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UNIVERSITY OF OKLAHOMA

IMAGES OF DECISION MAKING AND THE LAUNCH OF THE CHALLENGER SPACE SHUTTLE

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

By

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Norman, Oklahoma

1997

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APPROVED FOR THE DEPARTMENT OF POLITICAL SCIENCE

BY

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Dissertation Abstract

Images of Decision Making and the Launch of the Challenger Space Shuttle. Terence Michael Garrett, Ph.D. The University of Oklahoma, 1997. Chair: Professor David G. Carnevale.

The *Challenger* space shuttle launch incident on January 28, 1986 is a fascinating topic for comparison of theoretical conceptions offered by organization theorists. By examining this case study we can see the intricate complexities and richness of human activity surrounding a single event in organization theory. The case study method is useful for exploring theories of organization. This study provided me the opportunity to analyze a relatively widely known case within a government agency and make a contribution to the field of public administration. What is notable about this topic is that there was plenty of information concerning problems with the space shuttle system, such as weather-related and technical issues, available to managers prior to the launch to prevent the event from transpiring and yet the decision to launch took place anyway. Many scholarly interpretations have been offered so that this incident (case study) provided much theoretical evidence for consideration. These interpretations were oftentimes conflicting or contradictory in their respective interpretation of events. In order to analyze the disparate theories explaining the launch decision, I used Burrell & Morgan's metatheoretical frameworks method, which consists of functionalism, radical humanism, radical structuralism and interpretivism, to organize the various theoretical explanations about the *Challenger* space shuttle launch.

Furthermore, I found that the interpretation of events leading to the *Challenger* decision was subject to the analyst's preconception of what transpired. I confined my research primarily to theoretical interpretations of the the launch event in order to assess the state of the field of public administration

generally and in particular the subfield of organization theory. There are numerous qualitative theoretical conceptions available to scholars. These theories, or images, are valuable for analyzing a complex event like the *Challenger* space launch. There is no single theory or paradigm which completely explains the launch as there is no single all-encompassing theory which adequately explains human behavior in a predictable fashion in the social sciences. Instead, we (I mean we, the academic community) render scholarly judgments concerning events that we study using theoretical tools available to us. In a similar fashion, I have presented an analysis of the *Challenger* space launch decision. We offer judgments to members of organizations, particularly managers, to provide them with insights (the practitioners who live in and depend on the work-world, i.e., executives, workers, managers, clients and investors) so that tragic consequences may not result to human beings in the future. As such, I used Hummel and Carnevale's concept of the "knowledge analytic" to tie together some of the interpretations offered by scholars analyzing the *Challenger* incident. The knowledge analytic provides us with a means to appreciate and recognize that where we are in an organization affects how we perceive ourselves, each other, and the work we are involved in. "Knowledges" incompatibility is a primary cause for people in organizations to not come to an understanding about what should be done in order to accomplish a task in an organization or how we cooperate in completing organizational endeavors. I discovered in my case study analysis of the *Challenger* launch decision that a failure of recognizing differences in knowledges, particularly between executives, managers and engineers, led to disaster.

The framing or "images" method offers scholars the means to analyze in a comprehensive fashion theoretical explanations of human events. For example, the richness and complexity of the world we live in is inadequately covered by the simplistic, parsimonious and positivist-scientific theoretical renditions which are often used to explain reality. Human beings and human behavior cannot be scientifically categorized once and for all. Organizations, as human artifacts, similarly cannot be judged completely by science. Science may be useful in describing the superficial appearance of an organization at a single moment in history, but time and space limitations provide only an ephemeral snapshot of reality. The framing method is an appropriate beginning for managers and academicians to recognize and understand the shortcomings of all current theoretical explanations in public administration organization theory.

CHAPTER I:

AIM OF THE DISSERTATION

The purpose of this dissertation is to analyze the behavior of organizations, and individuals in organizations, when they are faced with critical management problems. I will be analyzing the decision to launch the *Challenger* space shuttle on January 28, 1996 using the "framing" or "metaphorical" multitheoretical approach from the organization theory literature, focusing primarily on the works of Morgan (1986) and Burrell and Morgan (1979). Several theoretical and historical explanations of the decision to launch the *Challenger* under poor conditions have been offered by government officials, journalists and social scientists. There is a notable lack of consensus about these explanations as to why this tragedy occurred and how it could have been avoided. My intent is to explore the events leading to the complex launch decision in a historical context to examine how and why academicians and practitioners have come to their various interpretations. By examining case studies such as the National Aeronautics and Space Administration (NASA) *Challenger* space shuttle disaster in 1986, we can begin to understand how managers and their organizations react to situations where lives were at stake, and subsequently lost, and how future managers may avoid some of the same pitfalls.

The general thesis will be outlined with three hypothesis statements, which will be supported by data and subsequent interpretation of the case study. I will also make my "case" for the the case study method for understanding complex managerial problems as opposed to using a more traditional quantitative analysis. The case-study method has been criticized by some in public administration, particularly as pertaining to dissertation research.[1] I believe that case studies are an important form of intellectual inquiry because of their contextual value, historical nature and time specific content.[2] There is considerable support for the case study approach from a significant number of scholars in the scientific, historical, critical theory, and phenomenological academic traditions.[3] Barrett and Srivastva (1991) have lamented the predominance of structural functionalism and logical positivist analytical techniques in organization theory and its lack of historical analysis. They find the tendency dehumanizing and inappropriate for human organizational analysis:

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1 Howard E. McCurdy and Robert E. Cleary (1984, 49) have decried the poor state of doctoral research in public administration and, in particular, the case study. They compared public administration to that of other social science disciplines and conclude that the field "must often rely upon scientific findings from other disciplines. But methods of inquiry developed in other disciplines may not be appropriate to the needs of public administration as its own techniques like the case study. The case study, however, is generally viewed as having limited validity."

2 See Gell-Mann (1994) for a physicist's perspective on statistical analysis on complex adaptive systems, such as human beings and organizations. Gell-Mann maintains that "the apparently hard-headed practice of ignoring values difficult to quantify is often advertised as being value-free. On the contrary, it represents the imposition on any analysis of a rigid system of values, favoring those that are easily quantifiable over others that are more fragile and may be more important. All our lives are impoverished by decisions based on that kind of thinking [e.g., economists and political scientists have a propensity for leaving fragile values to the political process] (324).

3 Scientists such as Robert K. Yin (et al) (1977, 19) point out that "the case study has had wide use because it can focus on an organizational change and cover the peculiar flavor, setting, and people that are likely to explain what happened and why. A good case study attempts to capture the unique blend of events occurring in an organization, much as the clinical approach in psychology is able to present the unique situation and personal background involved in analyzing an individual's behavior." See also R.K. Yin and Douglas Yates (1975, chapter 2). Yin (1994, 1) makes the argument that the case study method is one of several ways to conduct social science research and that case studies are the preferred strategy to answer questions of "how" or "why." A note of caution about what passes for "science" was outlined by Nobel prize winning physicist Richard Feynman (1985, 340.) He coined the phrase "cargo cult science" and described it as follows: "In the South Seas there is a cargo cult of people. During the war they saw airplanes land with lots of good materials, and they want the same thing to happen now. So they've arranged to make things like runways, to put fires along the sides of the runways, to make a wooden hut for a man to sit in, with wooden pieces on his head like headphones and bars of bamboo sticking out like antennas--he's the controller--and they wait for the airplanes to land. They're doing everything right. The form is perfect. It looks exactly the way it looked before. But it doesn't work. No airplanes land. So I call these things cargo cult science, because they follow all the apparent precepts and forms of scientific investigation, but they're missing something essential, because the planes don't land." More on the critical theory, phenomenological and historical perspectives will follow.

> Our romance with finding transhistorical principles and enduring patterns of behavior have blocked us from realizing the primary goal of science: making human *action* and *interaction* intelligible and understandable. In our efforts to *explain why*, we have been limited in *understanding how*. In a search for general patterns and structures, we have lost sight of the world of contingencies, choices, and dilemmas that do not fall into structural patterns. Human beings are simply not reducible to static properties. Human events are meaningful because of the possibility inherent in choiceful action, not because of inevitability (Barrett and Srivastva 1991, 234).

There is a role for interpretation of historical events because "historical research is inevitably an interpretive enterprise, a piecing together of contextual 'facts' selected by the historian to present a narrative idea or argument" (Barrett and Srivastva 1991, 244). This interpretation implies that when engaging in organizational history, the analyst must take into account her subjective biases "because every history consists of moral decisions, an interpretive process that reveals as much about the historian as it does the actors and events he interprets" (244).

Following the three hypothesis statements and a brief look at historical decision-making case studies, I will discuss the metatheoretical and metaphorical approaches developed by Burrell and Morgan (1979) and Morgan (1986). The *Challenger* case study will then be analyzed by using the "imaging," or metaphorical perspectives, approach. My intent here is to critically examine the various theoretical perspectives to determine whether they may yield new insight to complex problems for managers in the future.

Hypothesis #1: Managers ignored information from employees who knew what was going on.[4]

My first dissertation hypothesis is that NASA managers were conditioned or "stuck" within a theoretical orientation (or predetermined mode for action) described by Gareth Morgan (1986) as the "machines metaphor" or what Adams and Ingersoll (1990) call "technical rationality."[5] Efforts by subordinates holding vital information within the organization to stop the debacle were ignored by managers,[6] thus contributing to the deaths of seven astronauts in the *Challenger* incident.[7] Being highly rationalistic in orientation, organizations such as NASA have extensive rules and regulations which attempt to determine the actions and behaviors of their members. There is a common tendency by some managers in these organizations to ignore warnings by subordinates in order to accomplish their mission. For example,

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4 Apologies are in order here to Maureen Hogan Casamayou (1993) in her book *Bureaucracy in Crisis: Three Mile Island, the Shuttle* Challenger, *and Risk Assessment*. She takes a more traditional political science approach to analyzing case studies from a management perspective. Her three hypotheses are (1) Communication Blockage, relying on Anthony Downs, Herbert Simon and Harold Wilensky; (2) Misperception of the Received Communications, using Festingers' cognitive dissonance conceptual analysis; and, (3) External Pressures Overrode Warnings, using a perceptive political analytical framework.

5 See "Culture, technical rationality, and organizational culture," in *American Review of Public Administration*, 20:4. Adams and Ingersoll argue that the American political culture is dominated by a scientific-analytical mindset which consists of the belief in complete managerial control of organizational work processes, clear and concise organizational objectives, and complete efficiency and predictability which are paramount in importance within the organization. They are dubious about the consequences of this form of rationality which emphasizes classical individualism at the expense of the greater society. More explanation of Morgan's other metaphors will follow. Mary Timney Bailey (1994) in "Do Physicists Use Case Studies? Thoughts on Public Administration Research" also points out that "The recent focus on narrowly defined positivist social science, because of its inherent biases, may impede [the research issue] by creating a hierarchy for research and scholarship" (194).

6 R.P. Hummel (1994a, 208) offers significant insight here as he describes "modern organizations separate the thinking function radically from working....[And the] problem for workers is that managerial minds, empty of working experience through which alone objects can be known, give them the orders as to how to do their work--and evaluate their success."

7 See M.R. Schmidt, "Grout: Alternative Kinds of Knowledge and Why They Are Ignored," in *Public Administration Review* (November/December 1993), 53/6: 525-530. Schmidt argues that science, engineering, and bureaucratic institutions, under a common model of reality, often ignore and suppress insightful kinds of knowledge (that of the worker).

Casamayou (1993, 3, 26) points out that as early as 1977 a NASA engineer had warned his supervisors about in a crucial seal joint and predicted that the leakage of solid rocket fuel gases would result in "catastrophic failure." Casamayou also demonstrated that the agency fell into a mind set[8] in which the previous successful launches had justified the fateful flight, despite evidence of dangerous erosion (1993, 174).[9]

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[8] The deleterious effects of being stuck in a paradigm, or mind set, was illustrated by Nobel prize winning physicist Murray Gell-Mann (1994, 264) as follows: "Around 1970 I was one of a small group of physicists, biologists, painters, and poets assembled in Aspen, Colorado to discuss the experience of getting creative ideas....We had each found a contradiction between the established way of doing things and something we needed to accomplish: in art, the expression of a feeling, a thought, an insight; in theoretical science, the explanation of some experimental facts in the face of an accepted "paradigm" that did not permit such an explanation....First, we had worked, for days, weeks or months, filling our minds with the difficulties of the problem in question and trying to overcome them. Second, there had come a time when further conscious thought was useless, even though we continued to carry the problem around with us. Third, suddenly, while we were cycling or shaving or cooking (or by a slip of the tongue...) the crucial idea had come. We had shaken loose from the rut we were in." I would like to thank Professor Ralph P. Hummel for making me aware of this particular "feeling" insight, which is also developed further in his recent article on practical knowledge (1995).

[9] Diane Vaughan (1996), a sociologist from Boston College, argues from a Mertonian structural-functionalist and culture perspective that "mistakes are systematic and socially organized, built into the nature of professions, organizations, cultures, and structures" (415). Risky decisions have always been part of NASA's culture (hence, interwoven into its fabric) and pressure from political leaders to cut funding to the agency while simultaneously demanding more launches exacerbated and complicated the situation. This runs counter to most analyses in that the usual (and more simplistic) political explanation involves the Reagan administration's pressure to launch in order to make a good showing for the State of the Union address. Vaughan's thesis is interesting in that she makes the case that organizations cause irrational behavior incrementally by building higher levels of tolerance (what she calls the "normalization of deviance") and this inevitably leads to mistakes. In my view, however, she overstates her case when she determines that the organization itself is responsible for the disaster rather than the managers and engineers involved in the decision to launch. Furthermore, her solutions for resolving future "mistakes" are not helpful in that she advocates more structure, more rules, more control and more resources. Her solutions include: (1) managing better (416); (2) more rules and better "strategies for control" (though these solutions could backfire; rules cannot be made for every aspect of behavior in organizations) (417); (3) empower people, perhaps more democracy in decision-making (though she recognizes that there may be increase tension in hierarchical relationships) (419); and, (4) more money for the agency (problem of scarce resources was a major cause of the disaster) (422).

Hypothesis #2: Managers who ignore the useful knowledge of the workers will sometimes blame the workers when managements' plans go awry. Also, organizations will go to great lengths to protect the managers and the organization until compelled to do otherwise.

My second dissertation hypothesis is that some managers in organizations will not accept responsibility for decisions they have made, particularly under stressful conditions. They cite external factors or incompetent employees for the failure of the mission rather than themselves. This situation existed in the *Challenger* launch decision case study and NASA managers engaged in deceitful activities such as cover-ups and the blaming of victims. Sanger (May 11, 1986) of the *New York Times* reported that until two Morton Thiokol engineers testified, the Challenger disaster appeared to have been a freak accident rather than an accident that could have been prevented.

An important component of management is trust between managers and employees. Carnevale (1995, 4-5) demonstrates that trust, which he defines as faith in people, their motivations, and their capacities, is essential to a properly functioning organization. Without trust and truth in relations between workers and managers, the working situation deteriorates to the point that in low-trust organizations more is hidden than revealed. Because of the duplicity of human beings, it is often difficult to obtain the truth directly from people involved in events leading to a decision in which mistakes in management were made, even when there may have been no conscious intent to mislead. Gendlin (1973 , 302-4) offers a unique psychological and phenomenological framework in order to analyze experience and complex situations in organizations. Experience and situation are not separable and "are always already organized, but are capable of being further schematized and organized not only by verbalization but also by actions" and "there are truth criteria not for a single statement alone but for a kind of process, a kind of step, in relation to an earlier one" (303). Furthermore, Gendlin submits that "In phenomenological explication, as in ordinary action, you must not only interpret a situation, but you must also apply your organization if you are to live in the situation further" (303). He raises the issue that people can falsely state their feelings and later correct them. This change in previously stated feelings can have an impact on truth. Accordingly, Gendlin has developed "signposts" to help us recognize when phenomenological explication is occurring and when it is not:

> (a) Precise defined meanings of words and the defined aspects of situations are used, but they can be further structured and redefined in ways that would not follow from the extant definitions.
>
> (b) Something more than what is defined is employed. A not yet cognitively clear sense, feeling, or experience is used....Something directly referred to is involved in addition to statements.
>
> (c) Aspects, and aspects within aspects, of this experience can be found.
>
> (d) Demonstrative words such as "this" or "it" are used importantly, and yet such words alone convey little or nothing.
>
> (e) Several different descriptive words may be used for the "same thing," despite the fact that literally they mean different things. Such different words can have quite different effects even in regard to the present experience, and one may ignore this, or pursue it.
>
> (f) Previous assertions which enabled important steps to go forward may later be flatly denied.
>
> (g) Whatever one now says is held to be what the experience "was" all along.
>
> (h) Earlier false steps are believed to have been in the right direction, despite the fact that they are flatly contradicted now.
>
> (i) What is at first simply physically "felt" becomes explicated in words that are about situations and world (not in feeling-tone words such as "dull" or

"sharp" or "intense").

> (j) Despite revealing new aspects and despite its changing, what is talked about is held to remain "the same" (not *literally* "the same"; it is obviously capable of various organizations and aspects) (Gendlin 1973, 304).

Gendlin's criteria for signposts in his phenomenological method "makes the process, relationships, and steps of explication (rather than any given statements) basic....This shift from what is said to how it is related to experience has basic applicability to many fields" (1973, 305). His method is useful for us to understand how people deal with truth and complexity, particularly when interpreting data in human organizations.

Hypothesis #3: Managers hold the simplistic notion that they can control every aspect of their organization, and even those of other organizations.[10]

My third hypothesis is that managers believe they can control every aspect of the minds and actions of people in organizations, especially of organizations they are in conflict with. Other organizations were involved in the events which led to important differences in the outcome of the case study. These organizations had a significant impact on the ultimate decision-making process by the nature of their respective leadership and the limited ability of the workers (or lower organization participants) to be involved in the deliberation process. In the space shuttle case, Morton Thiokol engineers Allan J. McDonald and Roger M. Boisjoly were ignored by senior management when

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[10] Ian Mitroff's (1983) *Stakeholders of the Organizational Mind* is instructive here. See, in particular, chapter 3 "External Influences on Managers," (p. 47) "The somewhat inevitable laundry-list character of our social science demonstrates the particular kinds of complexities that a social science of complex problems faces. The question that confronts us is whether this complexity will become even greater or paradoxically less as we discover the even greater complexity of stakeholders [members of organizations.]"

they expressed objections concerning safety hazards pertaining to the space shuttle launch.[11] There is an indication here of excessive manipulation by the managers towards the completion of a symbolic act by getting the shuttle into space at almost any cost and by the pressure placed on NASA by the Reagan administration to launch.[12] Symbolism and political pressures, from lower participants and external organizations, indicate that the "culture" and "political" metaphors (Morgan 1986) may be useful in analyzing the behavior of organizations associated with the *Challenger* disaster.

My strong suspicion is that the culture of the organizations being analyzed and the qualities of their management and leadership play a pivotal role in intra- and interorganizational conflict. The primary government agency, NASA, and the peripheral, yet nonetheless critical, organizations will be examined both to explain and to provide insights to future administrators. The aim of this research is to analyze an historical case study through the lenses of each metaphor, focusing mainly on the decisions that were made by the respective organizations to launch the shuttle. A central theme to this analysis is the educational effects which managers encounter in an actual complex working environment and what knowledge can be learned from the experience. The hypotheses deliberated above will be considered in the overall analysis and are recounted here as: (1) managers ignoring employee warnings; (2) managers not taking responsibility, but rather blaming the employees, in the

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11 According to David E. Sanger in the *New York Times*, May 11, 1986, McDonald testified that the Challenger had been launched over the objections of its designers. Boisjoly had submitted a memorandum which warned that there "could be a catastrophe of the highest order" if the company did not fix the rocket seals.

12 Casamayou (1993, 78-9) notes the pressures to launch the Challenger may have been exacerbated by (1) the State of the Union address; (2) Office of Management and Budget cuts for NASA since the late 1960s, leading to layoffs of technically competent employees and reductions in overall safety, reliability and quality; and, (3) Cost-conscious external forces, forcing NASA to accept an "unrealistic launch rate."

name of protecting the organization; and, (3) managerial underestimation of other organizations and an intrinsic need of some managers to control every aspect of their own organization. The managers in this case study had to cope with complex problems of a life-and-death magnitude. It is my position that there is cogent information to be learned from these situations from the managers and workers involved in the case study. Also, the exploration of different theories as they pertain to and explain this case may yield insights for managers.

Managers and academicians gain knowledge from historical experience,[13] and an attempt will be made here to investigate possible alternatives in complex situations for managers confronting similar problems in the future to consider. Historians are no more predisposed to agreement or consensus than are other scholars when explaining complex or controversial events.[14] Historical analyses are more readily accepted by them as being subjective and artful and, for the most part, less scientific. Human beings in

[13] A note of caution is in order here. Habermas (1988, 27) in his essay on contemporary history and sociology notes 'the historian is hardly ever in a position to explain an event on the basis of sufficient conditions, that is, to give a full explanation of it. As a rule, he is limited to indicating a series of necessary conditions. He is left to judge when it makes sense to end the search for further "causes." He is methodologically compelled to make a decision within an arena that is in principle one of uncertainty. Insofar as he has not made this decision unintelligently, he relies on the authority of his "historical judgment"; within a positivist frame of reference, justifications of this kind are not susceptible of further analysis.'

[14] A classic example of this concept is a small collection of essays edited by Barton J. Bernstein entitled *The Atomic Bomb: The Critical Issues*. A traditional, or orthodox, interpretation as to how decision making was made to drop the atomic bombs on Hiroshima and Nagasaki was illustrated by Secretary of War Henry L. Stimson. Stimson defended the action on the grounds that the bombing was life-saving for American troops and, therefore, justified and rational. A realist view, held by Hanson Baldwin of *The New York Times*, was that policymakers had behaved both immorally and naively. Historical revisionists including a liberal-leftist, David Horowitz, and a socialist-economist, Gar Alperowitz, interpreted the bombings as a means to deal with the Soviet Union (American leaders were not naive about power, but used the bomb for international purposes, i.e., extracting concessions for the USSR in the post-World War II era.) The point here is that people in national security organizations made decisions affecting thousands of lives. In this collection of essays, there is virtually no consensus as to *how* or *why* policy makers arrived at their decision. There is only their respective *ultimately subjective* interpretations about *what really happened.*

organizations make decisions that often have important consequences. Therefore, it is important to recognize that scholars of organization theory and public administration should, while avoiding mistakes of the past, contribute ideas to practitioners which will prove to be helpful to them in the future. The academic theorist should examine history and cross-disciplinary approaches.[15]

One of the classic works and historical accounts in diplomatic strategic decision making was written by the political scientist Graham Allison (1971). His work is important because it contributes to "framing," a multitheoretical approach developed to analyze case studies. Allison created three models: (1) the rational actor (realist); (2) organization (pluralist); and, (3) bureaucratic politics (pluralist.) In order to develop an analytical framework to help policy makers in the future, he used the historical example of the Cuban missile crisis to illustrate what administrators faced in a critical international crisis. Allison admitted that the three "paradigms neglect or underplay a number of further aspects of governmental behavior. Additional paradigms focusing, for example on individual cognitive processes, or the psychology of central players, or the role of external groups, must be considered" (276-7). He also put forward the notion "that analogues of the three models can be used to analyze outcomes in areas of public policy outside foreign and military affairs" (272). In an earlier work, Allison (1969) postulated that

> At a minimum, the intended implications of the argument presented here are four. First, formulation of alternative frames of reference and demonstration that different analysts, relying predominantly on different models, produce quite different explanations should encourage the analyst's self-consciousness about the nets he employs. The effect of these 'spectacles' in sensitizing him to particular aspects of what is going

15 Guy B. Adams (1992, 363) of the University of Missouri makes the point that public administration has been lacking a "self-consciously historical approach to questions of knowledge and theory development." He further adds that our "culture of modernity" has led to an emphasis on technical rationality which combines individualism with ahistorical scientific analysis in the social sciences.

> on--framing the puzzle in one way rather than another, encouraging him to examine the problem in terms of certain categories rather than others, directing him to particular kinds of evidence, and relieving puzzlement by one procedure rather than another--must be recognized and explored (366).

Thus, Allison advocates a comprehensive and inclusive theoretical approach to analyzing historical events. His work is an important starting point for scholars interested in pursuing a more eclectic approach to understanding how policy makers in organizations reach crucial decisions.

Managers or decision makers in organizations must have analytical tools available to aid them in making important choices that could affect the lives of those within and outside of the organization. There are, of course, temporal and spatial limitations of which a manager must take into account when engaged in making decisions. There are no decisions which are completely appropriate for every situation or circumstance. Allison's call for a more comprehensive organization theory approach has initiated new thinking in the area of the theoretical nets which one employs in the decision making process. Before interpreting events as to how decision makers arrived at their decisions in a theoretical sense, we will start with a preliminary chronological diagram (admittedly mechanistic) of how and when the incidents took place (see below, 'Table 1.1'). It is my position that sticking to one paradigm for too long in a critical situation can lead to disaster. Following the decision making diagram, I will reiterate the metaphorical framework of Gareth Morgan (1986). It offers an important achievement in organization theory and, hence, an appropriate avenue for pursuing further research in case studies.

TABLE 1.1: A BRIEF OUTLINE OF DECISION-MAKING IN THE *CHALLENGER* CASE STUDY

1986 Space Shuttle Accident:

Result
Normal Every Day Activity ---------> Crisis ---------> Challenger Explosion January 28, 1986

Decision Options Considered (by managers)	Critical Factors Affecting Decision Considerations:	Rationalization and the Decision-Making Process (Deliberation)
(a) Launch/No Launch/Delay Launch option selected	(a) 36 degree Fahrenheit ambient temperature at launch; too cold, previous coldest temperature was 53 degrees	(a) Relatively little emphasis was given to workers (engineers) involved in the work; they were ignored at critical times in the deliberative process
	(b) O-Ring deterioration; sheets of ice threatened shuttle orbiter; naval rescue operations within acceptable tolerance	(b) Belief that odds were in favor of success, based on mathematical models and science; decision to launch was "managerial" and not based on worker experience

Table 1.1 does not take into account feeling, thinking, judgment, and time and space limitations faced by human beings in the making of complex decisions in crisis environments (which will be developed in the analysis of the case study.) The table is highly linear, static and simplistic but serves as a starting point for further discussion in the next section. An important aspect of this dissertation is the analysis of the "crisis" situation faced by managers in the case study, how and why they arrived at their decisions, and of the alternatives which were realistically available to them at the time.[16] Managers and academicians can learn from these experiences through subjecting themselves to appropriate

[16] Kelly and Moody (1994) make an interesting case for a "postpositive" critique of conventional (or logical-positivism] policy analysis: "...the postpositivist role for the policy analyst is to facilitate rational deliberation, to bring together multiple perspectives, to assist in the process of exploring alternative courses of action, and to aid policy makers and, perhaps, citizens in understanding the possible limitations of their current perspectives. The policy analyst is not an expert but a facilitator, who lends his or her own subjective but outsider perspective to the evaluation process" (203).

positive criticism.[17]

In the following chapters we will examine the *Challenger* launch decision through the lenses of images presented for interpretation of this complex event. We will begin in the second chapter with a critique of science and an investigation into metatheoretical assumptions and the usefulness of metaphors in organization theory. We will reveal the philosophical underpinnings of theories, represented by metaphors, that will be used to analyze the case study in order to understand what kinds of knowledge they may yield. In the third chapter we will examine *a* history of events leading to the launch decision. The sheer complexity of the historical process leading to *Challenger* has encompassed volumes and will not be completely covered here. That task must be left to the interested reader and researcher to pursue on their own. Instead, a short, chronological history touching primarily upon NASA documents and journalistic accounts from individuals inside and outside the NASA and Morton Thiokol organizations will be utilized to provide a background for putting the launch decision into context. The fourth chapter will include an examination of structural theories pertaining to the launch decision,

[17] Bensman and Lilienfeld (1991, 24-5) offer positive criteria for evaluating art criticism, which also serves well for evaluating the art of management: "First of all, the critic at his best can serve as press agent for new techniques, styles, and forms of art [management]....Secondly, the critic, within the framework of an established style or medium, provides an act of judgment which compares the art [management] work as technique with the conventional canons of the style or medium...the critic serves this function of maintaining standards. Thirdly, the critic may actually succeed in enlightening the artist [manager] as to what he is really doing...." The critic also can prevent "the artist [manager] from falling below the best technical standards," provide judgments that "enable [the] audience to know whether they have enjoyed a work of art [management]" and the "critic can serve as a 'prospector' discovering new works and styles of art [management], and old works or styles of value which have been neglected." Vaill (1991, 118) also notes that "Performers often have very intense feelings about how the quality of what they are doing relates to standards of the wider artistic community....If management is a performing art, the consciousness of the manager is transformed."

both functional and radical.[18] We will discover that the *Challenger* launch decision has been studied extensively, especially by theorists oriented to the functionalist paradigm, and that there are numerous theoretical representations and interpretations of its events. The fifth chapter consists of an examination of theories from the radical humanist and interpretive paradigms. The fifth chapter will contain a recapitulation of knowledges generated by theoretical explanations, culminating in the knowledge analytic. We will conclude our examination of the case study in the sixth chapter and reassess the knowledges and insights gained from the various images of the *Challenger* space shuttle. We will also look at the applicability and the usefulness of reframing a single case study to organization theorists and managers.

[18] The various theories which we will examine in this case study are not always "pure" representations from each paradigm. There are numerous examples of theories which have components of two or three of the paradigms considered. The categorization of theories in this case study will require a judgment by the author who will place them into context based on their dominant orientation.

CHAPTER II:
A CRITIQUE OF SCIENCE, META-THEORETICAL ASSUMPTIONS AND THE METAPHORICAL FRAMEWORK

Meta-theoretical assumptions, or what Burrell and Morgan (1979) also call world views, are important to understand when one interprets or analyzes case studies.[19] Scholars pursue scientific research with preconceptions concerning the subject to be studied, about how it will be studied, and concerning what conclusions can be drawn. The key here is that what constitutes traditional "science" for many scholars has become the unquestioned, accepted norm for inquiry into organizational analysis. Science is oftentimes taken *prima facie* without serious inquiry into whether its philosophical premises can adequately explain reality. There is considerable dissent from phenomenologists about the efficacy of traditional science in accounting for life-world experiences involving situations, language, and emotions which are important in understanding human events. From a psychological and phenomenological perspective, Gendlin (1973, 283) maintains that everyday-life experience is more complex than can be explained completely by any logical [scientific] or philosophical scheme. He also adds that in

> ...the Western tradition of philosophy, experience (and nature) has usually been interpreted as basically a formal or logic-like system. This was done through a philosophical analysis of the basic assumptions of knowledge or science. These assumptions were then attributed to experience....Philosophers have not agreed on their analysis of science

[19] Burrell and Morgan (1979, viii-x) show that social theory can be divided into four distinct and separate paradigms based upon mutually exclusive preconceptions of the social world. They also explain that there is an established orthodoxy [i.e., functionalism] based on science and rationality which pervades academic inquiry into organizations. Their primary aim is to take the student of organizations through the various paradigms to have him/her understand alternative points of view and to demonstrate that 'all theories of organisation are based upon a philosophy of science and a theory of society.'

> or knowledge, and therefore also not what they attributed to experience....Since Schleiermacher, Dilthey, Husserl, Heidegger, Sartre, Merleau-Ponty, Ryle, and Austin, this [Western science approach] has gone out of style. Instead, it is now widely held that experience need not, and in fact does not, have the same character as logic, science, or knowledge (Gendlin 1973, 281-2).

It is my position (and, hence, an indication of my world view and theoretical bias) that the conscious choice of the subject being studied indicates a value preference, or judgment, of the individual engaging in the pursuit of knowledge.[20] There also arises the question as to whether all or some of the theoretical knowledge developed by the academician or scientist is useful to the practitioner or manager in a real world situation, such as that which the NASA managers and engineers faced in the days, weeks and months leading to the loss of the space shuttle. Regarding modern or traditional science, Arendt (1978), following the philosopher Immanuel Kant, explains its pitfalls:

> ...it is common-sense reasoning ultimately that ventures out into the realm of sheer speculation in the theories of the scientists, and the chief weakness of common sense in this sphere has always been that it lacks the safeguards inherent in sheer thinking, namely, thinking's critical capacity, which...harbors within itself a highly self-destructive tendency....That modern science, always hunting for manifestations of the invisible--atoms, molecules, particles, cells, genes--should have added to the world a spectacular, unprecedented quantity of new perceptible

[20] Vickers (1995[1965]) provides some critical insight in *The Art of Judgment*. In particular, his system of appreciation is defined as consisting of (1) **Reality judgments**--making judgments of fact about the 'state of the system,' both internally and in its external relations. These include judgments about about *what the state will be or might be* on various hypotheses as well as judgments of *what it is and has been*; (2) **Value judgments**--making judgments about the significance of these facts to the appreciator or to the body for whom the appreciation is made(54)....*the dominance of governing human values must be taken for granted in any study of the process; and it is these values that select and in part create the 'facts' that are to be observed and regulated* (114). The relation between judgments of fact and of value is close and mutual; for facts are relevant only in relation to some judgment of value, and judgments of value are operative only in relation to some configuration of fact (54). (3) **Instrumental judgments**--or '*what are we going to do?*' A problem has been posed by some disparity between the current or expected course of some relation or complex of relations and the course that current policy sets as the desirable or acceptable standard. The object of executive judgment is to select a way to reduce the disparity (103). Managers, workers, practitioners and academicians can gain from Vickers's insights when evaluating events.

> things is only seemingly paradoxical. In order to prove or disprove its hypotheses, its 'paradigms' (Thomas Kuhn), and to discover what makes things work, it began to imitate the working processes of nature. For that purpose it produced the countless and enormously complex implements with which to *force* the non-appearing to appear (if only as an instrument-reading in a laboratory), as that was the sole means the scientist had to persuade himself of its reality....No matter how far their theories leave common-sense experience and common-sense reasoning behind, they must finally come back to some form of it or lose all sense of realness in the object of their investigation....Seen from the perspective of the 'real' world, the laboratory is the anticipation of a changed environment; and the cognitive processes using the human abilities of thinking and fabricating as means to their end are indeed the most refined modes of common-sense reasoning. The activity of knowing is no less related to our sense of reality and no less a world-building activity than the building of houses....the intellect (*Verstand*) desires to grasp what is given to the senses, but reason (*Vernunft*) wishes to understand its *meaning* (Arendt 1978, 56-7, italics hers).

Meaning, common-sense reasoning, and critical thinking are vital components that reveal the speculative nature of science. Gendlin (1962, 8) defines meaning as being "formed in the interaction of experiencing and something that functions as a symbol." Arendt (1978, 110), again following Kant, demonstrates metaphorically that "thinking" is based on sight (or the distance between subject and object) and "judgment" obtains its metaphorical language from taste. Furthermore, Arendt (1978, 112-3) cautions that "Metaphors...can be used by speculative reason, which indeed cannot avoid them, but when they intrude, as is their tendency, on scientific reasoning, they are used and misused to create and provide plausible evidence for theories that are actually hypotheses that have to be proved or disproved by facts." Hummel (1994b, 2), a phenomenologist, raises important concerns about the utility of traditional theoretical (or what scientists refer to as 'objective' or 'scientific') knowledge in all research and academic endeavors:

> 1 -- The most foundational judgments of which we are capable -- judgments about what is going on in reality -- cannot be made from

> within the proven propositions, hypotheses, or theories of science alone. (If so then practitioners of life and work have a role in knowledge acquisition.)
>
> 2 -- That judgments about formulating problems in such a way that something can be done to solve them must be made from within the realm of practice. (If so practitioners, not scientists or theorists, have the predominant role in problem formulation, judging the appropriateness of theoretical means to solve them, and ultimately in judging the appropriateness of solutions.)
>
> 3 -- That therefore, at two crucial moments of knowledge acquisition, in research design and in research utilization, the judgments of practitioners are superior to the judgments of academicians.
>
> 4 -- That it follows that academe, to admit for the first time the dependence of its theoretical and scientific knowledge on practice, must institutionalize procedures by which knowledge from the field of human life and work is formally admitted to the classroom, the dissertation committee, funded research and other consultancies (Hummel 1994b, 2).

Hummel (1994b, 27) also questions the importance of the utility of scientific theories for the practitioner as "the position of a philosophy of knowledge as it focuses on the larger realm of knowledge beyond the narrow confines of science must be taken into account at <u>all</u> points of the research process." It is important to recognize here through an interpretive approach that organization theories and their underlying premises must be scrutinized in order to determine whether they offer any utility to practitioners.[21]

Phenomenology represents one school of thought within one meta-theoretical framework (Burrell and Morgan 1979) and is particularly important for exposing the shortcomings inherent in traditional science (i.e., Arendt's

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[21] See Hummel's (1995) recent article "Why Work and the Study of Work Won't Mesh: Toward Standards for Practical Knowledge" in *Administrative Theory & Praxis*, 17/2:1-14. He makes the point that "If the philosophy of work can describe how those engaged in practical accomplishment make these kinds of judgments, then its salience for work and research is obvious. At two crucial moments of knowledge acquisition, in defining what is the matter and in formulating possible answers that can put the matter to rest, managers and professors must yield to their presumed inferiors: workers and practitioner students, respectively."

demonstration above that scientific conclusions may be lacking in common sense). Organization theorists are, however, not of one mind and there is not likely to be a consensus about what constitutes knowledge in the field for the foreseeable future (Shafritz and Ott 1992, 4). There are means available to incorporate various theoretical perspectives in the search for knowledge of what actually occurs in organizations. Burrell and Morgan (1979, 3) have recognized that there are distinct theoretical world views based on the philosophical assumptions of social scientists and have devised a basic taxonomy outlining the sociological differences:

Table 2.1 (Source: Burrell and Morgan, 1979)

The subjective - objective dimension

The subjectivist approach to social science		**The objectivist approach to social science**
Nominalism <----------	ontology	----------> Realism
Anti positivism <----------	epistemology	---------->Positivism
Voluntarism <----------	human nature	----------> Determinism
Ideographic <----------	methodology	----------> Nomothetic

Accordingly, selection of methodology by social scientists is influenced by a predisposition to different ontologies, epistemologies and models of human nature. Within the subjective - objective dimension, Burrell and Morgan (1979, 22) established four paradigms in which the "sociology of regulation" is juxtaposed to the "sociology of radical change," in order to create a useful typology for contrasting philosophical orientations of social scientists. "Philosophical orientations" are central to establishing the idea that various scientific (or other) explanations are not merely givens when analyzing organizational phenomena. The four paradigms for the analysis of social theory are reproduced here:

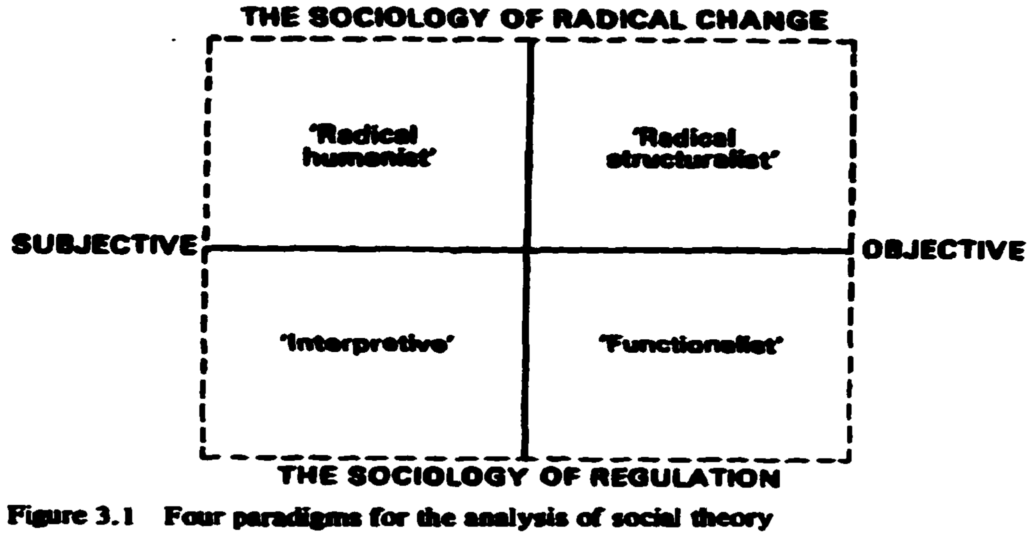

Figure 2.1 Sociological Paradigms (Source: Burrell and Morgan 1979, 22)

- The Radical Humanist and Interpretive paradigms are based on conceptions of 'German idealism' and are characterized as sharing a nominalist ontology, anti-positivist epistemology, voluntaristic assumptions of human nature, and have a tendency towards ideographic methodology. **Radical humanism** is distinguished by a propensity for radical change from a subjectivist standpoint. Branches of the radical humanism paradigm include French existentialism, anarchistic individualism, and critical theory. The **interpretive** paradigm attempts to explain society as to how it really is and to understand the fundamental nature of the social world at the level of subjective experience (individual consciousness). The paradigm includes phenomenology, hermeneutics and phenomenological sociology (See Burrell and Morgan 1979: 7, 28-9, 32, bold print is used for emphasis).

- The Radical Structuralist and Functionalist paradigms represent 'sociological positivism' and share common philosophical underpinnings such as a realist ontology, positivist epistemology, deterministic assumptions of human nature, and nomothetic methodology. **Radical structuralist** theorists advocate a sociology of radical change from an objectivist standpoint; emphasizing structural conflict, modes of domination, contradiction and deprivation. Elements of the radical structuralism include contemporary Mediterranean Marxism, conflict theory, and Russian social theory. **Functionalism** combines a

> sociology of regulation with an approach towards subject matter from an objectionist point of view. The functionalist paradigm encompasses much of social science and includes interactionism, social action theory, integrative theory, social system theory and objectivism (Burrell and Morgan 1979: 7, 25, 29, 33-4; Morgan 1980, 619, bold print is used for emphasis).

Table 2.1 and Figure 2.1 illustrate the metatheoretical perspectives predominant in sociology and in organizational analysis. Burrell and Morgan's analyses are useful for understanding and arranging the various theoretical perspectives (world views and paradigms) available to organizational theorists. Up to this point, we have been considering theoretical phenomena in a rather static and descriptive manner. A more dynamic way to consider an element of the objective-subjective dimension of philosophical and scientific inquiry is to examine the temporal-spatial (natural world) matrix developed by Bensman and Lilienfeld (1991):

Table 2.3: Action-Time Matrix

Action	Time	
	Objective	Subjective
Rationally Calculated	*Scientific Attitude*	*Planning Attitude*
Common Sense Rationality	*Ritualistic and Ceremonial Action*	*Attitude of Everyday Life*

(Source: Bensman and Lilienfeld 1991, 25)

Time and action are the crucial elements in our understanding of complex situations. Bensman and Lilienfeld (1991, 16-7), following the philosopher

Alfred Shutz, demonstrate that scientific attitude and attitude of everyday life represent different conceptions of time interpretation as "In the scientific attitude, time is measured in the objective sense of the term with standardized units, independently of a feeling of involvement [or rational detachment] which increases or decreases the experience of passing time." In the attitude of everyday life, "actions are situationally egocentric in the same sense that psychological time is temporally egocentric" (Bensman and Lilienfeld 1991, 16). The planning attitude incorporates the scientific and natural attitudes and reflects "an unselfconscious, nonreflective man who directly and immediately enters into social relations with others in terms of his immediate personal goals and his direct and intuitive apprehension of a situation" (17). The ritualistic and ceremonial action cell "suggests ritual and ceremony as means of organizing activity, especially in highly stylized or expressive ways [alternatives are not considered]" (18). Time is important for our understanding of the context in which decision makers in these case studies took action (made decisions) and under what conditions the decisions were made.

Paradigms and Metaphors

Morgan (1980, 606) identifies paradigms as "alternative realities" or as a "way of seeing." Within these paradigms[22] are "metaphors" which constitute a basis for schools of thought connected with particular kinds of scientific achievements. Metaphors are used for solving puzzles in organization theory and have been developed most extensively in the the functionalist paradigm

[22] Morgan, in a sense, borrows from Kuhn (1970, 10-11) who defines "'paradigms,' [as] a term that relates to ' normal science.' [He suggests] that some accepted examples of actual scientific practice--examples which include law, theory, application, and instrumentation together--provide models from which spring particular coherent traditions of scientific research....Men whose research is based on shared paradigms are committed to the same rules and standards for scientific practice. That commitment and the apparent consensus it produces are prerequisites for science, i.e., for the genesis and continuation of a particular research tradition."

(Morgan 1980, 619). The metaphorical conceptual framework offers a useful analytical tool to scholars of organization theory, public administration and has been employed by the "hard sciences," such as physics.[23] Metaphors are by no means strictly limited to scientific theories. Gendlin (1973) notes the following:

> *Metaphor* involves novelty. Here words are used in such a way as to create a new experience. The metaphor or simile is about this situation or experience....the metaphor involves a further creative organizing, as in direct reference. An aspect of experience emerges, and in the case of metaphor, a new one. Many such new aspects could metaphorically be made to emerge, if one brought many other areas of experience to bear on the present one (295-6).

According to Gendlin (1962, 113) "A metaphor achieves a new meaning...by drawing on old experience and by using symbols that already have some other, old familiar meaning. [And] old symbols and their meanings are employed in a new way to conceptualize the new meaning." Arendt (1978) further adds that "All philosophical terms are metaphors, frozen analogies, as it were, whose true meaning discloses itself when we dissolve the term into the original context, which must have been vividly in the mind of the first philosopher to use it. The metaphor, [bridges] the abyss between inward and invisible mental activities and the world of appearances [and] was certainly the greatest gift language

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[23] See Robert D. Behn, "Management and the Neutrino" in *Public Administration Review* (September/ October 1992) 52-5: 409-19, and W. Graham Astley and Raymond F. Zammuto, "Organization Science, Managers, and Language Games," in *Organization Science* (November 1992) 4-3: 443-459. Behn presents a compelling argument in which "hard" sciences such as physics rely on using metaphors to grasp elusive concepts which can never be conclusively proved. Behn (418) submits the idea that "Just as neutrinos and quarks help physicists make sense of their subatomic world and gravity and force help us make sense of ours, so concepts like 'stick to the knitting' and 'MBWA' may help public managers make sense of their scientists need only employ metaphors of social science." Astley and Zammuto (455) submit that managers need various conceptual devices such as "analytical categorizations, typologies, and metaphors" and that "Organization science may thus facilitate practice more through process than through content--instead of discovering empirically derived solutions to specific problems, it provides conceptual language that shapes managers' perceptions and thoughts, thereby enhancing their problem-solving capabilities. Conceptual language may increase mental agility, allowing managers to redefine problems in ways that are amenable to resolution." They further advocate that there is a need for managers "to see and understand organizational events from several, rather than single perspectives."

could bestow on thinking and hence on philosophy..." (104-5).

A significant contribution to the analysis of this dissertation's case study is the metaphorical framework developed by Gareth Morgan in *Images of Organization* (1986).[24] Morgan (1983) defines metaphor as one of four types of "tropes" (the others are metonymy, synedoche, and irony) from the Greek *tropos*, meaning "turn." His definition of metaphor is as follows:

> Metaphor turns imagination in ways that forge an equivalence or identity between separate elements of experience. Specifically, metaphor creates meaning by understanding one phenomenon through another in a way that encourages us to understand what is common. Thus the idea that "the organization is a machine" finds machine-like qualities in organization, just as primitive people find anger of the gods in thunder and friendliness in sunshine. Metaphor makes meaning in a primal way; its role is not just embellishment (602).

