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INSTITUTIONAL CHANGE VERSUS INSTITUTIONAL PERSISTENCE? THE TRANSFORMATION OF THE U.S. NUCLEAR REGULATORY COMMISSION SINCE THREE MILE ISLAND

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Institutional Change versus Institutional Persistence?

The Transformation of the U.S. Nuclear Regulatory Commission Since Three Mile Island

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Editorial Note

The final version of the text was derived from a manuscript provided to the Disaster Research Center by the author. She did not see the minor editorial changes that were made. However, a major effort was made not to change the substantive content or the tone of the text. Most of the references were left in the format and style in which they were originally provided.

To prevent accidents as serious as Three Mile Island, fundamental changes will be necessary in the organization, procedures, and practices--and above all--in the attitudes of the Nuclear Regulatory Commission and, to the extent that the institutions we investigated are typical of the nuclear industry (Report of the President's Commission on the Accident at Three Mile Island, 1979: 27).

INTRODUCTION

This paper attempts to show that while environmental shocks can lead to major institutional change, typically this change is not radical. Even in situations of institutional breakdown, due to violent and disruptive events such as disasters, it is possible to find institutional persistence which constraints and shapes the process of change. In this sense, the paper portrays institutional change and institutional persistence more as coexisting than as contrasting.

Focusing on the nuclear accident at Three Mile Island (1979), which "ended the first nuclear era in the U.S. (Weinberg, 1985: 1) "divided nuclear power history in two parts--before and after Three Mile Island (Rees, 1994:1), the paper examines forms of major institutional change that originated from it, but have also revealed themselves as consistent with institutional persistence. A new path in nuclear safety regulation developed after the accident at Three Mile Island (**TMI**). Yet, this new path has been consistent with an old path in nuclear safety regulation that **TMI** did not break down, and to a certain extent strengthened.

Emphasizing institutional persistence, the paper takes a historical perspective, paying attention both to the long-term institutional implications of the nuclear plant accident at **TMI**, and to its historical roots. History represents a basic framework for understanding the kind of institutional transformation developed in nuclear safety regulation after **TMI**.

The U.S. Nuclear Regulatory Commission (**NRC**) is the main institution we investigate in this paper. The **NRC** is a case of institutional continuity in itself. It was established in 1974, but it inherited its structure, staff and regulatory system from its predecessor, the Atomic Energy Commission (**AEC**) established in 1946. The paper looks at the process of the **NRC**'s transformation that developed because of **TMI**. That transformation has been constrained and mediated by the **AEC**'s institutional legacy.

A second institution we focus on is nuclear safety regulation. The whole concept of nuclear safety, its culture and approach have changed because of **TMI**. The main institutional breakdown that **TMI** produced was precisely in the body of assumptions, values, rules and procedures which had guided nuclear safety regulation until then.

The paper then describes and analyzes the main changes which took place in the institutional environment of the **NRC** as a result of **TMI**. More specifically, the paper focuses on the Institute for Nuclear Power Operations (**INPO**), the private regulatory agency set up by the nuclear industry in the aftermath of **TMI**, and on its partnership with the **NRC**. The **INPO** itself, and especially the partnership between **INPO** and **NRC**, represent a major institutional change in nuclear safety regulation. This change also built upon persistent institutional arrangements which originated in the early days of nuclear power development.

Institutional Change and Institutional Persistence A Theoretical Framework

While the concept of institutional change has received broad attention and definition within the neo-institutionalism literature (North, 1990; Powell-DiMaggio, 1991; Scott, 1995; Zucker, 1988), the concept of institutional persistence has not. It has been mainly overlooked because it has been perceived as included in the concept of institution itself. As a matter of fact, the concept of institution "connotes stability and persistence" (Scott,1995: 78), and the process of institutionalization expresses the maintenance and preservation of unique values "reflecting the organization's own distinctive history" (Selznick, 1957: 16; see also, Zucker, 1977).

However, theoretical interest in the concept of institutional persistence has recently increased. The new interest in the historical development of institutions and in the "inefficiency of history" (March and Olsen, 1989: 64) tries to explain why institutions are likely to persist even when inefficient or mysfunctional. Institutions have been portrayed as "carriers of history" (David, 1992:1; Scott, 1995), i.e., carriers of cultures, structures and routines, able to shape and constrain the forms of institutional development (Gidden, 1984; Japperson, 1991). The concept of institutional persistence has been contextualized in the dimension of *historical* development and given the specific connotation of maintenance of structures, routines and culture, "delivered" by history (Arthur, 1989: 116).

One of the main contributions on this view of institutional persistence comes from the "path dependence" approach, which has developed within economic theory (Arthur, 1989; David, 1985, 1992; Liebowitz-Margolis, 1995). This approach portrays institutional development as a nonlinear process, particularly "sensitive and dependent on initial conditions". It stipulates an intertemporal relationship between the initial conditions of a process of institutional development and the forms of this development. Early conditions and initial choices are likely to *persist* in the development path, which becomes constrained and cast by those initial conditions and choices.

The sources of persistence lie in mechanisms of self-reinforcement developed by the early sequence of historical events, strengthened by the early set-up costs and investment of capital. Given that sequence and that investment, the path of institutional development becomes "locked-in". The transformation of the existing path into a new one is prevented by "sunk costs" (Scott, 1995: 80), or "the continuing value of the capital equipment and skilled labor and the likelihood that these resources will remain in the same place" Stinchombe, 1968: 120). Consequently, institutional arrangements, their efficiency, and their possibility of development, are portrayed as outcomes of history, which "delivers the inevitable" (Arthur, 1989: 127).

The path dependence approach describes institutional development as "punctuated". Institutions change through isolated moments of crisis and breakdown over long periods of stasis. Institutional change is not incremental, but it is the result of agents of institutional breakdown, able to break the existing path of development and start a new one.[1] Institutional change is represented as exceptional and radical, contrasted and opposed to institutional persistence and historical continuity which are portrayed as the rule.

The opposition of institutional change and institutional persistence is frequently noted within the new-institutionalism literature. As a matter of fact, the relationship between institutional change and institutional persistence has not been broadly investigated or studied. Institutional persistence has been equated to institutional inertia, and the latter to the condition of non-change.

Genschel (1995) provides an interesting and original contribution on this point. He portrays institutional change and institutional inertia not as contrasting, but as coexisting. Inertia does not necessarily prevent institutional change. It can interfere with the radical replacement of old institutions, but nevertheless it is compatible with other forms of institutional change and transformation.

According to Genschel, institutional change does not necessarily equate to a radical break with the past. The view of history as a succession of alternating long phases of inertia and sudden moments of radical change is criticized as too dichotomous to be able to cover the whole complexity of institutional transformation. As a matter of fact, Genschel focuses on two common forms of institutional change which are consistent with institutional continuity:

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[1] For a further elaboration of the theory of "punctuated change" and application to American politics, see Kelly, 1994, 165.

patching up and *transposition* (1995:7). Inert, or persistent, structures can be patched up with new structures or transposed to new functions. In both cases, already existent institutions are used to face new problems, and the change is consistent with the preservation of the old institutional stock.

These forms of institutional change can be defined as practices of institutional *bricolage* (Lanzara, 1995). New institutions or new institutional arrangements are portrayed as the result of a process of recombination of preexisting institutional material. Practices of institutional *bricolage* prevent radical breaks and do not replace old institutions, while still allowing for institutional transformation.

According to Genschel (1995: 8), the sources of institutional inertia or, in other words, the factors which make *radical* change unlikely to take place--making preferable the recombination of already existing institutional structures--are three: *sunk costs*, *uncertainty*, and *political conflict*. First, institutional arrangements take time, money and effort to be built up. They are expressions of an embedded capital that includes rules, codes, conventions, skills, competencies, and personal contacts, and that have been developed in order to support that particular arrangement. This capital can not be easily transferred to a different institutional context. Such specificity makes institutional replacement costly, in terms of *sunk costs*.

Moreover, given the condition of bounded rationality, knowledge about institutional choices and alternative models of institutions is likely to be incomplete. While old institutions are known by experience, there can be only conjectural knowledge about new arrangements and their effects can. As a result, any change from an old to a new institution brings high levels of *uncertainty* which have to be managed.

Finally, in order to switch to new institutions, the beneficiaries of the *status quo* have to be overpowered, and the proponents of the switch have to agree on a common design. They also have to mobilize followers, forge coalitions, and settle *conflict*. All these actions are costly, time consuming and not necessarily successful.

Sunk costs, *uncertainty* and *political conflict* prevent radical change and are sources of institutional persistence. They do allow change; but this change has to be mediated by the structures of the pre-established institutional arrangements, in a way sothat the "new" and the "old" become joined in "an intimate and paradoxical relationship" (Skowronek, 1982: 285).

Moving from this theoretical framework, the paper next focuses on the**TMI** case study, showing the extent to which institutional change is likely to develop through practices of bricolage, even when originated by sudden and violent environmental shocks. Reflecting on the coexistence of institutional change and institutional persistence, the paper shows the limits of exogenous change (Japperson, 1991; Lanzalaco, 1995; Powell, 1988). Given sunk costs, uncertainty, and political conflict, environmental shocks do not result in radical institutional change. They can stimulate major change, but this change is mediated by preexisting arrangements. Such mediation takes the form of institutional patchwork.

The Accident at TMI: An Institutional Breakdown

The accident

The Three Mile Island accident, America's worst nuclear power accident, and one that came very close to a core meltdown, occurred on March 28, 1979, and was the result of a series of equipment malfunctions and operator errors (for detailed descriptions see Casamayou, 1993: Mornone and Woodhouse, 1986; Rees, 1994; U.S. NCR Special Inquiry Group Report, 1980; U.S. President's Commission on the Accident at Three Mile Island report, 1979;and Walsh, 1988). The accident began, around 4 a.m., when a maintenance crew trying to clearn a clogged pipe inadvertently shut off the main feedwater system of the Unit 2 reactor. This began a series of automatic safety measures which should have taken care of the problem,including the use of a back up pump to circulate water and a temporary shutdown of the reactor. But another error occurred. The pressure relief valve, which was supposed to close automatically, remained open. Even worse, the control room instruments indicated to the plant operators that the valve had closed.

At this point more serious problems began. Since the valve stayed open, pressure in the water loop fell, and water (220 gallons a minute) started boiling away through the open valve. In reaction to the loss of coolant and pressure, an emergency cooling system was automatically activated to replace the water that had been drained out. This would have prevented further problems, but then another fatal error occurred. Misled by the instruments, which showed the valve as closed, the operators turned off the emergency water supply, thinking that there was too much water in the reactor.

The water continued to escape and steam began to accumulate in the water loop, leading to vibrations in the pumps still in operation. That led to the final error: the operators, who had not understood what was happening, turned off those vibrating pumps. It was not until over two hours after the accident started, that the operators finally realized that the relief valve was open and parts of the fuel assembly were melting. A substantial quantity of fission products had already been released.

The accident at **TMI** was of prolonged duration, resulted in severe damage to the core, and left the Unit 2 facility highly contaminated by radioactivity. It disabled forever the TMI-2 reactor, which had started commercial operation just three months before.

