of Transportation, 1998). The proposed regulations would require railroads planning to engage in such transactions to file a Safety Integration Plan (SIP) with the FRA and STB for review and approval. An SIP must document the railroads' step-by-step plan for safe implementation of the proposed merger. Likewise, shippers concerned about the CSX and Norfolk Southern acquisition of Conrail pressured executives of those railroads to meet with UP officials to devise a plan to avoid the problems of the UP/Southern Pacific merger (Salpukas, 1999).

4.7 Mode Shifting

The trucking industry was economically deregulated with the passage of the Motor Carrier Act of 1980. Although trucking had long been a major source of competition for railroads, inter-modal competition in freight transportation increased following regulatory reform.

Boyer (1989) attempted to determine how mode shifting due to deregulation affected the overall safety of surface transportation. It is well established that railroads are considerably safer than motor carriers, and that this safety differential widened after regulatory reform. Many economists at the time believed that deregulation would encourage the growth of rail traffic at the expense of less-safe motor carrier traffic, and thus safety would improve. However, Boyer (1989), using data from 1963 to 1983, found just the opposite—that deregulation initially

resulted in some traffic shifting from railroads to motor carriers, even after controlling for an underlying historic trend to greater use of trucking. He attributed the shift to the fact that rates for trucking service fell after deregulation, whereas rates for rail service rose modestly after 1980. Boyer (1989, pg. 275) estimated that 29 additional deaths, 349 additional injuries, and 337 additional accidents per year were due to the deregulation effect of shifting traffic from rails to highways.

These results were questioned by Jovanis (1989, pg. 282), who claimed that, due to dubious assumptions, "Boyer's estimate is high, if significant at all, and that the mode shift effect is small at best." Jovanis points out that Boyer's calculations assume that railroads and trucks are equally competitive over all lengths of haul. In particular, he notes that "Because trucks will be generally more competitive over shorter distances, Boyer's method will overestimate total truck miles and thus total truck accidents due to mode shift" (Jovanis, 1989, pg. 282).

Although no study to date attempts to quantify the safety consequences of mode shifting using more recent data, most factors now suggest a reversal of Boyer's early results and point toward an improvement in overall surface transportation safety. While some rail rates did increase shortly after Staggers, by 1988 deregulation had significantly lowered rates for most commodities (Wilson, 1994). The AAR (1999b) recently noted that "average rail rates have fallen more than 50 percent on an inflation-adjusted basis since 1980." As a result, the railroad industry's share of the inter-city freight transportation market (measured in ton-miles) has increased from 35% in 1978 to more than 40% today (AAR, 1999b). Thus, it now appears that deregulation has resulted in a shift toward the relatively safer mode of surface transportation. According to the AAR (1999d), "Trains help ease highway congestion and make our roads safer by shifting highway-trailer traffic from public roads to private rails."

4.8 Labor Relations and Human Performance

While railroads and most shippers have benefitted under the Staggers Act, organized labor has clearly suffered. In particular, employment in the railroad industry has declined dramatically since deregulation, even as rail volume has begun to increase. Class I freight railroad employment fell 62% between 1976 and 1996, from 483,000 to 182,000 employees (GAO 1998a, chapter 0:2). This decline was facilitated by the heightened level of mergers, line abandonment, and the adoption of laborsaving technologies, but also by negotiated crew-size reductions. The bargaining power of unions had fallen significantly by the mid-1980s, with railroads aggressively seeking labor concessions such as wage freezes, two-tiered pay systems, and work rule revisions to reduce crew sizes (Hsing and Mixon, 1995; Talley and Schwarz-Miller, 1998).

According to the literature, the state of labor relations worsened following deregulation. Talley and Schwartz-Miller (1998, pp. 125-140) detail the particularly contentious negotiations that began in the mid-1980s and continued into the 1990s. As competition increased, both between railroads and from the trucking industry, railroads pushed harder for concessions. This push for concessions was largely backed by federal governmental actions. Presidential Emergency Boards were appointed on several occasions to issue recommendations, which were generally

more favorable to the railroads than to the unions. Moreover, Congress interrupted numerous strikes by enacting back-to-work legislation (usually within a day of the work stoppage) and making the disputes subject to mediation and arbitration. Such federal intervention clearly hurt rail unions, giving railroads "the leverage to make crew-reduction agreements possible" (Talley and Schwartz-Miller, 1998, pg. 130). Deregulation thus resulted in weakened bargaining power for unions and significantly falling employment and union membership. However, because barriers to entry have prevented a large influx of nonunion firms, the rail industry has remained highly unionized since deregulation. In particular, the percentage of employees that were unionized in the railroad industry fell only from 83.2% in 1974 to 70.6% in 1997 (Hendricks, 1994; Hirsh et al., 1998). This represents a small decrease compared to the economy-wide decline in private-sector unionization, which fell from 23.4% to 9.7% during the same period (Hirsh et al., 1998).

Although the weakened status of rail unions following deregulation had the potential to reduce safety levels (since unions have traditionally fought to improve safety in the workplace), it does not appear to have had severe safety consequences in practice. Railroad deregulation was associated with statistically significant reductions in worker injury and illness rates through 1985 (Viscusi, 1989, pg. 85), even controlling for factors thought to influence safety (e.g., output levels, prior-year injury and illness rates, and employment changes). More recently, AAR president Hamberger noted that "Both train accident and employee injury rates have declined by 70 percent since 1980" (AAR, 1999a).

Several factors related to labor may have contributed to these safety improvements, offsetting the negative effects of deregulation. First, work-rule concessions made by unions contributed to the financial improvements that helped railroads prevent further maintenance deferments. Significant labor concessions allowed railroads to reduce average crew sizes from four to two, and to increase the train mileage defining the basic work day, which reduced overtime costs. See for example Talley and Schwarz-Miller (1998), Davis and Wilson (1999), and MacDonald and Cavalluzzo (1996).[4] Profits thus increased after deregulation despite declining rail revenues, "because costs, particularly labor costs, fell sharply" (MacDonald and Cavalluzzo, 1996, pg. 81). Real labor expense per ton-mile dropped 56% between 1980 and 1990, compared to only a 20% drop in the decade before Staggers (MacDonald and Cavalluzzo, 1996, pg. 85). Overall, rail costs were as much as 40% lower than they would have been under regulation, according to Wilson (1997, pg. 21).

Another factor that may have contributed to safety improvements despite the weakened status of unions is that labor turnover remained low following deregulation. Low turnover helped keep experience and tenure levels high. Morrow et al. (1997, pg. 445) recently surveyed employees from the four largest Class I railroads, and found that rail workers had on average 21.2 years of

[4] Unions had traditionally argued that minimum crew sizes were necessary for safety reasons, but railroads claimed that changing technology, such as the shift from steam to diesel engines, made some positions unnecessary. See for example Fisher et al. (1971).

industry experience, 19.6 years of company tenure, and 20.8 years of union tenure.[5] The authors therefore characterize railroad employees as "long term workers with relatively low turnover." These results are not surprising considering the finding by Freeman and Medoff (1984, pg. 94) that unionism, along with the higher wages associated with unions, reduces turnover at firms. The continued high rate of unionization in the rail industry, coupled with improvements in labor productivity and railroad finances, helped maintain wages following deregulation. A study by Hendricks (1994, pp. 217-225), using data through 1988, found that relative wages of railroad workers actually increased slightly after deregulation.[6] While results from more recent studies find that bargaining power shifted to the railroads after the mid-1980s, they do not find any appreciable declines in relative earnings through 1993 (Talley and Schwarz-Miller, 1998; Belzer, 1998).

Finally, railroad workers have been found to place an extremely high value on workplace safety (Morrow et al., 1997, pg. 450), and rail unions are still active in promoting safety and fighting for pro-safety legislation. In the wake of the 1998 Amtrak accident in Illinois, for example, three unions in the rail industry formed a special task force to study the issue of unsafe railroad crossings. The Rail Crossing Task Force is building a database of unsafe crossings, and urging the FRA "to step up efforts to design and test crossing-safety systems that are more difficult to circumvent, such as four-way gates" (United Transportation Union, 1999). Unions have also worked with rail management to combat operator fatigue. The two groups recently reached an agreement on work/rest issues that United Transportation Union President Charles Little called "a big step toward improving rail safety and the quality of life for our members" (AAR, 1999c).

Despite these findings, however, some evidence suggests that railroad employment cuts following deregulation may have gone too far. Recent GAO reports (1997, 1998a) note that progress in reducing rail accidents has slowed since 1987. The GAO (1997) also notes that Class I freight railroads now use fewer people and less equipment to haul heavier loads over fewer miles of track. That report suggests: "these changes in operations could lead to more rail collisions and accidents as a result of greater congestion and fewer qualified employees to perform essential maintenance... While current safety trends are positive, it is uncertain how further advancements in technology or reductions in employment will affect safety in the future" (GAO, 1997, chapter 0:4.1). These concerns may have resulted from the findings of FRA investigations into several accidents at CSX and UP during 1997. According to the GAO, the FRA's review of CSX "recommended that CSX evaluate its staffing levels and hire additional employees where needed" (GAO, 1998a, chapter 0:3.2).

FRA investigations of UP revealed that human factors were the main cause of the 1997 accidents at the newly merged railroad. According to FRA Administrator Jolene Molitoris, under-staffing, fatigue, insufficient supervision, and dispatching deficiencies were the major problems affecting safety at the railroad (FRA, 1998). FRA investigations revealed that under-staffing was

[5] Data on turnover and human capital for employees of smaller railroads were not available.

[6] The data used for this study are cross-sectional data drawn from the March Current Population Survey (CPS) from 1968 to 1988 and the May CPS from 1973 to 1988. Rail wages are relative to wages of manufacturing production workers. Controls include age, education, marital status, veteran status, gender, race, occupation, weeks worked, hours per week, location, and union density.

particularly severe among train and engine service personnel, supervisors, and dispatchers at UP. The agency found that, due to a cutback in clerical workers, supervisors were overwhelmed with paperwork and thus unable to perform their intended safety functions. Moreover, UP had problems with dispatching due to under-staffing, insufficient supervision, and deficient training of dispatchers. The FRA noted that by the mid-1980s (shortly after deregulation), human factors had become the leading cause of train accidents (FRA, 1998a). Molitoris summed up the more recent environment as follows (U.S. House of Representatives, 1998, pg. 34):

> First of all...the train accident rate between 1985 and 1993 was basically flat... Secondly, human factors were becoming a very large part of the reason for injury and death, and the resolution of human factors issues is much more difficult than the capital investment solutions to other causes. Third, rail traffic was, and is, growing significantly, (over 30 percent since 1990), and at the very same time, employee numbers are half of what they were in 1980.

The FRA Administrator went on to discuss the important safety issues that can affect large railroads (U.S. House of Representatives, 1998, pp. 36-37):

> fatigue...is the number one underlying cause for human issue accidents, and hiring, training levels, and communications issues. Huge issues that are crucial to safety... I think what we are seeing is that the changes really are representing safety challenges that are much bigger than ever before. Clearly, with half the number of employees, even with improved technology, the whole issue of safety redundancy is often much more limited or absent.

Overall, however, the substantial drop in employment and the weakened status of unions following deregulation appear to have had little adverse impact on safety levels. One possible reason for this outcome is that technological improvement in the industry may have meant that at least some of the positions eliminated were no longer needed. Other potential factors include the industry's improved financial health, a continued low rate of labor turnover, and rail unions' ongoing efforts in promoting safety for their members. Nevertheless, given the recent increase in rail traffic, there is now concern that staffing levels in the industry may be inadequate. This concern has resulted from the simultaneous slowing of improvement in rail safety since the mid-1980s, and the fact that human factors, such as fatigue, have become the leading cause of train accidents.

4.9 Implications for the Federal Railroad Administration

Just as the railroad industry was being deregulated economically, the FRA simultaneously increased safety regulation. Savage (1998) provides a detailed description of the numerous safety regulations that were passed beginning in the late 1970s—standards that cover track, locomotives, grade crossings, and certification of locomotive engineers. In addition, FRA inspections of track, equipment, and operating practices increased significantly after deregulation (Savage, 1998).

The FRA takes some credit for the dramatic improvement in rail safety since Staggers (FRA, 1999):

> FRA's traditional site-specific safety inspection program has produced substantial gains in railroad safety with real benefits for the American people... These substantial safety improvements occurred even as freight railroad traffic and train density increased to record levels following economic deregulation of the industry as a result of the Staggers Rail Act of 1980.

The railroads, however, dispute this, and credit deregulation for making it economically feasible to increase capital expenditures on track and maintenance. The AAR noted: "Staggers had everything to do with this [improvement in rail safety] as it increased cash flow, providing railroads with the money needed to eliminate deferred maintenance, upgrade track and purchase new and safer equipment" (AAR, 1999b). Savage seems to side with the railroads, but cautions: "While the upward trend in accidents that started in the 1960s was subsequently reversed in the late 1970s, the causation of this reversal is open to question" (Savage, 1998, pg. 162).

Nevertheless, the railroads, the GAO, and industry experts have all leveled significant criticisms against the FRA since deregulation. The railroads have been particularly critical of safety regulations that specify detailed designs, finding them inflexible and unresponsive to changes in technology (Savage, 1998). Railroads also blame the FRA for being unwilling to amend rules that are deemed obsolete or effective. Perhaps the strongest criticisms, however, have been directed at the FRA's methods of monitoring and enforcement. The FRA has been charged with relying too much on violations and civil penalties as the primary means to obtain regulation compliance. A 1982 GAO report found that individual violations rarely captured the attention of senior management, possibly because they tended to receive only small penalties and there was often a significant lag in assessing those penalties. Therefore, the GAO (1982, pg. i) claimed:

> The Railroad Administration could more effectively fulfill its enforcement responsibilities if it would reduce the number of individual, routine inspections performed and shift its emphasis to broad-based system assessments, comprehensive evaluations of railroads' entire systems and operations.

Two articles in the trade journal *Railway Age* (Miller, 1993, 1996) echoed these criticisms. As revealed by interviews in the 1993 article, short-line railroad management was highly critical of some inspectors for writing up minor violations that, in the words of one railroad president, "divert the very scarce management time and attention from the real safety issues..." Both articles make it clear that management wanted inspectors to evaluate overall company safety procedures, not to randomly look for track and equipment violations. Savage (1998, pg. 164) notes: "One may argue that the FRA's strategy since 1970 has not only been pointless but actually may have been counterproductive in that it has alienated the industry rather than helped to enroll management in improving safety."

The FRA instituted a significant shift in its safety program starting in 1993. Instead of relying mainly on violations and penalties, the FRA has "emphasized cooperative partnerships" with

railroad management, labor unions, and the states (GAO, 1997). The FRA now works with labor and management through the Safety Assurance and Compliance Program (SACP), established in 1995 to "address systematic safety problems" (FRA, 1999b). Because of their new partnering approach, FRA inspectors conducted about 20% fewer site-based inspections in 1995 (FRA, 1996; GAO, 1997). The FRA also formed a Railroad Safety Advisory Committee in 1996 to develop recommendations for new rules or revisions to existing rules by seeking consensus between labor and management (GAO, 1997).

Although the GAO (1997, 1998a) seems generally supportive of the FRA's new approach to safety, the agency concluded that "it is too early to determine [whether it] will sustain a long-term decline in accidents and fatalities." The GAO also noted that "While the number of accidents declined rapidly prior to 1987, progress continued at a slower rate from 1987 to 1996" (GAO, 1998a, chapter 0:3). Others have complained that the rule-making process under the new Railroad Safety Advisory Committee is too slow (U.S. House of Representatives, 1998). Moreover, both railroad labor officials and the GAO expressed concern over the fact that the FRA has allocated fewer resources to concerns about railroad bridge safety and workplace injuries under its new approach (GAO, 1998a).

While the FRA acknowledges that the rail accident rate was essentially flat between 1985 and 1993, Molitoris attributes the more recent improvements to the SACP (U.S. House of Representatives, 1998, pp. 34-35):

> SACP minimizes the hostile relationships that were historic between the parties and focuses everybody's efforts on eliminating safety hazards now... Since 1993, rail-related fatalities have decreased by 18 percent. On-the-job casualties have decreased 46 percent, train incident rates decreased 11 percent, and grade crossing incident rates by 20 percent.

Nevertheless, the FRA is aware of the challenges that it faces as industry restructuring continues in the deregulated environment. The FRA has encountered new issues—related to mergers and the resulting "mega-railroads," the proliferation of smaller railroads, and the large reductions in employment—that have forced the agency to leverage its resources. According to the FRA Administrator, "Many of the human factor issues concerned areas outside of the realm of existing regulation, such as, training, staffing, and management oversight" (FRA, 1998). The FRA Administrator also noted: "[These] are tremendously complex issues that demanded that we retrain all of our team so that they would become expert in facilitating and uncovering these kinds of issues" (U.S. House of Representatives, 1998, pg. 36).

Despite these new challenges, the FRA's workforce has remained relatively static in recent years, consisting of approximately 750 safety professionals overall, with roughly 400 inspectors throughout the country (U.S. House of Representatives, 1998; FRA, 1999).

4.10 Summary—Impacts of Deregulation on Rail Safety

As noted above, many of the factors that have affected the performance of the railroad industry have counterparts in the nuclear power industry. For example, just as public subsidy of its competitors' infrastructure affected the rail industry, decisions regarding the recovery of costs associated with "stranded assets" may affect the financial performance of the nuclear power industry. To the extent that the public covers the cost of stranded assets through fixed charges, nuclear power plants should be better performers than they would otherwise be in the unregulated energy market. Also, just as advances in automotive and aviation technology affected the rail industry, changes in power generation technology may affect the relative competitive position of large electric generating stations such as nuclear plants. Finally, in both industries it is difficult to rapidly adjust the level of capital investment, which can create financial pressures in some circumstances. Therefore, the experiences of the rail industry with economic deregulation are potentially of interest to the nuclear power industry.

The U.S. railroad industry has been regulated almost since its beginnings in the 1800s. The earliest forms of regulation were based on concepts of common law. Additional regulation occurred as states began to establish state-level regulatory bodies. With passage of the Interstate Commerce Act in 1887, railroads began to be subject to federal regulation. Over time, struggles between state and federal regulatory agencies were typically settled in favor of the federal ICC.

Much of the regulation focused on economic aspects of the industry, including rate setting, obligations to serve, and prohibitions against price discrimination among customer classes. Despite a safety record that would be viewed as unacceptable today, railroads remained largely free of safety regulation until 1893. The dramatic expansion of railroads at the turn of the century resulted in large increases in the numbers of injuries and fatalities attributed to railroads. By 1915, it was legally established that the federal government had constitutional authority to regulate safety as well as economic aspects of railroads. While the federal government established safety standards, the railroads were largely self-regulated with respect to safety until 1970. From the 1920s until the 1960s, this self-regulation provided an ever-improving safety record in the railroad industry.

Throughout the period of economic regulation, railroads faced various financial challenges. These difficulties were related to the inability of railroads to drop service on unprofitable lines, the inability to raise and lower prices in response to changing economic conditions, and significant competitive threats from the trucking and airline industries. Thus, by the 1960s, many railroads (particularly those in the Northeast and Midwest) found themselves in significant financial trouble. Financial difficulties led to decreases in expenditures on track maintenance, which in turn resulted in higher rates of accidents.

Concern about the increased rate of accidents resulted in establishment of the FRA, whose mission was to regulate all aspects of safety in the railroad industry. The FRA attempted to carry out its mission by establishing track, equipment, and operational standards. These standards were enforced through inspections, with fines assessed for violations of the standards that were discovered during the inspections.

Concern about the financial health of railroads resulted in several changes in federal regulations, culminating in the Staggers Act of 1980. With the passage of the Staggers Act, railroads had significantly more latitude to set prices, abandon or sell unprofitable lines, and merge with other railroads. The reduction in economic regulation resulted in improved financial performance of the rail industry.

While the evidence is mixed, it appears that improvements in the financial health of railroads probably played a critical role in improved railroad safety performance. This conclusion is based on several important aspects of the rail industry:

1) The liability structure for the rail industry provides incentives for safe service.

2) The rail industry provided significant improvements in its safety record between 1910 and 1960. This was during a period when railroads were largely self-regulated in terms of safety issues.

3) The 1996 acquisition of the Southern Pacific and the Chicago and North Western railroads by UP resulted in cost-cutting measures to improve the financial performance of the merged firm. These cost-cutting measures were followed by decreases in safety performance.

Thus, while the presence of safety standards is important, it also appears that financial factors play an important role as to whether these safety goals are met. The large apparent impact of financial stresses on safety performance in the railroad industry raises the question of identifying the critical factors leading to these financial stresses. In addition to the obvious role played by economic regulation, insights can be gained by looking at the role of technology and the institutional context of the transportation industry:

- The railroad industry is based on long-lived capital investments, particularly rails, ties, and right-of-way. Thus, when experiencing financial difficulties short of bankruptcy, only a portion of railroad expenditures can be adjusted in the short run. For a period of time, economic regulation precluded cost reductions through service reductions or revenue increases through price adjustments. Likewise, the strength of unions constrained reductions in labor costs. Together these pressures apparently created strong pressures for the railroad industry to undertake actions that ultimately reduced safety performance.

- Early in the development of the U.S. transportation system, railroads appeared to enjoy a great competitive advantage. However, the development of automotive technology and the establishment of the trucking industry started to erode the cost advantage of railroads for the movement of high-value commodities. Likewise, the development of aviation technology greatly reduced the ability of the railroads to compete in a cost-effective manner for inter-city passenger travel.

- Finally, the institutional structure of the transportation industry plays an important role. The major competitors to the railroads all use publicly provided infrastructure. The successful development of the trucking industry as a competitor to railroads was dependent on the

development of a modern highway system. Likewise, the development of the aviation industry is based on substantial public investment in infrastructure, and transportation using barges is dependent on publicly provided waterways.

As we have seen, the overall safety record of the railroad industry has improved despite the dramatic employment declines that followed deregulation. It seems that initially, any negative effects related to employment cuts were offset by other factors, perhaps most importantly by the increased capital investment made feasible by the industry's improving financial health. Through mergers and acquisitions, the rail industry also saw the emergence of a few large railroads that dominate the long-haul business, and the proliferation of small firms (including many new entrants) that focus on short-haul and switching operations. The overall safety record of the industry suggests that these factors alone need not cause serious safety problems.

Nevertheless, there have been recent signs that employment cuts may have begun to adversely affect safety performance. This effect may become more apparent if rail traffic continues to increase. Evidence of this problem is seen in the fact that human factors have replaced equipment failure as the leading cause of railroad accidents (FRA, 1998). Major problems linked to recent accidents include under-staffing, fatigue, insufficient supervision, and inadequate training. As indicated by Molitoris, the continued industry restructuring and heightened importance of human factors in the deregulated environment have created new challenges for the FRA, and addressing these challenges, through new programs like SACP, has strained the agency's resources.

The acquisition of the Southern Pacific and the Chicago and North Western railroads by the UP in the mid-1990s provides a case in point. Pressures to reduce costs and improve the financial performance of the merged company led to both operational and safety problems in the new firm. The experience of the UP railroad suggests that careless cost cutting in trying to improve the financial performance of newly-acquired assets can compromise safety performance.

Figure 4-1: Railroad Industry Fatalities

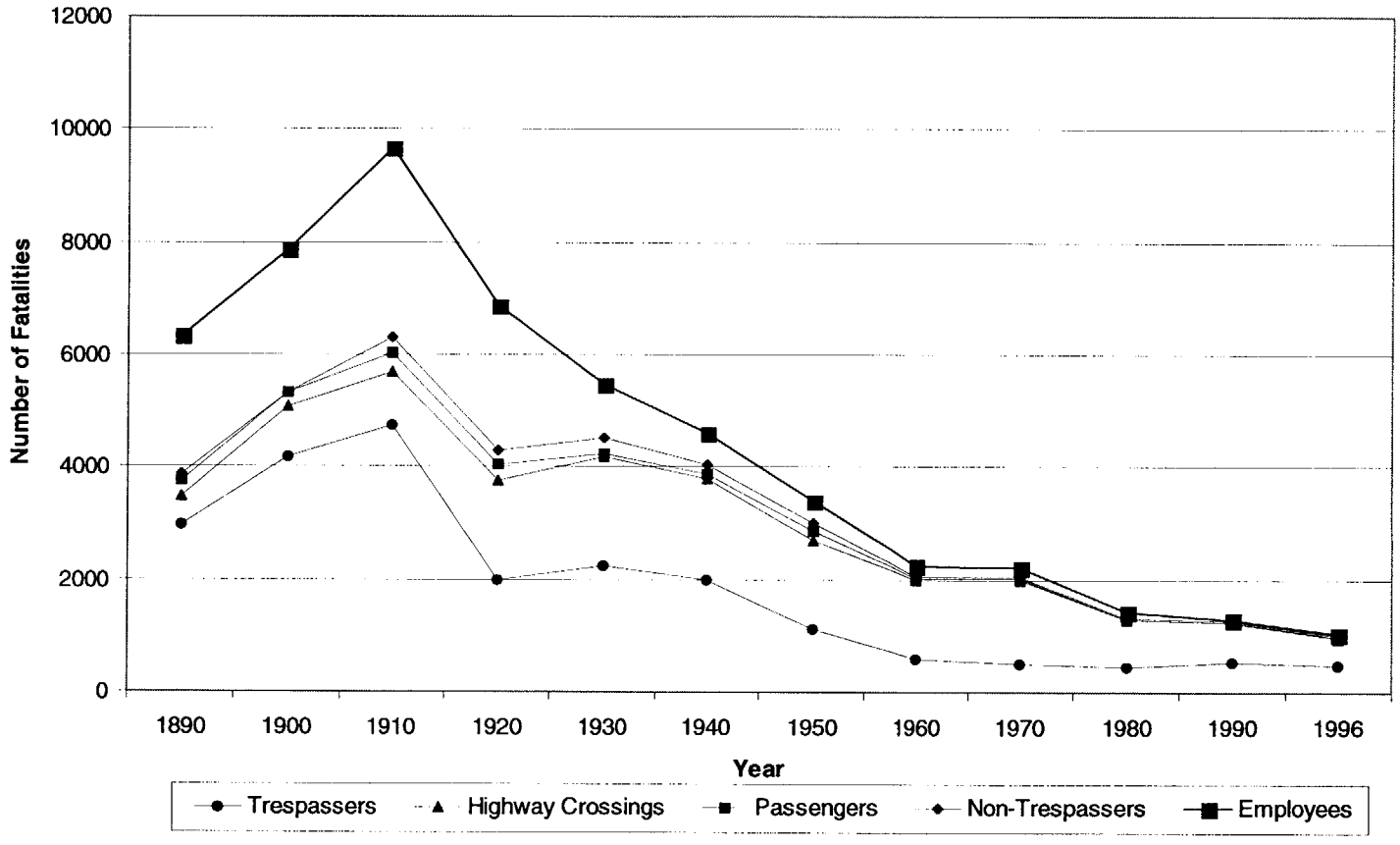


Figure 4-2: Railroad Industry Injuries to Nonemployees

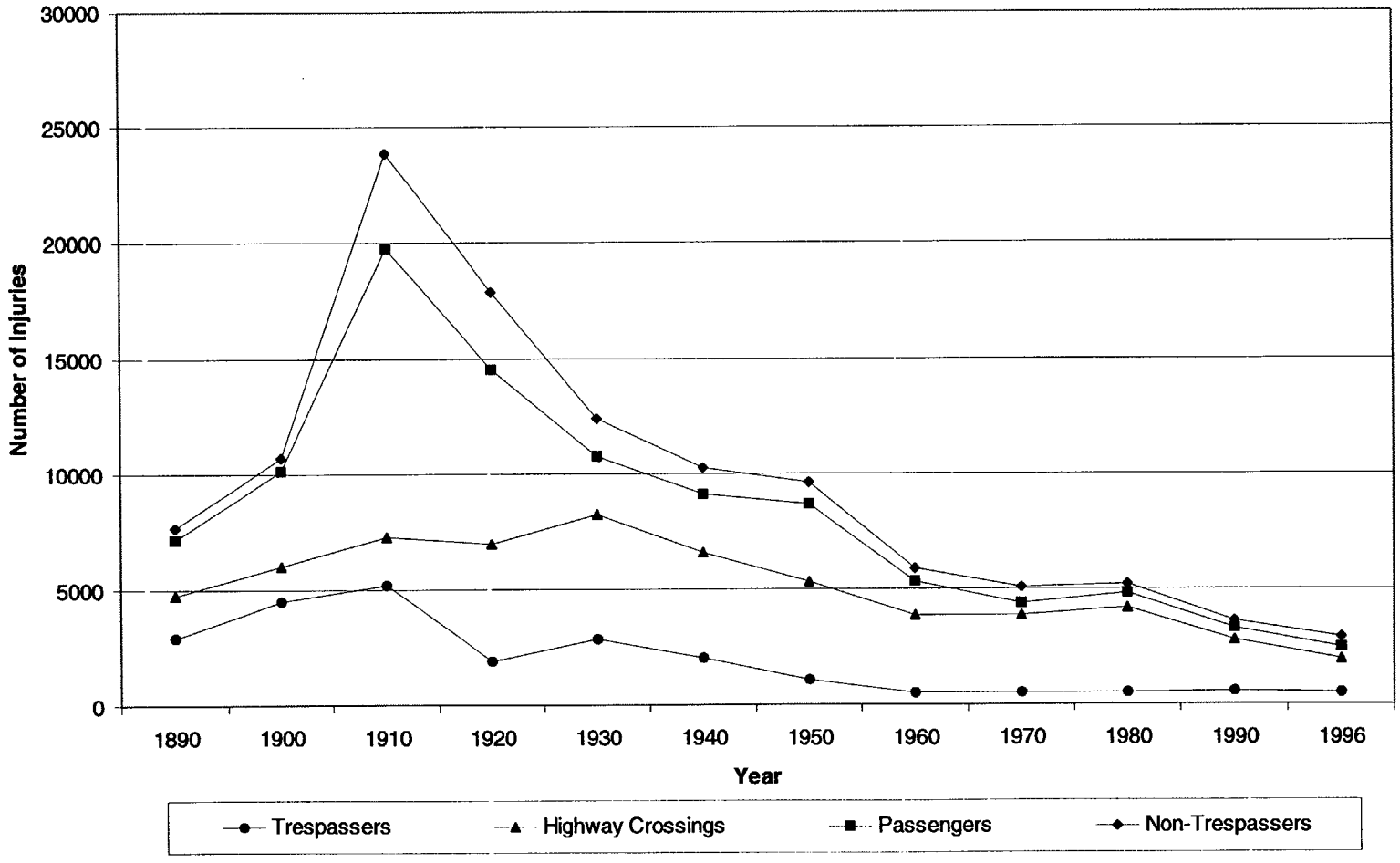


Figure 4-3: Railroad Industry Injuries to Railroad Employees

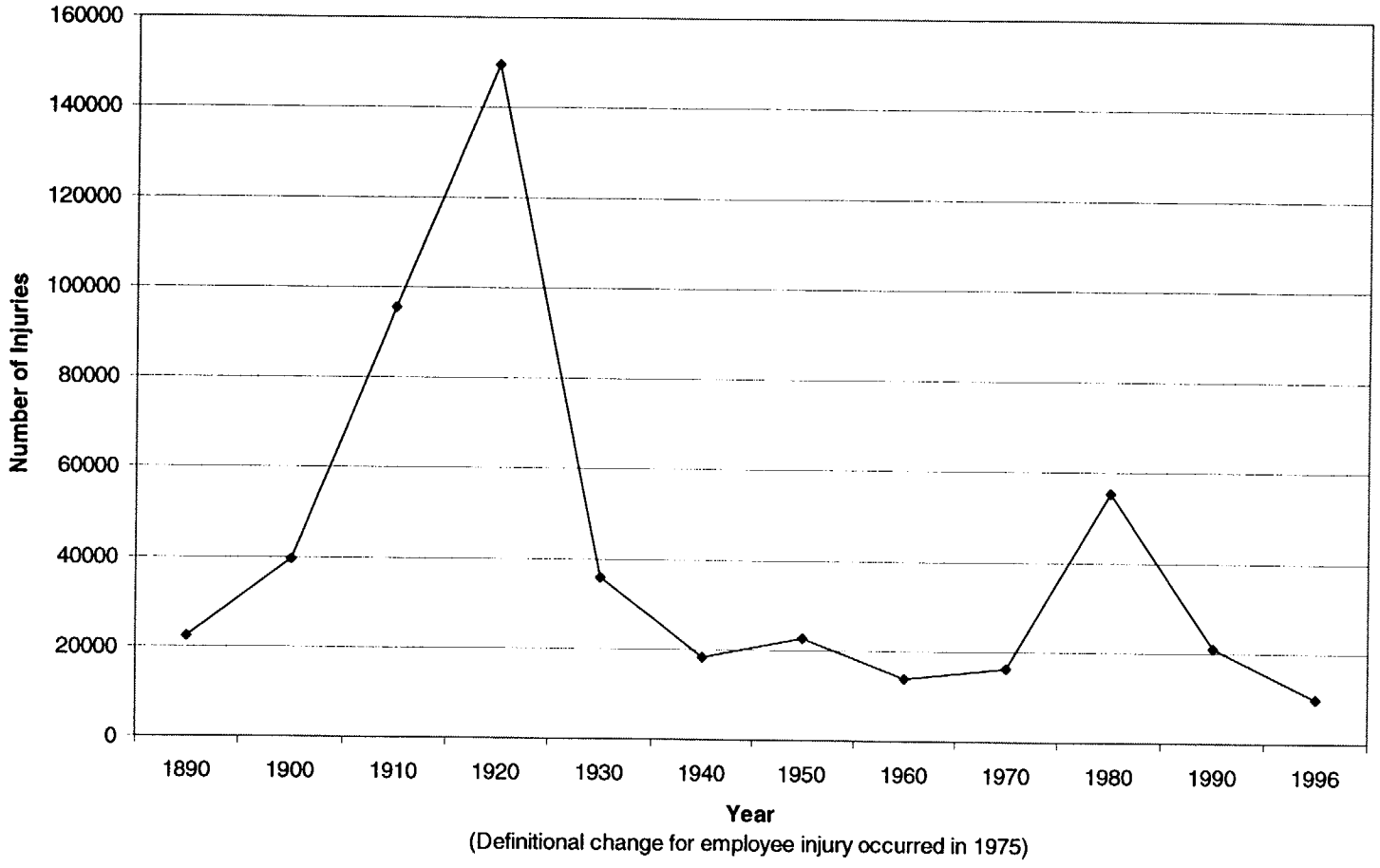


Figure 4-4: Railroad Industry Fatality Rates

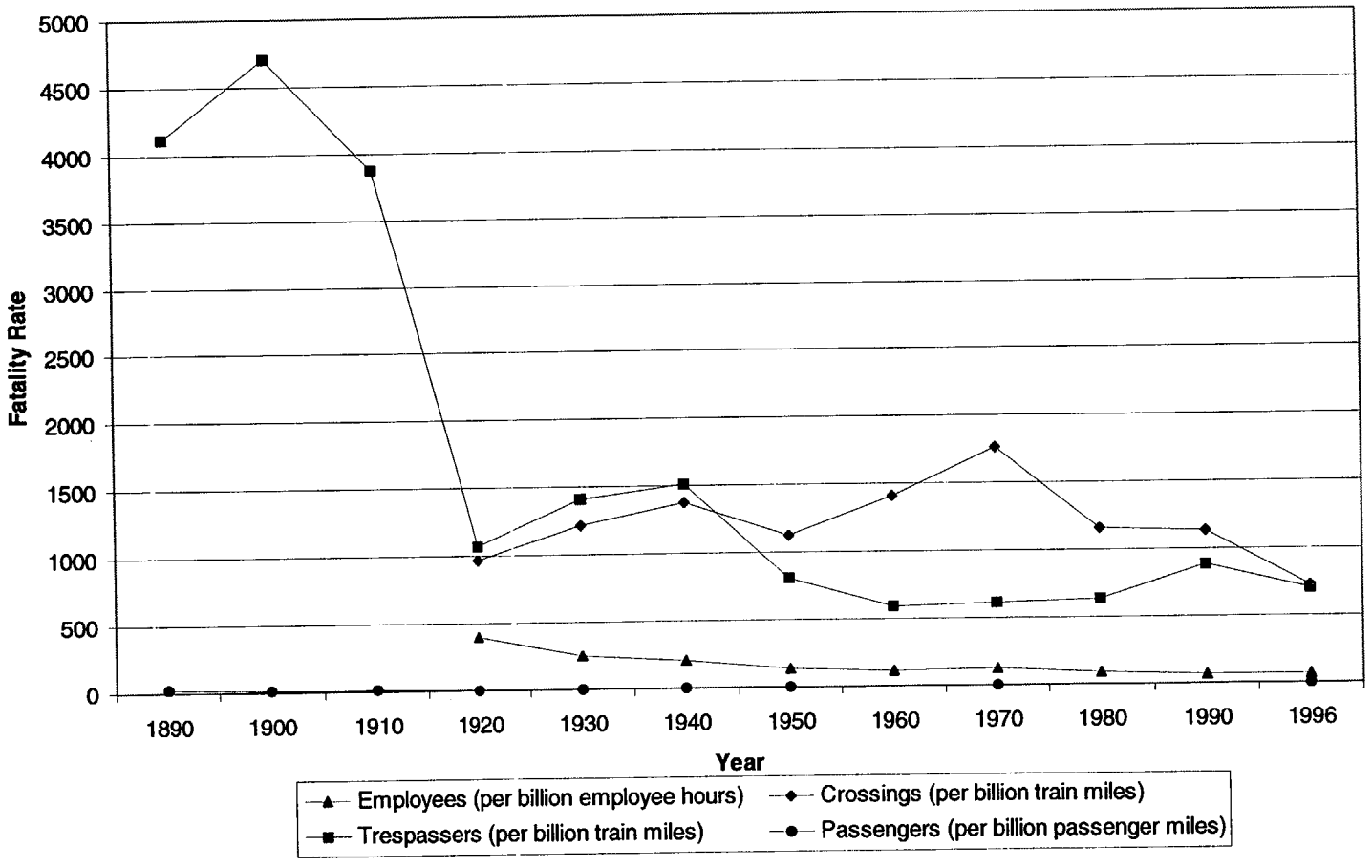
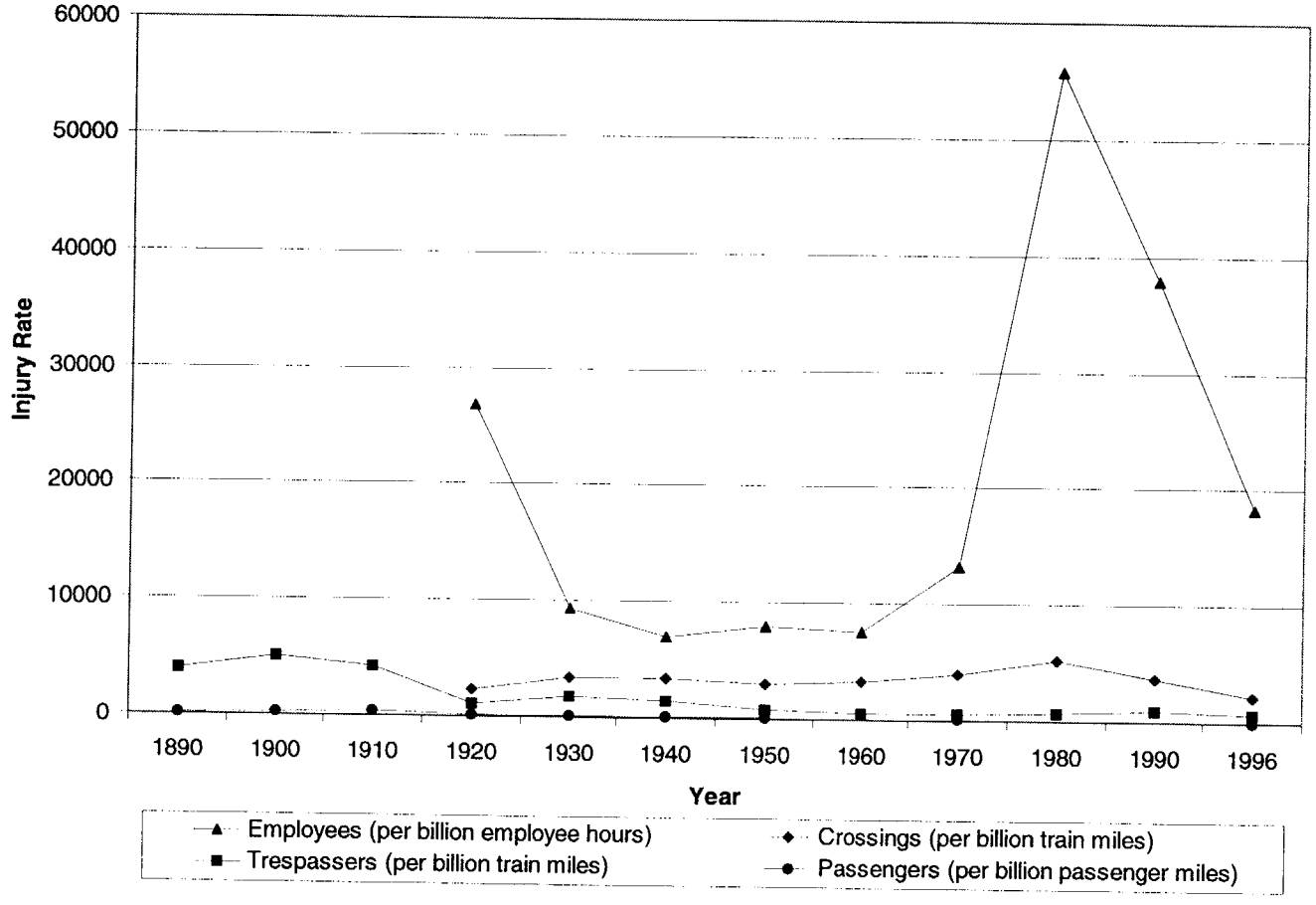


Figure 4-5: Railroad Industry Injury Rates



(Definitional change for employee injury occurred in 1975)

5. Rail Industry Interviews

5.1 Background

In order to examine the impact of economic deregulation on safety in the railroad industry, the existing literature provides a good starting point. Nevertheless, it leaves several questions unanswered. In particular, studies to date do not adequately address issues related to the impact of deregulation and the subsequent industry restructuring on human performance factors, such as:

1) How the environment for reporting safety problems may have changed following deregulation.
2) The effect of employment cuts on workloads, and the role of technology as a mitigating factor.
3) The severity of the problems related to fatigue.
4) Whether deregulation led to changes in morale and/or labor turnover.
5) The impact deregulation had on the level and quality of training.
6) Safety issues related to the use of contractor services.
7) The impact of corporate mergers on safety.

The main goal of the interview phase of this project was to shed additional light on these, and other remaining questions. Discussions were held with representatives of railroad management, labor, and the Federal Railroad Administration (FRA) in an attempt to better understand how individual companies responded to deregulation and industry restructuring, and to gain additional insight into the human performance and safety impacts of deregulation. We also sought to learn more about the programs and strategies that railroads used to guard against the potential detrimental impacts of deregulation.

The sample of interviewees was largely determined by the availability of contacts and the level of cooperation within the various organizations. In general, we found a high level of cooperation among potential interviewees. The sample was also determined in part by our assessment of the background and experience level of interview candidates. Our final sample included three corporate managers from Class I railroads; one manager in charge of safety at a smaller, regional railroad; one FRA safety official; and five railroad employees, representing most of the major crafts and several of the major unions. Each of these individuals had at least 25 years experience in the rail industry, holding positions directly related to safety issues.

The interviews were conducted between July and September 1999, and took approximately one hour to complete on average. Eight of the ten interviews were conducted by phone and two were in person; all but one were tape-recorded. To avoid "leading" the respondents, the interviews were structured such that the first questions were open-ended in nature, with subsequent questions becoming more focused on specific issues. Furthermore, the interviews were carried out like discussions, as opposed to following a highly structured survey.

Appendix B contains the interview discussion guide that was used during the interviews. The development of the discussion guide was based on areas identified during the literature review phase of the project as requiring further investigation, such as those listed above. It is important to stress that the resulting survey questions were used only as a guide; depending on their background, not all respondents were asked all of the questions, and the discussion often included topics not listed in the guide.

The responses of corporate management to our questions often differed sharply from those of labor, while the FRA seemed to weigh in as a more neutral observer. Overall, however, the respondents were surprisingly candid. In the next section, we summarize our interviews with these key industry representatives. (Some of the quotes that follow have been slightly edited to protect the sources.)