Morgan compiled eight "images" (also described as metaphors, frames or perspectives) from various theoretical points of view to help managers improve their management skills. Morgan (1980, 611-2) acknowledges that organization theory is metaphorical and that the "images" approach is essentially a subjective enterprise. He favors theoretical pluralism and maintains that no one metaphor can capture the total nature of organizational life. Each theoretical perspective has its limitations and can offer only partial explanations for understanding organizations. The images will be used to examine the *Challenger* case study and are as follows: (1) machines metaphor; (2) organizations as organisms metaphor; (3) holographic metaphor; (4) culture

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[24] The development of Morgan's ideas can be traced through his numerous works on the subject. A few notable examples are "More on Metaphor: Why We Cannot Control Tropes in Administrative Science," in *Administrative Science Quarterly*, 28 (1983): 601-7; "Paradigms, Metaphors, and Puzzle Solving in Organization Theory," in *Administrative Science Quarterly*, (1980): 605-22; "Accounting as Reality Construction: Towards a new epistemology for accounting practice," in *Accounting Organizations and Society*, 13 (1988): 477-85; *Riding the Waves of Change*, 1988 (San Francisco: Jossey-Bass); and, *Creative Organization Theory*, 1989 (Newbury Park: Sage). He has also collaborated with Gibson Burrell in *Sociological Paradigms and Organizational Analysis*, 1979 (London: Heinemann) and with Linda Smircich in "The Case for Qualitative Research," in *Academy of Management Review* 5 (1980): 491-500.

metaphor; (5) political systems metaphor; (6) psychic prisons metaphor; (7) flux and transformation metaphor; and, (8) instruments of domination metaphor. All of these metaphors are found within the metatheoretical paradigms listed previously.[25] A brief synopsis of Morgan's images will follow. More detailed applications and explanations will come within the context of analyzing the three case studies. Other important works from the framing literature will be utilized in my work to add support to Morgan's multi-theoretical images approach.[26]

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[25] There is, of course, an extensive body of literature that accompanies each of Morgan's metaphors. Investigation into the case studies will bring out various classic works within organization theory. For example, Morgan attributes the origin of the "machines metaphor" to Frederick the Great and other military experts who developed armies into "military machines" which greatly influenced organization theorists well into the middle twentieth century (e.g., Max Weber, F.W. Taylor, and Henri Fayol). Frank J. Barrett and Suresh Srivastva (1991) in "History as a Mode of Inquiry in Organizational Life: A Role for Human Cosmogony," in *Human Relations*, 44/3: 231, criticized most organization theory which "has been characterized largely by a structural-functionalist orientation to social life." Haridimos Tsoukas (1993), in "Analogical Reasoning and Knowledge Generation," in *Organization Studies* 14/3:331, is generally sympathetic to the metaphorical approach, but states that Morgan (1986) favors the metaphorical approach, but adds that Morgan (1986) "favors one particular type of discourse (and the machine, organismic and holographic metaphors) when he talks about effective management, improving current organizational practices, and enhancing the ability of organizations to solve problems through their emphasis on cultural socialization and decentralized control. [Also] Morgan finds himself in the contradictory position of theoretically proclaiming the usefulness of all metaphors (and their associated mode of discourse), while practically privileging some of them at the expense of others." Despite these criticisms, Morgan does distinguish between the various metaphors and places them in context within the sociological paradigms outlined by Burrell and Morgan (1979, see above), *Images of Organization* (1986), and "Paradigms, Metaphors, and Puzzle Solving" ASQ 1980. The functionalist perspective is dominant, consisting of the machines, organisms, brains, political systems, and flux and transformation metaphors. The radical humanist paradigm is limited to the psychic prisons (ideological) metaphor. Radical structuralism is encompassed by the domination metaphor and the interpretive perspective is addressed in the culture metaphor. By sheer volume, then, Tsoukas makes a valid point. In defense of Morgan, however, the functionalist school has had a clear advantage over the other perspectives in terms of the number of scholars involved in and maintaining the "orthodoxy" throughout this century and the ready acceptance of most organization theorists.

[26] See, for example,Lee G. Bolman and Terrence E. Deal in *Reframing Organizations: Artistry, Choice, and Leadership*, 1991 and Robert E. Quinn's *Beyond Rational Management: Mastering the Paradoxes and Competing Demands of High Performance*, 1991, both are excellent treatises on the subject.

The Machines Metaphor

Much of the classic literature in organization theory is encompassed by Morgan's (1986) "machines metaphor," essentially classic management theory and scientific management.[27] Belonging to the functionalist (scientific) metatheoretical world view, the metaphor has numerous strengths and weakness for understanding how organizations actually work. Morgan's analysis is as follows:

> Images or metaphors only create partial ways of seeing. For in encouraging us to see and understand the world from one perspective they discourage us from seeing it from others. This is exactly what has happened in the course of developing mechanistic approaches to organization.
> The strengths can be stated very simply. For mechanistic approaches to organization work well only under conditions where machines work well: (a) when there is a straightforward task to perform; (b) when the environment is stable enough to ensure that the products produced will be appropriate ones; (c) when one wishes to produce exactly the same product time and again; (d) when precision is at a premium; and (e) when the human "machine" parts are compliant and behave as they have been designed to do.
>
> [Limitations:] (a) can create organizational forms that have great difficulty in adapting to changing circumstances; (b) can result in mindless and unquestioning bureaucracy; (c) can have unanticipated and undesirable consequences as the interests of those working in the organization take precedence over the goals the organization was designed to achieve; and (d) can have dehumanizing effects upon employees, especially those at the lower levels of the organization hierarchy (Morgan 1986, 35-6).

The machines metaphor, though essentially limited in its ability to interpret or

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27 The origins of the machine metaphor are traced by Morgan (1986, 24) back to the era of Frederick the Great (1746-1780) of Prussia. The military armed forces he and others created were meant to resemble efficient war machines capable of defeating opponents. Other contributors include Adam Smith and his *Wealth of Nations* (1776) which celebrated the division of labor and increased efficiency by subordinating workers to their machines and supervisors (Morgan 1986, 23). This increasingly scientific or bureaucratic form of organization was described by Max Weber, who was interested in the social consequences of bureaucratization. Representatives of the "classical management school" cited by Morgan include F.W. Mooney, Lyndall Urwick and Henri Fayol. F.W. Taylor's scientific management principles are also included in the machines metaphor (30).

analyze organizations, is nevertheless a useful descriptive tool for administrators and academicians.

Organizations as Organisms

This metaphor consists of the human resources management school, systems theory, contingency theory and organizational ecology.[28] Features of the organisms metaphor include:

> **Strengths:** (1) emphasis is placed on understanding relations between organizations and their environments; (2) belief that management of organizations can often be improved through systematic attention to survival needs; (3) characteristically distinguishes or identifies different species of organizations; (4) stresses the virtue of organic forms of organization in the process of innovation; (5) contributes to the idea of associating theory with practice in organization theory; and, (6) contributes to the study of `ecology,' or interorganizational relations.
>
> **Weaknesses:** (1) we are led to view organizations and their environments in a way that is far too concrete; (2) there is an assumption of `functional unity,' [and that] the system is unified and shares a common life and a common future; and, (3) the danger of the metaphor becoming an ideology...where images or theories come to serve as normative guidelines for shaping practice (Morgan 1986, 72-6).

Like the machines metaphor, this metaphor is derived from the functionalist paradigm. Much organization theory literature has come from this image. This metaphor may be useful for understanding how organizations attempt to survive in a biological (scientific) sense. What can happen, for example, is that "the population-ecology view of organizations revives the ideology of social Darwinism, which stressed that social life is based on the laws of nature and

[28] See Morgan (1986) Chapter 3 for more information. For human resources management, Morgan includes the Hawthorne studies of Mayo and Roethlisberger, as well as Trist and Bamforth, Maslow, Argyris, Herzberg and McGregor. Systems theory is represented through the works of Bertalanffy and Parsons. Contingency theory is comprised of an extensive variety of views by Kast and Rosenzweig, Burns and Stalker, and Lawrence and Lorsch. Boulding and Trist are representative of the organizational ecology approach.

that only the fittest will survive" (Morgan 1986, 76). Morgan warns that if this metaphor is taken too seriously (as to whether there are exact parallels between nature and society), then "we fail to see that human beings in principle have a large measure of influence and choice over what their world can be" (76).

Holographic Metaphor (or Organizations as Brains)

Morgan uses this image to convey his idea that organizations are information-processing "brains," which consist of processes including communications, information and decision-making systems (1986, 81). Key concepts include Herbert Simon's "bounded rationality," and "single-loop" versus "double-loop" learning based on communications theory. The most important elements of the image are the facilitation of self-organization (what Morgan calls "principles of holographic design") and learning through: (1) getting the whole into the parts; (2) creating connectivity and redundance of functions; (3) creating simultaneous specialization and generalization; and, (4) creating a capacity to self-organize (1986, 97-8). The metaphor has the following limitations:

> **Strengths:** (1) holographic and other organization designs that break free of bureaucratic controls show that organizations can deal with uncertain and complex problems in ways that go well beyond the capacities of any single individual; (2) increased cognitive capacity as the holistic, analogical, intuitive, and creative capacities of the brain's right hemisphere are used [which could] provide further means of extending and transforming organizational capacities for rational action; and, (3) it provides a valuable means of thinking about how developments in computing and other microprocessing technology can be useful to facilitate new styles of organization.

> **Weaknesses:** (1) there is a danger of overlooking important conflicts between the requirements of learning and self-organization on the one hand, and the realities of power and control on the other (the process of

> learning requires a degree of openness and self-criticism that is foreign to traditional modes of management); and, (2) since any move toward self-organization must be accompanied by a major change in attitudes and values, the realities of power may be reinforced by an inertia stemming from existing assumptions and beliefs (Morgan 1986, 107-9).

This metaphor is representative of the functionalist, or scientific, paradigm (Burrell and Morgan 1979). It attempts to interject science with human characteristics in order to account for behavior limitations of human beings in organizations.

Organizations as Cultures

Morgan (1986, 112) defines culture as "the pattern of development reflected in a society's system of knowledge, ideology, values, laws and day-to-day ritual." Organizations are an integral part of society and are important components in the culture's milieu. Morgan describes organizations as cultural phenomena which vary from one society to another and that cross-national variations "may be understood by exploring patterns of corporate culture and subculture between and within organizations" (1986, 112). Furthermore, members of organizations oftentimes end up being what they think and say as their ideas and visions are realized in daily human interaction (133). Some of the characteristics of the image are as follows:

> **Strengths:** (1) it directs attention to the symbolic or even `magical' significance of even the most rational aspects of organizational life; (2) it contributes to our understanding organizational change and points towards another means of creating organized activity: by influencing the language, norms, folklore, ceremonies, and other social practices that communicate the key ideologies, values, and beliefs guiding action (135-7).

> **Trouble:** (1) management has always been to some extent an ideological practice, promoting appropriate attitudes, values and norms as means of motivating and controlling employees; and (2) to the extent

that the insights of the culture metaphor are used to create an Orwellian world of corporate newspeak, where the culture controls rather than expresses human character, the metaphor may thus prove quite manipulative and totalitarian in its influence (Morgan 1986, 138-9).

Analyzing organizations as cultures can bring critical insight as to what is occurring in complex organizations. The "organizations as cultures" image recognizes the variance of attitudes, values and beliefs in organizations as well as between organizations. This is a significant departure from the previous scientific (or functional) paradigms in that *subjective human behavior and artifacts* are taken into account when analyzing *distinctive* organizations. Changing an organization's culture can have deleterious consequences and even cause decay,[29] when used by managers against people dependent upon the organization for comfort, stability and identification. The organizations as cultures metaphor trancends and affects the four major paradigms (i.e., functionalist, interpretive, radical humanism, and radical structuralism) of Burrell and Morgan (1979). Along with "organizations as political systems" (see below), the culture metaphor takes into account the normative behavior of individuals within organizations and between organizations, transcending traditional science in organizational analysis.

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29 An instructive tome on this subject is Howard S. Schwartz's (1990) *Narcissistic Process and Corporate Decay: The Theory of the Organization Ideal.* Schwartz describes his "first understanding of narcissistic process, organizational totalitarianism, and the organization ideal...in moral terms, in terms of the psychological damage done to the individuals involved and in terms of the damage that could be wrought outside of the organization....I give the name *organizational decay* to the multidimensional degeneration that results when the nature of the organization shifts from doing work in the real world to presenting a dramatization of its own perfection in a fantasy world" (49). While Schwartz's work best represents the psycho-analytical perspective (see the "organizations as psychic prisons" metaphor below), Schwartz's analysis addresses the cultural aspects of organizational totalitarianism.

Organizations as Political Systems

Morgan (1986) points out here that organizations have political interactions (organizations are intrinsically political). There are various coalitions among people within an organization (organizations are coalitions themselves) and that "most approaches to organization actually foster the development of cliques and coalitions" (154). Conflict is the norm in organizations and make take on a variety of different forms: (1) personal; (2) interpersonal; (3) between rival groups or coalitions; and, (4) explicit or covert. Morgan (1986 159) also outlines various types of power in organization as formal authority, control of scarce resources, use of organizational structure, rules and regulations, control of decision processes, control of knowledge and information, control of boundaries, the ability to cope with uncertainty, control of technology, interpersonal alliances, control of counter-organizations, symbolism, gender relations, structural factors, and the power one already has. And, as most political scientists are aware, political power is ambiguous, asymmetrical and essentially difficult to define. Morgan believes that acknowledging power within organizations can be helpful to managers if they accept the inevitability of organizational politics. Characteristics of the political system image are as follows:

> **Strengths:** (1) organizational politics becomes a taboo subject which at times makes it extremely difficult for organization members to deal with this crucially important aspect of organizational reality; (2) it encourages us to see how all organizational activity is interest-based; (3) it helps to explode the myth of organizational rationality [rationality is always political]; (4) it points to disintegrative strains and tensions in an organization; (5) it obliges us to recognize that tensions between private and organizational interests provide an incentive for individuals to act politically; and, (6) it encourages us to recognize the sociopolitical implications of different kinds of organization and the roles that organizations play in society.

Potential danger: when we understand organizations as political systems we are more likely to behave politically in relation to what we see. We begin to see politics everywhere, and to look for hidden agendas even when there are none (Morgan 1986, 194-7).

Like the culture metaphor, the political systems image takes into account the more irrational aspects (subjective impulse) of human political behavior *vis `a vis* more traditional scientific analyses. The political systems metaphor is useful in understanding human power relationships in organizations and offers another crucial insight into organizational behavior.

Psychic Prisons

Under this metaphor, using the image of Plato's cave, Morgan describes organizations as psychic phenomena. Reality is constructed from known images that have always been explicitly taken as the explanation of the world. In its essence, individuals and organizations can become cognitively trapped, or involved in deleterious psychological actions such as "groupthink" (Janis 1971). Drawing on the scholarly works of Freud, Jung and Foucault, Morgan defines the strengths and weaknesses of the image as follows:

Strengths: (1) it directs attention to the fact that human beings can and do create social worlds that many may experience as problematic and confining; (2) it presents a set of perspectives for exploring the hidden meaning of our taken-for-granted world; (3) it shows us that we have over-rationalized our understanding as rationality and irrationality appears to be central to the human condition; (4) it draws specific attention to the ethical basis of organization by reinforcing the view that organization is human in the fullest sense; (5) it encourages us to recognize and deal with the power relations shaping the enactment of organizational life; and (6) it identifies many of the barriers standing in the path of innovation and change.

Weaknesses: (1) people are often locked into cognitive traps because it is in the interests of certain individuals and groups to sustain one pattern of belief rather than another; (2) it can be criticized for placing too much emphasis on the role of cognitive processes in creating, sustaining, and changing organizations and society; (3) it often encourages utopian speculation and critique; and, (4) it raises the specter of an Orwellian world where we attempt to manage each other's minds (Morgan 1986, 228-31).

The psychic prisons metaphor best represents the "radical humanism" paradigm as depicted by Burrell and Morgan (1979) and the phenomenological theoretical perspective, which I would include in both the radical humanism and interpretive world views [see Gendlin, Hummel, and Arendt above].

Flux and Transformation

Morgan uses this metaphor to demonstrate that organizations should get away from linear thinking and adopt logic systems based on more open-ended thinking. He adopts the theory of autopoiesis (from the Chilean biologists Humberto Maturana and Francisco Varela) that "encourages us to understand the transformation or evolution of living systems as the result of internally generated change [and] autopoiesis places principal emphasis on the way the total system of interactions shapes its own future" [or the antithesis of Darwinian theory] (Morgan 1986, 240). Hegel [originally] and Marx's dialectical analysis [thesis/antithesis, not the economic determinism of Engels] of society is combined with the autopoeisis perspective to create the basis of the flux and transformation metaphor in which "social arrangements generate inner contradictions that defeat the purposes for which they were set up leading to negation and counter-negation" (Morgan 1986, 258). Image characteristics are as follows:

Strengths: (1) it attempts to fathom the nature and source of change, so that we may understand its logic [through description and analysis]; (2) it exposes assumptions used in organizations that are rooted in layers of ideology that encourages us to accept them at face value [e.g., capitalism versus communism, whereas these different systems are usually presented as a matter of ideological or political choice. (And) the detailed consequences and inner logic of the alternative systems are rarely subjected to critical analysis].

Weaknesses: (1) [it] may be too idealistic, the ideology supporting a particular logic of change may eliminate the possibility of adopting others; (2) it is that a full understanding of logics of change always depends on hindsight (though all theories share this feature (267-72).

This metaphor also encompasses "systemic wisdom," including Vickers's (1995) "appreciative system" and Taoist Eastern philosophical methods (see Morgan 1986, 371-6). Morgan (1986, 382) attributes much of his framing method to the "general principles of dialectical thinking." The flux and transformation image may be included in the radical humanism or interpretive metatheoretical paradigms (Burrell and Morgan 1979). It also appears to resemble somewhat traditional systems theory but in essence stands systems theory on its head.

Instruments of Domination

This metaphor uncovers the seamier side of organizations. The general idea is that organizations, as instruments of domination, are often employed "to further the selfish interests of elites at the expense of others" (Morgan 1986, 275). Morgan draws on the analyses of Max Weber, Robert Michels and Karl Marx to show that organizations use rationality (even in more democratically oriented organizations) to dominate individuals through hierarchical or class-based arrangements. Limitations of the metaphor are as follows:

Strengths: (1) it draws our attention to [the] double-edged nature of rational action, illustrating that when we talk about rationality we are always speaking from a partial point of view....what is rational from one organizational standpoint may be catastrophic from another; (2) it shows us a way of creating an organization theory *for* the exploited; and, (3) it helps us to appreciate the issues that fuel this radical frame of reference in practice.

> **Weaknesses:** (1) [it] can be used to provide a crude conspiracy theory of organization and society; (2) there is a danger that in asserting an equivalence between domination and organization we may blind ourselves to the idea that non dominating forms of organization are possible; and, (3) the perspective is ideological, but it is certainly no more ideological than any other (Morgan 1986, 315-9).

This particular metaphor represents the radical structuralist paradigm (Burrell and Morgan 1979). Of all the preceding images presented by Morgan, the instruments of domination metaphor illustrates the bourgeois/proletariat and elite/partisan exploitation of those at the top of organizations and society. This image effectively offers the manager or academic another critical insight into organizational behavior, this time viewing the organization from the worker's perspective.

The advantages of the metaphorical approach (as opposed to a single or more limited theoretical analytical framework) will be demonstrated when we examine and interpret the case study. Morgan (1986) maintains the idea that "our theories and explanations of organizational life are based on metaphors that lead us to see and understand organizations in distinctive yet partial ways [and] the use of metaphor implies *a way of thinking and a way of seeing* that pervade how we understand our world generally" (12-13, his emphasis). There is no single, simple catchall theory which explains how all organizations behave.[30] There are, however, perceptions which human beings carry with them when they work in or manage organizations. Managers use what works best for them, oftentimes using analogy in situations where prior experience

30 Astley and Zammuto (1992) make a strong case that much of the research published in scholarly journals is ignored by management practitioners because it focuses too narrowly on particular operationalizations of single theories. Shafritz and Ott (1992, 4-5) note in their introduction that there is no general consensus on what constitutes knowledge in organization theory. Moreover, theories within the field exist as "intellectual constructs and as mutual support networks of organization theorists. They have one primary purpose: to organize and extend knowledge about organizations and how to study them."

may not exist. Practical improvement in managing organizations may occur if administrators have more metaphorical tools available to them.[31] The overall idea is that, at best, there are only partial paradigms available to the scholar of organization theory. Perhaps the best way to engage in the understanding of organizations is to use these images in order to make sense of complex phenomena.

We will be exploring the possibilities and potential usefulness for knowledge generation of theoretical explanations of the *Challenger* launch decision in more detail in chapters four and five. In the next chapter, we will examine a history of events leading to the launch decision. This brief historical analysis will trace the development of the NASA organization and the affected subcontractors and publics from its early beginnings through the Rogers Commission hearings.

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31 See Behn's (1992) "Management and the Neutrino" article in *PAR*. He equates metaphors with proverbs and compares management with physics. "Light's waves and light's particles. Both are metaphors--proverbs, if you will. They are valuable to scientists not because they represent reality, but because they help scientists think [and] managers want to have as many proverbs as possible in their tool kit. For proverbs help them to think" (415-6).

CHAPTER III:
Events Leading To The *Challenger* Accident

NASA Development and the Early Years: The 1950s and 1960s

An examination of the history of events leading to the *Challenger* explosion also involves simultaneously looking at the National Aeronautics and Space Administration in a broader context. After the accident in 1986, the Presidential Commission under the chairmanship of William Rogers found a number of causes:

> 1. The joint test and certification program was inadequate. There was no requirement to configure the qualifications test motor as it would be in flight, and the motors were static tested in a horizontal position, not in the vertical flight position.
>
> 2. Prior to the accident, neither NASA nor [Morton] Thiokol [the Solid Rocket Booster manufacturer] fully understood the mechanism by which the joint sealing action took place.
>
> 3. NASA and Thiokol accepted escalating risk apparently because they "got away with it last time." As Commissioner [Richard P.] Feynman observed, the decision making was:
>
> 'a kind of Russian roulette. . . . [The Shuttle] flies [with O-ring erosion] and nothing happens. Then it is suggested, therefore, that the risk is no longer so high for the next flights. We can lower our standards a little bit because we got away with it last time. . . . . You got away with it, but it shouldn't be done over again like that.'
>
> 4. NASA's system for tracking anomalies for Flight Readiness Reviews failed in that, despite a history of persistent O-ring erosion and blow-by, flight was still permitted. It failed again in the strange sequence of six consecutive launch constraint waivers prior to 51-L, permitting it to fly without any record of a waiver, or even of an explicit constraint. Tracking and continuing anomalies that are 'outside the data base' of prior flight allowed major problems to be removed from, and lost by, the reporting system.
>
> 5. The O-ring erosion history presented to Level I at NASA Headquarters in August 1985 was sufficiently detailed to require corrective action prior

to the next flight.

6. A careful analysis of the flight history of O-ring performance would have revealed the correlation of O-ring damage and low temperature. Neither NASA nor Thiokol carried out such an analysis; consequently, they were unprepared to properly evaluate the risks of launching the 51-L mission in conditions more extreme than they had encountered before" (*Report I*: 148).[32]

The *Report's* findings indicate a number of important issues for scholars interested in how an organization and its members, with virtually spotless reputations, could have committed such an egregious error in judgment. The question arises as to why did NASA not take action to prevent the O-rings from failing, especially since the members of the organizations involved in the work knew about the problem well in advance of the accident. In order to make sense of the decision to launch the space shuttle, I will engage the reader in a thorough historical analysis which will hopefully a better understanding as to why decision-makers made choices leading to the accident.[33] As we discovered earlier, scholars interpret which events will be selected thus making

[32] In the interest of brevity, I have condensed the title of the five volume work *Report to the President by the Presidential Commission on the Space Shuttle Challenger Accident*, to *Report I, II, III, IV, or V*, respectively.

33 See Malcolm McConnell, *Challenger: A Major Malfunction*, 1987 (Garden City, NY: Doubleday and Company) for an interpretation of events leading to the accident. This work is widely cited by researchers, is authoritative, and is especially useful examining the political intrigue involved in the NASA procurement process and personalities within the NASA organization itself. Joseph J. Trento's *Prescription for Disaster: From the Glory Days of Apollo to the Betrayal of the Shuttle*,1987 (New York: Crown Publishers) is particularly useful for its interviews of agency executives and analysis of political intrigue in various White Houses and other governmental agencies since NASA's inception. Trento shows the seamier side of leadership at NASA and recounts personal animus between rivals at the highest levels of organizations involved in the space program. Richard S. Lewis's *Challenger: The Final Voyage*, 1988 (New York: Columbia University Press) gives the reader an excellent technical account as to why the *Challenger* accident occurred from a more traditional perspective, largely reinforcing the Presidential Commission's findings. Diane Vaughan's *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA*, 1996 (Chicago: University of Chicago Press) is a provocative and thoughtful theoretical and revisionist historical analysis of the decision to launch the *Challenger*. Vaughan questions the findings of the Presidential Commission and uses extensive interviews of the principals involved to draw her conclusions. All four of these works along with the *Report of the Presidential Commission* must be consulted by anyone seriously interested in pursuing scholarly research about the *Challenger* launch decision.

an impact on the overall historical analysis and indicating something of the analyst himself. Furthermore, the organizational participants portrayed are complex human beings and there is always a danger that their actions may be oversimplified or taken out of context from their original historical meaning. There are numerous historical accounts and theoretical interpretations about this incident available to scholars, some of which will be recounted in this research project.

Several important themes recur throughout NASA's relatively brief history. Firstly, NASA as a government organization is subject to budget fluctuations and, as a result, finds itself competing with other federal government entities for scarce resources, particularly the Department of Defense. As we will see, costs were important especially in the initial critical stages of the shuttle's development. Research scientists also questioned whether spending money on expensive projects like the space transportation station is an appropriate use of limited NASA funds.[34] The highly charged procurement process will be examined and is an important aspect of the budgetary process. Secondly, from 1958 through 1986 the United States government was in the midst of the Cold War with the Soviet Union. The space

[34] See James A. Van Allen's criticism of manned space flight "Space Science, Space Technology and the Space Station," *Scientific American*, January 1986, "...to the ordinary person space flight is synonymous with the flight of human beings. The simple taste for adventure and fantasy expressed in that sentiments has been elevated in some quarters to the quasi-religious belief that space is a natural habitat of human beings....The directions embodied in NASA's budgetary policy ignore the basic history of space flight: in the more than 28 years since the launching of *Sputnik I* the overwhelming majority of scientific and utilitarian achievements in space have come from unmanned, automated and commandable space craft" (32). While Allen's criticism of manned space flight was not voiced until just prior to the *Challenger* launch in 1986, this attitude of astronomers such as Allen was indicative of some of the opposition throughout the history of the space program. McConnell (1987, 15) also observed that academic scientists had criticized NASA's meager effort to study Halley's comet. Shortly after the *Challenger* accident, scientists Ruth A. and John S. Lewis in "Getting Back on Track in Space," *Technology Review*, August/September 1986, pp. 30 - 40, point out that "NASA's history of pursuing costly dead-end programs [like the space shuttle] to ensure its own survival has undermined any attempts to develop long-term goals in space (30).

program was part and parcel of the space race between the two superpowers. The competition gave impetus to NASA's creation and growth as the United States was engaged in a contest for international supremacy with the Soviet Union after the launching of the *Sputnik* satellite in 1957 (Vaughan 17). The original NASA culture "did not rise from the sands of time when the space race began in 1957. It was formed out of a set of loosely supervised government laboratories and development centres already engaged in aeronautical research and rocketry" [the old National Advisory Committee on Aeronautics (NACA)] (McCurdy 1989, 304). The space race led to an initially strong interest in matters pertaining to space and national defense, but the U.S. government policy towards NASA fluctuated throughout the Cold War years, even during the peak years of interest in space flight and NASA:

> Although administration concern about how the space agency's accomplishments affected the national interest was continuous, historically its willingness to fund the agency waxed and waned in rhythm to national and international events and political swings...Apollo received abundant resources....NASA created an innovative system and rapidly progressed toward accomplishing a mission right out of science fiction: in 1969, astronauts planted an American flag on the bleak terrain of the moon....In the mid 1960s, however, international and domestic factors caused uncertainty about the future direction of the space program and a consequent decline in congressional appropriations for NASA....NASA, which had for so long enjoyed budgetary certainty grounded in consensus about its mission, suddenly experienced the uncertainty of other agencies (Vaughan 18).

Thirdly, domestic political factors, such as the development of President Johnson's Great Society programs and the Vietnam War, played a significant role in the development of NASA and the subsequent production of the space transportation system. NASA complicated its own budgetary situation by advocating the development of a space station, although the development of the station was also used as a justification for the expenditure of funds for the space shuttle system.[35] Fourthly, and finally, the sheer complicated nature of the technology used in space flight and the space shuttle in particular caused constant reevaluation and design of complex components for purposes of economy, efficiency and safety concerns. NASA administrators would advocate advanced systems from "off-the-shelf and state-of-the art technology" (Lewis 1988, 356), sell them to the public, Congress, White House or other government agencies and later have to return to the budgetary well for further funding consideration. Heimann (1993, 429) points out that levels of experience were seriously jeopardized due to a lack of funding as manpower was cut at the three major centers for manned space flight during the period of 1970 to 1985 (Johnson, Kennedy, and Marshall) "by 38, 54, and 84%, respectively." There is also the question which will be explored both in this chapter and in subsequent chapters concerning organization theory as to whether *idealism*[36] gets in the way of reality as to when the shuttle flies (i.e., is it an experimental aircraft or fully operational?), as to how many flights will take place and as to who will fly in the shuttle. All four of these themes will be examined in a chronological order as an historical analysis of NASA and the decision to launch the Challenger.

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[35] A good, brief chronological synopsis of the shuttle program up to the disaster is provided by Eliot Marshall in "The Shuttle Record: Risks, Achievements" *Science*, 14 February 1986, pp. 664 - 666. According to Marshall "On 20 July 1969, American astronauts walked on the moon, taking the Apollo program through its final paces. The logical next step, NASA said, was to build a space station, and its support vehicle--the shuttle--would come first" (664).

[36] Idealism here can mean several different things: (1) It could mean someone having an overly optimistic, unrealistic or utopian view of technological capabilities; (2) It could mean having a narcissistic view of one's self in the context of one's organization; or (3) idealism can mean someone or some organization having unrealistic expectations or goals of monetary or power rewards beyond what one would normally earn. All of these variations of idealism will be explored further in the following chapters of this research project.

Early Shuttle Development: The 1970s, the Seeds for Disaster Are Sown

We have seen in the previous section that from the end of the 1950s through the 1960s NASA had little trouble getting adequate funding for spaceflight initiatives such as the Apollo program which had successfully placed men on the moon. Satellite technology and transportation also made significant headway. NASA was interested in obtaining a space transportation system to achieve a permanent presence in space. By 1970, "early plans called for a complex double shuttle with a plane-like orbiter on top and a piloted, reusable launch vehicle beneath" (Marshall 664). Max Faget[37] of the NASA Manned Spacecraft Center argued for his design of the new space shuttle system:

> The wing on this vehicle supports subsonic cruise flight and landing maneuvers. Because entry takes place at a sufficiently high angle of attack to discount concern over high leading-edge temperatures, the wing planform can be selected solely on the basis of optimization for subsonic cruise and landing. The straight wing with a reasonable aspect ratio is clearly the lightest way to produce the requisite lift at conventional landing velocities, and it is also the ideal wing for subsonic cruise flight. Entry at high angle of attack also nullifies any desire to fold the wings: Weight estimates indicate that the lower surface can be given heat protection for about 10% of the weight required to fold the wing into the fuselage" (Faget 1970, 57).

Faget's design was favored by NASA but was by no means the only design available to all interested parties in the area of space flight. Marshall (664) notes that "In 1971, the White House gave NASA the bad news that its budget would not grow much. NASA decided the new space vehicle would fly better in Congress if it had military support." NASA would have to make compromises to

[37] Faget was one of the original 35 members of the NASA Space Task Group, served on the Project Mercury steering committee and was instrumental in the conception of the Mercury spacecraft.

its original straight-wing design. The Air Force had developed its own design with features different from those of NASA's version.[38] "After long negotiations, NASA agreed to Air Force specifications for a huge payload bay 15 by 60 feet, 60,000 pounds of lift capacity, and the ability to land on either the West or East Coast" (Marshall 664). Debate over which version of the shuttle should be put in production was carried out in the early 1970s, partly in the pages of *Astronautics & Aeronautics*, as to how the space shuttle should look. As noted above, NASA (through Faget) advocated a fixed-wing or "straight" version whereas the Air Force, through its Air Force Flight Dynamics Laboratory (AFFDL), promoted a "delta wing" version:

> A delta lifting body has the flexibility to provide either high cross range for the Air Force or low cross range at higher payload for NASA by changing its method of reentry. We view flexibility as a necessary feature of a new Space Transportation System (STS) to assure maximum utility to future users--flexibility not only as a payload carrier but also in maneuverability and performance. Air Force Flight Dynamics Laboratory (AFFDL) studies of how to best obtain this flexibility have shown an evolution to delta lifting bodies....Experimental studies have shown that peak temperatures and temperature gradients are less for the delta than a straight-wing configuration. And by following a re-entry mode different from the conventional, the delta would experience a lower heat load and still achieve high cross range.
>
> The over-all new space-transportation system must have the potential for major economic and operational benefits to future national space programs. Payload delivery to low Earth orbits currently costs on the order of $500 - 1000/lb; for synchronous equatorial orbits, $5000 - 10,000/lb. Payloads, at $3000 - 7000/lb, add significantly to costs.

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38 See also Vaughan (1996, 19). Factors for decline of the Space Transportation System include: (1) NASA had to combine resources with the Air Force to procure enough funding for the Space Transportation System program. This led to design compromise to meet military requirements (sending military payloads into space); (2) Budgetary constraints, Air Force refused to pay for a high-performance shuttle...in 1971 NASA called in a think tank, Mathematica, Inc., to come up with a cost-effective rationale which resulted in "a launch rate of more than 30 flights per year," which would allow for the shuttle program to pay for itself [which NASA never met] (Vaughan 19-20); (3) "Power struggles between NASA, OMB, Congress, and the administration directly affected [initial] shuttle design. Compromise was necessary to get the program going" (Vaughan 20). This led to: (a) low development costs; (b) a smaller Orbiter and SRBs which had to be reusable; (c) design decisions which led to safety compromise and loss of escape rockets on the Orbiter (Vaughan 20-22).

> Consequently, some sort of reusable launch system which would substantially decrease these costs becomes quite attractive....[I]f we truly want to maximize the applicability of the lessons learned from STS and advance the frontier of technology to assure a national technical capability for other future systems, then concepts with reasonable levels of aerodynamic performance are required.
>
> Over 10 years of investigating recoverable and reusable launch systems has brought forward many candidates, each judged best when measured against a different criterion. If, however, we are to reach defensible decisions, we must establish a single set of criteria for making rational comparisons with qualitative judgments. Nevertheless, any concept selected should most likely be assessed relative to (1) *economics*, (2) flexibility, (3) growth potential, (4) design sensitivity, and (5) technical confidence (28). (Draper, Buck, and Goesch 1971, 26 - 28; italics added for emphasis).

The Air Force was able to ensure that its design prevailed. The Air Force was also aided by NASA's need to have a senior partner to continue its survival in the long-term future. The increase in payload for the new shuttle necessarily created a need for larger rockets in order to propel the orbiter into space.

Once the basic shuttle concept was negotiated between NASA and the Air Force, the next step in the developmental process consisted of requesting bids from private contractors in order to actually produce the shuttle. McConnell (1987) depicts the seamier side of the awarding of government contracts in *Challenger: A Major Malfunction* as to how administrators and elected officials went through the bidding process in an unethical, if not illegal, fashion. In McConnell's chapter entitled "July 1971 to 1973: The Politics of Procurement," political intrigue and greed by North American Rockwell dominated the early phases of shuttle development:

> The process of awarding the prime contracts for the space shuttle's principal elements--the main engines, the orbiter, the solid rocket boosters, and the external tank--occurred during that period of political turmoil we remember as the Watergate years ...The President [Nixon] saw the shuttle, like the Apollo moon landings, as a clear demonstration to the world of America's technological superiority over the Soviet

> Union....While the White House and the OMB debated NASA's plans for a space shuttle, aerospace contractors lobbied for approval of the project. NASA actively encouraged the contractors in these efforts, which often took the form of feasibility and economic impact studies. And one company, North American Rockwell (later to become Rockwell International), was especially active. Rockwell had been the prime contractor for the Apollo project and needed a big shuttle contract to guarantee the survival of its civilian aerospace operations....One of the first priorities was securing a position of influence within the NASA bureaucracy where the contract decisions would be made. In 1970, when it became clear NASA was pressing ahead with the shuttle project, Rockwell intensified its lobbying efforts at the White House. That year the company managed to place Dale D. Myers, the Vice President and Manager for the company's Space Shuttle Program, as NASA Associate Administrator for Manned Space Flight. Next to the Administrator, James Fletcher, Mr. Myers would have the most power in awarding contracts (McConnell 1987: 44-6).

President Richard Nixon officially endorsed the big shuttle on January 5, 1972, although the launch system was still undefined (Marshall 1986, 664). Events leading up to the realization of the shuttle proceeded quickly, though technical issues pertaining to how the shuttle propulsion system should look remained to be resolved. Two of the primary issues included questions as to whether there was to be a piloted launcher and whether there was to be a solid or liquid fueled rocket system:

> In March 1972, the technical debate on the propulsion system ended. The piloted launcher was dropped; it would have been difficult to certify two vehicles. In a compromise, it was agreed that the propulsion would be part solid and part liquid, part recoverable and part throwaway. (The liquid hydrogen-oxygen system that has proved so troublesome and hazardous was included because it permitted greater specific impulse at lift-off and greater pilot control. Liquid motors can be throttled down; solid ones cannot) (Marshall 1986, 664).

The president's endorsement was followed by the announcement on March 15, 1972, by NASA that it would build the modified or partially reusable version of the shuttle with the price tag marked down to $5.15 billion. The first manned orbital flight was initially scheduled for March 1978. Then, following six flight tests, the vehicle would become operational in March 1979. As many as sixty flights a year were contemplated (Lewis 1980, 358). Prior to the awarding of government contracts, NASA, in essence, was influenced by Associate Administrator Dale Myers.[39] According to McConnell, Myers had interests at odds with those of NASA and subsequently went back to Rockwell International *shortly after the awarding of major contracts to Rockwell*. Safety apparently was compromised and the best space shuttle and orbiter designs were not selected for ostensibly political and economic reasons:

> ...In July 1971 new NASA Administrator Fletcher announced that he had made his choice. The Rocketdyne Division of North American Rockwell would develop the space shuttle's main engines, under a program to be administered by the Marshall Space Flight Center...Pratt and Whitney [Rockwell's competitor] did not take the announcement passively...[Pratt and Whitney appealed to the Source Evaluation Board and the GAO, but the Board did not have the final say in the matter. James Fletcher made the decision to go with Rockwell.] When the appeals were exhausted, Rocketdyne was home free with a contract worth a minimum of $450 million (McConnell 47 -48).
>
> On July 26, 1972, James Fletcher announced his choice [for the space shuttle orbiter] [other competitors included Grumman Aerospace, Lockheed Missiles and Space Company and McDonnell-Douglas Corporation's Astronautics Company]: Rockwell. The contract was worth a total of $2.6 billion over six years....Although the McDonnell-Douglas Astronautics orbiter proposal did not score high in the engineering competition, it must be noted that this design incorporated a practical abort capability that would have protected the shuttle crew during all

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39 Trento (1987, 238-9) adds the prophetic actions and insight of Rocco Petrone, who in the early 1970s was in charge of manned spaceflight for NASA: "During 1975, as Petrone spent long nights at Federal Office Building Six studying shuttle design plans and looking at the projected launch rates and costs, he understood where the trade-offs to make it all work would come from. His rule--the rule that von Braun and Gilruth passed on to him--was that when you build machines for man to fly, you put your own life aboard that spacecraft. As he looked at the shuttle design, Petrone understood that this was a vehicle dictated by political and economic considerations. Yes, Low and Fletcher and Myers were right when they called it the most sophisticated spaceship man has ever built. They were right when they said it was the most complicated machine ever built. But they never said that it was also the most dangerous to fly of any manned rocket ever built....Petrone argued that Low and Fletcher were wrong when they said no escape system existed on airplanes and therefore the shuttle did not need one. Because of the success in NASA's track record, Petrone argued that Americans would have great difficulty accepting the loss of astronauts....Petrone brought in outside experts to look at the shuttle system. Their findings confirmed his views for the record. Then he left NASA."

phases of the mission, including initial ascent....*Incredibly, the McDonnell-Douglas proposal actually anticipated the cause of the Challenger accident.* Their abort system provided for a 'burn through wire' that would have sensed 'O-ring leakage,' then triggered booster thrust termination and the orbiter's abort rocket escape system. However, this system added several thousand pounds of weight to the orbiter in the thrust neutralizer, the abort rocket, and airframe reinforcement so that the orbiter could withstand the stresses of the abort sequence. And NASA in the early 1970s was not about to trade weight for insured safety (McConnell 49-50, italics added for emphasis).[40]

Rockwell International had won the shuttle design contract. The design was ready in May 1973 and construction began in June 1974. The *Enterprise*, an unpowered flight test vehicle, rolled out in September 1976 (Marshall 1986, 664). Payload had been of paramount importance when the final shuttle model was selected. Cost considerations, while crucial to obtaining initial government approval, were primary in importance to spacecraft safety.[41] In 1980, well before the *Challenger* accident, critics of the space shuttle transportation system were uncovering pitfalls in the procurement process. Lewis (1980, 358) compared the shuttle development program with government procurement of airplanes and discovered that the whole process was an act of deception:

[40] Richard S. Lewis (1988, 235) also notes that " In 1971, Rockwell International had considered three launch escape modes: ejection seats, encapsulated ejection seats and a separable crew compartment. Compared to a $10 million ejection seat weighing 1,760 pounds, the separable crew module would weigh 7 to 8 1/2 tons and cost $292 million (in 1971 dollars), the commission reported. The commission said that conventional ejection seats do not appear to be a viable option because they limit crew size and thus restrict shuttle missions. Other options examined were the separable crew compartment or escape module that would be detached from the orbiter and descend by parachute; rocket-assisted extraction from the crew compartment using small rockets to boost occupant and parachute out and away from the orbiter; and a bail-out system enabling crew persons to make an unassisted exit through a hatch during gliding flight and descend by parachute."

[41] This was despite the fact that safety was being emphasized in NASA documents insofar as the initial design was concerned. In a report entitled *Technical Status of the Space Flight Shuttle Main Engine: A Report of the Space Shuttle Engine Development Program*, March 1978 (produced by the Assembly of Engineering National Research Council and National Academy of Sciences) , it states "Safety must always take precedence over scheduling concerns. Because no flight test of the space shuttle main engine is planned prior to the first manned orbital flight, confidence in the safety and reliability of the engine in manned flight must be based upon: Safety and reliability designed into the engine..." (19).

Hindsight reveals that NASA and its contractors miscalculated the development cost and order of difficulty. They portrayed the shuttle's development as a straight-forward process. It was well within the state of the art, relying on off-the-shelf components. So ran the illusion. These assumptions, which Congress accepted, rationalised the adoption of a development strategy that was supposed to control costs by minimising testing and redundancy in parts. It was a strategy a manufacturer might use in building a new aeroplane. Indeed, that is how the public perceived the shuttle--as a new type of aircraft modified to fly above the atmosphere. That perception tended to conceal its exotic features--such as the engines and the heat-shield--and to gloss over the difficulty in creating them.

> As it turned out, the space shuttle main engines and the heat shield were beyond the state of the art. They required a detailed development process which the 'bare-bones' funding did not cover. As a result, the shuttle was under-financed from the start--the success-oriented strategy adopted for its development failed. This strategy assumed that difficulties would be minimal, but instead the shuttle's development has experienced the most conspicuous sequence of breakdowns, delays and failures since the Vanguard rocket programme in 1957 (Lewis 1980, 358).

Not all interpretations of NASA and the development of the space shuttle transportation system (STS) were negatively centered on the procurement process. Former NASA Associate Administrator Dr. George E. Mueller[42] (1972, 20) was highly optimistic about the future of manned space flight and believed the STS was "designed for routine service" and that its development would allow for "a workhorse means of leaving the Earth, performing useful tasks routinely in space, and returning to an airliner-type landing, all in an economical and safe manner, costs and physical stresses of space flight [will be] greatly reduced--[we] will travel beyond our planet [and] open up [space

[42] See "Space Shuttle: Beginning a New Era in Space Cooperation" *Astronautics & Aeronautics*, September 1972 (20 - 25) by George E. Mueller. According to the brief biography accompanying the article, "Mueller heads System Development Corporation as president and chairman of its Board. He is a member of the AIAA International Cooperation in Space Committee and a vice-president of the International Astronautical Federation. Dr. Mueller directed the U.S. manned-spaceflight program from November 1963, at the beginning of Gemini flight operations, to the first manned lunar landing. He resigned as NASA Associate Administrator for Manned Space Flight to join General Dynamics as vice-president of the corporation for system programs and developments."

travel] to many men and women, of all nations." Mueller's ideas about the future of the space shuttle seemed boundless. His notions of what the space shuttle ought to become are critical in understanding the attitude of NASA decision makers to have the shuttle become *fully operational* as opposed to being merely *experimental*, or in the research and development stage. Mueller (1972, 20) articulated and anticipated by ten years NASA's desire for routine operational service as he noted that "In truth, the coming space-shuttle era will present not only opportunities but also necessities for international cooperation on an increasingly broad basis. Looking ahead, we can expect that this era will evolve *phases* of successive cooperative developments, wide-ranging passenger services, and then mature operations--large-scale space works and expeditions." Mueller's phases for the development for shuttle utilization are as follows:

> --1. *initial cooperative phase*: one nation takes responsibility for developing and operating a shuttle system (thus opening opportunities for other nations).
>
> --2. *passenger phase*: fostering world cooperation and human understanding....International crews for the shuttle can help advance the growing perception of the Earth as the single habitat of mankind rather than an arena of confrontation between a haphazard aggregation of national interests.
>
> --3. *mature operations phase*: large scale space works and expeditions. ...Truly effective space shuttles...must be fully tested and proven like airliners before entering service, and should not require much more extensive support and checkout facilities than exist at today's airports" (Mueller 1972: 21 - 4).[43]

One of the questions researchers have contemplated was whether there was a

---

[43] Mueller, apparently concerned with presenting the shuttle as an operational vehicle and with labor costs stated, "*A key challenge which must be met if we are to realize the potential of the space shuttle will be designing the vehicle with control and checkout systems on board so that the shuttle will not need the support of the thousands of technicians presently required for manned space launches, but more like the dozen or so required to turn around a 747 jetliner*"(1972, 24, his italics).

rush to operationalize the status of the Space Transportation System before the program was ready.