The accident at **TMI** drove investors away from nuclear utilities. The cleanup costs for the damaged **TMI** reactor were estimated at around $1 billion. Because the insurance totaled only $ 300 million, the owner of the reactor, General Public Utilities, faced bankruptcy (Campbell, 1988; Jasper, 1990). Moreover, as a result of concerns about safety which **TMI** created, nuclear plant costs became higher: by the 1980s when a new nuclear facility was estimated to cost 65% more than an equivalent coal-fired plant (Komanoff, 1981).

Given the disruptive impact on the economy of the nuclear industry, not a single reactor has been ordered since the **TMI** accident, and eighty earlier orders have been either cancelled or postponed. Moreover, in the first years following the accident, more than forty plants, each worth more than $50 million in investments, were neglected (Allison and Carnesale, 1983; Jasper, 1990; Thomas, 1988).

Regardless of its relatively limited environmental and health impact,[2] the socio-political reaction to the accident at **TMI** was very strong. **TMI** became the symbol of a possible nuclear catastrophe. Antinuclear organizations, already active at that time, took advantage of the publicity. They advocated the shutdown of all nuclear power plants and a moratorium on any future use of nuclear power, and mobilized hundreds of thousands of protestors in demonstrations. For the first time, American public opinion became antinuclear.[3]

Several criticisms were made and skepticism on nuclear power were raised within the congressional debate that followed the accident. The negative tone of Congressional hearings on civilian nuclear power increased dramatically (Baumgartner-Jones, 1991: 1063; Jasper, 1990: 212). Both the U.S. Nuclear Regulatory Commission, the federal agency charged with the function of nuclear safety regulation, and the nuclear industry were seriously questioned and investigated.

Which institutional breakdown?

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[2] The environmental impact of the accident at TMI was very limited. Most of the fission products that were released were trapped by the containment building. It was later established that the dose of radiation received by the population was too small to increase risks of cancer, birth defects or genetic abnormalities. The only health impact of the TMI accident that has been identified is the mental stress of those living in the vicinity of the plant, particularly pregnant women and families with teenagers and preschool children. See Upton, 1981.

[3] On the origins of antinuclear culture and movements and their radicalization after TMI, as well as on the symbolic impact of TMI, see Casamayou, 1993; Christian, 1993; Freudenburg-Rosa, 1984; Goldsteen-Schorr, 1991; Inglehart, 1984; Rothman-Lichter, 1987; Walsh, 1988; Weart, 1988.

> *TMI provided a traumatic shock to all institutions involved in nuclear energy applications - a shock badly needed to make those institutions aware of additional requirements for the safe use of this enormous new source of energy.*[4]

Several independent commissions were formed to investigate the causes of the accident at **TMI**. The two most important were the President's Commission on the Accident at Three Mile Island (the Kemeny Commission) appointed by President Carter, and the Special Inquiry Group (the Rogovin Commission) sponsored by the U.S. Nuclear Regulatory Commission.[5] All the investigations came to similar conclusions: "the fundamental problems are people-related problems and not equipment problems" The operators of TMI were poorly selected and poorly trained, unable to deal with the "unexpected". The "unexpected" was not even conceived because the prevalent *attitude* was that nothing could possibly go wrong (see, Casamayou, 1993; Kemeny, 1981).

Both the Kemeny and the Rogovin Commissions strongly criticized the U.S. Nuclear Regulatory Commission (**NRC**), and called for its abolition or radical reorganization. The **NRC** was described as "an organization that is not so much badly managed as it is not managed at all," and that "does not possess the organizational and management capabilities necessary for the effective pursuit of safety goals"(Kintner, 1988).[6] The whole nuclear regulatory system which had been developed until **TMI** was heavily criticized, and defined, by admission of the **NRC** itself, as "fundamentally deficient".[7]

The **TMI** investigations found out that the **NRC** "mindset" was too focused on the technology, and ignored the operator and the human factor in the regulatory process. The **NRC**'s approach to nuclear safety was defined as "engineering biased", because it was based on the assumption that well-designed hardware would take care of all contingencies that could threaten the safety of plant operations. Operational safety was not even conceptualized; rather it was equated with engineering design safety. The vast majority of regulatory standards concentrated on hardware-related issues such as how nuclear plants

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[4] E. Kintner, "After TMI-2: A Decade of Change", Speech delivered to American Nuclear Society meeting, 31 October 1988. Reference in Rees, 1994, 12.

[5] The President's Commission on the accident at TMI (Kemeny Commission) was established on April 11, 1979 by President Carter. It was charged with investigating the accident and reporting to the President within six months with recommendations based on its findings. The Commission was headed by John Kemeny, President of Dartmouth College, and included 11 others who came from a wide cross section of society. The Commission and its staff worked for 6 months, took more than 150 depositions, interviewed a large number of people. Parallel to the President's Commission on the Accident at TMI, the NRC instituted a special inquiry to review and report on the accident as part of its regulatory responsibilities. The Special Inquiry Group headed by M.Rogovin, a lawyer, was staffed with NRC and outside experts, and was granted full independence. The Rogovin Commission collected about 270 formal depositions and accessed data of the Kemeny Commission. Both Commissions produced a detailed public report as a result of their investigations.

[6] Respectively, U.S. NRC Special Inquiry Group Report, 1980, Vol. I, 112; and U.S. President's Commission On The Accident At Three Mile Island Report, 1979, p. 61.

[7] Testimony of Commissioner Bradford, U.S. NRC, NUREG - 0632, 1979.

had to be designed and constructed. Almost no notice was taken of the interaction between the human factor and the technology; and, moreover, for the management of operating nuclear reactors (Rees, 1994).

The **NRC** process for nuclear plant licensing was found seriously flawed.

> *Perhaps the most grievous deficiency in the licensing process . . . is the NRC's treatment of unresolved safety problems . . . The NRC staff adopted a procedure whereby if a safety problem applied to more than one plant, it was not necessary to address that problem in the review of any one single plant. By the simple act of classifying problems as 'generic,' they were removed from consideration within the licensing process . . . In 1976 the secret list of such problems numbered over 200. In January of 1978, in response to a Congressional order, the NRC provided a list of 133 unresolved safety problems (Gorison et al., 1979: 45).*

The Kemeny Commission strongly criticized the **NRC**'s handling of generic safety issues and explicity called for an end to this practice. Such a public condemnation led to the complete loss of trust and credibility in the **NRC**, which was perceived more as a promotional body for nuclear power than as a nuclear safety regulatory agency (Clancy, 1980).

In order to better understand the institutional impact that **TMI** accident had on the existing institutional arrangement for nuclear safety regulation, it is necessary to take a step back, and to undertake an historical view of the origins of that regulation and of the **NRC**.

The **NRC** regulatory approach to nuclear safety was technically called "defense in depth". It was based on strategies of "prevention" and focused on the engineering design of nuclear plants and emergency systems. The inherited "defense in depth" safety philosophy, and its biased engineering culture, came from its predecessor, the Atomic Energy Commission (**AEC**), the first U.S. nuclear regulatory agency, established in 1946. The **AEC** was set up to promote the rapid development of nuclear energy for eventual peaceful civilian purposes.[8] In 1954, given the success of the nuclear submarine program, when the commercialization of civilian nuclear power started developing, the **AEC** began its regulatory function in order to issue licenses to private companies to build and operate nuclear power plants.[9]

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[8] The AEC was established by the Atomic Energy Act of 1946. Although technically under civilian control, the AEC's primary function during its early years was the development of the military program. See Clarke, 1985; Walsh, 1988.

[9] The new function of the AEC was established by the revised Atomic Energy Act of 1954, which broke the government monopoly on nuclear power and allowed for its commercialization.

Given the "non governmental" (private) nature of the nuclear industry, the absence of standardization in nuclear plant design, and the very fast pace of nuclear reactor deployment, the licensing process soon became the main **AEC** regulatory tool for protecting public health and safety. The small regulatory division that the **AEC** had set up in 1954 to perform the new function soon became overwhelmed by the increasing number of license applications.

The complexity of the new technology and the statutory promotional role of the **AEC**, led to the development in the licensing process, in order to make it faster, of the practice of "unresolved safety problems". The regulation of nuclear plant design and its review in the licensing process became the *way* the **AEC** performed its double function: the promotion of the nuclear industry and the regulation of its safety. Unresolved design safety issues were postponed, and possible issues in nuclear plant management and operations were left to private industry.

The "defense in depth" safety approach developed by the **AEC** was a bad variant of the one developed by Admiral Rickover within the U.S. Navy.[10] Rickover, in order to carry out his Nuclear Submarine Program, had to guarantee that a nuclear accident would never happen. This was because, the submarine crew would have no avenue of escapein case of accident, and major ports for the submarines were generally in large populations centers. To prevent accidents in the Nuclear Submarine Program, "the engineering and reactor design had to be error-free, the components and assembly flawless, and the operating personnel totally competent and reliable" (Rolph, 1979: 24). So, the Rickover approach to safety was based on the engineering safety, but not just on that. Nuclear accident protection relied on hardware safeguard, but *also* on the competence of the operators of the nuclear submarines. The naval operators were viewed as the ultimate safety barrier, and they were put through rigorous selection and training programs (Gorison *et al.*, 1979: 126).

The **AEC** relied on the engineering know-how developed by Rickover in his Submarine Program but, given the land-based nature of civilian reactors and the private nature of the nuclear industry, it did not promote the same approach to operational safety.[11] In other words, the **AEC** promoted the same cultural value that no accident would ever happen, and also the same faith in the reliability of the technology. It focused just on the hardware

[10] In 1948 Admiral Hyman G.Rickover started the Navy Nuclear Propulsion Project, acting as director of both the Naval Reactor Branch within the Atomic Energy Commission and the Nuclear Power Division within the Navy Bureau of Ships. The project, carried out on the basis of the cooperation of the two agencies, led to the development of the light water nuclear reactor and to the construction of the first U.S. nuclear submarine - the *Nautilus* - in 1954. Later, the project was further developed, leading to the construction of the U.S. Nuclear Fleet. See Hewlett-Duncan, 1974.

[11] The AEC chose to rely ultimately on techniques that limited the consequences of an accident. The most important tactic of mitigation was the containment building, intended to prevent the readioactive fission products to be released from the core and escaped into the environment. A second tactic was that of remote siting: to build the plants away from popultaed areas. See Morone and Woodhouse, 1989, p. 76.

component of nuclear safety, neglecting the human one, and used the explicit premise of not interfering with nuclear plant management practices (Rees, 1994: 31). In 1974, following criticisms concerning its double statutory function--nuclear power promotion and regulation at the same time--the **AEC** was abolished and split into two new agencies: the Department of Energy for the promotional activity and the **NRC** for the regulatory function. In this change, the **NRC** inherited its whole regulatory staff, organization, and culture.[12]

In the aftermath of **TMI**, the legacy of the **AEC** which had been embodied into the **NRC**, was strongly criticized as being unable to regulate and to guarantee nuclear plant safety. The findings of investigations showed the cultural continuity between the **AEC** and the **NRC**:

> *The people here had grown up in the embrionic world of nuclear engineering and they did not know how not to be pro-nuclear. It was very difficult not to have a bias in favour of the technology, despite the fact there had been the split of the Atomic Energy Commission and we were just regulators and not promotional. The culture was in favor of the values of this technlogy . . . Our defenses were highly prescriptive, and engineering. We had almost a religious faith in the reliability of the machine. Also a religious dedication to the technology.*[13]

The **TMI** accident started the process of *deinstitutionalization* of nuclear safety regulation as it had been developed until then in its organization, culture and approach. A whole set of values embodied in the nuclear technology lost credibility. Before **TMI**, there had been the assurance that the probabilities of the occurrence of any nuclear accident were negligible. "It can't happen" was the basic cultural assumption in nuclear safety regulation (see, Casamayou, 1993; Walsh, 1988). The **TMI** accident broke down that assumption and called for a new approach.