5.2 Summary of Interviews

What are the most important safety issues in the railroad industry? What impact has deregulation had on safety according to those in the industry? How has the environment for reporting safety violations changed since 1980? Do railroad representatives have any advice for the NRC as the electric generating industry undergoes deregulation? What follows summarizes the opinions of railroad management, labor, and the FRA on these and other issues related to the safety impacts of deregulation.

5.2.1 The most important safety issues in the railroad industry

As the railroad industry continues to adjust to the impacts of deregulation, the most important safety issues seem to be related to human performance. According to railroad management, the biggest areas of concern include problems associated with human reliability, hours of service, and an aging workforce. One respondent, a safety official from a Class I railroad that has undergone several mergers since deregulation, also discussed communication problems associated with a diverse workforce (e.g., language, age, and cultural differences among employees). One manager said, "human reliability is really the problem... it is human reliability that leads to human error." He went on to explain that the problem of human reliability is due to several factors, including but not limited to fatigue. Other factors he mentioned included emotional stress, economic stress, and family problems.

Railroad labor often cited problems related to the steady decrease in crew sizes, including fatigue and increased pressure from management to maintain service even if it means taking risks. According to one union safety official, "Due to employment cuts, workers are forced to take short-cuts." Railroad laborers were particularly concerned with safety problems resulting from fatigue. As a former railroad employee put it, the biggest safety issue is "pushing men beyond their physical and mental ability to operate at an optimum proficiency level." A labor official noted that the continuous nature of railroad service, coupled with irregular work schedules and 12-hour shifts, often leads to exhaustion among employees. In general, labor respondents

seemed to feel that since deregulation, the increased focus on profits had skewed management's priorities, with respondents claiming, "It's production first, and safety is a distant second."

The safety official at the FRA echoed these concerns regarding fatigue. In addition, he cited "corporate culture," including problems with harassment of labor by management, as being one of the most important safety issues facing the railroad industry today.

5.2.2 Did deregulation affect safety?

When asked how deregulation has affected safety overall, the opinions of corporate management differed considerably from those of labor. Management often referred us to the publicly available safety statistics, which show improvement in virtually all safety measures since 1980.[1] The consensus among management was that deregulation, partly through the easing of abandonment restrictions, allowed railroads to become more profitable and to spend more money on safety-related issues (in particular, capital improvements). Management also claimed that deregulation increased competitiveness, and therefore railroads had to be more efficient and pay attention to safety. One Class I railroad manager cited sweeping benefits from deregulation and increased profitability:

> The major benefit of deregulation is that railroads are better able to apply the money they have to research and training. With respect to employee injuries, we are now dealing with a better-trained and educated workforce. It takes money to train workers... Line abandonment also helped—the less railroad you have to maintain, the more you can focus on maintenance and improvement of the rail that remains. Deregulation allowed railroads to put more money into capital maintenance and to become more efficient.

Another Class I manager, however, was not willing to claim that deregulation resulted in an unequivocal improvement in safety. He felt that the impact of deregulation on safety was railroad specific, and depended on "whether the executives really understood the relationship between safety and profitability." This respondent suggested that some railroads did emphasize profits over safety and seemed to lose sight of the relationship between the two, noting: "The push to enhance the bottom line performance was so great [for some railroads] that they did not properly take safety into account. They grew faster than they were prepared to."

Most of the labor representatives interviewed challenged the notion that deregulation has resulted in safety improvements.[2] One union safety official noted:

> Deregulation has destroyed safety, because [management] put[s] money ahead of safety. Their corporate spin people say "safety first," but it's really profit first. If

[1] However, this improvement slowed significantly between the mid-1980s and the mid-1990s.

[2] As discussed below, the labor representatives claimed that problems with harassment and intimidation have resulted in the under-reporting of safety problems, especially personal injuries.

> we suggest safety improvements that don't cost anything, they will respond. But if the suggestions are expensive, they say, "we will have to prioritize."

Other union officials noted that since 1980 there has been increased pressure to reduce the number of employees, and more pressure on management to "get things done in a timely fashion and within budget." The steady decrease in crew size and resulting efforts to do more work with fewer employees have led to increased crew fatigue, according to union representatives. "Fatigue issues are much worse since deregulation."

According to the FRA safety official we interviewed, the passage of the Staggers Act played a major role in the improved safety performance of the industry after 1980. He based his opinion on railroads' increased focus on their core operations following deregulation. The respondent stated that during the 1970s, railroads tended to be owned by holding companies. Since the railroads were regulated, these owners attempted to transfer as many financial resources as possible out of the railroads and into other non-regulated, and presumably higher-return, activities. This meant lower expenditures on all aspects of the railroad industry. Once deregulation occurred, this trend stopped and railroad owners focused on making money in the railroad business. The respondent claimed that this resulted in great improvements in track condition, with positive implications for safety.

5.2.3 How has the Federal Railroad Administration performed since deregulation?

When asked how effective the FRA has been at promoting safety, respondents seemed to give answers that are more consistent across groups. However, rail management was quite critical of the FRA's traditional approach to safety, which they felt tended to be "punitive" in nature. As one manager put it:

> They have written a "phone book" of regulations, and if a railroad does not comply, they hammer you with fines. If they come back and you are still not complying, they hammer you some more... I don't think this crime-and-punishment approach is the best way to get change. A hammer is the least effective way.

However, most corporate managers noted that the agency's performance has improved dramatically over the past few years, due mainly to the Safety Assurance and Compliance Program (SACP). "The SACP process has made dramatic strides in getting management and labor together in a cooperative way," according to one Class I manager. Another echoed this sentiment: "Now, SACP brings together the best folks from railroads and labor to develop cooperative ways to address safety issues." The FRA was viewed most favorably by a manager of a regional railroad, who also noted: "They are acting more as a teaching organization now, and less like a policing organization."

Several managers, however, commented that there now seem to be two cultures within the FRA, and that some of its employees still want to punish. One corporate manager explained, "Many

FRA agents are still confused about their role. 'Am I writing tickets or trying to help you identify problems? Because if I identify a problem, I have to write you a ticket'."

Railroad labor generally agreed that SACP has improved the FRA's effectiveness. A union official noted that, "Before, the system was bogged down in tickets. A few million dollars in fines did not have much of an impact." He went on to claim that "labor is helping to focus the FRA," partly through the SACP program. This respondent favored intense FRA investigations, similar to those that followed Union Pacific's merger-related accidents in 1997, as opposed to fines. "More intensive investigations lead to traffic loss... The railroad that is under scrutiny may lose business permanently, and this has a much greater impact than fines."

Nevertheless, several labor representatives expressed concern that the FRA is slanted toward management, having "too many ex-railroad officials on staff," and that it is too concerned about railroad profitability.[3] As one union official explained:

> In the 1970s, the industry was in chaos. If the railroads were going to survive, the attitude was that the FRA had to back off. So even prior to Staggers, the FRA unofficially backed off. For almost 30 years, we have had an attitude of "Don't be too hard on the railroads." It has only been in the last few years that the FRA has moved to tighten regulation. Unfortunately, since the Reagan Administration, the agency has been denied the necessary personnel and appropriations. And even when they had the people, without the additional money [e.g., for travel], they were ineffective.

Another union safety official who has served on SACP committees expressed concern over the FRA's effectiveness, because he felt "The regulations are not tight enough with respect to intimidation and harassment for reporting injuries or incidents." This respondent mentioned that he gets many reports from his union's members about intimidation and harassment.

The FRA official we interviewed felt that the agency was performing well, especially in the area of the SACP program. However, he said there was "always room for improvement," noting that it was impossible to force partnering between management and labor, "short of going out and tying up a railroad with inspections." He went on to admit that the FRA has some internal struggles between the "enforcement types" and the group that focuses more on the SACP process. However, it was his impression that writing up violations "didn't seem to be getting the attention of [railroad] management." The FRA official concluded that SACP was a success, and that one key to its success was access to, and participation by, senior railroad management.

[3] However, when asked if SACP represented a balanced team, a Class I manager said that he felt the FRA was probably more tied to labor because of politics, and "Union leadership represents a lot of votes."

5.2.4 *Which played a bigger role in improving safety performance, deregulation or the Federal Railroad Administration?*

As noted in the literature review, just as the railroad industry was being deregulated economically, the FRA simultaneously increased safety regulation. When we asked for opinions regarding whether deregulation or the stepped-up efforts of the FRA played a more critical role in improving safety performance, we again received mixed responses. The FRA official believed that while economic deregulation and the resulting improvements in financial performance played a key role in the safety improvements in the 1980s, the role of the FRA was equally important. He felt that it was "only human nature" to reduce expenditures on safety issues in the face of competition, and thus the FRA was needed to "play the role of the referee and ensure that rules are followed while the game is being played."

Rail management was fairly unified in their opinion that the financial improvements that followed deregulation played a more important role. "If a railroad doesn't have money, it doesn't make any difference how many tickets the FRA writes," one respondent noted. In addition to the importance of spending money on physical plant and technology, management stressed the importance of competition. "In order to compete, you must be safe," another manager said.

The regional line manager we interviewed seemed a bit more neutral, claiming that "physical improvements were generated by stricter enforcement of FRA rules and stricter inspection policies," but that maintenance improvements were also "driven by economics." "I think it was a combination," the respondent concluded; "the FRA brought safety to management's attention and continues to do that today."

Railroad labor representatives were more of a mixed mind. One union safety official refused to answer the question, citing his belief that safety has not really improved since 1980, but that instead, railroads have been under-reporting injuries and accidents. Another labor representative felt that the "FRA is very cognizant of the financial condition of railroads and this affects its judgment." This respondent provided an anecdotal example, in which he claimed the FRA attempted to shut down a Midwestern terminal due to severe safety problems, but after rail management's pleas, the agency considered the company's poor financial condition and decided not to shut it down.

Nevertheless, most respondents, management and labor alike, acknowledged that the economic health of the railroads played a key role in safety issues. Likewise, nearly all of the respondents felt that a safety regulatory structure that focused on systems and processes, and significantly involved all stakeholder groups, was superior to a safety regulatory structure that focused on inspections and fines. Respondents were divided, however, on the role that competitive pressures played with respect to safety. Labor representatives tended to associate increased competitive pressures with negative safety impacts. Industry representatives acknowledged competitive pressures, but maintained that a high level of safety performance is a prerequisite for the delivery of competitive, high-quality service.

5.2.5 How has the environment for reporting safety violations changed?

When we asked whether the environment for reporting safety violations has changed since deregulation, the responses we received suggested that intimidation and harassment of employees is a significant problem in the rail industry, and that this problem has probably worsened since deregulation. Although one corporate manager claimed that the environment had actually improved, because "now, instead of assessing discipline when an employee breaks a safety rule, management will meet with employees and ask why the accident happened," rail labor interpreted such meetings as an intimidation tactic. One labor safety official explained the situation as follows:

> In the 70s, everyone would report injuries... The tactic they use now is, they pressure you not to fill out [personal injury] reports. [Management] will call "standard investigations" under the guise of trying to investigate why this report came in "so we can make it safer so no one else gets hurt." So they send up a flag to employees: "Do not send this in." [Therefore, the official] reporting [of injuries and safety problems] has gone down because people are afraid and intimidated.

When asked if these meetings represented credible threats by management, the respondent replied, "If I tell you that if you file this report that you will be in on the carpet explaining it to your supervisor and [told] that 'we may have to take you further into the disciplinary process,' if that has a chilling effect, of course it does." He went on to explain that workers are asked what they could have done to avoid the accident, and that there is an insinuation of blame.

According to labor representatives, part of the problem is due to the compensation systems of management. Several union officials explained that management bonuses are based on performance criteria that include safety goals (i.e., the number of *reported* personal injuries and accidents) in addition to financial goals, and that managers therefore have a strong incentive to keep employees from reporting injuries.

A safety official at a Class I railroad admitted that workers may feel pressure from management not to report injuries:

> Yes, it does happen. It happens because managers and supervisors have production goals, and they have safety goals, and they have all these things. In an attempt to reach them, I'm sure that if it's a matter of making an injury reportable because a guy took a prescription painkiller instead of Tylenol, that probably, well not probably, we know it has happened. It's something that we try to police, and, well, we do police. Last year on our railroad, we had two senior officials fired for these types of violations.

The respondent went on to explain how his railroad was trying to deal with the problem: "We devote a lot of resources to identify [safety] problems." He told us that they had hired an

independent company to set up a 1-800 hotline for employees to report accidents, assuring the workers' confidentiality.

One corporate manager suggested that the Harriman Award, which is given out each year to the railroad with the fewest personal injury accidents, may have created a problem related to reporting and manipulation of statistics. In addition to the potential incentive problems posed by management compensation systems and the Harriman Award, railroad management claimed that the injury compensation system under the Federal Employers' Liability Act (FELA) might exacerbate the problems with intimidation and harassment. Under FELA, injured railroad workers can sue for damages resulting from railroad negligence, and recoveries tend to be much larger than under Workers' Compensation. One Class I manager was particularly opposed to FELA, explaining that "[Our railroad] wastes a great deal of resources dealing with FELA... It also makes for an adversarial relationship. I think Workmen's Compensation would certainly create a less adversarial relationship between labor and management in our industry, and that can only be beneficial."

Regardless of the cause, labor representatives firmly believe that the environment for reporting safety problems has worsened since deregulation. One union official explained that "The workers feel the pressure even if management denies it." He also claimed that there is not a strong enough system in place to encourage whistle blowing: "Notification of a defect related to safety is often viewed as a criticism of the next person up in rank, and is discouraged."

The FRA respondent acknowledged that harassment is an area of concern. He admitted that there are problems with management forcing employees to engage in activities that they feel are unsafe and putting pressure on employees to not report problems. Furthermore, he acknowledged that there might be incentive problems related to management compensation systems and to the importance of winning the Harriman Award, and felt that "middle management is probably more susceptible to these problems." He explained that "the path to promotion and bonuses is through running a profitable division on the railroad, which in the short term can be accomplished by reducing expenditures on maintenance items." Moreover, pressure to win the Harriman Award "could result in pressure to under-report or not report problems."

Apparently, the FRA has also had problems with railroads providing the data that they are required to collect. According to the FRA official, when injuries or accidents occurred, the reports "sometimes did not make their way into the system that funneled the data to the FRA." In 1997, the FRA took steps to both protect workers from harassment and ensure that all reported accidents and injuries would find their way to the FRA. Each railroad must now publish and distribute an Internal Control Plan stating: "Harassment or intimidation of any person calculated to prevent that person from receiving proper medical attention or reporting accidents or injuries will not be tolerated and will result in discipline of the harasser." Furthermore, each railroad must have a procedure in place to investigate complaints and discipline those who violate the policy, and railroads and/or managers may be fined up to $5,000 for harassment or failing to accurately report accidents.

5.2.6 *How do safety issues differ for the smaller railroads?*

In general, the consensus was that smaller railroads are less safe than the Class I railroads, but the reasons cited for the weaker safety performance differed among our respondents. While the Class I managers that we interviewed did not have any first-hand experience working at smaller railroads, they have maintained relationships with the short lines spun off after deregulation. The shared opinion of these managers was that short lines have limited financial and technical resources to address safety issues, but that these limitations may be mitigated somewhat by the fact that short-line managers have closer personal relationships and interactions with their employees. Class I management also noted that they share a lot of information with their spun-off lines regarding safety processes. As one manager explained, "[Our railroad] partners with its short lines—if it spins one off, it retains it in its infrastructure... Short lines are supposed to maintain the same level of safety that [our railroad] had during its last year of control. [We] also have the power of audit."

The regional line manager that we interviewed acknowledged the safety challenges associated with limited resources and inheriting deteriorated track spun off from major railroads. However, he seemed to indicate that these challenges caused short-line management to be more "proactive" and to use their limited resources more efficiently. He also noted:

> We probably have more of an incentive to be safety conscious as far as personnel is concerned because...if we lose an employee due to an injury, it's a bad experience for us—not only because of the injury, but there are very few of us. We have 150 employees and if one of them gets hurt, we really notice it. In today's work environment, to find someone to even come and work in the railroad industry is very hard. You try very hard to avoid injuries.

In contrast to management, railroad labor (virtually all of whom had first-hand experience at smaller railroads) blamed the weaker safety performance of the smaller lines directly on the lack of union representation. One union safety official called the industry restructuring following the Staggers Act an "unmitigated disaster." "Deregulation was equivalent to de-unionization of the short-line sector. [The nonunion short lines] ask their workers to engage in very unsafe behavior," he explained. Another union safety official claimed that the safety performance of smaller railroads is worse "because standards are lower, they expect more and push the envelope more. They are not in the spotlight as much." This respondent was recently involved in an organizing drive at a short line, claiming that the workers sought union representation "because they didn't have any voice to complain about safety issues, and were told to do unsafe activities."

The FRA safety official also pointed out that smaller railroads "simply don't have the knowledge or expertise that larger railroads have." Possibly for this reason, the respondent admitted that small railroads were "not regulated with as heavy a hand as the larger railroads," but that the emphasis was more on providing technical assistance and information. Nevertheless, the respondent believed that the smaller railroads were not significantly less safe than the Class I

railroads when adjusted for the relative risk of the activities undertaken by the small railroads. While the short lines typically operate at lower speeds and hence have lower risk than trains that run at high speeds, smaller railroads tend to have more yard operations, which are more labor intensive and inherently riskier than long-haul operations. The FRA respondent also indicated that accidents might have larger economic consequences for smaller railroads: "Smaller operators don't have as much equipment. You damage your locomotive and you are out of business." Even so, he noted that whatever happened with the smaller railroads in terms of safety, the overall safety performance of the industry is dominated by the performance of the Class I railroads.

5.2.7 The impact of mergers on safety

When we asked railroad management for their opinions regarding the impact of mergers on safety, the responses ran the gamut—from positive, to defensive, to negative. One Class I manager viewed mergers quite positively, noting:

> The benefit of mergers or consolidation is that it has made the industry stronger financially... Mergers allows you to re-deploy resources... They have also led to the adoption of common standards across more of the total track across the country. I think mergers tend to improve safety.

A senior safety executive at a Class I railroad that has undergone several mergers since deregulation initially seemed on guard when asked about the impact of mergers on safety, claiming that he did not think there was any relationship:

> We got a lot of press about our problems, but they really weren't related to the merger. Everyone has a bad year—a blip like that. Ours just happened to occur after the merger. The FRA and NTSB [National Transportation Safety Board] were quick to blame our problems on the merger... We had worse years in the past... We had [several] fatalities that year, but overall, our injuries were down...

Later on, when expanding on the relationship between mergers and safety, this respondent did admit that his railroad's recent merger might have affected safety. Commenting on the accidents and fatalities that followed the merger, he noted: "There were a lot of different reasons for the problems. In one case it was crew error, one was a dispatcher error, fatigue was also an issue... There were also a number of issues related to the merger, and yeah, maybe we did take our eyes off the ball."

Another respondent, a senior executive at a Canadian-based Class I railroad, claimed, "There are obvious problems with mergers." He noted that most of the mergers following deregulation were actually takeovers, and that "Some people thought that they had the ability to steam-roll their way into merging operations and did not have their eyes open. Big decisions coupled with extraordinary traffic growth caused some major problems." For example, he cited one takeover after which the railroad made major reductions in realignment and service, and then found that it

had overreacted and could not handle the resulting traffic. This respondent was of the opinion that parallel mergers pose bigger problems than end-to-end mergers. He expressed serious concern about the CSX/Conrail merger, "because there was so much [duplication] of service and routing... Even though it took two years to develop a safety integration plan, they are still having many problems."[4]

Likewise, a regional railroad manager (who did not have any first-hand experience with mergers) noted, "there seems to be a lot of confusion" at newly merged railroads. He indicated that there appears to be a transitional phase following the merging of two corporate cultures during which difficulties often arise. He also noted problems associated with the employment cuts that usually follow mergers: "They offer key personnel early buyouts, usually to the older and more experienced people, and then put in someone who is younger and maybe louder and more aggressive, but who doesn't really know what they are doing."

Our respondents from railroad labor unions and the FRA generally agreed that there are significant safety problems associated with mergers. The problems cited by labor included the clashing of corporate cultures, post-merger employment cuts (especially those subsequent to parallel mergers, which tended to be more severe than those following end-to-end mergers), and the disruption caused by changes in work schedules and co-workers. A labor representative felt that because mergers are often associated with pressure on management to reach financial goals to satisfy the investment community, safety problems are less likely to be adequately addressed. However, the most frequently cited problem associated with mergers was the apparent damage that they caused to the morale of company employees. According to our labor respondents, morale suffers after mergers for a variety of reasons, including the stress associated with relocating one's family and the merging of seniority lists. "The stress of having to move has led to heart attacks, divorce, et cetera," one union safety official told us. Another noted, "The merging of seniority lists means less seniority, which means less desirable shifts. [This] causes a lot of stresses on individuals and families." Overall, our labor respondents strongly believed that morale problems following mergers had hurt safety, "without a doubt."

The FRA is obviously concerned with the potential safety problems associated with mergers. Our respondent from the FRA noted that the agency now requires railroads to prepare a safety integration plan prior to the merger of two railroads, to make sure that safety issues are considered as part of the merger process. The requirement for safety integration plans resulted from the safety problems experienced in 1997 after Union Pacific's acquisition of Southern Pacific. According to our respondent, the safety problems and resulting accidents were mainly due to substantial congestion on the combined system in Texas, which led to overwork and fatigue as the merged railroad tried to work through the congestion problem. He also noted that the FRA felt that these problems could have been avoided had the two railroads paid more attention to safety issues prior to the merger. Although the FRA does not have formal veto power over railroad mergers, according to our respondent the agency would strongly recommend

[4] When asked about the nature of these problems, the respondent was unclear whether they were mostly service-oriented or safety-related in nature.

against a merger if a sound safety integration plan were not in place. He also cited the relatively successful mergers of Norfolk Southern/Conrail and CSX/Conrail as evidence that safety integration plans work.

5.2.8 Employment cuts, workloads, and fatigue

Despite the more than 60% decline in railroad employment since passage of the Staggers Act, most of our respondents in management denied any significant increase in workloads for laborers.[5] We were told that while the production numbers are up, "workloads have probably not increased much" because the work has become less labor-intensive. Moreover, virtually all of the managers that we interviewed stated that the employment cuts after deregulation did not negatively affect safety, because railroad equipment and technology have improved significantly. In particular, they noted that detection technology and laborsaving technology has meant that fewer workers are exposed to risks.

Nevertheless, one corporate manager acknowledged, "There has been a massive push to increase output per employee in order to increase productivity." However, he did not believe that this push has had an impact on safety, claiming that "busy workers are less likely to get hurt." This respondent also believed that the heightened discussion regarding whether employment reductions have affected fatigue was "mostly rhetoric, because overtime is usually voluntary." Interestingly, however, at another point in the interview he admitted that his railroad has problems with fatigue, and noted:

> Employees feel more pressure to produce than to be safe, but the executive position at [our railroad] is that you should not do anything if it isn't safe... The message seems to get lost in the mud in between... Sometimes the train master in the front-line area loses focus. He knows he must get the train out on time. But if you ask the president, he would say that the train should not have gone out if there was any [potential for safety problems].

Another corporate manager said he did not believe that problems with fatigue and morale have necessarily worsened since deregulation, but that now, "we identify it more." He went on to say that "Fatigue is definitely a problem for our industry and for society, but we are trying to work on it and devoting a lot of resources to deal with it." In an effort to address the issue of worker fatigue, his railroad is consulting with recognized experts on the topic. Moreover, he noted that his railroad has recently started to hire more workers in an attempt to keep up with attrition and increases in business volume.

The regional line manager that we interviewed felt that while employment cuts following deregulation might have had a negative impact on safety initially, over time "people have adjusted and found safe ways to do things." However, he was much less positive when asked

[5] One corporate manager did note, however, that the workloads of management and staff employees had increased since deregulation.

about the impact of employment cuts related to Class I mergers, explaining the situation as follows:

> When you start thinning the more experienced workers out, there is no one to train the new employees on a day-to-day basis... You can send a guy to a training program for 90 days, but if you don't have a mentor to work alongside that guy in the field to get him comfortable, and if he is not comfortable with his operations, he is going to make mistakes.

Not surprisingly, virtually all of our labor respondents agreed that the substantial reduction in employment following deregulation has negatively affected safety. They cited several reasons for this opinion. First, they noted that despite technological improvements and the less labor-intensive nature of the work performed in the industry, workloads have increased significantly as railroads try to do more work with fewer employees. Secondly, they felt that due to inadequate staffing levels, increased workloads, and employees working longer hours, problems with fatigue have intensified. One union representative claimed that the fatigue problem has gotten so bad that "there has been a rash of employees killed [on the highway] going to and coming from work." In addition, labor respondents were unified in their belief that there is more pressure from management to maintain service even at the expense of safety. One respondent explained: "If I stop my train, the dispatcher is on my tail, or the yard master will yell, 'you get that train out of my yard.' The pressure comes from the middle because they have to micro-manage, even though the top would say 'we would never do a thing like that'." In fact, several respondents, both labor and management, recounted instances of accidents that were believed to be associated with management pressure on workers to engage in unsafe activities. Lastly, our labor respondents noted that the drastic employment reductions have negatively affected morale and caused personal problems, such as depression and divorce. These problems, in turn, may jeopardize safety.

The FRA safety official noted that the agency was concerned about the impact of employment levels on safety. However, he also pointed out that the industry's overall safety record does not appear to have deteriorated, mainly due to the adoption of laborsaving technology. A further concern of the FRA is the possibility that safety problems may arise when a railroad has a low employment growth rate during a period of business expansion. He noted that Union Pacific has recently hired more employees, but only because of the SACP process initiated after the Union Pacific/Southern Pacific merger problems.

While fatigue has always been an important safety issue, our respondent informed us that the FRA has recently increased its focus on the problem. The FRA is concerned about both the increasing pressures to use overtime, and whether overtime has been properly reported. The pressure to use overtime stems from the fact that it is often more cost effective to pay overtime (despite the higher hourly wage) than to hire new employees. This is especially true in the rail industry, since training costs are substantial and benefits packages are generous. Furthermore, overtime provides a railroad with a great deal of flexibility in covering a variable workload. The

FRA official also acknowledged the existence of a conflict of interest, in that labor wants both safety and overtime, but the two may not be compatible.

5.2.9 The use of contractors

All of our respondents agreed that, in an attempt to control costs, the use of contractors has increased in the years since deregulation. However, opinions regarding the impact of such outsourcing were mixed. In general, management felt that the use of contractors has not affected safety. Many noted that their railroads "insist that contractors abide by the same rules, same processes, same equipment, et cetera." Moreover, they noted that contractors must be qualified and certified by the railroad that uses them. As one safety manager put it, "There are good contractors and there are bad contractors. The bad ones don't last very long." Nevertheless, there appears to be a shortage of safety statistics related to railroad contractors, as most respondents qualified their opinion that contractors are just as safe as full-time employees by saying things like, "I have not personally seen the numbers," or "I don't really have statistics on the level of injuries among contractors."

Union representatives, on the other hand, felt that the increased use of contractor services has negatively affected safety. We were told that contractors often do not abide by the federal on-track safety and roadway protection rules. A labor safety official gave the following example:

> Employees are supposed to have a lookout to watch for other equipment when working on the track. But contractors are entirely green, and have much less experience. They often push the envelope due to their payment schemes. For example, contractors are paid for laying fiber optic cable *by the foot*, and don't want to get off the track when they should [i.e., when other dangerous equipment is present]. They have no sense whatsoever of how important it is to abide by the rules.

Another union official stressed concern over the rapid increase in contracting out the service of transporting train crews from one point to another. Apparently, problems with fatigue and highway accidents are commonplace among these contractors due to a "loophole" in federal law. Because the contractors use vans that carry fewer than 15 people, they do not come under the hours-of-service law, and are not required to have a certified driver's license, "So they can drive almost continuously," the union official told us. He also explained that unions are currently talking with the NTSB to try to close the loophole.

The FRA safety official also noted that the use of contractors has increased since deregulation, attributing the increase to the railroads' belief that contractors can be cost-effective. He explained that the FRA has responded to this trend by trying to ensure that contractors are properly trained. However, he felt that the biggest area of contractor use is for roadway workers, and suspected that railroads did not have an interest in having contract workers perform more critical operations, such as train operations and dispatch.

5.2.10 Turnover

Labor turnover does not appear to have been a major problem after 1980. Most respondents agreed that deregulation was not associated with increased turnover rates, noting that railroad workers tend to be "married" to the industry because their skills are specialized and not easily transferable to other industries. Moreover, workers often feel tied to a particular railroad due to generous pension plans.

One labor respondent noted that experience levels in the industry might have actually increased following deregulation since new, younger employees were not being hired. In addition, although the negotiated crew-size reductions allowed Class I railroads to trim their workforces significantly, union contracts required them to lay off the least senior employees first.

Nevertheless, with the recent growth in rail traffic, railroads are now having difficulty attracting new employees. A manager from a smaller, regional railroad was particularly concerned with this issue. He discussed the problems his railroad was having finding and retaining "good people":

> A lot of [the workers we] hired on in 1980 were those with low seniority in the Class I railroads, so we now have a lot of guys who have 20-30 years of experience... As Class I railroads downsized, we were able to get relatively experienced workers. Now, in today's labor market, it's much more difficult.

Moreover, two labor representatives noted that since business and workloads have begun to increase recently, older, more experienced workers are starting to retire or find work in other industries because "they can't take the pace."

5.2.11 The quantity and quality of training

There was a consensus among our respondents that training has become much more important since 1980, mainly due to the additional training required for the new equipment and technology being used in the industry. Railroad management also felt that the quantity and quality of training have improved significantly, but that these improvements were not necessarily attributed to deregulation. Instead, many managers pointed to technological advances, such as better locomotive simulators. They also noted that methods of training had improved, with greater emphasis on computer-based training and more sophisticated training programs designed and run by professional educators.

Although labor respondents acknowledged that the quantity and quality of training have increased since 1980 (which they attributed to union demands and the SACP program), they argued that training is still severely inadequate given the complexities of the new equipment in the industry. Moreover, many argued that there is not enough mentoring, and that the training programs are too accelerated (echoing the regional line manager's comments in the above

section on "employment, workloads, and fatigue"). One union safety official explained the situation as follows:

> They will train new employees in six months and then throw them on a train with only one other worker. It's just too much to learn in such a short period of time. Before, there would be other employees around saying "don't do it that way, you may get killed"... The training is better, but it's too short of a time, and you are not apprenticing on the job.

According to another union representative, the problems associated with inadequate training were not as bad in the years immediately following deregulation, because there was a large pool of qualified workers from which railroads could hire "who were already trained but out of work due to restructuring." Now, with the recent increase in business volumes, "when they need a warm body, they are more likely to put inadequately trained individuals into unsafe circumstances."

The FRA safety official that we interviewed also noted that railroads now provide more and better training for their employees. He felt that once the industry had been deregulated, management had more incentive to put financial resources into the railroads. In addition to the increased expenditures on track and equipment, this also meant more training. However, the respondent went on to note that human factors are the leading cause of accidents and injuries in the railroad industry today. Apparently, while the additional expenditures on railroad infrastructure had dramatically reduced track- and equipment-related accidents and injuries, the industry is sill grappling with safety issues related to human factors.

5.2.12 Labor/management relations since deregulation

We received mixed responses to our questions regarding the impact of deregulation on labor/management relations. One Class I manager, for example, felt that the relationship has become slightly more adversarial, since "Unions feel that the companies can get away with a lot more because of deregulation. Some unions feel the system is too permissive to railroads...and they want re-regulation." Another corporate manager thought that the impact of deregulation on labor/management relations had been "neutral to good." He explained the situation as follows:

> The climate before Staggers was similar to public utilities, in which unions' attitude was "Oh well, you can give us anything we want, because where will the customer go?" Well, the customers went away in droves. Now, we have to cooperate to compete. It's less adversarial, more cooperative.

Virtually all of the union officials that we interviewed shared the opinion that there has always been a highly adversarial relationship between labor and management in the railroad industry, and that this relationship did not change significantly following deregulation. Nonetheless, labor respondents did note that the government intervention into labor conflicts following the Staggers Act, which resulted in significant crew-size reductions, had been disastrous for labor.

The FRA official also felt that deregulation did not have any significant impact on labor/management relations. However, he did feel that relations had improved since the initiation of the SACP process, because "the process involves both management and labor working together to identify and solve safety problems." He also noted that friction between labor and management tended to increase during times when the industry was profitable but labor felt that it was not getting an appropriate share of the profits.

5.2.13 Management and labor approaches to safety since deregulation

Railroad management noted that they had become much more involved in safety management since deregulation. The feeling was that now, management must actively work to develop a strong safety culture in order to be competitive. Moreover, one corporate manager mentioned that because deregulation led to the availability of more resources, railroads "can now afford to do what we wanted to do" in terms of safety programs. Another explained that he felt the safety culture had become more open since deregulation:

> Railroads used to hold employees accountable for operating/working of safety compliance. If an employee broke a rule, management would assess discipline—similar to the punitive approach the FRA used to take. Now, management will meet with employees and ask why the accident happened. There is more coaching and helping them to solve problems instead of punishment. This has led to a dramatic improvement [in safety].

In sharp contrast to this assessment, our labor respondents reemphasized their opinion that management intimidation and harassment of employees has increased since deregulation, leading to a marked deterioration in the safety culture. One individual noted: "Managers don't want to see injury reports, because their bonuses are tied to the number of injuries reported." Additionally, there was a strong belief that because the compensation of management is also tied to railroads' financial performance, "upper management now focuses much more on earnings and less on safety."[6]

When asked how deregulation has affected labor's approach to safety, one union representative summarized the opinions of most labor respondents: "Unions had to become more involved in safety issues... Now it's self-defense."

5.2.14 Thinking forward

The safety issues identified by our respondents as being crucial for the railroad industry over the next five years centered almost exclusively on human factors. There was a surprising amount of

[6] One union representative also claimed that "If the AAR [American Association of Railroads] can show that injuries and accidents have declined, it gives them more clout when they go to Congress and try to do away with FELA" (the afore-mentioned injury compensation system governing the railroads).

agreement between our three groups of respondents on this issue, with the biggest areas of concern being fatigue and training.

Other issues that management recognized as needing more attention included legal liability related to human factors, the importance of human behavior as a determinant of safety outcomes, and worker accountability. One corporate safety official also admitted that the industry "must get even better at training." However, the most frequently cited safety issues that management viewed as needing attention in the future were problems related to fatigue and attracting new employees into the industry. One respondent explained:

> The new generation coming into the workforce is going to be brighter than ever before, and we will need to keep them motivated... We need to get more predictability into work schedules, because fatigue is a big issue and new workers are more protective of their leisure time. We also need to make sure that jobs in our industry stay attractive.

Railroad labor identified three safety problems as being of critical importance in the near future: fatigue, which they linked to inadequate employment levels; training, or "the lack of commitment by the railroads to train their folks, and give them the tools and education they need"; and the "ongoing intimidation" of employees by management to under-report injuries and accidents. One union representative summarized by noting that railroads must deal with the issues at hand. "If they don't want to deal with the fatigue issue and expanding the number of personnel available to perform the services, and train those personnel, then human factors are going to continue to be [the leading cause of accidents]."

The FRA safety official felt that the biggest issue over the next five years is likely to be employee fatigue. "Odd schedules and lots of overtime tend to make for fatigued and less safe workers," he noted. Again, he characterized this issue as a two-pronged problem: "Management likes to use overtime since it is cheaper than hiring new long-term employees. Labor likes the overtime and people come to count on this extra income. However, the impact of the overtime can be fatigue, which leads to safety problems."

5.2.15 Suggestions for the U.S. Nuclear Regulatory Commission and the nuclear industry

Our respondents identified several areas that they believed might merit special attention as the U.S. Nuclear Regulatory Commission (NRC) prepares for deregulation of the nuclear power industry. In particular, respondents stressed three key lessons learned from the railroad industry's experience with deregulation:

> 1) The NRC should be cognizant of the potential safety problems associated with mergers and acquisitions.
> 2) Senior management must be committed to safety and willing to work directly with the regulatory agency; employee/union involvement is equally important.

3) Nuclear generating companies must balance the competing goals of improving productivity, cutting costs, and maintaining safety.

More specific comments included those from a Class I railroad manager whose railroad has undergone major restructuring since deregulation. This individual's advice for the NRC centered exclusively on the potential problems associated with mergers and acquisitions:

> We should have better identified the deficiencies [in the infrastructure of the railroad] that we took over... You need to identify exactly what you are acquiring, all the assets and liabilities. Then, you need to develop good, sound plans on how to manage those assets and liabilities well, so you are not surprised... You have got to ensure that as you are deregulating, the [merger] plans...[do] not result in safety issues because there are cuts in resources or investment. You have got to ensure that there are good plans in place that cover all of these critical things before you allow it to go forward. In other words, there can be no "shooting in the dark." You have to have good, solid...commitment in terms of capital and training and safety. And it can be done, but it is making sure that the commitment is there to do it and the resources are there to do it.

Another Class I manager provided the following insight:

> At [our railroad], safety did not mean anything until the CEO made it important... There are five essential ingredients necessary for ensuring safety [following deregulation]: One, the CEO must be committed to safety. Two, his executives will then be converted because it is a condition of employment. Three, you have to get employees and unions involved. If they are not part of the process, it will not work... [Four,] consistency—the biggest problems with our safety program used to be that it changed every month... Lastly, you need a good plan that is clear, understandable, and workable.

Our last Class I manager seemed less concerned about the potential detrimental impacts of deregulation, and advised that the NRC "should guard against the temptation to beat up on the industry from a safety point of view, as opposed to working with the industry." He also felt that the agency should "Let the market work. It is in the firms' best interest to be safe. You find that a safe operation is typically an efficient operation."

However, the regional line manager had this advice for the nuclear power industry:

> Don't phase out management too quick. Phase in new people to learn from the old people and to bring in new ideas, but don't be real quick to get rid of the old ideas. Look to see how to marry them together... Don't make large mergers real quick. Economically it makes sense...but you have the initial start-up problems if you go too quickly too fast, and you are going to have a lot of problems.

Our labor respondents were most concerned about competitive pressures resulting in the temptation to "cut corners," and stressed the importance of input from employees. One union official advised the NRC to:

> Rely tremendously upon the input from the people that actually do the work. They are the watchdogs, and if protected, they will tell the NRC what they need to know... Deregulation [in the railroad industry] has meant increased competition, and the bottom line is much more important than safety. Productivity improvements have come mainly from having fewer workers do more work, not from technological improvements, and people are pushing the envelope.

Another union official noted:

> Deregulation may be a disaster if [the NRC does] not recognize pressures to reduce costs. Regulators need to assure the continuance of strong skill levels, training, minimum staffing levels, and certification of employees... The use of contractors is also risky. Virtual companies that only contract out [may result in] employees that feel like they work for the contractor and don't have the commitment to the utility company... They [usually] do not receive decent pay and benefits, and thus the skill levels will be lower.

Finally, the FRA safety official offered the following three pieces of advice for the NRC:

> First, make sure that senior management is involved. These folks have the authority to make things happen, and may not be hearing everything from middle management that they should. Having senior management involvement will reduce the burden on the regulatory staff. Second, a partnership process involving labor and management is very beneficial. Third, even when things are going well, it is still important to have referees to make sure that the rules are being followed. Competitive pressures in the absence of referees will lead to safety problems.

5.3 Summary and Conclusions

Almost twenty years after passage of the Staggers Act, the railroad industry is still evolving in response to deregulation. Economic deregulation has led to considerable consolidation through mergers and acquisitions among the largest railroads, along with a proliferation of smaller short-line railroads, or "spin-offs." Overall, the Staggers Act is believed to be responsible for substantial improvements in the financial performance of the railroad industry, and published statistics show improvement in most safety measures.

Nevertheless, deregulation was also followed by a substantial reduction in employment, and significant challenges associated with human factor issues remain. Specifically, it seems

problems with fatigue have intensified in recent years as rail traffic has begun to increase. Several interview respondents also noted more problems with intimidation and harassment of employees by rail management, resulting in the under-reporting of injuries and accidents, along with increased pressure from management to maintain service even at the expense of safety. There was also some concern that the level and quality of training may be insufficient given the changes that have occurred in the industry since deregulation, such as the adoption of new technology and equipment. Moreover, it seems that the recent increase in business volume has created safety challenges, as railroads now attempt to reverse some of the past employment cuts at a time of unusually low unemployment. Two additional issues that emerged as particularly relevant to the nuclear power industry after deregulation were the safety problems associated with mergers and acquisitions, and the challenges associated with balancing the competing goals of improving productivity, cutting costs, and maintaining safety.

6. United Kingdom Electricity Supply Industry Deregulation Literature Review

6.1 Introduction

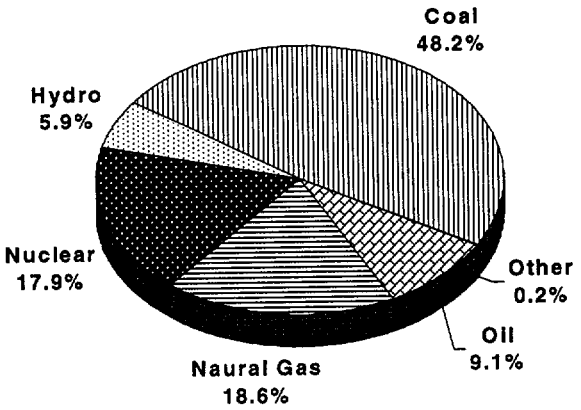
This section summarizes the evolution of the electricity supply industry (ESI) in the United Kingdom (U.K.), with a focus on recent privatization efforts and industry restructuring initiatives that may have the potential to affect the safety of the nuclear installations. Throughout this section, the term "restructuring" is used preferentially over "deregulation" for several reasons. First, the U.K. experience involved the privatization of ESI assets in addition to market deregulation. Also, as in the other case studies, safety was not deregulated. (In fact, in response to industry restructuring, the U.K. nuclear safety regulators added a new license condition, two additional inspectors, and a new level of management assessment to their previous regulatory program.) Finally, there are some indications that in the U.K. ESI, achieving increased competition has involved a change in the nature of economic regulation, rather than deregulation *per se* (see for example International Energy Agency, 1994).

This literature review draws from a wide variety of U.S. and European information sources. It is intended to provide background information on the current British nuclear energy sector and the entire U.K. ESI, in order to place it in perspective relative to the U.S. system. Additionally, a reasonably in-depth description of the historical evolution of the British ESI is included in Appendix C. This historical background is useful to understanding the political and economic driving forces behind recent change, as well as some specific developments, such as market distortions that were introduced to protect the viability of the nuclear sector.

6.2 Overview of the British Electricity Supply Industry

On a national level, the British ESI is currently the ninth largest program in the world, with a total annual electricity output of about 360 TW-hr (International Energy Agency, 1999b, pg. 532). By contrast, electricity supply in the United States is about ten times that amount (3680 TW-hr). The U.K. electrical generating capacity amounts to about 72.5 GW (International Energy Agency, 1999c, pg. 742), compared to about 792 GW for the U.S. (pg. 762).

Figure 6-1 United Kingdom Electricity Generation Capacity (72.5 GW Total)



The energy mix in the U.K. currently favors coal, as is the case in the United States. In 1998, coal and oil supplied about 35 GW and 6.6 GW of the U.K.'s electricity generation capacity, respectively. Nuclear power's share of electricity capacity, at 13 GW, was roughly equal to natural gas's share (13.4 GW). Hydroelectric

power accounted for just 4.3 GW of the U.K. total capacity, while geothermal, solar, tidal, wind, and other renewable energy supplies are insignificant contributors to electricity production (International Energy Agency, 1999c, pg. 742).

The trends in the U.K. energy mix over time shed some insights into the potential impacts of deregulation on the U.S. electricity generation industry. At the outset of privatization in 1990, coal and oil accounted for roughly 78% of the generation capacity, nuclear energy accounted for 15.5%, and natural gas was a relatively insignificant energy source. However, during the post-privatization and restructuring period since 1990, the competitive market pressures created a movement toward the use of natural gas in the British ESI, and led to a significant decline in the importance of coal and oil. By the close of 1997, coal and oil's share of generation capacity had declined to about 57%. Coal's share is expected to continue declining from 48% to just 31% by the year 2010 (International Energy Agency, 1997). Nuclear generation's share of capacity is approximately 18%, but is expected to decline to less than seven percent by 2010 under an assumption of no new orders. Natural gas's share of generation capacity, which rose from just one percent in 1990 to 18.6% by 1997 (International Energy Agency, 1999c), is expected to continue expanding to about 46% by the year 2010. The U.K.'s hydroelectric capacity (mainly in Scotland) is not expected to grow significantly beyond its current level of six percent (International Energy Agency, 1996).