Part of the shuttle selection process involved the issue as to who would get the subcontract for the development of the solid rocket boosters (SRB). This issue has been retrospectively scrutinized by McConnell (1987, 54-5) as Administrator James Fletcher, a Mormon, was alleged to have been leader of the "Mormon Mafia," bringing "home" to Utah and Morton Thiokol the SRB contract along with Utah congressional support. McConnell described Thiokol as a "medium-sized contractor with experience in munitions" and "the Minute Man and Trident missiles' solid rocket motors. But they were by no means the industry leaders in producing large, sectional solid boosters" necessary for a space shuttle (1987, 52). McConnell remarked that the Thiokol design was rated lower by the NASA Source Evaluation Board in comparison to Lockheed (1987, 53-4). In the *Report of the Presidential Commission on the Space Shuttle Challenger Accident* (1987, 120), one of the issues was that Thiokol's design was rated fourth and its management first. The issues of economy and efficiency were also examined:

> Thiokol was selected to receive the NASA contract to design and build the Solid Rocket Boosters on November 20, 1973. The booster was the largest Solid Rocket Motor ever produced in the United States; it was also the first solid motor program managed by NASA's Marshall Space Flight Center in Huntsville, Alabama.
>
> *Costs were the primary concern of NASA's selection board*, particularly those incurred early in program. In a December 12, 1973, report, NASA selection officials said Thiokol's 'cost advantages were substantial and consistent throughout all areas evaluated.' They also singled out Thiokol's joint design for special mention. *'Cost consideration overrode any other objections, they decided'*....The cost-plus-award-fee contract, estimated to be worth $800 million, was awarded to Thiokol...The design of the Shuttle Solid Rocket Booster was primarily based on the Air Force's Titan III solid rocket, one of the most reliable ever produced. Thiokol hoped to reduce new design problems, speed up the development program and cut costs by borrowing from the

Titan design....Despite their many similarities, the Thiokol solid Rocket Booster and the Titan motors had some significant design differences. For example, the joints of the Titan were designed so that the insulation of one case fits tightly against the insulation of the adjacent case to form a more gas-tight fit than the Thiokol design. One O-ring bore seal was used in each Titan joint to stop any hot gas pressure that might pass by the insulation overlap, but *in the Titan design the O-ring was able but not intended to take the brunt of the combustion pressure. In contrast, the Thiokol O-rings were designed to take the brunt of the combustion pressure,* with no other gas barriers present except an insulating putty. Also, the Solid Rocket Motor joint had two O-rings, the second to provide a backup in case the primary seal failed" (*Report I*: 120 - 21, italics added for emphasis).

Other critical differences between the Titan and Thiokol O-ring designs are as follows:

1. Thiokol used asbestos putty to compress the air between the putty and primary O-ring, which would then cause the primary O-ring to extrude into the gap between the clevis and tang in order to seal the opening. If the primary O-ring did not seal, the intent was that the secondary would pressurize and seal the joint be extruding into the gap behind its groove.

2. ...The tang portion of the Thiokol joint was longer in order to accommodate two O-rings instead of one [making it] more susceptible to bending under combustion pressure than the Titan joint....

3. ...The Thiokol design [has] a vent, or port, on the side of the motor case used after assembly to check the sealing of the O-rings.....this leak check eventually became a significant aspect of the O-ring erosion phenomenon.

4. The manufacture of the O-rings themselves constituted another difference between the Titan and the Thiokol Solid Rocket Motor. While both O-rings were Viton rubber, the Titan O-rings were molded in one piece. The Solid Rocket Motor O-rings were made from sections of rubber O-ring material glued together

5. Finally, unlike the Titan, the Thiokol Solid Rocket Motor was designed for multiple firings. *To reduce program costs, each Thiokol motor case for the Shuttle was to be recovered after flight and reused up to 20 times* (*Report I*: 121- 22, italics added for emphasis).

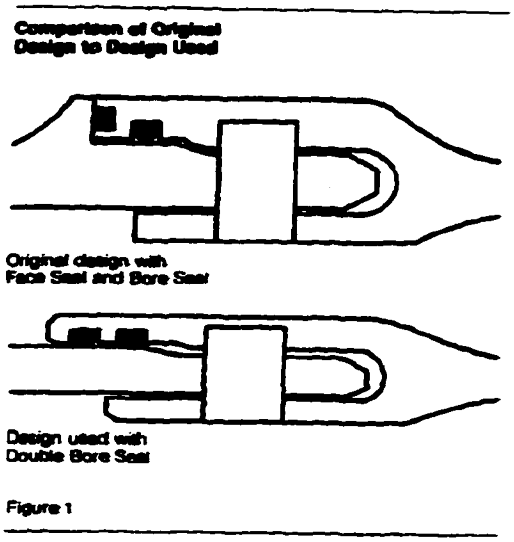

Figure 3.1: <u>A Comparison of SRB Joint Designs</u> (Source: *Report I*: 121)

The Solid Rocket Motor design function was described by Leonard H. Caveny, Kenneth K. Kuo and Benjamin Shackelford[44] in an article they published in the *Journal of Spacecraft and Rockets* entitled "Thrust and Ignition Transients of the Space Shuttle Solid Rocket Motor" (November/December 1980). The Solid Rocket Motor was described by Caveny et al. as "segmented motors consist[ing] of a series of sections which when joined together form circumferential slots" and

> Flame spreading is governed by couplings between the main chamber flowfield, convective heating rates and the propellant temperature distrubution....Flame spreading down the port is implicitly an output of the model, i.e.:
>
> 1) The hot gases from the igniter, as they flow down the port, heat the propellant.
>
> 2) The rate at which the propellant is heated rapidly decreases in the direction of flow because igniter gases give up their heat as they flow toward the nozzle.
>
> 3) After the head end of the motor ignites, the flow rate of hot combustion gases along the port begins to accelerate and thereby

[44] Caveny was described in the article as being a Senior Professional Stafff Member from Princeton University; Kuo, an Associate Professor from Pennsylvania State University; and, Shackelford was an Aerospace Engineer in the Propulsion Division, NASA Marshall Space Flight Center.

accelerates the heating of the preheated (but unignited) propellant.

4) As the flow rate increases, the acceleration of the combustion gases becomes one of the limiting factors and flame spreading rate becomes largely a characteristic of the motor and not the igniter.

5) As the hot combustion gases are driven down the port, the propellant is progressively heated to its ignition point, which is to say that flame spreading is described by successive ignitions (Caveny, Kuo and Shackelford 1980, 490; see Figure 3.2 below).

The technology involved in the firing of the SRM included a complex series of controlled flaming and hot gases. The system itself was inherently dangerous and was subject to various vagaries which became apparent after the design was actually put into effect.

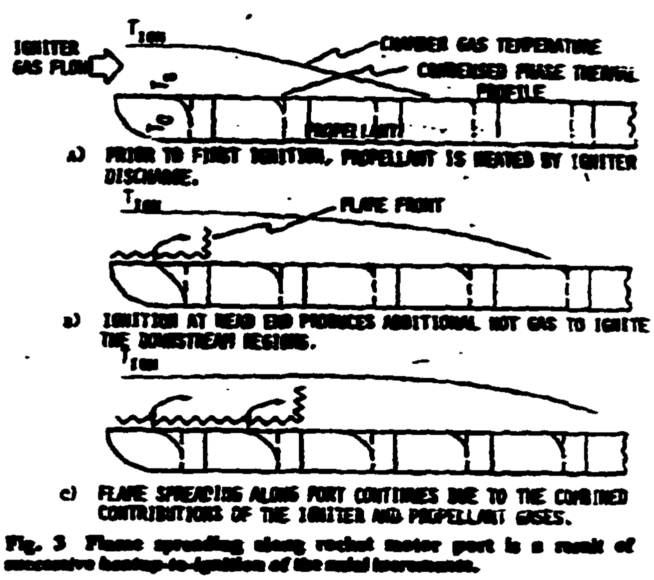

Figure 3.2: Solid Rocket Motor Heating-to-Ignition (Source: Caveny, Kuo and Shackelford, 1980, 490)

The differences between the designs were shown clearly after the *Challenger* accident in 1986. However, the groundwork for the fiasco was laid well in advance of January 1986. The seeds for the shuttle's destruction were sown, as we have seen, in the 1970s. The *Report's* findings and McConnell's reporting of the procurement process illustrate what can happen when economic and political considerations take effect in forming an expensive and complex machine. Also, as shown by an examination of the SRB deliberation process, safety considerations can be relegated to secondary importance. The ideal of a safer space shuttle can be compromised when the reality of human action takes effect.

Prior to the Challenger accident, NASA had an excellent reputation for safety relative to the risky technology involved. As early as "1974 the Program Office established a formal Space Shuttle Crew Safety panel as a mechanism for analyzing all activities of the Shuttle program to identify conditions which may be hazardous to onboard personnel and orbiter systems....N.A.S.A.'s overall safety plan for the Space Shuttle has been continuously to identify potential hazards early in development programs and to ensure that each hazard is either eliminated or reduced to acceptable safety levels" (Brown 1977, 17). Nelson E. Brown (1977),[45] a mechanical engineer for McDonnell-Douglas, wrote in an essay for *Technology Review*, that "Certain serious failures during launch would almost certainly either seriously damage or destroy the Shuttle system. These include:

--External tank rupture or explosion,
--Solid rocket booster burning through its casing,
--Major structural failure,
--Complete loss of guidance or control,
--Failure to ignite one solid rocket booster,
--Loss of thrust from one solid rocket booster,
--Shuttle main engine or thrust vector control locked in an abnormal attitude,
--Engine nozzle failure,
--Failure of external tank to separate from Orbiter,
--Premature separation of either or both solid rocket boosters.

[45] Brown had directed research and applications programs relative to manned extravehicular activities, crew flight safety and human factors design in spacecraft systems.

The possibility of such serious failures is, of course, being minimized by incorporating appropriate *safety margins* and *redundancy*[46] in the design of Orbiter systems, functions, and operations critical to crew safety. Extensive tests under all feasible failure conditions are also being conducted on the critical systems....*As with commercial aircraft flights, there will be critical times during any Shuttle flights in which very little escape or rescue capability exists regardless of the safety provisions incorporated. No space program can be risk-free.* To eliminate or control all hazards identified in the shuttle Program is a major program in itself. A certain level of risk must be accepted to achieve the Space Shuttle objectives; *N.A.S.A. accepts these minimum risks in return for the potential benefits*" (Brown 1977, 20-21, italics added for emphasis).

Risk was an accepted norm of NASA in all calculations involving the Space Transportation System. Balancing risky space flight, using huge and dangerous rockets, and trying to maintain safety standards for astronauts over an extended period of years are key to understanding how basic attitudes can change over time. Even so, there is the promise of safety for the astronauts whose lives are placed in jeopardy each time the shuttle lifts off from Kennedy Space Center. There is a problem concerning safety margins when a basic design for a critical component, in this case the Solid Rocket Booster design, is flawed from the beginning.[47]

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46 We saw an example of "redundancy" above in Figure 3.1 with the intention of using a double bore seal in order to insure that hot gasses would not pass through the joints of the Solid Rocket Boosters.

47 Hans Mark, former NASA deputy administrator, commented in his memoirs entitled *The Space Station: A Personal Journey*, 1987, that "There were some engineers knowledgeable in the area of seals and joints who, as early as 1977...raised some questions regarding the design of the o-rings....At the time a judgment was made that these objections were not serious enough to warrant changes....What is clear is that the seed for the ultimate tragedy nine years later had been sown" (218 - 9).

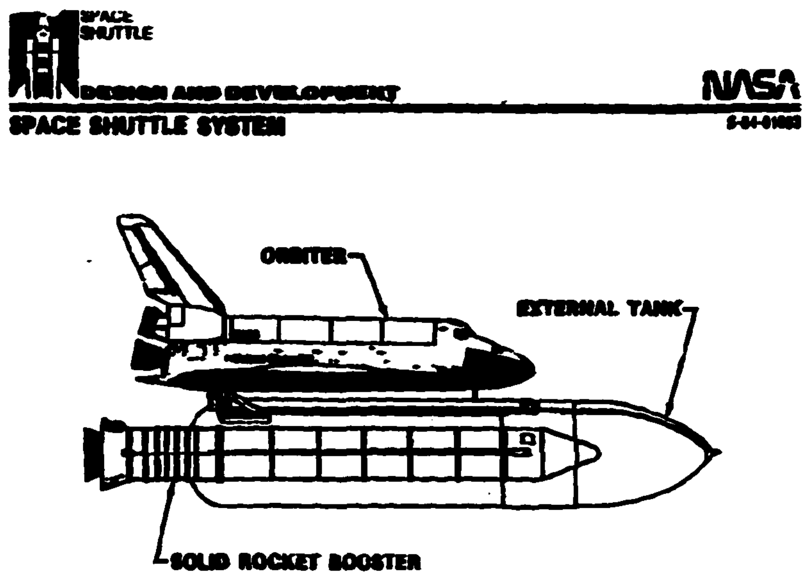

Figure 3.3: The Space Shuttle System (Source: *Report IV*: 73)

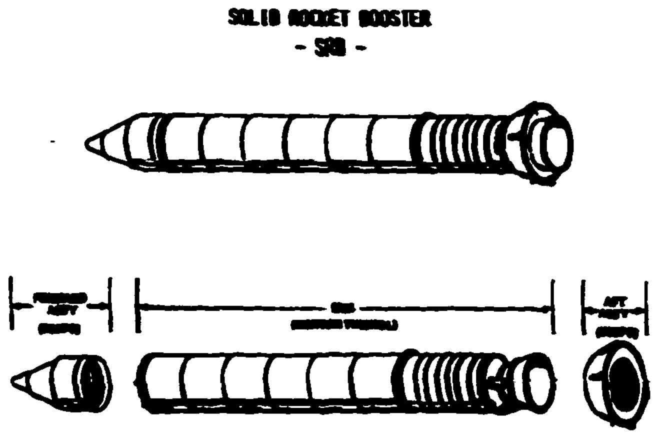

Figure 3.4: The Solid Rocket Booster Assembly (Source: *Report IV*: 110)

The end of the 1970s and the early 1980s: Knowing About a Problem and Doing Little About It?

We have seen in the previous section that the initial design and development of the SRBs, particularly in the area of the casing joints and O-ring seals, were poorly executed. It should be remembered, however, that the SRBs were just one complex system on one of the most complicated technological structures ever built. The Space Transportation System, as is to be normally expected, experienced many delays in actually getting the program underway. Critics such as Richard Lewis, writing in the journal *New Scientist* (1980: 356 - 9), pointed out discrepancies between words and deeds regarding the shuttle project:

The pattern of delays first appeared early in 1977 with turbopump failures in the shuttle's main engine system. It is a new, high-pressure rocket engine, burning liquid hydrogen with liquid oxygen. *Since 24 March, 1977, there have been 17 engine test failures caused by faulty seals, bearing loads, turbine blades and fuel injection, and failures in the heat exchanger, main oxygen valve, main hydrogen valve, hydrogen line and other parts*. It became apparent early in 1977 that the shuttle could not meet the initial launch schedule of 30 March, 1978.

Since then, the launch date has slipped to December 1978; to 28 September, 1979; to 30 November, 1979; to 30 March, 1980, to June-July 1980; to September-October 1980 and to November 1980-March 1981. With each slip, NASA has been less specific in setting a 'not before' launch date, but that has not repaired the widening credibility gap in its predictions about the shuttle....NASA adapted by fostering a public impression that from a technological viewpoint, developing the shuttle was a 'piece of cake'. It was all off-the-shelf state-of-the-art stuff. The fiction had the effect of giving the project a profile about as low as that of an interstate highway, but with an even lower priority. In a time of rising criticism about the costs and utility of manned space flight, an apparent lack of challenge seemed the safe way out (Lewis 1980, 356 - 359).

During this era of development problems involving the SRBs began to emerge. The effects of the complexity of the entire project began to become apparent. Differences between NASA and its contractor Morton Thiokol over the SRBs, the joints and the O-rings especially, demonstrated that while engineers and managers share a particular interest in the same work, they do not necessarily share the same meaning and intensity about a potential problem:

Early tests conducted by Morton Thiokol (1977), particularly a 'hydroburst test' showed that while the case strength requirements were met, the 'tang and inside clevis bent away from each other instead of toward each other and by doing so reduced--instead of increased--pressure on the O-ring in the milliseconds after ignition. This phenomenon was called "joint rotation." ...Thiokol reported these initial test findings to the NASA program office at Marshall. Thiokol engineers did not believe the test results really proved that "joint rotation" would cause significant problems, and scheduled no additional tests for the specific purpose of confirming or disproving the joint gap behavior'*(Report I*: 122 - 3).

Thus began the differences in perception of reality where engineers at NASA recognized that a potential safety problem (joint rotation) existed whereas the engineers at Thiokol perceived no significant discrepancy observing the same phenomena.

> Engineers from Marshall Space Center objected to the Thiokol design. Glen Eudy,[48] Marshall's Chief Engineer of the Solid Rocket Motor Division, informed Alex McCool, Director of the Structures and Propulsion Laboratory, that the assembly of a developmental motor provided early indications that the Thiokol design:
>
> 'Allowed O-ring clearance. . . . some people believe this design deficiency must be corrected by some method such as shimming and perhaps design modification to the case machined. . . . I personally believe that our first choice should be to correct the design in a way that eliminates the possibility of O-ring clearance. . . . Since this is a very critical SRM issue, it is requested that the assignment results be compiled in such a manner as to permit review at the S&E Director's level as well as project manager.'
>
> After seeing the data from the September 1977 hydroburst test, Marshall engineer Leon Ray submitted a report entitled 'Solid Rocket Motor Joint Leakage Study' dated October 21, 1977. It characterizes 'no change' in the Thiokol design as 'unacceptable' -- 'tang can move outboard and cause excessive joint clearance resulting in seal leakage. Eccentric tang/clevis interface can cause O-ring extrusion when case is pressurized.' Ray recommended a 'redesign of the tang and reduce tolerance on the clevis' as the 'best option for a long-term fix.'
>
> Subsequently (1978 and 1979) Marshall engineer Leon Ray and John Q. Miller, chief of the Solid Rocket Motor branch at Marshall sent a series of memoranda to Eudy and George Hardy, then Solid Rocket Booster project manager at Marshall, criticizing the joint design which could lead to a failure of the O-rings not sealing and resulting in catastrophic failure.
>
> [During the Commission hearing on May 2, 1986, Ray was asked why the 1978 and 1979 memoranda were written]:
>
> **Mr. Ray**: The reason they were written was as a result of test data that we had, and I have to go back to, I guess, a little bit further back in time than these memos. When the joint was first designed, the analysis produced by Thiokol says the joint would close, the extrusion gap would actually close.

[48] See the organization charts in Appendix A for clarification of the position of members in their respective organization for NASA, Morton-Thiokol and other relevant organizations.

> We had quite a debate about that until we did a test on the first couple of segments that we received from the manufacturer, which in fact showed that the joint did open. Later on we did some tests with the structural test article, and this is mentioned in the memo as STA-1 [Structural Test Article].
>
> At that time, we really nailed it down. We got some very accurate numbers on joint rotation, and we know for a fact that during these tests that, just what the memo says, the joint rotated. The primary O-ring was extruded up into the joint. The secondary O-ring did in fact detach from the seat.
>
> No records show Thiokol was informed of the visits, and the O-ring design was not changed....Thiokol's phase 1 certification review on March 23, 1979, mentioned leak check failures, and forces during case joint assembly that resulted in clevis O-ring grooves not conforming with tang sealing surfaces. However, this was not listed as a problem or a failure (*Report I*: 123 - 4).

Clearly by the late 1970s there was an acknowledged recognition that the O-rings and the SRB joint design were flawed and that the managers and engineers involved knew there was a problem with them. The Commission report implicated managers at NASA with primary responsibility for knowing about the failure of the Solid Rocket Boosters.

Marshall (1986, 664) chronicles the evolution of the shuttle as being troublesome well beyond the parameters of the SRBs. Other Space Transportation System components were having unexpected problems. Also, "the years 1978 and 1979 were the season of engine fires" (664). Regarding the liquid rocket portion of the STS, Marshall noted that "no one had built throttled liquid rockets of this size before, and the problems of pressurizing, heating, and containing the explosive fuel were (and still are) formidable. Leaks, fires, and turbo-pump failures occurred repeatedly--once during tests in September 1977, twice in December of 1978, and again in May, July, and November 1979. The first successful, full-duration firing of all three engines occurred in December 1979" (Marshall 1986, 664). In October 1979, NASA

Administrator Robert Frosch declared that the shuttle program was "fundamentally technically healthy," though the aforementioned safety risks involving the shuttle systems were raising concerns by former astronauts and critics of NASA. In January 1980, Frosch told Congress that the first launch of the shuttle would have to be put off another year, until early 1981. The delays had become increasingly noticeable to shuttle government and media critics, as the original launch date had been March 1978. Work on the insulating tiles and the engines continued (Marshall 1986, 664).

The *Report of the Presidential Commission* (1986) noted that "In 1980, NASA empanelled a Space Shuttle Verification/Certification committee to study the flight worthiness of the entire Shuttle system. A subdivision of that group, the Propulsion committee, met with NASA Solid Rocket Motor program personnel and raised several concerns about the joint design" (124). The Committee made the determination "that the booster's leak test pressurized the primary O-ring in the wrong direction so that the motor ignition would have to move the ring across its groove before it sealed" (124). The report from the Propulsion committee stated that "the Committee understands from a telecon[49] that the primary purpose of the second O-ring is to test the primary and that redundancy is not a requirement" (124). George Hardy, who was then SRB Project coordinator, testified that the Committee's statement conflicted with his understanding:

> The discussion there or the reference there to a telecon--and I don't know who that was with--that implies there was no intent for the joint to be redundant is foreign to me. I don't know where they would have gotten that information because that was the design requirement for the joint (*Report I:* 124;*Report V*: 1629).

Another critical aspect in the interaction of the inner/tang clevis and the SRB

[49] Note: "telecon" is bureaucratese for telephone conversation.

field joints was whether the O-rings were capable of providing an adequate seal, especially at temperatures between 40 and 90 degrees Fahrenheit. The temperature range was established by NASA in order to ensure that all system components would be functioning properly (*Report I*: 124). The Verification/Certification Committee was empanelled by NASA, which had concerns about the integrity of the rocket motors to investigate the flight worthiness of the entire shuttle system. The committee was concerned about the proper functioning of the O-rings in particular and asked NASA to:

> Perform [a] case burst test with one O-ring removed. During the burst test for final verification of the motor case safety factor, one of the two O-rings failed by extrusion and leaked. The analysis used for additional verification did not include further gap openings caused by joint deflection at pressurization or any deflections caused by bending loads. The panel considers the above to be inadequate to provide operational program reliability, and marginal to provide adequate safety factor confidence on [Shuttle flight] one.' (*Report I*: 124-125).

The O-rings and SRB joints were considered by NASA to be in the category of "Criticality 1R," defined by NASA as being "redundant hardware, total element failure of which could cause loss of life or vehicle" (*Report I*: 125). Furthermore, the use of the letter "R" meant "that NASA believed the secondary O-ring would be pressurized and seal if the primary O-ring did not," although the Critical Items List (CIL) of November 24, 1980 stated that "Redundancy of the secondary field joint seal cannot be verified after motor case pressure reaches approximately 40 percent of maximum expected operating pressure" (*Report I*: 125). Even with all these acknowledged problems and apparent contradictions associated with Thiokol's SRBs, the first shuttle *Columbia* had what was then generally considered a successful liftoff as it orbited the earth for two days with astronauts John and Robert Crippen, though sixteen insulating tiles were lost during the flight (Marshall 1986, 664).

The numerous instances of SRB failures in the initial design stage and subsequent testing were not enough to prevent the first shuttle launch on April 12 -14, 1981. In shuttle space flights following the initial launch, more problems began to emerge. The *Columbia* flew again as STS-2 on 12 November 1981. Official technical problems concerning the launch included a nitrogen tetroxide spill, a low reading on the oxygen tank, and over-pressure in the hydraulic system (Marshall 1986, 665). But more importantly in terms of the Solid Rocket Boosters and its eventual failure on STS mission 51-L (the *Challenger* accident launch in January 1986), the O-rings in the SRBs had shown significant erosion:

> The Achilles heel of the shuttle system showed up on STS-2, the second test flight of Columbia, during its launch, November 12, 1981. When the boosters were recovered, inspectors found that hot gas had penetrated the putty and damaged the primary O-ring in the aft field joint of the right booster....It was one of the worst cases of seal damage in the shuttle program. The commission found that this anomaly was not reported in the Level 1 (headquarters) flight readiness review for Columbia's third test flight and was not reported to the Marshall Space Flight Center's problem assessment system. Following high-pressure O-ring tests in May 1982, shuttle management at Marshall concluded that Thiokol's dual O-rings did not provide a fully redundant system because the secondary O-ring would not always function after joint rotation following ignition. It paraphrased the conclusion reached five years earlier by the Marshall engineers who were critical of the Thiokol seal design (Lewis 1988, 74).

For official public consumption, in 1982 the *Columbia* made three successful flights and the crew carried out a number of biological spaceflight tests. As with almost any relatively new complex technological system, there were problems with the auxiliary power unit; 36 insulating tiles were lost, and two recoverable booster rockets sank in the ocean.[50] In July 1982, a new, lighter fuel tank designed to help increase payload lift was readied for use (Marshall 1986, 665).

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[50] Lewis (1988) points out "the boosters on STS-4, launched June 27, 1982, were lost when their parachutes failed to open and they plunged into the Atlantic Ocean and sank" so that there was no subsequent analysis on the SRBs for that mission (76).

The O-ring erosion problem did not disappear as a cause for concern at the Marshall Space Flight Center. Lewis (1988, 74) noted that the problem had become so severe that "the criticality 1-R designation was changed at Marshall on December 17, 1982, and the O-ring seals of the field joints were reclassified as criticality 1." Marshall solid rocket motor managers *believed*, with Morton-Thiokol engineer Howard McIntosh, *that the secondary O-ring seal actually was redundant despite joint rotation in all but exceptional cases, even though this belief held life and death consequences* (Lewis 1988, 74).

And,

> the SRB critical items list defined criticality 1 items as those subject to a single-point failure. Leakage of the primary O-ring was classified as a single-point failure 'due to possibility of loss of sealing at the secondary O-ring because of joint rotation after motor pressurization.' The list summarized the effects of the failure as 'loss of mission, vehicle and crew due to metal erosion, burn through and probable case burst resulting in fire and deflagration. The shuttle criticality list covered 748 items for which there was no backup or redundancy. Only the primary structure and thermal protection system were exempted. The critical items list compiled by the National Space Transportation System and made public March 17, 1986 listed 335 items in the orbiter that were subject to a single-point failure. Most were simple items of hardware. On the solid rocket boosters there were 114 criticality 1 items, of which 59, including the O-ring primary seals, had been granted waivers. In substance, a waiver meant that a criticality 1 item could be tolerated as a flight risk. In any event, the shuttle was flown with hundreds of such items whether waivered or not. L. Michael Weeks, NASA associate administrator, approved a waiver on the criticality 1 joint, March 28, 1983. That settled the issue of whether the shuttle should continue flying in this condition. He told the commission that he signed the waiver because '*We felt at the time, all of the people in the program, I think, felt that this solid rocket motor in particular was probably one of the least worrisome things we had in the program*" (Lewis 1988, 74-5, italics added for emphasis).

As shown above, the upper management up to the associate administrator at NASA were cognizant of the problems concerning the SRB joint. Hans Mark, former deputy administrator, recalled in his autobiography *The Space Station: A*

Personal Journey (1987) that

> My own part in the chain of events that led to the accident began when I returned to NASA early in 1981. I first became aware of the fact that we had a problem with the o-ring seals on the Solid Rocket Motor at the time when our engineering people were questioning whether these 'field joints' on the SRM were really fail-safe. During the design of the space shuttle, an effort was made to make as many of the subsystems as possible 'fail-safe.' The idea was to design them in such a way that a single point failure would not have catastrophic consequences. In the case of the 'field joints,' this was accomplished by putting two o-rings in the joint on the theory that if the first one failed, then the second one would do the necessary job.
>
> *My memory is that questions as to whether the double o-ring system was really fail-safe began to be raised sometime in 1982.*[51] In February or March 1983 Mr. L. Michael Weeks, the deputy associate administrator of NASA for space flight, signed out a memorandum waiving the fail-safe requirements for the field joints in the Solid Rocket Motor. I remember discussing that matter with him at the time and concluding that such a step was justified. I argued at the time that we had more than a hundred firings of the Titan Solid Rocket Motor with a seal of somewhat similar design containing only one o-ring. I thought because of the Titan precedent that the precedent was small. As things turned out, this judgment was not correct because there are significant differences between the Titan and the SRM joints. *I did not look at these differences with sufficient care at the time* (Mark 1987: 219, italics added for emphasis).

The O-ring damage caused by "blow-by" and burning of O-ring surfaces "increased each year after 1981, except in 1982 when *Columbia* was launched three times without evidence of seal damage....In the six years of shuttle flight operations, evidence of O-ring erosion and blow-by of soot was found in 15 of the 25 shuttle launches, including *Challenger* 51-L" (76). According to Lewis' calculations "joint seal damage occurred in 63 percent of the shuttle launches"

[51] This account is somewhat at odds with Vaughan's (1996) version of events. Vaughan writes about the erosion analysis in the aftermath of STS - 2 (which flew in November 1981): "This erosion was the most extensive prior to the fatal Challenger flight, but it was not discussed in FRRs [Flight Readiness Reviews] for the next launch, STS-3, nor was it reported in the Marshall Problem Assessment System (MPAS), a computer system for tracking serious problems. After the Challenger tragedy, this reporting failure was interpreted as the first of many attempts by Level III Marshall managers to keep bad news about the joint from top NASA officials. Indeed, the STS-2 erosion was not discussed in FRR until erosion occurred again nearly three years later. However, it was working engineers, not managers, who were responsible for the failure to report" (122 - 3).

prior to the 51-L mission (76) [See Figure 3.4 below for the Commission STS breakdown below. Also note that the O-ring analysis covers the time period from the initial launch up to *Challenger*]. Lewis writes that this knowledge was not passed to those directly affected:

> In 1981, seal damage showed up in one of two launches; in 1983, in one of three launches; in 1984, in three of five launches; in 1985, in eight of nine launches; and in 1986, in two of two launches. This progression plainly pointed to a flaw in the solid rocket booster sealing system. But although Marshall and contractor engineers became concerned enough about it by summer 1985 to propose various fixes, no effective action was taken. NASA flight readiness reviews show that it was rationalized as tolerable because nothing terrible had happened.
>
> *An astonishing aspect of this situation was that so far as the public was concerned, it was one of the best kept secrets of the space age. The documents describing it were not classified and did not need to be. They were buried in the files at NASA headquarters in Washington and the Marshall Space Flight Center in Huntsville, Alabama.*
>
> *Along with the general public, the astronauts who were flying the shuttle were unaware of the escalating danger of joint seal failure. So were the congressional committees charged with overseeing the shuttle program.*
>
> *NASA never told them that the shuttle had a problem* (Lewis 1988, 76).

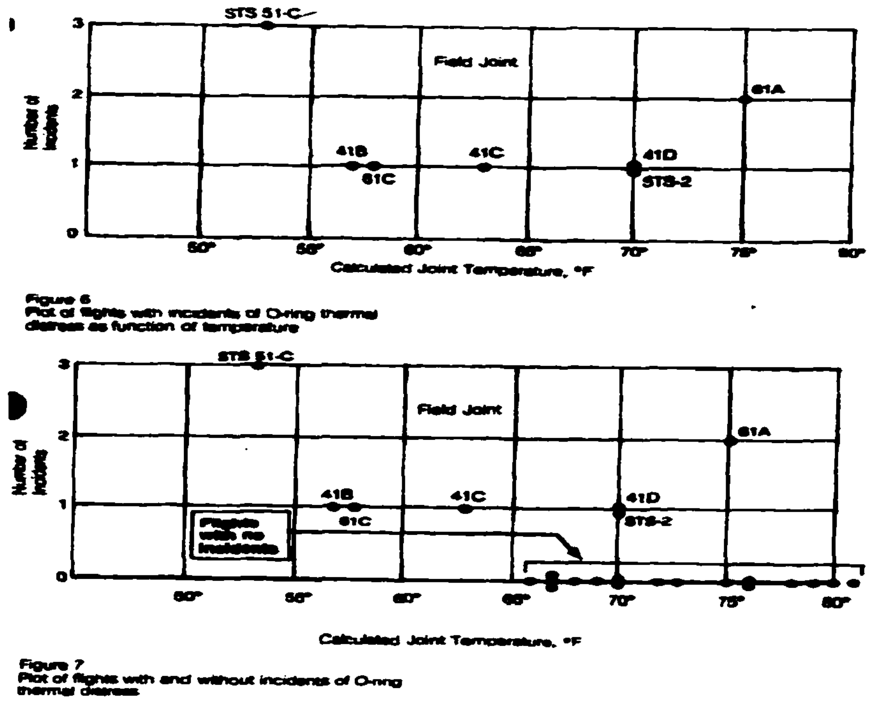

Figure 3.5: Plot Comparisons of Flights Affected by Joint Temperature
(Source: *Report I*: 146 [Note: Thermal distress is defined as O-ring erosion, blow-by or excessive heating])

While technical difficulties were being experienced in the Space Transportation System program, the issue of NASA effectiveness was being promoted. In an article published in *Astronautics and Aeronautics*, February 1983 (60 - 67, 72) by Paul E. Fitzgerald, Jr. (Martin Marietta Denver Aerospace, Michoud Division) and Edward A. Gabris (NASA Office of Aeronautics and Space Technology), the authors made a case for efficiency and economy: “As the ‘60s drew to a close, and even before the flight of Apollo 11, the United States’ first manned lunar landing, it became obvious relative to the future of our space programs, that

--1. The U.S. was in space to stay.
--2. The cost of expendable, single-use launch systems could not be sustained.
--3. Technology ‘existed’ to develop a reusable Space Transportation System (STS) that could assure item 1 and solve the problem posed by

single-use systems in Item 2.

> With respect to (1), U.S. determination to maintain technological leadership in the world assured the pressing of military, scientific, and commercial advantages of space. With respect to (2), extensive studies of potential space users underscored the wastefulness of expendable launch vehicles.
>
> Regarding (3), most technology for most Shuttle subsystems did exist and had been demonstrated; however, for some systems we could claim critical technology only in concept and had not demonstrated it even in laboratory prototype....
>
> *Program Structure*: One of NASA's great strengths--one not readily apparent in many government organizations--is its facility to respond rapidly to new program needs, opportunities, or problems with *agency-wide* organizational flexibility, cooperation, and sensitivity.
>
> When the 1969 Space Task Group identified a reusable STS (compatible with the economics of space use in the 1980s and beyond) as a goal and determined that the technology 'existed' to build it, there was a critical need to determine how much of that 'existence' had to be demonstrated....The job of overseeing this [technological] work fell to the Space Shuttle Technology Steering Committee.
>
> This Steering committee was created by the NASA Administrator in 1969....[It] had no budget, [and] no working staff....(Fitzgerald and Gabris 60-1).

In the same month as the publication of the Fitzgerald and Gabris article, NASA ordered a broad review of quality control, to be directed by Air Force Lieutenant General James Abrahamson. Abrahamson noted that an oxygen leak on an earlier *Challenger* mission could have created a "blow torch" in the engine area, had it not been detected fortuitously. "If it had gone undetected the leak could have resulted in a devastating explosion between 1 and 2 minutes after the *Challenger* had lifted off" (Marshall 1986, 665).

The year 1983 was an important one for NASA as a number of milestones were reached. *Columbia* and *Challenger* made four trips. Sally Ride became the first U.S. woman to travel in space, thus paving the way for others. Several satellites were launched. One was recovered from space for the first time and another (TDRS) limped to orbit when its booster failed.

Spacelab experiments were begun, and other "firsts" occurred (Marshall 1986, 665). Other significant developments included the use of more powerful solid rockets which were aided by the removal of "inhibitor material" which allowed the rocket fuel to burn faster. According to Marshall (1986, 665), the need for power caused the inhibitor material to be removed in an attempt to increase payload lift. The year was not without its share of trouble for NASA, however. By October 1983 NASA officials discovered another problem with the SRB insulation material in the nozzle of the booster. Marshall notes that "had it not been replaced, rocket flames could have burned through the metal, possibly leading to an explosion or sending the craft into a lethal spin" (1986, 665).

Significant events in 1984 included the announcement by NASA to solicit manufacturers for less troublesome engines. NASA indicated that it would spend up to $1 billion fixing the problem, making the engines more durable and reliable (Marshall 1986, 665). Also on August 24, 1984, President Reagan made the announcement that the first private citizen to fly on the Space Shuttle would be a teacher. Vaughan (1996, 27) points out that selecting a teacher was done for political reasons and that Reagan wanted to be seen as pro-education because of the previous National Education Association endorsement of Walter Mondale. Almost one year later, in July 1985, Vice President Bush stated from the White House that Christa McAuliffe and Barbara Morgan had been selected as primary and backup candidates for NASA's Teacher in Space Project (29).

Insofar as NASA's image was concerned publicly, "the year 1985 was by far the best for the program, with three shuttle orbiters in use and nine successful flights" (Marshall 1986, 666). However, nine relatively successful missions were insufficient for the NASA organization. Fiscal problems for the space agency made their appearance again when "in July 1985 the House cut

5 percent ($375 million) from NASA's fiscal year 1986" (Vaughan 1996, 29; see also McConnell 1987, 30). Engine problems were cropping up again as

> A near accident occurred with Challenger on 29 July 1985 when a sensor indicated that a turbopump was overheating, making a computer shut down one of three main engines 6 minutes into an 8-minute lift-off. The shuttle barely made it into orbit, flying at an initial altitude of 122 miles rather than 400. Had the engine cut out sooner, a NASA official said, the craft would have landed near Greece. Observers noted that a landing on water might well kill the crew (Marshall 1986, 666).

Given the aforementioned problems with the budget and the recurrence of engine problems, NASA wanted to increase its number of flights to 24 per year by 1990 (Vaughan 1996, 28). The increase in the number of flights effectively added stress to fatigued NASA maintenance crews and shuttle contractors to produce more. The work by 1985 was already more than the combined public and private space shuttle resources could handle. Vaughan (1996) detected a shift in the mood of NASA administration:

> When the shuttle was declared operational, the emphasis shifted from applying resources to a single flight, which was the during its developmental stages, to applying them to several flights concurrently. Human and material resources devoted to any single flight were diluted. The attempt to reach 24 missions per year was limited by lack of spare parts and resulted in compression of training programs. Resources became concentrated around short-term, not long-term problems....Also, flight manifests were changed, which resulted in last-minute changes, cost overruns and new crew assignments (28-9).

Labor resources were diluted throughout 1985 and well into 1986, thus contributing to unsafe and stressful work conditions [See Figure 3.5 below]. The Commission *Report* noted that

> Any discussion about the safety implications of shiftwork must also address the situational aspects of human error in the workplace. Industry today is well aware that it is important to minimize the potential for such error in the design of industrial equipment and procedures. This requirement becomes even more critical when individuals are required to perform in a high technology environment with the added demands of

shiftwork.

Shiftworker fatigue, high workload and faulty equipment design are a combination that can produce unnecessarily high safety risks (*Report I* 1986, G-4).

The *Report* went on to point out that managers had been deleteriously affected by lack of sleep, which may have contributed to poor engineering and management judgment and which culminated in making the ill-fated decision to launch in January 1986 (G-5).

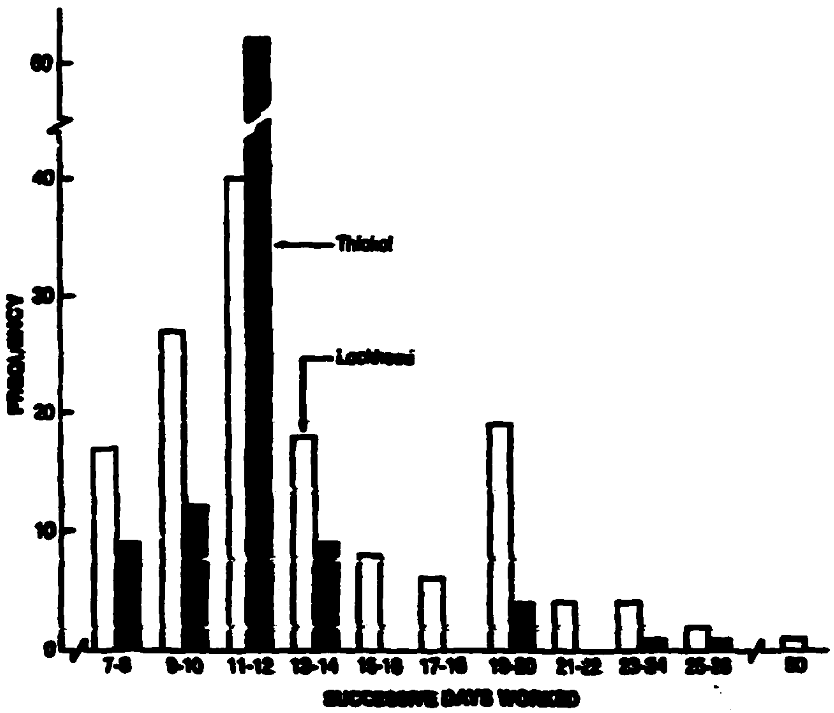

Figure 1—Incidence of more than six consecutive workdays among a group of Lockheed (N = 93) and Thiokol (N = 46) shiftworkers at Kennedy Space Center. Time period of sample varies from seven to ten weeks extending from October 26, 1985 to January 24, 1986.

Figure 3.6: Successive Days Worked (Source: *Report I:* G-3).

As shown above, 1985 was a harbinger of things to come for NASA's space transportation program. A recapitulation of 1985 shows ominous trends for the beginning of 1986. Problems endemic to NASA began take on greater significance and were exacerbated by the agency's attempt to take on more missions and work well beyond what it could handle. Budgetary restraints and the omnipresent problematic high-risk technology combined to put pressure on all organizations involved in the shuttle program.

The Year 1986 and the Challenger Accident

Nineteen eighty-six did not get off to a good start as far as NASA was concerned. On January 12, 1986, Columbia began a successful 6-day flight after seven launch delays, making this the most-delayed launch on record. The primary cause was bad weather (Marshall 1986, 666). Academic scientists and critics of NASA pointed out that the Space Transportation System was expensive, unreliable and that "the trouble-plagued shuttle had siphoned off so much of the agency's budget that America was reduced to taking an embarrassing and distant third place behind the Soviets and the Europeans when it came to observing [Halley's comet]" (McConnell 1987, 14). The prestige of the agency was called into question directly by the famous astronomer James Van Allen through an essay in the January issue of *Scientific American*, which was a scathing attack on the space shuttle [see footnote 34 above]. Van Allen pointed out that NASA was, in essence, wasting precious research funds on what he determined were expensive fiascoes such as manned-space flight. In a box entitled "Slaughter of the Innocents" [see Figure 3.6 below], Van Allen struck a blow at the concept of manned space-flight in favor of other scientifically based programs which did not require the high level of funding nor the risk to human life as the Space Transportation System.[52]

[52] See Robert Bless' "Space Science: What's Wrong at NASA" in *Issues in Science and Technology*, Winter 1988-89. This essay is after *Challenger* but the Astronomer Bless of the University of Wisconsin is critical of NASA's management of the Hubble Space Telescope (HST) debacle. Bless notes that "Despite the expected rewards...the story of the HST is also the story of what's wrong with how NASA conducts space science. Experience with the project has revealed three particular policy areas that render scientific programs less effective and mor costly than they ought to be. There are overreliance on the space shuttle, a predilection for big projects, and poor management" (67).

According to McConnell (1987) "such criticism coming from a pioneering American space scientist rankled NASA officials" (15). When the STS experienced delays, research satellites and all other space projects were put on hold. NASA was particularly anxious to meet its March 6, 1986 launch date for the *Columbia*-ASTRO flight in order to beat the Russians, who eventually sent a spacecraft to encounter Halley's comet on March 9 (McConnell 1987, 16).[53]

The precedent had been set for sending civilians into space with the launching of STS 61-C which was originally slated for early December and launched a month late. STS 61-C "carried a crew of seven, including an ambitious young Florida Congressman, Democrat Bill Nelson, who happened to be the Chairman of the House Space Science and Applications Subcommittee that approves NASA's budget" (McConnell 1987, 14).

[53] McConnell also points out that "Launching the March ASTRO flight on time would require a smooth turnaround for Columbia after the 61-C mission and a trouble-free Challenger flight" by January 23. McConnell notes that "the original purpose of Challenger's 51-L mission was the deployment of an important communications satellite, NASA's TDRS, the Tracking Data and Relay Satellite" (16).

INTERNATIONAL SOLAR POLAR MISSION (U.S. SATELLITE OF PROPOSED PAIR)	CANCELED
U.S. MISSION TO COMET HALLEY	CANCELED
GALILEO PROBE TO JUPITER	CANCELED (LATER RESCINDED)
DEEP SPACE NETWORK FOR TRACKING PLANETARY MISSIONS	THREATENED CLOSING
DATA RECEPTION FROM *PIONEER 10* AND *11*	TERMINATED (LATER PARTLY RESCINDED)
DATA RECEPTION FROM *PIONEER VENUS 1*	TERMINATED (LATER PARTLY RESCINDED)
INFRARED OBSERVATORY AT MAUNA KEA, HAWAII	CLOSED (LATER RESCINDED)
DATA RECEPTION FROM *VOYAGER 1* AND *2*	CUT BACK (LATER PARTLY RESCINDED)
DATA RECEPTION FROM *IMP-7* AND *IMP-8*	TERMINATED (LATER PARTLY RESCINDED)
LANDSAT PROGRAM	CUT BACK
GAMMA-RAY OBSERVATORY	DELAYED SEVERAL YEARS
PLANNED MISSIONS TO VENUS AND MARS	CANCELED (REVIVED IN REDUCED FORM AFTER DELAYS OF SEVERAL YEARS)
SUPPORTING UNIVERSITY RESEARCH	CUT BACK
NASA OFFICE FOR SOLAR-TERRESTRIAL PHYSICS PROGRAMS	CLOSED
PLANNED SOLAR-TERRESTRIAL AND ATMOSPHERIC RESEARCH SATELLITES	INDEFINITELY POSTPONED
SCIENTIFIC PAYLOADS ABOARD SPACE SHUTTLE	INADEQUATELY PROVIDED FOR
ADVANCED COMMUNICATION TECHNOLOGY	INDEFINITELY POSTPONED

"SLAUGHTER OF THE INNOCENT" was the result of the decision made by NASA in 1981 to proceed with the development of the space shuttle over all other projects. The table summarizes the effects of the decision. Some of the program cuts have since been rescinded, but the effect has been a severe chill on scientific and other civilian activities in space.

Figure 3.7: Van Allen's 'Slaughter of the Innocents' (Source: 'Space Science, Space Technology and the Space Station,' *Scientific American*, January 1986, p. 37)

Following Congressman Nelson on the next flight, *Challenger* 51-L, was Teacher-in-Space and private citizen Christa McAuliffe. McAuliffe was scheduled to fly on *Challenger* at a time to coincide with President Reagan's State of the Union Message. McConnell (1987) notes that "With such a disparate group of nonastronauts flying aboard the shuttle, the public's perception of the system's routine reliability only increased....The Soviets might risk a hapless woman and foreign "guest" cosmonauts aboard dangerous equipment to achieve propaganda coups, but NASA would never sacrifice safety for political gain" (14).

Final preparations for the *Challenger* mission 51-L began January 15, 1986. NASA routinely goes through a "ritual of certification" known as the Flight Readiness Reviews (FRR) in order to insure success of the mission:

On the afternoon of January 15, technicians at the Cape were busy refurbishing Pad 39A and servicing Challenger on Pad B. Senior NASA officials at the Cape, in Washington, at the Marshall Space Flight Center, and at the Johnson Space Center in Houston assembled for a meeting that was an important milestone in the preparation of Challenger for its January flight and for the success of this busiest year in space. This was the Level I Flight Readiness Review, the management and engineering conference that would guarantee that Challenger was ready for flight. The "FRR" procedure, as these conferences were called, had been designed at the start of the shuttle program as a formal, disciplined ritual of certification...

The original rationale for these formal reviews was to create a logical, smooth flow of information, from the hardware engineers among the various contractors--"Level IV"--to the project offices in the NASA centers--"Level III"--to the center directors and the National Space Transportation System office that supervised all shuttle missions--"Level II"--and finally to the agency's senior management in NASA's Washington headquarters, "Level I." Challenger's January 15 Level I FRR was the culmination of this process...(McConnell 1987: 17).