The main criticisms and recommendations which came out of the **TMI** investigations focused on two areas: a) the **NRC** policy, organization, and management; and, b) the safety performance of nuclear plants.

All the criticisms of the **NRC** organization, procedures and attitude, and moreover of the persistence of the **AEC**'s legacy, ended in the recommendation to abolish the **NRC** and to replace it with a new agency headed by a single administrator. The Commission, at the head of the **NRC**, was completely separated from the executive activities of the agency. The comissioners were to have little knowledge of the day-to-day conduct of regulatory actions. The regulatory work was done by the program offices, reporting to the Executive Director

[12] The AEC's split was regulated by the Reorganization Energy Act of 1974.

[13] Interview of J. McDermott, Deputy Director, Office of Personnel, U.S. NRC, Washington D.C., November 1995.

for Operations (EDO), whose function was that of just being a liaison between the Commissioners and the executive staff. (See Fig. # 1 in Appendix)

These competing centers of influence, as well as the multiheaded nature of the Commission with each Commissioner having equal responsibility and authority in all the decisions and actions of the Commission, made the **NRC** an "unmanaged and unmanageble" agency. It was suggested that in a reorganization that there be a single administrator because that would improve the management and the coordination of the agency itself.

Moreover, in order to develop an overall **NRC** safety policy, which had been found seriously deficient, and to regain the public credibility which had been lost, it was strongly recommended that an independent Nuclear Safety Oversight Committee be established. It was to examine, on a continuing basis, the performance of the **NRC**, and to give it safety policy recommendations.[14]

The **TMI** accident brought to light the lack of training, qualification and professionalization in nuclear plant management and operations. Before the **TMI** accident, the **NRC** simply ignored the role of human factors in nuclear plant safety; hardly any attention was gaiven to the arrangements required to manage, operate and maintain those plants (Rees, 1994).

Both the Kemeny and the Rogovin Commissions discredited the notion that adequate safety could be assured by the oversight of only the engineering parts of technological systems, and they called for a more "holistic" approach which would focus on the whole plant,and on human factors in particular. Moreover, it criticized the emphasis on the safety design (construction) of a plant; instead it recommended a major focus be on the safety performance (operations) of plants. Indeed, the whole nuclear plant management system was found deficient. The investigations found that neither the **NRC** nor the industry had set up a system to evaluate systematically the operation of existing reactors and to identify potential safety problems. No mechanism was in place to assess the safety performance of nuclear plants or to collect, analyze, and learn from their operating experience. The Rogovin Commission pointed out that since 1971 there had been eleven events of a **TMI**-type, and two of them were very similar to what happened at **TMI.** These situations had been broadly analyzed; yet those analyses had not been widely disseminated.[15]

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[14] See U.S. President's Commission on The Accident At Three Mile Island Report, 1979; U.S. NRC Special Inquiry Group Report, 1980, Vol. I; Wood, 1983.

[15] These events involved the Westinghouse reactor in Switzerland in 1974 and the Toledo Edison's Davis Besse plant in Ohio in 1977. See Rees, 1994, 22; U.S. NRC Special Inquiry Group Report, 1980, Vol. I, p. 94; Weinberg *et al*, 1985,p. 134.

The **NRC** inspection policy was found very deficient. The **NRC** inspectors relied on licensees to report their own safety problems. The whole inspection policy was just to validate the internal inspection process of the licensees.[16]

Consequently, in order to improve nuclear safety regulation, it was suggested that programs be developed for the qualification and training of operating personnel. At the same time, it was recommended that nuclear plant inspections be improved and that a program be established for the systematic assessment of experience and safety performance in operating reactors.

A New Path In Nuclear Safety Regulation

The Transformation of the Nuclear Regulatory Commission

Following the recommendations of the Kemeny Commission, and in an attempt to respond to all the criticisms that the **TMI** investigations had brought forth, the **NRC** developed the "TMI Action Plan".[17]

The TMI Action Plan transformed and combined all the recommendations and the regulatory ideas which had been discussed after the accident into discrete elements. It also scheduled tasks and specified a sequence of actions that should be attempted to gradually increase improvement in nuclear safety.[18]

The TMI Plan stressed different areas of action but the most significant, where most of the recommendations and criticisms were combined, involved **NRC** organization and procedures and nuclear plant safety performance. The plan called for improvements in operator training,the inspection of operating reactors, the analysis and dissemination of operating experience, and changes in **NRC** organization and management. Basically, the **NRC** agreed with almost all of the criticisms directed at it after the **TMI** accident.

The NRC Reorganization

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[16] See U.S. GAO Report, 1978, and U.S. NRC Special Inquiry Group Report, 1980, Vol. I, p. 95.

[17] U.S. NRC, *Action Plan Developed as a Result of the TMI-2 Accident*, May 1980. See also, U.S. NRC, *Clarification of TMI Action Plan Requirements*, NUREG 737, Washington D.C., November 1980.

[18] The NRC combined all recommendations - studies and investigations on TMI which produced more than 1,000 recommendations - into the TMI Action Plan, which comprises 347 detailed actions covering plant design, operation and emergency preparedness. The Plan implementation has consumed most of the NRC's resources since TMI. As of early 1983, the NRC had been largely successful in implementing the TMI Action Plan: 90% of the 198 priority items and 45% of the other 149 items had been implemented or were in the process of implementation.See Weinberg *et al*,1985, p. 19

Several reorganizations took place within the **NRC** to meet the **TMI** recommendations. The President's Reorganization Plan #1 of 1980 established new organizational units and offices in order to perform new regulatory activities and implement the TMI Action Plan. (See Fig. # 2 in Appendix).

NRC management

The criticism involving the weakness of **NRC** leadership and management was addressed by the President's Reorganization Plan of 1980 which strengthened and clarified the authority of both the **NRC** Chairman and the Executive Director for Operations (EDO). While the **NRC** Commissioners would retain formal responsibility for policy formulation, rule making and adjudication, the Chairman would be responsible for responding to nuclear emergencies and be required to keep the Commission fully informed about all matters. The Chairman would delegate to the EDO all administrative functions; and the EDO had to report to the Chairman in all matters. The heads of the program offices would report directly to the EDO.

Inspections and Investigations

As a result of the **TMI** accident, major changes took place also in the organization of the **NRC** functions of investigation, enforcement and inspection. In 1982, a new Office of Investigations was established in the staff at the Commission to unify responsibility and to carry out investigations of allegations about reactor plant safety.[19] The Office was later moved to be under the responsibility of the EDO.

The already existing Office of Inspection and Enforcement was broadly strengthened. The percentage of the **NRC** staff in the Inspection and Enforcement Division increased from 20.9% in 1975 to 32.8% in 1986. In 1987 a split was made in the Office in order to strengthen both **NRC** enforcement and inspection policies. A separate Office of Enforcement was established, and the Division of Inspection became part of the Office of Nuclear Reactor Regulation.

Human Factors

In order to meet the criticisms made after **TMI** , the President's Reorganization Plan established a Division of Human Factors Safety within the **NRC** Office of Nuclear Reactor Regulation. The new Division has concentrated on the problems represented by the human element in nuclear plant operation, and its work has provided an increased emphasis on the

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[19] See Weinberg, 1985, p. 202; U.S. NRC *Annual Report*, 1982.

"people oriented" aspects of reactor safety. It has developed a great number of new requirements for the licensees to satisfy, both in nuclear plant control room design and in operator training.

The Division of Human Factors Safety was initially staffed by 30-40 newly recruited people. The new recruitment brought into the division somehuman factors engineers and engineering phychologists. Some traditional engineers were retrained in order to develop human factor competencies.[20] Over the years, due to the fulfillment of most of its tasks (one-time reviews of the existing regulation) and the consolidation of the Institute of Nuclear Power Operations (see paragraph # 4.2), the Division has been reduced to a Human Factor Assessment Branch, with eleven people on the staff.[21]

Nuclear Plant Safety Performance

An Office for Analysis and Evaluation of Operational Data (**AEOD**) was established to conduct systematic and rigorous analysis of the performance of nuclear plants and their operating experiences, in order to detect trends and identify safety problems. The size of the **AEOD** has increased over the years, reaching a staff size of one hundred. Its area of competency has been mainly in engineering. It also has been responsible for the technical training of its own personnel.

The **AEOD** through its Safety Program Division carries on independent analyses of nuclear plant safety performance. It also performs training programs for **NRC** personnel through its Technical Training Division, and it is in charge of the incident response program (Incident Response Division). In order to perform these functions, it manages both the Technical Training Center and the **NRC** Operations Center. It collects its data and information through daily contact with the nuclear utilities and the **NRC** inspectors. To do so, it works in cooperation with the Office of Nuclear Reactor Regulation which manages the program of inspections.

The major achievements of the **AEOD** have been the development of the **NRC** information and communication system, and the organization of the **NRC** emergency response system. On the basis of its systematic analyses, the **AEOD** has issued several reports and policy suggestions to the Executive Director for Operations.

Budget & Recruitment

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[20] Interviews of J. McDermott, Deputy Director, Office of Personnel, U.S. NRC, Washington D.C., November 1995, and of C.Thomas, Chief of the Human Factor Assessment Branch, U.S. NRC, Washington D.C., December 1995.
[21] Interview of C.Thomas, Chief of the Human Factor Assessment Branch, U.S. NRC, Washington DC, December 1995.

These changes in the organizational structure of the **NRC** came along with changes in budget and recruitment. Between 1979 and 1982, the budget of the **NRC** increased by 42%. It went from $326 to $466 million. **NRC** personnel increased by almost 30%, moving from 2,691 to 3,468.

In recruitment, the **NRC** looked for competencies that were able to meet the new requirement. They mainly hired scientific and technical personnel with generalist backgrounds and human factor orientations. Most of them, especially in the Division of Inspections, came from the U.S. Navy, where the approach to nuclear safety had developed along a different path, with more focus on nuclear reactor operations and management:

> *We recruited broad gadgeted nuclear people rather than highly specialized people . . . not necessarily nuclear engineers, more generalist people . . . we looked for people who had experience in nuclear operations. You find these people either at the commercial nuclear plants, or in the Nuclear Navy. We recruited very strongly from the Nuclear Navy, both military and civilian personnel . . . We got in a major conflict with Rickover, because we were hiring all the best of his staff - all the gifted engineers. They were ideal. They were already inspectors, they knew how to check safety in a submarine. We hired lots and lots of them.*[22]

New regulatory programs

The most interesting manifestations of the new **NRC** regulatory strategy, developed as a result of the **TMI** accident, have been the Systematic Assessment of Licensee Performance (SALP) program and the Inspection Program. Both of them synthesize different and interconnected regulatory activities, and both are expressions of a safety strategy more holistic and focused on nuclear plant management and performance. Both of them are performed by the Office of Nuclear Reactor Regulation in the Division of Inspection and Support Programs.