Historically, the ownership of the British ESI has been consolidated through a process of nationalization from about 600 separate electric service providers before 1945, into essentially three generating companies, a national transmission grid, and fifteen Area Electricity Boards responsible for distribution and supply. At the onset of reform in the late 1980s, the U.K. had a system of public (governmental) ownership of electrical generating stations, transmission system, distribution, and supply. In England, for example, all power stations were owned by one entity, the Central Electricity Generating Board (CEGB), which effectively had a monopoly over generation. Similar generating boards also existed in Scotland and Northern Ireland. The ownership pattern of the U.K. electric industry contrasts with the system in the U.S., where the ESI involves mixed public and private ownership of the generating stations by roughly 3200 different electric service suppliers. About 90% of the American electricity suppliers are small cooperatives and publicly owned utilities, whose total output and sales are relatively small; most U.S. electricity is generated and sold by roughly 300 medium to large investor-owned utilities.

6.2.1 Aims of restructuring

The chief goal of the U.K. reform process was to improve the ESI's efficiency through the introduction of market competition. For the generating sector, this notion translated into plans for privatization and a breakup of the CEGB monopoly on power plants. In the U.K., the Area Electricity Boards also had a monopoly on electricity transmission services (a national grid). The lower voltage distribution and consumer supply (metering) systems were controlled independently by various regional electricity companies.

In contrast to their British counterparts, American electricity suppliers have tended to be locally based and vertically integrated companies. That is, at the retail level, electricity consumers from a particular geographic area typically purchase "bundled" electricity service from their local utility. This local utility usually controls its own power generation assets, transmission and distribution systems, and customer metering and billing. Within a utility's "control area," electricity surpluses and shortfalls are managed using interconnections to the transmission lines of neighboring electricity suppliers.

The chief goal of the U.S. reform process is similar to that in the U.K.—namely, to improve ESI efficiency through the introduction of market competition in the portions of the industry where that is feasible. In the U.S., the idea is to create competition in both the generation and merchant services.[1] This requires unbundling generation from transmission and distribution. Interestingly, in the U.S., horizontal mergers and acquisitions are permitted among power station owners, as evidenced by AmerGen's acquisition of the Clinton, Oyster Creek, and Three Mile Island 1 nuclear power stations.[2] By contrast, the U.K. generation sector was already heavily consolidated. The CEGB has now been broken up into four separate generating companies. In addition, there is a trend toward vertical integration of generation and merchant services in the U.K., as evidenced by British Energy's increasing sales directly to consumers (British Energy, 1999, pg. 10); note that this type of integration is not anti-competitive, because merchant services are inherently difficult to monopolize.[3] British Energy has also indicated an interest in acquiring a regional electric company (British Energy, 1999, pg. 10).[4]

With privatization, the transmission and distribution systems were recognized to be natural monopolies requiring regulation to protect the public interest. Consequently, an Office of Electricity Regulation was established. The U.K. government took the position that there was not a natural monopoly in electricity generation. Accordingly, it was felt that the generation stations could be

[1] Merchant services are the commercial sales to final customers. The merchant combines various generation services (possibly bundled with transmission and distribution services that they purchase from the regulated monopoly providers of those services), and offers pricing packages that reduce the overall financial risk to customers.

[2] The U.S. generation market has vastly more electricity suppliers than the U.K. market, so horizontal consolidation does not pose the same monopoly threat that it would in the U.K., as long as access to the transmission and distribution systems is open. Access to transmission and distribution is covered by continued economic regulation of those services. The distribution systems are under the purview of state utility regulators, while the transmission system is regulated primarily by the Federal Energy Regulatory Commission, especially under Orders 888 and 889 governing "open access."

[3] This integration of generation and merchant services has long been a hallmark of the U.S. regulated ESI, and is also being pursued by utilities in states that have deregulated their electricity markets (such as California and New England) as a way to manage their financial risks. In the U.S., state deregulation has generally required divestiture of generation by the incumbent local electric utility, but some of these companies are purchasing generation in other regions, where it is generally expected that they will also do business as merchants.

[4] Such plans might result in greater scrutiny by the regulator than the integration of generation and merchant services, since the regulator has opposed similar plans by at least one of the two dominant electricity suppliers in the past. However, the fact that British Energy is primarily a base load supplier and hence has relatively modest influence on market prices should diminish the anti-competitive threat of integrating generation and distribution, relative to similar plans by either National Power or PowerGen.

effectively regulated by competition. The market setting for the competition was set up to be a spot market for the dispatching and pricing of electricity or, more accurately, a "day ahead" market (Newberry and Green, 1996, pg. 61). Every morning, electricity generators must declare which of their generating stations will be available the next day, and bid the electricity prices for each station. At the same time, all electricity merchants submit estimates of the demand at each of the grid supply points from which they take power for each half-hour of the following day. The National Grid Company (NGC) then runs a computerized scheduling program that attempts to minimize generating costs over the next day based on the prices bid. This is known as the "unconstrained schedule," which does not take into account all transmission constraints. The interconnections with France and Scotland are treated similarly to the conventional generators, but they also provide schedules of the prices at which they are willing to buy power.

As will be seen in the following discussion, the U.K. efforts to create market competition were compromised by the government's decision to sell most of the generating stations to just two entities, PowerGen and National Power. As a result, these two companies hold market power and sometimes succeeded in systematically raising prices above marginal costs. The end result was that many U.K. consumers actually saw increases in electricity prices following the privatization and restructuring activities of the late 1980s (International Energy Agency, 1996), rather than the decreases that had been expected from more efficient operations. The government's solution to the "market power" dilemma has been to encourage greater consumer choice. In the U.K., electricity customers may now circumvent the daily market and contract directly with the power stations for their long-term electricity needs. In the U.S., such consumer choice initiatives are in earlier stages of development. Presently, the Federal Regulatory Energy Commission has mandated "open access" for generating stations to the transmission grid (i.e., wholesale market competition). Consumer choice initiatives at the retail level are presently controlled by state governments, but retail access in U.S. markets will likely include the ability to contract directly both with generators and with any other qualified merchants. About half of the U.S. states have already enacted consumer choice legislation, with most plans calling for consumer choice to be in place by 2002.

6.2.2 The United Kingdom nuclear program

Currently there are 35 commercial nuclear power reactors operating at 16 sites in the U.K., for a total net output of about 14,000 MW (Nuclear Engineering International, 1999, pg. 186). The U.K. nuclear program is the seventh largest in the world. As noted previously, the nuclear energy industry supplies about 18% of the generation capacity in the U.K. This share is currently slightly larger than the country's reserve margin of 16% and significantly larger than grid stability requirements (estimated to be about ten percent), implying that a significant portion of nuclear capacity is necessary, at least at times of peak demand.

With the exception of a single Westinghouse-designed pressurized water reactor (PWR) at the Sizewell B site, all of the operating power reactors in the U.K. are graphite moderated and carbon-dioxide cooled. The earlier reactors were brought into operation between 1956 and 1973. They are of the Magnox type, in which the fuel elements are natural uranium metal rods clad in a magnesium

alloy. Twenty of the Magnox-type reactors (3786 MW gross) are still operated by Magnox Electric under the direction of British Nuclear Fuels Ltd. (BNFL). The average age of all operating Magnox reactors is about 33 years, and the oldest Magnox reactor at Calder Hall was placed into operation roughly 43 years ago. The Magnox reactors have relatively low thermal efficiency (in the range of 19-28%) and relatively high back-end costs. Therefore, the continued operation of these units may be partially dependent on government subsidy. That is why the Magnox reactors were not privatized during the major ESI restructuring initiatives of 1989 and 1996.

Another 14 U.K. reactors are of the advanced graphite reactor (AGR) type, utilizing slightly enriched uranium as a fuel. The AGRs have an average age of about 13 years, and are currently owned and operated by British Energy Generation Limited (BEGL) and British Energy Generation (UK) Limited (BEG(UK)L), which in turn are wholly owned subsidiaries of British Energy. The final U.K. reactor, which was connected to the grid in 1995, Sizewell B (1258 MW gross), is a much newer PWR design based on the U.S. Standard Nuclear Unit Power Plant System.

The U.K. has permanently retired ten of its commercial power reactors, including: two fast breeder reactors (Dounreay DFR and PFR); six Magnox reactors (Berkeley 1 and 2, Hunterston A1 and A2, and Trawsfyndd 1 and 2); one advanced gas reactor (Windscale); and one steam-generating heavy-water reactor (Winfrith). The U.K. decommissioning program is based on the safe storage concept, as opposed to the rapid dismantling and decontamination approach typically assumed in the U.S. A storage period of about 120 years is currently envisioned prior to full reactor decommissioning. Since in the U.K. decommissioning costs are discounted over a long time period, its decommissioning funding assurance requirements are unusually small in comparison to U.S. requirements. The entire U.K. decommissioning fund for 35 reactors (roughly U.S. $200 million) amounts to only about one U.S. reactor's decommissioning fund requirement.

As recently as 1982, the U.K. government announced plans for an aggressive nuclear construction program of 10 PWRs. A moratorium on new construction was initiated in 1989, pending the results of a governmental review (MacKerron, 1996). That review concluded in favor of nuclear power in 1995. However, by that time, the plans to construct two new PWRs at the Sizewell C site had been canceled due to poor comparative economics in the late 1980s and early 1990s,[5] coupled with the discovery of large supplies of off-shore natural gas. Currently, no new reactor construction is planned in the U.K.

6.2.3 Nuclear safety regulation

The U.K. Health and Safety Executive (HSE) is the executive arm of the Health and Safety Commission, and reports to the Secretary of State for Employment. It was set up under the 1974

[5] The early economic analyses may have been based on assumptions of full market competition, rather than the sheltered market eventually created by the Fossil Fuel Levy, as discussed later in this section.

Health and Safety at Work Act,[6] and brought together the Nuclear Installations Inspectorate (NII) and a number of other Inspectorates under the umbrella of a single authority. The HSE is the competent authority for regulating the day-to-day safety of nuclear installations in the U.K., and for enforcing the health and safety provisions of legislation. The HSE is a statutory body of three people that delegates responsibility for the regulation of safety to the NII. Its inspectors have the necessary powers to enforce the appropriate parts of the relevant legislation. Although the HSE is not under the direct control of the Departments directly concerned with energy policy, it nevertheless remains ultimately answerable through the Health and Safety Commission to the Secretary of State for Energy and the Secretary of State for Scotland for nuclear safety matters.

In the U.K., licenses are granted to corporate bodies for the use of a nuclear site. This differs somewhat from the U.S. system, in which each reactor at a site must be licensed individually. The NII is the authority responsible for granting nuclear site licenses and enforcing compliance with the safety conditions attached to these, together with other health and safety legislation (U.S. Nuclear Regulatory Commission, 1999). A single license covers all activities on site, from construction through operation through decommissioning. The NII does not license individual operators at the site; however, a license condition requires that all persons who control or supervise operations affecting safety must be duly authorized. Breach of any law, regulation, or license condition is a criminal offense, and the offender may be prosecuted in the U.K. courts of law. Also, in contrast to the process in the U.S., the NII does not conduct a public hearing for the licensing of a nuclear power plant. Instead, the NII has relatively broad powers, and may issue licenses and set license conditions at its own discretion.

Another key feature of the U.K. nuclear safety regime is that it operates far less prescriptively than its U.S. counterpart. This is a point about which U.K. regulators express considerable pride. The NII effectively sets performance goals. Each licensee is then responsible for developing its own nuclear safety standards, and demonstrating that those standards reduce the risk to staff and members of the public to as low a level as reasonably practical. The NII then reviews and assesses the licensee standards against its own published Safety Assessment Principles. Unlike in the U.S., British reactor operating licenses are neither prescribed by law nor limited to a specific period of time. In effect, the U.K. licenses are of unlimited duration—provided, of course, that an adequate safety case can be made for continued operation. Short-term aging issues are addressed under maintenance program requirements; longer-term aging issues are addressed through a Periodic Safety Review process that must be completed at ten-year intervals. Regulatory permission is required for reactor restarts.

Similar to the Final Safety Analysis Report in the U.S., a fundamental feature of the British regulatory system is the requirement for each licensee to demonstrate the safety of its proposed operation in a document known as the "safety case." The NII also enforces safety and health regulations related to non-nuclear hazards at licensed sites. This role is perhaps comparable with

[6] The main legislation governing the safety, and enforcement of safety, at nuclear installations in the U.K. is the 1974 Health and Safety at Work Act. There are also relevant statutory provisions of the Nuclear Installations Act 1965 as amended and the Ionizing Radiations Regulations 1985, supplemented by the Nuclear Installations Regulations 1971 as amended.

those of the U.S. Environmental Protection Agency and state safety and health authorities. The relationship between the U.K. licensees and the safety authorities is generally less antagonistic than that found in the U.S. The majority of discrepancies found by NII inspectors are addressed at the individual inspector and plant operator level, without the need for formal documentation or regulator-issued enforcement actions.

The U.K. nuclear safety authorities oversee fewer nuclear reactors than their American counterparts (35 versus 103). However, the U.K. NII also oversees large fuel cycle facilities, nuclear weapons production facilities, nuclear submarine refueling facilities, and certain non-nuclear health and safety activities of its licensees (U.S. Nuclear Regulatory Commission, 1999a). Despite its broader mandate, the U.K. nuclear safety authorities manage to operate with substantially fewer regulators per reactor than in the U.S. This ratio is about 5.6 to 6.7 in the U.K., versus triple this level (17.2) in the U.S. (U.S. Nuclear Regulatory Commission, 1999a).

Another significant difference between the British and American nuclear programs is that all U.K. nuclear power stations are currently owned by just three licensees: Magnox Electric; BEGL; and BEG(UK)L. The U.S. Nuclear Regulatory Commission has claimed that this distinction allows the U.K. to operate a "goal setting regulatory regime" rather than a highly prescriptive regime (U.S. Nuclear Regulatory Commission, 1999a). However, this explanation may not be sufficient to explain the large difference. In practice, NII licenses each reactor site, so there are effectively 16 licensees, not three. Another plausible explanation for the staffing difference may be the fact that working relations between British licensees and the regulator are considerably more cooperative and less antagonistic than is generally true in the U.S. Therefore, a highly prescriptive approach to regulation never evolved in the U.K.

6.3 The Privatization Period (1987 to 1995)

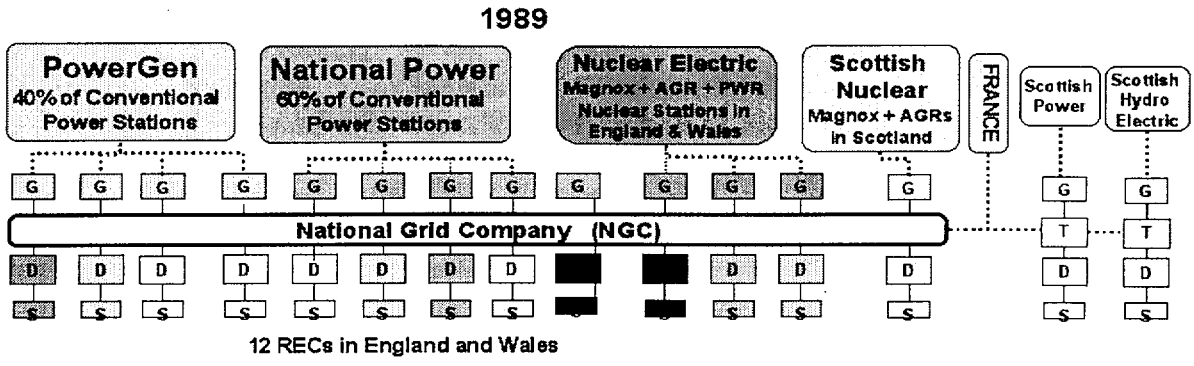
Privatization of the ESI in the late 1980s was aimed at radically changing the post-war structure and culture of the electricity industry (Ferner and Colling, 1993). However, it was not an isolated act of government policy (Thomas, 1996). Privatization of the ESI followed in the wake of the privatization of British Telecom and British Gas, during a decade of proposals by the Thatcher government that also included the coal, water, and railway industries. The Thatcher government published the initial plans for privatization of the ESI in 1988. The approach taken for the privatization of the ESI was different than that chosen for the telecommunication and gas monopolies in the preceding years. In particular, it was decided to break up the ESI prior to privatization. British Telecom had been sold as a single entity, and British Gas as a vertically integrated company (Newberry and Green, 1996). By contrast, the government's 1988 "White Paper" proposed that all of the nuclear stations, together with 60% of the conventional power stations, be placed under one large company (National Power), with the remaining conventional power stations going to PowerGen. The performance of the U.K. nuclear reactors at this point in time was less than optimal, and there were lingering concerns as to the true extent of nuclear liabilities such as waste disposal and decommissioning costs. The logic behind the disproportionate

breakup of the CEGB and the new duopoly was that a larger company could more easily cope with any nuclear liabilities, while the existence of a second power company would promote competition.

However, the government's time scale for privatization was aggressive, and concerns over the potential nuclear liabilities could not be resolved within the time that had been allotted. Consequently, at a late stage in the process, the government decided to withdraw all nuclear power stations from the sale of the CEGB. The nuclear stations in England and Wales were to remain within the ownership of the government under a new publicly owned company called Nuclear Electric, while the nuclear power stations in Scotland would be transferred to a newly created all-nuclear company called Scottish Nuclear.

The revised restructuring proposal became law under the Electricity Act of July 1989.[7] Under this plan, the national transmission grid was transferred as a regulated monopoly to the National Grid Company. Accordingly, the CEGB was divided into four companies: PowerGen; National Power; Nuclear Electric; and the NGC. The South Scotland Electricity Board was similarly divided into a nuclear company (Scottish Nuclear) and a non-nuclear company (Scottish Power). As shown in Figure 6-2, each of the resulting companies owned and operated its own power generating stations (G), while the NGC owned the high voltage transmission lines (T). In England and Wales, the 12 Area Electricity Boards were renamed regional electricity companies, and retained responsibility for lower voltage distribution lines (D) and customer supply (S) for metering, billing, and sales. Ownership of the NGC was transferred to the regional electricity companies, and they were sold to the public in December 1990. Sixty percent of National Power and PowerGen were subsequently sold to the public in March 1991, and the remainder four years later (Newberry and Green, 1996, pg. 59).

Figure 6-2 United Kingdom Electricity Supply System: Initial Privatization



[7]The Scottish non-nuclear industry was subsequently privatized as two vertically integrated companies, while Northern Ireland Electricity was broken up and sold as four separately managed concerns (Newberry and Green, 1996, pg. 58).

6.4 Evolution of the Nuclear Sector

The economics of nuclear power in the U.K. played a key role in the evolution of the ESI and the ultimate competitive structure of the resulting market. From the 1960s onward, the CEGB had regarded nuclear power as its first choice for new electrical capacity (MacKerron, 1996). The two plutonium production reactors at Calder Hall and Chapelcross in the 1950s became the basis for a civilian Magnox reactor program. Although they proved to be robust in safety features and fairly reliable in operation, the Magnox reactors carried large "back-end" costs associated with spent fuel management and decommissioning (MacKerron, 1996). The British later modified the design by adopting the AGR. However, these reactors proved to be less reliable, and all of them suffered cost escalations and lengthy construction delays. By the 1970s, the CEGB had become keen on building PWRs instead of graphite-moderated reactors. By 1979, the CEGB started to publish figures designed to show the relatively low cost of operating nuclear power stations.

The Conservative government that took office in 1979 quickly adopted a policy of major nuclear construction, and called for a program of ten large PWRs to start construction annually beginning in 1982 (Secretary of State for Energy, 1979). However, this timetable quickly ran into trouble. The government announced that a major public inquiry would be held on the Sizewell B reactor. The idea was to use the inquiry as a generic mechanism to facilitate the approval of future PWRs. However, the inquiry was delayed until 1982 because of design changes in the reactor. It then became bogged down on a wide range of subjects, including nuclear weapons and energy policy in general. The inquiry was not completed until 1985, and the report was finally published in 1987.

The report was highly favorable to the proposed Sizewell B reactor, and argued that there was only a one in 40 chance that a coal-fired project would be cheaper. However, much of the data had become outdated during the lengthy hearing. Furthermore, the cost figures that the CEGB had published failed to take into account the full costs, resulting in a systematic bias toward nuclear power. Eventually, Sizewell B's economics proved to be much worse than had been predicted. Its capital costs had escalated by 35%, and it was now estimated to generate electricity at roughly twice the spot price for electricity established by the Pool. Thus, by the time that privatization of the ESI was proposed in the late 1980s, the plans for rapid growth in nuclear power had been dashed.

Three of the AGRs that came on line in the late 1980s appeared to be chronically unreliable. This fact, coupled with high construction costs, led to high total production costs. Furthermore, the "back-end" costs of the Magnox reactors escalated sharply, in part because BNFL held an effective monopoly on spent fuel and waste management services. The dominant cost for Magnox reactors was reprocessing costs, which had roughly doubled between 1979 and 1985. Decommissioning costs had also become more clearly defined during this time frame. In short, as discussions of privatization began to surface, the total costs of running nuclear stations were being perceived as substantially higher than those of coal-fired generation. The nuclear liabilities were also proving difficult to estimate. In this climate, there were growing fears that it would be impossible to privatize the nuclear power plants in a deregulated market structure that would no longer pass

through costs to consumers. The Conservative government recognized these risks, and these concerns became the driving force behind the proposed structure of the British ESI.

Ideally, with about 60,000 MW of electric capacity, the power supply system of England and Wales could have been broken into several companies, to stimulate competition. However, the Government had decided that the financial risks of nuclear power were too great, and that the owners would need a strong financial shelter. Consequently, they proposed to create a large generating company, National Power, owning all of the nuclear stations and about 60% of the conventional stations (or about 70% of the current total capacity). It was then argued that another large company (rather than several small companies) was needed to offset National Power's market power. The second privatized company became PowerGen, which owned the remaining 30% of capacity in England and Wales.

Unfortunately, the negotiations between the government and National Power over the nuclear issue became difficult. National Power had an interest in inflating the apparent nuclear liabilities in order to secure for itself the best possible commercial terms for taking ownership of the nuclear power stations. Lord Marshall (former Chairman of the CEGB) tried to show that PWR costs could almost triple if private sector assumptions replaced those of the public sector. In the end, the government became convinced that the potential nuclear liabilities were sufficiently real that the nuclear assets of the U.K. should be removed from the privatization effort.

Just prior to privatization in 1988, the nuclear stations were withdrawn from public sale and placed under two government-owned utilities: Nuclear Electric; and Scottish Nuclear. It was determined that all Magnox, AGR, and PWR reactors in England and Wales would go to Nuclear Electric, while the AGRs and Magnox reactors located in Scotland would go to Scottish Nuclear. At this point, the rationale for a 60/40 split of fossil-fueled power stations between National Power and PowerGen no longer existed. However, the government was committed to a tight schedule for privatization, and therefore decided to simply keep the duopoly concept (National Power and PowerGen) that had been developed over the preceding months. Furthermore, the government was concerned that the regional electricity companies would not buy the more costly nuclear power if left to their own choice. This in turn would leave Nuclear Electric and Scottish Nuclear incapable of covering their large nuclear liabilities. Consequently, the government also created a "non-fossil fuel obligation," which mandated that the regional electricity companies purchase all nuclear electricity that was offered to them.

Since the regional electricity companies were to buy power at the Pool price, still another mechanism was required to cover the higher costs believed to be associated with nuclear power. In late 1988, the Government introduced the Fossil Fuel Levy in England and Wales, which was a broad tax of roughly ten percent on all electricity sales from fossil fuel sources. In essence, the Fossil Fuel Levy was a carbon tax. The proceeds of the Fossil Fuel Levy were to be given to Nuclear Electric, with the idea that it would use the funds to pay down its nuclear liabilities associated with reprocessing, decommissioning, and waste disposal. The payments made to Nuclear Electric under the Fossil Fuel Levy were kept secret until 1992, when it was discovered that they had resulted in windfall profits

for Nuclear Electric. In fact, in 1990, the levy amounted to over 50% of Nuclear Electric's revenue, and had diminished only to 43% of its total income by 1995. In addition, only about one percent of the Fossil Fuel Levy payments was applied to decommissioning liabilities. Reportedly, Nuclear Electric was able to complete the Sizewell B reactor and make other minor investments without any borrowing.

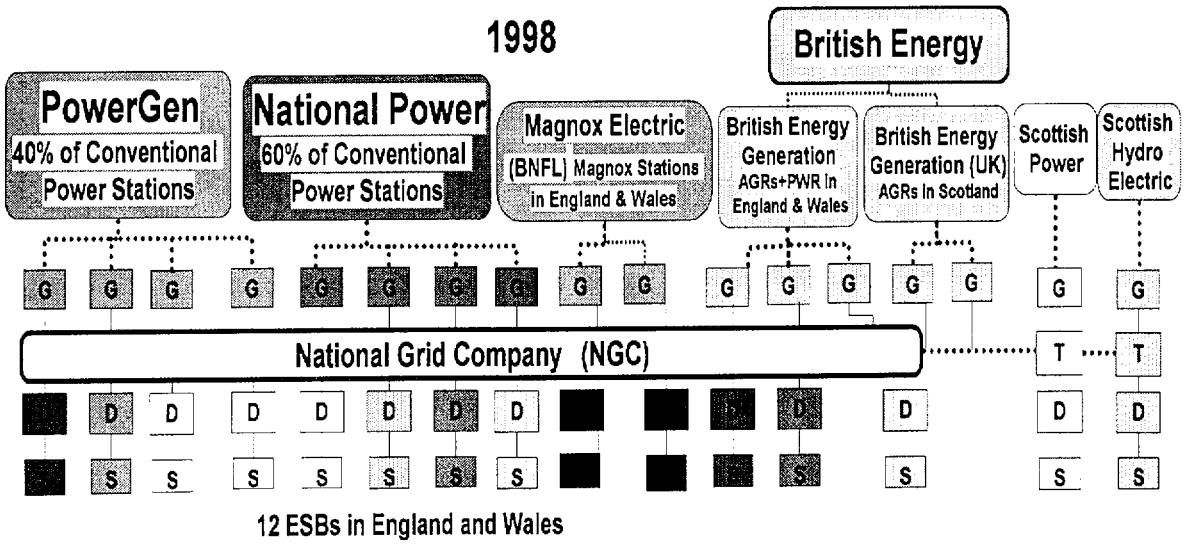
There were several shortcomings with the restructuring that took place in 1988 and 1989. First, a truly competitive market in electricity generation had not developed. PowerGen and National Power had significant market shares, which allowed them some degree of control over the market price of electricity. Nuclear power had not been privatized, and remained in the government stewardship of Nuclear Electric and Scottish Nuclear. Furthermore, the market for nuclear electricity been propped up in England and Wales by subsidies generated by the non-fossil fuel obligation and the Fossil Fuel Levy. Finally, a moratorium on new nuclear construction had been established until the government could complete a review of its policy towards nuclear power.

That review, published in 1995 (U.K. Department of Trade and Industry, 1995), proposed that the older Magnox plants should remain in government ownership under a new company called Magnox Electric, which would be controlled by the state-owned nuclear fuels and waste management company, BNFL (Chesshire, 1996, pg. 76). BNFL already owned two Magnox reactors, which had been built originally for the main purpose of producing weapons-grade plutonium. These plants currently produced electricity as their primary product. By now, the performance of the AGR reactors had improved and Sizewell B had come on line. Nuclear Electric's trading income had risen by over 600 million pounds from 1990 to 1995, while its operating cost had fallen by 100 million pounds. The income of Scottish Nuclear also rose during this time, while its operating costs declined. These positive developments led the 1995 review committee to conclude that the two Scottish AGR stations, the five English AGR stations, and the Sizewell B PWR could be combined into one large, viable, privatized nuclear company called British Energy. The government enacted the plan by creating Magnox Electric and British Energy in 1996 (Chesshire, 1996).

Shortly after its creation, British Energy underwent further reorganization. Nuclear Electric and Scottish Nuclear were renamed. The company further announced that it intended to merge these renamed subsidiaries—BEGL and BEG(UK)L, respectively—into a single licensee. These plans were later put on hold due to commercial concerns. However, the company nevertheless began to implement a "trial" integration of its upper management and nuclear support staff. The effects of this integration process and the associated downsizing are discussed later in this report.

With the new restructuring, the Fossil Fuel Levy could no longer be justified in a fully competitive privatized industry. The European Union had labeled the Fossil Fuel Levy a subsidy, and had mandated that it be terminated in 1998. However, the latest restructuring also left the large Magnox liabilities (roughly 17 billion pounds un-discounted) in the public sector.

Figure 6-3 United Kingdom Electricity Supply System: Privatization of Non-Magnox Nuclear Reactors



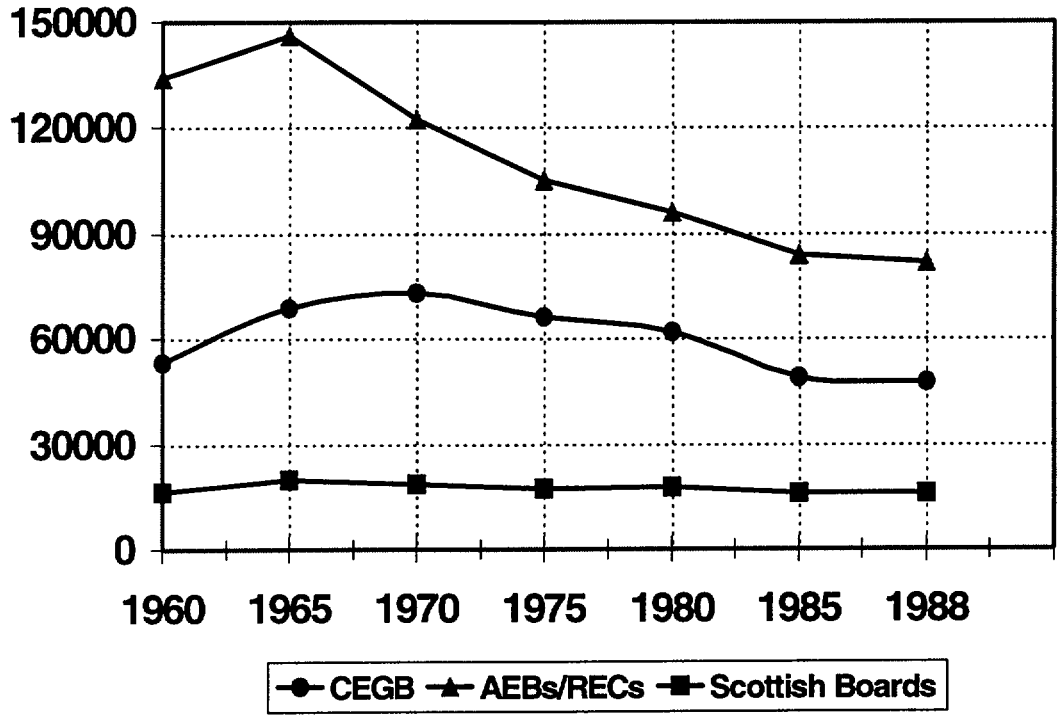
6.5 The Broad Impacts of the United Kingdom Privatization and Restructuring Process

6.5.1 Downsizing

Beginning in the mid-1960s, the transformation of the U.K. ESI led to large declines in employment. Ferner and Colling (1993) indicate that employment in the British ESI peaked in 1967 at 229,000. However, between 1960 and the onset of privatization in 1987, the CEGB closed more than 200 power stations. During the same time period, the number of employees in the CEGB was cut back from a 1967 peak of about 80,000 to 47,400 in 1988. From 1965 to 1988, the Area Electricity Boards experienced a similar 44% loss of personnel (64,500 jobs), as indicated in Figure 6-4.

In the early years, employment changes were linked to the replacement of labor-intensive power stations with larger, more modern ones. Also, reductions occurred due to a declining rural electrification program. The industrial staff felt the greatest impact of the personnel cuts until at least the early 1980s (Ferner and Collling, 1993). However, beginning in the 1970s, new office technology began to dramatically affect white-collar workers in the Area Boards, accounting for 22% of the overall drop from 1975 to 1985. Engineering staffs were less affected, and remained larger at the end of the 1980s than in 1960. Throughout this time period, the CEGB and the AEBs attempted to soften the blow of layoffs by reliance on attrition, early retirement, relocation, and restrictions on recruitment (Edwards and Roberts, 1971, pp. 201-203; Monopolies and Merger Commission, 1984, pg. 105). New technology and improved working methods reportedly led to greatly increased productivity (Pryke, 1981, pp. 22-23, and 34-35). In the mid-1960s, the estimated work rate norm for the CEGB industrial staff was reportedly about 60% of "standard" performance,

Figure 6-4 Pre-Restructuring Employment in the United Kingdom Electricity Supply Industry

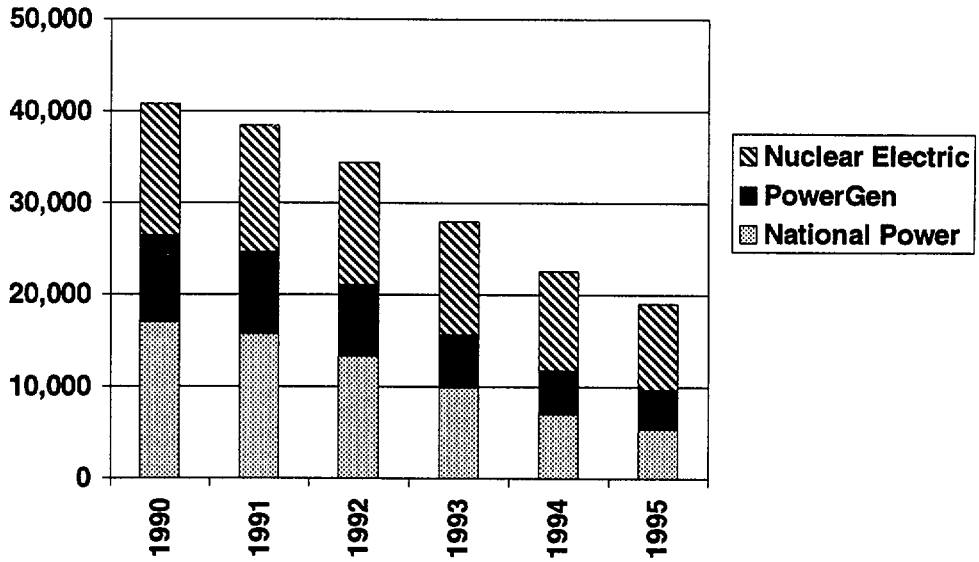


but by the late 1970s, 99% were achieving standard performance. The number of employees required for sending out a megawatt of electricity halved between the late 1960s and the early 1980s (Monopolies and Merger Commission, 1981, pg. 220).

The downsizing has not been uniformly implemented across the ESI. Gradual downsizing has occurred in the transmission, distribution, and customer service sectors. By contrast, relatively dramatic declines have occurred among the power generators during the privatization and restructuring periods. At its peak in about 1970, about 70,000 people were employed by the CEGB in the area of generation and transmission. Today, the transmission and generation sectors (coal, gas, and nuclear) employ less than 25,000 people.

The impact associated with such dramatic declines in employment has been tempered somewhat by the retirement of many old and labor intensive plants, the computerization and modernization of many functions at the remaining plants, and the introduction of greater efficiencies as a result of new competitive pressures. Another commonly used cost cutting technique has been the reduction of overhead costs through increased reliance on contractors to perform work.

Figure 6-5 Post-Restructuring Employment in United Kingdom Electricity Generating Companies

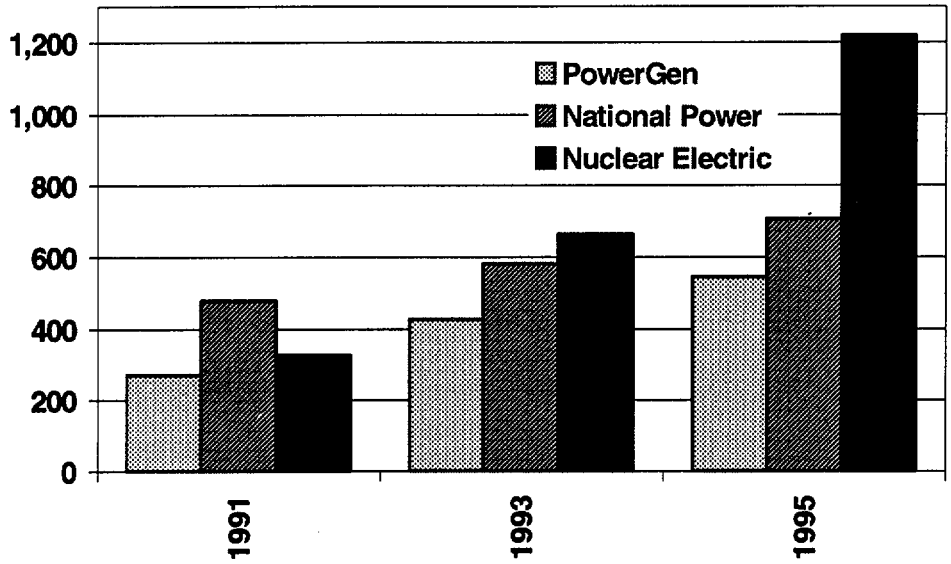


6.5.2 Profitability

Initial expectations were that the nuclear power stations would be unprofitable in the deregulated market, and would be unattractive from an investment perspective, owing to problems in waste disposal and large uncertainties about their decommissioning costs. The British government responded to these concerns first by withholding the nuclear stations from the privatization effort, and by creating special government-owned holding companies called Nuclear Electric and Scottish Nuclear. Eventually, it was realized that the largest decommissioning uncertainties were associated with the older Magnox reactors, and a plan was developed to privatize the other nuclear assets. To ensure safety and sufficient collection of decommissioning funds for this latter group of reactors, the government introduced a market distortion by imposing a levy on all fossil-fueled electricity generation. The proceeds of the levy were first paid directly to the government (Nuclear Electric and Scottish Nuclear), and later to the corresponding privatized entities.

Although the levy was intended to bolster the nuclear plant owners' ability to fund decommissioning, the government had established insufficient controls on how the levy proceeds were to be managed. The nuclear plant owners responded to the U.K.'s decommissioning fund assurance requirements by selecting the safe storage approach to decommissioning, and by projecting a relatively long (120-year) period of storage before decommissioning. As a result, using present value analyses, they have been able to argue that only a small percentage (about six percent) of the Fossil Fuel Levy should be directly allocated to a decommissioning fund. Consequently, the levy has resulted in windfall profits to the nuclear station operators, since their marginal costs of operation were already very competitive. In 1996, British Energy assumed control over Nuclear Electric and Scottish Nuclear.

Figure 6-6 Post-Restructuring Profitability of United Kingdom Electricity Generating Companies (in Million Pounds)



The financial strength of British Energy has allowed it to move into U.S. and Canadian nuclear generation markets through the creation of local joint ventures such as AmerGen and CanaGen.

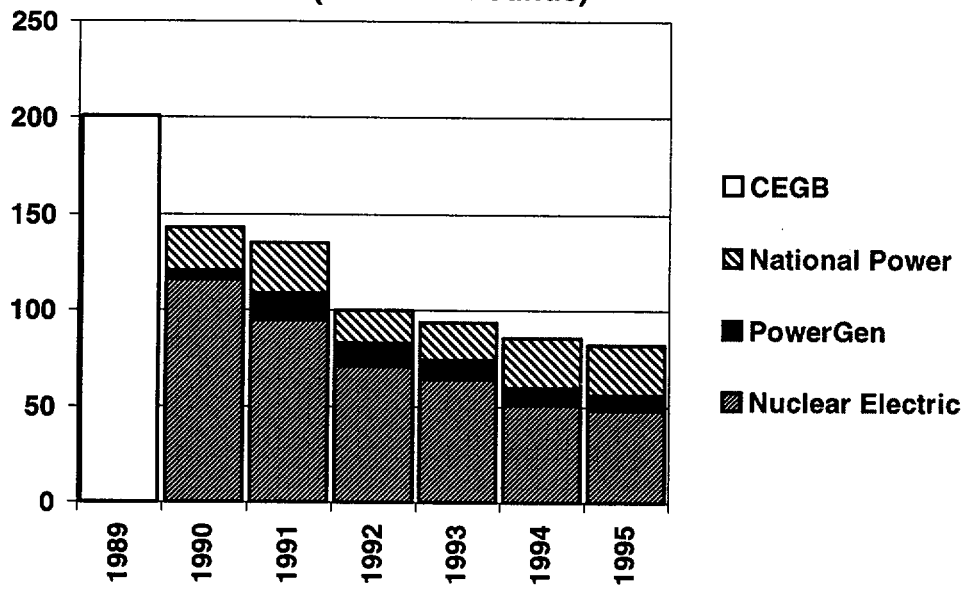
6.5.3 Research and development

There has been a substantial decline in U.K. nuclear research and development (R&D) funding since the onset of market competition in nuclear power. This can be partly explained by the fact that no new reactor orders are expected in the foreseeable future. In addition, the recent switch from a domestic AGR reactor design to the Westinghouse Sizewell PWR design eliminated the need for many domestic R&D activities. There appear to be trends toward diminished R&D associated with advanced reactor designs and advanced safety features. We did not have enough information to identify any other trends. However, there were some indications that R&D expenditures in areas relating to the reliability of safety components may have increased, due to the heightened interest in keeping power plants online and avoiding the large costs associated with unplanned interruptions of service in the new market.

6.5.4 General safety trends

This literature review produced relatively little meaningful information about the safety impacts associated with the British privatization and restructuring. Hood (1997) notes that in the U.K., there was some "stinging criticism" of privatization, based on anecdotal evidence to the effect that increased commercial pressures were in some way incompatible with good health and safety practices. In other words, some believed that safety expenditures might have a detrimental effect on

Figure 6-7 Research and Development Expenditures of United Kingdom Electricity Generating Companies (in Million Pounds)



profitability, and that employers that were prepared to spend money on the health and safety of their employees would be at a commercial disadvantage. However, Hood argues that reliable validation of many of these claims has been lacking. There is some evidence that privatization has led to a reduction in occupational health and safety standards; however, Hood suggests that it may be an oversimplification to cite commercial pressures as the only reason for that reduction (Hood, 1997, pg. 23).

Fears over the effects of privatization on nuclear safety have been responsible for many of the concerns about electricity privatization. In 1995, the former director of safety at Scottish Nuclear, Richard Killick, claimed that "Low morale, overworked operators, and the rush to reduce costs before privatization posed a threat of a significant reduction in safety [and that] privatization would erode safety culture" (The Herald, 1993). Criticism of nuclear safety was also leveled against Nuclear Electric following an incident at the Wylfa Twin Magnox Power Stations in 1993 (Safety Management, 1995). In this incident, reactor operation was allowed to continue even though safety had clearly been compromised. However, Nuclear Electric denied that commercial considerations played any part in the decision to defer shutdown.

Overall, the post-privatization track record concerning the safety of British nuclear power stations seems to indicate mixed results, and suggests that care must be exercised in discerning true safety impacts from politically or commercially motivated assertions. This is particularly true during the period of time from 1988 to 1996, when consideration was being given to dividing up the U.K.'s generating station assets.

7. United Kingdom Electricity Supply Industry Interviews and Safety Audits

7.1 Background

The interviews for this section of the report were handled differently than for the rail and aviation sections, in that the participants were allowed more latitude to describe the change process and impacts in their own terms. This approach was taken because there are cultural differences involved in collecting and analyzing information from a foreign country, and because the key discussions were also related to a sensitive, ongoing audit activity (i.e., involved pre-decisional matters).

The initial interviews were conducted in July 1999 with the British nuclear safety authorities, the Health and Safety Executive (HSE) Nuclear Installations Inspectorate (NII), and the main reactor licensee in England, British Energy. A second round of interviews was then conducted in January 2000 to follow up on open issues. In addition to the interviewees named in this section, additional background information was obtained from discussions with: trade union representatives; British Energy's director of Health, Safety and Environment; and a local U.K. trade press correspondent.

Both NII and British Energy were remarkably frank and cooperative. They provided a wealth of pertinent information to the interviewer, despite the presence of a pre-decisional audit of major impact. This high level of cooperation supports perhaps the very first interview finding—namely, that the working relations between the U.K. regulator and the U.K. licensee are seemingly less antagonistic than their U.S. counterparts. As a result, the U.K. safety authorities are able to operate under a more flexible, "goal setting" regime rather than the highly prescriptive regulatory process characteristic of the U.S. Nuclear Regulatory Commission (NRC). This finding is significant, since a more flexible regulatory regime may also be more adept at managing the relatively rapid, large-scale organizational changes associated with electricity supply industry (ESI) restructuring.