Thus, the normal course of events for the launch were in place. However, the 51-L launch was to experience weather and technical delays that had plagued the previous launch, 61-C.

The focus of flight 51-L was on a thirty-seven year-old high school teacher from Concord, New Hampshire, Christa McAuliffe. William Broad of The *New York Times* , on January 26, 1986 reported that the launch had been postponed because of the weather:

The clear focus of the six-day mission is the citizen crew member, Christa McAuliffe, a 37-year-old high school teacher from Concord, N.H. Mrs. McAuliffe is to broadcast school lessons from space and keep a diary of her experiences aboard the $1.2 billion winged spaceship.

NASA officials said tonight that the delay in the launching would postpone until Thursday her broadcast of a coast-to-coast school lesson that had been scheduled for Wednesday.

In addition, the astronauts are to carry out several scientific experiments and to launch two satellites, a small $5 million one to study Halley's comet and a large $100 million one to relay spacecraft communications around the Earth....

The chance to see Mrs. McAuliffe go into space has drawn crowds of tourists, teachers and reporters to the Kennedy Space Center. In 1984,

> amid the election campaign, President Reagan announced that the first person in nation's Space Flight Participant Program would be a teacher, and more than 11,400 educators subsequently applied.
>
> When the winner, Mrs. McAuliffe, was recently asked what she wanted to bring back from the mission, she replied: *'Just the message that space is for everybody, that it's a new world out there, a new frontier, and that there are a lot of people who we have in our classrooms who are going to be living and working in space.'* (January 26, 1986, "Cloudy Forecast Delays Teacher's Space Flight,' italics added for emphasis).

McAuliffe symbolically represented the promise of tomorrow and the future of NASA manned spaceflight. With her went every person that ever dreamed of fulfilling a quest in space. McAuliffes participation on board *Challenger* was also used symbolically for NASA that space was for everyone, as we have seen in numerous rationalizations by members of the NASA organization [see Mueller's 'phases' section above in this chapter].

The shuttle launch was again delayed subsequently on Monday, January 27, before it was switched to Tuesday, January 28 for the third time. The skies were clear on Sunday, January 26, but Air Force weather forecasts predicted trouble in the days ahead:

> A forecast of threatening weather forced space agency officials to postpone this morning's scheduled launching of the shuttle Challenger until 9:37 A.M. Monday.
>
> It was the second weather-related postponement of the launching of the Challenger....As if to torment the crew, the skies were clear today at the time the shuttle was to have taken off. The expected storm came along soon afterward, however, and things became even gloomier this afternoon when the latest Air Force weather forecasts raised the possibility of heavy clouds at the Monday launching time.
>
> ...Vice President Bush was to attend today's liftoff, but his schedule would not permit him to attend Monday's attempt, space agency officials said.
>
> ...If the Challenger is not launched Monday and the flight is rescheduled again, the delay could upset later shuttle launchings. Thirteen more launchings are scheduled this year (*The New York Times*, January 27, 1986).

And,

High winds and a balky bolt on a spaceship door combined today to force yet another 24-hour postponement for the space shuttle Challenger. It was the third such delay in as many days, and the crew is scheduled to try again Tuesday morning....The hatch itself, or rather a small bolt in its handle, was the main culprit this morning, although a series of human, technical and natural misfortunes came to play a part before the day was over.
...Officials of the National Aeronautics and Space Administration tentatively reset the launching for Tuesday at 9:38 A.M. barring new problems with the weather. Below-freezing temperatures are forecast for the new launching time, and that could force the liftoff to be postponed yet again, until Thursday....today's [Jan. 27] weather was perfect at the scheduled launching time, 9:37 A.M. But technicians hit a snag with the bolt. And by the time they fixed the problem, winds were blowing too hard for a safe launching....Around 12:30 P.M. officials called the whole thing off for the day...

When they eventually get off the ground, the Challenger astronauts are to launch two satellites and Mrs. McAuliffe is to teach two lessons that will be watched by millions of students across the country.

For Tuesday's launching attempt, the major concern is low temperatures. The forecast calls for the mercury to dip below freezing at around midnight, and to continue falling into the low 20's. Such cold could inhibit the proper operation of the shuttle and its ground support equipment.

'Its going to be close,' Mr. Sieck, the director of shuttle operations, said at a news conference after the scrub.

If Tuesday's attempt is called off before the shuttle is fueled, a launching could be tried again on Wednesday. But if Tuesday's attempt is called off after the shuttle has been fueled, it would mean a 48-hour delay as ground technicians check shuttle systems for damage after two back-to-back days of fueling. (*The New York Times*, January 28, 1986).

Delays for the shuttle launches had become a nuisance for all involved. The weather had played havoc with NASA's launch schedule which had been increased in 1986.

The final days before the launch of STS 51-L were grueling for NASA decision makers. Charles (1996),[54] using primarily the *Report of the Presidential Commission on the Space Shuttle Challenger Accident*, analyzed

[54] Charles (1996) is used here based on his excellent synopsis of events leading to the launch on the days closest to the launch.

the meetings of management and engineers in order to understand the circumstances behind the decision. The first two meetings of the mission management team on January 27 did not include discussions about the effect of the cold weather on O-rings. But on the afternoon of January 27, Robert Ebeling, Thiokol Manager of the Ignition System and Final Assembly, held a meeting at the Wasatch [Utah] facility where misgivings were expressed concerning the affect of cold weather on the O-rings of the SRBs. Allen McDonald, Thiokol Director of the SRM Project , then contacted the Kennedy Space Center (KSC) in order to collect temperature data for review by Mr. Ebeling (Charles 115). At 5:45 p.m. (EST) a teleconference meeting was set up with project managers from KSC, Marshall Space Flight Center (MSFC) and the Thiokol-Wasatch facility where Thiokol representatives explained their concerns about the performance of the SRB O-rings at low temperatures. They presented O-ring failure data, but the report was poorly organized and put together in a short amount of time. The Thiokol representatives believed that the launch would wait until the temperatures were warmer (Charles 115). The "penultimate," or fifth meeting, which began at 8:45 (EST), resulted in numerous charts from Roger Boisjoly, a senior scientist and member of the Seal Task Force at Thiokol, consisting of information about the history of O-ring blow-by and erosion in the SRBs of previous flights and subscale testing an static tests on the O-rings (Charles 116). Boisjoly opposed the launch and most of the data he presented supported a no-launch decision. Reasons given by Mr. Boisjoly included:

> (1) if there was erosion of the primary O-ring seal there would be a high probability that the secondary O-ring seal would be incapable of seating properly; (2) Given the weather forecast for the morning of January 28 (low 20s Fahrenheit), the launch would not be conducted under 'normal circumstances.' The lowest temperature that the shuttle had been

> launched previously was 53 degrees Fahrenheit. The thrust of Mr. Boisjoly's argument, therefore, was that there would be a change in the O-ring timing function....the possibility of joint failure was increased considerably. *The analogy used by Mr. Boisjoly before the Commission to explain this phenomenon was, '..it would be likened to trying to shove a brick into a crack versus a sponge.'* and (3) "it was also pointed out by Mr. Boisjoly that there had been evidence of blow-by found in the Solid Rocket Motor joints on previous shuttle flights" (Charles 1996, 117).

Boisjoly could not prove *quantitatively* to all the participants' satisfaction that he had the data to support his conclusions. It was pointed out to Mr. Boisjoly in the meeting that previous missions (61-A, for example) had flown at 75 degrees Fahrenheit, and that that flight had soot blow-by as well. The implication was that the temperature of the O-rings was not a salient factor, but "Mr. Boisjoly did, however, point out to the members of the teleconference that by far the worst blow-by to occur in the Shuttle's history was on flight 51-C, and that this was an indication that temperature was a factor of O-ring resilience" (Charles 1996, 117). Boisjoly was not alone in voicing his concerns regarding the effect on the O-rings as he was supported by Mr. Robert K. Lund (Vice President for Engineering at Thiokol). Mr. Lund recommended with the concurrence of the other engineers that the launch should not proceed until the O-ring temperature reached 53 degrees Fahrenheit. He also indicated that the launch was being considered at the lowest temperature of any previous flight (117).

Resistance to the no-launch decision was raised primarily from the managers from Marshall Space Flight Center as

> Stanley R. Reinartz was asked to comment on the Thiokol recommendation. Mr. Hardy recounted that Reinartz was 'appalled' by the recommendation, but that he would not go against the contractor's no-launch recommendation. Mr. Lawrence B. Mulloy (Manager, SRB Projects Office, Marshall Space Flight Center) made a statement that 'My God, Thiokol, when do you want me to launch, next April?' Mulloy and Hardy were 'not convinced that the cold weather would result in a slowed O-ring, blow-by or ultimate disaster of the Challenger' (Charles 1996,

118).

The Thiokol-Wasatch Caucus went off-line in order to come up with a "management" decision. Mulloy's and Hardy's comments added to the overall confusion. Mr. Joe Kilminster of Thiokol and others were confused further by Mr. McDonald's statements regarding the O-rings "...in the proper position to seal if blow-by of the primary O-ring occurred." While many members of the teleconference perceived Mr. McDonald's comment as a supporting statement for a launch go ahead, Mr. McDonald did not intend to communicate that message [and] was totally opposed to a launch at such cold temperatures" (118). For the most part, the engineers were ignored in the Thiokol-Wasatch caucus as

> The caucus began with Mr. Jerald Mason (Senior Vice President, Wasatch Operations) '...saying that a management decision was required.' During the caucus the Thiokol engineers and management people continued to discuss the issues presented during the teleconference....[Mr. Boisjoly and Mr. Arnold R. Thompson (Supervisor, Rocket Motor Cases) continued to argue vigorously against the launch because of the cold temperature...[and] were the most vocal participants of the caucus opposing the launch of 51-L, *not one engineer in a non-management position made any positive statement supporting a launch.* In fact, Mr. Boisjoly stopped arguing only '...when it was apparent that I couldn't get anybody to listen.' At that point a final 'management' review was conducted among executives at Thiokol-Wasatch. Those managers involved in the management discussion included, in addition to Mr. Mason and Mr. Lund, Mr. Joe Kilminster and Mr. Calvin Wiggins (Vice President and General Manager, Space Division, Thiokol-Wasatch) (Charles 1996, 118).

After the Thiokol-Wasatch meeting was concluded, the entire teleconference reassembled to conclude discussions involving the SRBs, O-rings and the decision as to whether to launch STS-51L. The conference ended in the following manner:

> The final management decision was presented to all members of the

teleconference by Mr. Kilminster when the meeting resumed at approximately [11 p.m.] EST. *Mr. Kilminster recommended that the STS 51-L launch proceed on January 28, 1986.* This new recommendation was supported by Thiokol management in the following manner: (1) the temperature data was not conclusive in predicting primary O-ring blow-by; (2) the demonstrated sealing threshold of the O-ring was 0.038, which was three times greater than the erosion experienced on STS 51-C; and (3) if the primary seal fails to seat the secondary seal will.

> The teleconference ended with Mr. Stanley R. Reinartz asking for any final comments from anyone on the net. No concerns were voiced at this time; even though none of the engineers at Thiokol-Wasatch supported the launch decision. Mr. Kilminster was then asked by Mr. Mulloy to send a copy of his flight readiness rational and recommendation, via telefax, to Marshall Space Flight Center.
>
> At this point in the meeting Mr. Allen McDonald informed NASA officials at Kennedy Space Center that '...I felt that I was the one who was going to have to sign it [the Thiokol flight readiness recommendation], because I was at the Cape; and I said I wouldn't sign it. I couldn't; it would have to come from the plant' (Charles 1996, 118-9).

Even with the problems involving the SRBs, other problems on the day of the launch occurred which, perhaps, should have had an impact on preventing the launch of 51-L on January 28, 1986. Mr. McDonald presented three reasons why the shuttle should not have been launched:

> (1) the concern for cold O-rings; (2) the booster recovery ships were in a survival mode, with seas as high as 30 feet and winds of 50 knots and gusts of 70 knots. Recovery ships were heading for shore. Under those conditions it would be highly likely that the Solid Rocket Booster parachutes or the thrustums would be recovered; and (3) the formation of ice on the launch pad....Mr. Aldrich did not feel that the launch should be scrubbed because of high seas. The loss of parachutes and thrustums was acceptable, and it was felt the the Solid Rocket Boosters would not be put in undue jeopardy (Charles 1996, 119).

Finally, there was the problem of ice forming on the launchpad (39B) and on the shuttle itself. Other organizations involved in the shuttle launch process were in a position to prevent the launch from occurring:

> During the late night of January 27, and the early morning of January 28, the ice problem at Kennedy Space Center was causing concern for NASA and Rockwell representatives. Due to the imminent launch of 51-

L it was decided that water should be left running through the water pipes to prevent their freezing. This caused considerable ice accumulation to form below the 240 foot level of the Shuttle's fixed service structure. The ice accumulation was discovered at approximately 02:00 on January 28, and was assessed periodically throughout the morning. A Mission Management Team meeting was called for [9 a.m.] at Kennedy Space Center, and Rockwell was to provide its assessment of the ice condition relative to the safety of the launch....Mr. Glaysher...described how the Rockwell no-fly decision was communicated. `My exact quote--and it comes in two parts. The first one was, Rockwell could not 100 percent assure that it is safe to fly which I quickly changed to Rockwell cannot assure that it is safe to fly....' Unfortunately, the non-committal communication from Rockwell representatives was not perceived by NASA officials to be a no-launch recommendation. Horace Lambarth (Director, Shuttle Engineering, NASA) reported to Commission investigators at Kennedy Space Center that the language used by Rockwell, `we can't give you 100 percent assurance,' did not mean to him that the shuttle should not fly the morning of January 28 (Charles 1996, 119 - 20).

The launch of 51-L was thus scheduled to liftoff at 11:38 a.m. (EST) on January 28, 1986. *The New York Times* had a recorded transcript of the event:

The last Flight of the shuttle Challenger lasted about 74 seconds. Here is the transcript, as recorded by The New York Times, of its final moments, before and after liftoff.

PUBLIC AFFAIRS OFFICER: Coming up on the 90-second point in our countdown. Ninety seconds and counting. The 51-L Mission ready to go...

T minus 10, 9, 8, 7, 6, we have main engine start, 4, 3, 2, 1. And liftoff. Lift-off of the 25th space shuttle mission and it has cleared the tower....

MISSION CONTROL CENTER: Watch your roll, Challenger.

PUBLIC AFFAIRS OFFICER: Roll program confirmed. Challenger now heading down range. [Pause.] Engines beginning throttling down now at 94 percent. Normal throttle for most of flight 104 percent. Will throttle down to 65 percent shortly. Engines at 65 percent. Three engines running normally. Three good cells, three good ABU's. [Pause.] Velocity 2,257 feet per second, altitude 4.3 nautical miles, down range distance 3 nautical miles. [Pause.]

Engines throttling up, three engines now at 104 percent.

MISSION CONTROL: Challenger, go with throttle up.

FRANCIS R. SCOBEE, CHALLENGER COMMANDER: Roger, go with throttle up.

PUBLIC AFFAIRS OFFICER: One minute 15 seconds, velocity 2,900 feet per second, altitude 9 nautical miles, down range distance 7 nautical miles. [Long pause.]

Obviously a major malfunction. We have no downlink [communications from Challenger]. [Long pause.]

We have a report from the flight dynamics officer that the vehicle has exploded (*The New York Times,* January 29, 1986 [no author]).

The year 1986 had not begun on a high note for the National Space and Aeronautics Administration and ended suddenly and unexpectedly on January 28, 1986. As we have seen, a number of factors came together which did not bode well for STS 51-L. Firstly, NASA was on a tight budget, having had funds cut by Congress in negotiations the previous July. This factor contributed to a public fight over the scarce resources of NASA, as indicated by the open political struggle as to where the funding should go. This battle over funding was manifested symbolically and publicly in the bitter criticism by the astronomer Van Allen. The press was also quick to point out the agency's problems. Behind the public annoyance lurked a more serious problem. That problem was the initial design of the SRBs which, through a combination of economic and political circumstances, were prone to mishap and not adequate for the serious task for which they were intended. Secondly, the Cold War competition influenced decision makers. For example, NASA wanted to be first to have a space vehicle in position to obtain scientific observations and data from Halley's comet. The strain of the Cold War began to show in the budget battles between the Department of Defense and NASA in the design of a bigger payload shuttle. Thirdly, NASA administrators sent confusing signals to budget decision makers by the administrators desire for a space station well before the administrators could effectively manage the STS. The shuttle program was declared to be fully operational in 1986 even though it was clearly experimental. Fourthly, the agency wanted high-cost items such as the STS, but NASA sold the idea that they could use preexistent technology. This tactic is typical of administrators in agencies where they start a project in the hopes that necessary funding will come later. These factors, limited though they are, provide a backdrop for understanding the rationale for decision-makers in an historical context. Most importantly, the question as to why the decision to launch was made is complex and consists primarily of human interaction. Various organization theories have been proposed to provide an explanation for this case study. We will explore them in the following chapters to determine what kinds of knowledge they yield.

Chapter IV: Functionalism and Radical Structuralism

The Machines, Organisms and Brains Metaphors: Building a Better Mousetrap

Most of the analyses of the *Challenger* space shuttle disaster are from the "machines metaphor," "organizations as organisms," or "organizations as brains" perspectives. These metaphorical categories may be summed up more broadly as being part of the "functionalist" paradigm (Burrell and Morgan, 1979).[55] Logically the work of getting the space shuttle into space successfully would involve a serious, unified, coordinated effort, or what Germans may call *gleichschaltung,* to achieve the goal of orbiting the earth safely, successfully and on time. At its most basic level, the *Challenger* was obviously a very complex machine with complicated components necessary for the mission it was designed to accomplish. Hence, the very nature of the shuttle would lend itself to a more mechanistic or scientific analysis. The primary motivating force of the machines metaphor is what Burrell and Morgan (1979: 127-8) call the golden rule of scientific management: "Get the situation right, and the appropriate human behaviour and organisational performance will follow." The weakness of this metaphor is apparent in that human beings cannot be counted upon to behave in a structured or highly rational fashion. Deborah Stone (1997) in *Policy Paradox: The Art of Political Decision Making* captures the deficiencies of assumptions made in the overall paradigm:

> First, I argue that the *rationality project* misses the point of politics. [According to Stone, the rationality project is progressive reformer induced, with notable advocates such as Herbert Simon and his search for a 'science of administration, Harold Lasswell and his dream of a

[55] See Burrell and Morgan (1979: 120) who explain that "most [theories] are located within the context of what we have called the functionalist paradigm. The other social science paradigms remain almost completely unexplored as far as theories of organization are concerned....Despite the apparent diversity reflected in current debate, the issues which separate the parties in academic controversy often tend to be of minor rather than of major significance."

'science of policy forming and execution,' and the current effort of universities, foundations, and government to foster a profession of policy scientists]. Moreover, it is an impossible dream. From inside the rationality project, politics looks messy, foolish, erratic, and inexplicable. Events, actions, and ideas in the political world seem to leap outside the categories that logic and rationality offer. In the rationality project, politics looks messy, foolish, erratic, and inexplicable. Events, actions, and ideas in the political world seem to leap outside the categories that logic and rationality offer. Rationality purports to offer a correct vantage point, from which we can judge the goodness of the real world.

> I argue, instead, that the very categories of thought underlying rational analysis are themselves a kind of paradox, defined in political struggle. They do not exist before or without politics, and because they are necessarily abstract (they are categories of *thought*, after all), they can have multiple meanings. Thus, *analysis is itself a creature of politics; it is strategically crafted argument, designed to create ambiguities and paradoxes and to resolve them in a particular direction* (Stone,7, italics added for emphasis).[56]

Stone's assessment demonstrates the pervasiveness of scientific or rational thinking by purveyors of the rationality project. Politics is omnipresent in every aspect of society and is often, though not always, ignored by logical positivists. When politics is taken into account, it is frequently subsumed by mechanistic theoretical conceptions. Stone uses the mechanistic metaphor to explain the impulsive tendency (or dominant orthodoxy) of American managers to discover "processes" in the *Challenger* explosion:

> When the space shuttle Challenger exploded, President Reagan appointed a commission to determine what went wrong. After months of investigation, the commission determined that the immediate cause of the accident was a faulty O-ring seal, the kind of rubber gasket in the bottom of your kitchen blender. Not a very dramatic explanation for a major tragedy, but fortunately the commission found a more interesting contributing cause: a 'flawed decision-making process' within NASA, the space agency. Of course, the commission recommended changing the design of the seals, but the bulk of its report concerned reforming NASA's

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56 See also Burrell and Morgan, (1979: 220) "The upshot of our argument...is that the conservatism or ideological and managerial bias which many theorists have suggested characterises social system theory and objectivism is built into the models which are used as a basis of analysis. For this reason many theorists are not conscious of being biased one way or another..."

> decision making: add an independent committee to oversee future rocket design, redefine and strengthen the program manager's authority, and represent astronauts in the program in management.
>
> This [book] is about policy solutions that entail reforming a decision-making process, or what might be called *constitutional engineering*. They are based on the ideas that different types of collective decision-making processes yield different kinds of outcomes. Advocates of process reforms usually argue that a new process will produce better policies--ones that are more just, more efficient, more consistent with liberty, or, as in the case of NASA, more safe. *These arguments are based on the metaphor of mechanism: the content of decisions is shaped by the structure of a process in a seemingly automatic fashion.*
>
> The impulse to restructure authority in order to solve problems goes all the way back to the founding of the nation. The American constitutional debates were about how to prevent tyranny and oppression by designing a system for making political decisions. Perhaps because Americans had an open choice about how to structure our government, we perceive structure as something eminently changeable rather than fixed, and we debate continuously about the merits of different decision-making structures. *From the Founding Fathers' constitution making to Vice President Gore's "reinvention" of government, Americans have shown a deep faith in the possibility of creating decision-making structures that will render good decisions.*
>
> ...Battles over the qualifications of officeholders are as intense as the ones over voters. Officeholders, be they legislators or administrators, theoretically represent the interests of their constituents. Therefore, the theory goes, by changing either the identity of representatives or the ability of constituents to control them, we can change the kinds of decisions they will render. The Space Shuttle Commission's recommendation to include more astronauts in program management exemplifies this logic: astronauts, more than any other group of people, have an interest in shuttle safety and so will make decisions in a way that gives priority to safety (Stone 1997, 351-6, italics mine for emphasis).

Stone's analysis of the American culture demonstrates how imbued we are with things "structural." History has led Americans to believe that they can build a better mousetrap.[57] It is as if one could merely change or improve a part and the whole would then be fixed. Based on this logic, an adequately functioning decision making process and a structurally sound organization will necessarily lead to a correct solution, or to the making of good decisions. An

[57] "Mousetrap" is used here as a metaphor for organizational structures.

executive or manager can correct a problematic area *objectively*[58] in an organization by restructuring or changing its components (getting the right people, the right tools or objects, changing the organizational chart, etc.) in order to improve the decision making process. The basic problem with the machines metaphor (and functionalism, generally) is that as long as the machine is performing normally the operators of the machinery, the executives and managers, generally do not question the operating process until something goes awry (the machinery breaks down).

Functionalism as a world view takes as a given basic philosophical assumptions that are founded upon "science" and a theory of society whether the theorists are aware of it or not (Burrell and Morgan 1979, 119). Functionalism is not simply one perspective but rather a series of systematic theoretical approaches to understanding complex phenomena.

> The functionalist paradigm generates regulative sociology in its most fully developed form. In its overall approach it seeks to provide essentially rational explanations of social affairs. It is a perspective which is highly pragmatic in orientation, concerned to understand society in a way which generates knowledge which can be put to use....It is usually firmly committed to a philosophy of social engineering as a basis of social change and emphasises the importance of understanding order, equilibrium and stability in society and the way in which these can be maintained. It is concerned with the effective 'regulation' and control of social affairs....The functionalist approach to social science tends to assume that the social world is composed of relatively concrete empirical artifacts and relationships which can be identified, studied and measured through approaches derived from the natural sciences. The use of mechanical and biological analogies as a means of modeling and understanding the social world is particularly favoured by functionalist theories (26).

[58] See Berger and Luckmann (1966, 82 - 3) for a discussion on the extremes of the "objectified world" and "reification." According to Berger and Luckmann, "The objectivity of the social world means that it confronts man as something outside of himself. The decisive question is whether he still retains the awareness that, however objectivated, the social world was made by men--and, therefore, can be remade by them. In other words, reification can be described as an extreme step in the process of objectivation, whereby the objectivated world loses its comprehensibility as a human enterprise"...(83).

We will pursue the theoretical variations involved as we trace the scholars attempting to explain the events leading to the shuttle disaster and subsequent attempts to eliminate future explosions. Following the examination of functionalist metaphors, the knowledge from the theories generated by the functionalist paradigm will then be summarized and compared.

The Machines Metaphor

Before pursuing the functional theoretical interpretations of the *Challenger* disaster specifically, I must briefly review both the work of the father of scientific management, Frederick Winslow Taylor, and the work of the German sociologist Max Weber as to the characteristics of a bureaucracy. A major distinction between the two scholars is in order here. Taylor was a strong advocate of scientific management whereas Weber feared the potential implications of his "ideal-type" bureaucracy.[59] Before a U.S. House of Representatives committee in 1912, Taylor advocated his new method over previously known practices, such as management by initiative and incentive. Taylor's (1987) four principles of scientific management are recounted here:

> 1. *The duty of deliberate gathering in on of all of this great mass of traditional knowledge* [and skill of workmen],..reducing it to laws, rules and even mathematical formulae, is voluntarily assumed by the scientific managers.
>
> 2. [The management should engage in] *the scientific selection and then the progressive development of the workmen*. It becomes the duty of those on the management's side to deliberately study the character, the nature, and the performance of each workman with a view to finding out his limitations....[This would then allow the manager to train the worker to]

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59 See Shafritz and Ott (1996: 35-6) *Classics of Organization Theory, Fourth Edition* for more on Weber. Max Weber's sociology intersects nearly all of the *weltanschauungen* in organization theory. His seminal essays in sociology cannot be ignored and have an impact to this day. Weberism is developed at length in the "radical structuralism," "interpretive" and "radical humanism" world views below. Functionalists have also incorporated his ideas into their work.

do the highest and most interesting and the most profitable class of work for which his natural abilities fit him.

3. *The third [principle] is the bringing of the science and the scientifically selected and trained workmen together.*

4. *[The] most difficult of all of the principles....consists of an almost equal division of the actual work of the establishment between the workmen...and the management* (Taylor 1987, 158-60).

Scientific management (or Taylorism as it is sometimes referred to) embodies much of what managers tend to idealize when analyzing or restructuring their own organizations in order to make them more "rational." "Rational" in this sense means more cost effective, efficient, or also, as in the case of the *Challenger*, safe. There is, too, the paternalistic implication that management has the exclusive right to "knowing" what is best as to how to do the work. Since the *Challenger* was an obvious failure, the scientific management explanation for the disaster lies in the failure of how the science was applied to the task, in this case of the launching of the shuttle. This failure is not necessarily the fault of anyone in particular but is primarily a fault of the breakdown of the *management system* that had been put into place.

Max Weber's characteristics of bureaucracy as outlined in *From Max Weber: Essays in Sociology* (1946) delineate the primary structural and functional features of organizations. His analysis shares tenets with the works of the Frenchman Henri Fayol and the British economist Adam Smith.[60] Elements of Weber's theory of bureaucracy (the organizational pyramid) are recounted here:

[60] See, for example, Henri Fayol (1949) *General and Industrial Management* (C. Storrs, Trans.) (originally published in 1916) and Adam Smith (1984) *An Inquiry Into the Nature and Causes of the Wealth of Nations* (originally published in 1776).

I. There is the principle of fixed and official jurisdictional areas, which are generally ordered by rules, that is, by laws or administrative regulations.

II. The principles of office hierarchy and of levels of graded authority mean a firmly ordered system of super- and subordination in which there is a supervision of the lower offices by the higher ones.

III. The management of the modern office is based upon written documents ("the files"), which are preserved in their original or draught form.

IV. Office management, at least all specialized office management--and such management is distinctly modern--usually presupposes thorough and expert training.

V. When the office is fully developed, official activity demands the full working capacity of the official, irrespective of the fact that his obligatory time in the bureau may be firmly delimited.

VI. The management of the office follows general rules, which are more or less stable, more or less exhaustive, and which can be learned (Weber 1996: 80-1).

This idealized theory of bureaucracy is generally considered to encompass the development of most subsequent functional theories. Early functionalist theorists are referred to as "classical" or "traditional" organization theorists (see Shafritz and Ott 1996) share some common characteristics:

1. Organizations exist to accomplish production-related and economic goals.

2. There is one best way to organize for production, and that way can be found through systematic, scientific inquiry.

3. Production is maximized through specialization and division of labor.

4. People and organizations act in accordance with rational economic

principles. (Shafritz and Ott 1996, 30-31).[61]

Classical organization theory serves as the basic model for other theories in the functionalist paradigm (see "organizations as organisms" and "organizations as brains" metaphors below.)

Insofar as understanding changes in an organization predominated by functionalism is concerned, I have chosen to begin the analysis of the machines metaphor as it applies to the *Challenger* case study with an examination of what structural changes were made, or were attempted to be made, after the fatal decision to launch. Recommendations to fix the NASA organization and make the Space Shuttle program more structurally sound are apparent in the *Report to the President: Actions to Implement the Recommendations of the Presidential*

[61] See George Soros' "The Capitalist Threat" in *The Atlantic Monthly*, February 1997 (48) for an account of the excesses of rational economic principles. "The main scientific underpinning of the laissez-faire ideology is the theory that free and competitive markets bring supply and demand into equilibrium and thereby ensure the best allocation of resources. This is widely accepted as an eternal verity, and in a sense it is one. Economic theory is an axiomatic system: as long as the basic assumptions hold, the conclusions follow. But when we examine the assumptions closely, we find that they do not apply to the real world. As originally formulated, the theory of perfect competition--of the natural equilibrium of supply and demand--assumed perfect knowledge, homogeneous and easily divisible products, and a large enough number of market participants that no single participant could influence the market price. The assumption of perfect knowledge proved unsustainable, so it was replaced by an ingenious device. Supply and demand were taken as independently given. This condition was presented as a methodological requirement rather than an assumption. It was argued that economic theory studies the relationship between supply and demand; therefore it must take both of them as given." I believe that a similar principle holds for organizations imbued with doing things for the sake of having done them. Even when events occur that contradict closely held assumptions of what ought to occur, they are dismissed as aberrant occurrences or new structures (givens) arise to explain away discrepancies (anomalies). Stone (1997, see above) has put her finger on a related concept with her notion of constitutional engineering.

Commission on the Space Shuttle Challenger Accident (July 14, 1986).[62] Lewis (1988: 216) notes that the recommendations were adopted unanimously "to help assure the return to safe flight." The recommendations are as follows:

> 1. Recommendation 1 called for the redesign of the faulty solid rocket motor joints--either a new design eliminating the joint or a redesign of the current joint and and seal. It stated that no options should be precluded because of schedule, cost, or reliance on existing hardware....Joints should be fully understood, tested, and verified. The integrity of the seals should not be less than that of the case walls. The integrity of the joints should be insensitive to dimensional tolerances, transportation and handling, test procedures and inspections, environmental effects, recovery and reuse, and flight and water impact loads.
>
> 2. Recommendation 2 deals with the management of the shuttle program. It said that a new definition of the program manager's responsibility is essential, noting that the project managers for the various elements of the shuttle 'felt more accountable to their center management than to the shuttle program organization.' As a result, vital information frequently bypasses the national shuttle program manager. Program funding and all program work at the centers should be placed under the program manager's authority. [Also, astronauts were to be placed 'into other positions in the agency' *Report to the President: Actions to Implement* (1986: 2).]

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62 For more elaboration of changes in management structure pertaining to safety see the report prepared by the Committee on Shuttle Criticality Review and Hazard Analysis Audit of the Aeronautics and Space Engineering Board entitled *Post-Challenger Evaluation of Space Shuttle Risk Assessment and Management*, National Academy Press, January 1988. NASA policy regarding safety is established by the Administrator (who is ultimately responsible) through NASA policy Directive 1701.1 and is to: "a. Avoid loss of life, injury of personnel, damage and property loss; b. Instill a safety awareness in all NASA employees and contractors; c. Assure that an organized and systematic approach is utilized to identify safety hazards and that safety is fully considered from conception to completion of all agency activities; and, d. Review and evaluate plans, systems, and activities related to establishing and meeting safety requirements both by contractors and by NASA installations to ensure that desired objectives are effectively achieved" (1 - 2). The report also defines "risk assessment" as "A comprehensive method for identifying potential failure modes and hazards associated with the system" and "A specific, quantitative methodology for identifying and assessing (or estimating) the safety risks of the system." "Risk management" is defined as "A management process by which the safety risks can be brought to levels or values that are acceptable to the final approval authority. Risk management includes establishment of acceptable risk levels; the institution of changes in system design or operational methods to achieve such risk levels; system validation and certification; and system quality assurance. The basic organizational elements are in place within NASA for assessing and managing risk; however, there is a need for a change in the scope of functions and the way that they are carried out. The Committee believes that the *management* of the STS must be the responsibility of line management...*not the safety organizations*" (3).

3. Recommendation 3 called for a review of the critical items list....The review should identify items that must be improved before flight to ensure safety. It was proposed that an audit panel, appointed by the National Research Council,should be installed to verify the adequacy of the criticality and hazard review. The panel would report directly to the administrator.

4. Recommendation 4 called for the establishment of the office of safety, reliability and quality assurance to be headed by an associate administrator, reporting to the administrator.

5. Recommendation 5 demanded an end to what the commission called "management isolation" at the Marshall Space Flight Center. It said that the commission found that Marshall project managers failed to provide full and timely information bearing on the safety of flight 51-L to other vital elements of shuttle program management. The recommendation said that NASA should take energetic steps to eliminate this tendency toward management isolation at the center 'whether by changes of personnel, organization, indoctrination--or all three.'

6. Recommendation 6 urged NASA to improve landing safety.

7. Recommendation 7 called upon NASA to 'make all efforts to provide a crew escape system for use during controlled gliding flight.'

8. Recommendation 8 stated that NASA must establish a flight rate 'consistent with its resources' and establish a firm payload policy with controls on manifest changes to reduce pressure on schedules and crew training. It urged NASA to avoid reliance on a single-launch capability in the future, because 'The nation's reliance on the shuttle as its principal space launch capability created a relentless pressure on NASA to increase the flight rate.' The recommendation implied that NASA should shift commercial payloads to expendable rockets to relieve pressure on the shuttle.

9. Recommendation 9 called for the establishment of a system of analyzing and reporting performance trends for criticality 1 items. Maintenance procedures for these nonredundant items should be specified in the critical items list, especially for the shuttle main engines. Also recommended for the orbiter was a comprehensive maintenance inspection plan, periodic structural inspections that could not be waived, and cessation of cannibalizing parts from one orbiter to repair another. The spare parts inventory should be restored and maintained (Lewis 1988, 216-8).

These recommendations primarily constitute structural repairs by the Rogers Commission for a perceived malfunctioning organization (or machine). Lewis (1988, 219) argues that two of the recommendations were not fulfilled: one was the Commission's warning against precluding design options for reasons of schedule, cost, or reliance on existing hardware [Recommendation 1 above]; and, vertical testing to recreate normal launch conditions for the newly redesigned booster joints [also included under Recommendation 1]. Lewis points out that NASA immediately skirted the recommendation because the costs were prohibitive (estimated at $30 million), and because the engineers were divided over "the efficacy of vertical vs. horizontal rocket testing." While not all of the recommendations may be directly attributed to the machines metaphor, some of the Commission recommendations reflect tenets of the image. Recommendation 1 is directly concerned with economic costs, though the commission advocated the principle that costs should not be a primary concern when astronaut safety is involved. Under the new administrator James Fletcher, NASA decided not to implement, however, the vertical testing procedures partly because of the costs and expert engineering assessments.

Recommendations 2, 3, 4 and 5 deal with increasingly centralized management and accountability, the establishment of new divisions of labor (establishment of a shuttle safety advisory panel, an audit panel, and an office of safety, reliability and quality assurance). These actions are designed simultaneously to strengthen the bureaucratic pyramid (Weber) and to strike a balance between the managers and the workmen (Taylor). The tendency in NASA shortly after the Challenger debacle to make structural changes in order to solve organizational problems may be summed up in the *Report to the President: Actions to Implement the Recommendations of The Presidential*

Commission on the Space Shuttle Challenger Accident (1986) "The NASA Administrator has announced a number of Space Station organizational and management structural actions designed to strengthen technical and management capabilities in preparation for moving into the development phase of the Space Station program" (*Report to the President* 1986, 5).

The organizations as machines metaphor is limited in assessing problems. Situations that arise such as the *Challenger* explosion cause proponents of the machines metaphor to reexamine how decisions are made in organizational structures. As shown above, leaders of the NASA organization paused only to retool by taking structural actions to move on to new programs.

The Machines Metaphor: Analyses Outside of NASA

Scholarly renditions have been offered from the machines metaphor image to correct the perceived deficiencies the NASA organization. In "Understanding the *Challenger* Disaster: Organizational Structure and the Design of Reliable Systems" in the *American Political Science Review* the political scientist C. F. Larry Heimann (1993) of Michigan State University makes the assessment that the "traditional public administration focus on organizational design has involved the pursuit of efficiency in the sense of minimizing costs for a given level of level of output.....As a result, the policy recommendations from this traditional line of thinking have been to streamline administrative systems and reduce organizational redundancy as much as possible" (421). Heimann believes that "redundancy" is the key to developing a safer system to increase organizational reliability. Heimann posits that one can improve an organizational system with the adoption of a parallel system (versus a serial configuration) based on engineering principles or a circuit board (similar to basic electronics). The system would then result in a subsequent increase in redundancy. Management by redundancy is inherently more expensive because it involves another layer of bureaucratic oversight, thus costing more to implement through the hiring or retaining of individuals in the organization. Heimann maintains that prior to the Challenger accident NASA changed changed its organizational configuration from parallel to serial which contributed to failure. "Structural design" is the operative phrase here:

> This theoretical approach to structural design can now be used to examine the institutional failures at NASA that ultimately led to the destruction of the *Challenger*. I will show that during the 1970s and 1980s, NASA altered its organizational structure in order to achieve different reliability goals. I examine changes within two specific areas of the NASA's structure that the Rogers Commission mentioned in its report on the *Challenger* accident in 1986. The first area of concern involves the organization of NASA's reliability-and-quality-assurance (R&QA) functions. The second area involves changes that took place in the agency's launch decision structure (Heimann 1993, 428).

Heimann's conclusion of the R&QA [reliability-and-quality assurance] function is "As this analysis has shown, streamlining the R&QA function increased the probability that a type I failure such as the *Challenger* would eventually occur" (430). Relatively scarce resources and the reduction in force initiatives occurring at NASA in the 1970s and 1980s exacerbated an already precarious situation. On the decision launch structure Heimann postulates that the "organizational structure can have an important impact on administrative reliability. I have demonstrated, both in theory and for the case of NASA, that changes in the number and alignment of administrative components alters the probability than an agency would commit [an]...error" (433). Also, Heimann notes that "This work helps us to understand *how* agencies may adjust their structural design to meet the demands for different forms of reliability. The question of *why* agencies make the choices they do is one that would be of great interest to political scientists" (Heimann 1993, 433).

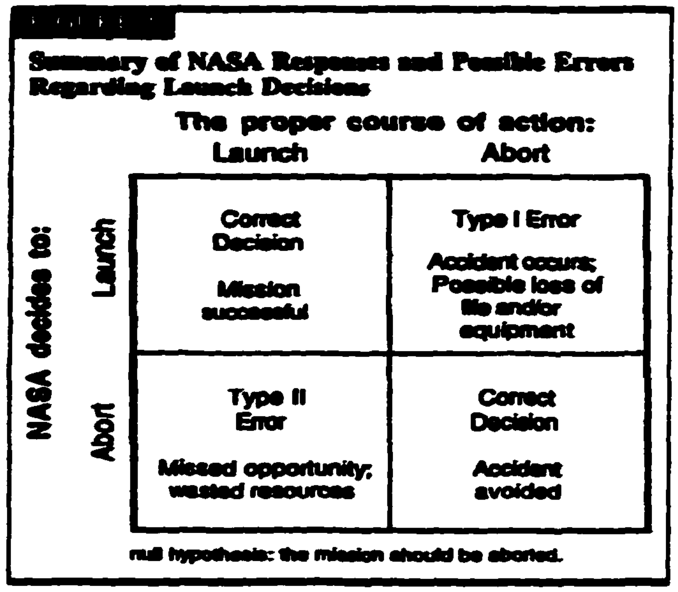

Figure 4.1 (Source: C.F. Larry Heimann, "Understanding the Challenger Disaster" *American Political Science Review*, Vol. 87, No. 2, June 1993, p. 423)

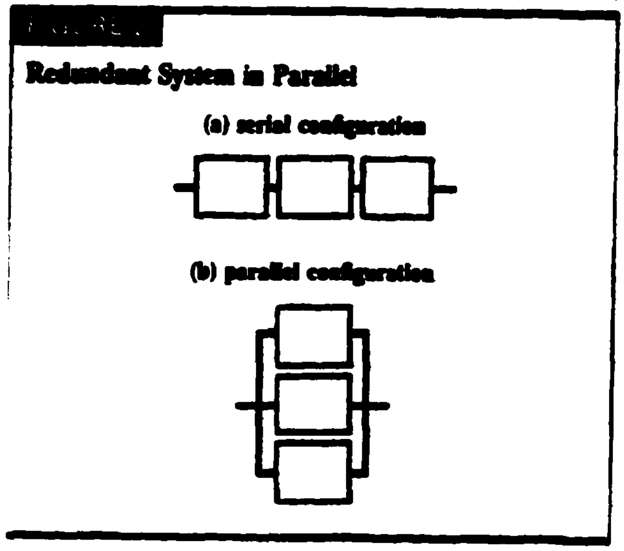

Figure 4.2 (Source: C.F. Larry Heimann, "Understanding the Challenger Disaster" *American Political Science Review*, Vol. 87, No. 2, June 1993, p. 424)

Figures 4.1 and 4.2 above illustrate the principle of "organizations as machines," or circuit boards, and one can readily see the inherent superiority of the parallel system. In the event that one of the components fail, the whole system does not fail because of the other components being in parallel with each other. Heimann (1993, 425) states that "Holding component reliability constant, the addition of redundancy in a parallel fashion will raise the reliability of the overall system, while creating serial redundancies decreases total system reliability. It is not surprising, therefore, that many scholars in this area have spurned serial systems and focused, instead, on parallel linkages when discussing this issue." Heimann's analysis parallels that of the second recommendation made in the *Report to the President: Actions to Implement the Recommendations of the Presidential Commission on the Space Shuttle Challenger Accident* with the establishment of the Shuttle Safety Panel:

> A Shuttle Safety Panel will be established by the Associate Administrator for Space Flight not later than September 1, 1986, with direct access to the Space Shuttle program manager. This date allows time to determine the structure and function of this panel, including an assessment of its relationship to the newly formed Office of Safety, Reliability, and Quality Assurance, and to the existing Aerospace Safety Advisory Panel (1986, 2).

Heimann posits that increased redundancy is a key to aid in preventing future catastrophes like the *Challenger* in the future, though he admits that "we must recognize that a theory of organizational reliability is not sufficient to eliminate risks altogether. Space exploration is still a risky business--it always has been and always will be" (1993, 433).

Organizations as Organisms Metaphor

The organizations as organisms metaphor is one of the most common paradigms used in organizational analysis. There are several theoretical examples from scholars using the organisms approach in their analysis of the *Challenger* shuttle disaster. Most of the analyses are, however, influenced by elements from the German idealist tradition of social thought (Burrell and Morgan 1979, 27) and are composites of theoretical perspectives with a basic structural-functionalist approach.

> ...[T]his approach reflects assumptions about the nature of social science which stand in opposition to those of sociological positivism. As a result of the work of such theorists as Max Weber, George Simmel and George Herbert Mead, elements of this idealist approach have been utilised within the context of social theories which have attempted to bridge the gulf between the two traditions. In so doing they have forged theoretical perspectives characteristic of the least objectivist region of the paradigm, at its junction with the interpretive paradigm. Such theories have rejected the use of mechanical and biological analogies for studying the social world and have introduced ideas which place emphasis upon the importance of understanding society from the point of view of the actors who are actually engaged in the performance of social activities.
>
> Since the 1940s there has been also an infusion of certain Marxist influences characteristic of the sociology of radical change. These have been incorporated within the paradigm in an attempt to `radicalise' functionalist theory and rebuff the general charge that functionalism is essentially conservative and unable to provide explanations for social change. These attempts underwrite the debate...as to whether a theory of `conflict' can be incorporated within the bounds of a theory of `order' to provide adequate explanations of social affairs.
>
> Put very crudely, therefore, the formation of the functionalist paradigm can be understood in terms of the interaction of three sets of intellectual forces....Of these, sociological positivism has been the most influential. The competing traditions have been sucked in and used within the context of the functionalist problematic, which emphasises the objectivist nature of the world and a concern for explanations which emphasise `regulation' in social affairs (Burrell and Morgan 1979: 27 - 8; see Figure 4.3 below).

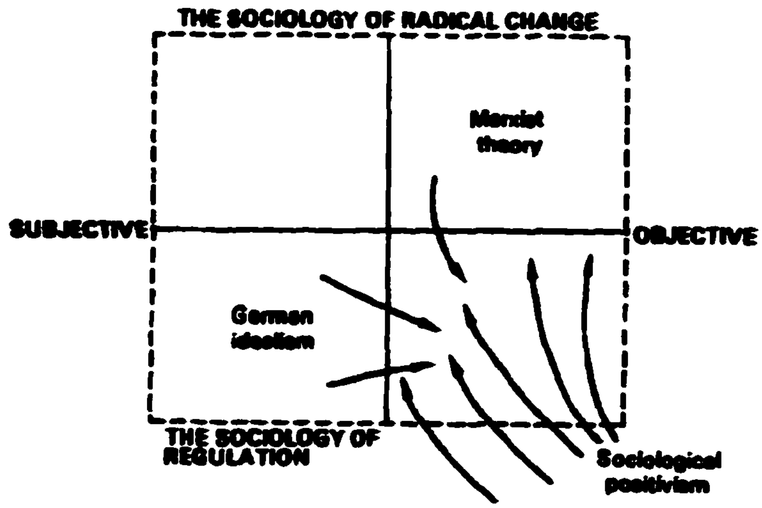

Figure 4.3 (Source: Burrell and Morgan 1979, 27 [Figure 3.2])

In terms of the images developed by Morgan (1986 and 1997), combinations of metaphors which can either enrich theoretical analysis or add to theoretical obfuscation are oftentimes used simultaneously .