The SALP Program represents the **NRC** response to post-TMI recommendations and criticisms concerning deficiencies in operational safety evaluation.[23] SALP is based on day-to-day monitoring of operating experience, and it is the principal **NRC** method for judging the safety performance of licensees. It is intended to "further NRC's understanding of the way in which the licensee's management guides, directs, evaluates and provides resource for safe plant operations, and the effectiveness of these actions".[24]

[22] Interview of J. McDermott, Deputy Director, Office of Personnel, U.S. NRC, Washington D.C., November 1995.
[23] See US NRC, *SALP History*, Office of Nuclear Reactor Regulation, US NRC, Washington DC
[24] U.S. NRC SECY-90-189, *Reevaluation of the SALP Program*, 25 May 1990.

SALP is a structured process for the operational safety review of licensees. The review develops over an extended period of time. The normal length of a SALP assessment period is about 18 months, and is based on information gathered from different sources (inspection findings, reported events, and other inspection-related information) in four functional areas: plant operations, maintenance, engineering, and plant support.[25] The safety review is carried out by a SALP Board, composed of **NRC** senior managers. The Board meets and, on the basis of different data and information, discusses safety issues regarding the specific plant under observation. Those analyses, observations and findings culminate in the SALP plant-specific report, a public written document which is discussed with the licensee. On the basis of the review, a rating is assigned reflecting the quality of the safety performance of the licensee. Superior performing plants (category 1) automatically receive a 24-month SALP assessment period and are considered for reduced inspections. Those plants which present only an acceptable level of performance (category 3) are given a 12 month SALP period and are considered for increased inspections.[26]

The **NRC** Inspection Program has been largely expanded after the **TMI** accident, particularly through the use of resident inspectors. The annual number of reactor inspections done by the **AEC/NRC** went from about 500 per year in the 1970s to 3,000 per year in the 1980s (Baumgartner - Jones, 1991).

The Resident Inspector Program has been designed to ensure that the utilities identify and resolve safety issues before they affect operational safety. It was established shortly after **TMI**, and it provides at least two resident inspectors, working full-time, in each of the 109 U.S. nuclear plant sites (nuclear reactors). The program has increased the **NRC** knowledge of the conditions of operational safety and provides a better technical base for regulatory actions. The resident inspectors are in daily communication with **NRC.** They report every significant event that happens at a plant, as well as the finding of their onsite inspections.

> *The idea of resident inspectors was to have them there for a more holistic approach to the safety of the plant. More attention to detail . . . The Resident Inspector Program was a major step for the agency to take.*[27]

The Resident Inspector Program has been the most significant change in the inspection policy of the **NRC**. However, other inspection activities have been developed and refined after the **TMI** accident. Among them is the Diagnostic Evaluation program, established in

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[25] For detalis see U.S. NRC, *Highlights of SALP Program*, BP8, July 1995; US NRC, SALP directive 8.6, revised January 27, 1995.

[26] The final rating for each functional area is a composite rating of the performance evaluated in each functional area. Also category 3 is an acceptable level of safety performance, just less excellent. If the plant does not present an acceptable level of safety performance, it goes to the "watch list", and it is taken under continuingobservation. Interview to D.Gasperoni, SALP Program Manager, Office of Nuclear Reactor Regulation, U.S. NRC, Washington D.C., Novemember, 1995.

[27] Interview of J. McDermott, Deputy Director, Office of Personnel, U.S. NRC, Washington D.C., November 1995.

1987, which is based on "team" supplemental inspections to diagnose specific problems that the evaluation of the licensee's safety performance might have brought to light.[28]

Both the SALP and the Inspector Programs have developed as a result of **TMI**, as actions to solve the deficiencies which had been identified in the **NRC** regulatory function. Both programs are expressions of a new approach to nuclear safety, more holistic and diagnostic, based on direct inspections and systematic operational experience assessment through day-to-day monitoring of operating reactors. They have been credited for the improvement of the quality of the **NRC** regulatory decisions, with more focus on the reality of nuclear plant management and operations than had been involved in earlier procedures (Rees, 1994; Weinberg *et al.*, 1985).

The Institute for Nuclear Power Operations

The Institute for Nuclear Power Operations (**INPO**) is considered the most interesting institutional change in nuclear safety since the **TMI** accident (Rees, 1994). Born nine months after the accident, it is funded by the large industrial institutions that own and operate all the nuclear power plants in the U.S.[29]

The nuclear industry's assessment of **TMI** concluded that nuclear utilities were individually and collectively responsible for achieving higher safety standards in the construction and operation of their nuclear plants, and that to accomplish these goals, merely satisfying the NRC regulatory requirements was not enough.[30]

The **INPO** was created to act as both helper and watchdog for the member utilities. Its key executives and managers were recruited from the U.S. Nuclear Navy, and its original mission was to assist members in safer reactor operation. Besides that, **INPO** has succeeded in making the nuclear industry less fragmented, obtaining higher levels of safety performance, and exercising "quasi-governmental functions" (Rees, 1994; Weinberg *et al.*, 1985).

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[28] These NRC inspection teams, composed of twenty inspectors each, spend from six to eight weeks at the plant diagnosing problems in nuclear safety practices. See Rees, 1994, p. 33. Interview of J. Rees, Washington DC, October 1995.

[29] INPO's constitutency includes all the 54 nuclear licensees in the U.S.; utilities and utility organizations representing 13 countries outside of the US; and 14 major nuclear supplier organizations from the US, Canada and abroad. Together INPO's member and participant utility organizations represent 73% of the world's operating reactors. INPO's budget is nearly $54 million. Testimony of W.Conway, Group Vice President, INPO, "Nuclear Regulatory Commission Oversight", Hearing before the Subcommittee on Nuclear Regulation of the Committee on Environment and Public Works. US Senate, 100° Congress, October 8 and 20, 1987. See also Rees, 1994.

[30] Testimony of W.Conway, Group Vice President, INPO, "Nuclear Regulatory Commission Oversight", Hearing before the Subcommittee on Nuclear Regulation of the Committee on Environment and Public Works. US Senate, 100° Congress, October 8 and 20, 1987.

INPO has mobilized an industry-wide effort to systematically collect, analyze and share among all the utilities the operating experience with safety related problems. **INPO** has set up an Information Network for Evaluating Significant Events (SEE-IN program). They get notified of Significant Events, i.e., those events that are considered significant to nuclear safety or plant reliability. Significant Operating Experience Reports are disseminated to all the utilities. Through these programs **INPO** has reduced the fragmentation of industry experience and has created a mechanism for learning from it.[31] Moreover, **INPO** has developed a partnership with the **NRC**, based on *memorandums* of agreements, and it has accredited *all* the nuclear training programs. In 1983, **INPO** set up the National Academy for Nuclear Training, and within it has developed twelve training programs, addressed to nuclear plant operators, managers and technicians.[32]

Even though **INPO** was not created to supplant the regulatory role of the **NRC**, it has been a successful self-regulatory body. Through its training programs, plant inspections, and SEE-IN program, it has succeeded in institutionalizing nuclear safety responsibility among its members (Rees, 1994). **INPO** has been given credit not just by the **NRC** but also by the Union of Concerned Scientists. This is a well known group of scientists opposed to nuclear power, which through a representative, stated "INPO is doing the job that the NRC inspectors ought to be doing".[33] As a matter of fact, the partnership between the **NRC** and **INPO** has raised several and controversial questions about the possible **NRC**'s "abdication" of regulatory responsibility to **INPO**.[34]

A new institutional arrangement

Nuclear safety regulation has changed after the **TMI** accident, and because of it. In many ways, the entire institution of nuclear safety has changed. Several new safety issues which have received attention and resources were not even discussed before **TMI**, including operator training, management of safety performance, systematic analysis of operational experience, and learning from significant events. A different and more holistic culture has developed in nuclear safety regulation based on an increased awarness of the complex

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[31] Before TMI the US nuclear industry was very fragmented. There was little coomunication and no operational experience sharing among the utilities. The whole industry was composed by some 140 reactors (70 in operation and 70 under construction) manufactured by four vendors, engineered by over a dozen architect-engineers, constructed by some 20 contractors, and operated by about 60 utilities. See Rees, 1994; Weinberg *et al*, 1985.

[32] The National Academy for Nuclear Training was actually created in 1985, but the training system and program was established in late 1982 (Rees, 1994,p. 220). Some of INPO's training programs are more operational oriented, other more maintenance and are more technically oriented. Interview of C.Thomas, Chief of the Human Factor Assessment Branch, U.S. NRC, Washington D.C., December 1995.

[33] Robert Pollard, a former NRC inspector now with the Union of Concerned Scientists. Reference from Rees 1994, p.10.

[34] See Hearings before the Subcommittee on Nuclear Regulation of the Committee on Environment and Public Works. US Senate, 100° Congress, October 8 and 20, 1987; Rees, 1994; U.S. GAO Report, 1991. See also *Inside N.R.C.*, Vol. 1, November 19, 1979; Vol. 12, April 23, 1990; Vol. 16, December 12, 1994.

interaction between human and technological factors in operating nuclear reactors. The focus has shifted from the engineering safety of nuclear plant design, to the evaluation and management of nuclear plant safety performance. New assumptions, new organizations, and new regulatory programs have been developed as a result of **TMI**.

All this has led to higher levels of nuclear safety performance, as it has been broadly recognized.[35] Yet, it would be hard to assess how much of this change and improvement, is connected to the **NRC** and how much to **INPO**.

The **NRC** has transformed itself through several changes. It has developed new programs, established new offices, and recruited more highly competent staff. It has developed a new approach to nuclear safety, through both the acknowledgement of the flaws of its previous "mindset", that is, the myth of "engineering safety" and through its recruitment from the US Navy where a different safety culture and approach had been developed.[36]

Change within the **NRC** has also been pushed by the change which has developed in its institutional environment after the **TMI** accident. Given the economic impact of **TMI** and the subsequent dropping in nuclear plants construction and license applications, the mission of the **NRC** has shifted from evaluation of construction permits to the regulation of a stable, mature, and declining industry.

> *We shifted from an organization whose main line of business was licensing new power plant to one whose main line of business is mainly or exclusively overseeing nuclear plant operations in existing plants.*[37]

The break in industrial expansion, and, consequently, the drop in the **NRC** licensing workload has helped the **NRC**'s new focus on nuclear safety performance and management.

The **INPO** has moved in the same direction as the **NRC**. It was set up as a reaction to the economic problems, the pressure for regulatory change, a peak in the mobilization of the antinuclear movement, and the decline of public acceptance that overwhelmed the nuclear industry after **TMI**. In order to meet such challenges, **INPO** has developed training and operational safety programs, and has mainly recruited its skills and competencies from the US Navy, as the **NRC** has done. In this sense, **INPO** and the **NRC** share a common interest

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[35] As a matter of fact, several safety requirements have been met, and there is general agreements that the levels of nuclear safety performance are higher today than they were before TMI. Evidence can be found in the evaluation ratings of the SALP program. Interview of D.Gasperoni, SALP Program Manager, Office of Nuclear Reactor Regulation, U.S. NRC, Washington D.C., Novemember, 1995. See also Rees, 1994; Morone and Woodhouse, 1989; Watkins, J. 1990; Weinberg *et al.*, 1985; U.S. Congress OTA Report, 1984.