This section is organized along the lines of the discussions that took place. First, British Energy explained the nature of their reorganization, and highlighted some of the positive safety benefits that resulted. Next, the British safety authorities explained how the regulators took a very involved and proactive approach to overseeing the utility's change management process. This included, for example, the need to re-license the nuclear stations because the original licensing bases would change significantly over the course of industry restructuring. The regulators then explained their first indications of "change management" safety problems surfacing at the Sellafield and Dounreay nuclear facilities, particularly with respect to excessive downsizing and the increased use of contractors. The results of the safety audits on British gas-cooled and light-water reactors, which are perhaps most applicable to the U.S. situation, are presented next. Both British Energy and the safety authorities also offer clarifications on the key issues involved in restructuring, and on the new license condition 36 (requiring the licensee to be "an intelligent customer" of contracted services, and requiring a safety analysis of significant management changes before they are implemented).

The key points of the interviews and documents are summarized below. Readers interested primarily in the main observations of this section may wish to turn directly to Sections 7.7 and 7.8, before reading the detailed background information on which those observations were based.

7.2 Initial British Energy Interviews

7.2.1 British Energy corporate office

Interviews were initially conducted at the London office of British Energy on July 5th, 1999, with its manager of corporate affairs and director of government affairs. These individuals presented a broad overview of the privatization process and corporate transformation of Nuclear Electric and Scottish Nuclear into subsidiaries of British Energy. They also provided several relevant corporate reports with additional facts and statistics. These included British Energy's *1997-1998 Health, Safety and Environment Report* (British Energy, 1998) and the *1998-1999 Annual Report and Accounts* (British Energy, 1999), as well as internet coordinates where further annual reports and information could be found (http://www.british-energy.com).

British Energy confirmed that when the privatization of nuclear power was first considered in the U.K. along with the creation of a competitive electricity market, the future viability of the nuclear stations was unclear. In the 1980s, the performance of several reactors had been found to be lower than expected, and it was also believed that there were potentially large decommissioning liabilities associated with the Magnox reactors. These factors, coupled with the uncertainties of a new electricity market, made it difficult to predict the future value of the nuclear stations. As a result, the government took the decision to keep the nuclear power stations under public (government) ownership initially while they studied the situation further. Two public companies were created (Nuclear Electric and Scottish Nuclear) to hold the nuclear assets, while the remaining conventional generating stations in the U.K. were transferred to PowerGen, National Power, and Scottish Power.

By the early 1990s, however, the performance of the modern advanced gas reactor (AGR) and pressurized water reactor (PWR) plants began to improve substantially. The uncertainties in their decommissioning costs also began to diminish as worldwide experience with decommissioning accumulated. Feeling more confident, the government then decided to proceed with the privatization of the AGR and PWR reactors, while at the same time keeping the older Magnox designs under public ownership. In 1996, British Energy was created, and acquired Nuclear Electric and Scottish Nuclear from the government.

British Energy indicated that contrary to the original government worries about nuclear power's viability, it has succeeded in operating the reactors very well and with high profitability. They noted that the company has set an objective of becoming a "world class energy company, the lowest cost U.K. electricity generator, while at the same time maintaining excellent safety performance." The establishment of such a goal indicates a noteworthy corporate objective in a competitive environment (the pursuit of excellence rather than minimums).

The company's results to date speak highly of the corporate management's skill. British Energy was privatized about five years ago, in July 1996. Despite facing the difficulties of a changing market, the company has shown remarkable growth and performance. During its 1998-1999 fiscal year, British Energy's profit before taxes was up 56%, and its generating stations had achieved their highest ever output. Two AGR stations (Heysham 1 and Hartlepool) had passed their life extension reviews allowing ten more years of operation, and another two AGRs (Heysham 2 and Torness) had extended their accounting lives by five years. British Energy's unit operating cost had declined, productivity per employee continued to steadily increase, and one of its large gas-fired power stations (South Humberside) had completed its construction ahead of schedule. The acquisition of several U.S. nuclear plants has been announced (http://www.british-energy.com/investors/fr_results.html), and the company's joint venture (AmerGen) with PECO Energy is also eyeing the acquisition of more U.S. nuclear stations (*Electric Utility Week*, 1999a).

Figure 7-1 British Energy Output
(TWh)

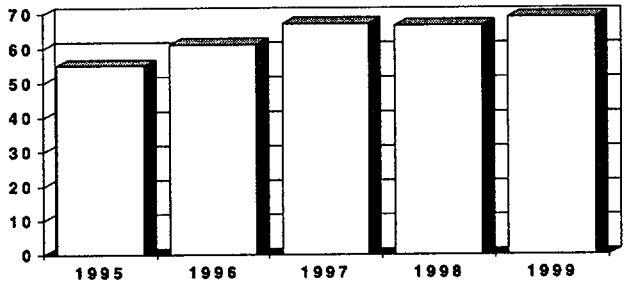
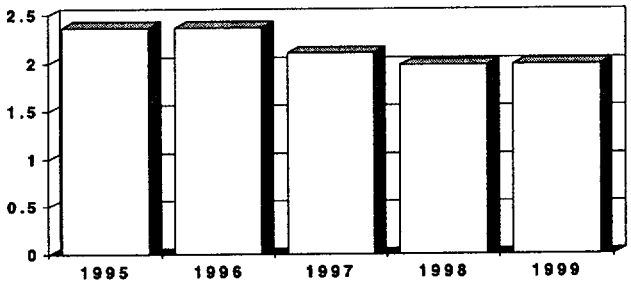


Figure 7-2 British Energy Unit Operating Cost
(pence/kWh)



British Energy's chairman has gone on record stating that "Safety continues to be our top priority" (British Energy, 1999). The interviewees provided evidence that the company was already moving toward or meeting its safety objectives in a number of areas, as outlined below; see also British Energy (1998).

The overall unplanned automatic trip rate for British Energy's reactors has shown a steady decline since restructuring. In the 1996-1997 reporting period, the rate had declined to 2.8 scrams per 7000 hours of reactor operation. In the 1997-1998 period, it declined further to 2.7

scrams. Although the scram rate for an AGR reactor is expected to be higher than the average world reactor, the company has nevertheless launched initiatives to reduce the unplanned scram rate even further. (Reductions in unplanned reactor trip rates are believed to offer a degree of safety enhancement, in that a reactor's safety systems are not challenged unnecessarily to perform their shutdown and control functions. With fewer transients and challenges to safety systems, it is theorized that the number of hardware failures during transients are also reduced. However, the use of reactor trip rates as a safety indicator remains controversial, since a failure to scram may also produce non-conservative safety results.)

The company has hired a U.S. firm to track and assess its overall safety performance using an International Safety Rating System. Of British Energy's eight nuclear power stations, all but one show either a safety improvement or steady safety performance during the post-restructuring period from 1996 through 1998 according to this rating system.

The record indicates that no British Energy workers or contractors exceeded the U.K. annual limits on radiation exposure (50 milli-sieverts). Furthermore, 98% of the workers received less than five percent of the annual limit (2.5 milli-sieverts). Another positive safety indication was that the collective dose to radiation workers at British Energy's reactors has declined from 0.174 milli-sieverts in 1996-1997 to 0.166 milli-sieverts in 1997-1998. Both levels are nearly an order of magnitude lower than the World Association of Nuclear Operators (WANO) midyear median value of 1.17 milli-sieverts per reactor.

In the U.K., industrial safety is commonly measured using two indicators: (1) the overall Accident Frequency Rate (which is the number of lost time accidents per 100,000 hours); and (2) the Accident Incident Rate (which is the number of accidents involving three or more days absence per 100,000 employees). British Energy's Accident Frequency Rate is relatively low, at 0.25, and has continued to decrease. It represents 20 accidents in a workforce of 5100, and is roughly equivalent to the WANO 1997 midyear median of 0.195. British Energy's Accident Incident Rate has also continued to fall. At a value of 322, it is currently less than half of the Accident Incident Rate for all U.K. industries (698.6). Virtually all accidents and incidents involve trips, slips, or falls. There have been no fatalities to either contractors or employees on nuclear power sites since 1993. As a result, seven of the eight nuclear power stations under British Energy's management have received gold safety awards for the 1997-1998 time frame from the Royal Society for the Prevention of Accidents; more recently, all eight plants won such awards (see British Energy, 2000).

No radioactive discharge limits were exceeded during the 1997-1998 reporting period. Maximum public doses from nuclear operations have been maintained at less than ten micro-sieverts (i.e., less than five percent of natural radiation doses).

The company believes that the continued deregulation of the U.K. electricity generation and supply sectors will result in further increased competition, and that the number of major companies in the sector will likely decrease. In order to compete effectively in the new market, where British Energy presumes electricity prices will fall, it feels its management must exercise stringent cost control in all aspects of the business—particularly with respect to unit costs (pence

per kWh). However, as the above results demonstrate, many initial safety concerns over cost cutting in the new competitive environment have yielded to the realization that maintaining high levels of safety and component reliability is critical to keeping the units on line and producing revenue.

Against this backdrop of safety improvements since restructuring, there have been some exceptions. For example, the *Health, Safety and Environment Report* (British Energy, 1998) indicates that the number of reportable abnormal events at British Energy's reactors has increased from the 1996-1997 figure of 3.9 events per station to 5.8 events per station in 1997-1998. The specific reason for the increase has not been identified, although the utility believes (British Energy, 1998) that it may be related to the recent creation of a "blame free" work environment that encourages a higher level of event reporting.

Significant downsizing efforts have been initiated to reduce the operating and maintenance costs, and the process of downsizing continues. In 1996, for example, British Energy absorbed Nuclear Electric and promptly announced its goal of cutting staff by 25%. The current staffing level for British Energy is about 5100 employees, and another 200 staff cuts have been proposed.

Another major finding relates to the increased use of contractors to perform safety-related work functions. This concept is sometimes referred to as "outsourcing" in the U.S. It is attractive to utilities because of its potential to reduce overhead costs. The downside to such "contractorization" is that it can degrade the license holder's control over safety-related operations, as will be discussed below.

7.2.2 Sizewell B site visit

A brief visit to the Sizewell B nuclear station on July 8, 1999, was arranged. British Energy provided an initial briefing on the plant's history and recent evolution. The Sizewell B reactor is a 1200 MW PWR similar to the Standardized Nuclear Unit Power Plant System design, which was constructed at a cost of about two billion pounds. The Sizewell B reactor currently supplies up to 1.5 million customers.

The briefing was followed by a tour of the site and a discussion with the shift control room supervisor. The reactor is relatively new, having been completed and synchronized to the grid in 1995. The site was in exceptionally good condition and appeared to be very well maintained. There were no signs of delayed maintenance (e.g., leaking valves or oil seals), nor any other evidence of a "competitive, cost-cutting" philosophy that might adversely affect the reliability of equipment. To the contrary, the condition of the plant served to support the hypothesis that the station management is willing to invest in maintenance that improves plant reliability.

Noteworthy was the physical security fence that partitions the station switch-yard from the main turbine hall and reactor site. It was indicated that following the 1989 ESI restructuring reforms, the switch-yard passed into the ownership of the National Grid Company (NGC) and was now effectively "off limits" to the British Energy operating staff. During an emergency blackout

condition, the operating staff must now coordinate/negotiate a re-alignment of offsite power supplies with the NGC.

A second physical security fence also partitioned the Sizewell A (Magnox) reactor from Sizewell B. It was explained that during the 1996 ESI restructuring, Sizewell A had been sold to Magnox Electric, and this led to the erection of a fence separating the two different licensees. The effect of the fence was to cleanly divide the staffs of the two sites, as well as to isolate certain previously shared facilities such as the emergency response center and fire brigade. New contractual arrangements have been drawn up whereby each licensee may utilize the formerly shared facilities in the event of an accident.

Following the site tour, an in-depth interview was held with the site manager and the business support manager. The site manager noted that the initial exclusion of nuclear power from the government's privatization plans had shocked many in the industry, who thought that nuclear energy had been doing well. The 1989 government view that nuclear might not be viable on its own merely served to motivate managers in Nuclear Electric to boost their performance. Because of the substantial gains that were made, Nuclear Electric was able to privatize in 1996. However, the site manager noted that the Magnox reactors remained in the public sector because they were perceived to be in the "autumn of their lives" and because they carried relatively large decommissioning liabilities. No one was prepared to buy them, so they were passed to British Nuclear Fuels Limited (BNFL), which was to remain a publicly owned entity.

The site manager noted that in a deregulated market, there are strong competitive pressures—particularly from the combined cycle gas turbine generators, which are relatively inexpensive to build, come on line quickly, and are generally less regulated. This puts strong pressures on the nuclear plants to be safe and reliable. In short, safety and reliability were "good for business."

According to the site manager, it was of great importance for the site management to have a clear vision of the rationale driving the needed changes, and for them to convey that vision to the staff. This concept is widely accepted in change management theory (see for example Galpin, 1996) as being critical to minimizing employee resistance and to building lasting, grassroots support. He noted that Sizewell's management had to set clear examples so as to reinforce the new management philosophy to the staff. Under the former regulated market, for example, when a reactor shut down, the entire staff would pull together to try to get the plant on line as soon as possible. That stimulus has not changed; everyone still wants to get the plant back on line as soon as possible. However, in the new competitive market, it is far more important to *keep the plant on line* (due to large costs associated with failure to deliver power as contracted)—hence, there is a new emphasis on ensuring component reliability. Also, the potential economic penalty associated with a regulatory shutdown (and associated regulatory uncertainty) is enormous in the new market. Consequently, this has led to much more management emphasis on compliance with the plant Technical Specifications than in former years. As a result, Sizewell B's management now find themselves telling the staff not to rush, "don't make mistakes which can lead to a non-compliance with the regulations." The site manager said, "We'd rather have the job done slowly but right." He also expressed the opinion that if a nuclear accident occurred now, in the highly competitive market, it would have far graver consequences on corporate well-

being than if it had happened in prior years. In his opinion, this has led nuclear managers to become even more sensitive to accident prevention, so the effect of competition on nuclear safety in a broad sense has been very positive.

The site manager was asked how well the interface between the site and corporate management was functioning—specifically, were the financial orientations of corporate management any different, and if so, have the changes affected the latitude of site decision making? He responded that some new managers had been hired with a different focus (non-nuclear backgrounds), and that the current plans are to run the site as a profit center, which naturally creates some tensions. However, he noted that the station manager is an "Agent of the Licensee" with special responsibilities defined in the law. Consequently, the station manager has had good support from upper management when he has taken a stand on safety and budgetary issues. He cautioned, however, that being a strong station manager is important.

The business support manager acknowledged that the plant has faced new budgetary pressures. The net result has been an emphasis on more cost-effective operation—that is, prioritizing the work and making sure that it is conducted efficiently.

It was noted that there were about 380 staff employed at Sizewell B (a single unit), whereas the two-unit AGR sites typically operate with about 400 people plus the security staff. The business support manager indicated that it was difficult to make staffing comparisons across reactor types, not only because of the different technology involved, but also because the AGR staffs had originated under the Central Electricity Generating Board (CEGB), while Sizewell B had staffed up during the new competitive market. If one looks at the reactor support staff, the personnel levels are roughly equal, but in terms of operating and maintenance staffs, the AGRs differ significantly from the PWR. Also, the AGRs had undergone more substantial staffing changes, in going from about 750 per site to about 400 presently. The site manager also highlighted some of the difficulties experienced by any utility that chooses to downsize by offering retirement packages to its staff—namely, sometimes the best people go.

In the interview, the site manager was asked how such dramatic staff reductions in the CEGB could occur without having an adverse impact on nuclear safety, and likewise how such performance improvements were achieved after privatization. He replied that in order to understand these changes, one must consider the activities of the CEGB *prior to* the staff cuts. For example, the Generation and Construction Division was involved in the new construction of nuclear, coal, and oil units. However, new orders for those units have effectively ceased. This group had also been involved in station re-engineering and modifications, activities that have also been cut back significantly in the new market.

The business support manager added that British Energy has also begun to focus on its core competency, so for example there are no longer canteen staff on the company's payroll at Sizewell B. Instead, meal preparation is outsourced, as is industrial cleaning. The company has clearly realized that core areas of competency such as operations or maintenance management should not be outsourced. However, there are cases of high specialization and infrequent need of skills where the company simply cannot retain a qualified individual on a permanent staff basis.

Furthermore, both interviewees noted that outside specialists might be more frequently engaged in their line of work, owing to the larger pool of customers. Therefore, not only could the company usually hire more experienced specialists on the outside, but also the contracted specialists often brought in new ideas and best practices from other sites. The site manager commented that there had to be a common sense approach to staffing and contractor use, due to peaks and valleys in demand. Clearly, the plant could not afford to retain permanently every possible type of expertise needed to operate and service a nuclear power station over its lifetime.

The site interviewees also noted that the company always has responsibility for safety, and must retain a level of core competency. Per the site license requirements, they must have "duly authorized persons" and "suitably qualified and experienced persons" for certain safety responsibilities, and the licensee must be able to demonstrate this convincingly to the regulator.

The interviewees noted that Sizewell's business plan (and those of all British Energy plants) was aimed at bringing the plant to effectively Institute of Nuclear Power Operations Level 1 conditions. Although such a category does not formally apply to British plants, the management nevertheless viewed this result as being the ideal level of management control and supervision. The site manager stated his belief that the overall quality of nuclear management and awareness of issues has been improving over the years, as new tools have been identified and systematically implemented.

Finally, he described the nuclear safety reviews as being an integrated part of the corporate strategy. He noted that each site has its own independent health and safety inspectors, which generally perform a similar role to that of the safety authorities (NII).

7.3 Health and Safety Executive Nuclear Safety Directorate Interviews

Interviews were conducted in July 1999 and January 2000 with representatives of the HSE Nuclear Safety Directorate. The senior staff began the initial interview by explaining a few basic differences between the British and U.S. regulatory processes. As noted earlier, contrary to the more prescriptive regulatory process in the U.S., NII operates essentially in a goal setting mode. NII also has authority to set specific conditions in the reactor owner's operating license; however, the current number of standard license conditions is only 36. NII establishes new license conditions after consultation with the licensee, but normally without a public hearing process as is commonplace in the U.S. Furthermore, the HSE's nuclear safety requirements carry a significantly different weight in law than their U.S. counterparts. That is, violations of U.K. nuclear safety requirements can be prosecuted in a criminal court system, whereas in the U.S., the NRC's regulations generally fall under administrative law.

The NII senior staff noted that the agency had a long history of being involved in the management of nuclear power stations, but that it had only recently begun to explore the idea of a new license condition (#36) relating to nuclear management and the management of change process (see for example Marshall and MacLachlan, 1999). This new license condition amounts to a major new development in British nuclear safety philosophy. It came about specifically in

response to recent audit findings in the aftermath of the restructuring and privatization of the British ESI.

To put the new license condition and current state of regulatory affairs in context, the staff members provided further insights on: (1) the governmental preparations preceding the restructuring and privatization of the UK nuclear industry; (2) the actual restructuring and privatization activities themselves; and (3) the results of post-restructuring audits and safety inspections. In essence, NII guided our information gathering process and provided insights to help put the various audit findings and changes in licensee organization[1] into perspective. Most of the summary information that follows has been drawn from actual audit reports to ensure its accuracy. Also, it should be noted that during our initial interview, NII had just completed a major audit of the British Energy licensees. The findings of this audit no doubt influenced NII's views of human factors issues. However, since those audit findings were still under active review with the licensee (i.e., pre-decisional), NII could not comment directly on them. Thus, the details of the 1999 British Energy audit were taken from a draft audit report that was provided to us confidentially by a third party (neither NII nor British Energy), and from the final audit report that NII released in January 2000 (U.K. NII, 2000).

7.3.1 Governmental preparations for nuclear industry restructuring and privatization

The NII senior staff began the discussion by presenting a report on the work undertaken by the HSE to grant replacement nuclear site licenses (U.K. HSE, 1996). This report describes the historical context of the restructuring and privatization of the U.K. nuclear power industry. They noted that the first activities on restructuring essentially commenced with the country's 1993-1994 nuclear review, in which Her Majesty's Government (HMG) decided to examine the prospects for privatization of the existing nuclear power stations. The nuclear review was undertaken in response to a commitment made by the Secretary of State for Energy in 1989, when nuclear power stations were excluded from the broader ESI privatization process. The aim of the review was to evaluate the economic and commercial arguments for building new nuclear power stations within a competitive energy market. Of prime concern was whether the nuclear plants would be able to attract private sector finance. HMG also wished to identify a mechanism for improving the management of nuclear waste and decommissioning liabilities safely while controlling costs.

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[1] For example, as discussed in the previous chapter, in 1989 the CEGB was split into two publically owned companies: Nuclear Electric; and Scottish Nuclear. Later, in 1996, the Magnox reactors were split off to a separate company, and Nuclear Electric and Scottish Nuclear were privatized. Also, a privately owned nuclear holding company was created, British Energy, of which Nuclear Energy and Scottish Nuclear became subsidiaries. Later, in 1999, Nuclear Energy and Scottish Nuclear changed their names to British Energy Generation Limited and British Energy Generation (UK) Limited, respectively, but remained subsidiaries of British Energy. More recently, British Energy Generation Limited was reorganized under British Energy Generation (UK) Limited, which is itself still under British Energy. The two current licensees are British Energy Generation Limited and British Energy Generation (UK) Limited; British Energy is not a licensee.

From the onset, the British government sought to broadly coordinate the ESI restructuring rather than let it proceed haphazardly. In conducting its nuclear review, for example, the HMG received advice from various officials of the HSE, and from the Health and Safety Commission's independent Advisory Committee on the Safety of Nuclear Installations (ACSNI). The ACSNI specifically reviewed and offered comments on the suitability of the present legislative and regulatory systems to manage the restructuring and privatization activities.

The results of HMG's nuclear review were reported in a 1995 White Paper (U.K. Department of Trade and Industry, 1995). That document proposed an initial three-phase plan to: (1) restructure the nuclear industry; (2) privatize the more modern (AGR and PWR) nuclear power stations within British Energy; and (3) keep the older Magnox reactors in the public (government-owned) sector for eventual transferal to BNFL ownership. Within the phase one restructuring, the following three stages were envisioned:

> 1) Separate the existing Nuclear Electric and Scottish Nuclear operations staff and central resources into Magnox and AGR/PWR divisions;
>
> 2) Create a "shadow trading"[2] arrangement to allow the new companies to gradually transition into the new working relationships; and
>
> 3) At the time new site licenses are issued, transfer all reactors to their post-privatization owners (Nuclear Electric and Scottish Nuclear for AGR and PWR assets, Magnox Electric for all Magnox reactors), and create a holding company called British Electric with the privatized Nuclear Electric and Scottish Nuclear as its subsidiaries.

In the White Paper, HMG also announced the arrangements by which private nuclear licensees should set up funding to meet their long-term decommissioning liabilities.

One of the interesting aspects of the proposed restructuring into Magnox versus AGR/PWR companies is that some of the existing dual-unit sites (which involved combinations of AGR/Magnox and PWR/Magnox reactors) were split into separate companies with separate licenses. These new arrangements would later pose management and contractual challenges to the safe coordination of formerly shared facilities such as the emergency operations center, the physical security system, fire brigades, and the offsite power switch-yard.

7.3.2 The Health and Safety Executive's approach to the safe regulation of restructuring

The NII staff stressed that the restructuring undertaking was well planned by both the regulator and the licensee, was accomplished in stages, and that there were good communications among the parties involved. The re-licensing process (see for example U.K. HSE, 1994a) ensured that

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[2] By "shadow trading," HSE intended that the staffs of the Nuclear Electric and Scottish Nuclear organizations begin to reorganize along the future AGR/PWR and Magnox divisional lines and begin practicing their new roles and relationships in advance of formally restructuring the companies.

the various safety implications of restructuring would be comprehensively and rigorously assessed as well as documented. This effort, taken together with a regime of special site inspections, was considered sufficient to ensure adequate regulatory control during the massive reorganization that would take place. NII placed special regulatory attention on the proposed splitting of the Magnox/AGR and Magnox/PWR sites.

A need for careful plans and coordination between the regulator and industry quickly arose because the British government had set an aggressive schedule for accomplishing the restructuring process. HMG's White Paper proposal had been published in May 1995, and the HSE had targeted March 1996 as the date for the re-licensing of the 16 sites. However, in order to accomplish the rapid re-licensing, each of the licensees would be required to develop submittals, commence the shadow trading arrangements, and coordinate with the HSE's safety inspection and license review processes. An outline of activities was developed in consultation with all the parties involved in restructuring and privatization.

Furthermore, NII had to manage the regulatory aspects of the new restructuring in a manner that was consistent with fulfilling its normal safety functions of overseeing safety at the operating reactors. To achieve this, NII first established a "project group" with members from each of the main regulatory areas of activity (Site Inspection, Management of Safety, Engineering Assessment, Legal and Licensing Advice, and liaison with other government departments). The project group developed a detailed plan to accomplish its objectives. Furthermore, NII believed that the restructuring work would be resource intensive, so two additional inspectors were recruited for 1995-1996. These inspectors were used to release more experienced inspectors to help and advise on the restructuring work. At the same time, NII undertook a re-prioritization of its normal work in order to accommodate the restructuring review while at the same time ensuring that all important safety-related work progressed as necessary. About 60 NII inspectors were involved at one stage or another, plus staff from other parts of HSE.

The NII went about its main task to provide a robust and rigorous regulatory process. NII asked its licensees to provide sufficient information to demonstrate how they would be carrying out the changes in a safe manner while maintaining their transparency. The notification and transparency requirement enabled NII to inspect the process of change and to ensure that systems were in place to prevent any degradation of safety.

The NII senior staff noted another critical feature of the U.K. restructuring process—namely, that the HSE recognized from the onset that the proposed restructuring activities would be sufficient to alter the basis upon which the existing nuclear site licenses had been granted. That is, the restructuring had the potential to fundamentally affect the management of safety and the safety culture within licensees' organizations. Therefore, HSE advised at an early stage that it would be necessary for Nuclear Electric and Scottish Nuclear to replace the existing licenses at all 16 of their nuclear reactor sites. The HSE recognized that the nuclear licensing process was essential to providing independent assurances to the government and the public that adequate safety would be maintained. The re-licensing process also provided a framework for a comprehensive safety review process, rather than undertaking a piecemeal review process that would leave open the possibility for error. NII used its normal approach to license reviews, in

which the license applicant proposes and justifies changes, and the regulator assesses and inspects on a sample basis. As NII's re-licensing assessments progressed, further information was requested from each licensee, on topics such as:

1) Splitting of existing nuclear sites;
2) Emergency planning;
3) Nuclear safety committees;
4) Technical support (including research);
5) Licensee health, safety, and environmental departments;
6) Decommissioning strategies (including the form of the segregated fund for managing long-term liabilities, and the impact of the generic decommissioning strategy on site-specific decommissioning plans);
7) Cross-company service contracts;
8) British Energy/subsidiary relationships important to safety; and
9) Management of change arrangements (in particular, the impacts of proposed changes on the existing license conditions, the site safety case, and the waste management plan).

7.3.3 Safety management prospectuses

It had been expected that the newly restructured companies would undergo minimal internal change (i.e., that the new companies would be composed of essentially the same individuals, and that they would be based heavily upon the existing Nuclear Electric and Scottish Nuclear organizational models). Nevertheless, since the restructuring necessitated the formation of new corporate management structures, NII specifically asked each licensee to submit a safety management prospectus (SMP) in support of its re-licensing application. The SMP is a British licensing document that has no direct counterpart in the U.S. nuclear regulatory scheme.[3] It is similar to the U.S. Final Safety Analysis Report (FSAR) section that deals with a nuclear plant's management organization. However, the SMP is usually more detailed, and covers the parent corporation and centralized corporate support functions (e.g., engineering) more comprehensively than is done in the FSAR. For example, the British SMPs discuss the relationship between British Energy and its subsidiaries, and the licensees' corporate structures, legal titles, financial and technical resources, and managerial arrangements. In addition, the SMPs are "living documents." That is, they are regularly updated by licensees to reflect the current licensee organization. By contrast, the U.S. FSAR nuclear management information tends to quickly become outdated, and there does not appear to be a centralized NRC repository that describes the nuclear licensees' current management organizations.

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[3] Unlike the U.S. Final Safety Analysis Report, which is a single safety analysis document that includes both hardware and organizational (personnel) descriptions, the British "safety case" is a collection of documents with a hierarchical structure. The SMP is one element of the overall safety case. When a change takes place, neither the safety case nor the SMP are rewritten *per se*. Rather, new documents are issued describing the change. They become part of the current safety case, much as U.S. licensees maintain a collection of commitments as part of their current licensing basis.

The baseline SMP information about the licensee's management structure facilitated NII's assessment of the impacts of management restructuring. For the case in point, NII was particularly interested in the structures of the final licensee organizations. Therefore, within the new SMPs, each licensee was asked to identify its proposed ultimate organization and to provide an assurance on how the final organization would adhere to established safety practices. NII reviewed the new SMPs, and was relatively satisfied with them. (Note that the British review process for proposed management changes appears to be similar to the American 10CFR50.59 review process for proposed hardware changes.)

7.3.4 Nuclear Installations Inspectorate baseline inspections

The NII senior staff noted that in 1995 and early 1996, the agency undertook an initial set of about 50 "baseline" inspections to examine how the license applications and existing organizations matched with the target corporate and site organizations. The initial inspections were of two types:

1) Focused inspections, in which the inspectors examined a specific topic such as emergency planning or technical support; and

2) Restructuring site inspections, in which the NII site inspector sought to judge the adequacy of the station's restructuring implementation plan.

During this phase, the main focus was on the adequacy of the target organization as judged in relation to the existing organization. All three licensees were audited.

For Magnox Electric, the NII felt that the principle of minimizing change, coupled with the development of the business plans and quality management systems, provided sufficient confidence about the transition to a new organization. There was no evidence to suggest problems with the current use of contractors. NII also found that Nuclear Electric's management of Magnox safety systems was being transferred appropriately to the new Magnox Electric organization. Furthermore, NII's assessments and focused inspections indicated that Nuclear Electric's approach was systematic and structured, and had suitable independent oversight by the company's internal safety department.

For Nuclear Electric, the NII also found that the company was attempting to minimize organizational change. Persons interviewed by NII inspectors displayed a belief that Nuclear Electric's senior managers were committed to safety. The safety arrangements for the management of contractors were also found to be well documented and of a high standard. With regard to Nuclear Electric's own staff, there were some plans to reduce staffing in response to efficiency gains and reduced engineering work. However, in the safety area, Nuclear Electric planned to increase its internal safety department. NII ultimately concluded that there were no major issues that would prevent the re-licensing of Nuclear Electric.

At Scottish Nuclear, the NII concluded that the existing management of safety systems would be carried forward with very few changes. Of those changes that were proposed, most were merely

an extension of the existing management systems. The NII nevertheless carried out a series of initial inspections, both to confirm the implementation of the proposals as well as to establish a baseline record for future inspections. At the time, the NII inspectors were generally satisfied that adequate staff resources would be available during the restructuring. NII observed that the Scottish Nuclear personnel who were interviewed during the inspections demonstrated a high level of commitment towards safety and were keen to pursue initiatives to obtain improvements. Again, NII ultimately concluded that there were no major issues to prevent the re-licensing of Scottish Nuclear.

7.3.5 Regulating the transition process itself

According to the NII senior staff representative, the re-licensing review was intended to verify that the licensee had developed a suitable management change process, and that it functioned pro-actively rather than retroactively. Particular focus was on the nuclear safety committees, emergency planning, technical support, safety research, safety culture, staff morale, and the maintenance of the licensee's health and safety department, which functions as an internal policing organization and provides independent nuclear safety assessments of the safety case when, say, modifications are proposed by the operations or engineering staff.

He stated that an important aspect of HSE's approach to regulating the U.K. nuclear restructuring activities was their insistence that each of the licensees must approach organizational change in a systematic and controlled manner. It was not enough to merely assure that the final management structures would achieve safety. Each license was also required to ensure adequate safety during the *transition* to a new management organization.

The staff said that to accomplish this regulatory objective, the HSE assessed and inspected the licensee's approach to managing change. For example, as part of their re-licensing applications, Nuclear Electric and Scottish Nuclear each prepared a description of the process by which the licensee would ensure control of its activities throughout the transition to the new company structure. According to the staff, NII had assessed these submittals, and was generally content with the approaches that had been proposed. The effect of change on the technical safety cases, license condition commitments, site technical support, waste management, and decommissioning plans had been particularly scrutinized.

Following the assessment of the submittals, NII then developed an inspection strategy to verify the license applicant's adherence to its proposed process for controlling change. The inspection strategy consisted of six elements:

1) Additional baseline inspections at each site in October-November 1995 to confirm that all required changes to the station's restructuring implementation plans had adequately addressed those actions necessary for re-licensing.

2) Three focused inspections of single sites in December 1995 dealing with the adequacy of operational experience feedback mechanisms, training programs, and safety case support.

3) Inspections of the license applicants' central (shared) arrangements for restructuring.

4) Focused inspections at two "split sites."

5) Demonstrations of the revised emergency plans.

6) Follow-up inspections by the nominated NII site inspector.

Within each licensee organization is an internal, independent, self-policing health and safety department. The health and safety departments are organized in a similar manner to most quality assurance (QA) departments. That is, they report to the site or corporate senior management through a mechanism that is independent of the operations department line of command. The corporate health and safety departments function as independent counterparts to the NII staff. They play a vital safety role in ensuring that the safety consequences of a contemplated action are properly evaluated. The health and safety departments are typically staffed with (or have access to) people with broad experience in safety matters. Accordingly, NII considers the licensee's health and safety department staff to be a vital element of its own system of non-prescriptive regulation, and key to ensuring that the high standards of nuclear safety are maintained. Following the proposed restructuring, each new company would require its own health and safety department. Consequently, NII conducted special focused inspections to ensure that there was no significant change in health and safety department resources. Some issues were identified, but these were rectified, and ultimately NII concluded that the health and safety department proposals were adequate.

7.3.6 Financial qualifications and decommissioning funding assurance

The NII senior staff noted that each licensee must have sufficient financial resources to discharge its obligations and liabilities. There are three main areas that are considered in the U.K.: financial well being or standing; third party liability insurance; and decommissioning funding. To assess the financial standing of Nuclear Electric and Scottish Nuclear, the HSE essentially relied upon the assurances of the U.K. Department of Trade and Industry (DTI) and its financial advisors. HSE also relied upon DTI's confirmation that sufficient funds would be available to meet third party liabilities.

With regard to decommissioning liabilities, the NII senior staff explained that a power generation facility must set aside segregated funds for the ultimate decommissioning of the site. A separately registered nuclear trust is also set up to manage the decommissioning funds, independent of the power station owner. The trust receives funds, invests them, and pays out the funds as required for decommissioning activities. The funds cannot be used for any other purpose. The interviewees noted that once every five years, each licensee must present its decommissioning strategy for NII review and approval. The licensee, not NII, proposes the ultimate strategy; i.e., whether to decommission immediately or delay (analogous to the DECON and SAFSTOR options, respectively, in the U.S.). Thus far, the U.K. licensees have proposed a delayed decommissioning strategy (SAFSTOR).

The interviewees stated that NII used financial consultants to review the financial strength of the parent company, British Energy, in order to ensure that it had sufficient capability to meet the decommissioning obligations of its subsidiary licensees. NII then obtained a formal commitment from the parent company, British Energy, that it would do all within its power to ensure that its subsidiary licensees would provide adequate funds for decommissioning. Effectively, the two licensees (Nuclear Electric and Scottish Nuclear) must cross-guarantee each other with regard to decommissioning liabilities. In the event that both default, the parent organization, British Energy, will cover the decommissioning liability. Furthermore, NII set up the decommissioning funding scheme in a manner such that the licensee cannot pay "in kind" (e.g., by buying back debt), but rather must set aside actual cash funds.

Another interesting aspect of the British decommissioning fund assurance scheme is that the funds set aside are ascribed to a particular site, rather than being loosely maintained in the licensee's name. Therefore, if a reactor on the site is sold in the future, the decommissioning funds that have been earmarked for that site will be transferred as part of the sale. Since the Magnox reactors will continue to be owned by a public (government) company (Magnox Electric), the British government decided not to require segregated funds for their long-term liabilities.

The NII interviewees noted that the licensees' proposed decontamination and decommissioning strategies call for a relatively long period (roughly 120 years) of storage before reactor dismantlement is undertaken. As a result of the long time period over which the costs can be discounted, only a relatively modest amount of decommissioning funds has been set aside (a total of about $200 million) to cover all of Britain's 15 AGR and PWR reactors. They indicated, however, that HSE was currently reconsidering the appropriateness of the long storage period assumption.

7.3.7 Support services

With respect to nuclear safety research, the interviewees had no specific comments on how the U.K. nuclear safety research programs had been affected by restructuring and privatization, although they confirmed that a general downward trend in funding had occurred. The U.K. licensees fund their own nuclear research, and NII assesses its adequacy (U.K. HSE, 1996). Additionally, the Health and Safety Commission has established a nationwide system for the management and coordination of generic nuclear safety research. Finally, in consultation with the licensees, HSE also conducts its own nuclear safety research; charges are levied against the licensees according to an agreed formula to cover the costs of this research. Management of this program is via a steering committee headed by a senior manager from HSE. After reviewing the research programs for restructuring impacts, HSE accepted the changes that had been proposed.

Another of NII's initial concerns was the possibility that the centralized collection and dissemination of operational experience to the various nuclear plant operators might be compromised during the restructuring activity. Prior to the restructuring, a central office in Nuclear Electric had provided a well-respected information service to all of its reactors and the entire U.K. As part of its assessment process, NII investigated Nuclear Electric's plans, and

satisfied itself that the program would continue satisfactorily in the restructured environment. Effectively, British Energy offered to continue the program, and Magnox Electric will be able to participate in it via contractual arrangements.

7.3.8 Downsizing

The NII senior staff representative noted that NII had recognized the potential for rapid structural change to affect the safety culture of the licensees, and also the possibility of future downsizing. These factors had been considered during the re-licensing process. However, at that point in time, NII had taken the position that it would not pre-determine the limit of staff reduction that would be acceptable. Rather, it was the licensee's responsibility to assess proposed changes and demonstrate that the proposed reductions would have no adverse impacts on safety. NII, in turn, would independently judge such safety arguments when presented by a licensee. The interviewees further noted that during the time period of shadow trading and re-licensing leading up to privatization (1995-1996), no overall reductions in staffing levels had been proposed by Nuclear Electric and Scottish Nuclear, and all licensees had adopted a policy of minimal change. In effect, NII felt sufficiently confident in 1996 to issue the new licenses, but left open the possibility of monitoring and re-considering the issue at a later date. However, downsizing commenced almost immediately following privatization.

7.3.9 Coordination of responsibilities

One potential consequence of restructuring was the disruption of certain services important to safety as a result of the invalidation of, or changes to, existing licensee contracts. NII had two main concerns in this regard:

1) Services that were previously provided within the company, but would now be transferred to another licensee; and

2) Services that were required on both portions of a split site, and that the new licensees chose not to duplicate.

NII took the position that any contracts for services that were essential for the safe operation of the sites must be re-established by the new licensees (Nuclear Electric and Scottish Nuclear), who held sole responsibility for safety under their licenses, not by the parent holding company. They rationalized that any failure of a contractor could not release the licensee from the total responsibility associated with its site license. NII ultimately concluded that the new contract arrangements were satisfactory.

The restructuring (splitting) of portions of Nuclear Electric and Scottish Nuclear also created safety issues with respect to leases and property transfers. Some of the U.K. nuclear sites had combinations of Magnox, AGR, and PWR plants. For sites with only a single reactor type, the transfer of ownership was accomplished relatively easily via the direct transfer of the site and some adjacent property to the new owner. However, on mixed sites (such as Sizewell) that were to be split among two licensees, the transfer of ownership was far more complicated, since the

new licensees required rights to some previously shared facilities, and in some cases, rights of access across the other licensee's adjoining site. As a result, certain leases were drawn up that came into effect with the granting of the new licenses.

The establishment of Nuclear Electric and Scottish Nuclear as subsidiaries of a holding company, British Energy, also posed some new challenges. Consistent with the objective of minimizing change, it was decided that Nuclear Electric and Scottish Nuclear would remain the licensees in the privatized portion of the nuclear industry. NII recognized that British Energy's management might wish to exercise some oversight and control on the resources of its subsidiaries; however, British Energy would not be a licensee holder itself. Thus, the proposed restructuring using a holding company called into question the very relationship between the safety authorities (HSE) and the non-licensed parent company, as well as the "safety" relationship between the parent company and its subsidiaries. HSE ultimately approved this arrangement, after first receiving assurances that British Energy would not put constraints on the two licensees' abilities to fulfill their nuclear site license obligations (and other assurances, such as the parent company guarantee of payments into the segregated fund for decommissioning liabilities). This agreement was significant, because it provided a degree of assurance that safety-related decision making at the nuclear reactor sites would be shielded from corporate financial pressures associated with market competition.

The NII interviewees indicated that they did not have data readily available about the security of offsite power supplies, and that to their knowledge, no specific studies on reliability impacts had been conducted recently. However, no one could recall any significant interruptions of service. NII had examined the general issue of the security of onsite electricity supplies as part of its re-licensing assessment. The power grid system had been transferred from the CEGB to the NGC during the initial phases of the Thatcher ESI restructuring plan in 1989. During the subsequent re-licensing phase, NII required that the three applicants assess: the security of the grid connection; the quality of the power supply, which is controlled by the NGC; and the operational regime (e.g., load-following versus base load operation) that the NGC might expect each electricity generator to meet. The operational regime is significant, for example, because power contracts may impose penalties if the plant deviates from a certain power output scheme. The NII senior staff added that the licensees were not required to re-perform their original safety analyses for loss of offsite power, but rather were required to demonstrate that the grid reliability assumptions had not changed significantly as a result of the restructuring. These demonstrations were largely incorporated into the ongoing plant safety review program for each licensee. After reviewing the licensees' submittals, NII finally decided that Nuclear Electric and Scottish Nuclear had adequate control over any proposals to change the quality and security of power supplies to the sites, or the operating regime. In fact, both Nuclear Electric and Magnox Electric had contractual arrangements ensuring that no changes could be made to offsite electrical power quality or security, or to the operating regime, without first being brought to the company's attention so that the effects of the proposed changes on nuclear safety can be assessed.

Another area of potential safety impact from restructuring activities relates to the maintenance of offsite emergency preparedness and response capabilities. The licensees had adopted a principal of minimal change, and sought to use existing emergency planning arrangements to the extent

possible in the new restructured companies. Nevertheless, each licensee reviewed and, where necessary, revised both its generic emergency plans and the site-specific plans. NII inspectors verified that any necessary contracts for inter-site services and support would be in place. In particular, for sites with different reactor types (which were to be split), the interfaces and contractual arrangements between the sites required careful review. To assure itself that the new arrangements would be adequate, NII also required that four demonstration emergency exercises be conducted, at the Hinkley A, Hinkley B, Sizewell B, and Hunterston A reactors. (Although the Dungeness site was also to be split, the changes there were deemed to be relatively minor.) The emergency exercises included testing of both local and corporate support activities, such as inter-site cooperation, communications, and activation of the emergency response/support centers. After reviewing the exercises and making a few adjustments, NII concluded that the revised emergency arrangements were an adequate basis for re-licensing.

7.3.10 Proactive approach to regulation

In the second round of interviews (held in January 2000), the NII senior staff noted that the Nuclear Safety Directorate had recently developed a guidance document on assessing licensee proposals to reduce staffing levels, both at licensed sites and at corporate headquarters. They observed that historically, NII had responded to most licensee operational matters in a reactive manner, as is typical of nuclear regulatory approaches worldwide. However, with regard to human factors issues (specifically, downsizing), NII had become concerned that staff reductions may have a long latency period, and that licensees could find it difficult to restore safety functions once they had been lost due to the departure of highly competent personnel. Consequently, NII has adopted a new proactive regulatory approach in the area of human factors that requires licensees to demonstrate *a priori* that proposed staff reductions do not have a negative impact upon nuclear safety. The key question that NII expects the licensee to address is whether "...the proposal results in a loss of personnel who carry out a safety-related role without the need for that role also being removed." The SMP and other required licensee submittals, such as the station's register of suitably qualified and experienced personnel (SQEP), provide a baseline from which the British licensees and safety authorities are able to quickly identify, assess, and document changes to the "human" licensing basis for each plant. Again, this proactive regulatory approach to managing human and organizational change bears strong similarity to the U.S. 10CFR50.59 process for safety review of hardware modifications to the plant licensing basis.

The interviewees further noted (see also Reiersen, 1999) that it is generally not sufficient to focus on the impact of organizational changes on front-line activities. Attention should also be given to the impact of change on other functions that make an important contribution to safety, such as the retention of corporate and site-based technical expertise and memory, and the use and control of contractors. They also indicated that management change proposals are expected to cover not only short-term operational safety needs, but also the resource and competency demands that can be reasonably foreseen in the longer term.