The incorporation of aspects of other theoretical approaches into structural-functionalism is important for us to understand many of the explanations of the *Challenger* disaster. Romzek and Dubnick (1987) promote an interpretation of the incident primarily from an "institutional perspective"[63] based on the work of Talcott Parsons and James D. Thompson (227). As such, there are three levels: the technical (organization focus on the effective performance of specialized and detailed functions), managerial (an organization provides for mediation among its technical components and

[63] See W. Richard Scott's article entitled "The Adolescence of Institutional Theory" in *Administrative Science Quarterly*, 32 1987): 493-511 for a more thorough elaboration of institutional theory. Topics in the essay include institutionalization as (1) a process of instilling value; (2) a process of creating reality; (3) a class of elements; and, (4) distinct societal spheres. The main thrust of the institutionalist approach is with organizational structure as "Institutional theorists have directed attention to the importance of symbolic aspects of organizations and their environments....All social systems--hence, all organizations--exist in an institutional environment that defines and delimits social reality" (507). The primary component of institutionalism is structural-functionalism. Human values being brought into the theoretical mix to support various conceptions of institutionalism exemplify the argument illustrated by Burrell and Morgan (see figure 4.3 above).

between its technical functionaries and those `customers' and `suppliers' in the organization's `task environment'), and institutional (the organization deals with the need for being part of the `wider social system which is the source of the "meaning," legitimation, or higher-level support which makes implementation of the organization's goals possible') (Romzek and Dubnick 1987, 227-8). This essay also consists of metaphors such as political systems, machines metaphor (identified as technical and `bureaucratic pressures' [233-4]), and the issue of ignoring the workers and the domination metaphor. The theoretical interpretation of the article is, at its base, structural-functionalist. Romzek and Dubnick use the language of the organizations as organisms metaphor to explain what happened. The primary focus of their research may be summed in their conclusion:

> It was inevitable that the *Challenger* disaster would generate strong institutional pressures for NASA, and those pressures are creating new demands and expectations for the agency. Ironically, the direction of those pressures has been toward enhanced bureaucratic structures and growing resilience on legal accountability mechanisms which stress NASA's formal responsibilities for the safety of its astronauts (235).

The Romzek and Dubnick (1987) article is an example of an explanation in which structural-functionalism is embellished by other theoretical perspectives. Notably, an attempt is made in which functionaries in the organization are taken into account. In this case, functionaries with important information were ignored by higher level administrators. The information held by the engineers and lower-level administrators was important to the conduct of the operation (i.e., the decision to launch). In essence, one of the causes of the accident was the inability of the experts within the organization to effectively communicate the information to the decision-makers, thus representing a breakdown in the scalar chain.[64]

The problem of effective communication is further articulated in an article by William H. Starbuck and Frances J. Milliken (1988a) entitled "Challenger: Fine-Tuning the Odds Until Something Breaks" in the *Journal of Management Studies*. The basic premise of the article is that repeated successes in the previous shuttle launches, combined with an acclimatization (repeated successes and incrementalism) and differing responsibilities between engineers and managers, led to disaster. Starbuck and Milliken contribute three theories as to the probabilities of future success:

> [**Theory 1**:] Neither success nor failure changes the expected probability of a subsequent success (321) [gambler's fallacy]. (b) [**Theory 2**:] Success makes a subsequent success seem less probable, and failure makes a subsequent success appear more likely....Successes foster complacency, confidence, inattention, routinization, and habituation; and so human errors grow increasingly likely as successes accumulate. Failures, on the other hand, remind operators of the need for constant attention, caution, and vigilance; and so failures make human errors less likely (322)....when applied to successes, Theory 2 is more an observer's theory than a participant's theory. Although bosses might use Theory 2 when appraising their subordinates' actions, they would probably not apply it to themselves (323). (c) [**Theory 3**:] Success makes a subsequent success appear more probable, and failure makes a subsequent success seem less likely. Expected probabilities of success are not well-defined facts, but hypotheses to be evaluated through experience. Even if engineers or managers believe that a probability of success remains constant for a long time, they need to revise their estimates of this probability as experience accumulates (323). Theory 3 offers a very plausible characterization of the beliefs of managers at

[64] See Miller (1993) for more elaboration on the effects of a breakdown in communication between the engineers and NASA managers. The main thrust of this article was that the engineers were unable to persuade the managers responsible for the launch decision because they could not communicate their views of the situation to the managers holding the knowledge. The engineers were ignored by managers who did not know the subtleties of their work. In this case, Miller places the blame squarely on the engineers: "...To the extent that NASA engineers could talk to themselves as a group and to non-experts, most notably NASA managers, they attempted to bridge discourse communities....the very fact that the space shuttle Challenger was launched notwithstanding objections by the engineers indicates they did not adequately communicate their reservations to the non-experts....if a community of experts believes that a problem exists and a community of non-experts either disputes the existence of the problem or doesn't know it exists, the experts must persuade the non-experts to adopt the competing orientation" (101).

Thiokol's Wasatch Division and NASA's Marshall Space Flight Center (SFC) as they tried to evaluate the risks posed by joints in the shuttle's solid rocket booster (SRB). As successful launches accumulated, these managers appear gradually to have lost their fear of design problems and grown more confident of success (Starbuck and Milliken, 1988a).

Theories 1 - 3 represent a rationalistic approach in the genre of game theory, in this case the theoreticians apply the "gambler's fallacy" as a possible means to explain the decision-making process. Starbuck and Milliken subject the organization participants to a form of analysis imputing motivations to the individuals involved. There is an implication here that the decision-makers thought they had perfect knowledge and in fact did not.[65] Furthermore, the managers at Thiokol and Marshall were victims caught in a web of their own making. Another aspect of Starbuck and Milliken's theories (especially Theory 2) is the notion that managers have a tendency in this case to apply a set of evaluative criteria to employees for failure which do not apply to themselves.

Central to Starbuck and Milliken's analysis is the notion of *hubris.* There is a sense of inevitability exemplified by their work, in which the event occurred regardless of consequences. They maintain that only after the fact of the launch and the subsequent explosion was NASA capable of seeing its own folly:

NASA's incremental changes in hardware, procedures, and operating conditions were creeping inexorably toward a conclusive demonstration of some kind. In retrospect, it now seems obvious that numerous launches had generated increasingly threatening outcomes, yet NASA's managers persisted until a launch produced an outcome too serious to process routinely. They seem to have been pursuing a course of testing to destruction.

NASA's apparent insensitivity to escalating threats has attracted criticism, and NASA could undoubtedly have made better use of the available evidence, but NASA was behaving in a commonplace way. Because fine-tuning creates sequences of experiments that are supposed to probe the limits of theoretical knowledge, people tend to continue one of these experimental sequences as long as its outcomes

[65] This section has much in common with Morgan's (1986) organizations as brains image, including Herbert Simon's notion of "satisficing."

are not so bad: the sequence goes on until an outcome inflicts costs heavy enough to disrupt the normal course of events and to bring fine-tuning to a temporary halt[65] (Starbuck and Milliken 1988a, 337).

Similarly, subsequent works by William H. Starbuck demonstrate his propensity for interpreting events which have a predetermined outcome. No event within an organization occurs without someone having a plan for every occasion. Human beings are limited only by their "humanness" which causes reasonable plans to go awry. Rationalization happens in the organization through the entire deliberative process. Organizations become reified under Starbuck's theoretical process:

> Individual human beings can learn without having to erase what they already know; they can record new knowledge on top of their current knowledge. This causes some confusion, because people often end up with inconsistent chunks of knowledge in their memories, but it does make learning easy. Organizations, especially the older ones, find it harder to ignore their current knowledge, because they build up explicit rationalizations for why they are doing what they are doing, and because they tend to associate specific people with specific policies. So organizations integrate their knowledge into very rigid and coherent structures in which the intellectual and political elements buttress each other. Organizations can readily learn knowledge that fits into what they already believe, but they find it very difficult to learn knowledge that conflicts with their current knowledge. Before they become willing to accept radically different knowledge, organizations actually have to unlearn what they know, by dismantling their existing ideological and political structures. In particular, before organizations are willing to contemplate radically different policies and strategies, they have to convince themselves that the arguments supporting their current policies and strategies are wrong, and they have to lose confidence in their

---

[65] In a later work the authors seem to qualify their analysis as "People seem to see past events as much more rationally ordered than current or future events, because retrospective sensemaking erases many of the causal sequences that complicate and obscure the present and future....Observers who know the results of actions tend to see two kinds of analytic sequences:

Good results --> Correct actions --> Flawless analyses --> Accurate perceptions
Bad results --> Incorrect actions --> Flawed analyses --> Inaccurate perceptions

Knowing, for example, that bad results occurred, observers search for the incorrect actions that produced these bad results; the actual results guide the observers toward relevant actions and help them to see what was wrong with these actions... " (Starbuck and Milliken 1988b, 37 - 8).

current managerial hierarchies (Starbuck 1989, 26 - 7).

Another facet of Starbuck's theoretical argument entails organizational learning. Organizations, as such, can learn as if they were individual human beings. It is as if they take onto themselves a life of their own:

> Consider the means by which organizations learn. Most powerful tools are two-edged swords that can produce harm as well as good. Organizational learning mechanisms show this duality: while they foster autonomy, efficiency, and predictability, they simultaneously promote blindness, rigidity, and self-deception.
>
> [1] Organizations have three basic learning mechanisms. One of these is buffering. An organization builds buffers between itself and sources of random variation in its environment...
>
> [2] Slack resources afford a second learning mechanism. ... Slack resources resemble buffers in that they enable an organization to satisfy environmental demands at low cost; and by lowering what would otherwise be peak profits, slack resources also make an organization's performance appear smoother to its environment.
>
> [3] The third, and most important, learning mechanism is programming. Programs enable organizations to repeat the same activities over and over again. People figure out how to solve some kind of problem or how to perform some task effectively, so they create a program that enables them to do it over and over again the same way....Programs afford the main means by which organizations accumulate experience, coordinate activities, and control actions hierarchically (Starbuck 1989, 18 - 9).

With his later theoretical analysis, Starbuck promotes the use of mechanisms and structures within the organization in order to foster the internal coherence of the traditional organization structure: the pyramid. Starbuck's analysis here favors the machines and organizations as organisms metaphors. Learning mechanisms are important cogs in the organizational machine.

The power structure of the NASA organization is further exemplified by Starbuck and Milliken's analysis of the actions of the Rogers Commission. The Rogers Commission was found culpable of "retrospective perceiving" after the failure of the shuttle launch:

...Thus, after the space shuttle exploded and destroyed the Challenger spacecraft, a Presidential Commission searched for the human errors that caused this disaster. Physical evidence from the sea bottom, laboratory tests, and television tapes ruled out several initial hypotheses and focused attention on design flaws in the wall of the solid-rocket booster. Confident that mistakes had occurred when NASA decided to continue using this booster, the Presidential Commission could then review these processes and identify the mistakes. The Commission did spot some data that should have been taken more seriously, some rules that should have been enforced more stringently, some opinions that should have been used, and some specific people who had played central roles in the faulty decision processes. Many of these same actions had occurred before previous flights--the same rules had been bent, the same kinds of discussions had taken place, and the same communication channels had been ignored. But, after previous flights, no participant said these actions had been mistakes; and when inspectors noted defects in the solid-rocket boosters, NASA personnel concluded that these defects were not serious.

Retrospective perceivers are much more likely to see bad results, if they did not themselves play central roles in the events.... (Starbuck and Milliken 1988b, 38).

Starbuck and Milliken's interpretation of the *Challenger* event rests upon an assessment by NASA commission investigators concerning when bureaucratic rules were broken, communications within the scalar chain were disrupted and that hubris came into play interfering with the decision-makers' judgments. Beyond the normal structural-functionalist failures (machines and organizations as organisms metaphors), Starbuck and Milliken indicate that those who perceived bad results as a normal occurrence in the events leading up to the launch were those in power.

Risk Assessment and Its Variants

Risk theorists have attempted to explain the Challenger launch disaster in a number of ways. Sociologists tend to dominate the theoretical image.[67] There is by no means a consistent interpretation of events surrounding the launch decision amongst its advocates. Indeed, as will be shown, there are basic disagreements among the theorists as they interpret the event. In addition to theoretical disharmony, there are some common elements which comprise the various conceptions of risk theorists. First, risk theorists share with other structural-functional theorists a propensity to consider the organization as a mechanical device or as a system comprised of interchangeable components which, in the case of risk theorists, varies with the system's complexity. Because of this aspect of risk theory, it can be placed under the heading of the "rationality project" as put forward by Stone (1997) above. A second element of risk theory is culture. Risk theorists are primarily advocates of the impact of the organization's culture on the behavior of individuals in the organizations. "Organizations" is the key here as the collective members are influenced more by *being in* or *of* the organizational totality rather than by behaving or acting separately as independent beings. Individual actions tend to be subsumed within the organizational culture. No particular organization members are responsible or accountable for the events that transpire, rather the organization (or the climate created by the organization's culture) is intrinsically culpable for any negative consequences that occur. Accidents happen in a deterministic fashion (i.e., accidents are inevitable in complex organizations) even with the best of intentions by members within the organization when they attempt to avert an undesirable action.

One of the key insights into risk theory is that the organization by its very

[67] See the previous discussion (Chapter I especially footnote 9 above) of Vaughan's (1996) work, more of it will be covered here. Another prominent sociologist whose work has involved an assessment of the *Challenger* launch decision is Charles Perrow. Criticism of risk theorists, particularly the work of Perrow, will follow in the discussion of the radical structuralist paradigm after this section.

nature as a human construction is fallible, particularly in high risk systems. Accidents are built into the system in an unintended fashion, despite attempts to alleviate potential human error. In regard to other structural-functionalist theories, risk theorists tacitly recognize, or at least qualify, the inherent imperfections of complex organizations built by humans and when engaged in theory building they attempt to take these flaws into account. This recognition of "humanness" constitutes a movement away from strict functionalism but is at its core objectivist and an attempt to provide law-like generalizations for human activity.

The first risk theorist we will assess here is Charles Perrow (1984) and his theory of "normal accidents." Perrow's conception may be summed up by a quotation from his work *Normal Accidents: Living with High Risk Technologies*:

> ...Risk will never be eliminated from high-risk systems, and we will never eliminate more than a few systems at best. At the very least, however, we might stop blaming the wrong people and the wrong factors, and stop trying to fix the systems in ways that only make them riskier.
>
> The argument is basically very simple. We start with a plant, airplane, ship, biology laboratory, or other setting with a lot of components (parts, procedures,operators). Then we need two or more failures among components that interact in some unexpected way. No one dreamed that when X failed, Y would also be out of order and the two failures would interact so as to both start a fire and silence the fire alarm. Furthermore, no one can figure out the interaction at the time and thus know what to do. The problem is just something that never occurred to the designers...for most of the systems...neither better organization nor technological innovations appear to make them any less prone to system accidents. In fact, these systems require organizational structures that have large internal contradictions, and technological fixes that only increase interactive complexity and tighten the coupling; they become still more prone to certain kinds of accidents.
>
> If interactive complexity and tight coupling--system characteristics--inevitably will produce an accident, I believe we are justified in calling it a normal accident, or a system accident. The odd term normal accident is meant to signal that, given the system characteristics, multiple and unexpected interactions of failures are inevitable. This is an expression of an integral characteristic of the system, not a statement of frequency. It

is normal for us to die, but we only do it once. System accidents are uncommon, even rare; yet this is not all that reassuring, if they can produce catastrophes (Perrow 1984, 4 - 5).

There is some question as to whether Perrow really means that the *Challenger* would qualify as a complex system which would meet his criteria as a normal accident. Indeed, there is apparently some confusion by Perrow as to whether normal accident theory (NAT) even applies in the case of the shuttle disaster. Two subsequent interpretations of the event are offered by Perrow for comparison below. One of the key issues to be assessed here is the element of time, as eight years had passed between Perrow's assessments. Another issue concerns information or knowledge about the incident with hindsight providing a motive for a reevaluation of Perrow's initial analysis. In an April 1986 *Discover* interview with Kevin McKean entitled "Do Assessment's Risks Outweigh Its Benefits?", Perrow outlines how his NAT works:

'The sources of accidents are infinite,' says Perrow. 'A lot of designers have to work together to build these systems, and they don't even know what the others are doing. So naturally there are all kinds of failures they didn't think of.' As examples of technology coming a cropper, he cites the Three Mile Island nuclear accident, the Bhopal toxic chemical leak, and the explosion of *Challenger*.

In Perrow's view, these accidents have several characteristic features:

- They usually begin with small events. 'I'm willing to bet that when the shuttle accident is completely understood, its cause will turn out to have been something completely trivial.'

- They are frequently driven by what Perrow calls 'production pressures' -- in NASA's case, the need to get on with further shuttle missions, especially since many of them were military missions considered crucial to defense.

- A disproportionate share of them is unfairly blamed on human error: 'If the operator is confronted with unexpected and mysterious interactions among failures, saying that he should have zigged instead of zagged is possible only after the fact. During the accident, no one could know what was going on or what should be done.'

- Finally, even patient investigation of accidents does little to prevent others from occurring: 'There are so many unexpected interactions--literally millions--that every accident is unique. They'll find out what caused this one. But it's really irrelevant, because ten feet is another accident waiting to happen.'

The shuttle explosion, Perrow adds, only proves that 'money and talent won't stop accidents. I draw a comparison with the toxic chemical leak at Bhopal. That was supposed to have happened because of things those "dumb" Indians did. But a few months later, a very similar leak took place at a prosperous West Virginia chemical plant run by a bunch of "smart" Americans. And it happened again even after inspectors had gone through the plant to make sure that Bhopal couldn't happen again.'

The feature linking these mishaps, Perrow says, is that each resulted from some complex and unanticipated interaction--either among parts of the system, between the system and its environment, or between the system and its human masters....*Perrow concludes that 'normal' accidents simply make some technological enterprises too dangerous. 'I don't care about the space shuttle, because there's little potential for an accident that would be catastrophic to the public," he says. 'But I do care about nuclear plants, nuclear weapons, and Star Wars, where the catastrophic potential is enormous.'* Perrow argues that these endeavors should be scrapped, while other risky enterprises--chemical manufacturing and genetic engineering among them--should be more carefully regulated (McKean 1986, 54 - 5, italics added for emphasis).

Upon further review, Perrow posited that his initial summation of the events leading to the *Challenger* explosion qualified as normal accident theory, though the event was not as significant as other incidents involving NAT, such as the 1979 Three Mile Island incident.

Perrow (1994) has retreated from his earlier analysis, i.e., that the *Challenger* space shuttle disaster was a normal accident, or could be explained by NAT.[68] From the *Journal of Contingencies and Crisis Management*, Charles Perrow explains in his article "The Limits of Safety: The Enhancement of a Theory of Accidents" (1994) about the application of normal accident theory to the decision to launch the *Challenger*:

> NAT predicts 'systems accidents' rather than the more ubiquitous commonplace failures of operators, equipment, procedures, environment and so on (called 'component failure accidents', where there is no significant unexpected interaction of failures). It focuses on something quite different than the elements of HRT [high reliability theory] (safety goals, redundancies and learning which all organizations attempt). It argues that major accidents are inevitable in some systems. Since nothing is perfect, if the organization is 'complexly interactive' rather than linear, and 'tightly coupled' rather than loosely coupled, small errors can interact in unexpected ways and the tight coupling will mean a cascade of increasingly large failures (216).
>
> And,
>
> We may have been lucky that the space shuttle *Challenger* blew up; the next shuttle flight, with the same multiple and high risks of the *Challenger*, was to take up 47 pounds of highly toxic plutonium which could have drifted as a powder over the Florida coast after an explosion. Incidentally, I do not find that Bhopal, the *Challenger* [and other incidents]...are normal accidents, though NAT helps us understand them and the aftermaths. They are alarmingly banal examples of organizational elites not trying very hard at all and are what I call 'component failure accidents' ...(Perrow 1994, 217 - 8).

Perrow posited that NAT did not apply to the *Challenger* situation. Perrow, instead, indicates rather that the organizational elites with power over the

[68] Perrow received support for his original notion that the Challenger incident could be explained by NAT. See McCurdy (1989) as he states that "The space programme is exceptional. It operates in the arena of 'tightly coupled' technologies, where small errors easily turn into major system failures....NASA is one of a handful of government agencies whose employees must perform their tasks at very high levels of reliability in order to make their programmes work. Sailors on the decks of large aircraft carriers and civil servants operating air traffic control centres provide other examples of such 'high reliability organizations'. Work in these organizations is simultaneously tedious and exciting; it is also uniformly catastrophic if a serious error is made. Such organizations depart markedly from the tyical standards of trial and error that have traditionally been considered 'good enough for government work' (302 - 3).

decision to launch rendered a bad judgment.[69] Symbolically, too, the organizational elites represent *components* within the organizational system.

A logical extension of Perrow's notion of normal accident theory is provided by Diane Vaughan (1996).[70] Similar to the work of other risk theorists, there is a deterministic strain embodied in Vaughan's work. In particular, Vaughan's theory contain the notions of the "normalization of deviance"[71] and the "inevitability of mistake" (415):

> ....mistakes are systematic and socially organized, built into the nature of professions, organizations, cultures and structures. Collectively, they are chilling in their suggestion that the normalization of deviance creates the potential for mistake in organizations large and small. We are left with a disturbing question: If the *normalization of deviance* neutralizes signals of potential danger in intimate relationships--two decision makers, unencumbered by complex hierarchy, technology, and 'blizzards of paperwork'--how can we expect to control it in larger organizations that deal in risky technology? In *Normal Accidents*, Perrow concludes that accidents are normal, or inevitable, in certain technological systems. He identifies the source of dangerous accidents as the system, not its component parts. *[Note: compare with Perrow 1986 & 1994 above].* When a technical system has parts that interact and also are tightly coupled, it is capable of generating unfamiliar, unexpected sequences that are not visible or not immediately comprehensible. Because tightly coupled technical systems have little slack, or 'give,' they offer few opportunities to recover when something begins to go wrong. The *Challenger* disaster can justifiably be classed as a normal accident: an

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[69] See also Karl E. Weick's "Organizational Culture as a Source of High Reliability" in *California Management Review*, Winter 1987 for a continuation of this theme. Weick states "The point is that accidents occur because the humans who operate and manage complex systems are themselves not sufficiently complex to sense and anticipate the problems generated by those systems" (112). With Weick's analysis, *culture is to be used as part of an objective process* to better the organizational system in a rational fashion: "To make decisions, you need a stable environment. When environments become unstable, then people need first to make meaning in order to what, if anything, there is to decide.....Stabilization and enactment make meaning possible, which means they necessarily precede decision making.....Making meaning is an issue of culture, which is one reason culture is important in high reliability systems" (123).

[70] See footnote # 9 in Chapter 1 above for more background on Vaughan's thesis.

[71] See Leon Festinger's *A Theory of Cognitive Dissonance* (1957). Vaughan's normalization of deviance owes much to the work of Festinger's theory of cognitive dissonance. Festinger's hypotheses are as follows: "(1) The existence of dissonance, being psychologically uncomfortable, will motivate the person to try to reduce the dissonance and achieve consonance; and, (2) When dissonance is present, in addition to trying to reduce it, the person will actively avoid situations and information which would likely increase the dissonance" (1957, 2).

organizational-technical system failure that was the *inevitable* product of the two complex systems. But this case extends Perrow's notion of system to include aspects of both environment and organization that affect the risk assessment process and decision making. Increasing the basic pessimism of the original model of normal accidents, we learn that even when technical experts have time to notice and discuss signals of potential danger in a well-attended meeting prior to putting the technology into action, their interpretation of the signals is subject to errors shaped by a still-wider system that includes history, competition, scarcity, bureaucratic procedures, power, rules and norms, hierarchy, culture, and patterns of information.

An obvious advantage of the workplace over the settings of the other examples is that formal organizations can create rules, structures, and processes to regulate risky decision making (Vaughan 1996, 415, italics added for emphasis).

Vaughan's notions of the "normalization of deviance"[72] and "the inevitability of mistake" as applied to the space shuttle *Challenger* incident characterize the essence of Burrell and Morgan's (1979, 27 - 8; see also figure 4.3 above) contention that elements of other theoretical paradigms (i.e., radical structuralism and interpretive) are used to resolve the functionalist paradigm problematic. At its core, Vaughan's theory attempts to objectify human reality by providing for contingencies not readily explained by traditional structural-functionalism. Imperfections in human activity are "accounted" for by tacit recognition of subjective organizational psychological factors (the normalization

[72] In an interview with *New York Newsday* reporter Earl Lane on January 26, 1996, Vaughan said that there was no obvious wrongdoing on behalf of the NASA managers involved in the decision to launch the Challenger: "'Instead of evil managers, competent technical people made a disastrous decision while abiding by all the rules....Everyone followed the same rules,' Vaughan said. 'But that was a situation for which the normal rules did not apply...you can see how well-intentioned individuals, following all the mandates of their system, can make a mistake.' The organizational behavior, she said, tended to 'normalize deviance.' The shuttle had flown in the past with unexplained O-ring erosion. It had not blown up. Teams had been working on the problem. It seemed okay to fly again. Judson Lovingood, a retired Marshall Space Flight Center manager who took part in the telecon, objects to Vaughan's characterization. 'We didn't normalize the deviant,' he said. 'We were trying to resolve it.' He said that after O-ring problems were noticed in previous flights, engineers had changed a putty in the joint in one attempt to prevent the seal erosion. But he added, 'We decided to keep flying while we were trying to get rid of it [the O-ring erosion],' a choice that buttresses Vaughan's point. On the issue of culpability, Lovingood is clear: 'I think everybody who participated in that meeting the night before the launch shared some responsibility.'"

of deviance) and recognition of the potential for human-made errors (the inevitability of mistake), the eternal "human curse."

A Note on Functionalism: Knowledge and Insights Gained

Functionalism and all of its effects are best described by Stone (1997) as stated above as encompassing the rationality project. There is a tendency for scientific enterprises and highly technical organizations to *cause* members within the affected organizations to act in a similarly rational manner. Stone points out that there is an all-pervasive orientation towards behaving rationally in the American scientifically dominated culture, an orientation which she aptly describes as constitutional engineering.[73] Social aspects of human behavior in organizations are to be ignored, or at least subsumed, under the metaphor of mechanism. Human beings become "objects" or interchangeable mechanical parts. Problems become "problems" only when the machine breaks down. Early theorists such as Max Weber, a critic of the dehumanizing effects of bureaucracy, and Frederick W. Taylor, an advocate of scientific management, have had an impact on subsequent functionalist theorists.

Members of scientifcally oriented organizations such as NASA make mechanical corrections to alleviate structural problems that occur. In the *Recommendations of the Presidential Commission on the Space Shuttle Challenger Accident* report the ostensible causes of the shuttle's failure were mechanical, both technical and human. The faulty solid rocket motor design was redesigned and, hence, fixed. Prescriptive recommendations were made for a broken machine. New managers were brought into the NASA organization to replace those who had failed (Note that under the terms of

[73] See Adams and Ingersoll (1990; footnote #5 above) and their similar conception of technical rationality.

scientific or classical management, those management components were simultaneously repaired). The organization's procedures (i.e., rules, regulations and checklists) were improved and a new safety bureaucracy was proposed to alleviate any potential safety risk to subsequent shuttle launches.

Academic analyses with a functionalist worldview outside of the NASA organization and the Presidential Commission have focused on mechanical things to improve function of the organization. Heimann (1993) advocates using the metaphor of the circuit board in electronics logic in order to create a parallel system with built-in redundancy, which is inherently superior (safe) in design and more expensive than a serial circuit.

The organizations as organisms image is represented in this case study largely through the "institutionalist" work of Romzek and Dubnick (1987). NASA as an organism exists within a hostile environmenment in which internal and external pressures are put on the institution. These pressures consist of internal technical and mechanical problems, managerial problems between various components within the organization, and with customer relations and outside suppliers. In sum, the problems of the NASA organization are within the societal and political milieu (technical and bureaucratic conflicts between institutions). The primary cause for the organization's dysfunction was that there was a communication breakdown in the organization's scalar chain (See also Starbuck and Milliken 1988a and Miller 1993). The implication here is that if all the NASA organization functionaries were doing their jobs properly, the pyramid would not have experienced a 'malfunction.' Starbuck and Milliken (1988a) also stress that repeated success led to a malaise and an incremental descent to bad decision-making. Another element of Starbuck and Milliken's analysis includes the notion of hubris; successful launches led to more (misplaced) confidence with the shuttle system even though there were known design flaws. In a final aspect of their analysis, Starbuck and Milliken (1988b) submit that the members of the Presidential Commission (as retrospective perceivers) were looking for scapegoats to an otherwise properly functioning organization.

Risk theorists attempt to gain access outside of the functionalist paradigm by engaging in a discussion of culture, with all its implications. Risk theorists begin by qualifying organizations as human constructs subject to human fallibility. However, once this concession is made, risk theorists make an effort to establish nomothetic generalizations to explain all complex organizations. Accidents become inevitable; it is only a matter of when they will occur. Systems are so complex and interactive that when a component fails, it may not be readily apparent to managers and employees, thus leading to further events causing a potential catastrophe.

Charles Perrow (McKean 1986) put forward the notion that the *Challenger* decision to launch was a normal accident. A few years later, however, the decision was in retrospect a failure of organizational elites and not a normal accident. Diane Vaughan (1996) argues that the January 28, 1986 *Challenger* launch decision was a normal accident. The *Challenger* accident was inevitable, even with organizational elite discussions as to whether the space shuttle should be launched, given the historical circumstances. Vaughan (1996) submits that there was a normalization of deviance and that no one was essentially at fault for the decision to launch, noting that everyone involved in the decision-making process had followed the rules.

Functionalism and Hypotheses Explanation: How Useful Is the Paradigm?

The hypotheses stated in Chapter One are reiterated here in order to examine them in light of the explanations offered by functionalist theorists addressing aspects of the *Challenger* launch decision:

1. Managers ignored information from employees who knew what was going on.

2. Managers who ignore the useful knowledge of the workers will sometimes blame the workers when managements' plans go awry. Also, organizations will go to great lengths to protect the managers and the organization until compelled to do otherwise.

3. Managers hold the simplistic notion that they can control every aspect of their organization, and even those of other organizations.

There is evidence from functionalist theorists that the managers in the decision process ignored information from the workers who know what was going on (hypothesis one). There is, however, a bewildering array of explanations offered, but there are two broad categories that functionalist theorists use for explaining the event. Firstly, theorists explained the phenomenon as a series of bad judgments and a breakdown in the scalar chain, thus indicating that the organization was dysfunctional by classical or traditional bureaucratic standards. The organization (machine) had failed. In order to repair the broken NASA organization, components, i.e., technical parts and defective managers, had to be replaced. In addition to some academicians, this method was favored and used by the NASA managers after the launch decision and was reinforced by the Presidential Commission. Secondly, some structural-functionalist and risk theorists advanced the notion that a proper decision was rendered by managers using the best available information to them. Functionaries lower in the scalar chain had had their ideas considered. The organization worked properly. Also, the workers could not offer enough technical (quantifiable) data in order to convince the managers not to launch. No individuals were at fault and all of the rules had been followed.[74] Accidents occur normally in complex organizations. The NASA organization is a human construction and subject to human fallibility.

As far the second and third hypotheses of this dissertation are concerned, functionalist theories have an incapacity to adequately address the issues raised. Individuals within the chain of command in the organization exist to provide information to the managers in higher positions. The utility of their arguments is placed within an organizational decision-making context. Workers become objects to be employed within the organization based on their usefulness. As noted above, mechanical solutions were found to a perceived breakdown in the machinery. Engineers who raised concerns about the launch due to the inclimate weather and their knowledge about the inelasticity of the O-rings were given a hearing and could not provide adequate, quantifiable data to the launch decision-makers. Hard, technical and scientific data were needed by the managers, not sloppy intuitive judgments rendered by the engineers who had designed and maintained the solid rocket boosters. Ultimately, under theorists of the functionalist paradigm, in particular the risk theorists, *no one is at fault for the* Challenger *launch decision because everyone involved in the decision process had followed the rules.*

[74] Miller (1993) offers the point that if anyone were at fault, it would be the engineers who could not effectively make their case not to launch. Thus, the engineers failed in performing their proper organizational function.

The Radical-Structuralist Paradigm: The NASA Organization as an Instrument of Domination[75]

The radical-structuralist paradigm represents theories in which organizations are instruments of domination and exploitation. The focus in this section, as well as the other analyses from the various images, will rest primarily on whether the decision makers rendered an appropriate judgment at the time of the *Challenger* launch.[76] The image exposes the unintended consequences of rational actions in organizations, revealing its double-edged nature (Morgan 1997, 340). Thus, according to Morgan:

> ...the domination metaphor also shows a way of creating an organization theory *for* the exploited. In exposing the seamy side of organizational life, whether in terms of structured inequality, institutionalized racism, occupational accidents and disease, or exploitation in the Third World, and in attempting to develop theories to account for these phenomena, the organization theorist has a means of using organization theory as an instrument for social change. Those interested in pursuing this agenda thus make much of the possibility of developing a radical organization theory to counter the influence of more conventional theory, which they see as serving and reinforcing vested interests in the status quo (1997, 341).[77]

Radical-structuralist theorists are keen on developing explanations about organizational behavior in which members are exploited for their human skills and abilities without just compensation or are in danger of life and limb. The structure of the organization, i.e., the traditional management-subordinate,

[75] See Morgan (1997, 422) as the radical-structuralist paradigm is equated with the instruments of domination metaphor.

[76] Of course it could be argued that having human beings in space flight is inherently dangerous, unnecessary, dominating and exploitative. See J. A. Van Allen (1986) above and Marvin Minsky (MIT Professor and recognized as a leading expert in the fields of robotics and artificial intelligence) in his article "NASA Held Hostage: Human Safety Imposes Outlandish Constraints on the U.S. Space Program" in *Ad Astra* June 1990, pp. 34 - 7. Scientists, obviously with a stake in the allocation of limited NASA funding, have an interest in whether human space launches should even continue. Minsky notes that "Our astronauts now play the roles, not of leaders, but of 'hostages,' because we will do virtually anything to protect their safety....Our culture has imposed a no-win scenario on NASA: human flight is too risky and expensive; automated missions are too inflexible and unsensational" (34 - 5).

[77] See Morgan (1997), especially Chapter 9, for more insights and information on this metaphor. This metaphor owes much to the work of Robert Michels, Max Weber and Karl Marx.

authoritarian-hierarchical relationship, becomes the problem.

Prior to radical-structural theories concerning the *Challenger* launch decision, members within the NASA organization were coming forward with information about how managers knew of the ill effects of the O-rings. Managers refused to do anything consequential about the problem.[78] In particular, Richard Cook, the budget analyst in the comptroller's office of NASA when the Challenger exploded, wrote memoranda stating the concerns of engineers about the potential catastrophic consequences of the solid rocket booster O-rings in July 1985 and after the decision launch on February 3, 1986. Cook testified at the Presidential Commission hearings on February 11, 1986 about the memos and concerns that were expressed:

> CHAIRMAN ROGERS:...I would like just to ask one question about the [February 3, 1986, second] memo. You say at one point when you are referring to the engineers, I believe you say--well, let me read the whole thing, 'It is also my opinion that the Marshall Space Flight Center has not been adequately responsive to headquarters concerns about flight safety, that the Office of Space Flight has not given enough time and attention to the assessment of problems with SRB safety raised by senior engineers in the Propulsion Division.'
>
> Now, this is the part I want to ask about. 'And that these engineers have been improperly excluded from investigation of the Challenger disaster.' In light of the work of this Commission and the investigations that are being conducted now at Kennedy, are you still of that view?
>
> MR. COOK: Well, let me just comment very briefly on that paragraph. I editorialized a bit at the beginning and the end of this, and I did so on the basis of my general point of view in retrospect on some of these issues, and since I wasn't prepared to comment on this memo at all today I'm not going to try to go into a lot of detail about the first two items.
>
> CHAIRMAN ROGERS: Well, it is really not necessary. I think the thing that concerns me most is whether you have confidence that the investigations are being properly conducted.
>
> MR. COOK: Well, if I had access to my files and time to write, I would try

[78] See , for example, Appendix A for written memoranda from the Morton-Thiokol engineers Boisjoly and Thompson.

to be more specific. That is all. But let me say this. The last item, frankly I was amazed that when this incident occurred the engineers in Washington were over there in their offices getting the data on the investigations from the newspaper and the media, and now and then phone calls from guys down at Kennedy about what was being found.

These were the top propulsion engineers who prepared reports for the Office of Space Flight and for the Administrator and for us. I just couldn't understand why that group wasn't down there going through the data and looking at the photos and everything else. Frankly, and I will be honest with you--and I'm not intending to explain why that was or criticize anybody--I was just, in a way I was glad because I could go over and talk to them and get my information from them.

But I just couldn't understand why the headquarters propulsion office didn't have their guys down taking part in that. I have no question whatsoever about the investigation or the Commission's work. I don't feel I'm really competent to make much of a comment on that, although I must say I am glad that you all are having public sessions and that it is a presidential level group. I think that is absolutely in order and really needed.

The only thing that I would urge would be that as much as you can to get just the ordinary working guys, such as me and the engineers and the guys from the Marshall S&E Lab, and if you can get them in from Thiokol, just the ordinary engineers who break these things down, who look at them, who call each other on the phone and say hey, look what I found here. You've got to take a look at this. And that is what I hope will be included.

And I think that if everybody who has firsthand knowledge and experience and feels they can come up and talk freely, I think that you will have a good investigation (*Report IV*, 388 - 9).

Cook's skepticism as to whether the Rogers Commission would get to the bottom of the investigation and as to who was ultimately responsible for the launch decision was borne out. Subsequent to his testimony in *The Washington Monthly* November 1986 edition, Cook lamented the entire commission process as part of an extraordinary cover up in order to protect senior NASA administrators:

The commission's final report absolves high NASA officials of any direct responsibility for the accident. Yet it ignores substantial evidence--some of it presented to the commission privately and some of it at public hearings--that those officials were fully aware of the long history of problems that led to the explosion. The commission left unchallenged statements by NASA officials that were contradictory and often obfuscatory. Indeed, at times the commission seemed to be coaching NASA witnesses on how to deal with tough public questions. On the key question of why the final decision to launch was made, the commission ignored so many suspicious coincidences and left so many questions unanswered that further investigations will undoubtedly be needed (Cook 1986, 13).

Richard Cook also added that

> The Rogers Commission, then, failed on three major counts. First, it didn't hold NASA's top officials responsible for not acting to guarantee flight safety when they knew about the long history of O-ring problems. Second, it never determined who was really responsible for the decision to override Morton Thiokol's objections to the launch. Third, and most important, it failed to answer the question--in many ways it failed to even ask the question--of why NASA officials behaved so differently regarding that launch.[79] What possible pressures were acting upon them to cause them to send up a space shuttle that they knew could explode? Unfortunately, the Rogers Commission has not done its job (Cook 1986, 21).

According to Cook, ignoring the testimony of potential witnesses with relevant information, particularly members at the lower end of the organization, gives the appearance of protecting those decision-makers in the upper management levels.[80]

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[79] See Casamayou (1993) for further elaboration as to whether anyone in the Reagan administration was a participant in sending the order, or at least applying pressure, to launch the shuttle. The gist of her argument, which involves the political systems metaphor, is that "external forces pressured officials into sacrificing safety concerns for those of production....Agency officials appeared to exhibit perceptual problems with the incoming information and, in the case of NASA, they were also experiencing very strong pressures from the external environment to keep the shuttle flying" (173).

[80] See Jim Heaphy's "Challenger's Trail of Blame" in *In These Times*, June 25 - July 8,1986, for an even blunter assessment of the *Challenger* disaster. Heaphy 's radical critique of the NASA organization and the leadership provided by the Reagan administration (which is held ultimately responsible for the catastrophe) alleges that the Rogers Commission was a co-conspirator in the cover-up. Heaphy does cite John Pike, associate director for space policy with the Federation of American Scientists in Washington, as saying "The report does a real good job of answering the questions it asks....But I think there are other questions. It gives a very good portrayal of how the launch pressure was operationalizing itself internal to NASA. What is largely, almost totally lacking from the report is where that launch pressure came from. I point the finger at the administration. They were clearly declaring the thing operational before it was operational, and that's something that has taken place entirely under the Reagan administration."

The Presidential Commission hearings did provide insights from lower NASA organizational participants and from participants in the launch decision from other organizations. The Morton Thiokol engineers were key players in the launch decision process and they were subsequently overruled by their own management who had received extensive pressure from NASA management. The Morton Thiokol engineers did have some support from at least one lower-level NASA engineer based on the Commission testimony of March 27, 1986:

> CHAIRMAN ROGERS: And there was testimony yesterday that he [George Hardy, Deputy Director, Science and Engineering, Marshall Space Flight Center], at one point said he was appalled [about the Morton-Thiokol engineering decision not to launch], and Thiokol people thought he was appalled at the decision. Mr. Hardy said he was appalled at the data that was presented
>
> Were you appalled by the data or the decision?
>
> MR. POWERS [engineer, Structures and Propulsion Laboratory, Marshall Space Flight Center]: Sir, I fully supported the Thiokol engineering position and was in agreement with it.
>
> CHAIRMAN ROGERS: And you made that known to Mr. Hardy?
>
> MR. POWERS: No sir. I report to Mr. John McCarty, and we were caucusing, and I also reported it to Mr. Jim Smith, which is our chief engineer, and this would be a typical thing that we would do. I would report to my boss and to my associate project management in Engineering. I don't want to confuse this.
>
> CHAIRMAN ROGERS: Did you report, too, that you agreed with the Thiokol engineers?
>
> MR. POWERS: Yes, sir. . . .
>
> CHAIRMAN ROGERS: Who did you report that to?
>
> MR. POWERS: Mr. John McCarty. He is my--well, he is not my immediate supervisor. He is my deputy lab director, but he was the senior man in line at that time, and I reported to him that I thought that the temperature would reduce the margin of safety for the joint performance.
>
> CHAIRMAN ROGERS: And were there others in that telecon that agreed

with you, that you know of?

MR. POWERS: I can't identify anyone joining me in that position, sir, I cannot make that statement.

CHAIRMAN ROGERS: And have you talked to them since, any of the people that were in that telecon, to find out how they stood on the issue?

MR. POWERS: Yes, sir, I have.

CHAIRMAN ROGERS: And what did you find out?

MR. POWERS: Some of the engineering people have mentioned that they, too, were concerned, primarily with the temperature effect on the O-ring resilience, the spring-back ability of the O-ring.

CHAIRMAN ROGERS: Was there anybody who agreed with Mr. Hardy or Mr. Mulloy, as far as you remember, on that telecon?

MR. POWERS: There was no dissent with Mr. Hardy, to my knowledge, other than the discussion that I had. I was the only dissenting engineer.

CHAIRMAN ROGERS: But the others remained quiet, I assume?

MR. POWERS: Yes, sir (*Report V*, 1064 -5).

Testimony earlier in the Commission hearing by Morton-Thiokol engineers brought out Powers' testimony in the latter days of the hearings. In particular, Roger Boisjoly, an engineer with the Structures Section of Morton-Thiokol, gave testimony about the launch deliberation process on February 14, 1986:

MR. BOISJOLY:...I first heard of the cold temperatures prior to launch at 1:00 o'clock on the day before launch, and from past experience, namely the SRM-15 launch, of which I was on the inspection team at the Cape, it just concerned me terribly.

And so we started in motion to question the feasibility of launching at such a low temperature, especially when it was going to be predicted to be colder than the SRM-15 [previous cold weather shuttle launch].

So we spent the rest of the day raising these questions.

...I felt we were very successful up until early evening, because it culminated in the recommendation not to fly, and that was the initial conclusion. I was quite please with that.

I presented and prepared charts 2-1, 2-2, 2-3, 4-1, and 5-1, and basically those were the charts where I had that exaggerated view showing the O-ring in joint rotation.

There was the summary that put a probabilistic sequence on the timing of the seals, and then I prepared the chart of primary concerns.

I was basically concerned with how temperature, low temperature, affects the timing function and the ability of the seal to seal. Low temperature--and I stated this for over a year--is away from the direction of goodness. *I cannot quantify it, but I know that it is away from the direction of goodness.*

I feel very strong, and I always have felt very strongly, that SRM-15 was telling us a message, and at the flight readiness review, we did not have any data to support anything but a generalized statement that said we feel that temperature was a contributor....

...On the net that night, after I presented those feelings very strong--I get very emotional about these things--and I was quite strong over the net about it, as George Hardy remembers.

Somebody brought up about SRM-22 [Another shuttle launch which had significant erosion and blow-by past the O-ring in warmer weather, 75 degrees]. I was not personally at the Cape, and disassembled, seeing the hardware in 22. But one of my colleagues was, a younger engineer. And I questioned him about this.

He told me that the gas blow-by that was observed on that gray, splotchy-type blow-by, over a specific arc length, which I don't remember at the moment. I made that point that on SRM-15 we had over 100 degrees of arc, and the blow-by was absolutely jet black. It was totally intermixed in a homogeneous mixture in the grease. I attributed that to the pumping action of the joint as we were towing it back into the Cape. That is why it was totally homogeneous.

But we analyzed that chemically and found the products of combustion in it, we found the products of putty in it, we found the products of O-ring in it.

I made that point.

During the course of the evening, I also produced photos of the SRM-15, and my colleague produced photos of SRM-22. And you could visually see the difference in the amount of soot, as characterized past the O-ring seal.

I was asked then on the net to support my position with data, and I couldn't support my position with data. I had been trying to get data since October on O-ring resiliency, and I did not have it in my hand. We have had tremendous problems in trying to get a function generator and a machine to actually operate and characterize this particular pressurization function rate.

At that point, the telecon basically continued, and Mr. Lund presented his conclusions and recommendations.

So the formal part of the presentation was finished.

Listeners on the other line seemed not very pleased with the recommendation. In fact, somebody asked Mr. Hardy what he thought about it, about our recommendation, and Mr. Hardy said he was appalled at MTI's decision. However, he would not go against that. He would recommend not to fly also.

There was a very short discussion that ensued, and we had, we asked for a five minute caucus. Our people asked for a five minute caucus to discuss the situation. Those opposed to launching continued to press their case with MTI management, and those opposed to the launch that pressed this case in the caucus were basically myself and Mr. Thompson. And we did everything we could to continue to try and press for not launching describing--I took the photographic position of the evidence and Mr. Thompson was trying to further elaborate on the sealing characteristics of the seals. When we realized that we basically had stopped in the discussion and we could go no further because we were getting nowhere, we backed off, both of us. We just sat back down.

GENERAL KUTYNA: What was the motivation driving those who were trying to overturn your opposition?

MR. BOISJOLY: They felt that we had not demonstrated, or I had not demonstrated, because I was the prime mover in SRM-15, because of my personal observations and involvement in the flight readiness reviews, they felt that I had not conclusively demonstrated that there was a tie-in between temperature and blow-by.

My main concern was if the timing function changed and that seal took longer to get there, then you might not have any seal left because it might be eroded before it seats. And then, if that timing function is such that it pushes you from the 170 milliseconds region into the 330 second region, you might not have a secondary seal to pick up if the primary is gone. That was my major concern.

I can't quantify it. I just don't know how to quantify that. But I felt that the observations made were telling us that there was a message there telling us that temperature was a discriminator, and I couldn't get that point across.

I basically had no direct input into the final recommendation to launch and I was not polled.

I think Astronaut Crippen hit the tone of the meeting exactly right on the head when he said that, the opposite was true of the way the meetings were normally conducted. *We normally have to absolutely prove beyond a shadow of a doubt that we have the ability to fly, and it seemed like we were trying to prove, have proved that we had data to prove that we couldn't fly at this time, instead of the reverse.*

That was the tone of the meeting in my opinion (*Report IV*, 674 - 6, Italics added for emphasis).

The testimonies provided by an engineer and budget analyst of NASA and the testimony provided by an engineer from the Morton-Thiokol organization are examples of employees having knowledge about the work that they are involved in being suppressed by higher members of their respective organizations. From the instruments of domination metaphor (or radical-structuralist paradigm), the scenarios above indicate domination by elites within the respective organizations over their subordinates. The result was disastrous in the *Challenger* launch decision.