[36] Interview of J. McDermott, Deputy Director, Office of Personnel, U.S. NRC, Washington D.C., November 1995. See also Gilinsky, 1992,p. 706.

[37] Interview of J. McDermott, Deputy Director, Office of Personnel, U.S. NRC, Washington D.C., November 1995.

and mission, that is, safety and reliability in the operation of nuclear plants, as well as to a certain extent, a common language and safety approach coming out of an engineering and Nuclear Navy background.

Besides the condition of identity-sharing in mission, culture and, safety approach, the**INPO** and the **NRC** have a shared need for mutual collaboration. This provides a basis for the **NRC-INPO** partnership. The **TMI** accident impacted strongly and negatively, both the **NRC** and the nuclear industry. The new task of nuclear safety regulation, as it came out from the **TMI** investigations and recommendations, was too tough to be performed just by the **NRC**. To check and monitor the 109 U.S. nuclear reactor sites in detail requires an incredible amount of resources.

Moreover, there was the fragmented and not standardized nature of the US nuclear industry, with each utility having a different plant design. Thus, standards of *excellence* (higher than minimum requirements) in safety performance could hardly be developed and mandated by the**NRC**. At the same time, given the economic and institutional shock produced by **TMI**, the nuclear industry had to take direct action in order to guarantee its survival, which was seriously questioned.[38] Following the Kemeny Commission recommendations, **INPO** changed the attitude of the nuclear industry toward safety and improved its regulation.[39]

A Memorandum of Agreement between the **NRC** and **INPO** was first signed on June 1, 1981, and it has been continually revised in order to coordinate the regulatory functions of the two agencies. **INPO** has been in charge of all the training programs for the nuclear industry. The **NRC** participates in the meetings of the **INPO** Accreditation Board where training issues are discussed, and also oversees the **INPO**'s plant inspections.[40] Moreover, on several issues the **NRC** has refrained from regulating nuclear industry management practices and has embraced, implicitly or explicitly, **INPO**'s regulatory guidelines and programs.[41]

> *INPO is a change. Before TMI there was no INPO. We are now allowing the industry to do things that before we would not have allowed . . . As long as INPO does a good job, it is fine. Industry initiatives are welcome*

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[38] See Allison and Carnesale, 1983; Christian, 1993; Freudenburg-Rosa, 1984; Goldsteen-Schorr, 1991; Jasper, 1990; Morone-Woodhouse, 1989.

[39] U.S. President's Commission On The Accident At Three Mile Island Report, 1979, p. 68.

[40] Interview of C.Thomas, Chief of the Human Factor Assessment Branch, U.S. NRC, Washington D.C., December 1995. For details about the INPO's plant inspections, conducted by peer evaluators, see Rees, 1994,p. 220.

[41] In 1980 NRC prepared a draft for "Guidelines for Utility Management Structure and Technical Resources" but in 1983 it abandoned these efforts and endorsed INPO's regulatory program. In 1982, the NRC recognized the INPO Significant Events Analysis and Information Network program (SEE-IN) by issuing Generic Letter No. 82-04. The NRC recognized INPO's Nuclear plant Reliability Data System (NPRDS) in July 1983. In 1988 the NRC took a step toward developing a comprehensive maintenance rule for the nuclear industry; but in 1989 it embraced INPO's maintenance program as an industry standard. See Rees, 1994, p. 38, p. 196.

> . . . *We have a day-to-day relationship with INPO, where we do not regulate them, we regulate the licensees, but we do it through INPO.*[42]

Nevertheless, the relationship between the **NRC** and **INPO** has not been only cooperative. The basic difference beteween the two agencies has never been forgotten: the **NRC** is the statutory *regulator* for nuclear safety, while **INPO** is a private industrial self-regulating body, a representative of the *regulated*. The **NRC** does have legal authority over nuclear utilities, meaning it can shut down a nuclear plant if it is judged unsafe. In other words, the **NRC** has tools to enforce its regulations, and this power is feared by the utilities.[43] **INPO**, in contrast, is an organization sponsored by the nuclear industry, and this raises skepticism regarding its autonomy. Moreover, it has been shown that **INPO** cannot exert sufficient pressure to bring the industry's poorer performers into line. Lacking statutory authority, **INPO** can at best just suspend their membership (Rees, 1994; Weinberg *et al*., 1985).

Given these differences in the**NRC** and **INPO**'s roles and functions, the relationship between the two agencies reveals itself as far more complex than simply one of cooperation. It has been developed on the basis of a constant tension and process of negotiation, in order to combine the two different, complementary, but also overlapping jurisdictions.[44]

The current institutional arrangement for nuclear safety regulation is different than the one in place beforethe **TMI** accident. The new arrangement is mainly an expression of the negotiation between two regulatory institutions. The nuclear industry does not rely just on the **NRC** for nuclear safety regulation anymore; and it is undeniable that **INPO** has contributed to change and has improved nuclear plant safety performance. The new institutional arrangement is based on a different approach to safety regulation, which deals with new safety issues, and which shows a new way to focus on them through nuclear plant safety performance. Finally, the new institutional arrangement has developed in a different institutional context, characterized by the stabilization and the possible decline of the nuclear industry. The **NRC** has shifted its mission from the licensing of, to the monitoring of nuclear plants; consequently, most of the regulatory issues connected to the licensing process and the construction of nuclear plants have lost importance.

The Old Path In Nuclear Safety Regulation

Organizational Persistences

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[42] Interview of C.Thomas, Chief of the Human Factor Assessment Branch, U.S. NRC, Washington DC, December 1995.
[43] See Rees, 1994; U.S. NRC, NUREG 1395, 1990.
[44] Interviews of J. Rees, Washington D.C., October 1995; and to C.Thomas, Chief of the Human Factor Assessment Branch, U.S. NRC, Washington D.C., December 1995.

Both the Kemeny and the Rogovin Commissions strongly recommended the abolition of the five-member commission structure of the **NRC** and the establishment of a new executive agency headed by a single administrator. They also suggested establishing a Nuclear Safety Committee to oversee and guide **NRC** safety policy. These suggestions were supposed to strengthen and improve **NRC** policy, management and organization, which had been found very deficient. As said already, the regulatory staff had been found to be completely separate from the Commission, and there was no overall **NRC** safety policy.[45]

Yet, such a recommended radical change never took place. The Commission structure has never been abandoned and a Nuclear Safety Board or Committee, has never been established. As a result, the **NRC** nowadays still has the same weak collegial leadership, the same lack of internal coordination and the same nuclear safety policy that was denounced after the **TMI** accident.

The origins of these persistences, or resistences to radical change, have historical roots. They go back to the predecessor of the **NRC**.

When the **AEC** was created in 1946 to promote the development of nuclear power, the commission structure was chosen for three main reasons:to have diversity of opinion in the process of development of the new technology, to have public accountability given the secret nature of some nuclear military decisions which were part of the **AEC**'s jurisdiction, and to guarantee policy continuity in the maintenance of nuclear power technology, despite fluctuations in political environment (Klein, 1981).

As we have seen, it was only in 1954, when the commercialization of nuclear power began, that in order to regulate the developing industry, a regulatory division was established within the **AEC**. That division was a small component of the agency, and it developed physically and functionally separated from the promotional arms of the **AEC**.[46] Given the potential conflict of interest between the promotor and regulator role of the **AEC**, it was felt that by keeping separate the regulatory staff from the rest of the agency, impartiality could be ensured. A strict *ex-parte* rule was put in place to prevent the involvement of the **AEC** Commissioners in licensing matters before they were asked to deliberate in their adjudicatory function. By separating the staff reviewing of a license application from the Commission and prohibiting informal communication, conflict of interest charges were likely to arise

[45] The agency was defined "unmanaged and unmanageable". It was not clear from NRC organizational chart which office was actually responsible for day-to-day management of the agency. See U.S. NRC President's Commission On The Accident At Three Mile Island Report, 1979; U.S. Special Inquiry Group Report, 1980, Vol. I.

[46] The total AEC employment in the 1960s was around 7,000 entities, and the regulatory staff in 1964 had just 339 entities. The two staff were housed in two separate locations: respectively, in downtown Washington D.C. and in the Maryland suburbs. See Walker, 1992, p. 339.

(Rolph, 1979: 40). Such decisions started a trend that isolated the Commissioners more and more from the actual business of regulation (Wood, 1983).

In 1974, the **NRC** was created out of the **AEC** to be an independent regulatory agency without any promotional role, thereby removing the potential for conflict of interest.[47] Yet, the ex-parte rule and the Commission structure were retained by the **NRC**. As a matter of fact, the regulatory bureaucracy of the **AEC** was transferred almost intact to the new agency: the **NRC** kept the same organization and procedures, and it was mostly staffed by those who had staffed its predecessor.[48]

The Commission structure, and moreover the separation between the Commission and the regulatory staff, lost its meaning completely in the transition from the **AEC** to the **NRC**. The **NRC** was only a regulatory agency, without any responsibility for nuclear power development or nuclear military policy. Consequently, guarantees for diversity of opinion and public accountability at the very top of the **NRC** organization, were not necessary anymore, as well as a separation between the Commission and the executive staff. The only reason that could still support a collegial leadership was to guarantee "policy continuity".

The five member Commission structure, as well as the *ex-parte* rule, were denounced for being completely inefficient and senseless after **TMI** accident. The Presidential Reorganization Plan, which was implemented to meet the **TMI** recommendations, strengthened the role of both the Chairman of the Commission and the Executive Director of Operations. Yet it did not take the radical step of reorganizing the **NRC**into a single administrator agency, abolishing both the commission structure and the separation with the executive staff. Instead, the reform took place "within the existing agency".[49] As a result, the Commission and the staff under the Executive Director for Operations remained organizationally distant. (See Fig. # 2 in Appendix).

Over the years, the progressive shift in the mission and function of the **NRC** has made the five-member Commission structure and its separation from the executive staff even more inefficient and senseless:

> *In 1954 when Congress enacted the Atomic Energy Act, a collegial body was a sound structure to formulate licensing procedures and resolve the licensing and policy issues arising from the development of this highly complex new technology. In 33 years much has changed. The workload*

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[47] As we have seen, following more and more criticisms concerning its double statutory function, the AEC was abolished and split into two part by the Reorganization Energy Act of 1974: the Department of Energy for the promotional activity, and the NRC for the regulatory function.
[48] See Aron, 1982; Gorison et al., 1979; Rolph, 1979; Temples, 1982.
[49] U.S. NRC, 1979, NUREG - 0632.