7.4 Safety Audits of British Nuclear Fuels Limited and United Kingdom Atomic Energy Authority

Since privatization, the NII has conducted three significant audits that shed light on the impacts of restructuring on nuclear safety management. The first two of those are discussed below. The remaining major safety audit, of British Energy, is discussed in more detail in the next section.

7.4.1 Audit of British Nuclear Fuels Limited (Sellafield site)

NII's focus on nuclear management issues began to intensify in the mid-1980s, when the government's first proposals for industry restructuring were issued. NII launched a variety of licensee inspections and assessments aimed at identifying, in advance, any potential safety impacts from restructuring. In essence, NII realized that it must first obtain a sound understanding of the current licensee organizational conditions (i.e., a baseline) that could be used in later post-restructuring safety assessments of the change process. In 1986, the NII conducted an in-depth safety audit of the BNFL Sellafield reprocessing site (U.K. HSE, 1986a and 1986b). The site includes two groups of plants: (1) Britain's first nuclear power station (four reactors); and (2) a complex of buildings associated with the reprocessing of spent fuel. The 1986 NII audit included a close examination of management practices and operational safety. The reprocessing plant's managerial controls over radiological exposure, effluents, quality assurance, and incident reporting are similar to those of a nuclear power station. Consequently, the NII audit provides some insights into BNFL's overall management policies and priorities during the early period of privatization and restructuring.

The NII inspectors found that BNFL had serious difficulty "in managing large beneficial change" (U.K. HSE, 1986a, pg. 3). Specifically, the audit documented reduced capital expenditures needed for plant renewal, and reduced attention to management and skilled labor. The audit concluded that:

> It appears to us that there has been an approach both to maintenance and planned investment, of coping with short term problems without adequately considering the long term.

Furthermore, the 1986 inspections at Sellafield provided some of the first signs of a communication breakdown in nuclear management. In particular, the auditors stated: "It did not...appear to us that the management of the reprocessing plants has been in sufficient command of all matters for which it is responsible and in possession of all the relevant resources."

Specifically, at Sellafield, a number of findings (U.K. HSE, 1986b, pp. 28-43) were suggestive of a laissez-faire attitude on the part of the licensee. Taken individually, none of the NII findings indicated a serious breach of plant safety. However, taken together, they were indicative of a plant management whose priorities lay elsewhere.

A key concern of any organizational restructuring activity is whether the new unit functions smoothly as a team, or in an uncoordinated manner. The Sellafield audit provided some interesting insights into this question. A reprocessing plant operates primarily on a material balance basis. Consequently, the movements of various chemicals, radioactive wastes, and uranium/plutonium process streams through the site are controlled by an inter-departmental transfer process (i.e, "hand-offs"). Interestingly, the NII audit at Sellafield found significant breakdowns in the inter-departmental transfer process after corporate restructuring. These included, for example, a lack of procedural adherence, the use of outdated procedures, the existence of procedural incompatibilities, and inconsistencies between receiving and dispatching documents. The inspectors also found a noticeable lack of coordination with regard to maintenance records, use of computers, and sharing of experience across the site as a whole.

With regard to the use of work authorization forms, there appeared to be confusion over issues of authority, such as who should sign the various forms. In addition, staffing shortages were discovered in the health physics and safety departments. As a result, routine health physics surveys were found to be only 70-90% completed. The NII subsequently asked BNFL to clarify the roles and responsibilities of line management and the plant safety committees (U.K. HSE, 1987, pg. 10). BNFL has responded to the audit by undertaking radical steps to improve the situation.

7.4.2 Audit of United Kingdom Atomic Energy Authority (Dounreay site)

The Dounreay site contains three reactors, as well as ancillary facilities for nuclear fuel manufacture, post-irradiation examination of fuel, reprocessing, waste treatment, and waste disposal. The site was initially managed by the U.K. Atomic Energy Authority (UKAEA), a public entity, but in 1986, the UKAEA's status was changed to require it to operate on a commercial basis, and it was licensed for the first time in 1990.[4] During the onset of ESI privatization in 1988, the government also decided to abandon near term research and development of fast reactor technology, and to close the Prototype Fast Reactor (PFR). This decision led to a major reduction in UKAEA staffing from about 13,600 to 8,300 between 1988 and 1993. The bulk of UKAEA's engineering and scientific support staff were eliminated, leaving its Government Division with few engineering resources to support its own operations and project management. The reduction in engineering resources was apparently based on the notion that it was no longer necessary to retain in-house capability to do even preliminary design work, and that contractors and managing agents could be used to reap the benefits of competition and cope with decommissioning.

In 1994, the shortage of skills needed to decommission Dounreay's PFR, coupled with regulatory concerns over progress, led the site director to hire additional contractors. The contractors included both those charged with discrete tasks (implementation contractors) and those charged with managing the activity (managing agency contractors). Although the managing agency concept was intended to bring additional resources and expertise to the site, in

[4] Previously, Dounreay had been outside the jurisdiction of the HSE licensing regime.

practice it also introduced additional interfaces and (since it was implemented in conjunction with downsizing) raised questions about the extent to which the licensee was passing safety responsibility to the managing agency.

In 1994, the UKAEA decided to split its operations into three groups,[5] in preparation for the eventual privatization of two of these businesses. These organizational changes at Dounreay, and the lack of safety progress in some areas, began to concern the NII. Furthermore, the use of a "managing agency" by UKAEA was considered to be a novel (un-reviewed) approach. Accordingly, in 1997-1998, the NII decided to conduct a special audit on the management of safety at Dounreay. The audit focused on: the effects of outsourcing or contractorisation; the interface between site and corporate management; and the management of reprocessing, waste handling, and decommissioning. The key findings were as follows:

1) The corporate reorganization blurred the responsibilities and accountability for safety. The roles and reporting routes for staff members were defined inconsistently across the site. In some cases, those responsible for safety operations were not employees of the licensee (the UKAEA).

2) There was an inconsistent use of "safety representatives" between the licensee staff and the contractors. (In the U.K., such safety representatives are trade union representatives who take on part-time safety responsibilities in addition to carrying out their normal work for their employer.)

3) The licensee had introduced a "safety performance index system" that financially rewarded individuals with the smallest number of safety incidents reported. The NII was concerned that such a system, coupled with the significant staff downsizing at the UKAEA, might encourage under-reporting of safety incidents.

4) The Dounreay safety documentation consisted of a mixture of corporate and site-specific documents. Revisions and updating of the safety documentation had not kept pace with the rapid reorganization of the company.

5) The NII found signs of low morale among employees, presumably as a result of the recent large-scale changes in the organization and the uncertainty about future employment prospects. These employee perceptions had arisen for a number of reasons, including the divestment of engineering services and the lack of new investment. Contractor staff expressed concern over the security of their employment beyond the current contracts.

6) The division of the UKAEA into three separate organizations appeared to have been undertaken with little forethought as to the range of skills that were required in the Government Division to fulfill its obligations as the site licensee. Instead, the main

[5] The three agencies were AEA Technology, the Government Division, and the Facilities Services Division.

emphasis in corporate restructuring seemed to focus on ensuring the commercial viability of the AEA Technology Group. As a result, the UKAEA management simply assumed that they could supplement any shortfalls in the Government Division with contracted help.

7) The NII identified significant shortcomings in both the licensee's and contractors' understanding of the nuclear regulatory system and licensing requirements.

Most significantly, the NII found that the licensee had failed to maintain itself as an "intelligent customer" for nuclear services, and that in doing so, it had effectively relinquished its control of safety management to its contractors. The audit at Dounreay focused the NII's attention on the importance of maintaining licensee capabilities and the potential safety risks associated with excessive use of proxies. Consequently, an explanation of the intelligent customer concept is presented in the annexes of the Dounreay audit report. Currently, the NII's view[6] is that a licensee must have, and take steps to retain, adequate capability within its own organization: (1) to understand the nuclear safety requirements of all its activities, and also those of any contractors; (2) to take responsibility for managing safe operation; and (3) to set, interpret, and ensure the achievement of safety standards. It must have the capability to understand the advice and service provided by its contractors, and to specify, assess, and manage the work of contractors. A U.K. licensee must also understand its legal duties.

For example, with regard to the use of contractors, the NII view is that a licensee's staff must have the appropriate skills and sufficient time and effort to:

1) Specify the work (including its safety aspects);
2) Assess tenders and proposals from contractors;
3) Choose an appropriate contractor, after assessing its capabilities and safety record;
4) Supervise and manage the work;
5) Ensure that the contractor's staff are suitably qualified, experienced, and trained;
6) Ensure that the contractor is delivering the agreed product or work; and
7) Monitor the performance of the contractor, and take appropriate action if the need arises.

The implications of this concept are that the licensee, as the end user, must retain sufficient staff (at the site and elsewhere) with the skills and competencies to operate, understand, and manage the plant safely throughout its life. Finally, the NII takes the view that it is up to the licensee to analyze its operation and justify to the regulator what, in its view, constitutes sufficient in-house expertise, resource control, and supervision of operations.

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[6] F. E. Taylor, "HMNII View of the Licensee as an Intelligent Customer," draft paper for submission to *Nuclear Energy International*, dated January 2000.

7.5 Safety Audit of British Energy (Pressurized Water Reactor and Advanced Gas Reactor Sites)

The most significant findings in our review of the U.K. electricity restructuring process relate to the NII audits in 1999 of British Energy's AGR and PWR management organizations (U.K. NII, 2000). As noted above, the NII undertook a series of inspections in the 1995-1996 time-frame to establish the basis for re-licensing of the various nuclear power stations. Those inspections focused on ensuring that the "target" privatized organization would be adequate and that the "management of change process" during the transition period would be sufficient to ensure safety. While the situation was considered acceptable for the purpose of granting licenses in 1996, there had been lingering areas of concern (e.g., the level of resources in certain specialist areas, and the extent and nature of their use of contractors) that the NII wanted to monitor as the experience of the new companies evolved.

The NII's decision to re-license had been based in part on company assurances of "minimal change" to ensure stability during the process of transition to private ownership. Some downsizing had occurred in the years immediately preceding privatization. However, just three months after British Energy was privatized, Nuclear Electric and Scottish Nuclear each instigated a large program of staff reductions. The downsizing process was known as "Vision 2000" within Nuclear Electric, and "Route 21" within Scottish Nuclear.

The NII had intended to undertake follow-up inspections in 1998, after the re-licensed sites had effectively stabilized. However, before those inspections could commence, British Energy approached the regulator with a proposal to integrate its Nuclear Electric and Scottish Nuclear subsidiaries into a single unified management (see for example Marshall, 1999). To demonstrate the feasibility of the concept, British Energy proposed to integrate the technical management (e.g., engineering and other support functions) of the two licensees for a limited period of time, before formally re-licensing them as a single entity. The integration of these central functions was expected to result in the loss of some jobs, since the new structure was expected to be more efficient.

Due to subsequent commercial concerns, British Energy eventually abandoned the single licensee notion, but still wanted to integrate its central functions. That is, British Energy management planned to maintain the separate licenses held by Nuclear Electric and Scottish Nuclear, but to use integrated corporate management and a central technical team to support plant operations at the two subsidiaries. This novel management approach had not previously been used in the U.K.

The NII accepted British Energy's plan to integrate some non-safety-related company functions, as well as a board-level integration plan. However, the NII decided to withhold approval to integrate safety-related functions until an audit of Nuclear Electric and Scottish Nuclear could be completed. The audit was intended to fulfill two main objectives: (1) to determine whether downsizing had reduced the licensees' capability to deliver acceptable safety performance; and (2) to provide a baseline against which to judge future changes.

The NII had become concerned with the performance of the two licensees because of a variety of problems. These included the diminished quality of recent Periodic Safety Review (PSR) submissions, the inability of the licensees to deliver promised PSR modifications, the failure of the licensees to make long-term commitments in areas such as research, and the degraded quality of some technical advice. The NII had followed up on these problems individually, but the frequency and consistency of the observed problems started to suggest a systemic underlying weakness arising from the restructuring activities.

In March and April of 1999, the NII conducted management reviews at British Energy headquarters and the technical centers of British Energy Generation Limited (BEGL) and British Energy Generation (UK) Limited (BEG(UK)L). These visits were followed up by additional inspections of some of the principal contractor organizations who were providing technical support to the licensees. The audit addressed: corporate management; the Engineering Division; the Health, Safety, and Environment Division; and the Operations Division. It focused on the implications of downsizing, rather than the process for managing change. The NII also examined the relationships between each licensee and its principal contractors, in order to ascertain, for example, whether safety had been compromised by excessive outsourcing.

7.5.1 Areas of good practice

The NII found that the organizational structures of both licenses, BEGL and BEG(UK)L, had not changed fundamentally from what was in place at the time of privatization in 1996. The NII considered these organizational structures to be "tried and tested." Company directors and senior managers were also found to be sensitive to the pitfalls associated with downsizing, and aware of the types of problems that had sometimes been encountered in nuclear companies elsewhere that had undergone downsizing.

The NII concluded that the majority of managers had sufficient ability and desire to mitigate any adverse impacts of downsizing. For example, BEGL management had decided to retain experts in the areas of graphite moderators and structural integrity methods, and to develop experience-sharing programs, research, and special training programs aimed at maintaining technical and managerial competence. The NII also observed a policy of bringing in new graduates to renew and refresh the technical core of the company. Furthermore, some of the initial targets set for downsizing had been revised when managers had made cases to limit the reduction in staff numbers. The NII was also told that there would be a period of stability without large-scale changes after the ongoing integration and downsizing processes (Vision 2000 and Route 21) had been completed.

The NII found other noteworthy examples of good practices. For example, BEG(UK)L had created a formal SQEP register, which was intended to provide the basis for identifying and maintaining the requisite skills base. Similarly, the NII concluded that BEG(UK)L made effective use of its Technical Development Committees as a vehicle for coordinating work and linking the central functions to the stations. At BEGL, the NII found a philosophy of retaining in-house technical specialists, rather than relying upon generalists, which was generally consistent with the NII's intelligent customer concept. Finally, the NII found that both licensees

expressed a desire to achieve world class standards, rather than achieving only minimal compliance for competitive reasons.

7.5.2 Findings on British Energy Generation Limited (formerly Nuclear Electric)

BEGL operates five AGR stations (Dungeness B, Hinkley Point B, Hartlepool, and Heysham 1 and 2) and one PWR station (Sizewell B), all located in England. A key factor in the company's Vision 2000 integration and downsizing process was a predicted reduction in workload ("doing less with less"), which overall had not transpired. Despite the failure to achieve the predicted reduction in workload, however, staffing levels had been reduced as planned. To compensate for the shortfall in human resources, contractors were hired (some of whom were ex-BEGL staff recently released on voluntary severance terms). In some key safety areas, this resulted in an increased workload for BEGL staff, since they now had to manage their normal safety responsibilities in addition to supervising the work of contractors.

The NII also found that systems for recording work did not accurately reflect the number of hours being worked by staff. Their interviews with staff at different levels within BEGL revealed that some were working significant amounts of overtime or unpaid excess hours, with the potential for degradation in the quality of the work. Although BEGL seemed to be aware that its staff's overtime hours were being under-reported, the NII was not convinced that BEGL could accurately gauge the extent of the problem. The NII concluded that further effort was required by BEGL to match work loads with staffing levels, and to ensure an accurate accounting of the hours staff are working (whether paid or not).

BEGL's inability to reliably predict its future workload had clear safety implications with respect to its future plans on staff downsizing. The NII concluded that BEGL needed to develop a firmer foundation upon which to base its workload plans and staffing levels.

The NII had expected to find a clear definition of the skill base BEGL considered necessary in order to function effectively as a licensee. NII had concluded that BEGL could not delegate these responsibilities to another organization. Instead, BEGL had to maintain the requisite expertise within its own staff. However, during the audit, the NII did not find a clear definition of the requisite skills base. In short, the downsizing process had been undertaken without first knowing the limit on downsizing (i.e., the minimum necessary skills base). The NII concluded that BEGL needed to quickly develop an accurate baseline for the range and depth of expertise that it needs to retain as a licensee. Furthermore, the licensee was required to develop effective, long-term succession planning, so as to maintain its technical expertise in nuclear matters over the lifetime of its nuclear facilities (including decommissioning).

The NII audit also found that downsizing activity had resulted in certain types of nuclear knowledge and expertise being vested in a single expert. Similar to the single failure criterion for hardware, the NII feared that BEGL might now be particularly vulnerable to loss of the remaining in-house expertise; e.g., if staff members leave to pursue careers elsewhere (as has happened), or simply take a vacation. The inspectors noted that in some cases, BEGL had found it difficult to find replacements with the necessary nuclear expertise. The NII concluded that

BEGL could not simply assume that such expertise could be readily purchased from the labor market. Instead, the availability of qualified manpower must be considered when developing the in-house skills baseline (with some element of "defense in depth").

The NII found that BEGL had a variety of relationships with contracting organizations, ranging from the employment of individuals through agencies, to standard contracts, to longer-term partnership arrangements. However, the NII found that BEGL did not have a formal policy about why, when, and how to use contractor support, taking into account its own responsibilities as a licensee. The NII believed that the lack of a policy on contractor use, combined with the lack of a clear baseline for in-house skill levels, led to a situation where staffing levels in some areas needed to be increased. In short, BEGL needed to clearly define and apply an appropriate policy governing the use of contractors.

On a positive note, NII found that BEGL was developing closer relationships with key contractors (known as "partners"). In most cases, the partner organizations were well established in the nuclear field. Nevertheless, the NII concluded that the partners must still be seen as contractors, and that BEGL cannot delegate any of its licensee responsibilities under such arrangements. (Note that the NII did not rule out the use of partnerships in principle. However, it noted that partnering arrangements contribute to the loss of the licensee's corporate knowledge and expertise, reduce opportunities for technical development of licensee staff, and ultimately create the potential for loss of control and a diminished sense of the licensee's responsibility in performing safety analyses.) In pursuing and developing partnerships, the NII felt that BEGL must retain the necessary range and depth of in-house expertise to be able to perform an informed and critical review of work or advice received from external sources. Based on the audit findings, NII judged that the relationship between the BEGL and its partners must also be considered within the framework of an overall policy on the use of contractors.

Given the extent to which BEGL utilizes contractors and partners, the NII had also expected to find its regulatory concept of "the intelligent customer" and the requirements of that role to be well defined within the licensee's organization. However, the NII found only one manager who had anything formally written down on the subject. The NII concluded that BEGL needed to promulgate a company-wide policy on the intelligent customer role and requirements.

In addition to the findings listed above, the NII focused primarily on the *outcomes* of BEGL's downsizing, and on the management of change process itself. The NII had expected that the licensee would require specific preconditions (enabling conditions) to be satisfied before an individual was released from employment on voluntary severance. These preconditions were presumably necessary to ensure that the organization would be able to cope without that individual. A key assumption in the downsizing plans was obviously a reduction in workload (or else the determination that a particular work role was no longer required). The NII was aware that in some situations, the licensee might compensate for the downsizing by relying on work deferral, reallocation of responsibilities, deferral of severance dates, or use of contractors to fill gaps. However, the NII found that these exceptional compensating measures had tended to become the norm rather than the exception. In short, staff had been pre-released under the restructuring process without the concomitant reduction in work load. The NII found that some

of the stated prerequisites for downsizing were changed to ongoing (open-ended) commitments, which were then not always satisfied before someone is released. For example, a requirement to "provide a trained replacement before release" might become simply "provide training." The small sample of records checked by the NII did not provide confidence that the principles of the change management process had been honored and that the procedure had been followed rigorously. In the NII's view, a management of change process that could reduce staffing in an essential area of expertise down to a single person was open to question. They concluded that BEGL needed to carefully review its management of change process to address these shortfalls.

7.5.3 Findings on British Energy Generation (UK) Limited (formerly Scottish Nuclear)

BEG(UK)L operates two AGR stations (Hunterston B and Torness) in Scotland. BEG(UK)L's Route 21 downsizing plans had been based on a predicted reduction in workload. Here, the NII found that the company's workload had decreased, although not as much as predicted. The management of change process at BEG(UK)L also required that staff members be retained in their posts until the workload had actually decreased, and the NII found that this requirement had been honored. However, BEG(UK)L substantially underestimated the amount of new work that would develop, so that some individuals' workloads grew quite high. Consequently, some staff members were found to be working significant amounts of overtime. The NII also found under-reporting of hours worked. Therefore, the NII viewed the company's downsizing decisions as suspect, since the company had not adequately foreseen its future workload (even over reasonably short periods or time, such as two or three years), and could not accurately assess the level of effort being applied by its current staff members. The NII concluded that BEG(UK)L must develop a sound basis for establishing its staffing needs.

On a favorable note, Scottish Nuclear's original SQEP register provided an adequate means for establishing the requisite skills base within the new BEG(UK)L. However, the NII found that in some technical areas there were no BEG(UK)L staff members on the SQEP register, only contractors. The NII also found some areas that were covered by only a single BEG(UK)L expert (although usually with contractors as backup). In at least one case, the NII found an actual gap in the SQEP coverage (i.e., no coverage by either licensee or contractor staff). BEG(UK)L's formal objective was to have all SQEP posts covered by at least two individuals, at least one of whom was a BEG(UK)L employee. However, the NII concluded that BEG(UK)L had to expedite attainment of this objective. In addition, the audit found that BEG(UK)L had to also establish a clear baseline for the breadth and depth of expertise that it needed to retain as a licensee. The audit report noted that this baseline should include assurances that sufficient nuclear expertise would be maintained throughout the full lifetime of the nuclear stations (including decommissioning). The NII concluded that the SQEP register was a good concept, but that implementation of the concept required further development.

The NII recognized that BEG(UK)L, like BEGL, had close working relationships with various external organizations. These organizations were contracted to provide technical expertise, under "satellite office" arrangements whereby BEG(UK)L was able to nominate specific individuals to work on those contracts. These individuals met the BEG(UK)L SQEP requirements, were included on the SQEP register, and helped to ensure the quality and

consistency of the technical support. However, the NII found that in some areas, BEG(UK)L had become over-reliant on this outside support. That is, downsizing had resulted in a greater proportion of contractors filling SQEP roles, and also an increase in the total number of contractor staff on the SQEP register. The NII concluded that BEG(UK)L needed to redress this imbalance, taking into consideration those skills that must be maintained within the licensee's own organization in order to maintain sufficient control of its operations. The NII audit also concluded that BEG(UK)L must adopt a clear policy on the use of contractors, which (together with its intelligent customer role and requirements) would specify limits on the extent of reliance on contractors consistent with BEG(UK)L's responsibilities as a licensee.

Some aspects of the management of change process at BEG(UK)L also came under review. For example, the NII's interviews revealed that some prerequisites for change management had been relaxed, and were implemented as ongoing commitments that were not always satisfied before the change took place. Also, the downsizing process had led to the retention of only a single expert (or none at all) in some areas. The NII concluded that BEG(UK)L's management of change process required careful review to resolve these problems.

7.5.4 Findings on the proposed integration of British Energy Generation Limited and British Energy Generation (UK) Limited

The NII found that the proposed structure of the integrated (central technical support) organization was well defined. However, few of the staff members below the senior level seemed to know what additional responsibilities they might be expected to undertake following integration. The NII was concerned that the pared-down, integrated staff would lack the capacity to accommodate any new workload that might be associated with integration. Accordingly, the NII asked both BEGL and BEG(UK)L to clearly define their states of readiness for integration, and to demonstrate that they could maintain adequate control of their operations.

This audit finding raised a potential problem that the NII had not previously considered in detail. That is, the NII was concerned about the additional responsibilities and workload that would be placed on managers with restructuring and integration, and about the managers' ability to adequately control and supervise safety- related activities. For example, the NII had not yet assessed the safety impacts associated with individuals working for one licensee (e.g., BEGL) while providing advice to the other licensee (e.g., BEG(UK)L) as part of a central (integrated) team. The NII felt that each licensee should maintain control of its own operations and retain its own intelligent customer capability, and was concerned that the arrangements being proposed by British Energy could violate these principles. Some shared capabilities already existed between the two licensees (notably, civil engineering and electrical engineering expertise), and the 1999 audits raised questions in these areas. While the integration of these functions had not been deemed unacceptable by the NII, it nevertheless was looking closely at the licensing implications of broader integration. Resolution of these particular issues was found to be necessary before the NII would agree to the proposed integration.

7.5.5 The conclusions of the British Energy audit

The overall objective of the 1999 management audit was to establish whether the restructured resources and capabilities of BEGL and BEG(UK)L were sufficient for them to continue discharging their responsibilities as nuclear licensees. Overall, the audit established that the principal organizational structures of BEGL and BEG(UK)L had not changed significantly from those prior to privatization. The main changes that occurred in recent years had been staff downsizing. Within BEGL, the NII judged the current staffing levels to be "just sufficient" to discharge the responsibilities of a licensee, but did not specifically evaluate the long-term effects of employee overtime. Within BEG(UK)L, similar downsizing was found, along with excessive reliance upon agency or contractor staff. The NII expressed concerns that the downsizing effort had focused excessively on reducing staffing levels, without adequate attention to maintaining a licensee organization that meets license requirements.

The NII audit identified significant issues that could affect the future capability of the sites to maintain their licenses, and the future safety performance of BEGL and BEG(UK)L, unless effective corrective actions were taken. The overriding safety issue concerned the lack of a clear definition of the requisite skills base that must be retained within both BEGL and BEG(UK)L in order to fulfill their responsibilities as licensees. This problem was exacerbated by the absence of formal policies covering the use of contractors to provide technical resources and expertise. Specifically, there were no policies or procedures to define the extent of the allowable reliance on contractors. The NII also found the need for a long-term strategy to ensure retention and development of the required expertise within a licensee's organization throughout the lifetime of its nuclear power stations (including decommissioning), and a lack of contingency plans to address the licensees' vulnerability to the loss of key contractors.

Accordingly, the NII concluded that the management of change process at both licensees was flawed and in urgent need of review. For example, the change process had not prevented downsizing to the point of singleton expertise, which made both licensees vulnerable to the loss of key individuals. Similarly, a reduction in workload had been a principal prerequisite in the downsizing plans of both licensees, yet there were cases where staff members had been released without the necessary workload reductions being achieved.

The NII found that the licensees' predictions of workload were inaccurate in practice, due to the difficulty of taking into account unexpected new work. Therefore, the NII concluded that both the staffing level targets at the licensees and their management of change processes had to be adjusted to take into account this uncertainty.

As a result of the above findings, the NII concluded that several key issues needed to be resolved before the proposed integration of BEGL and BEG(UK)L could be approved; namely, that BEGL and BEG(UK)L should:

> 1) Stop the planned reduction of in-house staffing levels, until they can demonstrate that their workload predictions are reliable, and that the changes will not adversely affect the safety of their nuclear plants.

2) Ensure that their business plans are matched to their in-house staff capabilities and workloads.

3) Formalize, record, and achieve the skills base required to perform the duties of a licensee to retain control of its operations.

4) Develop and promulgate policies to guide decision making on why, when, and how to use contractor resources (including the licensees' intelligent customer requirements).

5) Investigate the reasons for the high levels of overtime worked in certain areas (including estimates of time not reported), and take steps to prevent excessive hours being worked by staff handling work relevant to nuclear safety.

6) Critically review their management of change processes and incorporate the lessons learned from the shortcomings in those processes (including the findings of the NII audit).

7) Resolve issues of licensing, control, and readiness before seeking NII agreement to the proposed integration of the technical management and resource teams of BEGL and BEG(UK).

7.6 British Energy Followup Interviews

A second round of interviews with British Energy was conducted in January 2000 with the director of British Energy's governmental affairs office and a representative of British Energy's department of Health, Safety and Environment. At the time of this interview, an official British Energy response of to the NII audit findings was not yet available. Nevertheless, despite the obvious sensitivities of an unresolved audit, the company was willing to offer its perspective in order to provide a more complete picture of the situation. Specifically, British Energy provided additional historical details on the restructuring process, downsizing, and the management of change process that had been implemented in Nuclear Electric, Scottish Nuclear, and British Energy. Overall, the company provided compelling arguments for the actions that it had taken. Portions of the second interview and extracts from relevant documents are given below. However, a complete accounting is not provided here, so as not to interfere with the licensee's discussions with the NII. More information can be found on the company's web site.

British Energy indicated that its thinking on the management of change process, the use of contractors, and downsizing issues was very similar to that of NII, and that any differences in opinion had been greatly exaggerated in the media. British Energy had created a management of change process in 1996 in response to NII concerns over the control of change, and the process had been used ever since. British Energy was also generally in agreement with the regulator's "intelligent customer" concept, and with the concerns about over-reliance on contractors. However, British Energy pointed out that contractors have always been used in the nuclear

industry, and that the "intelligent customer" concept was still evolving within the U.K. and even within the NII itself. (This point was confirmed in our discussions with NII staff.)

With regard to downsizing, British Energy provided some numbers on its downsizing analysis, and indicated that further downsizing efforts had been put on hold while British Energy studied the situation further. British Energy also noted that the original licensees, Nuclear Electric and Scottish Nuclear, had held many prior discussions with NII, and had conducted careful, transparent planning and advance reviews of their restructuring activities, meeting with general agreement and satisfaction throughout the 1995-1997 planning and transition period. At that time, British Energy had reasonable expectations of a reduction in workload within its subsidiary companies, for several reasons. First, the PWR export program had been put on hold, since the U.K. had failed to secure a contract to construct a PWR in Taiwan. Second, the former CEGB was widely believed to have been inefficient. Third, further modifications and design work on the AGRs was expected to be limited in scope. Finally, further efficiency improvements were expected to result from the integration of the Nuclear Electric and Scottish Nuclear technical support groups.

With its eye on the welfare of its employees, British Energy carefully began to devise various human resource plans, such as early retirement offers and advance layoff notices, to facilitate the eventual downsizing. Their aim was to provide employees with sufficient opportunity to look for other jobs and make smooth transitions into their next jobs while at the same time maintaining the necessary core capabilities in-house.

Unfortunately, British Energy found it difficult to accurately predict the future corporate organization and employee workloads amid an uncertain electricity market and rapid organizational change on many fronts. Some workloads actually increased instead of declining, as a result of the extra tasks associated with the transition to a new privatized organization. Furthermore, the PSR work did not decline as expected. The net result was that British Energy's expected reductions in workload did not materialize as quickly as had been expected.

The company then faced a dilemma with its employees, since many of them had already secured their next employment or made firm plans to leave the company. Where possible, the company tried to encourage employees with needed expertise to remain a little longer. However, the company also felt obligated to respect the severance agreements that it had already made. Thus, a need developed to hire a larger percentage of temporary contractors than British Energy perhaps would have liked. Overall, considering various employee morale issues as well, they felt that they had made the best possible choices.

British Energy further noted that it recognized that the use of contractors in safety-critical industries requires careful consideration and control. British Energy uses essentially two types of contractor control. Some individuals work under the direct oversight and line control of the Engineering Division staff. Alternately, some work is carried out by consulting companies that are responsible for managing their own staffs. The performance of contractors working under the direct control of the Engineering Division staff is controlled through the application of standard QA procedures, reviews of performance, and business-related training reviews. By

contrast, the performance of consulting companies is controlled though the application of their own QA procedures, which must be acceptable to British Energy in order to win the bid, and which are audited by British Energy's QA organization and various performance reviews in the field. British Energy pointed out that there is no ideal ratio of staff to contractors, and that judgment had to be applied in each case. Contractor-to-staff ratios may reach 30 to one, for example, if routine non-destructive testing is carried out during an outage, whereas if the work is innovative and highly technically demanding, the ratio would normally be low. The company also noted that there are positive aspects to hiring contractors. In particular, contractors bring to the plant skills and outside perspectives (e.g., good practices from other high-performing plants) to which staff may not otherwise be exposed.

One of the British Energy representative indicated that the main concerns of the NII related to downsizing of the centralized support (engineering) functions, which had been integrated. At the nuclear stations, however, the staffing levels and personnel qualifications have remained essentially the same as before privatization.

British Energy's staff then further described the detailed considerations that the company had undertaken as part of its management of change program. In preparation for privatization in 1996, British Energy had put in place various guarantees acceptable to the NII between British Energy and the two licensee subsidiaries, to ensure that as far as reasonably practicable, funding would be made available for safety-related work. Since privatization, the licensees have approved all necessary safety-related work without hindrance from the parent company. (This same viewpoint had independently been provided during our interviews with the Sizewell site manager in July 1999.)

Reductions in the central technical resources of British Energy had taken place only after a major review process that covered the Engineering Divisions, the stations, and all contract support. A structured approach to reviewing future work requirements had also been established within British Energy. For example, an Engineering Review Group had been established consisting of BEGL and BEG(UK)L management teams, the key managers from each of the stations, and the corporate Health, Safety and Environment Department. This group considered all future engineering work at a series of intensive sessions (spanning a four-month period), with the objective of identifying future resource needs. The overall process was heavily scrutinized by their internal safety organizations (the Health, Safety and Environment Divisions), to ensure that any proposed changes presented no risk to safety-related support services and key work teams.

Overall, the interviewees expressed the view that the projected workload for BEG(UK)L had fallen in line with the prediction. In BEGL, however, the workload was significantly greater than expected. One of the primary reasons for this was a large underestimate of the resources required to support follow-on work arising from the Periodic Safety Review process on the AGR fleet. However, British Energy noted that the countermeasures identified in the implementation plans (mainly, the use of qualified contractors) had been successfully applied to deal with this shortfall.

7.7 Observations on the United Kingdom Nuclear Program

The sweeping transformation of the British ESI that began in 1988 for the purpose of privatizing the electricity sector and increasing market efficiency had substantial impacts on hardware reliability, human factors, and safety regulation in the U.K. nuclear power industry. Those impacts are briefly discussed below.

7.7.1 Hardware issues

While one might have expected to see adverse hardware safety impacts arising in response to the restructuring of the electricity market (e.g., cost-saving reductions in safety-related maintenance, reductions in surveillance activities, hurried startups, delayed shutdowns, and a general higher level of risk-taking through exploitation of gray areas in the regulations), no such findings surfaced in this review. To the contrary, it would appear that the immediate impact of restructuring and increased market competition on nuclear power station operation in the U.K. has been to further reduce risk-taking by the licensees and to improve the overall level of hardware-related safety.

There are several possible explanations behind this apparent improvement. First, the operating staff at nuclear power stations have only minimal exposure to the cost competition issues that have developed in the corporate headquarters offices. The nuclear sites tend to be distant from corporate offices. Additionally, most operating staff personnel are either unaware or only marginally aware of the day-to-day profitability of the parent company. Furthermore, the income of the nuclear staff is either unaffected or only marginally affected by cost saving decisions; however, the plant operating personnel (as well as their immediate friends and families) are directly affected by nuclear safety. Hence, it is natural for safety philosophy to play a predominant role in decision making on hardware issues.

A second factor contributing to enhanced hardware-related safety is the fact that the financial risks associated with a forced shutdown (e.g., an inadvertent scram) are substantially higher in the new competitive market. As a result, there is a new emphasis on hardware reliability in the competitive market. This has given rise to a new generating station directive that it is more important to ensure the reliability of the hardware than to rush the plant back on line. In other words, the operating staff have been directed to complete all necessary maintenance (and do it well), even if this results in a delayed reactor startup. This is because delays to planned outages would generally occur under relatively favorable economic conditions, and are hence preferable to risking an inadvertent shutdown later on under highly unfavorable conditions.

In addition, the financial risks associated with regulatory non-compliance, regulatory uncertainty, or a prolonged regulatory shutdown are much higher in the new competitive market. Therefore, there are stronger incentives to remove regulatory uncertainty wherever possible through increased attention to hardware compliance issues. A component repair or replacement time can be predicted far more accurately than a regulatory discussion about the adequacy of a proposed action.

Finally, market competition has encouraged the management of commercial nuclear power stations to become more efficient and less bureaucratic. This change is especially great in the U.K., which had recently evolved from governmental ownership and direction under the CEGB. As a result, it is possible that resources required for addressing safety and reliability issues can now be allocated more quickly than under the previous ownership regime.

7.7.2 Human factors issues

The key safety impacts arising from the restructuring of the U.K. ESI were found in areas relating to human factors—specifically, the management of organizational change. In particular, the underlying safety question is whether the new commercial and governmental organizations have adapted sufficiently to accommodate to their new environment. The initial evidence is mixed.

In particular, the British experience suggests that the impacts of restructuring and downsizing cannot always be accurately predicted by licensees, and that reorganization can impose burdens on the licensees in excess of their anticipations. In short, reductions in workload predicted to occur through greater efficiency sometimes failed to materialize.

The rapid rate of organizational change introduced by privatization and restructuring has challenged the capabilities of both the generating stations and the safety authorities to effectively manage those changes. As a result, a new license condition (#36) has been added to the license of every nuclear power station in the U.K. This license condition effectively requires that the human contribution to nuclear safety be managed in a manner comparable with past practices for managing hardware safety issues. In other words, the minimum human safety requirements must be identified and documented by licensees, and a safety analysis must be performed prior to implementing significant organizational modifications, changes in human qualifications, or staff downsizing. Similar to the U.S. NRC's 10CFR50.59 requirement to evaluate hardware changes to the licensing basis of the plant before they are implemented, the British License Condition 36 mandates a proactive human factors safety analysis. This approach contrasts significantly from the recent emphasis in the U.S. on performance-based regulatory approaches, which are generally retrospective in nature, and address human factors only indirectly (as a cross-cutting issue). Thus, the U.K.'s proactive approach to managing industry restructuring, its recent audit findings on the impacts of excessive downsizing and outsourcing, and in particular its new deterministic-based *license requirement on change management,* are significant features of the British experience.

7.7.3 Experiences of safety regulators

The British nuclear safety regulators appear to have taken a more proactive role in reviewing and influencing the anticipated restructuring activities than their U.S. counterparts. This included active consultation with the U.K. governmental bodies that were deciding on the scope and pace of ESI restructuring and market competition initiatives. The British regulator also became involved with licensees during the planning stages of their corporate responses to restructuring and market competition. In particular, baseline audits were conducted to provide a basis for

assessing the impacts of later reorganizations and the effectiveness of the change management process. Audits and safety assessments of the target management structures were also initiated.

In addition, the British nuclear safety regime appears to have some characteristics that may lend themselves to more effective management of large-scale organizational change. In particular, the NII operates in a goal setting mode, and is less prescriptive and accordingly more flexible than its U.S. counterpart. The heightened flexibility of the British regulatory scheme suggests that the NII may be more capable of responding to rapidly changing management conditions. By contrast, in the U.S., for example, it takes the NRC a minimum of about two years to enact a new regulation, which may be problematic given the rapid pace of change expected in association with electricity industry restructuring.

The HSE also specifically recognized early on that ESI restructuring changes had the potential to fundamentally affect the management of safety and the safety culture within a nuclear power station. In particular, the HSE recognized at an early stage that the nuclear site licensing process could provide needed assurance (both to the government and to the public) that adequate safety of nuclear power facilities would be maintained during large-scale restructuring. Such a license review establishes that a prospective licensee will be capable of fulfilling its duties and responsibilities as a user of a nuclear licensed site. Furthermore, the license review system provides a reliable and well understood approach to assuring a comprehensive review of potential safety impacts. The re-licensing of nuclear facilities prior to privatization in the U.K. was intended to ensure that the various safety implications of restructuring would be rigorously assessed and documented. This approach to safely managing the change process was facilitated, in part, by the legal system in the U.K., which does not require public hearings for the re-issuance of a license. Therefore, HSE decided that it would be both desirable and feasible to replace site licenses prior to privatization. In essence, HSE recognized the need to establish that the new licensees had in place all of the policies, structures, systems, and resources necessary to ensure that safety would not be compromised.

The British nuclear safety regulators also require baseline information submittals regarding those aspects of a licensee's organization that form an important part of the licensing basis or safety case; no equivalent requirement exists in the U.S. In particular, an SMP describes each nuclear licensee's management organization, including the parent corporation and centralized corporate support functions (e.g., engineering). As noted above, the SMPs are more comprehensive than their U.S. FSAR counterpart. They are part of the safety case justifying a U.K. site license, and have been recently updated by licensees to reflect their current organizations. Therefore, the British SMPs provide information on the current baseline, from which licensees and regulators can assess the safety impact of organizational changes, much like in a 10CFR50.59 analysis.

During the U.K. restructuring process, the NII recognized that it had to handle the new work associated with restructuring in a manner that was consistent with fulfilling its other safety functions at the operating reactors. To achieve this, NII established a project group with members from each of the main regulatory areas of activity. In addition, the NII recognized that the restructuring work would be resource-intensive, so two additional inspectors were recruited, work was re-prioritized, and 60 NII inspectors (plus staff from other parts of HSE) were

assigned to the agency's restructuring activity at one stage or another. By contrast, electricity deregulation in the U.S. is taking place at a time of staffing and budget cuts at the NRC (as discussed in Section 8); there has not been a scale-up to manage restructuring issues.

7.8 Summary

Beginning in 1988, a sweeping transformation of the U.K. ESI was launched for the purpose of privatizing the electrical energy sector and increasing market efficiency through the introduction of more competition among suppliers. This transformation of the energy sector resulted in radical changes to the ownership patterns and management of nuclear power stations. The underlying safety question is whether the new commercial and governmental organizations have adapted sufficiently to accommodate to their new environment. The initial evidence is mixed.

On the one hand, privatization and restructuring have brought about many new safety improvements and efficiencies in operations. For example, there appears to be a significantly heightened interest in system, structure, and component reliability for those systems that can affect power output or threaten regulatory action. A leaner commercial owner of the nuclear power stations has also reduced the former degree of bureaucracy. As a result, it is possible that resources for safety and reliability issues can now be allocated more quickly.

On the other hand, the rapid rate of organizational changes and changes in available resources introduced by privatization and restructuring has challenged the capabilities of both the generating stations and the safety authorities to effectively manage those changes. As a result, a new license condition has been added to each nuclear power station's license requiring that a safety analysis be performed prior to implementing significant organizational modifications or staff downsizing. This represents a significant change in regulatory philosophy that was adopted in response to the challenges of industry restructuring.

8. Relevance of Case Studies to the U.S. Nuclear Power Industry

8.1 Introduction

The U.S. aviation and rail industries and the United Kingdom (U.K.) nuclear power industry have many parallels with the U.S. nuclear power industry,[1] as noted in the previous sections. In particular, all four industries are capital-intensive and technologically sophisticated; in addition, all four have significant safety issues, and are under stringent safety regulation. In addition, like the case study industries, the U.S. nuclear power industry is undergoing significant economic deregulation and restructuring. Restructuring dramatically affected the structure and performance of all three case study industries. Consequently, we would expect (and have already seen) significant changes in the U.S. nuclear power industry as well. Therefore, it makes sense to carefully evaluate safety problems that were encountered in the other case study industries for their potential relevance to the U.S. nuclear power industry.

It is also important to note that the U.S. nuclear power industry (like the other case study industries) is not being deregulated with respect to safety, since the U.S. Nuclear Regulatory Commission (NRC) still maintains its safety oversight and regulatory roles. However, while safety regulation is being maintained, it is not a static process. Economic deregulation and restructuring are taking place in the context of a changing regulatory philosophy (e.g., an increased reliance on risk-informed and performance-based regulation) and a reduction in regulatory staff and budget.[2] Thus, the experiences of safety regulators in the other case study industries could be helpful to the NRC in adapting to its changing environment.

However, there are also significant differences between the case study industries and the U.S. nuclear power industry. To give just a few examples, the aviation industry experienced significant growth subsequent to economic deregulation, but electricity restructuring is not expected to give rise to new nuclear plant construction in the near future. Similarly, the rail industry experienced a dramatic improvement in financial health after deregulation, as did British Energy in the U.K., but it is not yet clear whether electricity restructuring will have similarly beneficial effects on the financial performance of nuclear generating companies. Finally, the U.S. nuclear power industry operates under different restructuring rules, market forces, and labor laws than the nuclear power industry in the U.K. Therefore, care needs to be taken in extrapolating the results of the case studies to the U.S. nuclear power industry to distinguish which of the outcomes experienced in other industries are most relevant to this industry.

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[1] Actually, nuclear power is a sector of the electricity industry, rather than a self-contained industry. Although they use different technologies, nuclear generating companies produce a product that is essentially indistinguishable from, and interchangeable with, the electricity produced by other companies in the industry. In addition, because nuclear power is typically used to meet base load demand, the nuclear sector of the electricity industry has relatively little effect on market prices of electricity. Nevertheless, for simplicity, throughout this report we refer to the "nuclear power industry" rather than the nuclear power sector of the electricity industry.

[2] See U.S. NRC (2000). The agency's authorized staffing has fallen from more than 3300 full-time equivalent staff members in 1993 to roughly 2800 in 2000. Similarly, the agency's appropriations have fallen from $540 million in 1993 to only about $400 million (in constant 1993 dollars) in 2000, a decrease of about 25%.