Gouran, Hirokawa, and Martz (1986) in their article "A Critical Analysis of Factors Related to Decisional Processes Involved in the Challenger Disaster"[81] in *Central States Speech Journal,* note that a rigid adherence to observation of role boundaries played an important part the failure of the shuttle launch decision. Gouran, Hirokawa, and Martz, commenting on the lack of persuasiveness by the engineers involved in the launch decision and the rigidity of upper management , note that

> It may have been that they simply reached the point where further argument seemed pointless. A more compelling and generally applicable explanation lies in the rigidity with which roles in a hierarchically arranged decision structure are often enacted....A[n]...explicit illustration of the unwillingness to violate role boundaries surfaced in the testimony of William Lucas, Director of the Marshall Space Flight Center. Although Lucas was not involved in the teleconference, Lawrence Mulloy and Stanley Reinartz, Shuttle Projects Office Manager, apprised him before the teleconference and the following morning that concern had been expressed about weather conditions, but not specifically about the possible effect of temperature on the functioning of the O-rings. When asked why he did not report the concern to Level II, however generally it had been conveyed to him, Lucas's response was, 'That is not the reporting channel' [*Report V*: 1039] (Gouran, et al. 1986, 124).

In addition to the barriers to effective communication through role boundaries

[81] There are also many functionalist elements to Gouran, Hirokawa and Martz's analysis.

thesis [or the failure of the organizational pyramid], Gouran, Hirokawa and Martz note other influences on poor decision-making: (1) the perceived pressure to produce a desired recommendation and concurrence with the recommendation among some of those initially opposed to the launch; (2) the questionable patterns of reasoning by key managers, (3) the ambiguous and misleading use of language that minimized the perception of risk; and (4) the frequent failure to ask important questions relevant to the final decision (1986, 121).[62]

The strongest indictment of the *Challenger* launch decision from a radical-structuralist perspective comes from Ronald C. Kramer's "The Space Shuttle *Challenger* Explosion: A Case Study of State-Corporate Crime" (1992). Kramer posits that the incident involved government entities (the state) and private industry (Morton-Thiokol, Inc.) were working in conjunction with the state and that organizational misconduct occurred (214 - 5). Kramer states that the *Challenger* explosion was a prime example of what he calls an "integrated theory of organizational misconduct":

- ...the explosion of the shuttle was not an 'accident.'

- ...the Challenger explosion was the collective product of the interaction between a government agency (NASA) and a private business corporation (MTI) and thus can be viewed as an instance of state-corporate crime. This disaster cannot be attributed solely to the actions of one organization....It is hoped that the concept of state-corporate crime will direct further attention to the structural relations between corporate and governmental organizations and to the importance of interorganizational relationships and organizational sets in the study of organizational misconduct.

- The *Challenger* case study provides general support for the hypothesis that criminal or deviant behavior at the organizational level results from a coincidence of pressure for goal attainment, availability and perceived

[62] One of the keys here is that Gouran, et al, point to *management* failure. They note in the conclusion of their article that "Our analysis has revealed that no matter how carefully crafted a decision structure may appear in terms of the sequence of analysis and choice to which it commits decision-makers, its effective utilization is still reliant on the social, psychological, and communicative environment in which responsible parties function" (1986, 133).

attractiveness of illegitimate means, and an absence of effective social control [external political pressure, unreasonable launch rate schedule, and unsafe launch commit criteria].

Thus, all three catalysts for action that are indicated by the integrated theoretical model were present in this case...(Kramer 1992, 238 - 9).

Radical-structuralist theorists G. Richard Holt and Anthony W. Morris (1993), wrote in *Human Organization* and described what they call "activity theory" based on the work of Evald Ilyenkov's Soviet Communitarianism.[83] The activity theory advanced by Holt and Morris reexamined the basic philosophical assumptions of traditional scientific [or functionalist] theories, and they based the theory on the Soviet sociohistorical school.[84] Activity theory has been further developed by Yrjo Engestrom (1988) who examined organization process and "posit[ed] that the unit of analysis in accounting for emerging institutions is neither that which occurs in the individual mind (the cognitivist position), nor the structure of the organization (the functionalist position), but the activity through which both are continuously generated" (Holt and Morris 1993, 97).[85] Holt and Morris also criticize interpretations of Descartes' dualism as "frequently characterized as an incommensurability between mind and body" and for being an "anthropocentric reading of dualism" (97). And,

David Bakhurst [1988:31] explains 'that the cultural-historical school, from within a different world view, conceptualizes as *a priori* the interaction of minds and world....[there are four theoretical insights:] First, the higher mental functions of the human individual "exist in, and are mediated by,

[83] See Yrjo Engestrom's (April 1988) article "How to do research on activity?" in *The Quarterly Newsletter of the Laboratory of Comparative Human Cognition*, 10/2: 30-1, and David Bakhurst's (April 1988) article "Activity, Consciousness and Communication" in *The Quarterly Newsletter of the Laboratory of Comparative Human Cognition*, 10/2: 31-8, for more background on the Soviet sociohistorical school.

[84] See Burrell and Morgan (1979: 7,25, 19, 33-4) for further elaboration of Russian social theory in the radical-structuralist paradigm.

[85] Certain aspects of activity theory share theoretical insights developed independently by Vickers (1995) and his human systems or "appreciation theory." Under Burrell and Morgan's (1979) sociological paradigms, therefore, activity theory could be considered to be influenced by the radical humanist and/or interpretivist paradigms.

language" and person/object interaction. Second, language, comprised of a set of societally shared media that complement activity, presupposes "a set of shared social meaning" historically constructed by the community. Third, cultures are real and comprised of shared social meanings brought into existence by the collective's activity. Finally, the human child/individual progressively becomes a full participant in the generation of a society's institutions via exposure to a community's activity and internalization of its culture. It follows, then, that the higher mental functions are internalized forms of the activity of the community in which an individual acts. Since activity is the antecedent of culture and thus of language, activity should be a unit of investigation in the explanation of emerging minds and institutions' (Holt and Morris 1993, 97-8; Bakhurst 1988, 31).

With Holt and Morris, functionalist theories such as systems theory embody a blurring of human activity. Indeed, the *humanness* in time and space is lost when theorists are engaged in systems analysis. In a comparison with Charles Perrow's *Normal Accidents* (1984)[86] and the Presidential Commission's report, Holt and Morris emphasize the weaknesses of the functionalist approach as observed from a radical-structuralist perspective. I submit that that the same criticism also holds for Vaughan's theoretical analysis from a radical-structuralist perspective:

> Perrow [Vaughan] takes a systems theory approach to the phenomenon of the conflict between ideal means of solving problems in high-risk complex systems and their real-world implementation....By emphasizing coupling of system 'components,' Perrow [Vaughan] is perhaps unconsciously assenting to an inappropriate reification of the activity system as something separate from the people who make it up. After all, a 'system' did not make the decision to launch the Challenger; the people who make up the system are responsible for that particular decision....Excessive abstractions, such as those found in the Perrow [Vaughan] model, are appealing for their neatness and theoretical elegance, but in fact they obscure the real functioning of activity, which is frequently 'messy,' disorganized, seemingly chaotic, and hence endlessly fascinating. Perrow's model represents a decided advance over the simplistic structural repairs prescribed by the Rogers Commission, but it still fails to recognize the complexity of the activity

[86] It needs to be remembered here (Burrell and Morgan 1979) that theories from incompatible paradigms may be used to criticize other theoretical interpretations.

system as a whole (Holt and Morris 1993, 102).

Other differences between activity theory analysis from more traditional analyses of organizational production-consumption paradoxes [functionalism] include:

> 1. Activity theory unrelentingly emphasizes the fluidity of the social system under examination....the human organization is a dynamic entity, fueled by the tensions between the contradictions inherent in its history of production and consumption and continuously evolving toward a number of future states.
>
> 2. Activity theory is consistently oriented toward the evolving future state of the organization....One problem with traditional analyses of such resources--particularly those resources connected with decision making--is that they are nearly always oriented toward a fixed view of some past dysfunction of the resource, a kind of 'let's-fix-what-went-wrong' mentality that only enhances the tendency to try to justify one's own actions in the wake of an organizational disaster.... By focusing, as Marx did, on the mediating instrument as occupying a dynamic, unfixed balance point that coordinates both past and future state of the system and to the mediating instrument's potential role in that future state (102-103).

Holt and Morris apply activity theory in the case study of the *Challenger* in order to explain what had occurred. Furthermore, Holt and Morris prescribe analytical solutions to practitioners and scholars in order to prevent a similar episode from occurring, both in the actual case itself and any future complex organizational endeavors. They blend elements of the radical-humanist paradigm and interpretive paradigm, i.e., the theoretical notion that time and space are crucial to understanding human behavior in context in combination with a dialectical analysis, and with a Marxist class-structure analysis. To wit:

> Our analysis will delineate the flight readiness system [based on the Flight Readiness Review] as one activity system within NASA's shuttle program. To do so, we will employ the following organizational schema: (1) *define the nodes of the activity triangle* that correspond to the shuttle program preparing to launch according to a given timetable; (2) *discuss the production/consumption paradox* inherent in the '24 safe flights per year' mandate; (3) *identify the primary contradictions* arising at each of

the activity triangle's nodes; and (4) *demonstrate the emergence of secondary contradictions* from the primary contradictions. We will conclude with a discussion of how the present shuttle flight readiness system has emerged from the older form of the activity, impelled by the springboard of the explosion itself (Morris and Holt 1993, 104; See also Figure 4.4 below).

The primary question raised previously was how the faulty O-ring seals could be used on the *Challenger* despite previous warnings is answered by Holt and Morris:

(1) *The ideal form* of the FRR [Flight Readiness Review] did, indeed, flag the defective O-rings long before the accident, though NASA chose to change the directions of the agency *from a focus on research and development to a focus on profit* (104)....this idealized version of the Flight Readiness Review (FRR) may be seen as a mediating instrument that supposedly ensures that a large amount of information from the various Shuttle subsystems is evaluated by decision makers in a thorough and timely manner. The FRR is an example of the kind of *institutional rationality* that is so often designed to compensate for the limited decision making of individual human beings...

(2) *The production/consumption paradox*: (i) shuttle program had overspent or consumed too much; (ii) Kruglanski (1986), writing about the Challenger disaster, cites this form of rationality as an example of the power of sociohistorical antecedents to constrain symbolic action in the present, noting that the pressures to prove the value of one's program in a highly competitive funding environment often leads to *'freezing,'* a psychological commitment to a decision even in the face of evidence that the decision is wrong....The response of the NASA officials to the paradox of the conflict between NASA-as-consumer of Federal funds and NASA-as-producer of a money-making enterprise is one that is often resorted to by persons in similar situations: they reverted to a decision already settled upon, mistakenly believing that organizational procedure would make up for individual indecision.. In activity theory terms, they ignore the fluidity of the activity system in favor of a static picture of how they perceive the system to have performed successfully in the past; thus, it is

the ongoing nature of activity evolution that is 'frozen.' [87]

(3) *The contradiction between the increased number of flights (24) versus the contradiction of flight safety otherwise known as a 'double-bind'.*[88] Three secondary contradictions accrue from this (a) between the community and the decision makers; (b) between the decision makers and the instrument [hard-reading vs. convenient reading of FRR]; and (c) between the rules and the object [safe shuttle vs. timely and cost-effective shuttle].

(4) *Other secondary contradictions*:...if one chooses to look at the accident in a certain way, the explosion of the Challenger is tantamount to a *springboard* which, though a tragedy, has nevertheless served as an impetus for positive change in the flight readiness activity system. Before the explosion (that is, under the former, cost-conscious, system) the choice of competing forces on each primary node was dictated by a 'bottom-line' mentality; 'cost-conscious,' not 'safety-conscious' decision makers (subject node); 'cost-efficient,' not 'safe' shuttle (object node); and so on. Following the explosion, a new set of priorities emerged in line with the expanding system....it is highly unlikely that any mission planner will forget the Challenger explosion, and thus, even when increased utilization of the shuttles is contemplated, it will always be with an awareness of the potential for disaster (Holt and Morris 1993,105 - 6).

[87] See Arie Kruglanski "Freeze-think and the Challenger" in *Psychology Today*, August 1986, pp. 48-9. Kruglanski concludes his article in much the same way as Vaughan (1996) arrives at her interpretation of how the NASA organization behaved during the launch decision: "When disaster strikes, it is only human to look for someone to blame, but in the Challenger tragedy the real culprit might have been the decision-making system rather than any individual decision-makers" (49). Kruglanski does offer a prescription to prevent future occurrences within the organization (as opposed to Vaughan who does not): "Decision-makers should...be taught the effects of psychological freezing. Research on the aspects of decision-making show that increasing people's awareness of the process that leads to biased judgments increases their ability to resist those biases. This psychological consciousness-raising could be done in two ways: through workshops for decision-makers at which the mechanisms that lead to freezing biases are explained and illustrated and during times of decision by reminding decision-makers periodically to consider whether they had frozen prematurely and asking them to reassess the available options" (49).

[88] See Gregory Bateson (1972) *Steps to an Ecology of Mind.* NY: Ballantine Books.

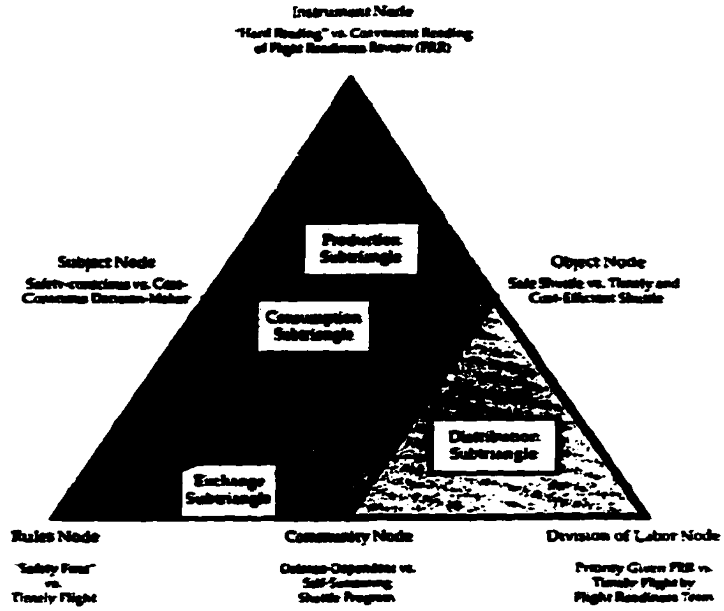

FIGURE 5. SECONDARY CONTRADICTIONS IN ACTIVITY TRIANGLE REPRESENTING NASA'S FLIGHT READINESS SYSTEM

Figure 4.4 NASA's FRR Nodes of Contradiction (Source: Secondary Contradictions in Activity Triangle Representing NASA's Flight Readiness System, Holt and Morris 1993, 106).

Holt and Morris show the benefits of using activity theory in order to analyze the *Challenger* space shuttle launch and to prevent social conditions from occurring which may lead to a similar disaster in the future. Paramount in importance is the consideration of the paradoxical relationship between members in the organization and the organization itself. According to Holt and Morris, activity theory also demonstrates the complexity of human relationships:

> (1)...the activity model...locates the tension between the individual organizational actor's perceptions, and their awareness of what is going on in the activity system as a whole. Had Mulloy and the people at Thiokol been made aware, over extended periods of time, of the internal contradictions embodied in the activity triangle on the night of January 27, 1986, it is less likely that they would have clung so stubbornly to their individual viewpoints that a launch on the following morning would have occurred.

(2) [The] analysis brings into serious question the assumption of the Rogers Commission...that the contradictions are obstacles to effective organizational functioning, aspects of the system that must be 'fixed.'...contradictions are not only inevitable in any dynamic system, but are signs that the system is growing, expanding, and evolving [contradiction is a sign of function and not dysfunction].

(3) Application of activity theory to such a complex problem virtually forces the analyst to account for *inter*relationships among a plethora of contributing factors (Holt and Morris 1993, 107 - 8).

Thus, Holt and Morris engage the organizational theorist to consider the human complexities involved in the mix of recreating organizational reality. Organizations like NASA are not established on a fixed, or static, point in a limited time and space continuum.[89] Rather, organizations are constantly evolving and as such are subject to internal contradictions. Members within organizations need to become aware of these ever-changing internal contradictions in order to prevent catastrophes from occurring again.

A key aspect to activity theory is Marx's economic determinism, which ultimately underpins Holt and Morris's notion of the production/consumption paradox. Holt and Morris are persuasive in their demonstration of how the NASA system moved from first, a safety conscious organizational system to second, a cost conscious system and finally, to one in which safety concerns became of the utmost importance following the explosion the *Challenger* space shuttle system. The NASA agency had moved historically from a more safety conscious and experimental research and development focus to a focus on making a profit. The number of missions had been increased significantly and prematurely in order to realize a material gain. These internal contradictions

[89] See Bensman and Lilienfeld (1991, 25) for a more thorough analysis, or Table 2.2 in this dissertation. Holt and Morris's conception of the FRR process would be placed in the "Ritualistic and Ceremonial Action" quadrant of Bensman and Lilienfeld's typology. Rituals and ceremonies are followed in organizations without any effective criticism (alternative choices or decisions are not considered).

ultimately led to a series of bad judgments having been rendered by decision-makers in the organization.

Holt and Morris also identify the Flight Readiness Review (FRR) prelaunch decision making process as an instrument of the ubiquitous *institutional rationality* which attempts to compensate for limited human decision-making capacity. The FRR system leads to domination of human beings by displacing human decision making with a cognitive construction rationally designed with an economic incentive to limit human input. The NASA organization had been corrupted by an institutionalized process which moved away from safety (Holt and Morris' safety node) to consumption or cost efficiency (Holt and Morris' object node). The internal contradictions within the NASA organization proved to be too much for the NASA organization. The result was the shuttle explosion which symbolically is analogous to Marxist circumstances leading to a proletarian revolution. It took the ill-fated Challenger launch decision to expose the inherent contradictions and systematic domination of the NASA organization.

A Note on Radical-Structuralism: Knowledge and Insights Gained

Radical-structuralism best represents the domination of lower-level organization participants, as defined by Burrell and Morgan (1979) and Morgan (1997). Under radical-structuralism, members within organizations who have experienced oppression based on the structure of the organization *feel* the impact of decisions rendered by managers. Lower organizational participants react to the environment created by executives and managers who regard the members as objects. As recipients of the dehumanizing effects of the established bureaucracy, lower participants in the organization's scalar chain become frustrated and alienated in their efforts to control aspects of their own work-world. We see from the examples offered in this *Challenger* case study how organizational structures can become instruments of domination. In the Presidential Commission hearings we have observed several examples of the seamier side of organizational behavior. The NASA budget analyst Richard Cook was frustrated by the NASA management hierarchy when his memoranda were ignored. Cook's pleas for the Commission to investigate the complaints of engineers within the NASA organization fell upon deaf ears. Cook later further alleged that higher-level NASA officials had not been properly held responsible for the launch decision. Cook maintained that the Rogers Commission had failed to do its job and was, therefore, part of the organization's cover up. The Commission exposed the fact that some within the NASA organization opposed the *Challenger* launch. It was apparent from the testimony of Ben Powers (the Marshall Structures and Propulsion Laboratory engineer) that channels of communication were not open. Members were compelled to maintain their silence and to offer advice or dissent only through proper organizational channels. Roger Boisjoly of Morton Thiokol was cowed by George Hardy of the NASA organization who was appalled by the initial decision of MTI engineering not to go along with the launch, even though there were well-known ill effects of cold weather on the Solid Rocket Booster rubber O-rings. Boisjoly could not *immediately* quantify (or justify) what he knew intuitively, that the frozen O-rings would not properly seal. This inability of the O-rings to seal allowed hot gases to pass through the O-rings and ignite the rocket fuel. All three testimonials of the lower-level participants demonstrate the effect of the NASA organization as a dominating instrument.

Radical-structural theorists who analyze the *Challenger* launch decision place the responsibility for the launch decision on the NASA managers. Gouran, et al. (1986) and Kramer (1992), note that the structure of the organization *caused* the accident, in particular the strong role delineations and rigid hierarchical boundaries. Holt and Morris (1993) believe that the ubiquitous and traditional interpretations of Cartesian dualism (functionalism) prevalent in Western society lead to an artificial separation of the *individual minds* of members in the organization from the *structure* of the organization. The traditional functionalism/systems theory of risk theorists Perrow and Vaughan fails to capture the paradoxical nature of human activity. Organizational structures such as NASA's FRR take human beings out of the deliberative and contemplative process in an attempt to rationalize decision-making. Systems put in place by managers seeking cost reductions make decisions rather than do the workers who are involved in the work. This action does not, however, alleviate internal contradictions from persisting in organizations, especially when there is a conflict between the values of economy and efficiency versus the safety of human beings.

Radical-Structuralism and Hypotheses Explanation: How Useful Is the Paradigm?

The hypotheses stated in Chapter One and earlier in this chapter under the functionalist heading are reiterated here in order to examine them in light of the explanations offered by radical structuralist theorists addressing aspects of the *Challenger* launch decision:

1. Managers ignored information from employees who knew what was going on.

2. Managers who ignore the useful knowledge of the workers will

sometimes blame the workers when managements' plans go awry. Also, organizations will go to great lengths to protect the managers and the organization until compelled to do otherwise.

3. Managers hold the simplistic notion that they can control every aspect of their organization, and even those of other organizations.

Radical-structuralist paradigm theorists are concerned primarily with the nefarious effects of organizations as instruments of domination. There is a human tendency for one to want to blame someone else for ill-considered or unwise action. Radical-structuralist theorists have an inherent bias against traditional management structures, which they see as part and parcel to the economic and political status quo. To them, traditional management represents oppression: slaves have been replaced by paid functionaries in organizations who still do the will of their masters.

The hypotheses statements laid out in this dissertation are well-suited for analysis by theorists of the radical-structuralist paradigm. Of course managers ignore or disregard information coming from subordinates. Organizations are designed by those in power in order to protect managers from the actions of their workers. Employees are merely tools at the disposal of managers. Modern organizations, no less so than more primitive organizations, are structured in order for lower participants to follow orders and directives from higher authorities.

Radical-structuralism also addresses the third hypothesis (stated above) in that the NASA organization obviously controls aspects of the Morton Thiokol company. There is a consensus among most radical-structuralist theorists that NASA managers Hardy and Mulloy clearly intimidated Thiokol management into overturning their initial decision not to launch the *Challenger* on January 28. Indeed, both NASA managers directly threatened Thiokol officials. In this case, the Thiokol organization was subordinate to NASA. Thiokol members, particularly the engineers, were used as objects by NASA managers to legitimize the launch decision.

The radical-structural theorists analyzing the *Challenger* launch decision offer convincing arguments as to *why* the decision was rendered. Holt and Morris (1993) rendered an analysis in which human organizations such as NASA are complex and should not be subject to over-simplified interpretations. The radical-structuralist paradigm is particularly helpful in explaining events in which conventional organizational activity has been turned upside-down. Radical-structural theorists have tools readily available to them to explain problems in organizations when they occur. Marx's concept of internal contradictions and Max Weber's concept of the dehumanizing effects of bureaucracies offer analytical tools for the organizational theorist to come to grips with some of the paradoxical complexities inherent in human organizations.

An objection could be raised here that radical-structural theorists are too accusatory (and hence, ideological) or conspiratorial in their biases against traditional management structures and the managers *themselves* in those organizations. Perhaps organizational structures assume greater prominence and importance than is warranted. Human history is replete with examples of revolutionaries over-throwing the status quo powers and installing similar economic, social and political arrangements which ensure the continued domination of elites over those out of power. Thus, solutions advocated by the revolutionaries are ephemeral and transparent. The potential for abuse *over time* in human organizations persists.

Holt and Morris (1993) managed to place an emphasis on the movement away from a focus on safety to a focus on cost and efficiency in the NASA organization. In particular, the Marxist internal contradiction problematic provides a useful means of examining the *Challenger* launch decision. As Commission testimony amply illustrates, safety considerations were clearly compromised.

Another objection that could be raised is that the radical-structural theorists overstate their case. The NASA organization upper-level managers do not always mistreat their employees by ignoring member's needs and insights. It could be argued that the organization was for most of the time more or less functional rather than dysfunctional. Radical-structural theorists can be as deterministic in their outlook of human nature as their functionalist counterparts. In other words, managers are not always prone to ignoring information and to ignoring the knowledge of the work by members employed under them. Otherwise, the organization would fail to have the cooperation necessary for its continued existence.

Structuralism, Functional and Radical, Reconsidered

Functionalist and radical-structuralist theories are primarily concerned with organizations as structures. Human beings tend to be subsumed into the organizational miasma. Functionalist theories promote the hierarchical arrangement of people, as cogs in a machine, in order to render them as useful objects for effective and efficient utilization for those at the top of the hierarchy.[90] Radical-structuralist theories in the modern organization focus on the dehumanizing effects of the organization as a structure. Various functionalist

[90] See Rosenbloom (1993) for further discussion of his managerial approach which encompasses the logic of economy, efficiency and effectiveness in organizations.

and radical structuralist theoretical interpretations of the *Challenger* launch decision reaffirm these tendencies. The major difference between the two paradigms considered is that functionalist theorists promote the status quo by keeping the organization's functionaries in their proper place, whereas radical-structural theorists promote an overthrow of the existing organization in order to benefit groups being oppressed by organizational elites.

The central weakness of structural theories, both radical and functional, is that the organization is objectified to the point that human beings lose their individual identity and the ability to render judgments which affect their condition in the real world. Another problem peculiar to functionalist and radical-structural theories is that there is an automatic consensus concerning the members in the organization as being fundamentally healthy and normal in a psychological sense.[91] Hence, a further consideration of workers as individual actors capable of rendering decisions and/or promoting the organizational working environment is necessary. A sense of the pitfalls of functionalism is captured by psycho-analytical organization theorist Howard Schwartz (1990), who is a critic of functionalism generally:

> ...traditional organization theory does not enable us to understand organizations that are fundamentally unhealthy. Our theories of organization are basically functionalist theories, which assume that organizational processes make sense in terms of the overall purposes of the organization. Within this paradigm, these overall purposes go unquestioned, and the validity of the fundamental organizational processes that carry them through is taken for granted. Thus, within this paradigm, organizational disasters and the bad decisions that lead up to them *must* be seen as aberrations (Schwartz 1990, 73).[92]

[91] Functional theorists exhibit concern for profit making, economy, efficiency, etc., all part of the rationality project. Radical-structural theorists reaffirm the effects of the rationality project, but seek fundamentally to overthrow, or give pause to, the status quo powers-that-be.

[92] [This issue is raised by Schwartz as he is highly critical of structural-functional theories such as Karl E. Weick's (1988) "Organizational culture as a source of high reliability," and Starbuck, W.H., and F.J. Milliken, (1988) "Challenger: Fine-tuning the odds until something breaks." Both theories are considered above. Schwartz's work is considered more in depth in the next chapter.

In our attempt to capture the complexities involved in the decision to launch the *Challenger*, we will need to pursue other theoretical avenues in order to explain the conditions leading up to the explosion. This necessarily involves a more thorough consideration of the role of individual human beings in the fateful course of events. The next chapter will consist of an examination of the radical humanist and interpretive paradigms in order to see what insights and knowledge those theoretical perspectives yield.

Chapter V: Radical Humanism and Interpretivism

The radical humanist and interpretivist paradigm explanations offered by theorists of these respective worldviews are rather few in comparison with the structuralist paradigms, particularly the functionalist theories. This is to be expected given the predominance of the rationality project as indicated by Stone (1997), Adams and Ingersoll (1990), Schwartz (1990), Morgan (1980, 1986 and 1997) and Burrell and Morgan (1979). Nevertheless, the *Challenger* launch decision has been analyzed from a psychic prisons (psycho-analytic) and an organization communication theoretical perspective. I have interpreted both the psychic prisons and organization communication theoretical concepts as belonging to the culture metaphor where the emphasis is on how language shapes organizational reality (see Morgan 1997, 399). In contrast to the aforementioned theories, the flux and transformation metaphor has an emphasis on the paradox of organizational reality.[93] Morgan notes that "humans--whether scientists or individuals in everyday life--[act] as interpreters and creators of an 'objective reality,' rather than neutral observers" (429).[94] Despite the paucity of theoretical analyses from the radical humanist and interpretive paradigms, the theoretical explanations offered by scholars interpreting the *Challenger* launch decision are remarkable and distinctive in their approach as compared to the previously examined structural analyses. At the end of the chapter, I will offer a mostly phenomenological interpretation

[93] See Morgan (1997, 420) for a discussion of the dialectics of management, or managing paradox. Morgan notes that considering paradox in organizations can "provide ways of thinking about the management of competing tensions and of how paradoxes can often be reframed through creative insights." Tompkins (1993) as we will see below demonstrates the tensions exhibited by managers and employees of the Marshall Space Flight Center which had an impact on the launch decision.

[94] Note here that the organization communications theories offered by academicians vary widely but are categorized as belonging for the most part to the interpretive paradigm for this case study as put forward in Morgan's (1986; 1997) analytical framework.

based on the knowledge analytic developed by Carnevale and Hummel (1996).

Psychic Prisons, Culture and the *Challenger* Launch Decision

Organizational Decay and Idealism

As was indicated in the previous chapter, structural theories, both radical and functional, have a propensity by their advocates to consider the organization as an entity whose existence is separate and apart from individual human beings. There is an assumption in structural theories that the collective group of individuals within the organization subsume their distinct human conception of being into the organizational totality. Thus, the organization assumes, in a reified manner, a distinct identity and being of its own. Functionalist theories reinforce the status quo and enable elites to maintain control over organizational members. Radical structuralist theorists demonstrate the oppressive nature of the same organizational totality, but have a tendency to prescribe a change in leadership by replacing the nefarious social arrangement with a new, or revolutionary, structure. Both theoretical paradigms are concerned with structural causation and analysis. The role of the independent actor is either not considered at all or is relegated by structural theorists to being secondary in importance.

The major antithetical theoretical argument in juxtaposition to functionalism is presented by Howard S. Schwartz in his work *Narcissistic Process and Corporate Decay: The Theory of the Organization Ideal* (1990).[95] Schwartz presents the case that the NASA organization was psychologically dysfunctional. The organization was led by leaders with an unhealthy

[95] One of the major points of emphasis in Burrell and Morgan (1979) is that the radical humanist paradigm is primarily anti-organization in principle. As we will see from Schwartz's work, the NASA organization represents an instrument of decadence for the psychologically dysfunctional leaders.

disposition to being narcissistic which ultimately became critical to the ill fated *Challenger* launch decision. Relying primarily on the works of Sigmund Freud and Carl Jung, Schwartz makes the argument that NASA, prior to the *Challenger* space shuttle launch, was the embodiment of the organizational ideal in the form of egocentric behaviors manifested by NASA decision makers. Schwartz demonstrates *the impact of individual human beings* and their behaviors which impact activities in organizations. Schwartz emphasizes that it is not organizations which make decisions, rather human beings within the organization do. As such, Schwartz focuses our attention on leaders in organizations who make decisions for others and the resulting consequences which follow.

Before contemplating Schwartz's psycho-analytical theory as applied to the *Challenger* case study, we will examine his conception of the differentiation of traditional management practices taught in university courses which do not adequately represent reality. According to Scwartz, the propensity to foster traditional technical rationality in organizations by managers and students alike is irresistible. First, Schwartz develops the *clockwork metaphor* which represents "textbook" explanations of organizations, i.e., "the organization is like a clock: everybody knows what the organization is all about and is concerned solely with carrying out its mission; people are basically happy at their work; the level of anxiety is low; people interact with each other in frictionless, mutually supportive cooperation; and if there are any managerial problems at all, these are basically technical problems, easily solved by someone who has the proper skills and knows the correct techniques of management" (1990, 7).[96] Schwartz describes this method as an "ego ideal" as not being a true depiction of reality,

[96] The clockwork metaphor has much in common with the rationality project or technical rationality described above.

rather he states that the ego ideal does not explain human organizations as it "represent(s) the return to narcissism--the healing of the rift between subject and object, self and other, freedom and necessity, that permeates post infant mental life....[Schwartz's students] wanted to know about the clockwork organization not because it represents a perfect organization, but rather because it represents the possibility of becoming perfect themselves" (Schwartz 1990, 9). According to Schwartz, the clockwork organization is not a true depiction of reality but is rather an "ego ideal" which does not exist nor can ever be attained.

The second metaphor, termed the *snakepit*, is the opposite of the clockwork metaphor, or the traditional textbook projection. According to Schwartz, the snakepit metaphor represents a truer sense of reality of organizational life:

> Here, everything is always falling apart, and people's main activity is to see that it doesn't fall on them; nobody really knows what is going on, though everyone cares about what is going on because there is danger in not knowing; anxiety and stress are constant companions; and people take little pleasure in dealing with each other, doing so primarily to use others for their own purposes or because they cannot avoid being so used themselves. Managerial problems here are experienced as intractable, and managers feel that they have done well if they are able to make it through the day....How was it possible to reconcile the interest of my students in the textbook/clockwork image of the organization with the fact that the best evidence of their own senses, and of the senses of their peers, was that such things do not exist?....*the idea of the clockwork organization had much more than pragmatic significance for them. It was rather an article of faith. And, as with all articles of faith, the way to understand this one is to understand its place in the individual's psychological configuration. We hold to articles of faith because we need to. That is why they cannot be dislodged by facts. In other words, the question becomes what did the idea of the clockwork organization mean to these students? What did it represent to them that was so important for them to believe in?"* (Schwartz 1990, 8, italics added for emphasis).

The clockwork model is the organizational ideal, or myth, taught and desired by students in management even though they know that the snakepit is the truer depiction of reality.

Schwartz notes that most theories explaining the events leading to the *Challenger* incident are functionalist, have a propensity to perfect the allegedly inerrant system in question by offering structural fixes, and that "traditional organization theory does not enable us to understand organizations that are fundamentally unhealthy":

> Within this [functionalist] paradigm, [the purposes and processes of the organization] go unquestioned, and the validity of the fundamental organizational processes that carry them through is taken for granted. Thus, within this paradigm, organizational disasters and the bad decisions that lead up to them must be seen as aberrations (1990, 73).[97]

Schwartz shows that most of the previous launches were not successful and that in fact "many of them were near catastrophes and had been so for a long time" (1990, 74). There are two major elements provided by Schwartz's analysis. Firstly, the theory of organization decay delineates the process by which the organization loses sight of its responsibility to its members. And secondly, the theory of the organization ideal depicts the psychologically dysfunctional NASA organization dominated by the narcissism of its leadership and their commitment to the fantasy of perfection. The NASA organization was in a constant state of denial about the importance of the SRB O-rings and this denial was an important element of narcissistic behavior, i.e., the notion of infallibility due to the managers' conception of themselves being perfect. History[98] shows that the NASA organization was headed towards organizational

[97] Note here that Schwartz is taking particular aim with his criticism of Karl Weick's "Organizational culture as a source of high reliability" and W.H. Starbuck and F.J. Milliken's "Challenger: fine-tuning the odds until something breaks." Both of these functionalist articles were considered in the previous chapter.

[98] See also the chronological history of the *Challenger* shuttle disaster developed in Chapter 3 of this dissertation

decay.[90] Schwartz recounts the incidents chronologically:

1. As early as October 1977, NASA rejected as 'unacceptable' Morton-Thiokol's design for solid rocket booster (SRB seals because 'joint rotation' prevented the secondary O-rings from sealing.)

2. After tests performed in May 1982, NASA 'Accepted the conclusion that the secondary O-ring was no longer functional...when the Solid Rocket Motor reached 40 percent of its maximum expected operating pressure' [*Report I*, 1986: 126] and therefore ruled the seal system non redundant.

3. In-flight erosion of the primary seal occurred as early as the second shuttle flight, in November 1981, and, beginning with flight 41-B in February 1984, it became a regular occurrence, with some primary rings not sealing at all.

4. On flight 51-B, not only did a primary O-ring fail altogether to seal, but a secondary O-ring eroded.

Thus, NASA knew that it could depend on neither the secondary O-ring nor the primary O-ring. It also knew, of course, that if neither O-ring sealed, the result would be catastrophic. This condition was deemed so serious that NASA issued a launch constraint on all subsequent flights--and then waived it in each case.

The second premise, that the system was healthy, also turns out to be false. Rather, a closer look at the organizational context shows that, despite Weick's claim, there certainly *was* something wrong at NASA. Indeed, the system *had* changed its character. To be sure, it had not changed suddenly. Nonetheless, over the years, NASA had become a hollow shell of its former self.

Consider the problems that had arisen in four cross-cutting dimensions:

1. *Hardware Problems*: The solid rocket booster joints that were found to have caused the Challenger explosion were far from being the only unreliable items in the shuttle system. On the contrary, the Rogers Commission found that the wheel, braking, and steering systems were all

[90] See also Donald Christiansen's "A System Gone Awry" in *IEEE Spectrum*, March 1987, 24/3:23. Christiansen notes that "...The loss of Challenger in January 1986 was the result of a long-recognized and well-understood fault in the booster rocket design. [A board appointed by NASA administrator James Fletcher in the 1973 Skylab misadventure] stated that 'the management system developed by NASA for manned space flight places large emphasis on rigor, detail, and thoroughness. In hand with this emphasis comes formalism, extensive documentation, and visibility in detail to senior management. While nearly perfect, such a system can submerge the *concerned individual* [emphasis added] and depress the role of the intuitive engineer or analyst. It may not allow full play for the intuitive judgment or past experience of the individual. An emphasis on management systems can, in itself, serve to separate the people engaged in the program from the real world of hardware'.

faulty and that the main engines had a number of serious problems, including cracks in the turbine blades, valve failures and leaks from heat exchangers.

2. *Loss of Administrative Control*: NASA had virtually lost control of its spending and had wasted, according to federal audits, at least $3.5 billion....

3. *Loss of Technical Control*: In its early years, NASA had maintained the technological capability and the staff to oversee its contractors....

4. *Loss of Control over Operations*: NASA came to have extreme and increasing difficulty in conducting and coordinating the complex processes involved in shuttle operations. The Rogers Commission, in assessing NASA's difficulties in this area, maintained that 'an assessment of the system's overall performance is best made by studying the process at the end of the production chain: crew training' (*Report I*, 1986: 166). And, in this regard, the commission quoted astronaut Henry Hartsfield:

'Had we not had the accident, we were going to be up against a wall; STS 61-H...would have had to average 31 hours in the simulator to accomplish their required training, and STS 61-K would have to average 33 hours [Note: normal time was 77 hours]. That is ridiculous. For the first time, somebody was going to have to stand up and say we have got to slip the launch because we are not going to have the crew trained' [*Report I*, 1986: 170].

On the whole, the picture of NASA that emerges from thorough investigation is of an organization characterized by the generalized and systemic ineffectiveness that we associate with organizational decay--an organization in which the flawed decision to launch the *Challenger* was not an aberration but a normal and ordinary way of doing business (Schwartz 1990, 74-77).

The decay of the organizational culture was hastened by the narcissism of the NASA managers at the expense of Morton-Thiokol engineers. The manifestation of this narcissism was apparent in the January 27th teleconference:

Perhaps the fact that the 27 January teleconference was the most minutely investigated element of the disaster is the reason that it also gives us the best example of what the denial of pressure looks like with regard to the people who are being pressured. For, it is clear that, on the one hand, Morton-Thiokol was under considerable pressure to please an important customer and go along with NASA's desire to launch, while on the other hand, it appears that this pressure was not regarded by Morton-Thiokol management, as opposed to Morton-Thiokol engineers, as pressure at the time, nor remembered as pressure by them. Thus, engineers Allan McDonald and Brian Russell, as well as other Morton-Thiokol engineers, testified that they had felt pressure, but Jerry Mason, senior vice president, [and] Joe Kilminster, vice president for shuttle projects [did not].

Evidently, the differentiation coincided with a disparity in perception of the way that NASA had redefined the situation, from one in which they had to prove that it was safe to fly, to one in which they had to prove it was unsafe to fly. Morton-Thiokol engineers evidently realized that the situation was being redefined, while management did not. Thus, Robert Lund said:

'We have always dealt with Marshall for a long time and have always been in the position of defending our position to make sure that we were ready to fly, and I guess I didn't realize until after the meeting and after several days that we had absolutely changed our position from what we had before' *[Report I*, 1986: 94].

It appears that we have here, in the case of Morton-Thiokol management, an example of the dynamics Freud[100] associated with leadership. *For Freud, the leader takes the place of the follower's ego ideal. In the process, the individual's sense of judgment, his or her reflecting, critical ability, is given over to the leader, and consequently the individual's sense of moral autonomy is lost. With regard to the Morton-Thiokol engineers, this had not happened, or at least not completely. This is why the Morton-Thiokol engineers felt pressure, while the managers did not. The experience of pressure involves a sense of oneself as a distinct entity against another distinct entity. Thus the engineers maintained a sense of their authority by retaining their own ego ideal--an ego ideal in which their professional engineering standards played a large part. For the managers, however, putting NASA in the place of their ego ideal meant, in effect, that they had taken NASA as their image of what they should be themselves, the realization of their own narcissism. In this way, the boundaries between them and NASA vanished. They fused with NASA and gave up their sense of being distinct entities. In effect, these people had given up their own selves. There was no self that could*

[100] For a more comprehensive (yet still brief) analysis, see Sigmund Freud's (1984) "Group Psychology and the Analysis of the Ego" in *The Major Works of Sigmund Freud* (664 - 96) [translated by James Strachey and originally published in 1921]. Chicago: Encyclopedia Britannica, Inc.

have experienced pressure (Schwartz 98-99, italics added for emphasis).

By fusing their individual identities with the NASA organization, the managers lost their sense of judgment and the individual's sense of moral autonomy. The engineers were consumed by the decision making process and were largely unconscious of the narcissism of the NASA managers.

Part of the problem with NASA's narcissism is that it is pervasive in the American culture (Schwartz 1990, 124). Americans want heroes and gods to protect them from the evils present in the world:

> When the original astronauts were chosen, during a period in which American rockets did nothing but blow up, the adulation for them was instant. They, our bravest and best test pilots, would ride the rockets into space and symbolically do battle with the Russians, in much the same way that earlier lone warriors had stood for the armies of which they were part and prefigured or replaced the battle between the armies themselves. The public would grant them anything. It would be the loving world of which they were at the center. It would fulfill for them the ego ideal...*the astronaut would take upon himself the role of a protecting god* (Schwartz 111-2).

The American public had been caught up in an overly romanticized and unrealistic fantasy concerning what mere mortals could do in such a complex undertaking. At the same time, the space shuttle launch system had been sold by NASA[101] and by government leaders as becoming fully operational. According to Schwartz,

[101] Schwartz criticizes and questions the competence of Acting NASA Administrator William R. Graham whose "arrogance may be understood as a natural concomitant, and even a requirement, of his high position in an organization like this. His position meant that he could, and even should, idealize himself and require that others do the same. He was, according to his ideology and the ideology of an increasingly totalitarian NASA, the ego ideal, and that meant to him that his ideological agenda was the meaning of NASA" (84). Schwartz was referring to Graham's public statements referring to the Solid Rocket Boosters as being the sturdiest part of the space shuttle system. Schwartz also pointed out that "As the political criteria for NASA selection became more important, Trento shows, the managerial and administrative competence of its high officials steadily decreased. The ultimate act in this tragedy came with the appointment of William R. Graham as Begg's deputy,...Graham was forced on Beggs, who was tricked and browbeaten into taking him even though Graham's background was not in the space program but as a nuclear weapons expert.....Beggs, as he himself says, 'had been warned by this time that the guy was a right-wing kook, a nut'" [Trento 1987, 261] (Schwartz 1990, 83 - 4).

> ...Having proved its capacity to create magical transformations, the space shuttle had nothing left to show.
>
> This is the context in which the sorts of abuses of organizational process described earlier occurred at NASA: appointments to technical position based purely on politics, loss of technical capacity to properly oversee contractors, submission of schedules that could not be met, commitment to projects that were grossly underfunded, extreme miscalculation of risks, suppression of unpleasant information, degeneration of organizational processes into empty rituals, and so on.
>
> In a word, *I submit that what occurred was a neurotic regression of the symbolic structure in which the American people saw manned space flight and through it themselves. This regression went from a religious framework, where danger was acknowledged, the possibility of failure was present, and competence was required, to an animistic system, in which safety was assured, perfection was assumed, and nothing was required at all. In the first system, technological achievement was possible. In the second it was not* (Schwartz 124).

Schwartz thus takes Stone's (1997) notion of the policy paradox to task in that American managers and executives hold a deep and abiding faith in resolving complex problems by restructuring organizational processes. While agreeing in principle with Stone's contention concerning America's fixation with structural solutions to human entities, Schwartz takes Stone's analysis a step further by indicating that the managers in the NASA organization have a deep-seated psychological disorder which is increasingly prevalent in the American culture:

> ....NASA was serving a symbolic function within the American culture....upon NASA had fallen the burden of maintaining the narcissism of a strikingly and perhaps increasingly narcissistic American culture....Gaining a sense of the place of narcissism in American society requires a concept that I have not made much use of before: the *superego.* In the normal case, partly through projection and partly through introjection, an individual comes to have a relatively stable image of the person he or she is 'supposed to be' or 'should be' in order again to become the center of a loving world. Thus, a set of obligations is understood as expressing the conditions for the attainment of the ego ideal. This set of obligations provides the basis for the superego.
>
> The superego gives a sense of direction to one's life and especially to those areas of life, such as one's organizational role, that are dominated and motivated by a sense of the appropriate. But between people and within the same person at different times, the balance between the

fantastical aspect of the ego ideal and its obligatory aspect, the superego, may differ. When the obligatory aspect gains the upper hand and displaces the fantastical, we speak of the person as an obsessive-compulsive. When the obligatory aspect is very weak as compared with the fantastical, we refer to the person as narcissistic. Such persons may be said to identify themselves with their own ego ideal.

The difference between the narcissistic and the normal case, then, has a developmental dimension. The obligatory component develops through the course of a person's life--a course that begins with primary narcissism but that progresses through identifications with adults whom the individual regards as having attained the ego ideal and whom the individual strives to be like. Thus, the normal person believes that he or she needs to live up to certain standards, to 'become somebody' in order to attain the ego ideal. The narcissist, maintaining an infantile orientation to the world, believes that he or she is already the ego ideal and in one way or another denies those elements of reality that contradict this preferred vision....note that the *denial of difference* is at one and the same time a denial of the difference between the world and the self, reality and fantasy, achievement and desire, between technology and magic. A society thinking of itself in these terms, living its emotional life on this level, would have lost the motivational basis for technological achievement (Schwartz 1990, 109-11, italics added for emphasis).

With Schwartz's analysis we see a sense of the loss of obligation to those workers and astronauts affected by the decision to launch the *Challenger*. Narcissistic managers possessing idealized conceptions about their own abilities and limitations lose their capacity to render appropriate judgments in critical situations.

Psychic Prisons and Ethical Dimensions

The question of ethics and ethical conduct represents another theoretical approach within the radical humanist paradigm. An aspect of Morgan's psychic prisons metaphor is that of ethics. While there is some mention of ethics in his work, it is may be summed by the following comment:

...the psychic prison metaphor plays a powerful role in drawing attention to the ethical dimension of organization....[T]here is nothing neutral about the way we organize. It is always human in the fullest sense and...an increased awareness of the human dimension needs to be built into everything we do. While the metaphor offers obvious guidance on the management of change, it also warns us that we may be walking on dangerous ethical ground, especially when we use our knowledge of archetypal feelings or social defence mechanism to achieve instrumental ends (Morgan 1997, 248).