> *of the NRC has shifted form evaluation of construction permit and operating license applications to the regulation of a maturing operational industry. A single administrator can maximize the effectiveness of NRC's resources.*[50]

Between 1987 and 1989, several congressional hearings discussed the restructuring of the **NRC** into an independent executive agency headed by a single administrator appointed by the President. The intent was to make substantial improvements in nuclear regulation effectiveness and in day-to-day operation plants monitoring. Many reorganization bills were proposed. All of them failed, without any convincing argument in terms of organization and management of the **NRC**.[51]

> *I believe the record amply demonstrates that the NRC is a collegial body that rarely makes its most important decisions collegially . . . The simple fact that less than 10% of the decisions that have come from the agency during the past 3 years can be attribuited to collegial discussions occurring in an open meeting with a majority of the commissioners present. Accountability and effective consistent regulation are big answers to the problems of the nuclear industry, and I do not believe that effective and consistent regulation is possible in the context of the commission form of goverment.*[52]

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[50] Testimony of Lando Zech, Chairman of NRC, "Proposals To Reorganize The Nuclear Regulatory Commission", Hearing before the Subcommittee on Nuclear Regulation of the Committee on Environment and Public Works. US Senate, 100° Congress, October 29, 1987

[51] A list of the proposed bills follows. The Independent Nuclear Safety Board Act of 1987 (S.14), to amend the Energy Reorganization Act of 1974 to provide for Presidential appointment of an independent Nuclear Safety Board for review of nuclear power plant licensing and regulatory policies and investigation of nuclear accidents at NRC-licenced facilities. The Improved Nuclear Standards Act (S.100) and similar Inspector General Act Amendments (S. 908; S. 1769) of 1987, all to amend the Inspector General Act of 1978 to establish an Office of Inspector General in NRC. The Nuclear Regulation Reorganization Act (S. 1770) of 1987, to amend the Energy Reorganization Act of 1974 to replace NRC with an independent Nuclear Regulation Agency headed by a single administrator appointed by the President. Another draft bill was reported by the Senate Committee on Environment and Public Works on March 29, 1988 (consistent with the bills proposed in 1987) and discussed in Hearing before the Committee on Governmental Affairs. US Senate, 100° Congress, April 27 and May 12, 1988. The Nuclear Regulation Reorganization and Reform Act of 1989 (S. 946) to amend the Reorganization Act of 1974 and the Atomic Energy Act of 1954 to replace the NRC with an independent Nuclear Safety Agency headed by a single Administration, and establish an independent Nuclear Reactor Safety Investigations Board within the Agency to investigate significant nuclear safety incidents.

For arguments in favor or against the reorganization, see also Testimony of A.Dean - Chairman of the Standing panel on executive Organization and Management of the National Academy of Public Administration; "Proposals To Reorganize The Nuclear Regulatory Commission", Hearings before the Subcommittee on Nuclear Regulation of the Committee on Environment and Public Works. US Senate, 100° Congress, October 29, 1987; and Testimony of D.Peach, Assistant Controller General, U.S. General Accounting Office, "Restructuring of The Nuclear Regulatory Commission", Hearings before the Committee on Governmental Affairs. US Senate, 100° Congress, April 27 and May 12, 1988.

[52] Senator J.Breaux, Chairman of the U.S. Senate Environment & Public Works Subcommittee on Nuclear Regulation, on May 9 1989. From, *Inside N.R.C.*, Vol. 11, May 22, 1989.

In 1988 the Senate succeeded in passing a piece of legislation to reorganize the **NRC** into an agency with a single administrator. However, the House of Representative did not act.[53] The main argument against the new legislation was still that of policy continuity.

> *If you had a President that had strong antinuclear views, your industry would be better served by a Commission . . . I would certainly think very hard about who that individual would be, whose hands your industry would be in following, appointed by the president and confirmed by the Senate.*[54]

The congressional hearings and the proposed bills for the restructuring of the **NRC** also discussed the establishment of a Nuclear Safety Board as an independent body to oversee safety issues and give policy recommendations. Such a proposal had been discussed since the **TMI** recommendations, when there was discovered a need for both an investigation body on **NRC** performance, and an advisory body for the development of an overall safety policy.

A Nuclear Safety Oversight Committee was actually set up by President Carter in 1980 to monitor and review the **NRC** implementation of the Kemeny Commission's suggested reform. The Committee later reported that despite some genuine efforts at self-criticism and reorganization, the **NRC** still suffered from "fundamental problems of leadership and responsibility," lacked "an underlying regulatory philosophy" and presented a "business-as usual mindset" (Temples, 1982:359). In 1981 the Committee was abolished. The new administration (President Reagan) said that the Committee's work was completed and its responsibilities could be more appropriately handled by a science adviser.[55]

Both the **NRC** and the nuclear industry have never recognized the need for establishing a Nuclear Safety Board. The **NRC** has strongly advocated that such Board, if established, "should become part of the agency rather than a separate federal body".[56] Moreover, according to the **NRC**, functions of investigation and policy recommendation have been already performed by both the **AEOD** and the Office of Investigation established after **TMI**. Therefore, there is no need for a Nuclear Safety Board. Yet, both the **AEOD** and the Office of Investigation have displayed a confused independent investigatory role. They have been

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[53] In 1988 the Environment & Public Works Committee of the U.S. Senate passed the NRC Reform Bill by a margin of 89 to 6. The U.S. House Energy & Commerce Committee did not pass it. On may 9 1989 a new bill was introduced at the U.S. Senate by J. Breaux, Chairman of the Environment & Public Works Committee. It was not approved. From, *Inside N.R.C.*, Vol. 10 & 11. See also Davis, 1988.

[54] Rep. J.Dingell, Chairman of the U.S House Energy & Commerce Committee. From *Inside N.R.C.*, Vol. 10, May 9, 1988.

[55] The Nuclear Safety Oversight Committee's functions were transferred to G.Keyworth, President Reagan's new science adviser on Sept. 30, 1981. From *Inside N.R.C.*, Vol. 3. No. 14, July 13, 1981.

[56] Testimony of Lando Zech, Chairman of NRC "Proposals To Reorganize The Nuclear Regulatory Commission", Hearing before the Subcommittee on Nuclear Regulation of the Committee on Environment and Public Works. US Senate, 100° Congress, October 29, 1987

located under the Office of the Executive Director of Operations, not even in staff to the Commission, and it has never been clarified if they had to investigate the nuclear industry or the **NRC**, and to which exent.[57] The nuclear industry, through the Nuclear Energy Institute(the organization which leads the nuclear industry lobbying effort in the Congress) has strongly opposed the establishment of the Nuclear Safety Board, which would independently investigate significant incidents at nuclear plants.[58]

The Ambiguous Relationship Between Regulators and Regulated

The relationship between the U.S. government and the nuclear industry has been ambiguous since the beginning of nuclear power developement (Allison and Carnesale, 1983; Morone and Woodhouse, 1986). Consequently, the role of the nuclear power regulatory agency, especially that of the **NRC** after the **AEC**'s abolition has also been ambiguous.

Three early decisions, all in 1954, set up the path of the relationship between regulators and regulated: a) the federal government was charged with *both* the promotion and the regulation of nuclear power, and the two functions were housed within the same agency, the **AEC**; b) the regulation of nuclear energy was given to an agency, the **AEC**, which was dealing *exclusively* with nuclear power; c) the Atomic Energy Act, which broke the governmental monopoly on nuclear power, set up the *private* nature of the U.S. nuclear industry.

This arrangement persisted for 20 years (1954-1974), covering the formative years of nuclear power regulation (Allison and Carnesale, 1983). Several ambiguities developed from this situation. Three among them were that: the regulation for nuclear power developed separately from both the U.S. environmental protection policy and the U.S. energy policy; the nuclear industry developed privately, but under very strong governmental protection; and, the development of the regulation of nuclear safety was biased by the **AEC**'s promotional activities.

Within this arrangement, the **AEC** and the nuclear industry shared faith and enthusiasm for the rapid expansion of the new technology. The **AEC**'s regulatory mission was based on the pro-industrial assumption that "nuclear power, if properly regulated, was the viable source of energy for the nation" (Casamayou, 1993). The commonality of viewpoints between the **AEC** and the nuclear industry, relied on the statutory pronuclear function of the **AEC**, but it was reinforced by shared professional skills: nuclear "scientists and

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[57] "Nuclear Regulatory Commission Oversight", Hearings before the Subcommittee on Nuclear Regulation of the Committee on Environment and Public Works, U.S. Senate, 100° Congress, October 8 and 20, 1987. Interview of D.Ross, Deputy Director, AEOD, U.S. NRC, Washington D.C., December, 1995.

[58] From *Inside N.R.C*, Vol. 10, August 15, 1988.

engineers were talking to (nuclear) scientists and engineers" (Casamayou, 1993). This facilitated access by the nuclear industry to the Commissioners as well as communication between the regulators and the regulated (Brady-Althoff, 1973). Given the small size of the nuclear industry in those early years, informal working relationships between the **AEC** and the industry developed (Rolph, 1979). The nuclear utilities could count on the **AEC** to facilitate their development through pro-industrial licensing procedures and a stable regulatory climate.[59]

Several studies have shown the continuity between the **AEC** and the **NRC** in nuclear plant licensing and regulatory programs. This continuity made several observers denounce the persistent "promotional role" played by the new regulatory agency. The relationship between the pre-TMI **NRC** and the nuclear industry has been defined as one based on "mutual trust and sympathy".[60]

For example, a Common Cause study in 1976, found that most of the **NRC** staff personnel was recruited from the nuclear power industry.[61] It also found clear evidence of high-ranking **NRC** personnel moving to the regulated industry (Casamayou, 1993). This study portrayed the persistent promotional role performed by the new regulatory agency:

> *For while NRC's mandate was safety, its top priority was licensing nuclear power plants. Performance in the new regulatory agency tended to be measured in terms of how many licenses were granted and how fast the proceedings were closed.*[62]

As already said, most of the criticisms in the aftermath of **TMI** directed toward the **NRC** were based on finding the pro-industrial attitude of the **AEC**'s legacy. Critics denounced both the practice of unresolved safety issues in reactor licensing and the **AEC**'s policy of overreliance on industry data and voluntary self-regulation.[63]

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[59] During the early years of the nuclear power industry in the U.S., Congressional activity could not have been organized in a way more favorable to the industry. The Joint Committee on Atomic Energy (JCAE) was created by the Atomic Energy Act of 1946 and given unprecedented power. The JCAE assumed an strong role in advancing reactor development, and, along with the AEC, devised an elaborate structure of incentives to make nuclear power a tempting investment. As a matter of fact, it was abolished several years after the AEC because it was accused of promoting nuclear energy. See Baumgartner-Jones, 1991; Cook, 1980; Del Sesto, 1980; Fenn, 1981; Rolph, 1979; Temples, 1980; Walsh, 1988.
[60] See Casamayou, 1993, p. 146; Cook, 1980,p. 31. See also Jasper, 1990; Rolph, 1979; Temples, 1982; U.S. President's Commission On The Accident At Three Mile Island Report, 1979, p. 19.
[61] It found that 307 of the 429 senior officials at the NRC were hired from private industries with heavy involvement in the energy field. About 90% of them came from private enterprises holding license permits, or contract with NRC. See Kneier. A., *Serving Two Masters: A Common Cause Study of Conflict of Interests in the Executive Branch*, Washington D.C.: Common Cause, 1976.
[62] Victor Gilinsky, NRC's chairman, speech at Brown University, Nov. 15, 1979. Reprinted in *N.R.C. News Release*, Vol.5, No.35, October 2, 1979.
[63] See Temples, 1982,p. 336; U.S. GAO Report, 1978; U.S. President's Commission On The Accident At Three Mile Island Report, 1979.