As a basis for this evaluation, it was necessary to track the ongoing and anticipated changes in the U.S. nuclear power industry. This was accomplished primarily through reliance on published sources (e.g., published surveys of industry representatives, and trade periodicals such as *Electric Utility Week*, *The Electricity Journal*, *Public Utilities Fortnightly*, *Inside N.R.C.*, and *Nuclear Energy Insight*). It is important to bear in mind that the U.S. electricity industry is in a state of flux, and that the degree and timing of deregulation also differ from state to state. As just one example, between January and July 1999, eight states took legislative action on some form of electricity deregulation (Brubaker and Associates, Inc., July 1999). Therefore, the analysis presented here should not be considered comprehensive, since we have not attempted to analyze the specific situation in each state. Rather, the emphasis was on identifying the general approaches to deregulation being adopted in the U.S. nuclear power industry. As such, this overview provides an informed basis for assessing the relevance of experiences in the case study industries to the U.S. nuclear industry as a whole, but it is important to recognize that situations may differ at some plants or in some states.

8.2 General Trends in the U.S. Nuclear Power Industry

Over the last decade, a variety of measures suggest that the performance of the U.S. nuclear power industry has improved, both financially and with respect to safety. For example, Westinghouse Electric Company president Pryor (1998, pg. 40) claims that the median cost of electricity from nuclear power plants decreased from 2.6 cents per kWh in 1987, to only 1.9 cents per kWh in 1996, with more than 70 plants achieving costs of two cents per kWh or less. According to the Nuclear Energy Institute (NEI, 1999, pg. 30), capital additions "at operating nuclear plants have dropped dramatically—from $60-70 per kilowatt per year industrywide in the mid-1980s to $20-30 per kilowatt in the early 1990s." Those capital requirements could conceivably drop still further; for example, NEI anticipates future values of roughly $10-15 per kilowatt per year. Pryor (1998, pg. 40) notes that "A number of U.S. nuclear plants are recording capacity factors in excess of 90 percent," and suggests that capacity factors in excess of 93.5% will be necessary to achieve competitively low electricity prices. However, Maidment and Rothwell (1998, pg. 29) argue that "capacity factor, fuel costs and capital additions show little chance for any further industry-wide improvement," since major improvements have already been seen. A significant portion of the improvement in capacity factors observed to date has been due to shorter refueling outages; Pryor (1998) indicates that the average refueling outage was 30 days shorter in 1997 than a decade earlier.

With regard to safety, several key performance indicators have shown significant improvement in the last ten years. For example, the average number of reactor scrams (i.e., automatic reactor shutdowns), safety system actuations, and significant events, the equipment forced outage rate, and collective radiation exposure have shown significant downward trends from 1986 to 1999 (U.S. NRC, 2000). The average number of safety system failures has also followed a generally declining trend. These performance indicators must be interpreted with caution, however, since they do not capture all aspects of safety. For instance, attempts to "manage the indicators" (e.g., by "inhibiting reactor trips") can actually be detrimental to safety (see for example Taylor, 1989). Similarly, trends in indicators such as the number of significant events can be affected by changes in definitions and reporting practices, and there can be significant variation in the values of the various performance indicators from one plant to another.

Overall, the industry appears to be maturing, reactor performance in a number of areas is improving, and there is a general safety benefit associated with the resulting steady-state operations. Some of this improvement in both economic and safety performance is attributable to bench-marking, peer reviews, and other "cooperative industry programs"; in particular, the programs of INPO, EPRI, and the World Association of Nuclear Operators are cited as beneficial by NEI (1999).

The electricity generation industry in the United States (including the nuclear power sector) is rapidly making a transition from an extended period of cost-of-service regulation[3] to a less economically regulated mode of operation. Due to the rapid pace of change and the fact that much economic regulation is carried out by individual state utility commissions, the situation is complex and difficult to describe in detail. Joskow (pg. 31) lists several overall goals for electricity deregulation, including "more efficient operation of existing facilities" and "shedding of excess labor and other cost burdens in the fuel and equipment areas." He describes the general trends in electricity deregulation as involving "competition in the supply of generation services... [revised] transmission network access rules... [and] new approaches to transmission pricing," coupled with continued regulation of the distribution function as a "natural monopoly" (pp. 32-34).

As a result, deregulation significantly changes the incentives for electricity generating companies. In particular, companies that cannot generate electricity with operating costs at or below the market price for electricity in their region will not be competitive. (Note also that individual nuclear power plants will have little influence on market prices, since they are generally run to meet base loads.) In contrast to the incentives under cost-of-service regulation, generating companies will also have stronger incentives to achieve operating costs (per unit of production) substantially below market prices, since any productivity improvements or cost savings will contribute directly to increased profit.

In the remainder of this section, we examine the experiences of the case study industries in critical safety-related areas to help determine how the ongoing deregulation or restructuring of the electricity industry is likely to affect future operations, safety, and financial performance of nuclear power plants. In particular, we examine the following issues:

1) Equipment failure rates and possible trends in maintenance investment (including the related issues of aging, plant life extension, and premature shutdown).

2) Whether financial pressures are likely to be associated with safety problems.

3) The role of human performance (including issues of human capital and labor relations).

4) Possible effects of mergers, acquisitions, and new entrants on corporate safety culture.

[3] In cost-of-service regulation, which has been the standard in the U.S. throughout the 1900s, companies are allowed to recover those operating expenses that are deemed "prudent" by the economic regulator, as well as a reasonable rate of return on their capital investments. This is accomplished by regulator-approved price increases, which are possible because the companies are not competing with other providers on the basis of price.

5) The possibility of reduced participation in cooperative industry bench-marking and information sharing programs.

6) Experiences of other safety regulatory agencies after deregulation, and their implications for the NRC.

Finally, we also discuss the favorable conditions that accompanied deregulation and/or restructuring in the three case study industries, and that may have mitigated some adverse safety consequences. We then investigate whether similarly favorable circumstances are likely to exist in the U.S. nuclear power industry.

In each subsection, we briefly summarize the relevant experiences from the three case studies, discuss whether similar developments are taking place in the U.S. nuclear power industry, and evaluate the implications of the case studies with regard to safety in the nuclear power industry. Thus, this section is intended to synthesize the results of the case studies and assess their relevance to the nuclear power industry, rather than providing a comprehensive summary of all case study results.

8.3 Equipment Failure, Maintenance, and Aging

Both the aviation and rail industries exhibited significant shifts in the allocation of resources to equipment maintenance as a result of deregulation. In fact, in a review of the effects of deregulation in the rail, aviation, and other major industries, Winston (1998, pg. 98) observes that "since deregulation, each industry has substantially improved its productivity and reduced its real operating costs from 25 percent to 75 percent."

In aviation, the best documentation of such changes was provided by Kennet (1993), who found that airlines reduced engine maintenance after deregulation, but did not experience a higher rate of engine failures as a result. This was apparently because the airlines succeeded in improving the efficacy and efficiency of their maintenance programs; reducing maintenance frequencies may also have reduced the number of engine failures caused by maintenance errors. In the rail industry, even more dramatic reallocation of resources was observed, with workforce reductions of more than 50% (partially due to reductions in allowed operating crew sizes), and nearly a factor of five increase in capital expenditures on track maintenance. The increases in track maintenance in the rail industry are widely viewed as having been beneficial for safety.

In the U.K., our data sources did not allow us to identify specific changes in maintenance expenses. However, there appears to be a clear realization in the U.K. nuclear industry that maintaining high levels of component reliability is critical to keeping nuclear units on line and producing revenue, borne out, for example, by initiatives to reduce the rate of unplanned reactor trips. Furthermore, the new competitive market has apparently created new incentives to avoid unplanned shutdowns, even at the expense of delayed startups in order to complete maintenance and do the job right, due to the high costs associated with unplanned outages in the new electricity market. Similarly, there are stronger incentives today than in the past to comply with technical specifications in order to avoid regulatory shutdowns.

From an economic point of view, these types of changes make sense. In particular, while some have raised concerns that competition would reduce the amount of money available for maintenance, experience indicates that companies will generally expend the funds necessary to ensure the reliability of their product in a competitive market, while searching for the most cost-effective means to do so. Thus, the reductions in maintenance expenditures observed in the aviation field and the increased maintenance observed in the rail industry are not necessarily inconsistent. The airlines appear to have reduced the amount of money they spent on *inefficient* maintenance. By the same token, the railroads increased their investment in maintenance at exactly the time when deregulation of shipping rates led rail lines to become more profitable, and hence those investments became more worthwhile.

8.3.1 Relevance to the U.S. nuclear power industry

Under the cost-of-service regulation that has been the mainstay of electricity regulation in the U.S., there was relatively little incentive for utilities to be efficient in their maintenance expenditures. Joskow (1998, pg. 31) notes that "Price regulation weakens incentives for cost minimization." By contrast, under competition, Joskow (pg. 36) states that "We should...expect to see short and medium term productivity gains associated with improvements in the performance of existing generation, transmission and distribution equipment."

Deregulation systematically changes the incentives faced by nuclear generating companies with regard to maintenance expenditures. Some of these incentives will encourage minimization of maintenance expenditures, with possible adverse safety consequences, while others will encourage increased maintenance and/or capital investments in particular areas. On the one hand, cost minimization will be more important after deregulation than before. As a result, some safety-related maintenance activities that were undertaken in a regulated environment may be cut back or eliminated after deregulation. In particular, since the costs of such activities can no longer be passed through to ratepayers, a given level of expenditure is effectively more costly to the company. Moreover, companies will no longer be able to justify their expenditures on safety-related maintenance based on "prudence." Instead, licensees will now have an incentive to evaluate such expenditures based on the rate of return that they achieve. Thus, it is reasonable to assume that investments in maintenance might decrease in areas that are not viewed as essential to productivity or asset preservation, possibly including some safety-related items that are perceived as "gray areas." As noted by Kahn (1997, pg. 17), "While there certainly are economic incentives for safety, there are also incentives that might...have negative safety consequences."

Note, however, that the NRC maintenance rule (U.S. Code of Federal Regulations, 1996) states that if the performance or condition of a structure, system, or component does not meet established goals, appropriate corrective action shall be taken (regardless of whether it is justified based on the rate of return). In principle, this requirement should prevent any problems in this area. Moreover, for those safety-related maintenance activities that *do* yield significant benefits in productivity, asset protection, or avoidance of regulatory sanctions, the economic value of those benefits is likely to be greater after deregulation than before, since any savings will contribute directly to increased profit.

Moreover, not all cost cutting will have adverse safety consequences. As in other deregulated industries, companies can be expected to become more efficient (at least from the industry's point of view) by optimizing their levels of maintenance activity. First, companies can be expected to more effectively identify those maintenance activities that are cost-effective and risk-significant. For example, based on an interview with several South Texas Project (STP) managers, *Inside N.R.C.* reported that STP expects to achieve significant annual savings by "optimizing maintenance frequencies, [reevaluating] how detailed post-maintenance testing needs to be and reconsidering how detailed plant documentation packages need to be" on components with little or no risk significance (Stellfox, 1999, pg. 3). Second, for a given maintenance activity, companies will attempt to find ways to accomplish that activity at lower cost after deregulation than before. Third, deregulation will remove any economic distortions or inefficiencies induced by imperfections in economic regulation, such as different treatment of capital investments and maintenance expenditures. Finally, companies will have stronger incentives to identify alternative (lower-cost) activities to accomplish a given end. Thus, initiatives to optimize maintenance effort and expenditures (similar to those observed in the aviation and rail industries) are likely to be seen in the U.S. nuclear power industry.

It is sometimes possible to achieve maintenance reductions without jeopardizing safety, as was noted with engine maintenance in the aviation industry. However, caution may be in order. In particular, cuts can sometimes go too far, since feedback indicating the adverse effects of deferred maintenance may be ambiguous and/or delayed. For example, at Millstone, "the need to trim costs in the face of future competition resulted in managers' choosing to defer maintenance and allow backlogs of corrective actions to grow, eventually creating...a shutdown and several hundred million dollars worth of repairs" (General Accounting Office, 1998b, pg. 8). Thus, Carroll et al. (1998, pg. 100) note that some organizations in both the nuclear power and chemical processing industries "fail...to give due consideration to preventive maintenance in organizational decisions," even though "sparse allocation of resources to maintenance is not a rational strategy for the organization as a whole." Similarly, former Pacific Gas and Electric vice president Shiffer (1999, pg. 262) comments: "We're on the offensive in cost-cutting but on the defensive in quality and safety... I firmly believe that it is entirely possible to achieve both high quality/safety performance and necessary cost reductions. But it is also possible to go overboard on cost-cutting such that it adversely impacts quality/safety performance."

Some cost cutting efforts have already been observed. The adoption of risk-informed and performance-based inspection, surveillance, testing, and maintenance is one method of reducing potentially burdensome requirements. Although risk-informed regulation holds a great deal of promise conceptually, it is still too soon to determine whether it will be successful in significantly reducing regulatory burdens while still ensuring nuclear power safety. Entergy Corporation president Hintz predicts that the industry will embrace this approach, because "You've got to operate these plants at the very top level of safety" (*Nuclear Energy Insight*, 1999b, pg. 4). However, some segments of the industry are concerned that the benefits may be too small to justify the effort, or that economic gains in one area due to risk-informed maintenance may be outweighed by increased regulatory requirements in other areas. As stated by ComEd vice president Helwig (1999), "the economic benefit to come out of this endeavor is not entirely obvious."

Moreover, the Advisory Committee on Reactor Safeguards (ACRS, 1999, pg. 2; see also ACRS, 2000) has noted that risk-informed regulation requires a strong research program. In particular, the ACRS (1999, pg. 3) was concerned about the adequacy of current risk assessment methods for dealing with "fires; software-based digital systems; aging of structures, systems and components...; human performance; safety culture," and "low-power and shutdown operations."

Another element of cost reduction is reducing the durations of refueling outages. A number of plants have recently achieved refueling outages shorter than 30 days (see for example Schiffler, 1999; *Nuclear Professional*, 1999; Pryor, 1998). In particular, the *Wall Street Journal* (Schiffler, 1999) reports that one contributor to achieving reduced refueling outage duration is an increased emphasis on online maintenance.

While maintenance investments in some areas may be reduced, it is also reasonable to expect maintenance expenditures to increase in those areas that are believed by management to be critical to productivity and profitability. For example, Elder et al. (1999, pg. 17), of GE Nuclear Energy, cite "increasing the generating capacity and extending the lifetime of the plants" as potentially useful areas for investment. Gupta and Thompson (1999, pg. 40) list possible improvements for the electricity industry as a whole as including "capital upgrades to decrease costs and increase the capacity factor, fuel procurement savings, and labor force restructuring." One area of possible increased investment—plant life extension—is discussed in more detail in the next subsection; others are discussed briefly here.

One area that may see increased investment to improve plant productivity is power upgrades. For example, Duke Power president Coley (1999, pg. 34) notes that "increased capacity...can have significant impact on O&M [operations and maintenance] costs." Similarly, the ACRS (1999, pg. 3) observes that "As the nuclear industry is challenged to perform more competitively in the future, in response to deregulation and low costs of alternative electrical generation, the NRC will be asked to approve power uprates...that have the potential to reduce real margins of safety." The concern about safety margins associated with capacity increases is reiterated in ACRS (2000).

Plants will also strive to achieve reduced forced outage rates, particularly at times of peak demand and high electricity prices. Pryor (1998, pg. 40) notes that this will require "greater outage and maintenance optimization, and increased sophistication in planning"—generally consistent with the changes that were observed in the aviation industry. However, forced outage rates are already quite low at many plants in recent years, so added investments in improved equipment reliability to further reduce those rates may be modest.

As mentioned previously, generating companies may also increase their emphasis on those areas of maintenance needed to avoid regulatory shutdowns. For example, Cudlin (1998, pg. 6) observes that the importance of regulatory shutdowns had grown in recent years, from a historical level of "less than 20% of total [capacity factor] losses to 27% in 1996 and 38% in 1997." He attributes the increased relative importance of regulatory shutdowns both to reductions in other sources of capacity factor losses, and also to "a dramatically higher level of shutdowns, including several high visibility cases and the closure of three plants" (Cudlin, 1998, pg. 4). As a result, Cudlin concludes, "*Regulatory shutdowns now pose the greatest unplanned*

loss of generating capacity for the nuclear industry, and the only one where there has been no improvement over an entire decade" (pg. 6, emphasis in original). He therefore recommends that "*Nuclear operating organizations must take a proactive approach to issues that could affect the regulatory assessment of their performance*," noting that "the spread of regulatory shutdowns [in 1996-1997]...suggests that organizations have not been sufficiently proactive" (pg. 8, emphasis in original).

In this regard, it is important to realize that while a nuclear generating company does have strong incentives to avoid an accident or even serious incidents, some of the risks of nuclear power are still "externalized" (i.e., borne by parties other than the plant owner/operator and personnel).[4] As a result, the level of safety considered desirable by an individual company may differ from that considered desirable by safety regulators or society as a whole, unless an appropriate system of regulations and accompanying regulatory sanctions provides incentives for the company to maintain the socially desired level of safety.

The experiences of the airline industry with maintenance violations and falsification of records after deregulation, and the widespread concerns about under-reporting of safety problems identified in the rail industry interviews, raise another note of caution here. In particular, there is some indication that financial and union difficulties in the airline industry exacerbated the incentives for some airlines to "cut corners on maintenance" (Transportation Research Board, 1991, pg. 184). To the extent that deregulation causes similar stresses within the nuclear power industry, some companies may face similar incentives to ignore or under-report safety problems, and/or avoid regulatory sanctions by evasion rather than by enhanced maintenance efforts. This is consistent with the prediction that less effort may be devoted to issues that are perceived as "gray areas," but can have unforeseen safety consequences.

8.3.2 Aging

With respect to equipment aging, no significant evidence was found of a trend toward older equipment after deregulation in the rail industry. In fact, aging and deterioration of track had been a significant problem prior to deregulation in the rail industry. The quality of track maintenance improved significantly after deregulation, due to the improved financial health of the major railroads and the abandonment of unprofitable lines. The aviation industry did experience a pronounced trend toward longer operating lives for aircraft. While the available statistics do not show a clear empirical link established between aging aircraft and reduced safety (presumably due to effective aviation maintenance), two aviation interview respondents identified concerns about maintenance of aging aircraft as an important safety issue in the future, especially at smaller carriers that may not have either the resources or the commitment to adequately maintain their aircraft as they age. In the U.K., the profitability of nuclear power after restructuring has prompted licensees to seek extended operating permissions, creating the possibility of reduced safety margins due to phenomena such as erosion, corrosion, embrittlement, and fatigue.

[4] For example, Matsuki and Lee (1999, pg. 11) define "externalities" in the electricity industry as "damages...not reflected in the market for electric power."

In the U.S. nuclear industry, there has been relatively strong interest in life extension as deregulation proceeds. Because the marginal costs of producing nuclear electricity are generally favorable compared to the costs of coal and oil, companies are interested in getting the most out of their nuclear plant assets by maximizing their productive lifetimes. Thus, companies that have confidence in the profitability of their assets have taken steps to maintain that profitability over a longer time period. Perlman (1997, pg. 28) observes that "The longer its operating life, the more attractive the asset, both from the point of view of cash generating potential and from the timing and magnitude of decommissioning payments and expenses." At present, Calvert Cliffs and Oconee have received renewed licenses, and an additional 33 units have filed applications or expressed interest in license renewal (U.S. NRC, 2001). As a result, the ACRS (1999, 2000) has argued that support of license renewal efforts requires additional research. Suggested research areas include probabilistic risk assessment models for aging, as well as additional research on steam generator integrity, reactor vessel embrittlement, and stress corrosion cracking (ARCS, 1999).

By contrast, companies with less profitable power plants (or plants facing large short-term costs or especially large uncertainties about cost recovery and future economic conditions) have in some cases decided to close those plants. Joskow (1998, pg. 37) notes that

> Cost-based regulatory rules and political constraints have historically led electricity suppliers to continue to operate some generating facilities beyond the date they would be retired if they had to live on the revenues they could obtain in competitive markets... The pressures of emerging competition have...led to the early retirement of at least four nuclear reactors in the U.S. More are likely to follow this path in the next few years.

Thus, deregulation may simultaneously both accelerate the rate of plant closures and increase the interest in life extension for those plants that are above the threshold of profitability for continued operation.

In particular, while the marginal electricity costs of many nuclear plants are quite favorable, the industry today faces substantial uncertainties regarding future conditions (e.g., electricity prices), and also about recovery of stranded assets and decommissioning costs. Such large uncertainties make it difficult for companies to project the productive operating lives of their plants with confidence, which may result in some additional plant shutdowns. This is especially likely to occur if a plant is facing a major required investment (such as steam generator replacement). Such investments would generally not be economically justified unless the remaining operating life of the plant is substantial, and the margin between market prices and operating costs is large enough to recoup the investment. For example, Lee (1998) notes that a plant faced with major back-fitting costs "may decide that the remaining years of its license is insufficient time to amortize the capital cost of these improvements and still meet the market-clearing price."

As noted in the next section, impending plant closures can reduce the incentives to invest in safety and maintain the plant's condition during the last few years of a plant's operation. Of course, most plants will eventually go through a period during which near-term shutdown is

anticipated (with the associated reduction in investment incentives that this entails), but deregulation may accelerate the timing of the shutdowns for some plants.

8.4 Financial Pressures

Two of the three case study industries provide evidence suggesting that financial difficulties may be associated with poor safety records. In the aviation industry, there have been two empirical studies addressing this question. Statistical analyses of pre-deregulation airline data by Golbe (1986) found that "safety and profits have no significant relationship." However, a more extensive analysis by Rose (1989, 1990, 1992), covering data from both pre- and post-deregulation time periods, concludes that "lower profitability is correlated with higher accident and incident rates, particularly for smaller carriers" (Rose, 1990). Rose (1990) speculates that "Smaller firms...may be more responsive to fluctuations in the economic environment." In reviewing her results, Rose (1989), specifically recommended that "more intense scrutiny of the safety practices of financially marginal carriers is desirable."

In the rail industry, the poor safety performance of the railroads in the period leading up to deregulation is generally believed to be associated with their poor financial health during the same period (and their inability to abandon unprofitable routes). In addition, studies of accident rates in the railroad industry prior to deregulation found that better financial health was generally associated with lower accident rates (Golbe, 1983), with the relationship being strongest for those railroads that were actually unprofitable.

In the U.K. electricity industry, no empirical evidence was found to indicate that financial difficulties were associated with safety problems, since the privatized nuclear plants became very profitable following deregulation. A contributing factor to this financial success was the fact that the structure of the U.K. privatization process provided significant subsidies for nuclear power, thus helping to ensure the profitability of the country's privatized nuclear operating company in the years immediately following privatization.

The link between poor profitability and inadequate safety investments is also consistent with economic theory, which predicts that firms facing financial difficulties are more likely to take chances, such as deferring spending on safety improvements (Golbe, 1988). In particular, a profitable company will have incentives to ensure safety in order to maintain the profitability of its assets. By contrast, a company facing imminent bankruptcy has less incentive to invest in safety improvements, since those investments by themselves will not be sufficient to ensure the future economic viability of the enterprise. Instead, the company's incentive to cut corners will be stronger. If this cost-cutting pays off, the company will then be in a better position to make needed safety investments in the future; if not, the maximum possible losses are limited by bankruptcy, which already seems likely in any case. Note that even a company faced with impending bankruptcy may still have some incentive to invest in safety in order to preserve the future sales value of its assets; however, that incentive is weak if the company's assets are likely to have little resale value at bankruptcy. Thus, while the precise mechanisms by which poor profitability is linked to lower levels of safety are not well understood, on both empirical and theoretical grounds such a link seems likely.

8.4.1 Relevance to the U.S. nuclear power industry

A central issue for the financial viability of nuclear power in a competitive market is the fact that the construction costs of most nuclear power stations in the U.S. were high, usually much higher than anticipated. Under cost-of-service regulation, the capital costs (a rate of return on capital, plus depreciation) are included in regulated rates. Over time, the real (inflation-adjusted) book values of these plants have been reduced,[5] but still result in electricity prices higher than would be achieved under competition. Despite the partial pay-down of these costs, not many nuclear power stations would be competitive if the plants were sold at their book values. Similarly, if maintained by their current owners, many plants would no longer generate a return on that portion of their book values that exceeds the actual market value of the plant in a competitive electricity market. In most states that have enacted plans to open their electricity markets for competition, owners of such overvalued plants have been allowed to collect "stranded cost" payments as part of the approved plans. The intent is to compensate them for at least a portion of the returns that they would otherwise have received under cost-of-service regulation.[6] Thus, these sunk costs are effectively removed from the market.[7]

This stranded cost recovery process is financially similar to bankruptcy, in that the owning company exits its prior commitment without a large debt that its future revenues cannot readily repay. Plant sales at significantly below book value accomplish much the same purpose (as did privatization in the U.K.), since the new owner/operators are unencumbered by the high initial construction cost of the plant. As a result, the competitive viability of nuclear power stations is determined by the difference between the revenues that they can produce and their incremental operating costs (i.e., marginal costs).

A number of industry observers agree that some nuclear plants will be competitive after deregulation, on a marginal cost basis. For example, Moody's Investors Service (1999, pg. 5) states that nuclear power can "provide the buyer with a marginal cost advantage over most other types of power plants in a competitive market." Similarly, Entergy's Hintz observed that "a well-run nuclear plant of a certain size, in a good location, can be extremely competitive with any other generation that is available today" (*Nuclear Energy Insight*, 1999b, pg. 3). Thus, the most successful nuclear generating companies may have strong operating profits after deregulation, and these profits will not be artificially limited by economic regulation.

On the other hand, deregulation is generally expected to create financial difficulties for at least some plants during the transition period, and creates the possibility of further plant closures. For example, Lee (1998) cites estimates of the number of plants that might close ranging from 17

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[5] This reduction in book value reflects the collection of depreciation through regulated rates.

[6] In addition to nuclear costs, the main component of stranded cost collection is from above-market power purchase agreements that were, to some extent, required of utilities by state commissions under the provisions of the Public Utility Regulatory Policies Act of 1979.

[7] By and large, decommissioning costs are similarly sunk costs. This is because the decommissioning must be performed regardless of whether the plant continues to operate. In fact, the discounted net present value of the decommissioning costs may be lower if a plant continues to operate for many years than if it is shut down immediately. This is because the cost is put off for a long period, giving it a lower discounted present value.

units based solely on "poor capacity factors and high O&M costs," to 25% of all capacity when uncertainties about license extension are taken into account. Despite the variability in the estimates of plant closure rates, the general consensus seems to be that "most nuclear units should be able to compete with other sources of electricity in a competitive generation business" (NEI, 1999, pg. 30). However, like impending bankruptcy, anticipated plant closures reduce the incentives to invest in some types of safety improvements during the last few years of a plant's operation, since these costs can be amortized over only a short time.

A study performed by Arthur Andersen (1996) for the NRC recommended that:

> the NRC should evaluate economic, management and operational factors in order to prevent future events. Given the economic factors behind production and safety, assessing indicators of economic stress and management's response to them ahead of time should allow the NRC to achieve...:
>
> - Earlier identification of problems;
> - Fewer safety risks to the public; and
> - Earlier and less costly resolution of problems.

These recommendations, together with the statistically significant links between financial difficulty and safety problems that were observed in two of the three case study industries, suggest that financial difficulty may be a leading indicator of declining safety margins in the nuclear power industry. The NRC has undertaken some limited study of this issue; see for example Raughley and Lloyd (1999).

While the empirical evidence from the aviation and rail industries indicates that the greatest risks are associated with low profitability, note that the transition to a more competitive industry can create risks at all companies, even those that are highly profitable after deregulation. In particular, under cost-of-service regulation, utilities could expect to recover costs that were deemed "prudent" (by raising electricity rates), and investments on safety improvements were generally considered prudent. Under competition, expenditures will be judged according to their net present value or internal rate of return, and companies that face greater financial risks than under economic regulation are likely to apply higher thresholds or "hurdle rates" to their investments. As noted by Gupta and Thompson (1999, pg. 43), "high risk devalues the potential revenue stream and increases the internal discount rate." Thus, some safety investments that would have been justifiable, and hence recoverable, under the standard of "prudence" applied in cost-of-service regulation may no longer be considered justified once companies can no longer simply raise prices to cover costs. However, as noted by Cudlin above, safety expenditures that significantly reduce the risk of future shutdowns and thereby make future revenue flows more likely will still generally be desirable.

The nuclear power industry today faces substantial uncertainties. Gupta and Thompson (1999, pg. 43) cite uncertainties about "the tax consequences (and time requirements) of transferring ownership, revaluing the asset, and transferring the decommissioning funds," and note that "these significant uncertain costs affect the plant's [discounted cash flow] valuation." Similarly, Lee (1998) cites uncertainties associated with plant life extension, nuclear disposal, and future attitudes to nuclear safety. Such large uncertainties (and the corresponding financial risks that

they create) will generally lead companies to adopt higher discount rates in their investment decisions. For example, Joskow (1998, pg. 39) states that under deregulation, "generation suppliers will be required to bear much more performance and market risk than have traditional utilities and, as a result, will base decisions on higher costs of capital, shorter payback periods and more stringent cash flow requirements." Based on economic theory, this can be expected to result in a trend toward shorter-term planning, with long-term investments requiring higher levels of profitability in future years before they can be considered.

8.5 Human Performance and Labor Issues

The three case study industries differed widely in the specific effects of deregulation on human performance and human capital. In the aviation industry, rapid industry growth created significant growth in total employment. As a result, human performance problems were generally associated with relatively inexperienced personnel and high turnover rates, especially at smaller carriers.

By contrast, both the rail industry and the U.K. electric supply industry experienced dramatic downsizing in personnel. In the rail industry, employment decreased by more than half in the first decade after deregulation. The rail industry was generally able to maintain high levels of employee experience despite the downsizing that occurred (in part because union contracts generally require layoffs by seniority), with few concerns being raised about employee inexperience. However, concerns have been raised that downsizing has sometimes gone too far (especially after mergers), resulting in problems with under-staffing and inadequate supervision. There are also significant concerns about fatigue, especially in relation to work-rule changes regarding minimum crew sizes. In the rail industry interviews, labor representatives felt that the steady decrease in crew sizes had increased problems of fatigue, with one union representative specifically stating that "Fatigue issues are much worse since deregulation." One respondent even noted that a number of rail workers have been killed in commuting accidents before or after their work shifts due to fatigue. The Federal Railroad Administration (FRA) has also increased its focus on fatigue in recent years, and an FRA representative indicated concern about increased use of overtime, with some overtime possibly being under-reported. These problems appear to have intensified in recent years, in association with a recent growth in rail traffic, a tight labor market, and a problematic major merger.

Dramatic cuts were also observed in the electricity industry following deregulation, both in the U.K. and elsewhere. For example, Joskow (1998, pg. 36) notes that "From England and Wales to Chile and New Zealand, restructuring for competition has led to significant labor shedding." More specifically, total employment in the U.K. electricity industry fell by roughly half in the five years immediately after the restructuring of the industry in the late 1980s. This followed a long period of significant but slower downsizing (another factor of two over the previous 20 years). Based on information from British Energy staff, *Inside N.R.C.* reports that downsizing at British Energy (the privatized owner of nuclear power plants in the U.K.) continued after its privatization in 1996, with roughly "a 25% staff reduction" over several years (Marshall, 1999, pg. 8).

However, as noted in the U.K. case study, the Nuclear Installations Inspectorate (NII) has expressed concern that the rapid cuts in employment, accompanied by substantially increased use of contractors, may have left the nuclear operating companies with questionable levels of experience and expertise to safely operate the plants. Concerns were also raised about the qualifications and safety culture of the contractors. It is interesting to note in this regard that similar concerns about the safety of contractors have also been raised in the petrochemical and mining industries (see Wells et al., 1991; Kochan et al., 1994; Rebitzer, 1995; Rousseau and Libuser, 1997). An NII safety audit (U.K. Health and Safety Executive, 2000) found that some British Energy employees were "working significant amounts of overtime or unpaid excess hours to keep abreast of the workload." As a result of such concerns, under License Condition 36 (adopted in 1999), the NII has begun requiring prior approval of significant changes in staffing, precisely in order to prevent problems of this nature.

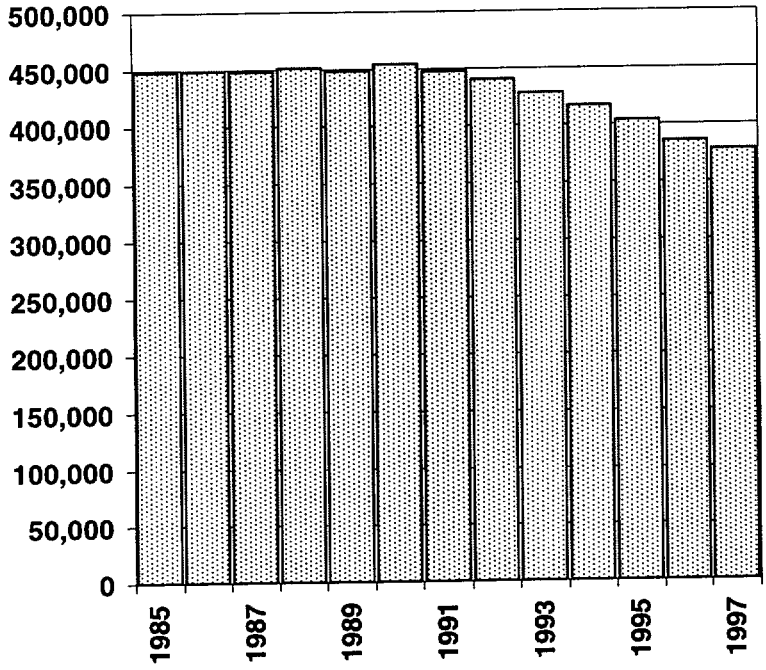
Interestingly, in both the aviation and rail industries, average levels of training were reported to have increased after deregulation, based on the results of our interviews. However, this was generally attributed to the increased level of technical sophistication within these industries (in particular, the need to operate and maintain increasingly sophisticated pieces of equipment), and the increased reliance on simulators in both industries over time, rather than being viewed as a direct effect of deregulation. Some rail industry respondents (especially labor representatives) also raised concerns that training levels may still be inadequate given the increased technical sophistication of the equipment being used in the industry today.

8.5.1 Relevance to the U.S. nuclear power industry

A number of the issues discussed above seem potentially relevant to the U.S. nuclear power industry. In particular, human performance is critical to safety in all three case study industries as well as in the U.S. nuclear power industry. This is partly because the effectiveness of many hardware-based safety features can be compromised or even negated by inappropriate human actions, but also in part because other (e.g., equipment-related) causes of safety problems have often been addressed more successfully than human performance. Therefore, in the remainder of this section, we discuss the experience of the U.S. nuclear power industry with respect to downsizing, use of contractors, and overall human capital (e.g., experience levels and qualifications), in addition to general human performance issues that may be associated with deregulation. Labor relations will be discussed in detail in the next subsection.

Downsizing is currently one of the most common approaches to reduce costs. The U.S. electric services industry (Standard Industrial Classification code 4911) downsized by 18% during the early 1990s (Jacobs, 1999; U.S. Department of Labor, 1996); see Figure 8-1. Similarly, Fox (1999, pg. 24) states that "total labor requirements on average across the [nuclear power] industry have fallen by 14 percent during the past five years." The trend to downsizing appears to be continuing, as it did in the U.K., where the history of significant downsizing before privatization did not prevent further cuts afterward. For example, the utility vice presidents surveyed by *Public Utilities Fortnightly* (Schuler, 1999) generally report downsizing of 10% or more in their companies, and as much as 20% in the former Unicom (pg. 64). Shiffer (1999, pp. 262-263) notes that the Diablo Canyon nuclear power plant is cutting its total workforce by roughly a factor of two; many of the cuts have affected contractors rather than full-time staff,

Figure 8-1 Employment in the U.S. Electric Services Sector



but even the reduction in the permanent staff is substantial. Downsizing has not been spread evenly across all job categories; see for example Fox (1999). We were not able to find much evidence regarding trends in overtime utilization in the U.S. nuclear power industry, and former NRC chairman Jackson (1999) concluded that available data were inconclusive as to the existence of a trend.

Plant staffing levels appear to vary as a function of factors such as location, size, age, reactor type, number of units, and utility characteristics (see for example discussions of statistical analyses by Fox, 1999; Maidment and Rothwell, 1998; and Sunder et al., 1999). This creates a risk that plants attempting to determine staffing levels based on the low-cost performers in the industry, without correcting for such differences or considering each job category separately, could downsize too much in safety-critical areas (with possible adverse safety consequences), or else too little (with adverse economic consequences). McKinley et al. (1995, pg. 38) note that determining appropriate staffing levels is especially difficult when "organizational units lack clear performance standards" and when "the relationship between means and ends is ambiguous." Both "gray areas" in performance standards and ambiguous relationships between means and ends may be more likely to apply to safety functions than to those activities necessary for day-to-day production.

Evidence is mixed about the use of contractors in the U.S. nuclear power industry. Some industry observers (e.g., Miller, 1998, pg. 27) have recommended that power plant purchasers consider "Staffing for baseload operation, using...contractors for peaks and outages," suggesting that outsourcing may increase with deregulation. However, economies of scale associated with consolidation of numerous nuclear power stations within a single operating company may permit reductions in the use of outside contractors by making it feasible to rotate in-house specialists among the various plants.

8.5.2 Effects of deregulation on human capital

The situation with respect to human capital issues (in particular, experience and qualification levels) is even more complex. As noted above, the aviation industry saw rapid growth in employment, coupled with concerns about employee inexperience. By contrast, the rail industry saw significant employment cuts, and was able to retain an experienced work force. The U.S. nuclear power industry is not expected to grow after deregulation. For example, *Energy User News* (Price, 1999, pg. 17) notes that "no new reactors are planned for construction in this country at this time." Joskow (1998, pg. 47) states that "Unless fossil fuel prices rise significantly or a large tax is placed on carbon I do not expect to see new nuclear plant investments taking place in a competitive regime." Therefore, the experience of the case studies would suggest that as a static or shrinking sector of the electricity industry, nuclear power (like the rail industry) should be able to retain a highly qualified and experienced workforce. However, the situation is more complex than it at first appears. First, as we saw above, significant concerns about experience levels were raised in the U.K. nuclear industry, where downsizing rather than growth was the predominant pattern. Moreover, from a labor economics perspective, the quality of the labor force in a given industry is influenced by a number of different factors, some of which work in opposite directions.

On the one hand, a number of factors may work against the maintenance of institutional memory and an experienced work force. First, there is a long learning curve associated with deregulation, and feedback regarding adverse safety consequences of cutbacks may be delayed or ambiguous; for example, cutting back experienced staff may lead to safety problems only after an extended period of time. This is especially true since accidents and even serious accident precursors are rare, so an increase in their frequency may not be quickly observed. Moreover, to the extent that safety concerns are not fully internalized (e.g., by regulatory requirements), companies may have insufficient incentive to preserve institutional memory by retaining highly qualified workers. This is even more problematic if institutional memory is more important to safety than to economic productivity. Therefore, some managers may choose to cut costs by laying off those employees with the highest levels of seniority and qualifications (at least at companies or in job classifications that are not subject to union seniority provisions).

Even if most companies would prefer to hire and retain highly qualified and experienced personnel, various factors may impede their ability to do so. First, as noted in the aviation industry interviews, relocation is often stressful, so employees that have been laid off from a plant in one region may be unwilling to relocate to another. For example, Shiffer (1999, pg. 263) notes that "of some 40 employees who were given the opportunity to relocate [from the San Francisco area to Diablo Canyon], only abut five accepted." Second, early retirement programs

generally focus on senior employees, and hence can reduce institutional memory. Third, as discussed below, rapid organizational change (including mergers, acquisitions, and other major management changes) is likely to accompany deregulation. For example, Miller (1998, pg. 31) argues that power plant purchasers "should not attempt to duplicate the seller's benefit plans," and "may be in no position to offer the same range of benefit choices." Concerns about deteriorating working conditions, reduced benefits, opportunities for advancement, and/or future layoffs can cause even those employees that have not been laid off to look for employment elsewhere, especially in job categories that do not involve extensive industry- and plant-specific skills. Fourth, Shiffer (1999, pg. 264) notes that the unpopularity of the nuclear industry in this country makes it difficult to recruit "the best and brightest" new employees. Finally, deregulation of the rail and aviation industries took place around the time of a significant recession, whereas electricity deregulation is taking place at a time of economic growth. Therefore, some employees who wish to leave the industry may have ample job opportunities elsewhere; for example, nuclear power plant maintenance technicians may be able to find well-paying jobs in a variety of industries.

However, other factors may limit the possible loss of human capital. First, the expected reduction in the workforce of the U.S. nuclear industry (due to both firm-level downsizing and plant closures) means that there may be a pool of experienced nuclear power plant workers available to be hired (see for example Shiffer, 1999, pg. 264). Second, hiring and retaining experienced employees can be an effective strategy for maintaining or improving productivity. For example, Northern States Power president Howard (1999) indicated that one strategy of the joint Nuclear Management Company in which Northern States Power (now Xcel) is participating will be to "retain and attract the best [employees] in the industry." Third, employees in some job categories (e.g., reactor operators) possess extensive industry-specific training, knowledge, and skills. This will tend to make their average earning power greater in the nuclear power industry than elsewhere, providing an incentive for people to remain in the industry even if the conditions of employment become somewhat less desirable than in the past. Fourth, both the geographic dispersion of the industry, and also pensions and seniority rules, can help employers retain valued employees, since these factors make changing employers within the nuclear power industry relatively difficult and costly, thus reducing the extent of voluntary turnover. Finally, with respect to involuntary turnover, layoffs at unionized plants and in unionized job categories will generally be in order of seniority. All of these factors may help to limit the loss of experienced employees and institutional memory from the industry.

8.5.3 Human performance and downsizing

Human capital is not the only determinant of human performance, since even highly qualified and experienced personnel can make mistakes under difficult working conditions. It remains to be seen whether industry strategy in the face of competition will emphasize human performance and productivity improvement, or simply cost cutting. Some companies do seem to be aware of the importance of maintaining good human performance in a competitive environment. For example, Gale et al. (1998, pg. 18) report that Virginia Power (now Dominion Virginia Power) attributes North Anna's 33% cut in operations and maintenance costs in part to excellent human performance, including "teamwork and the importance of...high standards of performance from the top down." This suggests that one strategy for becoming and remaining competitive is to

emphasize high quality work and a work environment conducive to good human performance, but this strategy may not be universally adopted.

Concerns have already been raised that cost cutting and downsizing may have gone too far at some plants. In Canada, the Atomic Energy Control Board raised concerns about the consequences of downsizing at Ontario Power Generation Inc. (the company that will own the nuclear power plants currently owned by Ontario Hydro after deregulation). In particular, according to *Nucleonics Week*, they expressed concern about "the potential for competitive pressures to undermine funding for...staffing of nuclear facilities" (Silver, 1999, pg. 6). Similar concerns about overtime, fatigue, and staffing levels at nuclear power plants have been raised in the U.S. by Representatives Markey et al. (1999) and others; see also Markey and Dingell (1999), Union of Concerned Scientists (1999), and a recent Petition for Rulemaking (Quigley, 1999). These sources often attribute problems of under-staffing to the advent of competition. Although they do not provide data to support the claim that fatigue and use of overtime have increased in recent years, such concerns can be expected to intensify if deregulation leads to significant further downsizing in the nuclear power industry.

8.5.4 Labor relations

In both the aviation and rail industries, deregulation was quite disadvantageous to labor, resulting in major concessions in both work rules and wages. We were not able to assess the impact of privatization on labor relations in the U.K. nuclear power industry. However, deregulation (at least in its initial phases) has almost uniformly been unfavorable for labor in the U.S. For example, *Nucleonics Week* (Barber, 1999, pg. 6) reports that "In other businesses that have gone through some degree of deregulation—railroads, trucking, and telecommunications to name a few—the number of thorny labor issues has increased dramatically." From an economic perspective, labor organizations were often able to extract "above-market rents" from regulated industries, since the lack of competition and the ability to pass through many components of operating cost diminished the incentive for management to resist labor demands and initiatives. The subsequent concessions after deregulation are naturally viewed unfavorably by labor unions. For example, Peoples (1998, pg. 114) notes that in both the railroad and airline industries (and also trucking and telecommunications, "the bargaining power of labor declined...following deregulation." (One interview respondent in the aviation industry was of the opinion that labor was actually significantly stronger today than before airline deregulation, since intense competition makes strikes potentially disastrous for the airlines. However, this does not challenge the general consensus that the *initial* post-deregulation period was deleterious for labor interests.)