Ethics, here comprising manifestations of conscience and having normative connotations, is represented in analyses of the *Challenger* disaster. Analysts of ethics tend to view the events surrounding the accident from the worker's (or engineer's) perspective. Individual identities within modern, highly technical organizations have been hidden within the organizational milieu to the point that "it is no longer the individual that is the primary focus of power and responsibility, but [rather] public and private institutions"[102] (Boisjoly, Curtis, and Mellican 1989, 217). The *Challenger* accident represents a challenge to traditional conceptions of ethics in the workplace:

> A disturbing feature of so many of the analyses and commentaries on the *Challenger* disaster is the reinforcement, and implicit acceptance, of this shift away from individual moral agency with an almost exclusive focus on the flaws in the management system, organizational structures and/or decision making process. Beginning with the findings of the Rogers Commission investigation, one could practically conclude that no one had any responsibility whatsoever for the disaster...
>
> When the Commission states in its...finding that 'waiving of launch constraints appears to have been at the expense of flight safety,' the immediate and obvious question would seem to be: Who approved the waivers and assumed this enormous risk...There are two puzzling aspects to this Commission finding. First, the formal system already contained the requirement that project offices inform at least Level I of launch constraints....Second, the Commission clearly established that the individual at Marshall who both imposed and waived the launch

[102] See also Steven Goldberg, "The Space Shuttle Tragedy and the Ethics of Engineering" in *Jurimetrics Journal*, Winter 1987, 155 - 9. Goldberg develops the concept of "separatism", or the notion that scientists and engineers should have technical inputs only in decision making. Goldberg does not attribute heroism to the Morton-Thiokol engineers, particularly Roger Boisjoly: "There is a name for Boisjoly's approach. It is not heroism, it is separatism: the notion that scientists and engineers should supply the technical inputs, but appropriate management and political organs should make the value decisions. Separatism is the dominant approach today to policy problems of this type, and it is an approach that has been explicitly applied to engineers...(156 - 7).

> constraint was Lawrence Mulloy, SRB Project Manager. Then why blame the management system, especially in such a crucial area as that of launch constraints, when procedures of that system were not followed? Is that approach going to increase the accountability of individuals within the system for future Flights?....
>
> The approach of the Rogers Commission and that of most of the analyses of the *Challenger* disaster is consistent with the growing tendency to deny any specific responsibility to individual persons within corporate or other institutional settings when things go wrong....
>
> The problem with this emphasis on management systems and collective responsibility is that it fosters a vicious circle that further and further erodes and obscures individual responsibility. This leads to a paradoxical -- and untenable --situation (such as in the space shuttle program) in which decisions are made and performed by individuals or groups of individuals but not attributed to them. It thus reinforces the tendency to avoid accountability for what anyone does by attributing the consequences to the organization decision making process. Again, shared, rather than individual, risk taking and responsibility become operative. The end result can be a cancerous attitude that so permeates an organization or management system that it metastasizes into decisions and acts of life-threatening irresponsibility (Boisjoly, et al, 1989, 225 - 7).

In accordance with the psychic prisons metaphor, the Rogers Commission represents the instrument through which irresponsible NASA launch decision makers are protected. The central tendency of the modern organization is, in essence, to protect careless managers from receiving adequately their just desserts.

Another example of managerial coverup is cited by Trudy Bell and Karl Esch in their article "The fatal flaw in Flight 51-L" in *IEEE Spectrum*, in their interview with former NASA Associate Administrator Hans Mark[103]:

> The only criticism that I have of the [Rogers commission] report is that they laid more blame on the lower-level engineers and less blame on the upper-level management than they should have. As with most of those commissions, the guys on the bottom took the rap. They quote [associate administrator for space flight Jesse] Moore and [administrator James] Beggs and a few others saying they didn't know about the O-ring problems, which I find awfully hard to believe. I mean, hell, I knew about it two years before the accident and even wrote a memo about it. I just find it very hard to believe (Bell and Esch 1987, 49).

And from an organization communications scholar:

> The Rogers commission report did not explicitly grapple with the question of the locus of responsibility--whether it was primarily people, or primarily procedures, or a mixture of the two. The Conclusions and Recommendations sections of the Rogers report reflect this lack of clarification. At the end of the volume in which causes are discussed, paragraph one states, 'the decision was flawed;' paragraph two states, 'the decision-making process was flawed;' and paragraph three states that the cause was 'failures in communication' [*Report I*, 82]. These expressions are confusing, ambiguous, perhaps even contradictory. Were particular decisions flawed, suggesting personal responsibility; were the procedural systems themselves flawed, indicating procedural responsibility; or did someone fail to do something required by procedures, indicating personal responsibility?
>
> ...[P]ersonal judgment, rather than procedural shortcomings, accounts for the loss of Challenger. The Conclusions and Recommendations sections of both investigations, however, make little mention of personal judgment or responsibility. That the conclusions do not follow logically comes to light only when key decisions are examined to assess whether personal judgment or procedural requirements determined important

[103] Mark (1987) makes the following observation: "My own part in the chain of events that led to the accident began when I returned to NASA in 1981. I first became aware of the fact we had a problem with the o-ring seals on the solid Rocket Motor at the time when our engineering people were questioning whether these 'field joints' on the SRM were really fail-safe....My memory is that questions as to whether the double o-ring system was really fail-safe began to be raised sometime in 1982. In February or March 1983 Mr. L. Michael Weeks, the deputy associate administrator of NASA for space flight, signed out a memorandum waiving the fail-safe requirements for the field joints in the Solid Rocket Motor. I remember discussing that matter with him at the time and concluding that such a step was justified. I argued at the time that we had more than a hundred successful firings of the Titan Solid Rocket Motor with a seal of somewhat similar design containing only one o-ring. I thought because of the Titan precedent that the risk of failure was small. As things turned out, this judgment was not correct because there are significant differences between the Titan and the SRM joints. *I did not look at these differences with sufficient care at the time*" (219, italics added for emphasis).

decisions. Repeatedly, key decisions show that personal decision-making was much more important than impersonal procedural decision-making. Two examples follow.

First, Lawrence Mulloy (Manager, SRB Project, Marshall Space Flight Center or MSFC) testified that he had told 'everyone' about the problem with the O-ring seals, yet there is absolutely no mention of it in the flight readiness reviews [*Report* V, 85]. Thus, the all-important decision whether to put a verbalized reservation into print was a personal judgment. This decision shows that procedures operate only derivatively on the basis of written inputs that might not reflect the whole decision-making picture.

Second, there existed alternative, independent paths for reporting problems such as O-ring charring, but their existence did not prevent the disaster [*Report V*, 84]. Thus deliberate procedural redundancy was rendered ineffective by decisions that were erroneous or misleading (e.g., that charring was not "anomalous"). This circumventing of procedural safeguards shows the futility of expecting too much of procedures themselves.

Thus, many crucial decisions were made not through procedural algorithms but personally and separately from the system of procedures. Procedures were involved only after personal decision-making, to effect decisions already made....It therefore does not make sense to recommend the implementation of more and more impersonal procedures to prevent poor judgment and ethical lapses (Dombrowski 1995, 147 - 8).[104]

The problematic of ethical dilemmas is especially difficult for functional and radical structural theorists to come to terms. In particular, personal responsibility and judgment are emphasized rather than making structural repairs.[105] Theorists who examine ethical problems in organizations make the case that individual human beings within an organization who have authority

[104] The problem of human values and judgment in technical communication is also addressed by Pace (1988) in which he notes "The Challenger disaster illustrates that technical communication is not a mechanistic process which can be reduced to transmission and receipt of messages. The testimony gathered by the President's Commission illustrates in graphic terms how 'human' the process of communication is, even in a highly technical organization like NASA. Technical communication scholars, as well as technical decision-makers, should broaden their perspectives of communication to include the human values inherent in the process. Understanding those values more clearly and further investigation into the unique problems of differentiating technical information can hopefully prevent a future disaster like the loss of Challenger from occurring" (218).

[105] See also Dombrowski (1991) where he criticized the Rogers Commission that "[had focused] largely on procedural aspects in the conclusions and recommendations...[and] personal responsibility was not a significant factor" (214).

and legitimacy bestowed upon them by the organization determine events and not bureaucratic procedures and processes. In ethical theorist analyses, someone is ultimately responsible for the ill-fated launch decision and fingers are pointed toward the culpability of senior and higher level NASA managers, rather than toward some abstract organizational system or the lower organizational participants -- in this case toward the scapegoated engineers.[106] Radical humanist ethics theorists go beyond Schwartz's theories of the organizational decay and ideal. The previous analyses also indicted the Rogers Commission for being part of the cover-up of the launch decision and, in addition, ethics theorists make a compelling case about the ill effects of technology on ethics in organizational behavior.

Radical Humanism and Hypotheses Explanation: How Useful Is the Paradigm?

The hypotheses stated in Chapter One are reiterated here in order to examine them in light of the explanations offered by radical humanist theorists addressing aspects of the *Challenger* launch decision:

1. Managers ignored information from employees who knew what was going on.

2. Managers who ignore the useful knowledge of the workers will sometimes blame the workers when managements' plans go awry. Also, organizations will go to great lengths to protect the managers and the

[106] For a more detailed explanation of organizational behavior and ethics see Thompson (1987): "When a superior puts great pressure on subordinates to produce results and gives the impression that questionable practices to achieve these results will be condoned...then the blame falls equally on the superior. Ignorance ceases even to mitigate responsibility.

But that an official apply pressure...is not a necessary condition for making an official responsible for the subsequent actions of others. Officials who set in motion bureaucratic routines cannot escape culpability for the consequences even if they are no longer involved in the process when the consequences occur....Whether the bureaucratic routines are pathological or conventional (or both), they can be anticipated. That they have a life of their own, often roaming beyond their original purpose, is a fact of organizational behavior that officials should be expected to appreciate. The more the consequences of a decision fit such bureaucratic patterns, the less an official can plausibly invoke the excuse from ignorance" (60 - 1).

organization until compelled to do otherwise.

3. Managers hold the simplistic notion that they can control every aspect of their organization, and even those of other organizations.

There is evidence from the psychic prisons metaphor that pertains to the *Challenger* launch decision to support the three hypotheses above, although there is some variation. Explanations offered by Schwartz demonstrate that narcissistic NASA managers gave the Morton Thiokol engineers a hearing but were predisposed to ignore information from them because it contradicted their own perfect conception of themselves and NASA. Schwartz shows that the unhealthy psychological orientation of NASA managers prevented the right decision from taking place (the no-launch alternative). Boisjoly et al., and Dombrowski contend that the NASA managers were ethically challenged, refusing to accept responsibility and holding themselves accountable for having made the wrong decision (the decision to launch).

The first statement of the second hypothesis does not receive the same support from the psychic prisons metaphor theories presented here. Schwartz, Boisjoly et al., and Dombrowski conclude that the organization *itself* is used as a means to deflect criticism from the managers who had rendered the decision rather than the engineers or others involved in the decision making process. With Schwartz, the whole NASA organization was neurotic. The blame for the launch decision rests primarily with the managers who, engaged in their psychotic fantasy, were in a state of denial about their own culpability. The second statement of the second hypothesis does receive support. Boisjoly et al., and Dombrowski demonstrate the absurdity of the Rogers Commission report which ultimately claimed that no one was responsible for the launch decision. There is rather a tendency to blame the management system and the decision making process. Boisjoly et al., and Dombrowski also note that personal judgment was not considered in the Rogers Commission report, even though the testimony provided by various witnesses was damning towards high-level NASA management. In effect, the Rogers Commission was part of the NASA organization cover-up in order to protect senior managers.

The third hypothesis is well supported by the radical humanist theorists work presented here. Schwartz's narcissistic manager was clearly predisposed to using any means available, including the browbeating of managers and engineers from Morton-Thiokol, in order to manipulate his will (the will of NASA). There is evidence from testimony and documentation from the Rogers Commission to support this claim. Boisjoly et al., and Dombrowski imply that the managers were protected by the organization through the Rogers Commission proceedings, and therefore, that they were able to avoid the blame for the incident. The ethics theorists believe that the Commission was a co-conspirator with NASA to protect the managers from responsibility for the tragedy. Thus, this episode reaffirms the beliefs of those managers within the organization that the organization will protect them from being held accountable for their actions, even at the cost of lower-level organizational participants being manipulated.

The Interpretive Paradigm and the Challenger Launch Decision

As we have seen from the first chapter of this dissertation, the interpretive paradigm in Morgan's metatheoretical conception (see Figure 2.1 above) contains theories from phenomenology, phenomenological sociology and hermeneutics which attempt to explain human society as to *how it really is* and *to understand the social world from the subjective experience of individual* *consciousness* (Burrell and Morgan 1979). There is a concentration on basic human experience and interaction. Theoretical analyses from this paradigm have been written about the *Challenger* accident, although, like the radical humanist paradigm considered above, there have not been many. Theories from the interpretive paradigm will be considered below. In addition to those works, we will examine a phenomenological interpretation based on the knowledge analytic developed by Carnevale and Hummel (1996).

Feynman's "Orgcom" Theory

Nobel prize-winning physicist and member of the Rogers Commission Richard P. Feynman was one of the few members of the Commission who did not have ties to the NASA organization prior to the ill-fated Challenger launch decision. Organization communications theorist Philip K. Tompkins[107] (1993) writes in *Organizational Communication Imperatives: Lessons of the Space Program* that Feynman is credited with having established a theory of organization communication in which he defines the differences between engineers and management:

> As a result of his communication difficulties with the engineers who testified before the Rogers Commission, and particularly with those who had been promoted into management positions, according to his book, Feynman felt he needed to break away from the insulated atmosphere of the Rogers Commission. He had begun to suspect that there might be a management problem behind the technical problem of the O-rings. He wanted face-to-face communication with ordinary NASA workers and engineers, to talk to them without the inhibiting presence of their bosses.
>
> Feynman spoke with a group of workers, who were initially fearful of talking to a member of the Rogers Commission, and asked them detailed questions about their jobs. They willingly described without success to communicate these problems to their supervisors. Happily enough for the astronauts in the Apollo Program, upward-directed communication at the Marshall Center had received high priority under von Braun. The

[107] Note: Tompkins was previously an organizational communication consultant to Von Braun at Marshall Space Flight Center.

system Feynman was examining did not seem to work in the same way.

It was at the Marshall Center that Feynman conducted his second less well-known experiment[108] [See also Feynman 1988, 213 - 5] (Tompkins 1993, 143).

Feynman was attempting to get to the truth of what had transpired prior to the *Challenger* launch decision. Feynman was trained as a physicist but had an intuitive grasp of the differences between management and engineers, which led him the Marshall Space Flight Center. In the following article he wrote for the February 1988 edition of *Physics Today*, Feynman explained how his theory of organization communication works :

> Suddenly I got an idea. I said, 'All right, I'll tell you what. In order to save time, the main question I want to know is this: Is there the same understanding, or difference of understanding, between the engineers and the management associated with the rocket engines as we have discovered associated with the solid rocket boosters?'
>
> Mr. Lovingood says, 'No, of course not. Although I'm now a manager, I was trained as an engineer.'
>
> I gave each person a piece of paper. I said, 'Now, each of you please write down what you think the probability of failure for a flight is, due to a failure in the engines.'
>
> I got four answers--three from the engineers and one from Mr. Lovingood, the manager. The answers from the engineers all said, in one form or another (the usual way engineers write--"reliability limit," or "confidence sub so-on"), almost exactly the same thing 1 in about 200. Mr. Lovingood's answer said, 'Cannot quantify. Reliability is determined by studies of this, checks on that, experience here' --blah, blah, blah, blah.
>
> 'Well,' I said. 'I've got four answers. One of them weaseled.' I turned to Mr. Lovingood and said, 'I think you weaseled.'
>
> He says, 'I don't think I weaseled.'
>
> 'Well, look,' I said. 'You didn't tell me *what* your confidence was; you told me *how* you determined it. What I want to know is: After you determined it, what *was* it?'
>
> He says, '100 percent.' The engineers' jaws drop. My jaw drops. I look at him, everybody looks at him--and he says, 'Uh...uh, minus epsilon?'
>
> 'OK. Now the only problem left is, what is epsilon?'

[108] The other experiment was Feynman's well known use of the O-ring material in the ice water incident which had the effect of dramatizing to the public the problem of O-ring shrinkage which led to the escape of hot gases causing the solid rocket boosters to explode.

> He says, '1 in 100,000.' So I showed Mr. Lovingood the other answers and said, 'I see there *is* a difference between engineers and management in their information and knowledge here, just as there was in the case of the rocket, but let me not bother you about; let's continue with the engine' (Feynman [February]1988, 34).

In this story Feynman was able to convey to his readers the problem of perception between members of the same organization. Feynman's theory is based upon the knowledge of engineers and their immediate and day-to-day work in contrast with the more distant and abstract knowledge of managers. In addition to the differences in knowledge between the managers and engineers, Feynman also modified his "orgcom" theory to accommodate the apparent organizational decay at NASA[109]:

> ...I would like to say something about the general deterioration of NASA--and the fact that there was no information coming up from the engineers to the management...
>
> I invented a theory, which I have discussed with a considerable number of people, and many people explained to me why my theory is wrong. But I don't remember their explanations as to why it's wrong--you never can, because that's the way you're built! I am a weak human, too, so I cannot resist telling you what I think is the problem.
>
> When NASA was trying to go to the Moon, it was a goal that everyone was eager to achieve. Everybody was cooperating, much like the efforts to build the first atomic bomb at Los Alamos. There was no problem between the management, and the other people, because they were all trying to do the same thing. But then, after going to the Moon, NASA had all these people together, all these institutions and so on. You don't want to fire people and send them out in the street when you're done. So the problem is what to do.
>
> You have to convince Congress that there exists a project this organization can do. In order to do so, it is necessary (at least it was *apparently* necessary in this case) to exaggerate--to exaggerate how economical the shuttle was going to be, to exaggerate the big scientific facts that would be discovered. (In every newspaper article about the shuttle there was a statement about the useful zero-gravity experiments--such as making pharmaceuticals, new alloys and so on--on board, but I've never seen in any science article any results of anything that have

[109] Feynman's simplified theory has been replicated by the organization decay models of organization theorists previously considered. See, for example, Schwartz (1990) and McCurdy (1989) above.

ever come out of any of those science experiments which were so *important*!) So NASA exaggerated how little the shuttle would cost, they exaggerated how often it could fly, to such a pitch that it was *obviously incorrect*--obvious enough that all kinds of organizations were writing reports, trying to get the Congress to wake up to the fact that NASA's claims weren't true.

I believe that what happened was--remember, this only a theory, because I tell you, people don't agree--that although the engineers down in the works knew NASA's claims were impossible, and the guys at the top knew that somehow they had exaggerated, the guys at the top didn't want to *hear* that they had exaggerated. They didn't want to hear about the difficulties of the engineers--the fact that the shuttle can't fly so often, the fact that it might not work and so on. It's better if they don't hear it, so they can be much more "honest" when they're trying to get Congress to OK their projects.

So my theory is that the loss of common interest--between the engineers and scientists on the one hand and management on the other--is the cause of the deterioration in cooperation, which, as you've seen, produced a calamity (Feynman [February] 1988, 37, italics added for emphasis).

Another problem which came to the attention of Feynman on his trip to the Marshall Space Center is the differences in types of knowledge between executives and managers. In this case, he is referring to a discrepancy between a range safety officer and "the big cheeses at NASA":

We finally divided into working groups [between Commission hearing meetings], and I went to Marshall with General Kutyna's group. The first thing that happened there was, a range safety officer by the name of Ulian came to tell us about a discussion he had had with NASA higher-ups about safety. Mr. Ulian had to decide whether to put explosive charges on the side so ground control could destroy the shuttle in case it was falling onto a city. The big cheeses at NASA said, 'Don't put any explosive on, because the shuttle is so safe. It'll never fall onto a city.'

Mr. Ulian tried to argue that there was danger. One out of every 25 rockets had failed previously, so Mr. Ulian estimated the probability of danger to be about 1 in 100 -- enough to justify the explosive charges. But the higher-ups at NASA said that the probability of failure was 1 in 100,000. That means if you flew the shuttle every day, the average time before your first accident would be 300 years -- every day, one flight for 300 years -- which is obviously crazy! Mr. Ulian also told us about the problems he had with the big cheeses -- how they didn't come to the meetings sometimes and all kinds of other details (Feynman [February]

1988, 33 - 4).

Feynman's theory, devised from a single case and his own life experience, provides an insight into how various levels of an organization, i.e., executive, manager, and worker, can become uncooperative in joint endeavors. The NASA organization was obviously suffering from a lack of communication. Tompkins (1993) offers his interpretation Feynman's "orgcom" theory:

> If Feynman's thesis is correct that NASA apparently needed to exaggerate the benefits and economies of the shuttle to Congress, then these claims may have also been heard by NASA's own employees. Those employees would have had three choices: (1) to try to fulfill those exaggerated claims; (2) to communicate to their superiors that it would be difficult if not impossible to realize them; or (3) to avoid communicating their problems to their superiors. Managers who make exaggerated claims run the risk of believing their own rhetoric. They then have the choice of encouraging people to talk about their problems--as was done during the von Braun era--or of discouraging any defeatist messages from their employees.
>
> Similarly, corporations that make exaggerated claims about their products or services can run into unintended difficulties with employees who know better. Credibility and trust can be expected to be among the first casualties in such a system....
>
> Whether Marshall's management was ignorant of the O-ring problems because it had inhibited the upward-directed transmission of those problems, or did know about the problems but pretended otherwise, the system failed in both a technical and moral sense. To know about a technical problem that can cause the loss of human life, and then fail to act upon that problem, is also a failure of communication and morality. Marshall management knew about the O-ring problem; that is well documented. The failure of communication in the decision to launch Challenger was the failure to exercise automatic responsibility--to solve the problem or see that it was communicated up the line, rather than encouraging Morton Thiokol to recommend the flight (Tompkins 1993, 149 - 150).

Tompkins demonstrated that a communication problem existed between workers and management through an examination of the Marshall leadership over the years of the space center's existence. Von Braun was a "charismatic" leader, and Tompkins asked the rhetorical question: "The sociologist Max

Weber expressed the crisis for charisma in the question: How to avoid mere routinization after the person of the organization is gone?" (Tompkins 1993, 159). Tompkins then traced the Marshall leadership subsequent to Lucas. Prior to Lucas's arrival as chief of the MSFC in 1974, Rocco Petrone was sent in 1973 to Marshall where he had a brief tenure. Tompkins described unsolicited characterizations of Petrone by interviewees "as a 'hatchet man' who was determined to 'weed out' all of the Germans, to 'cut out the fat'...Petrone's methods created a 'persecution complex' at the Marshall Center" (160). Tompkins also confirmed Malcolm McConnell's (1987) harsh assessment of Dr. Lucas (161). Employees Tompkins interviewed at Marshall had made numerous scathing remarks about Lucas's leadership at the space center. To wit:

> **Colleagues Assessments of Lucas.** The following remarks were made by my interviewees. The comments are nearly literal transcriptions, with some editing and paraphrasing to provide context:
>
> • It's not hard to get up here [to the ninth floor of Building 4200] and become isolated. Dr. Lucas lost touch. We were not being effective in downward communication and did not make people comfortable coming up the line. Dr. Lucas sincerely wanted to know, but he didn't get the information he should have. The ninth floor is hallowed ground.
>
> • I feel bad about saying this, but people were afraid to bring bad news [to Lucas] for fear they would be treated harshly. They didn't want to be chewed out. It was kill the messenger. There was a tendency to push things down, to keep the lid on problems; no news is good news. Lucas was not sinister or nasty--it was just his management style. It seemed apparent to everyone that to reinstill our organizational pride, it was best that Dr. Lucas leave.
>
> • Lucas was a dead fish. Cold, vindictive, he would embarrass people publicly. It was very hard to go to him with a problem--you could expect no sympathy. He could chill you with that hostile expression of his: 'Good grief.'
>
> • Dr. Lucas related poorly to the press and his superiors....He never

acknowledged we made a mistake with Challenger but left his key subordinates swinging in the wind during the investigations....Dr. Lucas resigned under pressure.

- I thought the world of Dr. Lucas, even though he was so rigid and formal. People were afraid to raise problems with him. We started canning and preprogramming what went up to Dr. Lucas. We were afraid of his response. He'd jump all over people if what they said didn't suit him.

- Dr. Lucas's team presented an image of strength. As such, they gave the impression they didn't like to hear bad news. When they did, they'd say we didn't anticipate the problems and solve them. The messenger gets shot, in other words. It takes a strong messenger under those circumstances. That caused us to put the shiniest face on everything we could, put on the biggest smile. I don't want to up there to the ninth floor and get shot down, so they got less than totally accurate information. You delay, you put the best face on it. If he expects you to be perfect, you're going to flunk. If you carry a problem to Dr. Lucas, he would demand, out of frustration, 'How many more of these are out there?'

- Dr. Lucas's group expected us to be conversant about every technical detail. They made us apprehensive, reluctant to volunteer information. To volunteer an opinion subjected you to uncomfortable critiques. So, you didn't volunteer. We suffered embarrassment and humiliation. Your career could be in jeopardy. Lucas constrained communication. There were too many managers trying to master too much detail....

- My feeling was that Dr. Lucas was secluded. He ate his meals on the ninth floor. It was not easy to get through to Lucas. He was protected....And then they [Lucas, Kingsbury, Mulloy, Reinartz] had to leave after *Challenger*. They deserve some blame for Challenger because of their communication style.

- Communication with Lucas was more constrained than with von Braun, not as open, but you could get through if you wanted to. My opinion is that if somebody was forceful he could have been heard.

- Communication for a year or two or more before *Challenger* was a problem.

- The pre-Challenger period was the worst we've seen in communication. There was a fear on the part of people to surface problems at a high level: kill the messenger. I'm at fault for not surfacing problems. I saw it in meetings with Dr. Lucas--people humiliated in front of peers and contractors.

- Lucas wanted information filtered. His communicative style was intimidation. The way he did business didn't encourage people to bring up problems. Before a formal review, he wanted people to tell him what was going on. He didn't want to hear about it for the first time in a formal review.

These concerns from top and middle managers establish something close to a consensus that Lucas's communication style produced an ineffective system of organizational communication...(Tompkins 1993, 163 - 5).

Tompkins also discovered during the interviews that enough information had been volunteered to inspire him to ask a small number of the interviewees as to whether there was an adverse impact on the *Challenger* launch decision based on poor communication practices at the Marshall Space Flight Center:

Communication as a Factor in the *Challenger* Accident

Could the communicative style of MSFC have been a factor contributing to the Challenger accident? I had not planned to put that question directly to my interviewees. But it seemed to be a natural one to pose during six of the interviews because of the concerns I heard expressed.

Here is what the six I asked had to say:

- I don't know. Lucas's style did intimidate a lot of people. I'm not sure, but society requires us to say 'yes'--we fire the football coach when the team doesn't win.

- Yes, the communication problem was a factor--but not the night before. We knew about the O-rings, but I'm not sure the problem was communicated to the right people. And it was not clear who was to be the project director, the Center Director or someone else.

- Was it a factor? My opinion is that is probably a true statement. We developed a feeling, 'Well we've had 25 flights and weren't going to have a failure.' We ignored or put off the problem.

- Was it a factor in *Challenger*? We all knew about the O-ring problem. We met in August and had a solution, but Lucas and Hardy were under pressure to be on time with the flights. To hold up a flight was difficult. The level of fatigue was dangerous....The teleconference got turned around. When challenged, Thiokol, rather than standing behind their data, told the government what they thought it wanted to hear....Yes, there was a communication problem.

- There were four factors that I see: (1) There was some basis in Lucas and his style; (2) some basis in the goals from Beggs [the NASA administrator who determined the frequency of shuttle flights] and his advertising to the public; (3) some basis in the misinterpretation of the O-rings--we were misreading the hardware; and (4) if Thiokol had said 'We don't want to fly,' then there would have been no flight.

- Was communication a factor in the *Challenger* accident? I worry about that a lot. My impression is that Thiokol was opposed to the launch at the engineering level. They were surprised at the stance of the Marshall managers. Always before, the Marshall managers would make sure that it was okay to launch. the teleconference was atypical. We needed more openness in the agency than we had then. We've seen the results otherwise.

I asked, 'What results?'

The manager said, '*Challenger*' (Tompkins 1993, 166 - 7).

Clearly Tompkins demonstrated that the Marshall Space Flight Center had some serious communications problems.[110] Tompkins provided the cover of anonymity to the Marshall employees in order to get them to express their true feelings concerning the management style of Dr. Lucas. Using Gendlin's (1973, 304)[111] signposts for phenomenological explication, we discover from the interviews that the Marshall Space Flight Center (MSFC) organization that a pattern of hostility and intimidation had been built into the organization's culture during Lucas's tenure. Managers Mulloy, Kingsbury and Reinartz were also a critical part of the decision to launch the Challenger and, according to organizational participants above, were important to maintaining the

[110] This style of management fostered by Dr. Lucas at the Marshall Space Flight Center could certainly be construed as being symptomatic of a culture of narcissism and supportive of Schwartz's argument above.

[111] See also Chapter 1.

dysfunctional management style of the senior managers at Marshall.[112]

Tompkins' analysis of the dysfunctional managerial style of communication at the Marshall Space Flight Center, which was influenced by Feynman's orgcom theory, provides us with an insight into some of the management practices at NASA prior to the *Challenger* launch decision. *Tompkins and Feynman show that there is a major discrepancy between what managers and workers know.* This theoretical insight will be further explored and developed in the next section.

The Challenger Launch Decision and the Knowledge Analytic

Theories previously considered in Chapter Four and earlier sections of this chapter, whether from the functionalist, radical structuralist, or radical humanist paradigms, depict events leading to the *Challenger* launch decision in a single framework of knowledge. A recapitulation shows that knowledge from the functionalist paradigm is limited in its ability to explain the hypotheses statements which encompass (1) managers ignoring employee warnings; (2) managers not taking responsibility, but rather blaming the employees, in the name of protecting the organization; and, (3) managerial underestimation of other organizations and the intrinsic need of managers to control every aspect of their own organization. Functionalism promotes the status quo and reinforces the traditional management notion of hierarchy.[113] Recall that in regard to the first hypothesis, functionalist theorists, insofar as they attempted to explain phenomena, presented arguments indicating that managers had position power and the prerogative to ignore the engineers warnings by virtue of their position within the organization's scalar chain. Other functionalists,

[112] See Appendix A for organization charts on NASA and the Marshall Center, specifically.
[113] We have also seen that this "notion" can be an ideology. See Stone (1997) above. We will also cover this topic more thoroughly below.

notably the risk theorists, noted that a proper decision was rendered. Due process was granted to lower organizational participants in that their concerns about the O-rings and other work aspects were given a proper hearing. No evil deeds were done and the decision makers simply made a mistake. According to risk theorists, no one in the organization was at fault for the accident, because all of the rules had been followed. Their view was that the organization functioned normally and that it was unfortunate that the accident had occurred. As far as the second and third hypotheses are concerned, workers became objects to be used by managers as part of the regular organizational process. No one was to be blamed for a properly functioning organization in which control of employees is part of the normal state of affairs. With functionalist theories, we see from this *Challenger* case study *the generation of knowledge about the shuttle launch decision from the traditional managerial perspective.*

Radical structural theorists represent events surrounding the Challenger launch decision from the worker's (or in this case study, the engineer's) perspective. Engineers critical of the launch decision were either systematically ignored or exploited by managers. Managers, promoters of the status quo and part and parcel to the bourgeois hierarchical structure, moved the engineers into a position where the engineers were dominated in the decision to launch process. The NASA organization was the instrument of domination used by executives and managers to exert their will over the affected employees in the NASA and Morton-Thiokol organizations. *Radical structural theories as demonstrated in this case study contribute to knowledge generation from the point of view of the workers affected by the launch decision process.* Workers were used as objects to justify and legitimize the preconceived and predetermined decision to launch by the managers. When objections to launch were voiced by the engineers, they were intimidated by the NASA managers to stop voicing their dissent. Radical structural theorists also add that this a normal part of the exploitation process of the capitalist-based management ideology prevalent in western society. Safety concerns for lower organizational participants were of secondary importance to economic considerations.

Radical humanist theorists are primarily concerned with showing how individuals can affect, or are affected by, organizations. In this case study, there are two primary means by which radical humanist theorists are critical of the NASA organization. Firstly, NASA executives and managers were ill psychologically, or narcissistic, and had a fantasy-oriented representation of the world. The NASA organization was suffering from the effects of narcissistic leadership. Sound judgments which would be normally made were lost to the absurdities of the decaying organizational culture. Fantasy replaced reality and allowed for the ill-fated launch decision. Secondly, we find that other radical humanist theorists approached the case study from an ethical dimension. They contend that the unethical NASA organization, with the equally culpable Rogers Commission, engaged in a coverup to protect NASA managers, who were identified as being a critical part of the organization. In effect, radical humanist theorists concerned with the ethics of the NASA organization show the absurdity[114] of a situation wherein no single individual is held responsible for making the launch decision. *Knowledge gained by the analysis of the* Challenger *case study by radical humanist theorists demonstrates what can happen when the utopian absurdities of idealism, promoted by executives and managers, are foisted upon lower level members of the organization.* Regarding the hypotheses statements presented above, managers ignored important information from workers when it did not suit what they ideally wanted. The NASA organization also attempted to protect executives and managers through the Rogers Commission hearings, where it was pointed out that no one was at fault for the launch decision. Finally, control over every aspect of the NASA and Morton-Thiokol organizations was attempted by the NASA managers as they held a narcissistic conception of their ability to control events in a preconceived perfect world.

We have now arrived at the point where multiple conceptions of knowledge may be considered when analyzing the *Challenger* launch decision

[114] An important distinction is drawn here on Heidegger's (1962) discussion of "meaning" and "absurdity," or what Heidegger calls "unmeaning": "The *concept of meaning* embraces the formal existential framework of what necessarily belongs to that which an understanding interpretation Articulates. *Meaning is the 'upon-which' of a projection in terms of which something becomes intelligible as something; it gets its structure from a fore-having, a fore-sight, and a fore-conception.* In so far as understanding and interpretation make up the existential state of Being of the "there", "meaning" must be conceived as the formal-existential framework of the disclosedness which belongs to understanding. Meaning is an *existentiale* of Dasein*, not a property attaching to entities, lying "behind" them, or floating somewhere as an "intermediate domain". Dasein only "has" meaning, so far as disclosedness of Being-in-the-world can be "filled in" by the entities discoverable in that disclosedness. *Hence only Dasein can be meaningful [sinnvoll] or meaningless [sinnlos].* That is to say, its own Being and the entities disclosed with its Being can be appropriated in understanding, or can remain relegated to non-understanding.

This Interpretation of the concept of "meaning" is one which is ontologico-existential in principle; if we adhere to it, then all entities whose kind of Being is of a character other than Dasein's must be conceived as *unmeaning [unsinniges]*, essentially devoid of any meaning at all. Here "unmeaning" does not signify that we are saying anything about the value of such entities, but it gives expression to an ontological characteristic. *And only that which is unmeaning can be absurd [widersinnig].* The present-at-hand, as Dasein encounters it, can, as it were, assault Dasein's Being; natural events, for instance, can break in upon us and destroy us" (193).
*Note to readers Dasein means literally "being there" or existence. For a more thorough discussion of Dasein see Husserl (1973, 387 - 8).

case study. We have seen in the interpretive "orgcom" theoretical frameworks provided by Feynman and Tompkins that there is a discrepancy in assessing reality by executives, managers and workers. Traditional and unconventional interpretations offered by theorists analyzing the launch decision represent a largely mutually exclusive and one-dimensional image of what transpired in this complex human event. As we have seen, there is a tendency by theorists to perceive the *reality* of the event from either the management or the worker perspective. When theorists engage in an explanation of an actual event and pursue it from a single image, something of the complexity of the event is lost in translation. Clearly Feynman and Tompkins were intrigued by the evidence that they had gathered from individuals about the phenomena of perceptual differences between members of the organization. Feynman pointed out the wild discrepancy regarding the probability of a mishap based on the SRB technology between the Marshall manager, Judson Lovingood, and the engineers. Feynman also was bewildered by the safety concerns expressed by Mr. Ulian, i.e., the safety factor of putting explosive charges on the space shuttle launch system in order to prevent a mishap which would affect population centers near the launch site, in that the "big cheeses" had an unrealistic assessment about the chances of a catastrophe occurring. Tompkins uncovered the veil of secrecy about the excessive absurdities through which the Marshall Space Flight Center had operated under Dr. Lucas. A culture of intimidation was built in order to control information received from lower level participants in the organization. Information, or knowledge about the work that was presented by members of the MSFC, was suppressed and devalued by the omnipresent management ideology. Feynman and Tompkins indicate and anticipate in their analyses that there are at least two kinds of knowledge in organizations: executive/managerial and worker.

There is a conceptual framework available for interpreting differences between *knowledges* (plural) provided by Carnevale and Hummel (1996, 9). Based largely upon the work of the philosophers Immanuel Kant, Edmund Husserl and Martin Heidegger, Carnevale and Hummel (1996, 19) developed the *knowledge analytic*[115] as follows:

> Once we...raise the question of how we know and how different people at different places in organizations know, problems arise, for us and and for them:
>
> How do we know what we want?
>
> How do those whom we instruct know what we want?
>
> How do they know what it takes to work out what we want?
>
> The modern organization structures the answers to these questions because it structures knowledge:
>
> We, we executives, know what we want by the numbers.
>
> We, we managers, know what we see and want as objects;
>
> these we define and manipulate: organizational structures, the work as an object, the workers as objects; all these get named by us and moved around for maximum economy and efficiency like [a] piece on a chessboard.
>
> 'They' ...well, they, the workers, are not assumed to know much of anything. They simply do. They work. They carry motions of working according to our plans.
>
> The resulting knowledge/work pyramid...

---

[115] See, for example, Immanuel Kant's *The Critique of Pure Reason*, (1984) (trans. J.M.D. Meiklejohn), Chicago: Encyclopedia Britannica, Inc. (originally published in 1781), Edmund Husserl's *Experience and Judgment*, (1973) (trans. J.S. Churchill and K. Ameriks), Evanston, IL: Northwestern University Press (originally published in 1948), and Martin Heidegger's *Being and Time* [*Sein und Zeit*], (1962) (trans. J. Macquarrie and E. Robinson), San Francisco: Harper Collins Publishers (originally published in 1926).

Executives know the ideal product;

Managers know the means as objects.

Workers work.

...contains, after all, the genius of modern organization. Moving away from the uncertain and ill-defined knowledge of actual hands-on work to ever more certain, objective, and ultimately numerical standards of product and process, the modern organization is able to produce its miracles of mass production, mass service, and mass controls according to highly precise standards.

The assumption, however, that executives and managers have knowledge and workers don't is simply not borne out by further analysis. It is a *management ideology*: a way of thinking about knowledge that furthers management interests and prevents profound questions from arising, not only about work, not just about respect and reward, but about necessity of having workers who know what they are doing.

...The underlying principle here is that organizations are not simply divided into those who have knowledge and the rest is simply working. Instead: *both the organizing and the working require knowledges, plural, and these knowledges are not only different but incompatible in the sense of one not comprising the other....*

[The first principle of the modern organization] is that modern rational and scientific knowledge of work processes must be balanced by opportunities to translate it back into actual working moves. Knowledge of pure ideas, even the detached objective knowledge of mid-managers, must be translated into the less pure but engaged knowledge of what to do. Since modern organizations ordinarily value ideas more than reality, reforms tend to tighten the rule of ideas and subvert the reality of work. In short the answer to idealism's move toward perfection is: the protection of imperfection.

For all of these questions, however, it is necessary to inquire into the nature of the knowledges involved: to engage in a knowledge analytic.

The knowledge analytic asks: *What are the kinds of knowledges in modern organizations, how do they work, how can they be brought to work together?....*

The approach reexamines management's claim to possessing a monopoly of knowledge....[though it] does not share the conventional modern assumption that there is only one kind of ultimate knowledge in organizations. The analytic asks a simple question: *How do people in organizations know things?* [There is not simply just the knowledge of pure reason]....

Questioning the monopoly of reason also calls in question the *possibility of a single knowledge elite*.....the knowledge analytic asks whether there is not a prejudgment or bias in the way the modern way of thinking ties effective work to ever greater perfection in one, single kind of knowing which we are used to calling by the singular term 'knowledge'....When it was tacitly assumed that there was only one kind of knowledge, all reforms could be viewed in terms of perfecting that kind of knowledge. The history of reforms could be read as gradual but solid progress toward a perfect state when no more adjustments and adaptations would be needed. The tolerances could be tightened and closed....the knowledge analytic begins by reopening the question of a plurality of valid knowledges (Carnevale and Hummel 1996, 2 - 9, italics added for emphasis).

We have seen from many of the previous interpretations offered by theorists analyzing the *Challenger* launch decision a parallel rationalization to the knowledge/work pyramid for the position of workers and/or managers with the knowledge analytic. We have found that the ubiquitous scientific (functionalist paradigm) theoretical renditions of events leading to the *Challenger* launch reinforce the tendency for the dominant management knowledge ideology manifested in modern Western society. Radical structuralist theories specific to this case study explore the domination of the management ideology as it pertains to the workers (engineers). The Thiokol engineers were used as instruments for their knowledge by managerial elites in order to legitimate the management decision to launch *Challenger*. When the engineers, who were intimate with the working knowledge of the space shuttle system, refused to cooperate with the management decision they were harassed, ignored, and later fired, as in the case of Roger Boisjoly. As we have seen, psycho-analytic organization theorist Howard Schwartz made the argument that the NASA organization managers charged with making the decision to launch were narcissistic and had an idealized conception of themselves to the point that common sense was lost. Sound judgment was altered by a psychosis which was prevalent in the NASA organization culture.

The NASA was thus the "perfect" organization captured by its idealism. NASA managers *were* the organization.

The tendency to think about the case study in a preferred way of thinking, or under the rubric of a single knowledge, is powerful and difficult to overcome. As we have seen from various perspectives, the theoretical explanations of the *Challenger* launch decision generally are from one major paradigm with embellishment from theories mostly to resolve the *functionalist problematic* which emphasizes the objectivist nature of the world. The functionalist problematic, used by scientific theorists in trying to overcome science's shortcomings, has a propensity to show a concern for explanations which emphasize the regulation of social affairs *for* the dominant management ideology (see Chapter 4; Burrell and Morgan 1979, 28). Worker knowledge and human relations within the organization have presented problems for the idealized functioning of organizations through the eyes of management elites. Modern management has been attempting to address the shortcomings of science through various reforms in order to deal with the functionalist problematic. Carnevale and Hummel (1996) point out the futility of management reforms with a single dominant ideological orientation as "Perfectionist reform may be seen as futile attempts to homogenize the knowledge structure of modern organizations. Reformism pursued in the face of evidence of plural knowledges would be challenged as a totally unjustifiable totalitarianism" (10). Carnevale and Hummel also add that "evidence of different kinds of knowledge is indeed found in modern organizations" (1996, 10) and that an analysis which leaves behind any of the different kinds of knowledges is incomplete.

In order to get beyond the traditional focus of seeing events from the view of either just the management perspective or just the worker perspective, we must be prepared to understand that there are differences in how members in modern organizations perceive reality. The knowledge analytic

> ...outlines the differences between how managers know and how workers know as the paradoxical key problem to be overcome by modern organization -- paradoxical because what makes modern organizations so powerful is that they have solved the problem of translating working knowledge into management knowledge but not the problem of translating management knowledge back into working knowledge. In anticipation of the results of what we call a knowledge analytic of the modern organization, we can summarize our findings:
>
> 1 -- The modern organization is not, contrary to all claims, built on one kind of knowledge, not even on two but on five: three types of knowledge inside the organization and an additional two outside.
>
> 2 -- The three types of knowledge inside the organization are: the numerical knowledge of administrators and executives, the often scientific but minimally at least objectifying knowledge of managers, and the experiential knowledge of workers. These are distinct enough of each other to be named separately: pure reason, science, and experience.
>
> 2a -- The three types of knowledge harnessed inside the modern organization are in fundamental ways incompatible. As knowledge and control ascend from the worker to the manager to the executive or administrator, parts of each type of knowledge are left behind. This clears the way for rational calculation governing the organized components of the organization but at the same time creates a paradox: The type of organization that knows so much in general about all its structures and functions knows in reality so little, the higher up you go, that it is incapable of instructing its workforce in any meaningful way: that is, without translation by the workforce. This is the ultimate paradox: Those whom the organization considers to know the least are charged with the most knowledge-demanding task: the translation of essentially meaningless orders into work.
>
> 3 -- The dominance of reason and science is both driven and modified by two types of knowledge outside the organization. These are, served by science and reason at the very top, the system of ideas of those who have an investment in organizations whether economic or political. Following usage in philosophy we can call a system of pure ideas or of ideas claiming to be more real than the real: idealism. At the

bottom of the organization, however, is the utilitarian realism of the consumer and client: there the knowing of what an organization does is in terms of pragmatic use. Idealism and user realism (in a sense: utilitarianism) are at odds and produce contrary pulls.

4 -- In a clear way, the organization is pulled in opposite directions: At the top, toward success in investment markets, including political investment in the legitimacy of the political system (Is there a profit? Are ideals upheld?); at the bottom, toward success in consumer markets and client constituencies (Does it work?).

5 -- Idealism of 'investors' and realism of consumers and clients exert a constant pull and tension throughout all the knowledge types of the organization, even in normal times. In times of crisis, when one or the other seems to win out, the pull becomes destructive of the organization itself, and those with the most power threatened find they must reorganize to maintain it.

6 -- The long term victor in the contest between idealism and realism has been -- over the 400-plus years of modern thought -- idealism. Modern Western civilization's idea of progress is simply that mind will triumph over matter. The actual work of accomplishing that triumph is correspondingly devalued: it is bound too closely to what is the matter.

7 -- The recurrent reforms of the last three decades -- recurrent and coming at ever closer intervals -- reflect the triumph of the idealism that has guided the work of modern organization during the centuries. In its perfect incorporation in the modern organization, the dogma that ideas are more real than the real, has finally reached such perfection that in some organizations working experience and customer/client knowledge of the real have been almost totally driven out of the enterprise or agency. Paradoxically, the cause for every newly needed redesign and reorganization is the increasing perfection of the organization itself, driven most lately by the dominance of the pure reason of the computer (Carnevale and Hummel 1996, 11 - 14).[116]

Following Carnevale and Hummel (1996 17 - 8), we can readily see in the *Challenger* case study the problem of different knowledges and how this can affect the way decisions are made. The Thiokol engineer Roger Boisjoly, involved in *worker realism*, could not *quantify* his rationale for not allowing the

[116] See Appendix A for Carnevale and Hummel's (1996, 63) "Figure 2: Knowledge Taken and Left Behind by Leading Groups."

shuttle to launch, even though he believed, based on his experience, that the O-rings would not be able to respond properly to the cold temperatures at the time of the launch. Also, note the strange twist in NASA culture as demonstrated by the claim "there was pressure to launch" put upon Morton Thiokol engineers as opposed to traditional organizational conceptual statements "prove to me we can fly", "give me a study" or statements such as "where is the statistical evidence" to support your conclusion not to fly. This requirement of scientific or mathematical proof displaces intuition, particularly on the part of Boisjoly and Thompson, where the "blow-by" in the temperature range at 53 degrees Fahrenheit would not seem reasonable in comparison with the 36 degree temperature (questioning judgment). It is paradoxical that those individuals with the least experience and inclined towards using scientific rationality, the NASA managers Mulloy and Hardy, overruled those workers with the most experience, Boisjoly and the Thiokol engineers. In a less dire yet revealing tale, physicist and investigating Rogers Commission member Richard Feynman demonstrated the disparity in knowledge about the possibility of engine failure with his "adventure" to Marshall Space Flight Center. Engineers at Marshall with first-hand experience about the reliability of the solid rocket motors had a radically different interpretation than the manager over them, Judson Lovingood. Also, Feynman recounted the incident of Mr. Ulian's problem of using explosives to destroy an out-of-control shuttle and the big cheeses (executive *rationalism*) exerting their idealistic and unrealistic conception about the numerical odds and possibility of a shuttle falling on a populace and causing tremendous damage, death and destruction.