After the **TMI** accident, several changes took place within the **NRC** and in its institutional enviroment. Yet the two radical changes which could have solved the persistent and denounced ambiguity in the relationship with the nuclear industry did not take place. The abolition of the Commission structure and the establishment of an independent Nuclear Safety Board, would have ended the easy access to the **NRC** and strengthened its regulatory identity and mission. Instead, the **NRC**'s identity has become even more confused. As a matter of fact, the **NRC** is a regulatory agency that deals exclusively with nuclear power, but without any statutory role for promoting the development and maintenance of that technology.

Currently, the **NRC** is not anymore asked to license nuclear plants, and its main activity is to monitor nuclear safety performance, and to provide standards and regulation. Given this picture, it could be asked why the **NRC** has not become part of the U.S. Environmental Protection Agency. In other words, what is the specificity of the **NRC**'s mission nowadays? Why is the regulation of nuclear power plants separate from that of chemical plants? Why is nuclear safety policy not developed within the environmental protection policy?

The partnership between the **NRC** and **INPO** has not helped in solving the ambiguous role of the **NRC,** and to a certain extent, has strengthened it. The limited regulatory role played by the governmental agency, nurtured by faith in industrial self-regulation, has not changed since the early day of the **AEC**, even though it has become more negotiated and formalized in the partnership with **INPO**.[64]

The **NRC**'s current mission seems more and more simply that of "policy continuity", or in other words, of a maintenance of the nuclear technology investment:

> *Congress established as a policy that we should preserve the nuclear option. That means do not regulate out of existence. Especially after TMI.*[65]

A whole set of common values between the **NRC** and the nuclear industry is behind this. And a pronuclear attitude is one of them. As a matter of fact, both the identity and the function of the **NRC** are persistently and completely committed to faith in nuclear power.

The Irreversible Demise of The Nuclear Industry

> *The failure of the U.S. nuclear power program ranks as the largest managerial disaster in business history. . . The utility industry has*

[64] Interview of J. Rees, Washington D.C., October 1995. See also Cook, 1980,p. 32; Donner-Ledbetter, 1988.
[65] Interview of J. McDermott, Deputy Director, Office of Personnel, U.S. NRC, Washington D.C., November 1995. See also Gavaghan, 1991.

> *already invested $125 billion in nuclear power, with an additional $140 billion to come. . . and only the blind, or the biased, can now think that most of the money has been well spent.*[66]

The **TMI** accident strengthened the demise of the nuclear industry, but this decline was already on its way. Economic studies on the origins of the U.S. nuclear industry decline show that the factors which locked-in the system developed in the 1960s: the choice to commercialize the light water-type reactor; the rapid scaling-up of reactor sizes; the too rapid commercialization of the new technology; and the competitive nature of the nuclear industry. A combination of economic choices and governmental choices, magnified by skyrocketing capital costs and declining demand for electricity before **TMI,** already froze the future of nuclear industry.[67] Between 1971 and 1978 nuclear capital costs increased by 142%, twice as much as the capital costs for coal plants. By 1974 the rate of new plant orders had declined dramatically, and by 1978 it was already down to zero (Komanoff, 1981: 2).

When the **TMI** accident occurred, the nuclear technology was already locked into a form that would reflect the values of the early days of nuclear power development: the faith in the new technology and in its quick development led to the too rapid commercialization of nuclear power; a U.S. promotional policy that led to the choice of the light water reactor, the most economically appealing but not the safest type; and the private nature of the nuclear industry which led to the too high market competition for the infant industry.

To reshape the system and the technology on the basis of the impact of the **TMI** accident would have required a radical change. Several economic studies suggested as the only way out of a stronger governmental role in nuclear power commercialization was a partial nationalization of the nuclear industry.[68] This could have lessened competition, standardized the technology, reduced the costs of safety, and improved its monitoring. Yet no radical change took place, and soon after **TMI**, the U.S. nuclear power became a "politically" unsafe technology, a source of fear and anxiety unaccepted by both the investor and the public (Morone and Woodhouse, 1989: 4).

Even though the safety performance of nuclear plants has improved a great deal in the past fifteen years, the path toward a demise has not broke down, and the decline of the U.S. nuclear industry seems irreversible. By the year, 2000, most of the operating U.S. nuclear reactors will be approaching 40 years of age, and their licenses will expire. So far, there has been just one application for licensing renewal. Several predictions project the year, 2020,

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[66] James Cook, "Nuclear Follies", *Forbes*, February 11, 1985, cover page.
[67] See Allison and Carnesale, 1983; Campbell, 1988; Morone and Woodhouse, 1989; Jasper, 1990; Weinberg *et al.*, 1985.
[68] Besides the previous references see also Marbach, *et al.*, 1987.

as the end of the U.S. nuclear industry.[69] After **TMI**, the **NRC** might have won the challenge of improving nuclear plant safety performance, but it could not have succeeded in making it accepted by the public or in turning nuclear power into a competitive source of power (Allison and Carnesale, 1983; Goodman-Andes, 1985). The lack of an overall safety policy, the weakness of the **NRC** leadership, and the ambiguity in the relationship with the nuclear industry have not helped (Cook,1982).

Institutional Change or Institutional Persistence?

The **TMI** accident represented an institutional turning point in the development of nuclear power in the U.S. It did develop a new path and a new institutional arrangement for nuclear safety regulation, inwhich both the **NRC** and **INPO** have played an important role. A better and more institutionalized environment for nuclear safety performance has been built, consisting of safety performance assessment, training of operators, management safety standards, and the collection, analysis and sharing of operating experience.

The whole system of nuclear safety regulation has moved from prescriptive engineering regulations to performance standards for operational safety . The concept of nuclear safety has changed, based on new assuptions and new rules. The **NRC** has been an important part of this change, moving from the taken-for-granted philosophy of engineering safety to an acknowledgement of the inadequacy and flaws of such an approach. Given the **TMI** accident, and in order to meet ensuing recommendations, the **NRC** has gone through a process of change which has led to the establishment of new offices, the recruitment of new competencies, the development of a new cultural approach, and the implementation of new regulatory programs.

Yet the institutional change manifested in the transformation of the **NRC** has not been radical. It has been mainly a process of change by patchwork, where persistent structures and persistent institutional arrangements developed in the early day of nuclear power regulation, have been patched up with new structures and arrangements.

To deal with new commitments and tasks, the new organizations and regulatory programs developed after **TMI** (such as the Office for Analysis and Evaluation of Operational Data, the Division of Human Factors Safety, the strenghtened authority of EDO and the Chairman, the Inspection Program and the SALP program) have been tacked onto the preexisting structure. But the structure as such has not changed and an overall safety strategy to provide a framework able to give strength and sense to those changes has not been

[69] Interview of J. McDermott, Deputy Director, Office of Personnel, U.S. NRC, Washington D.C., November 1995. See also Morone and Woodhouse, 1989; U.S. NRC, 1995, *Information Digest*, NUREG 1350, Washington, D.C.

developed. The **AEOD** has never been able to play its potential investigative and advisory role. The Division of Human Factors Safety has never developed training programs, and its role soon became that of overseeing **INPO**'s work.[70] The strenghtened authority of EDO and the Chairman has never overcome the separation between the agency's head and its regulatory body. Previous institutional arrangements have shaped the forms of the changes.

Given the development of **INPO** and its partnership with the **NRC**, the relationship between **NRC** and the nuclear industry has changed, becoming more institutionalized in its negotiation and cooperation nature, and more focused on the safety of nuclear reactor operations. Yet, the basic nature of the relationship between regulators and regulated, developed by the early choices in nuclear power regulation, has persisted. The **NRC**'s commitment to the nuclear industry's existence and nuclear technology maintenance has continued. The **NRC** does not play the same "promotional" role it used to, that is nuclear development regardless of safety, but it is still deeply committed to the continuity of nuclear power. Its own existence, history and mission are based on that.

The radical restructuring of **NRC** into an agency with a single administrator, overseen by an independent Nuclear Safety Board, was strongly recommended after the **TMI** accident. Such a radical change, the abolition of the existing agency and a replacement of it with a new one, would have provided a clearer regulatory role for **NRC** in its relationship with the nuclear industry, and a more explicit and defined safety policy and agency strategy. That would have had a positive impact on **NRC**'s loss of credibility and public trust. Moreover, it could have helped to provide a better monitoring of the complex array of factors affecting the demise of nuclear industry. However, such a radical restructuring process would have required high disinvestments (sunk costs), led to high conflict and uncertainty for alternative arrangements and future implications (Genschel, 1995).

As Genschel says,[71] the reasons for preventing radical institutional change can be found in internal resistences due to sunk costs, uncertainty and conflict. Aron (1982), in his study on the **NRC**'s reorganizations, portrays how uncertainty concerning expected results, continuity in professional interests, and the fear of losing autonomy by internal organizational divisions have characterized both of the two reorganizations the **NRC** has gone through. There was the one of 1974, which split the **AED** and established the **NRC**, and the one of 1980 which was a response to recommendations resulting from the **TMI** accident. These made it closer to examples of organizational inertia than of organizational change (Aron, 1982: 472). The strong organizational continuity between the **AEC** and the **NRC** prevented the possibility for radical change.

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[70] Interview of C.Thomas, Chief of the Human Factor Assessment Branch, U.S. NRC, Washington DC, December 1995.
[71] See paragraph # 2.

However, in the institutional transformation of the **NRC** after the **TMI** accident, those internal resistences to radical change have been amplified by environmental factors which **TMI** impacted. In the aftermath of **TMI**, the environmental conditions for nuclear power became very uncertain and conflictual. Besides the flaws in the current nuclear safety regulation, the **TMI** accident brought up several basic issues concerning the public acceptability of nuclear risk and it also raised strong opposition. Questions concerning the "reliability of nuclear technology" could not find any definitive answer. Experts were divided, and the Congress was polarized: nobody took a clear position on "how safe is safe enough" (Aron, 1982; Clarke, 1988; Rolph, 1979). The **TMI** accident became "a crisis in confidence over institutions": it made the future of the nuclear industry extremely uncertain, and the political conflict around the nuclear technology very strong. Public opinion became anti-nuclear, and the political climate radicalized (Kasperon *et al*, 1980).

In such a situation, it became very difficult to think of alternative institutional arrangements in nuclear regulation and their possible implications. The whole institutional investment in nuclear technology which had been developed since 1946 was at stake: the socio-political enthusiasm for the new technology was lost; instead, skepticism grew, and the decline of the industry suddenly revealed its possible irreversibility. More than ever nuclear policy continuity and the preservation of the nuclear power option needed to be defended.

A radical change in the **NRC,** such as a single administrator appointed by the President, and an independent Nuclear Safety Board, in the context of of strong political opposition and nuclear economic decline, could have meant the end of the U.S. nuclear power program.

As several economists pointed out, given those conditions, the only radical change that would have been able to maintain the institutional investment in nuclear technology, was the partial nationalization of the nuclear industry. That could have broken the path of decline of the nuclear industry, solved the ambiguous relationship between regulators and regulated, standardized the technology,and improved safety policy and control.