Despite the significant economic and work-rule concessions that unions made after deregulation, however, both the aviation and rail industries in the U.S. have remained heavily unionized. For example, Peoples (1998, pg. 112) states that "the findings on railroad workers do not reveal any especially substantial effect of deregulation on the union membership rate in this industry." The unions in both industries have also maintained their strong historic interest in safety issues. In both industries, a number of post-deregulation work-rule changes (such as reduced staffing levels for trains and increased flight duty hours for pilots) were widely criticized by labor organizations as being adverse to safety. However, while such changes may have eroded safety

margins in some cases, we have seen that safety records generally improved in both industries in the post-deregulation time period.

In the U.S. nuclear industry, several labor organizations have already taken positions opposed to aspects of deregulation. The International Brotherhood of Electrical Workers (IBEW), which represents employees at the majority of the country's nuclear stations, has posted position papers critical of deregulation on its web site (see for example IBEW, 1999a and 1999b), and has testified before Congress about its concerns (Barry, 1997). While the IBEW objects to several aspects of the plans for electricity deregulation, they do specifically raise "the issues of worker safety, reduction of staffing levels or worker transitions which would be needed as a result of reduction in the labor force, which usually occurs during competition" (IBEW, 1999b). The Utility Workers Union of America has also issued a position paper critical of some aspects of deregulation (Utility Workers Union of America, 1999), which again cites concerns about "worker and public safety." In fact, the Executive Council of the American Federation of Labor-Congress of Industrial Organizations (AFL-CIO), which includes both of the above labor organizations, adopted a position statement on energy policy in the United States that raises concerns about potentially destabilizing effects of deregulation and restructuring (AFL-CIO Executive Council, 1999). IBEW International President Barry (1996) also submitted comments to the NRC on its *Draft Policy Statement on the Restructuring and Economic Deregulation of the Electric Utility Industry* (U.S. NRC, 1996), expressing doubts about the speed of deregulation and industry restructuring, and urging caution "to ensure...safe operations."

Industry observers generally expect the majority of the nuclear power industry to remain heavily unionized after deregulation, as did the U.S. aviation and rail industries. For example, Miller (1998, pg. 27), in an article about the process of plant acquisition, states that "Operating non-union is almost never an option for the buyer, since the seller typically has gained workforce and community support by requiring a union-friendly transaction." Similarly, *Public Utilities Fortnightly* associate editor Schuler (1999, pg. 56) states that "Nearly all [of the utility vice presidents that he surveyed] recognize the roles of unions in the future employee mix." Thus, unions will undoubtedly continue to be players in the industry.

However, union concerns about the effects of deregulation on the economic well-being of their membership appear to be well founded. In addition to downsizing, other undesirable changes in work rules, benefits, and even union representation may be forthcoming at some plants. For example, attorney Miller (1998, pg. 30), in advising potential nuclear plant purchasers on how to manage workforce and labor relations issues, cautions against accepting many current contract terms and conditions:

> Any restrictions on scheduling of work and training, assignment of work, overtime distribution, and performance evaluations should be viewed as presumptively unacceptable. And where the business unit employs a baseline staffing philosophy, any restrictions on the use of non-union staff or contractors should be unacceptable. Seniority should be eliminated as a controlling factor in assigning call-out work, scheduling emergency work, scheduling relief overtime or making promotion decisions.

He even suggests that in some cases employers may wish to consider petitioning "the National Labor Relations Board to remove a whole job classification from union control." It is clear why unions may choose to resist such threats. For example, Unicom's Snodgrass noted that "Unions will want to soften the impact of industry restructuring on their organizations" (Schuler, 1999, pg. 64). *Nucleonics Week* (Barber, 1999) concludes that "Labor issues are apt to intensify."

Therefore, it is essential to consider the possible interactions between labor issues and plant safety. Here, there may be a divergence between the unions in the aviation and rail industry and those in the nuclear power industry. In the aviation industry (and to a lesser extent the rail industry), union concerns about employee safety are often aligned with public safety concerns, since many of the accidents and incidents that can cause risk to employees also pose a threat to members of the general public; public and occupational safety issues are not always as strongly aligned in the nuclear power industry. However, one valuable safety-related role that unions can fulfill is to provide protection for whistle-blowers or others attempting to raise safety concerns. This role is likely to be at least as important in the nuclear power industry after economic deregulation and restructuring as before; for example, *Nucleonics Week* (Barber, 1999) discusses "The question of how grievances or whistleblower issues are handled" during power plant purchases. Labor organizations may also adopt a more aggressive approach to reporting of safety violations (Conway, 1988, pg. 214) or a "Work Safe" slowdown (Halliday, pg. 28) as means of creating pressure on management without going on strike.

Despite these favorable effects of labor activity on safety, severe labor strife can in principle impede safe operations in high-hazard industries, due in part to its impact on employee morale. For example, in the aviation industry, labor difficulties have been reported to result in instances of sabotage. However, in a discussion of sabotage at one airline, Halliday (1987, pg. 1) noted that "There is no suggestion that any employee has done anything to endanger safety." Our interview respondents also generally felt that labor strife had not adversely affected safety, largely because aviation professionals were described as dedicated people who did not allow their dissatisfactions to spill over into safety-related aspects of their work.

8.6 Influences on Corporate Culture: Mergers, Acquisitions, and New Entrants

Issues of corporate culture were identified as being critical to safety in all three case studies. In both the U.S. aviation and rail industries, these concerns were primarily associated with mergers and acquisitions, which were prevalent in the post-deregulation period. Winston (1998, pg. 94) states that "Substantial merger activity has generally occurred within a decade of an industry's deregulation." Cudahy (1998, pg. 441) goes so far as to suggest that "Nothing is certain about deregulation except the mergers that follow," commenting that "Mergers are accomplished in the name of efficiency and perhaps...in the hope of some easing of competitive pressures."

In the rail industry, a *New York Times* economics writer (Passell, 1998) described the acquisition of the Southern Pacific and Chicago and Northwestern railroads by Union Pacific as "the most spectacular merger fiasco of modern times," resulting in several fatal accidents as well as significant freight delays. In particular, he noted that "Union Pacific's by-the-book culture clashed badly with Southern Pacific's, where managers had long been accustomed to making do with chewing gum and bailing wire." As a result, commenting on the recently proposed merger

of Burlington Northern Santa Fe Corporation and Canadian National Railway Company, a financial analyst with Merrill Lynch was quoted in the *Wall Street Journal* as saying: "Investors are scared by the potential downside of rail mergers... In the past, rail mergers have led to distraction of management as a minimum and, in the worst cases, led to disastrous results" (Machalaba and Chipello, 1999). Concern about the possible negative effects of mergers even prompted the FRA to promulgate regulations (U.S. Department of Transportation, 1998) requiring advance approval of mergers, consolidations, and acquisitions of control, based on a documented plan for safe implementation of the proposed merger. The issue also emerged as a key recommendation for the NRC in the rail industry interviews, with several respondents urging the NRC to be cognizant of the potential safety problems associated with mergers and acquisitions.

In the aviation industry, the U.S. Office of Technology Assessment (1988, pg. 39) noted that mergers had a potentially adverse impact on corporate culture, and hence on aviation safety. As in the rail industry, several respondents in the aviation industry interviews also mentioned this issue, one describing issues of corporate culture as the biggest single problem associated with mergers and acquisitions. However, one respondent with significant experience in both the regulatory arena and airline management noted that in the longer term, "consolidation has led to the creation of stronger companies with more resources at their disposal."

Corporate culture issues also appear to have played a part in the increased risk associated with some new entrants to the airline industry; for example, Gray (1987, pg. 34) stated that "Many new carriers have little notion of or experience in how an airline must be run." By contrast, corporate culture issues did not appear to pose as much risk in the new spin-off railroads established after rail industry deregulation, in part because they were largely staffed by experienced personnel from the larger railroads. In addition, because of interconnections between the new short-line railroads and the major rail carriers, the smaller railroads were generally required to meet certain minimal levels of safety performance. Similarly, the recent trend toward partnerships between the commuter air carriers and the major airlines may be associated with a reduction in the average risk of the commuter carriers.

In the U.K. nuclear power industry, several corporate culture concerns have been raised by safety regulators. Some of these relate to the extensive use of contracting, which was discussed briefly above (in the section on "human performance"). With respect to consolidation, the U.K. nuclear power industry is already heavily consolidated due to decisions made during the privatization process. However, further consolidation has been noted (Allars, 1999), primarily in the form of alliances ("two or more companies...mutually assisting each other, generally without exchange of money") and partnerships ("a contractual arrangement to maximise the profit of all parties"). In this regard, the U.K. NII acknowledges that "there may be benefits from alliancing/partnering" (Allars, 1999), but also raises some possible pitfalls with this trend, citing Admiral Rickover: "You can delegate authority, but not responsibility." In particular, Allars emphasizes the "need for partners to fully understand the hazard/risks and to share in safety culture initiatives and goals set by the licensee."

8.6.1 Relevance to the U.S. nuclear power industry

We believe that there are valuable lessons to be learned from experiences with new entrants, mergers, and acquisitions in other industries. As noted earlier, deregulation is not expected to result in the construction of new nuclear power plants in the immediate future, so it would appear that the experiences of new entrants would be largely irrelevant to the U.S. nuclear industry. However, in this study we view new entrants (and new owners with little or no prior nuclear experience) as one end of a spectrum that also includes mergers and acquisitions, changes in management teams, and even major changes in management philosophy or shareholder expectations, all of which can be expected to take place in the U.S. nuclear industry. All of these changes can affect the corporate culture at a particular organization, and the differences among them may be more a matter of degree than of kind.

The extent to which consolidation will be financially beneficial is somewhat open to debate. Pryor (1998, pg. 43) claims that "by combining resources across industry organizations [both plants and vendors], economies of scale on the order of 30 percent can be achieved in modifications, compliance, materials management and fuel management functions." Similarly, Hintz (1999, pg. 3) states that "There are economies of scale when you can have contracts that go across a number of plants or a number of sites, for instance, in the purchasing of supplies and materials." However, pointing to the experiences of Ontario Hydro, Tennessee Valley Authority, and Commonwealth Edison, Gale et al. (1998, pg. 21, emphasis in original) caution that "*It is not...a panacea to move nuclear plants into larger companies.*" (Note, however, that these were all either government-owned or under economic regulation, so their experiences may not be fully relevant to industry consolidation after deregulation.)

Many observers expect to see significant mergers and acquisitions within the electricity industry in general, and the nuclear power industry in particular, in the next few years, largely due to economic deregulation and the advent of competition. For example, Moody's Investors Service (1999, pg. 8) states: "We expect that there will be a consolidation of the nuclear utilities or nuclear generating stations...to achieve economies of scale and combine financial and operating resources and expertise." Similarly, Entergy's Hintz (*Nuclear Energy Insight*, 1999b, pg. 3) predicts that "there will be drastic consolidation, and I don't think you are going to see many utilities operating a single nuclear unit. It could be maybe a dozen operators."

So far, most of the companies acquiring nuclear power plants have been utilities with significant nuclear management experience. Moody's Investors Service (1999, pg. 1) states that "Demand for these plants is expected to come from a 'select' group of specially skilled nuclear operators." Companies that are frequently cited as possible players in this market include AmerGen (a joint venture of British Energy and PECO Energy), Exelon (a merger of Unicom and PECO), Duke Energy, Entergy Corporation, and Southern Company (see for example *Wall Street Transcript*, 1999).

Entergy Corporation recently announced that it intends to invest $1.7 billion "to buy and operate nuclear plants...five to eight more in the next five years" (*New York Times*, 1999). In particular, Entergy initiated a possible merger with Florida Power and Light (*Nuclear Energy Insight*, 2000b), which was subsequently called off. Entergy has also purchased the Pilgrim nuclear

power plant from Boston Edison (*Nuclear Energy Insight*, 1999a; *Nuclear Plant Journal*, 1999), and the Fitzpatrick and Indian Point 3 plants from the New York Power Authority (*Electric Utility Week*, 2000; *Nuclear Energy Insight*, 2000a); a Power Authority spokesperson indicated that sale of the plants was attractive because "larger nuclear operations achieve better efficiencies than smaller operations" (*Electric Utility Week*, 1999i, pg. 13). Pending NRC approval, Consolidated Edison is also planning to sell Indian Point Unit 2 to Entergy (*Electric Utility Week*, 1999l), citing the "trend toward concentrated ownership in the nuclear power business."

AmerGen has announced that it plans to purchase up to twenty nuclear power plants over a five-year period (*Electricity Journal*, 1999a). The NRC has approved AmerGen's purchase of Clinton (*Electric Utility Week*, 1999k) as well as Three Mile Island (TMI) 1 and Oyster Creek (*Nuclear Energy Insight*, 2000a). AmerGen is also one of several companies that has expressed interest in Vermont Yankee (*Electric Utility Week*, 1999g).

Similarly, Dominion (which owns Dominion Virginia Power, as well as other energy resources) has announced interest in acquiring additional nuclear power plants (*Electric Utility Week*, 1999b, pg. 7), and recently purchased Northeast Utilities' Millstone nuclear power plants (*Nuclear Energy Insight*, 2000a). A Northeast Utilities spokesperson stated that with deregulation, "it would be necessary to buy and run several additional nuclear facilities to take advantage of economies of scale... Once we decided we would not be trying to buy our own fleet of nuclear plants, we felt that the best course of action was to auction our Millstone interests as soon as practical" (*Electricity Journal*, 1999b; see also 1999d). Finally, Constellation Nuclear (the owner of Calvert Cliffs Nuclear Power Plant) is requesting regulatory approval to purchase Nine Mile Point units 1 and 2 (Yablonski and Duttinger-Porter, 2001).

The recent merger of PECO and Unicom to create Exelon is another instance of consolidation; executives of both companies were described as believing that "other nuclear acquisitions are possible" (*Electric Utility Week*, 1999f, pg. 9). The merger was expected to yield savings in the range of $100 to $200 million per year, "primarily from eliminating duplicate corporate and administrative positions and programs, and gaining efficiencies in operations, business practices, and purchasing" (pg. 9). These cost savings were described as "modest" by Standard and Poor's, but Moody's analysts were reported as stating that "PECO management could help strengthen ComEd's nuclear operations" (pg. 10).

Note that acquisitions or mergers involving nuclear power plants need not involve companies with extensive nuclear management experience; as a case in point, consider the purchase of MidAmerican Energy Holdings by a team of investors with "no other energy interests" (*Electric Utility Week*, 1999h, pg. 3). Thus, some nuclear plants may find themselves under financial ownership with little or no past nuclear experience. Even those plants that are acquired by experienced nuclear management companies may still find major changes in store. For example, Moody's (1999, pg. 4) notes that "Utilities that have a highly regarded reputation as nuclear operators will benefit from acquiring efficiently operated nuclear facilities—and even mediocre ones whose efficiencies can be improved upon." This suggests that changes in management philosophy will frequently be one of the rationales for buying nuclear plants that have not been strong performers in the past.

Even companies that are not currently acquiring or divesting nuclear assets are establishing other forms of alliances. In particular, NEI (1999, pg. 31) notes that "new business structures are evolving," and predicts "the formation of new corporate entities such as joint nuclear operating companies." Shiffer (1999, pg. 264) also supports the development of operating partnerships, noting that such partnerships "should be able to maintain greater technical expertise, ...remain attractive to ambitious employees, and...be able to squeeze out the greatest efficiencies through synergism." Alliant Energy Corporation, Consumers Energy, Northern States Power Company (now Xcel), Wisconsin Electric Power Company, and Wisconsin Public Service Corporation are participating in the recently formed Nuclear Management Company, which as reported in the *Wisconsin State Journal* "could save millions and position them to join forces if the electric industry deregulates" (Theimer, 1999). Among the functions that member companies believe "can be offered to the fleet of nuclear units more efficiently than they can be offered to individual plants" are "nuclear fuel procurement and analysis, quality assurance, probabilistic risk assessment, [and] plant security" (*Electric Utility Week*, 1999j, pg. 15). Northern States Power president Howard (1999, pg. 28) stated that the Nuclear Management Company will pursue a strategy involving "economies of scale, ...fleet-wise application of current 'best practices'...a specialized management team," and attraction and retention of experienced employees. He also suggests that they may reduce their use of contractors.

Similarly, Ameren/UE, Pacific Gas and Electric, STP, TXU Electric Company, and the Wolf Creek Nuclear Operating Company have formed a Strategic Teaming and Resource Sharing alliance (MacDougall and Numark, 2000). In fact, MacDougall and Numark remark that if one includes such alliances, "about 60% of all U.S. plants are now affected by...some...form of consolidation." Pryor of Westinghouse (1998, pg. 43) also notes the development of "innovative working partnerships (among and between utilities and suppliers, and even among competitors)." Another major vendor representative confirmed that he is seeing unprecedented levels of cooperation between vendors, largely to support joint activities being undertaken by several different owners groups.

In the air and rail industries, the rapid pace of the mergers and acquisitions associated with deregulation sometimes resulted in periods of confusion that compromised safety. Similar concerns have already been raised in the U.S. electricity industry. For example, Anderson (1999), a consultant for the utility industry, discusses a number of problems that can arise from inadequate planning or implementation of mergers and acquisitions. In particular, he cites "poor cultural integration" as a possible pitfall: "Typically, [mergers and acquisitions] either do not accomplish cultural integration, or the acquiring firm simply imposes its values upon the other firm. Both of these outcomes may lead to...lack of communication and poor activity coordination" (pg. 51). He also notes (pg. 52) that "risk management, regulatory compliance, environmental affairs, and internal audit functions" may not be implemented uniformly across the resulting company.

Due to the highly localized, geographically dispersed, and plant-specific nature of nuclear power operations, the problems associated with mergers and acquisitions may not be as severe as those observed in the airline industry, where pilots from different airlines suddenly found themselves working side by side in the same cockpit. Similarly, some of the worst merger problems in the rail industry involved the complications of merging the networks of railroads that had parallel

routes in the same region of the country. By contrast, in the nuclear power industry, the situation within individual power stations seems unlikely to change as rapidly; operators or maintenance technicians are likely to find themselves still working with many of the same co-workers after a merger or acquisition.

However, numerous changes in management personnel and procedures are likely to take place after any major corporate reorganization. Thus, individuals may be unsure which manager has a particular area of responsibility, how to request and obtain help from other corporate departments (such as engineering), how to most effectively communicate critical information to senior managers, what types of justifications are expected in support of requested safety improvements, and how the new management will respond to safety-related (as distinct from production-related) problems or anomalies. Such management changes can also create high workloads and stress levels for managers, who may be learning a new job or role, working with a new team, accustoming themselves to a new corporate or plant culture, or even doing two jobs at once during a transitional period.

Despite the possibility of significant short-term problems, however, many observers expect consolidation to be good for the industry in the long run. For example, Hintz (*Nuclear Energy Insight*, 1999b, pg. 3) anticipates that consolidation will be beneficial, arguing that "there is an advantage to having all the plants operated by operators with good performance records—companies that have a real focus on nuclear." Gupta and Thompson (1999, pg. 43) similarly observe that "Successfully operating a nuclear plant requires a unique set of skills that all utilities do not possess... Only a few utilities...have the experience and skill required to be a top-notch nuclear operator and perform O&M enhancements." They cite Entergy and PECO as examples of excellent nuclear operating companies with the requisite expertise.

From the perspective of economic theory, consolidation of the nuclear power industry into a small number of relatively large companies can be expected to yield safety benefits, at least in the long term. As noted above, there may be economies of scale in the provision of safety-related functions, potentially making it economical for companies to provide higher levels of safety. For example, a large company with a number of nuclear power plants may be able to maintain certain types of safety expertise within its permanent staff that would be uneconomical for a smaller company. In addition, larger companies internalize more of the externality costs associated with safety problems than small companies, for two reasons. First, in the U.S. nuclear industry, accidents or serious safety problems at one plant can create significant costs for all plants in the industry. Therefore, even before the current trend to consolidation, the nuclear industry worked together (e.g., through INPO amd EPRI) to ensure that one or two problem plants did not take actions that would have adverse regulatory and financial impacts on other companies. As individual companies begin to own a larger fraction of the total nuclear generation, they will effectively pay a larger fraction of the cost associated with any accidents or incidents, and hence will have an even greater incentive to avoid such problems. In addition, the larger a company is, the greater the loss necessary to push them into bankruptcy. Thus, large companies have less protection from the financial consequences of safety problems at their facilities. Thus, there are reasons to believe that consolidation of the industry might be beneficial for safety in the long term. However, as observed in both the aviation and rail

industries, this does not diminish the possible safety problems associated with mergers and acquisitions in the transitional period.

Note, by the way, that changes in organizational structure can pose risks even if they involve divestiture and unbundling rather than consolidation. For example, Raughley (1999, pg. 7) cites a number of effects that electricity restructuring could have on offsite power availability. In particular, he observes that "Licensees are selling their generating facilities that supply offsite power to the nuclear plants. In some cases, licensees are selling the black-start power supplies that are used to restore power to the grid following a grid blackout." He notes that such arrangements may extend the time needed for nuclear plants to recover from events such as loss of offsite power or station blackout: "Changes in ownership and control of generation and transmission facilities may increase recovery time because of less coordination between generation and transmission facilities following a grid disturbance." This reinforces the point made by Anderson (1999) regarding the pitfalls of inadequate planning or implementation of major organizational changes.[8]

8.7 Reductions in Support Services

In two of the case study industries, there were indications of reductions in support services that could have potential safety consequences. In particular, in the airline industry case study, there were concerns about cuts in corporate support departments such as engineering and meteorology, which could leave the airlines more dependent on other information sources (e.g., equipment vendors). Concerns about the elimination of most airline weather departments and the reliance on publicly available weather services were also raised independently by one of the airline industry interviewees. Finally, claims were also made that competition and financial pressures had reduced the resources available for inter-airline bench-marking on safety-related issues.

In the U.K. electricity industry, there were dramatic reductions in nuclear research and development (R&D) funding—cuts of well over 50% in six years. This was primarily associated with the fact that no new reactor orders are anticipated at present in the U.K. However, the observed cuts in R&D expenditures could reduce the levels of expertise available to deal with critical safety problems that may arise. For example, the reduced funding could result in R&D staffing levels falling below a critical mass, or lead to attrition of the most talented researchers. The U.K. nuclear power industry also experienced problems with loss of specialized skills among the technical support staff.

8.7.1 Relevance to the U.S. nuclear power industry

Reductions in support services are potentially a concern in the U.S. nuclear power industry, especially because of its extensive reliance in the past on cooperative information-sharing mechanisms such as INPO and EPRI to accomplish key economic and safety goals. In fact, some reduction in industry-wide cooperative ventures has already been observed. Joskow (1998, pg. 49) notes that "Utilities are cutting R&D budgets and several have reduced or eliminated their participation in EPRI as they endeavor to cut costs to be competitive." Dooley (1997) goes

[8] The rapid increase in power flows over the transmission network is also degrading grid reliability, posing a risk for the safe operation of nuclear power stations (see for example Rogers, 1997).

so far as to comment that "One of the first effects of deregulation is to encourage utilities to reduce their overall investment levels in energy R&D, in part because of a general need to cut costs." A study by the U.S. General Accounting Office (GAO, 1996a, pg. 6) notes that "R&D spending by the nation's investor-owned utilities has declined by nearly one-third...from 1993 to 1996," with further declines still expected. Some utility representatives interviewed by the GAO "expressed concerns about the funding of electricity-related R&D (GAO, 1996a, pg. 14). Moreover, that study notes that many utilities are "shifting the focus of their R&D from collaborative projects benefiting all utilities, to proprietary R&D, giving their individual companies a competitive edge" (pg. 10). This has resulted in significant declines in EPRI funding and participation. In particular, the GAO finds that "the utilities' contributions to EPRI...have declined faster than the utilities' R&D spending overall" (pg. 10); contributions fell by almost a third just between 1994 and 1996. In fact, out of 80 utilities surveyed by the GAO, "12 dropped out of EPRI between 1994 and 1996" (pg. 11). Similar reductions in participation in a roughly comparable R&D organization in the U.K., EA Technologies, have also been observed (Dooley, 1997). It is important to note, however, that participation in EPRI's nuclear research program is believed to have fallen less than participation in other areas, since nuclear safety research is perceived as beneficial to the entire industry, rather than conferring a competitive advantage. Other organizations have also been affected; for example, the Edison Electric Institute, an electricity industry lobbying organization, announced a 10% cut in personnel and a 5% cut in funding (*Electric Utility Week*, 1999a, pp. 4-5).

From a theoretical point of view, it is unclear whether participation in such cooperative ventures will be reduced or maintained. On the one hand, companies in financial difficulty may not be able to spare either the funding or the personnel time to participate in collaborative industry programs such as safety bench-marking activities. Similarly, successful companies may choose not to participate in order to maintain their competitive advantage rather than share knowledge with their competitors. Thus, NEI president Colvin (1997, pg. 35) reports, "Some have suggested that in a competitive era, nuclear power plants will become reluctant to continue to share [safety and operating] information."

On the other hand, the fact that the costs of accidents and serious safety problems are borne by the entire industry creates an incentive for companies to ensure that all plants in the industry are run safely. Thus, chairman emeritus Lee of Duke Power Company is reported to have said, "Even with the competition between and among utilities, we in the nuclear industry recognize that it is in our competitive self-interest that each nuclear plant succeed" (Colvin, 1997, pg. 35). Moreover, Colvin (1997, pg. 35) notes that "Nuclear power plants generally do not compete with each other, but rather with other forms of generation—coal, gas, and, sometimes, renewables." Similarly, Joskow (1998, pg. 50) comments that "Competition is creating new market opportunities for innovations in generating technology aimed at improving thermal efficiency [and] improving reliability." Thus, to the extent that there are economies of scale to be achieved through cooperative ventures in areas such as productivity and efficiency improvement, these can be expected to continue. For example, Colvin (1997, pg. 35) notes that NEI recently began offering "benchmarking programs that are helping plants share information about best practices that are boosting safety while reaping economic benefits."

We also expect (and have begun to see) the development of more market-based mechanisms of information sharing, whereby companies that are perceived as leaders in a particular area begin to sell their services to other nuclear generating companies, rather than sharing information on a purely cooperative basis. The recent establishment of Constellation Nuclear Services to sell life extension services (*Electric Utility Week*, 1999c) provides one such example of a company leveraging its experiences and expertise into a marketable commodity. Similarly, organizations such as Constellation Energy Source, Inc., and Duke Engineering and Services, Inc., allow companies to capitalize on strong reputations by selling services—e.g., to "assist in reducing operational costs while enhancing efficiency and productivity" (Constellation Energy Source, http://www.cesource.com/). Thus, industry knowledge and expertise is likely to continue to remain available to those who want it after deregulation and restructuring, though not necessarily via the same mechanisms as previously, and often at a price.

8.8 Experiences of Safety Regulators

In all three case study industries, deregulation had significant implications for safety regulators. In particular, in the aviation industry, the general consensus is that deregulation significantly increased the workload of the Federal Aviation Administration (FAA), without any concomitant increases in budget and/or staff (at least initially). Part of the increase in FAA workload was due to the increase in both travel volume and number of airlines after aviation deregulation. However, other factors (such as increased reliance on contractor maintenance, increased pilot turnover, and an aging fleet of aircraft) also increased the burden on FAA inspectors. At the same time, FAA staffing levels were being cut. In particular, the number of FAA inspectors was cut by roughly 20% in the years immediately following deregulation. As a result, the FAA has acknowledged that it was unprepared for the effects of deregulation, and inadequate FAA oversight has occasionally been cited as a contributing cause to accidents such as the Air Florida crash in Washington, D.C., in 1982. The challenges to effective FAA oversight were especially problematic since, prior to deregulation, many airlines had internal rules and procedures that were more stringent than FAA requirements, but many of these margins of safety were reduced or eliminated after deregulation. The FAA's reliance on written documentation as the primary basis for its inspection activities also interfered with the agency's ability to promptly detect violations of maintenance requirements.

Nance (1986, pg. 342) remarked that: "To meet the challenges thrown at it by deregulation, the FAA would have required a massive infusion of funds, significant alteration of its surveillance and monitoring authority, and a significant alteration of its philosophical approach to airline safety. Congress, however, gave it only the additional work load." Two of our interview respondents specifically recommended that the NRC study the FAA's experiences after deregulation, and strive to keep a highly trained and skilled regulatory workforce in place. In particular, one individual who had formerly worked for the FAA noted that the agency today has a significantly larger oversight infrastructure than at the time of deregulation. That respondent suggested that the NRC may likewise have to strengthen its staffing in areas such as oversight of facility operations, monitoring of regulatory compliance, and maintenance of effective working relationships with nuclear generating companies.

With respect to the FAA's performance, the GAO (1996b) has criticized the FAA for not targeting its resources effectively. In particular, the GAO observed that the FAA had not singled out new airlines for increased inspection effort, despite their apparently higher risk, and did not effectively tailor its level of inspection effort in response to leading indicators of safety performance (such as incident rates) at particular airlines. The GAO also emphasized the importance of high-quality data on leading indicators as a basis for targeting of inspection and monitoring efforts, and cited problems with uneven or inadequate training of FAA inspectors. Since that time, the FAA has instituted the Air Transportation Oversight System (ATOS), which is intended to encourage a more systems-oriented, data-intensive, and collaborative approach to safety, and to foster the adoption of a "systems safety approach" to oversight (FAA, 1998). Our interview respondents differed significantly on the FAA's performance, with one individual describing the FAA as a model regulatory agency, but others commenting that it is still struggling with scarce resources, funding cuts, and scale-backs. For instance, some respondents felt that ATOS had good potential, but had been implemented too quickly and with inadequate resources.

Unlike the FAA, the FRA had actually embarked on a significant increase in both the number of safety regulations and the level of inspection effort around the time of rail deregulation, and these changes are often cited as contributing to the post-deregulation improvement in rail safety. Nevertheless, the FRA was frequently criticized for being inflexible and unresponsive to changes in technology, and for relying too heavily on punitive sanctions as the primary means to obtain compliance. As a result, in 1993 the FRA instituted the Safety Assurance and Compliance Program (SACP), which emphasizes building more cooperative relationships between regulators, railroads, and labor to solve safety problems. In addition, as noted above, the FRA has also recently increased its emphasis on human factors, and has proposed requiring prior regulatory approval of mergers and acquisitions to help ensure adequate planning and avoid potential safety problems.

In the U.K., the NII is less prescriptive than the U.S. NRC, and generally has a more cooperative relationship with its licensees. It also operates with lower staffing levels. However, the current cooperative relationship between licensees and regulators in the U.K. may change if competition induces licensees to cut corners and reduce safety margins, especially in gray areas.

It is noteworthy that the NII was actively involved in planning for and monitoring the privatization process in the U.K., and actually increased its staffing somewhat in anticipation of increased regulatory workloads associated with privatization. In addition, as was proposed in the rail industry, the NII has begun requiring prior approval of major changes with the potential to adversely affect safety, such as significant downsizing or increased use of contractors.

8.8.1 Relevance to the U.S. Nuclear Regulatory Commission

A number of interviewees in the case study industries were specifically asked whether they had any recommendations for the NRC. The primary recommendations provided by our interview respondents were:

To be cognizant of the potential safety problems associated with factors that can affect corporate culture, such as mergers and acquisitions; and

To maintain an adequate regulatory workforce to cope with the challenges of deregulation.

Several respondents also stressed the benefits of establishing cooperative working relationships with both labor and nuclear generating companies as a basis for resolving safety problems, and the importance of ensuring that nuclear generators appropriately balance the competing goals of maintaining safety versus improving productivity and cutting costs.

As mentioned previously, staffing and budget cuts of roughly 20% have already taken place at the NRC over the past seven years. In particular, the agency's authorized staffing (U.S. NRC, 2000) has fallen from more than 3300 full-time equivalent staff members in 1993 to roughly 2800 in 2000, at the same time as the agency's funding fell from $540 million to about $400 million (in constant 1993 dollars). Comparison with historical data helps to put these numbers in context. In particular, the staffing level for the year 2000 is lower than at any time since 1978, before the accident at TMI. Similarly, in constant-dollar terms (based on the Consumer Price Index), recent budgets are also at historically low levels, and are 40% below the post-TMI peak in the early 1980s. These cuts are roughly of the same order of magnitude as those experienced by the FAA in the years immediately following airline deregulation, which were indicated as a cause of concern in the airline industry.

Some reductions in staffing and budgets at the NRC may be appropriate, given the "safety record of the commercial nuclear industry [and] the maturity of the technology" (NEI, 1998). However, as in aviation, deregulation can be expected to cause workload increases for the NRC; e.g., due to the need for approval of license transfers and review of decommissioning fund adequacy associated with mergers and acquisitions, and the large number of anticipated requests for life extension. The workload increases may not be as dramatic as those experienced in the aviation industry, since the U.S. nuclear power industry is not expected to experience significant growth in the years following deregulation. Hence, it is unlikely that the NRC will need to regulate an increased number of licensees or reactor operators. However, some of the factors observed in the aviation industry (e.g., reduced safety margins at some companies) may also contribute to increased workloads for NRC safety regulators.

As at the FAA, effective targeting of scarce agency resources may be required after deregulation. The NRC already recognizes "the agency's need to effectively regulate the industry with a smaller staff and budget," and has implemented a substantial revision to its reactor regulation process (U.S. NRC, 1999c), partially in response to previous reviews. In particular, a report by Arthur Andersen (1996) had noted that "the NRC identified numerous plants [for inclusion on the Watch List] well after plant performance had begun to decline," also commenting that "the level of oversight and scrutiny appears to differ from plant to plant." The report observed that, "rather than strategically anticipate—and therefore mitigate or avoid—events, the NRC comes to terms with them in their aftermath...the NRC must change its strategy from one that reacts to one that anticipates; from retrospection...to proactivity." The GAO (1998b, pg. 5) has similarly criticized the NRC for failing to "aggressively act on identified problems." With the speed of

change likely to be associated with deregulation, the need to identify and manage the change process in a proactive rather than retroactive manner will become even more important. Hopefully, the NRC's revised inspection and oversight process (U.S. NRC, 1999c), which was developed with timeliness of the agency's response in mind, will help to address this need. An additional goal of the revised oversight process is "To improve effectiveness and efficiency...by focusing agency resources and utility resources on those issues with the most risk-significance (U.S. NRC, 1999c).

Some observers within both the NRC and the nuclear power industry view more widespread implementation of risk-informed, performance-based regulation (see for example U.S. NRC, 1999b) as a way of cutting regulatory inspection, enforcement, and compliance costs, by targeting resources at the most risk-significant concerns. For example, Duke Power president Coley (1999, pg. 32) has stated that "the single most important challenge facing the nuclear energy industry is to develop a regulatory process that does not consume licensee and NRC resources on issues that have little or no safety significance." While the approach being adopted by the NRC is substantially different from the regulatory approaches adopted by other safety regulatory agencies, both the FAA and the FRA have also recently adopted more collaborative, systems-oriented approaches to safety, as noted above. In particular, ATOS is intended to foster adoption of a "system safety approach," and is expected to "lead to a more collaborative partnership with the air carriers to identify and correct safety related issues" (FAA, 1998). Similarly, the SACP is designed for "detecting and focusing on the root causes of systemic safety problems," rather than rigidly enforcing a multitude of highly prescriptive regulations with little regard to their levels of safety significance (FRA, 1996). One of the FRA's goals was specifically to establish a "less adversarial" regulatory process (FRA, 1996), and the SACP has in fact helped to establish more constructive problem-solving relationships between regulated companies, regulators, and labor unions, according to our rail industry interview respondents.

The industry has indicated support for NRC's development of a revised and better-focused safety regulatory regime. For example, the NEI (1999, pg. 18) has stated that "Risk insights from probabilistic safety assessments can greatly improve the safety focus of regulatory requirements," and observed that risk-informed regulation has the potential to contribute to this goal. However, as noted above (in the section on "equipment failure, maintenance, and aging"), it is still too early to determine whether risk-informed and performance-based approaches to regulation will prove adequate to the task of protecting safety while simultaneously providing substantial reduction of the regulatory burden. In particular, corporate culture issues such as the management of organizational change (which emerged as a key safety concern associated with deregulation in the case study industries) are not well modeled in risk analyses. Another concern is that performance-based inspection and enforcement can be retroactive instead of proactive, unless the performance indicators on which it is based include some that are known to be reliable leading indicators of risk.

One difference between the NRC and safety regulators in the case study industries is that both the FRA and the NII have recently proposed or implemented requirements for prior approval of major organizational changes—mergers and acquisitions in the U.S. rail industry, staffing changes in the U.K. nuclear power industry. This is quite different from the regulatory philosophy that has generally been adopted by the NRC—namely, "inferring licensee

performance from existing plant inspections and other routine assessments" (GAO, 1998b, pg. 6). However, the Arthur Andersen (1996) report recommended that the NRC review process explicitly consider such "management measures" as safety culture, "oversight/discipline," "communications," and "stability." Similarly, the GAO (1998b, pg. 6) has observed that "despite the importance of competent management, NRC does not have an effective process for ensuring that licensees maintain it for their nuclear plants." They suggested that "NRC assess management competency and performance as part of its inspection process... evaluating licensees' management competency as part of plant inspection would provide an important early warning of potentially unsafe practices" (GAO, 1998b, pp. 6-7). Finally, the ACRS recently recommended that the NRC "examine domestic and international studies to determine whether it is possible to develop useful [performance indicators] for safety culture" (Powers, 1999; see also ACRS, 1999).

The revised regulatory process currently implemented at the NRC does recognize "management attention to safety" (especially as reflected in a "'Safety-conscious' work environment") as an important "cross-cutting element" that affects reactor safety (U.S. NRC, 1999c). In particular, the NRC notes that "Possible indications of an 'unhealthy' safety culture include a high number of allegations, a weak employee concerns program, and a high corrective maintenance backlog" (Baranowsky et al., 1999, pg. 15). The reactor oversight process currently does not include a "separate and distinct assessment of licensee safety culture...because it is subsumed by either the [performance indicators] or baseline inspection activities," such as "inspection of licensee problem identification and corrective action programs" (Baranowsky et al., 1999, pg. 16). However, this view is not universally held; for example, the ACRS has commented that "more justification is required for this argument" [that safety culture problems would necessarily be detected either by performance indicators or by baseline inspections] (Powers, 1999).

8.9 Summary—Impacts of Deregulation on Nuclear Power Safety

In all three case studies, many aspects of safety appear to have been maintained, or even continued their pre-deregulation improving trends. In particular, both the air and rail industries in the U.S. had better safety records after deregulation than before (despite problems in particular industry segments, such as new entrant airlines or companies that had recently undergone mergers and acquisitions). The safety of the U.K. nuclear power industry also shows improvement in several areas, although strong concerns over the management of change have surfaced. Thus, deregulation need not be detrimental to safety, especially in those areas that are positively related to productivity.

However, it would be a mistake to conclude that deregulation does not create challenges to safety. By its very nature, deregulation stimulates reorganization and restructuring, and the resulting management changes pose a threat to maintaining former levels of safety, at least in the short run. In addition, in all three case study industries, deregulation occurred in parallel with other changes that were beneficial for safety, which may have mitigated or counteracted any safety problems due to deregulation and restructuring. Hence, it is not possible to conclude that deregulation was necessarily the cause of observed safety improvements.

8.9.1 Conditions favorable to safety in the case study industries

In the aviation industry, the primary condition favorable to safety was the decades-long trend toward safety and technology improvements leading up to deregulation, and continuing after deregulation. Among the changes observed in the decade or so immediately after deregulation were: improved training (due to both high-fidelity flight simulators and crew resource management techniques); increased automation in the cockpit; improved equipment reliability (especially engine reliability); and a better understanding of effective preventive maintenance practices. While deregulation may have accelerated the trend towards technology improvement (due to increased incentives for efficiency), some of the observed changes might have occurred even without deregulation. In any case, the increased safety due to these technological improvements may well have masked some adverse safety consequences of deregulation, such as disruptions due to mergers and acquisitions. The U.S. nuclear power industry has also experienced significant improvements in many measures of safety and productivity over the last decade or two. Ongoing developments (such as the advent of risk-informed regulation) could lead to further improvements in the future. However, with steadily declining budgets (both at the NRC, and at industry R&D organizations such as EPRI), it remains to be seen whether the U.S. nuclear power industry will continue to experience technological and safety improvements similar to those observed in the aviation industry after deregulation.

In the rail industry, one of the primary factors conducive to safety was simply the improved financial performance of the industry after deregulation. While this improved financial condition was clearly the result of deregulation, it was largely due to the distinctive character of the regime by which railroads were regulated prior to deregulation, under which they were precluded from abandoning unprofitable routes, and price regulation made many routes unprofitable. Deregulation of the U.S. electricity industry has the potential to improve the financial profitability of some nuclear power plants. However, it remains to be seen how many plants will be able to produce electricity economically enough to take advantage of this opportunity, and how many will instead find deregulation financially stressful, with possibly adverse consequences for safety.

Moreover, rail deregulation took place at a time when the FRA was becoming more active with regard to safety regulation. While the advent of risk-informed regulation could improve the effectiveness of safety regulation by the NRC, other developments (such as staff and budget cuts at the NRC) may work in the opposite direction, so it remains to be seen whether the effectiveness of safety regulation in the nuclear industry will in fact increase.

Finally, in the U.K. nuclear power industry, extensive subsidies (in the form of a non-fossil fuel obligation and a Fossil Fuel Levy) protected the financial health of the industry after privatization. In the absence of these financial protections, downsizing and other potential threats to safety might have been substantially more severe than the changes that were observed with those protections in place. In addition, as noted above, the U.K. NII was actively involved in planning for and monitoring the safety-significant impacts of privatization, and this proactive role could have reduced or mitigated some possible safety problems.

8.9.2 Outlook for the future

Overall, the experience of the case study industries suggests that economic deregulation need not be incompatible with a reasonable safety record, but also that safety cannot be taken for granted after deregulation. Neuschel (1988, pg. 109, emphasis in original) warns that "achieving safety under deregulation is a particularly demanding task that requires intensive management skill and dedication...*safety can be managed even under deregulation.* But it takes total commitment, special know-how, a highly disciplined work force and exemplary skill by management."

The magnitude and speed of the changes associated with deregulation can be expected to create major challenges to the management of safety in the U.S. nuclear power industry, as they did in all three case study industries. Careful review and study of those challenges may make it possible to avoid similar safety problems in the U.S. nuclear power industry.

9. Summary and Conclusions

The ongoing economic deregulation of the U.S. electricity industry is causing major restructuring of the nuclear power sector of the industry. In fact, evidence of competitive pressures and significant management changes has already been observed in the U.S. The objective of this project was to provide a comprehensive list of those consequences of U.S. electricity deregulation with the potential to affect the risk of nuclear power plants. In particular, the study addressed not only the effects of deregulation on safety-related equipment failures and human errors, but also the effects on other variables that could affect safety, such as financial pressures and corporate culture.

A historical case study approach was adopted, focusing on the effects of economic deregulation and/or restructuring in other industries. The case studies focused on experiences with deregulation in the U.S. aviation and rail industries, and the United Kingdom (U.K.) electricity supply industry. These industries were chosen based on their relevance to the U.S. nuclear power industry. Factors considered in judging relevance were the importance of safety in each industry, its organizational and technological characteristics, its degree of safety regulation, and the nature of the economic deregulation or restructuring. It is also important to note that *safety was not deregulated in any of the three case study industries, nor is the safety of the U.S. nuclear power industry being deregulated.* Rather, in each case, safety regulation remained in place, while economic regulation was largely replaced by a transition to a competitive market.

The project team collected and evaluated evidence regarding the effects of deregulation in each of the case study industries, using both literature reviews and selected interviews with industry representatives. We then assessed the potential applicability of those effects to the U.S. commercial nuclear power industry. This summary briefly recapitulates what we consider to be our most important findings and conclusions.

9.1 Major Findings of the Case Studies

First, it is worth noting that adjusting to deregulation is a lengthy process. In fact, all three case study industries are still undergoing significant changes in response to deregulation, even though the U.S. air and rail industries were formally deregulated more than 20 years ago. Thus, it seems likely that the U.S. electric power industry, and its nuclear power sector, will also undergo a lengthy period of adaptation. As a result, the ultimate nature of the industry after deregulation will remain uncertain for quite some time. Despite these uncertainties, however, some general conclusions can be drawn from the case studies.

9.1.1 Overall safety performance

Both the air and rail industries in the U.S. had generally better safety records after deregulation than before (continuing these industries' long-term trends of improvement in safety performance). Similarly, the advent of competition in the U.K. has prompted nuclear plant managers to focus more intently on regulatory compliance and hardware reliability issues, to avoid costly shutdowns and reduce regulatory uncertainty. Thus, if managed appropriately (by

both the industry and safety regulators), deregulation is clearly not incompatible with maintaining or even improving safety, especially in areas where safety is positively related to revenue generation.

However, our research revealed that deregulation posed substantial challenges to the management of safety in each of the industries that we surveyed. Specifically, the magnitude and speed of the changes associated with deregulation proved difficult for both companies and safety regulators to manage effectively and safely. In particular, with major organizational changes, managers are asked to accomplish more with fewer resources in an uncertain and often confusing work environment, with changing lines of communication and corporate priorities. The result has sometimes been a loss of control over safety management. Such problems were particularly severe in certain industry sectors, such as companies that underwent major mergers (especially in the rail industry) and new entrant airlines.

As a result, a number of concerns were identified in the case study industries, as discussed in detail in the body of this report. The remainder of this section focuses on those areas that could have significant safety impacts, occurred in more than one case study industry, and might plausibly occur in the U.S. nuclear power industry as well.

9.1.2 Re-prioritization of corporate expenditures

Companies in all three case study industries undertook major re-prioritizations of their corporate investments and expenditures on capital, maintenance, and labor. For example, one study of aviation maintenance found that airlines increased the amount of time between engine overhauls after deregulation, but did not experience a higher rate of engine failures as a result. This is presumably because the airlines successfully focused their maintenance efforts on the most significant problems.

In the rail industry, even more dramatic re-prioritization of expenditures took place. In particular, annual capital expenditures on track maintenance increased by nearly a factor of five. These increases were made possible, in part, because the requirement to maintain unprofitable routes was eliminated. During the same period, employment in the rail industry was cut by roughly a factor of two. Despite the dramatic labor downsizing, the period after deregulation was also associated with improvements in many aspects of rail safety. In particular, consistent with the increased track maintenance, especially large reductions were noted in those types of accidents related to track condition, such as derailments and collisions.

The nuclear power sector of the U.K. electricity supply industry also experienced dramatic reorganization and downsizing after deregulation, coupled with increased use of contractors. Problems identified in the aftermath of these changes triggered safety regulators to impose a new license condition on reactors in the U.K.

In preparing for deregulation, U.S. nuclear power plant owners are already undertaking similar re-prioritization of their expenditures on capital, maintenance, and labor. For example, significant downsizing has begun, and this process can be expected to continue. Such changes

are not necessarily always adverse to safety (as demonstrated by the example of engine maintenance in the aviation industry, for instance). However, re-prioritization of expenditures can cause safety problems if organizations make excessive cuts in safety functions once the costs of such activities can no longer be passed through to ratepayers. The fact that feedback about the adverse effects of cutbacks may be ambiguous or delayed exacerbates this possibility.

9.1.3 Influences on corporate safety culture

Another concern is the potential of deregulation to create challenges to the maintenance of an effective corporate safety culture. In the aviation and rail industries, corporate culture problems affected safety in the aftermath of mergers and acquisitions, and also at some of the new entrant airlines established after deregulation. In the years after deregulation, there were also indications of pressure to under-report some types of safety problems in the railroad industry, and evidence of maintenance violations at several major airlines. In the U.K. nuclear power industry, corporate culture concerns dealt with the excessive use of contractors and the loss of corporate expertise and institutional memory.

As a result of such challenges, safety regulators in both the U.S. rail and the U.K. nuclear power industries have proposed requiring prior review of major organizational changes that can adversely affect safety. For example, safety impacts of significant management changes, downsizing, or staffing changes at U.K. nuclear licensees must now be analyzed before implementation. Similar efforts in the rail industry have focused on prior review of major mergers. Such new regulatory requirements formally place the human and organizational contributions to safety on a par with the hardware contribution, and thus constitute a significant change in regulatory philosophy.

At present, the trend toward consolidation of the U.S. nuclear power industry through mergers and acquisitions seems unequivocal. While not all mergers and acquisitions in other deregulated industries have resulted in safety problems, such problems clearly have been documented (most notably after the Union Pacific/Southern Pacific merger in the rail industry). Safety problems following mergers and acquisitions seem to be exacerbated by factors such as poor labor relations, under-staffing, and insufficient planning. Ensuring that the potential safety consequences of major organizational changes receive adequate consideration is therefore critical for the safety of the nuclear power industry under deregulation.

9.1.4 Association between financial pressures and safety problems

Yet another key concern that arose in two of the case study industries is the apparent association between financial difficulties and safety problems. This association is also potentially applicable to the U.S. nuclear power industry. The mechanisms underlying the link between profitability and safety are not yet well understood. However, empirical studies have indicated that poor profitability was associated with poor safety records in both the rail and aviation industries. The link between poor profitability and safety problems appears to be strongest for small companies and those companies that are actually unprofitable (as opposed to those that are only marginally profitable).

In the U.K. nuclear power industry, no empirical evidence of a link between poor profitability and poor safety was observed, since the privatized nuclear plants were highly profitable following deregulation. A contributing factor to this financial success was the fact that the structure of the U.K. privatization process provided significant subsidies for nuclear power. These subsidies helped to ensure the profitability of the country's privatized nuclear operating company in the years immediately following privatization, and may have prevented adverse effects due to financial difficulties.

Even if the most competitive U.S. nuclear power plants are financially healthy after deregulation, some plants (especially those at which incremental electricity generation costs are at or above wholesale electricity prices) may experience financial difficulties, with possible adverse safety consequences.[1] Companies in financial distress may have reduced incentives to invest in some types of safety measures, and/or increased incentives to cut corners. Therefore, financial difficulty may be an indicator of declining safety margins in the nuclear power industry.

9.1.5 Potential safety impacts of downsizing

Significant concerns were raised regarding the safety impacts of downsizing, fatigue, and increased workloads, especially in the rail and U.K. nuclear power industries. In particular, federal investigations of major railroad accidents in recent years have identified inadequate staffing levels and fatigue as contributing factors. In addition, labor representatives specifically cited reductions in minimum crew sizes on trains as exacerbating problems of fatigue in the industry. In the U.K., as noted above, safety regulators have raised concerns that excessive downsizing has led to loss of institutional memory and excessive reliance on contractors. In addition, planned layoffs were sometimes implemented even if anticipated workload reductions had not yet materialized. Safety regulators in both the rail industry and the U.K. nuclear power industry have also raised concerns about pressures to increase the use of overtime, and possible under-reporting of overtime. All of these issues are likely related to the increased cost-cutting pressures associated with competition in deregulated industries.

9.1.6 Experiences of safety regulators

The Federal Aviation Administration experienced staff and budget cuts around the time of aviation deregulation, and later found that its staffing levels were insufficient to meet the additional demands that arose from economic deregulation. By contrast, the U.K. Nuclear Installations Inspectorate anticipated that there would be some workload increases associated with electricity industry restructuring there, and staffed up accordingly. If deregulation increases the workload of safety regulators in the U.S. nuclear power industry as well, staffing levels and other resources at the U.S. Nuclear Regulatory Commission (NRC) may need to be adjusted.

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[1] The financial health of nuclear generating companies will also be influenced by the regulatory treatment of factors such as decommissioning funding assurance, financial qualifications, and stranded asset recovery. A detailed discussion of these issues and their effects on financial health was considered outside the scope of this study, but the subject is worthy of further investigation.

In addition, due to the organizational changes associated with deregulation, safety regulators in both the rail industry and the U.K. electricity industry found it advisable to begin requiring prior regulatory approval of significant corporate changes with the potential to adversely affect safety, such as downsizing or major mergers and acquisitions. The approach taken has generally not been prescriptive (i.e., requiring a particular approach to safety management), but rather requiring that regulated parties demonstrate that they have an adequate plan in place for maintaining safety.

9.2 Conditions Favorable to Safety

In all three case study industries, circumstances favorable to safety may have mitigated or counteracted safety problems due to deregulation and restructuring. It remains to be seen the extent to which similar conditions favorable to safety will occur in the U.S. nuclear power industry. Therefore, even though statistics show that safety improved following deregulation in both the aviation and rail industries, it would be a mistake to conclude that similar improvements will necessarily be observed in the U.S. nuclear industry.

9.2.1 Aviation safety

In the aviation industry, the primary condition favorable to safety was the decades-long trend toward safety and technology improvements leading up to, and continuing after, deregulation. In particular, numerous beneficial changes were observed in the aviation industry in the decade or so immediately after deregulation. For example, the quality of training is generally believed to have improved, due to both high-fidelity flight simulators and crew resource management techniques. Similarly, equipment reliability improved, especially for aircraft engines, due to design improvements and also a better understanding of effective preventive maintenance practices. Finally, increased automation in the cockpit has reduced the vulnerability to pilot error.

Deregulation may have accelerated the trend towards technology improvement in the aviation industry, due to increased incentives for airlines to become more efficient. However, some of the observed changes might have occurred even without deregulation. In any case, the increased safety due to these technological improvements may well have masked some adverse safety consequences of deregulation, such as disruptions due to mergers and acquisitions. The U.S. nuclear power industry has also undergone significant improvements in many measures of safety and productivity over the last decade or two. Ongoing developments, such as the application of risk-informed regulation, could lead to further safety improvements in the future. However, it remains to be seen whether the U.S. nuclear power industry will continue to experience technological and safety improvements similar to those observed in the aviation industry after deregulation.

9.2.2 Rail safety

In the rail industry, one of the primary factors conducive to safety was simply the improved financial performance of the industry after deregulation. This improved financial condition was

clearly the result of deregulation. However, it was largely due to the distinctive character of the regime by which railroads were regulated prior to deregulation, especially the imposition of significant restrictions on the ability of the railroads to abandon unprofitable routes. The most competitive U.S. nuclear power plants are likely to be financially healthy after deregulation. However, it remains to be seen how many plants will be able to produce electricity economically enough to be competitive, and how many will instead find deregulation financially stressful.

Moreover, rail deregulation took place at a time when the Federal Railroad Administration was becoming more active with regard to safety regulation. The advent of risk-informed, performance-based regulation, and other changes in the regulatory process, could improve the effectiveness of safety regulation by the NRC. However, other developments (e.g., workload increases, staff and budget cuts) may work in the opposite direction. Therefore, it remains to be seen whether the effectiveness of safety regulation in the U.S. nuclear power industry will in fact increase.

9.2.3 Nuclear power safety in the United Kingdom

In the U.K., privatization of nuclear power plants was accompanied by extensive subsidies in the form of an obligation to purchase nuclear power, as well as a tax on electricity from fossil fuel sources (the proceeds of which went to the privatized nuclear operating company). These subsidies provided substantial protection for the financial health of the nuclear power industry after privatization. Thus, downsizing and other potential threats to safety could have been substantially more severe in the absence of these financial protections. The proactive role of the U.K. Nuclear Installations Inspectorate in planning for and monitoring the safety impacts of privatization may also have reduced or mitigated some safety problems.

9.3 Overall Conclusions

Based on the case studies, this report has identified a number of issues that have potential safety significance for the U.S. nuclear power industry under deregulation. The experience of the case study industries indicates that economic deregulation need not be incompatible with a reasonable safety record, especially in those aspects of safety that are positively related to productivity. However, safety clearly cannot be taken for granted after deregulation, since safety problems were observed in aspects of each of the three case study industries; these problems are summarized briefly in Table 9-1.

The situation is well summarized by Neuschel (1988, pg. 109, emphasis in original), who warned that "achieving safety under deregulation is a particularly demanding task that requires intensive management skill and dedication...*safety can be managed even under deregulation.* But it takes total commitment, special know-how, a highly disciplined work force and exemplary skill by management."

The magnitude and speed of the changes associated with deregulation can be expected to create major challenges to the management of safety by the U.S. nuclear power industry and its safety regulators, as in all three case study industries. Careful review and study of the problems

observed in the case studies may make it possible to identify proactive ways of minimizing similar safety problems in the U.S. nuclear power industry, where their consequences are potentially severe.

Table 9-1
Conditions with the Potential for
Negative Effects on Safety

Long learning curve
Major re-prioritization of expenditures (e.g., maintenance)
Challenges to safety culture: – Mergers and acquisitions – New entrants – Other management changes – Pressures to under-report – Use of contractors – Loss of institutional memory
Financial pressures
Downsizing: – Inadequate staffing – Excessive overtime – Increased use of contractors – Loss of institutional memory
Increased workloads for safety regulators
Other possible effects: – Aging of equipment – Maintenance violations – Effects on human capital (e.g., skill/experience) – Reduced support services (e.g., engineering) – Reduced bench-marking – Poor labor relations

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APPENDIX A

Interview Discussion Guide - Airlines

I-1 *Thank you for agreeing to this interview. Since I will not be making a tape recording, during the interview you will have to be patient while I make my written notes. I am never able to write quite as fast as people can talk.*

I-2 *I have a few housekeeping details to go over before we get to the heart of this interview. First, I want to assure you that all your answers will be kept confidential. By that I mean that we will never report anything that you say in a way that will allow your name to be associated with what you say during the interview. In addition, you do not have to answer any question that you do not want to answer.*

QO1 *Please describe your professional background in the airline industry.*

[Probes:
Can you tell me how your positions interfaced with safety issues?
Were you involved in these positions/issues prior to deregulation?]

QO2 *What are the biggest safety issues in the airline industry?*

[Continue to probe "*Any other issues?*" until respondent identifies no further issues]

QO3 *How would you assess the performance of the airline industry in these areas right now?* [Obtain an assessment for each issue in QO2]

QO4 *How has the performance of the airline industry in these areas changed since the advent of deregulation in 1978?* [Obtain an assessment for each issue in QO2]

QO5 *Your industry experienced substantial deregulation during the late 1970s and 1980s. In your opinion, did deregulation have any impact on safety performance in your industry?*

No → *Why do you think deregulation had no effect?*

Yes → *Can you tell me about these impacts?*

QO6 *How do you think the FAA is doing in terms of safety regulation? We are interested in things you think the FAA does that are very effective in promoting safety as well as things the FAA does that are not effective in promoting safety.*

[In the next section we will ask for your perspective on specific safety issues]

QS1 *The safety performance of the aviation industry improved substantially shortly after the passage of the Airline Deregulation Act of 1978. Are you familiar with safety issues during this period?*

No

Yes→ *What do you think explains the safety improvement observed shortly after the aviation industry was deregulated?*

QS2 *Subsequently, in the mid-1980s, the safety performance of the aviation industry deteriorated somewhat (although not to the point it had been prior to deregulation). Are you familiar with safety issues during this period?*

No

Yes→ *Some people attribute this deterioration to reductions in expenditures on maintenance and reduced pilot and ground crew qualifications after airlines were deregulated. Others attribute the deterioration to the effects of increased travel volume. What do you think explains the deterioration in safety performance observed in the mid-1980s?*

QS3 *Do you think the environment for reporting safety violations has changed since deregulation?*

No

Yes→ *Tell me more about these changes. Do you think they have affected safety performance?*

[Possible probes:
Is there more pressure to maintain production/service, even if it means noncompliance with safety regulations?
Do you think violations, injuries or accidents are more likely to be under or over reported?]

QS4 *As you know, the structure of the industry changed significantly after deregulation, including the emergence of many small new airlines, and mergers and consolidation among the larger airlines. I would like to ask a few questions about these issues. First, from your point of view, are safety issues or performance different in the small and medium airlines compared to the large airlines?*

[Possible probes:
Do you have any first-hand experience with safety issues at small airlines (for those currently associated with large airlines)?
Are safety issues different at smaller airlines?
Are smaller airlines more likely to have safety problems?
Are safety problems in small airlines masked within the statistics that reflect the overall performance of the larger airlines?
Are the small airlines less extensively unionized than the large airlines, and if so does this have implications for safety performance?]

QS5 *There have been many mergers and acquisitions among the airlines since deregulation. In your opinion, have mergers and acquisitions affected safety performance in the aviation industry?*

No → *Why not?*

Yes → *What has been the impact?*

[Possible probes:
Impacts on staffing levels?
Cost-cutting in safety programs?
Employee morale?
Pressures to not report accidents or safety problems?
Affected training?
Integrating safety programs at two different companies?
Anything else?]

QS6 *Have you personally worked for an airline company that has been involved in a merger or acquisition?*

No

Yes→ *Did the merger or acquisition have any impacts on safety performance?*

[Possible probes:
Impacts on staffing levels?
Cost-cutting in safety programs?

Employee morale?
Pressures to not report accidents or safety problems?
Integrating safety programs at two different companies?
Affected training?
Anything else?]

QS7 *There was a large increase in employment in the aviation industry as travel volumes increased. In your opinion, do you think the increase in employment levels has had any effect on safety levels?*

No

Yes→ *Can you tell me more about this?*
[Possible probes:
Are current staffing levels adequate with regard to safety issues?
Were certain kinds of positions affecting safety performance increased more than other positions?
Were employment increases accomplished by hiring of people with marginal or inadequate experience and qualifications?]

QS8 *Has there been an increase in the use of contractor services? Do you think this has impacted safety?*

QS9 *Have workloads in the aviation industry changed significantly since deregulation*?

No

Yes→ *How have they changed (increased or decreased, to what extent), and to what do you attribute this change? Do you think it has affected safety performance?*

[Possible probes:
Have workload increases been concentrated in any specific areas that might affect safety?
Have workload increases resulted in problems with fatigue?
Affected morale?
What are the relative roles of management pressure versus increased business volume in increased workloads?]

QS10 *Has there been a change in management or labor turnover rates in the aviation industry since deregulation?*

No

Yes→ *What impact do you think changes in turnover have had on worker skill levels? Do you think this has affected safety performance?*

QS11 *Have you noticed a change in the level or quality of training since deregulation?*

No

Yes→ *Tell me more about these changes. Do you think they have helped or hindered safety performance of the aviation industry?*

QS12 *In your opinion, has deregulation affected labor-management relations in the aviation industry?*

No

Yes→ *Tell me more about the impact. Do you think this has had any affect on safety performance?*

[Possible probes:
Have there been work-rule changes that have affected safety performance?
Has there been a decline in the number of job classifications (increase in craft flexibility), and has this impacted safety?
Has worker morale or job satisfaction been affected to such a degree that it has impacted safety? How?]

QS13 *Has management's approach to safety issues changed over the last 10 to 20 years?*

No

Yes→ *Tell more about these changes. Do you think they have helped or hindered safety performance of the aviation industry?*

QS14 *What about aviation unions? Has their approach to safety issues changed over the last 10 – 20 years?*

No

Yes→ *Tell more about these changes. Do you think they have helped or hindered safety performance of the aviation industry?*

QS15 *Reduced maintenance of airplanes was identified as a safety concern in the aviation industry in the 1980s. Do you think there have been changes in maintenance practices over the last 10 – 20 years?*

No

Yes→ *Tell more about these changes. Do you think they have helped or hindered safety performance of the aviation industry?*

[Possible probes:
What were the causes of these changes in maintenance practices?
How was maintenance effort reprioritized after deregulation?
Have there been changes in frequency, expenditures, philosophy (e.g., preventive vs. corrective), training of maintenance staff?]

[In this last section we will wrap up with a few general questions]

QW1 *Thinking forward, what do you think the biggest safety issues will be in the aviation industry 5 years from now?*

QW2 *As you may know, the electric generating industry is in the process of being deregulated. If you were an advisor to the Nuclear Regulatory Commission, what safety issues would you suggest the NRC should consider during the deregulation process?*

That is all the questions I have for you at this time.

Is there anything else you would like to add that may help with our understanding of how deregulation has affected safety?

Thinking back over the questions I asked and the answers you gave, is there anything you would object to having included in a summary of our discussion today?

If when I am reviewing our discussion I find that there are a few more issues I would you to consider, would it be OK for me to call you back?

No

Yes

APPENDIX B

Interview Discussion Guide - Railroads

I-1 *Thanks you for agreeing to this interview. I would like to start the tape recorder at this time. Do you have any objections to me making a tape recording?*

No

Yes→ *That's OK. But during the interview you will have to be patient while I make my written notes. I am never able to write quite as fast as people can talk.* [Goto I-4]

I-2 *I have started the tape recording just now. For the record, I need to verify once again that you are aware of the recording and do not object to it.*

[If respondent does not agree, recode I-1 as Yes and read follow-up to yes response.]

I-3 *We will keep this recording only until the final report on this project has been accepted. Once the final report is done we will physically destroy the tape. If you would like, we can make a copy of this tape and provide it to you. Do you want us to do that?*

No

Yes

I-4 *I have a few housekeeping details to go over before we get to the heart of this interview. First, I want to assure you that all your answers will be kept confidenitial. By that I mean that we will never report anything that you say in a way that will allow your name to be associated with anything you say during the interview. In addition, you do not have to answer any question that you do not want to answer.*

QO1 *Please describe your professional background in the rail industry.*

[Probes:
Can you tell me how your positions interfaced with safety issues?
Were you involved in these positions/issues prior to deregulation?]

Q02 *What are the biggest safety issues in the rail industry?*

[Continue to probe "*Any other issues?*" until respondent identifies no further issues]

Q03 *How would you assess the performance of the rail industry/your company in these areas right now?* [Obtain an assessment for each issue in QO2]

QO4 *How has the performance of the rail industry/your company in these areas changed since 1980?* [Obtain an assessment for each issue in QO2]

QO5 *Your industry experienced substantial economic deregulation beginning in 1980 with the passage of the Staggers Act. In your opinion, did economic deregulation have any impact on safety performance in your industry?*

No → *Why do you think deregulation had no effect?*

No → *Can you tell me about these impacts?*

QO6 *How do you think the Federal Railroad Administration (FRA) is doing in terms of safety regulation? We are interested in things you think the FRA does that are effective in promoting safety, as well as things the FRA does that are not effective in promoting safety.*

[In the next section we will ask for your perspective on specific safety issues]

QS1 *Now I would like to get your reaction to some specific safety issues. When we looked at the safety statistics, it appeared that the railroad industry had a period of poor safety performance in the late 1960s and 1970s. Were you aware of this period of safety problems?*

No

Yes→ *In your opinion, what were the causes of these problems?*

QS2 *The safety performance of the railroad industry improved substantially shortly after the passage of the Staggers Act in 1980. Are you familiar with safety issues during this period?*

No

Yes→ *Some people attribute this improvement to increases in expenditures on track and equipment after railroads were deregulated. Others attribute the improvements to the efforts of the FRA. What do you think explains the safety improvement observed shortly after the railroad industry was deregulated?*

QS3 *Do you think the environment for reporting safety violations has changed since deregulation?*

No

Yes→ *Tell me more about these changes. Do you think they have affected safety performance?*

[Possible probes:
Is there more pressure to maintain production/service, even if it means noncompliance with safety regulations?
Do you think that violations, injuries, or accidents are being either under-reported or over-reported?]

QS4 *What role do you think FELA plays in promoting safety? How would the incentive structure differ if the rail industry were instead covered by Worker's Compensation?*

QS5 *As you know, the structure of the industry changed significantly after deregulation, including the emergence of many small new railroads and mergers, and consolidation among the larger railroads. I would like to ask a few questions about these issues. First, from your point of view, are safety issues or performance different in the small and medium railroads compared to the large railroads?*

[Possible probes:
Do you have any first-hand experience with safety issues at small railroads (for those currently associated with large railroads)?
Are smaller railroads more likely to have safety problems?
Are safety problems in small railroads masked within the statistics that reflect the overall performance of the larger railroads?
Are the small railroads less extensively unionized than the large railroads, and if so does this have implications for safety performance?]

QS6 *There have been many mergers among the larger railroads. In your opinion, have mergers affected safety performance, either directly or indirectly, in the railroad industry (at your company)?*

No → *Why not?*

Yes→ *What has been the impact?*

[Possible probes:
Improved financial conditions?
Better maintenance?
Impacts on staffing levels?
Cost-cutting in safety programs?
Employee morale?
Pressures to not report accidents or safety problems?
Impacts on training?
Integrating safety programs of two different companies?
Anything else?]

QS7 *Have you personally worked for a railroad company that has been involved in a merger?*

No

Yes→ *Did this merger have any impacts on safety performance?*

[Possible probes:
Improved financial conditions?
Better maintenance?
Impacts on staffing levels?
Cost-cutting in safety programs?
Employee morale?
Pressures to not report accidents or safety problems?
Impacts on training?
Integrating safety programs of two different companies?
Anything else?]

QS8 *There has been a large decline in employment in the railroad industry at the same time as freight volumes have continued to increase. In your opinion, do you think the drop in employment levels has had any effect on safety?*

No → *Why not?*

Yes→ *Can you tell me more about this?*

[Possible probes:
Are current staffing levels adequate with regard to safety issues?
Were certain kinds of positions affecting safety performance cut back more than other positions?
What role has technology played?
How were employment reductions accomplished (attrition, firings, layoffs (by seniority, forcing people out of jobs, buyout plans,...)?]

QS9 *Has there been an increase in the use of contractor services? If so, do you think this has impacted safety?*

QS10 *Have workloads in the railroad industry changed significantly since deregulation*?

No

Yes→ *How have they changed (increased or decreased, to what extent), and to what do you attribute this change? Do you think this change has affected safety performance?*

[Possible probes:
Have changes in workloads been concentrated in any specific areas that might affect safety?
Have changes in workloads affected levels of fatigue?
Have workload changes affected morale?
What are the relative roles of employment decreases versus increased business volume in increased workloads?]

QS11 *Has there been a change in either management or labor turnover rates in the railroad industry since deregulation?*

No

Yes→ *What impact do you think changes in turnover have had on skill levels? Do you think this has affected safety performance?*

[Possible probes:
Have these changes been observed across all job categories?]

QS12 *Have you noticed a change in the level or quality of training since deregulation?*

No

Yes→ *Tell me more about this change. Do you think it has helped or hindered the safety performance of the railroad industry?*

QS13 *In your opinion, has deregulation affected labor-management relations in the railroad industry?*

No

Yes→ *Tell me more about the impact. Do you think this has had any affect on safety performance?*

[Possible probes:
Have there been work-rule changes that have affected safety performance?
Has there been a decline in the number of job classifications (increase in craft flexibility), and has this impacted safety?
Has worker morale or job satisfaction been affected to such a degree that it has impacted safety? How?]

QS14 *As you may know, human factors are now the biggest cause of rail accidents. What do you think has led to the increase in accidents caused by human factors?*

QS15 *Has management's approach to safety issues changed since deregulation?*

No

Yes→ *Tell me more about these changes. Do you think they have helped or hindered the safety performance of the railroad industry?*

QS16 *What about railroad unions? Has their approach to safety issues changed since deregulation?*

No

Yes→ *Tell me more about these changes. Do you think they have helped or hindered the safety performance of the railroad industry?*

QS17 *Poor maintenance of track and equipment has been identified as a key factor in railroad accidents in the 1970s. Do you think there have been changes in maintenance practices since deregulation?*

No

Yes→ *Tell more about these changes. Do you think they have helped or hindered safety performance of the railroad industry?*

[Possible probes:
What were the causes of these changes in maintenance practices?
How was maintenance effort reprioritized after deregulation?
Have there been changes in frequency, expenditures, philosophy (e.g., preventive vs. corrective), training of maintenance staff?]

[In this last section we will wrap up with a few general questions]

QW1 *Thinking forward, what do you think the biggest safety issues will be in the railroad industry 5 years from now?*

QW2 *Thinking back, if you will, how do you think safety performance would be different today if the railroad industry had not been deregulated?*

QW3 *As you may know, the electric generating industry is in the process of being deregulated. If you were an advisor to the Nuclear Regulatory Commission what safety issues would you suggest the NRC should consider during the deregulation process?*

That is all the questions I have for you at this time.

Is there anything else you would like to add that may help with our understanding of how deregulation has affected safety?

Thinking back over the questions I asked and the answers you gave, is there anything you would object to having included in a summary of our discussion today?

Are there any public sources, such as articles or testimony containing your thoughts on safety issues in the railroad industry, that you would like us to review?

If when I am reviewing our discussion I find that there are a few more issues I would like you to consider, would it be OK for me to call you back?

No

Yes

APPENDIX C

Evolution of the United Kingdom Electricity Supply Industry

The privatization of the electricity supply industry (ESI) in the United Kingdom was one of the earliest and most ambitious attempts to introduce competition into an integrated "natural monopoly" (Newberry and Green, 1996). There are four generally recognized phases of evolution in the U.K. ESI (Newberry and Green, 1996): the early period (1857 to 1925); the initial reform period (1926 to 1946); the nationalization period (1947 to 1987); and the privatization period (1987 to 1995). The first four of these are discussed below; the privatization period is discussed in Chapter 6.

C.1 The Early Period (1857 to 1925)

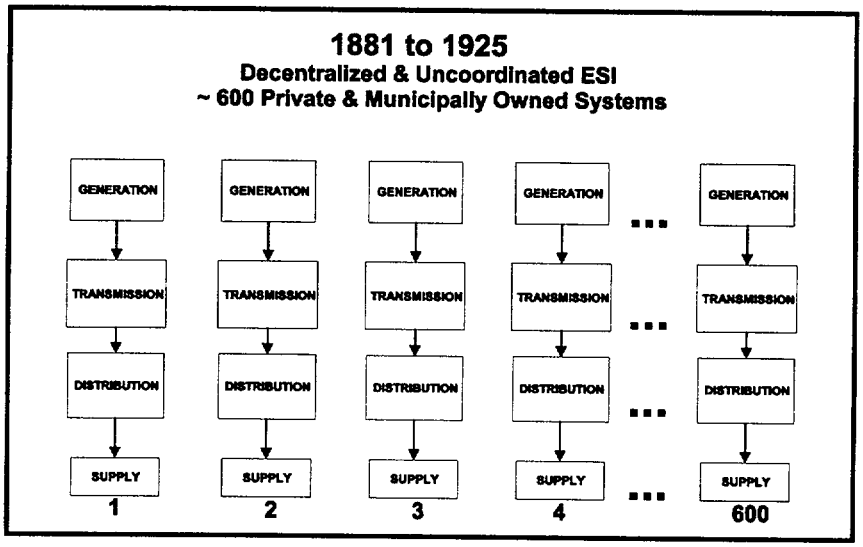
The early electricity industry in Great Britain can be characterized as "fragmented" and not subject to effective regulation (International Energy Agency, 1999a). The first small electric generators were introduced into the U.K. in 1857 to produce light for lighthouses (Hannah, 1979). The first central power station was later introduced in 1881, when Siemens commissioned a small hydroelectric plant in Godalming, Surrey (Chesshire, 1996). One year later, in 1882, the first law was introduced that effectively regulated the maximum price of electricity, also allowing local authorities to purchase the electricity companies after 21 years. This purchase right was later extended to 42 years by the 1888 Electric Lighting Act.

The early development of the British ESI proceeded at a relatively slow pace for two reasons (Newberry and Green, 1996). First, the low demand for electricity led to the initial construction of small generating stations. In 1900, the average size generator was about 250 kW, and most stations used high-speed reciprocating engines. These stations were seemingly cheaper since they avoided transmission costs (Byatt, 1979, Chapter 6). However, as the number of interconnections and the customer base expanded, the small plants soon failed to reap economies of scale. This situation ultimately led to higher electricity prices, which further impeded demand. The economies of scale were also later affected by the introduction of the steam turbine from 1904 to 1913. Secondly, during the early period of electricity growth, gas lighting held a competitive advantage over electrical lighting in the British domestic market. It was not until 1906 that sufficient industrial demand for electricity developed which in turn created a demand for larger generating stations. By contrast, the early development of electricity generation in the U.S. proceeded more smoothly. Since gas was more expensive than electricity here, Edison was able to sell electric lighting at "the gas price" and thereby break out of constraints on market size (Newberry and Green, 1996).

Interestingly, during the first half of the nineteenth century, the British relied on the doctrine of competition for the control of natural monopolies (Byatt, 1979, Chapter 12; Ballin, 1946; Robson, 1935), but abandoned the concept after 1850. Thereafter, around the time electric power was introduced, the natural monopolies were granted franchises or were operated by municipal organizations. The small, early electricity supply systems were typically vertically integrated monopolies. As shown in Figure C-1, each company or municipality owned and operated its own

power generating stations (G), its high voltage transmission lines (T), its lower voltage distribution lines (D), and a customer supply system (S) consisting of metering, billing, and sales. In short, the early period of electricity supply in the U.K. could be characterized as decentralized, fragmented, inefficient, and uncoordinated, with generation under a combination of both private and municipal ownership and subject to loose regulation (Newberry and Green, 1996).

Figure C-1 United Kingdom Electricity Supply Industry: The Early Period



Reforms of the British ESI were undertaken following World War I, with the aim of replacing the many small generating stations with larger ones; however, progress was slow. Existing municipalities could not expand into neighboring jurisdictions, and thus local interests often blocked technical improvements. At the close of this period, in 1925, there were about 600 separate electricity supply undertakings using over 400 generating stations (Weir Committee, 1925).

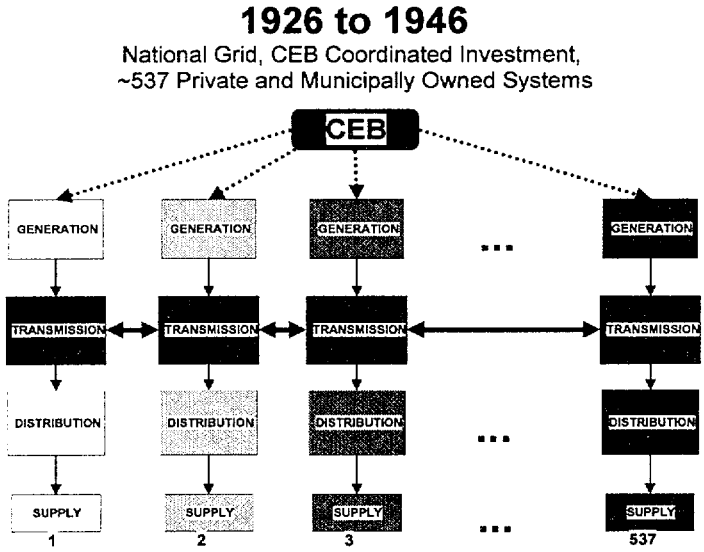
C.2 The Initial Reform Period (1926 to 1946)

Worldwide, the first attempts by national or local governments to guide the electricity market came in the 1920s and 1930s (International Energy Agency, 1999a). In 1925, for example, the British Weir Committee successfully argued for the creation of a national grid to resolve the ongoing conflict between public and private electricity suppliers, as well as problems of non-uniform voltages and frequency. The Parliament subsequently established the Central Electricity Board (CEB) in 1926, marking the second phase of British ESI development. The CEB was a statutory corporation similar to the BBC, which operated more like a commercial corporation than a nationalized industry (Newberry and Green, 1996). The role of the CEB was to build and operate the national grid. Existing power companies remained responsible for building and operating generating stations and

local power distribution and supply systems. However, new investments and dispatch were to be coordinated through the CEB. The Electricity Supply Act of 1926 (Chesshire, 1996) mandated that the CEB embark upon standardization of the AC frequency (50 Hz) and transmission line voltage (132 KV) across the U.K. (Newberry and Green, 1996). Although the national grid was completed in 1933 (Newberry and Green, 1996), it initially was not intended to transmit power over long distances. Newberry and Green describe the grid at that time as "an interconnected set of local interconnection schemes." Consequently, power supply remained essentially a local activity, with only limited power transfers between the small utilities (Chesshire, 1996).

Despite the low level of interaction between suppliers, the transmission grid coordination introduced by the CEB was highly successful in promoting reliability of supply and fostering new construction. From 1929 to 1939, the U.K. plant reserve margin was reduced from a staggering 84% to just 16% (Chesshire, 1996), while the electrical output of the public electricity supply system increased by 70% from 1929 to 1935 despite the Depression. This phase of the British ESI evolution could be characterized as a state monopoly on the high-tension grid with mixed ownership of the generation, distribution, and supply sectors. About 600 separate electrical supply undertakings persisted through this period. Newberry and Green (1996) note that the failure of this period lay in not extending the benefits of coordination to the electricity distribution sector, since it became increasingly evident that voluntary negotiation would continue to be blocked by the vested interests of private companies and municipalities. As of 1946, the bulk of British electricity was being generated in England, Wales, and the South of Scotland. Total generation for this region was about 12.9 GW, and came from 297 plants. During roughly this time period, a Northern Scotland Hydro-Electric Board was also established in 1943 to provide public electricity supply, exploit hydroelectric potential, and develop the remote and sparsely populated areas of Northern Scotland (Chesshire, 1996).

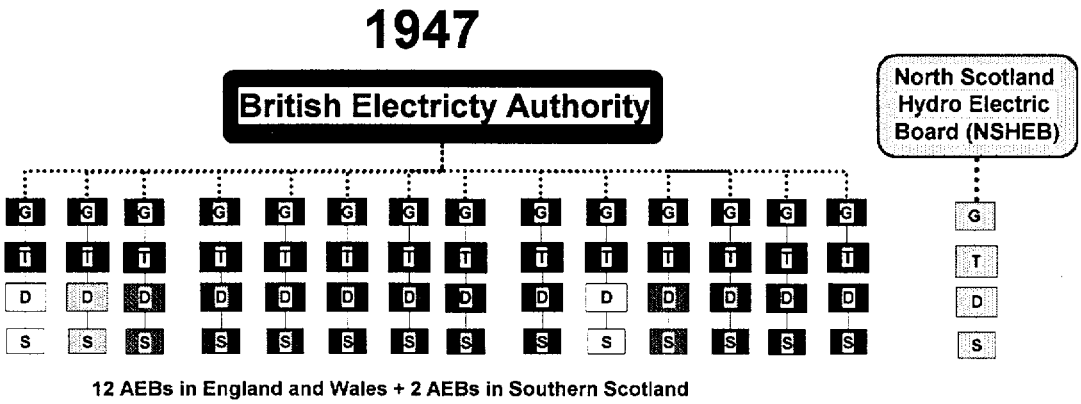
Figure C-2 United Kingdom Electricity Supply Industry: The Initial Reform Period



C.3 The Nationalization Period (1947 to 1987)

In the aftermath of World War II, many European governments concluded that the entire electricity supply sector was a natural monopoly, and that the multitude of small producers should be merged into a single nationwide monopoly (or several large regional monopolies). They felt that the best way to prevent monopolistic behavior was to place these producers under public ownership.[1] France decided to create Electricite de France (EdF) in 1946 (International Energy Agency, 1999a). Shortly thereafter, in 1947, Great Britain decided to nationalize the electric industry in England, Wales, and Southern Scotland. In that year, the British Electric Authority (BEA) was created and given overall responsibility for generation and bulk transmission of electricity (Chesshire, 1996). Ownership of the 297 power stations and the high voltage transmission grid was given to the BEA. The responsibilities for local distribution, metering, billing, customer support, and ancillary activities were given to 14 statutory independent Area Electricity Boards: 12 in England and Wales; and two in Southern Scotland. Effectively, the nationalization effort merged about 537 ESI undertakings into just 15 publicly owned organizations. Owing to its unique history, the North of Scotland Hydro-Electric Board remained a separate entity.

Figure C-3 United Kingdom Electricity Supply Industry: Post-War Nationalization



In 1955, it was further decided to split off the two Area Electricity Boards in Scotland from the BEA. A new autonomous entity, the South Scotland Electricity Board (SSEB), was created. From about 1965 onwards, the two Scottish Boards operated a joint generating account and merit order dispatch system. A Scottish interconnection with England and Wales existed, but the generating systems were planned on the basis of zero trade (Chesshire, 1996). With the creation of the SSEB, it was decided to rename the BEA to the Central Electricity Authority (CEA). However, the CEA was short-lived (Chesshire, 1996). The 1957 Electricity Act transformed the CEA into the Central

[1] In the United States, a different model prevailed—namely, the private monopoly regulated by an independent regulator, the Federal Energy Regulatory Commission. Vestiges of this early development structure persist, since a large number of federal, municipal, and privately owned power companies (roughly 3200) remain in business today.

Electricity Generating Board (CEGB), which was responsible for power station operation and construction in England and Wales, and for the national grid. The 12 Area Electricity Boards in England and Wales were left in place. The Act also established the Electricity Council, which was given broad supervisory responsibilities for the ESI in England and Wales. In practice, however, the Electricity Council amounted to a paper tiger, with no formal control over either the CEGB or the Area Electricity Boards.

In 1972, Northern Ireland Electricity (NIE) was also created as a separate entity from the CEGB. NIE operated as a vertically integrated utility responsible for generation, transmission, distribution, and supply. In 1975, terrorists destroyed the Irish interconnection to the U.K. mainland, and Northern Ireland remained isolated until 1995. During the period from 1947 to 1986, several nuclear stations owned by the U.K. Atomic Energy Authority and British Nuclear Fuels Ltd. were connected to the grid. Additionally, in 1986, a 2000 MW DC link with France was established (Chesshire, 1996). Although two-way flows of power are possible, the link has been used almost exclusively to import electricity from EdF in France. By 1987, the U.K. electricity supply system had reached a combined capacity of about 63.8 GW. Of this, 79% was provided by fossil-fueled generation, ten percent was nuclear, six percent was hydroelectric, and five percent was from other sources, such as gas turbines and internal combustion engines (Chesshire, 1996).

Although the nationalized ESI produced substantial benefits, it also led to financial control problems. The nationalized ESI came into being in a climate of post-war dilapidation and reconstruction. The early years were characterized by a program of heavy construction aimed at "meeting the capacity crisis" (Hannah, 1982), and the industry continued to be preoccupied with availability and security of supply (Ferner and Colling, 1993). Under the U.K. nationalized system, the CEGB sold almost all of its energy to the 12 Area Electricity Boards, which in turn distributed and sold electricity to consumers in their respective regions. As a result, the CEGB generated the bulk of the ESI costs, and automatically passed the costs onto the Area Electricity Boards through the Bulk Supply Tariff. Each Area Electricity Board then sold the electricity to customers at its own tariff. Critics characterized the CEGB as a "cost plus centralized monopoly" (Henney, 1988). Other critics of the CEGB (Ferner and Colling, 1993) claimed that:

> the need to guarantee capacity, together with public accountability through the minister in Parliament gave rise to a management culture dominated by engineering values and concern with operating issues, and to what internal observers saw as a bureaucratic and 'civil service' mentality that stressed uniformity of procedure, 'form filling,' and 'backside covering.' This was compounded on the nuclear side of the industry by overriding concern with safety.

These concerns led to the period of privatization.

NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, If any.)

NUREG/CR-6735

2. TITLE AND SUBTITLE

Effects of Deregulation on Safety: Implications Drawn From the Aviation, Rail, and United Kingdom Nuclear Power Industries

3. DATE REPORT PUBLISHED

MONTH	YEAR
August	2001

4. FIN OR GRANT NUMBER

K6892

5. AUTHOR(S)

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6. TYPE OF REPORT

Technical

7. PERIOD COVERED *(Inclusive Dates)*

8. PERFORMING ORGANIZATION - NAME AND ADDRESS *(If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)*

Center for Human Performance and Risk Analysis, University of Wisconsin-Madison, 1513 University Avenue, Madison, WI 53706
Connect-USA.com, 25131 Chambliss Court, Gaithersburg, MD 20882
Laurits R. Christensen Associates, Inc., 4610 University Avenue, Madison, WI 53705

9. SPONSORING ORGANIZATION - NAME AND ADDRESS *(If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)*

Division of Systems Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research
U.S Nuclear Regulatory Commission
Washington, DC 20555-0001

10. SUPPLEMENTARY NOTES

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11. ABSTRACT *(200 words or less)*

Changes associated with economic deregulation of the U.S. electricity supply industry are causing major restructuring, with the potential to affect nuclear power safety. This study was undertaken to identify possible consequences of deregulation for nuclear power safety. A historical case study approach was adopted (using literature reviews and interviews), focusing on the U.S. aviation and rail industries and the United Kingdom nuclear power industry because of their relevance to the U.S. nuclear power industry. Overall, the experience of the case study industries suggests that economic deregulation need not be incompatible with a reasonable safety record, especially in areas where safety is positively related to productivity. However, safety clearly cannot be taken for granted after deregulation, since adverse effects on safety were observed in each of the three case study industries. Among the most notable of those involved financial pressures, safety culture problems associated with mergers acquisitions, increased use of contractors, and downsizing. The magnitude and speed of such changes can create major challenges to the management of safety. Careful review and study of the problems observed in the case studies may make it possible to identify proactive ways of minimizing similar safety problems in the U.S. nuclear power industry.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

Economic Deregulation
Safety
Aviation
Rail
United Kingdom
Restructuring

13. AVAILABILITY STATEMENT

unlimited

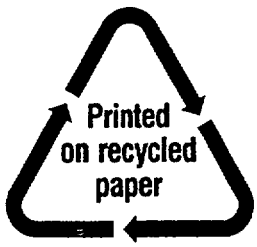
14. SECURITY CLASSIFICATION

(This Page) unclassified

(This Report) unclassified

15. NUMBER OF PAGES

16. PRICE



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