Yet, in either hypothetical scenarios (the end of the nuclear power option or its partial nationalization) the level of uncertainty, political conflict and sunk costs which needed to be managed were too high, both within the **NRC** and in its institutional environment.

The institutional transformation that the **NRC** has actually experienced has been a lot less radical. Institutional change in nuclear safety regulation has been consistent with the institutional persistence of early choices: the Commission structure, the *ex-parte* rule, the limited regulatory role, the committment to the nuclear power option, the practice of negotiation with the nuclear industry, and the preservation of the nuclear power option. These persistences, on the one hand, have led to weaknesses in the **NRC**'s regulatory role and in its public perception; however, on the other hand, it has been able to improve the level of nuclear safety performance, and to preserve the value and level of the technological investment.

Conclusion

> *Institutions are not simple reflections of current exogenous forces. . . they embed historical experience into rules, routines, and forms that persit beyond the historical moment and condition [Yet] lags in the adjustment of institutions to their environments . . . make institutional history somewhat jerky and sensitive to major shocks that lead not only to occasional periods of rapid change, but also to considerable indeterminacy in the direction of change (March and Olsen, 1989, 167, 171).*

The **TMI** accident brought to light several inefficiencies that historically developed in nuclear safety regulation, as well as flaws in the existing institutional arrangement, and started a process of change. Some of this change took place within the **NRC**, some in its broader institutional environment.

The **NRC** went through several changes in its organization, procedures and regulatory activity. Yet, all of them were mediated by the preexisting structure of the **NRC**,the cultural legacy, and the historical arrangements. Institutional persistence and institutional change have coexisted in the process of the **NRC**'s transformation since **TMI**. Uncertainty, political conflict and sunk costs prevented the radicalness of the change which **TMI** revealed was needed. Practices of patchwork and institutional bricolage developed, that were consistent with the history of the **NRC**. Indeed, these practices have characterized the whole process of transformation of the U.S. nuclear power regulation, starting with the reorganization of the **AEC** in 1954 until the reorganization of the **NRC** in the post **TMI** accident. Institutional continuity, the maintenance of the nuclear power program, has been preserved despite all the criticisms, changes, and shocks that developed in the institutional environment.

The creation of **INPO** was the major change resulting from the **TMI** institutional breakdown. This private regulatory body did not exist before the accident , and it soon started performing important functions for nuclear safety which had been neglected until then, covering several inefficiencies which had been "delivered by history" both within the nuclear plant operations and the nuclear safety regulation. Yet, even the **INPO** cannot be seen as a radical institutional change: its activity has been constantly negotiated with the **NRC**, the pre-existing statutory regulatory agency, and framed within the irreversible path of nuclear industry decline, over which **IPNO** itself has had virtually no influence.

Given this picture, the current arrangement for nuclear power regulation still shows itself as sensitive to the initial conditions for the development of that power (the regulatory agency structure and mission, the ambiguous relationship with the nuclear industry), irregardless of the negative change which has taken place in the economy of the nuclear industry (its demise), and in the the socio-political environment (conflict). In this sense, despite the fact that **TMI** broke down some institutional patterns in nuclear safety and allowed for institutional change, most of the old path of nuclear regulation has persisted.

The inefficiency of history can lead to major institutional change as a result of environmental shocks. Yet, this change is nevertheless mediated by preexisting structures and arrangements, as delivered by history. Institutions are likely to persist even in disruptive situations, but this does not prevent forms of institutional change. Institutional change and institutional persistence are not contrasted; rather, they coexist.

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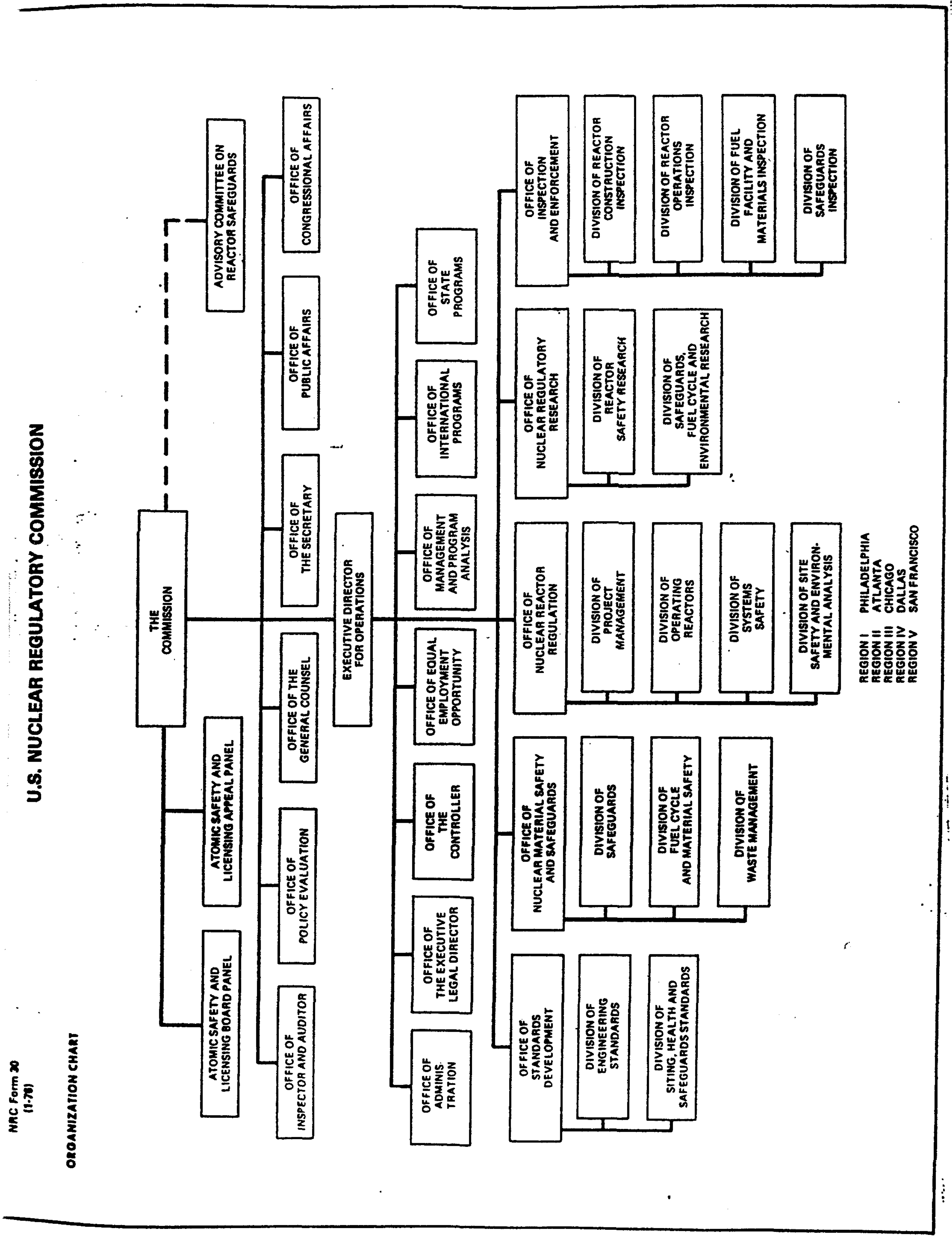
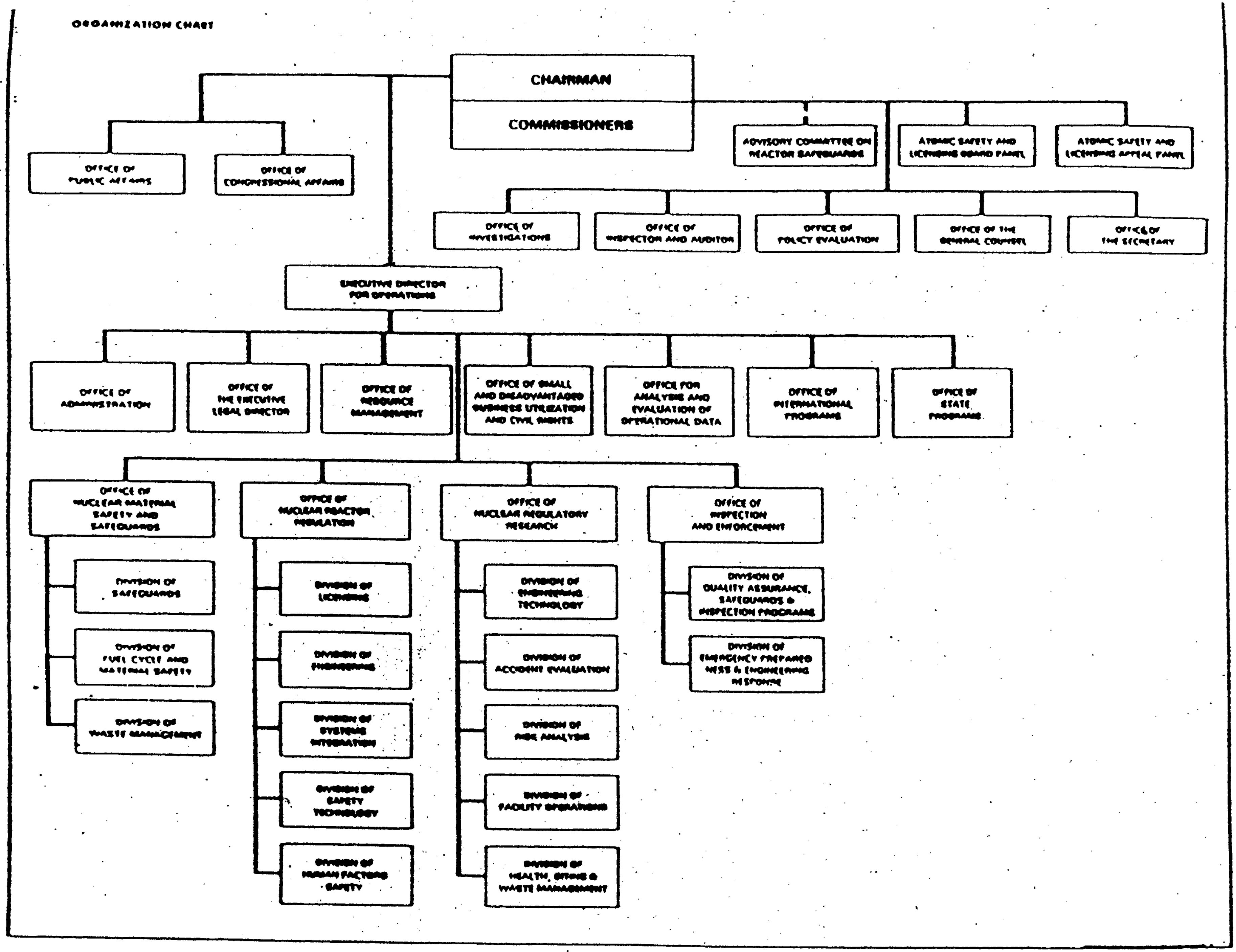
Appendix - Fig. # 1





Appendix - Fig. # 2