As applied to the *Challenger* case consider the "operational" unrealistic launch rate that led to worker fatigue (*Report I* 1986; McConnell 1987) and

Trento's (1987) depiction of Acting NASA Administrator Graham "as a right-wing kook" driving the organization beyond its realistic limitations. Profit motive was a major concern for management at NASA based on *investor idealism*. Holt and Morris (1993) showed in their production/consumption paradox node that there was an inherent contradiction between the high monetary costs of the operational mode of 24 flights per year mandate from NASA executives and the problem of crew safety. The economy/efficiency argument superseded the crew safety concern.

We can see the result of the decision to launch on those clients who experienced the loss of their lives: the astronauts. One of the results of the Rogers Commission was that those affected by the launch decision directly, the astronauts, would have representation on any launch board or panel. This is surely a correct and appropriate response to the tragedy and it should have been in place prior to the *Challenger* incident. The fact that astronauts were not involved in deliberating whether the shuttle should be launched is indicative of the predominance of management ideology. It took a tragic event of the magnitude of the loss of *Challenger* and the realism of what happened to the clients (*client realism*) to force a change in management thinking.

Scientists who favored unmanned spaceflight also had a stake in the NASA organization. The astronomer James Van Allen and the robotics scientist from MIT, Marvin Minsky, were in favor of scientific missions which entailed the use of unmanned spaceflight for research purposes and were in principle opposed to the space shuttle program. Manned spaceflight was expensive, risky and ultimately tragic for human beings. There was a battle for scarce resources between a small contingent of scientists with a vested interest in how the NASA organization allocated its funds.

The NASA organization was, *from its inception*, constantly selling itself as a potentially profit-making enterprise for economic and political investors.[117] A prime example of selling the NASA Space Shuttle Program was put forward by James C. Fletcher, former and future NASA Administrator, who penned the article "Are SKYLAB and the Space Shuttle Worth the Investment?" in *Government Executive*, January 1974, to rationalize to potential investors the benefits of flying with NASA, which [erroneously] would be *fully operational by 1980*:

> I will summarize the benefits we expect from the Shuttle...
>
> - ...the Shuttle will save more than $1 billion per year in launch costs and payload costs.
> - The Shuttle is also much more versatile than present rockets...
> - It will be a great boon to scientists and other users because it will greatly reduce the lead time and cost of preparing their experiments and permit them to accompany their experiments to orbit when necessary.
> - The Shuttle wipes out the long-standing argument whether we should empahsize (sic) man's role in space or automated spacecraft. The shuttle makes it highly advantageous to use both men and machines.
> - The Shuttle will be used for both science and practical benefits in Earth orbit. It will open up new opportunities such as space manufacturing.
> - The shuttle will give us a space rescue capability at all times and at reasonable cost.
> - The Shuttle calls for significant advances in aerospace technology...
> - Like Skylab, the Shuttle initiative of the United States greatly encourages and facilitates international cooperation in space...
> - The Shuttle is the key to America's bright future in space. There is no substitute for it as the lead project and focal point for developing space technology and space uses in this decade.

[117] See the history of the NASA organization presented in Chapter 3.

..In short, there is no new frontier in space for America and for mankind without the Shuttle.

All of our cost/benefit studies show the Shuttle a very worthwhile investment. Even if they did not, I would say we should build it. We cannot run spaceship Earth without it (Fletcher 1974, 41 - 2).

We see here an appeal to the idealism of the investor ostensibly in order to obtain support for space shuttle program.[118] From Fletcher's bullets and an examination of the history of the space shuttle, we gain an insight into the problem of selling the then not-yet-completed idea of NASA's space shuttle program. There were several aspects of investor idealism appealed to that have never come into being. Firstly, the shuttle space system has never been able to pay for its launch costs as advertised. Secondly, several scientists, as we have seen previously, have never believed that the shuttle project was a great scientific boon; rather they have seen the space system as a bane to their research. Thirdly, space manufacturing has not materialized as implied within the time frame put forward by Fletcher. And finally, while it remains to be seen as to whether the space shuttle systems is effective as a rescue vehicle, it certainly has not lived up to the cost schedule as outlined by Fletcher even after seventeen years beyond 1980.

NASA Administrator Fletcher is by no means alone in his idealistic rendition of selling the space shuttle program to investors, both client and consumer. The essence of the distinction between the idealism of the administrator and the reality of the life-world is captured by Carnevale and Hummel (1996):

[118] In reality, of course, most of idealistic these goals outlined by Fletcher *have never happened.* Heidegger (1962) on idealism points out that "When something no longer takes the form of just letting something be seen, but is always harking back to something else to which it points, so that it lets something be seen as something, it thus acquires a synthesis-structure, and with this it takes over the possibility of covering up" (57). This conception of synthesis-structure is in marked contrast to the "as-structure," or what "The philosopher Martin Heidegger calls this higher sense of what a thing is when connected to human use the 'as-structure' of things" (Carnevale and Hummel 1996, 30; see also Heidegger 1962, 199 - 200).

We find ourselves in an economy that ritualizes not only investment activity, but organizational activity and work activity. This parallels the ritualization of politics and administration. Things are done this way because they have always been done this way. And besides, it is popularly argued, the reinvestment economy, the hierarchical political and organizational design, scientized work -- these are the structures for conducting productive economic and political life that exist and one must work within them.

The investor and the citizen are as imprisoned by the structures within which his knowledge of the world runs as anyone else (59)....the government worker, like the administrator and middle manager, is constantly called to account for actions...whether they make sense in working life or not. All the complaints about bureaucratic administration ultimately have their source in the separation between judgments made ahead of time about administrative situations by people who know nothing about administrative work and judgments that must be made in the situation by those who know administrative work only too intimately (Carnevale and Hummel 1996: 59 - 60).

The knowledge analytic represents the reality that multiple forms of knowledge exist in organizations. Carnevale and Hummel (1996, 17 - 8) note that "Different forms of knowledge indeed exist, each affiliated with a different interest. Drawing from the total repertoire of major types of knowledge in modernity, we identify them as:"

Idealism -- affiliated with investors and citizens [Congress, President, shuttle contract investors, scientists with interests outside of unmanned spaceflight, and the American public.]

Rationalism -- affiliated with chief administrators [Graham, Lucas and other NASA officials, particularly at the highest levels]

Science -- affiliated with management scientists and mid managers [Mid-level managers such as Kingsbury, Reinartz, and Mulloy at NASA and Lund at Morton-Thiokol]

Realism -- dominant among those who ultimately and directly produce the goods and services and those who use them [engineers such as Boisjoly & Thompson, analysts such as Richard Cook, and the seven *Challenger* astronauts]

Consider these types of knowledge. Their location on an outline of the organizational pyramid can already be mapped:

Figure 5.1 [Fig. 1]: Interests and Their Types of Knowledge

Investor Idealism

Executive Rationalism

Management Science

Worker Realism

Consumer/Client realism

The idealism of investors will not only be compatible with the rationalism of administrators but will command such rationalism (Carnevale and Hummel 1996, 17 - 8) [Note: I have applied here my conception of the *Challenger* case study to Carnevale and Hummel's typology].

We have seen from examining the *Challenger* launch decision case study a clear distinction between the relationship of knowledges between the various interests in the NASA organization and the Morton-Thiokol organization. Knowledge incompatibility and the question of the ultimate reconciliation of the divided reality of everyday working knowledge, scientific knowledge, and investor knowledge are central to the knowledge analytic:

> The question now becomes: What is the relation between these different kinds of knowledges?...Is a comprehension of these types of knowledge by one of them possible? If not then all management reforms will continuously follow the chimera of a unified knowledge system when the reality -- which someone has to absorb --is one of different kinds of knowledges in a state of mutual misunderstanding (Carnevale and Hummel 1996, 31).

The primary compatibility problematic[119] for organizations is the differences in knowledges between science and the everyday work experience of the workers:

> Ultimately, management science 'proves' it is in certain ways superior to working knowledge. This certainly holds true for scientific management's ability to control energy input into work (economy) and in reducing the ratio between energy input and output (efficiency)....scientific management and science in general must deny the validity of a working knowledge that is adequate for its own purposes....It must also deny any worker's ability today to make judgments about that which he directly experiences unless these judgments can be generalized....
>
> What needs to be considered here is the possibility that scientific knowledge and everyday working knowledge are far removed from one another in the definition of experience and things. The two may, in fact, be so far apart as to be possibly incompatible: i.e., requiring transformations into each other's terms that leave essential characteristics and knowables behind....As long as there are economic and other power interests that value such scientific products as control, economy and efficiency, they can also compel a worker attitude that pretends to be appreciative of science's findings and, as management science, its working imperatives (Carnevale and Hummel 1996, 47 - 8).

We see clear evidence of the incompatibility of scientific knowledge and worker (engineer knowledge) as depicted in the testimony of Morton Thiokol engineer Roger Boisjoly given during the Rogers Commission hearings. Despite repeated warnings to the NASA managers in both written[120] and oral form, Boisjoly's knowledge about the possibility of O-ring failure based on experience, a gut feeling and intuition (or worker realism) was ignored by the NASA managers charged with rendering a management decision (or management science) who wanted Boisjoly to quantify his position in a limited

[119] The compatibility problematic shares the same puzzling aspects as the functionalist problematic for theorist of a scientific or functionalist orientation. In Chapter 4 above we examined how sociological positivism attempts to reconcile its explanatory shortcomings by incorporating more radical influences from the radical structuralist and interpretive paradigms. See also Burrell and Morgan (1979, 27). The knowledge analytic makes a clear distinction between subjective worker knowledge and the allegedly more objective management science, acknowledging their mutual incompatibility.

[120] See Appendix A for written warnings about the O-rings from Boisjoly and Thompson.

amount of time.

The knowledge analytic as presented by Carnevale and Hummel (1996) does not pretend to be a perfect theoretical conception. There is a recognition, instead, that imperfection is an ever-present fact of human existence. What the knowledge analytic provides for managers, practitioners and academicians is a systematic means to recognize the reality of differences of knowledges in organizations. In order to reform mistakes and/or errors in organizations, the manager or analyst must be cognizant of the reality of the following conclusions as presented by Carnevale and Hummel (1996):

> 1 -- *No total knowledge system so far conceived under the reign of idealism and positivism can ever be perfect*....it tends to [capture] itself within its own techniques which are insensitive to human demands outside of them.
>
> 2 -- *With the existing knowledge system dominated by idealism and positivism, reform is ever and again needed* [permanently].
>
> 3 -- *The viable reform can nevertheless be defined.* Its place is wherever purportedly irresistible pure thought must be modified, in order to get work done, by the immovable realities of work itself, including the organization of work in such a way as to make work possible (69 - 70).

Interpretivism and Hypotheses Explanation: How Useful Is the Paradigm?

I will reiterate here the hypotheses stated in Chapter One in order for us to examine them in light of the explanations offered by interpretive theorists addressing aspects of the *Challenger* launch decision:

1. Managers ignored information from employees who knew what was going on.

2. Managers who ignore the useful knowledge of the workers will sometimes blame the workers when managements' plans go awry. Also, organizations will go to great lengths to protect the managers and the organization until compelled to do otherwise.

3. Managers hold the simplistic notion that they can control every aspect of their organization, and even those of other organizations.

Evidence presented by organization communications theorists Feynman and Tompkins demonstrated clearly that in the first hypothesis managers ignored the information from the Marshall workers. While there may be mental illness on the part of the Marshall Space Flight Center managers involved in the decision making process, there is no conclusive proof. By virtue of their position in the organization, the managers made a judgment about the odds of a disaster occurring based on management science rather than the worker realism of the engineers. As a result of the dominant management ideology, workers tended to be treated as objects useful only for their utility in performing organizational tasks. Feynman took the notion of differences in knowledge a step further by showing the discrepancy of management versus executive knowledge.

Carnevale and Hummel's knowledge analytic provided the conceptual framework for interpreting the different knowledges in organizations. The paradoxical nature of organizations have the internal problem of reconciling the numerical knowledge of executives (reason), the objectifying knowledge of science, and worker experience. There is also of the problem of investor and citizen idealism outside of the organization. Using the knowledge analytic I showed how scientific rationality was used by the NASA managers Mulloy and Hardy to overrule the Thiokol engineers in the course of the decision process (this aspect also applies to the third hypothesis statement.) Investor idealism affected the NASA organization by forcing the space shuttle program to operationalize when in reality it was still in an experimental stage. This led to deleterious consequences, such as worker fatigue, an unrealistic launch rate, and a focus by executives and managers on economy and efficiency rather than safety concerns. These factors all led to the ill-fated decision to launch which resulted in the loss of the seven astronauts (client realism).

The second hypothesis was supported by Tompkins's interviews of the MFSC workers. Dr. Lucas promoted an organization culture which humiliated and intimidated lower participants into not truly representing problems as they existed. Mulloy, Reinartz and Kingsbury protected their boss from bad news by resorting to methods such as "killing the messenger" and letting his "key subordinates [swing] in the wind during investigations." The acknowledgement in the interview by Tompkins also revealed that "[Lucas] never acknowledged we made a mistake with Challenger....Dr. Lucas resigned under pressure" (1993, 163 -5).

The major contribution by interpretive paradigm theorists is the discovery of multiple knowledges in organizations. The incompatibility of knowledges, especially between worker realism and management science, contributed to the ill-fated decision to launch the *Challenger* space shuttle. The perfect idealism of management science represented by the NASA managers dominated the imperfect worker knowledge of the Morton-Thiokol engineers.

CHAPTER VI:

CONCLUSION: KNOWLEDGES AND PARADIGMS

At the outset of this dissertation I undertook as my task the examination of the ill-fated decision to launch the space shuttle *Challenger*. In the accomplishment of that endeavor I utilized a framing, or metaphorical, approach from the organization theory literature devised primarily by Morgan (1986; 1997) and Burrell and Morgan (1979) in order to cover thoroughly the rich complexity of the single, historical event. Organization theorist Gareth Morgan anticipates this notion of complexity in the following passage:

> Organizations are many things at once! They are complex and multifaceted. They are paradoxical. That's why the challenges facing management [indeed, all members of the organization as we have seen] are often so difficult. In any given situation there may be many different tendencies and dimensions, all of which have an impact on effective management....metaphors...reveal this complexity. Each provides a comprehensive view of organization and management from the perspective created through the metaphor. Each generates insights. But taken to an extreme, these insights encounter severe limitations. Any given metaphor can be incredibly persuasive, but it can also be blinding and block our ability to gain an overall view (1997, 347).

I discovered in my pursuit of various explanations of the tragedy that *numerous scholars had interests similar to those of the organizational participants they portrayed and, in effect, had explained the events leading to the decision with an affinity for the manager's or the worker's perspective.* Of the two perspectives there is a noticeable tendency to overrepresent management rationalism. Morgan's work also generally tends to reflect this tendency (See Tsoukas 1993, 330).

The reframing, or images, method is useful for organization theorists and managers to acknowledge that several *insights*, not just one, exist when one analyzes behavior in organizations. The *Challenger* case study had numerous theoretical interpretations representing all four of Burrell and Morgan's sociological and metatheoretical paradigms. The paradigms are useful for categorizing the various perspectives offered by theorists in this case study. it was not, however, until we examined the interpretive paradigm (consisting of the "orgcom" theories presented by Feynman and Tompkins) that we could begin to comprehend that managers and engineers were not able to come to a basic understanding concerning "the work" in the NASA and Morton Thiokol organizations. Feynman explained his orgcom theory as the loss of common interest between the engineers/scientists and management which led to a deterioration in cooperation, thus resulting in the *Challenger* explosion. Tompkins embellished Feynman's theory by showing that the employees of the NASA organization were intimidated by the superior position of management and that communication between the managers and workers atrophied until credibility and trust were lost. The knowledge analytic (Carnevale and Hummel, 1996), as applied to the *Challenger* case study, extended Feynman and Tompkins's orgcom theories by revealing the incompatibility of knowledges between the engineers, managers and others in the organization. With the knowledge analytic we can begin to see possibilities regarding irreconcilable knowledge differences in organizations and expand our understanding of human interaction.

The decision to launch the *Challenger* case study has been thoroughly analyzed by social scientists, journalists, government officials and members of the NASA organization *themselves*. The hypotheses are recapitulated here as: (1) managers ignored employee warnings; (2) managers did not take responsibility for their own actions, but rather blamed the employees, in the name of protecting the organization; and, (3) managers underestimated other organizations and some managers sought to control every aspect of their own organization. From these hypotheses I found that *how* one interprets the course of events surrounding the disaster is determined in large measure by one's view of the world. The hypotheses had the effect of organizing theoretical arguments to address questions pertaining to human relations in the affected organizations. Of course, as we have seen, *how one perceives the tragedy depends on one's orientation to and identification with organizational participants involved in the tragedy*. That usually meant that managers were exculpated from the incident either *directly* by functionalist theorists who blamed the mishap on the engineers for ineffectively communicating their concerns up the organizational pyramid, or *indirectly* by other functionalist theorists and the Rogers Commission who blamed the decision making process. Some functionalists (notably risk theorists) directly implicated the organization structure and culture, thereby relieving anyone from decision making responsibility. Presenting the concerns of the worker, radical structural theorists in the *Challenger* case study showed the seamier side of organizational life by depicting the engineers as exploited victims of NASA managers and the *process* of the capitalist-based management ideology prevalent in Western organizational culture. Safety concerns for the astronauts and the shuttle were sacrificed for the sake of economy and efficiency. Radical humanist theorists demonstrated the ill effects of narcissism on the NASA organization and the absurd idealism of its senior managers which ultimately led to the *Challenger* tragedy.

The history of the *Challenger* accident will be explained for years to come. This is desirable. I have rendered a historical judgment of the events leading to the launch. It would be incorrect and presumptuous of me to pretend that this should be the final word (See Habermas 1988). The sheer complexity of human activity, especially complicated by the passage of time, invites continuous artistic interpretations of history beyond the scope covered here.

It is worth remembering here Allison's (1971, 276 - 7) admonition that paradigms neglect or underplay a number of aspects of governmental behaviors and that additional paradigms are needed. That wisdom is as true now as it was then.

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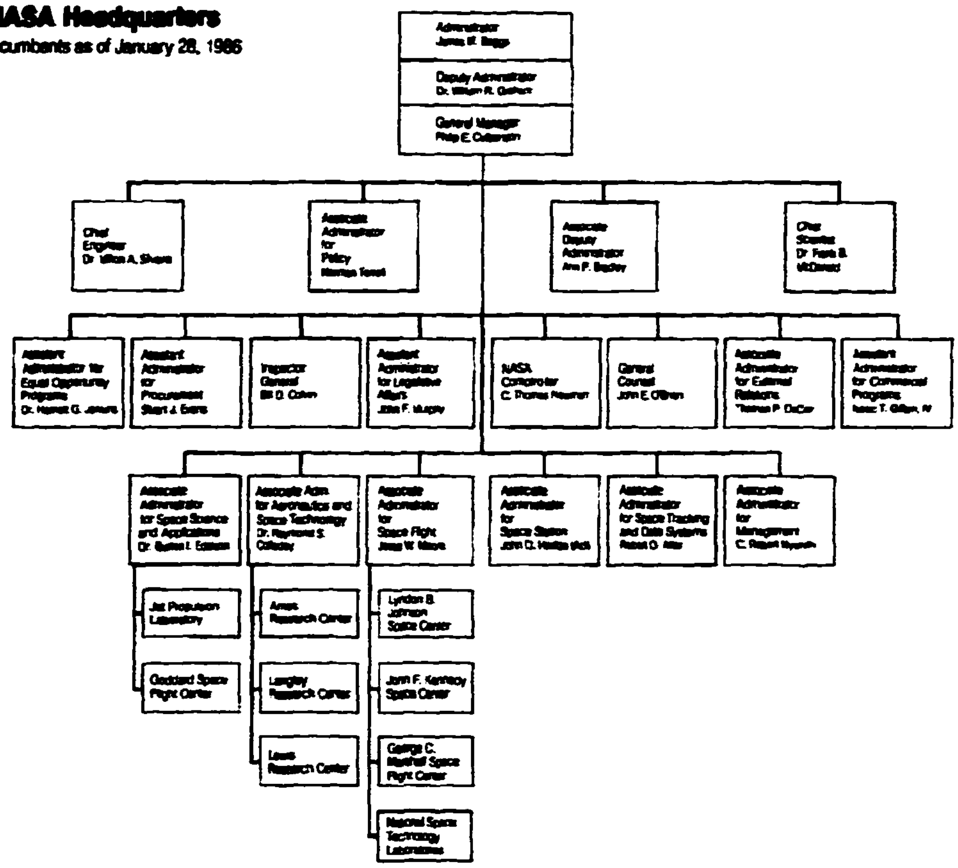
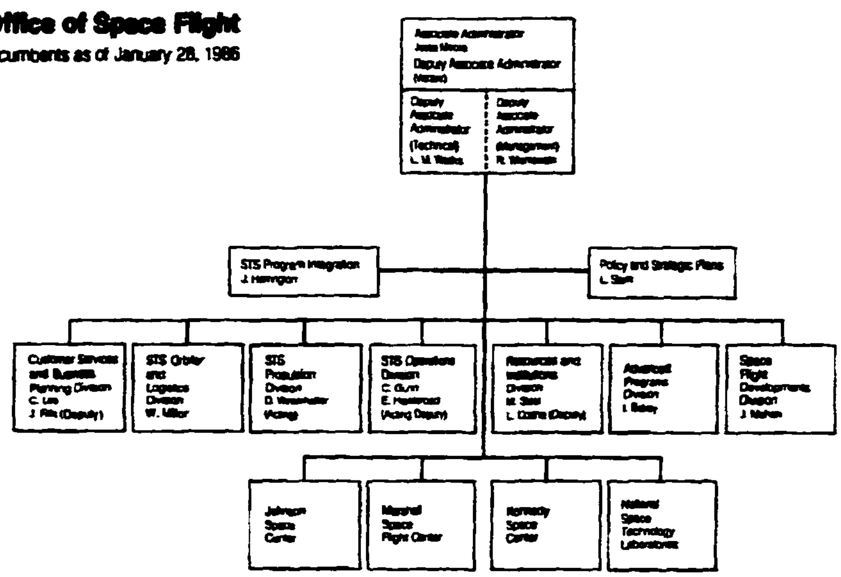
Relevant Organization Charts of NASA and Morton Thiokol

NASA Headquarters
Incumbents as of January 28, 1986



Office of Space Flight
Incumbents as of January 28, 1986

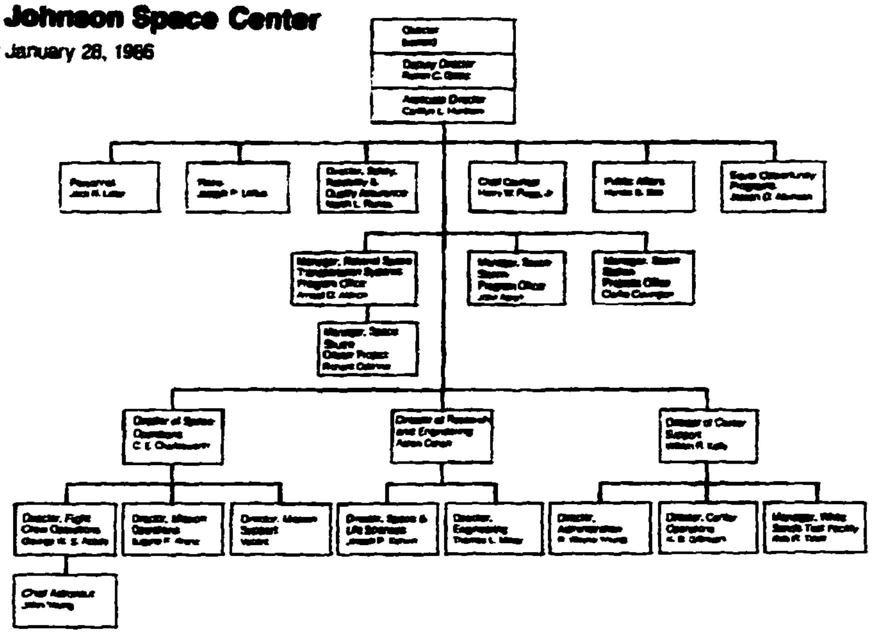


(Source: *Report I*, 226)

1 Appendix A

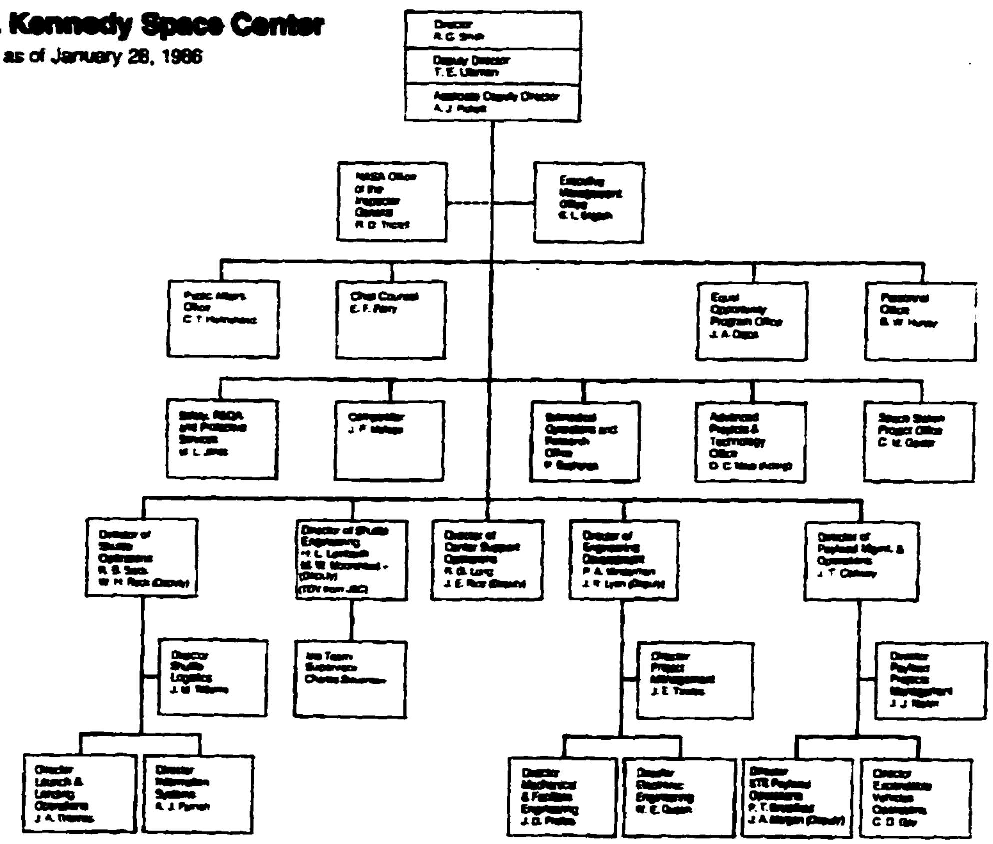
Lyndon B. Johnson Space Center

Incumbents as of January 28, 1986



John F. Kennedy Space Center

Incumbents as of January 28, 1986

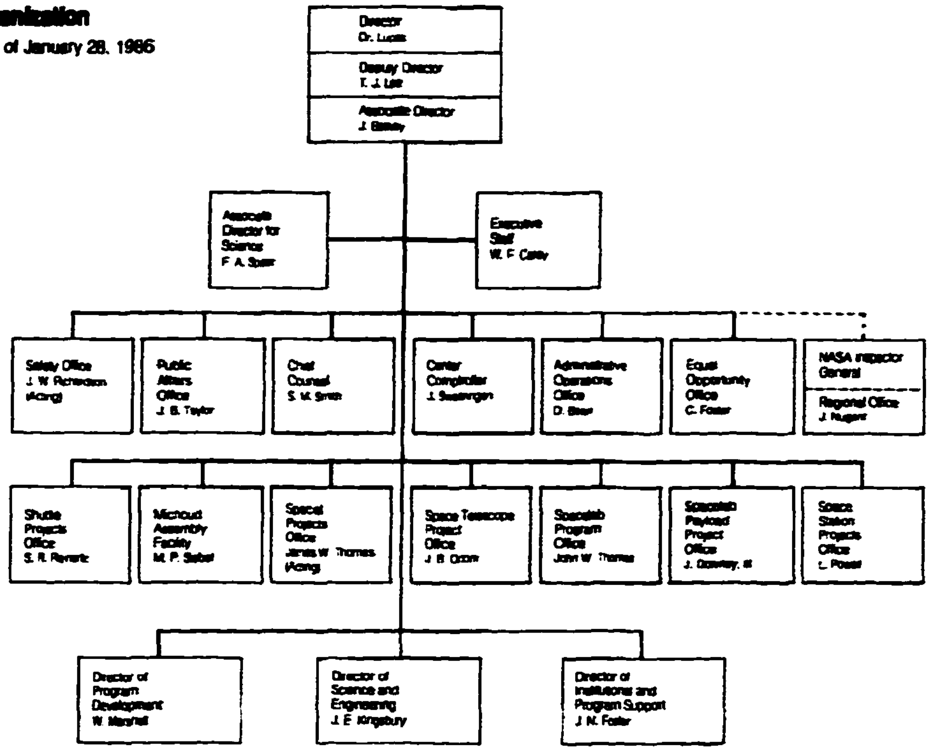


(Source: *Report I*, 227)

George C. Marshall Space Flight Center Organization Charts

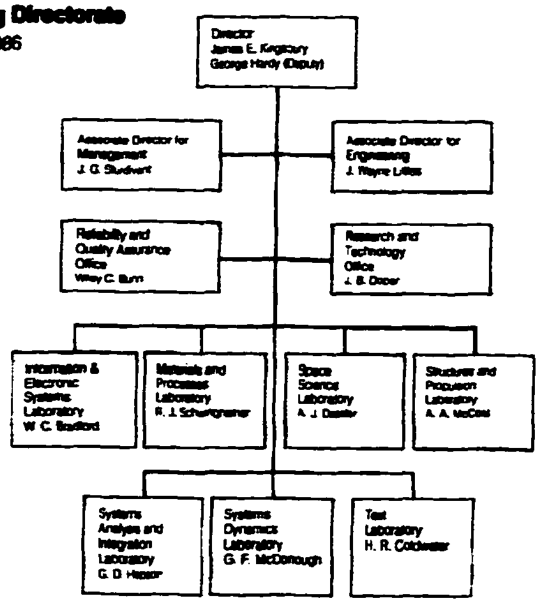
Center Organization

Incumbents as of January 28, 1986



Science and Engineering Directorate

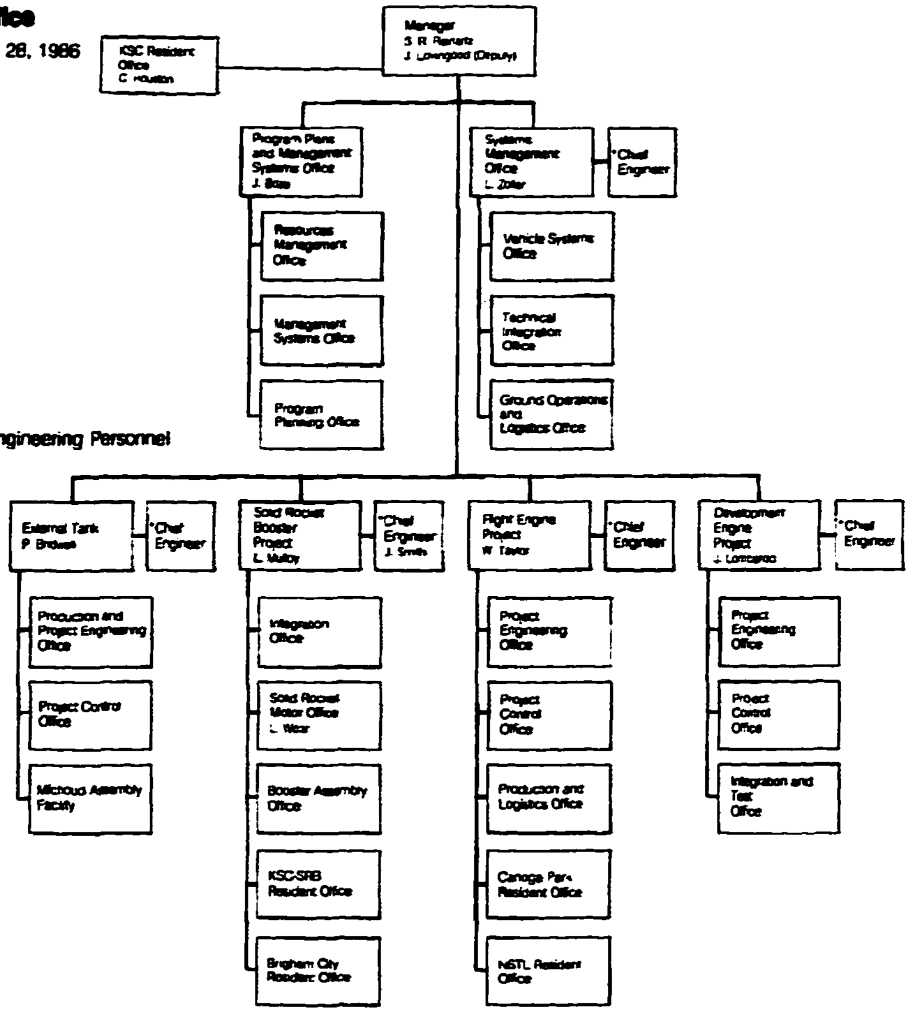
Incumbents as of January 28, 1986



(Source: *Report I*, 228)

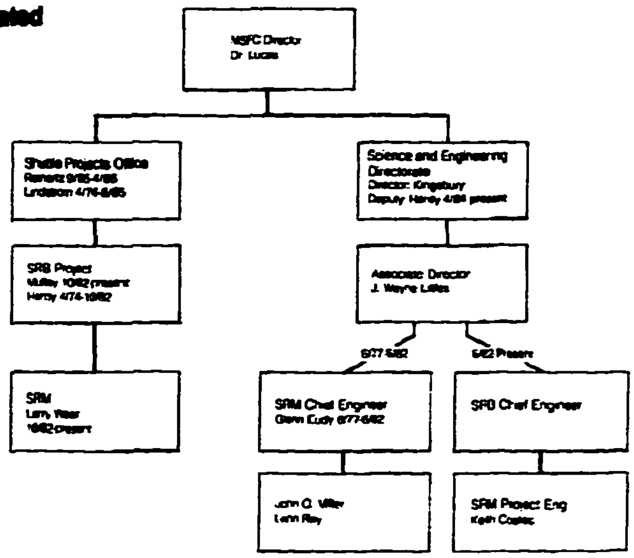
Shuttle Projects Office

Incumbents as of January 28, 1986



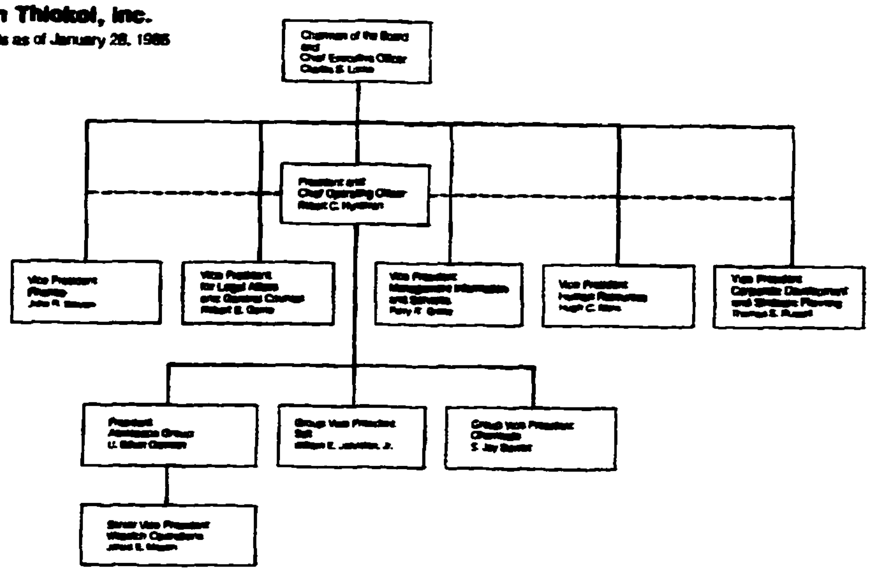
*Staffed by Science and Engineering Personnel

Key Marshall Personnel Related to the Solid Rocket Booster

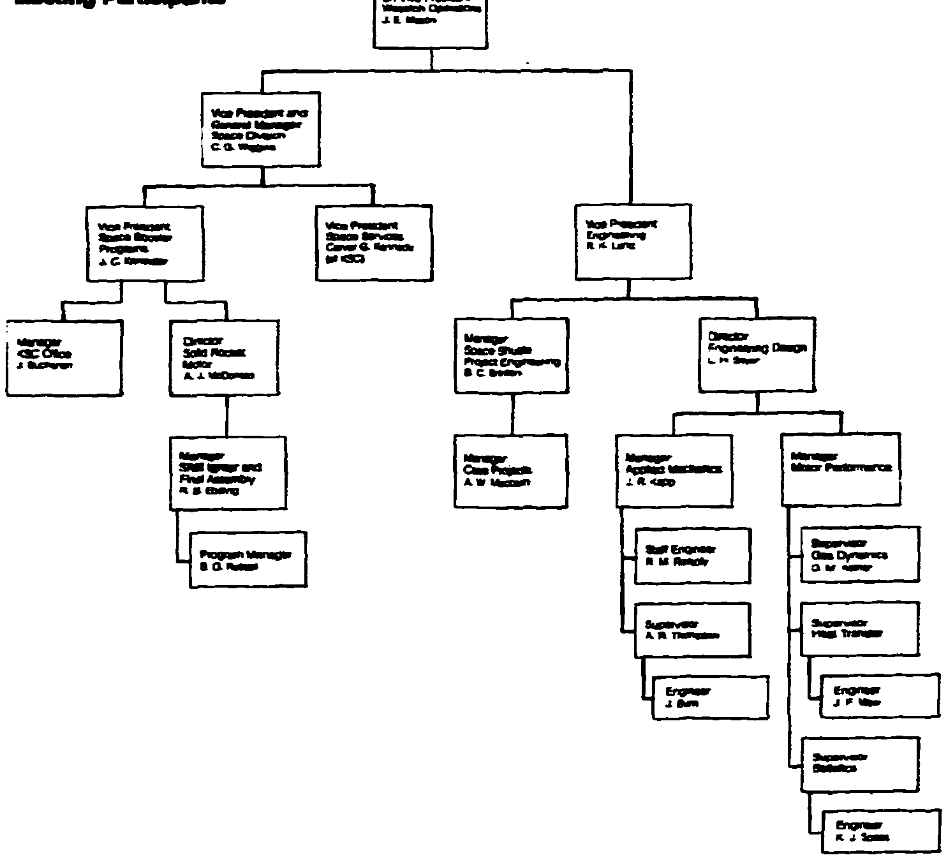


(Source: *Report I*, 229)

Morton Thiokol, Inc.
Incumbents as of January 28, 1986



Morton Thiokol 27 Jan 1986
Meeting Participants



(Source: *Report I*, 230-1)

MORTON THIOKOL INC. COMPANY PRIVATE

Wasatch Division

Interoffice Memo

31 July 1985
2870:FY86:073

TO: R. K. Lund
Vice President, Engineering

CC: B. C. Brinton, A. J. McDonald, L. H. Sayer, J. R. Kapp

FROM: R. M. Boisjoly
Applied Mechanics - Ext. 3525

SUBJECT: SRM O-Ring Erosion/Potential Failure Criticality

This letter is written to insure that management is fully aware of the seriousness of the current O-Ring erosion problem in the SRM joints from an engineering standpoint.

The mistakenly accepted position on the joint problem was to fly without fear of failure and to run a series of design evaluations which would ultimately lead to a solution or at least a significant reduction of the erosion problem. This position is now drastically changed as a result of the SRM 16A nozzle joint erosion which eroded a secondary O-Ring with the primary O-Ring never sealing.

If the same scenario should occur in a field joint (and it could), then it is a jump ball as to the success or failure of the joint because the secondary O-Ring cannot respond to the clevis opening rate and may not be capable of pressurization. The result would be a catastrophe of the highest order - loss of human life.

An unofficial team (a memo defining the team and its purpose was never published) with leader was formed on 19 July 1985 and was tasked with solving the problem for both the short and long term. This unofficial team is essentially nonexistent at this time. In my opinion, the team must be officially given the responsibility and the authority to execute the work that needs to be done on a non-interference basis (full time assignment until completed).

page 1

Roger Boisjoly's first attempt after STS 51-B (flight 17) to convince his management of the seriousness of the O-ring erosion problem.

(Source: *Report I*, 249)

R. K. Lund 31 July 1985

It is my honest and very real fear that if we do not take immediate action to dedicate a team to solve the problem with the field joint having the number one priority, then we stand in jeopardy of losing a flight along with all the launch pad facilities.

R. M. Boisjoly

Concurred by:

J. R. Kapp, Manager
Applied Mechanics

COMPANY PRIVATE

(Page 2)

(Source: *Report I*, 250)

MORTON THIOKOL, INC.

Wasatch Division

Interoffice Memo

2871:FY86:141
22 August 1985

TO: S.R. Stein,
Project Engineer

CC: J.R. Kapp, K.M. Sperry, B.G. Russell, R.V. Ebeling, H.H. McIntosh, R.M. Boisjoly, M. Salita D.M. Ketner

FROM: A.R. Thompson, Supervisor
Structures Design

SUBJECT: SRM Flight Seal Recommendation

The O-ring seal problem has lately become acute . Solutions, both long and short term are being sought, in the mean time flights are continuing. It is my recommendation that a near term solution be incorporated for flights following STS-27 which is currently scheduled for 24 August 1985. The near term solution uses the maximum possible shim thickness and a .292 +.005/-.003 inch dia O-ring. The results of these two changes are shown in Table 1. A great deal of effort will be required to incorporate these changes. However, as shown in the Table the O-ring squeeze is nearly doubled for the example (STS-27A). A best effort should be made to include a max shim kit and the .292 dia O-ring as soon as is practical. Much of the initial blow-by during O-ring sealing is controlled by O-ring squeeze. Also note sacrificial O-ring material is available to protect the sealed portion of the O-ring. The added cross-sectional area of the .292 dia O-ring will help the resilience response by added pressure from the groove side wall.

Several long term solutions look good; but, several years are required to incorporate some of them. The simple short term measures should be taken to reduce flight risks.

A.R. Thompson

ART/jh

[illegible]

In this memorandum to S.R. Stein, A.R. Thompson indicates the O-ring seal problem is acute and short-term measures should be taken to reduce flight risk.

(Source: *Report I*, 251)

MORTON THIOKOL INC.

Wasatch Division

Interoffice Memo

1 October 1985
E150/RVE-85-47

TO: A. J. McDonald, Director
Solid Rocket Motor Project

FROM: Manager, SRM Ignition System, Final Assembly, Special Projects and Ground Test

CC: B. McDougall, [illegible] Russell, J. McCluskey, [illegible] Cooper, J. Kilminster, B. Brinton, T. O'Grady, [illegible] Macbeth, J. Sutton, J. Elwell, [illegible] Adams, F. Call, J. Lamere, P. Ross, [illegible], [illegible] Bailey, [illegible] Smith, L. Bailey, [illegible], [illegible], P. Petty, J. McCall

SUBJECT: Weekly Activity Report
1 October 1985

EXECUTIVE SUMMARY

HELP! The seal task force is constantly being delayed by every possible means. People are quoting policy and systems without work-around. MSFC is correct in stating that we do not know how to run a development program.

GROUND TEST

1. The two (2) STM center segments were received at T-24 last week. Optical measurements are being taken. Significant work has to be done to clean up the joints. It should be noted that when necessary SICBM takes priority.

2. The QM-6 test report less composite section was released last week.

ELECTRICAL

As a result of the latest engineering analysis of the F-1 case it appears that high stress risers to the case are created by the phenolic OFI housings and fairings. As it presently stands, these will probably have to be modified or removed and if removed will have to be replaced. This could have an impact on the launch schedule.

A. J. McDonald, Director
1 October 1985
E150/RVE-85-47
Page 2

FINAL ASSEMBLY

One SRM 25 and two SRM 26 segments along with two SRM 26 exit cones were completed during this period. Only three segments are presently in work. Availability of igniter components, nozzles and systems tunnel tooling are the present constraining factors in the final assembly area.

IGNITION SYSTEM

1. Engineering is currently rewriting igniter gask-o-seal coating requirements to allow minor flaws and scratches. Bare metal areas will be coated with a thin film of HD-2 grease. Approval is expected within the week.

2. Safe and Arm Device component deliveries is beginning to cause concern. There are five S&A's at KSC on the shelf. Procurement, Program Office representatives visited Consolidated Controls to discuss accelerating scheduled deliveries. CCC has promised 10 ABM's and 38 B-B's no later than 31 October 1985.

O-RINGS AND PUTTY

1. The short stack finally went together after repeated attempts, but one of the o-rings was cut. Efforts to separate the joint were stopped because some do not think they will work. Engineering is designing tools to separate the pieces. The prints should be released tomorrow.

2. The insert segments are at T-24 and are undergoing inspection.

3. The hot flow test rig is in design, which is proving to be difficult. Engineering is planning release of these prints Wednesday or Thursday.

4. Various potential filler materials are on order such as carbon, graphite, quartz, and silica fiber braids; and different putties. They will all be tried in hot flow tests and full scale assembly tests.

5. The allegiance to the o-ring investigation task force is very limited to a group of engineers numbering 8-10. Our assigned people in manufacturing and quality have the desire, but are encumbered with other significant work. Others in manufacturing, quality, procurement who are not involved directly, but whose help we need, are generating plenty of resistance. We are creating more instructional paper than engineering data. We wish we could get action by verbal request but such is not the case. This is a red flag.

R. V. Ebeling

MORTON THIOKOL INC.

Wasatch Operations

Interoffice Memo

1 October 1985
[illegible]

TO: R. K. Lund, Vice President, Engineering
A. J. McDonald, Director, Space Booster Programs
B. C. Brinton, Manager, Project Engineering
L. H. Macbeth, Manager, Project Engineering
O-Ring Investigation Task Force Members

FROM: S. R. Stein
Space Booster Project Engineering

SUBJECT: Potency of O-Ring Investigation Task Force

The task force for investigation of O-ring erosion and related joint problems has now existed for more than a month. We are finally getting enough people aware of our efforts so that in some areas we are receiving full cooperation. In other areas however, it is truly a struggle to get work performed. The QM-5 firing, VLS-1 launch, and safety of every other shuttle launch are all directly related to the work currently underway. Unless drastic improvements in the potency of the task force are realized, the time required to complete the necessary investigations, testing, and analytical work will not support a desirable schedule.

We are currently being hog-tied by paperwork every time we try to accomplish anything. I understand that for production programs, the paperwork is necessary. However, for a priority, short schedule investigation, it makes accomplishment of our goals in a timely manner extremely difficult, if not impossible. We need the authority to bypass some of the paperwork jungle. As a representative example of problems and time that could easily be eliminated, consider assembly or disassembly of test hardware by manufacturing personnel.

Currently an AO must be generated, which triggers the manufacturing engineer to generate detailed planning. Once the planning is released, we must go to scheduling, who puts us on the list of priority work to do. We then wait until our job reaches the top of the list, and a crew begins the work. If any problems arise, we get tangled in more paperwork. In recent operations, we have had full cooperation from all involved parties, but getting all the procedures lined up takes too long. We need the authority to have a "team" formed which would include a Design Engineer, Manufacturing Engineer, Quality Engineer, Safety Engineer, and the foreman. The crew should perform the work as directed by the team. Paperwork to describe each step in detail should not be necessary. The team engineers should be allowed to take responsibility for the work.

Distribution
1 October 1985
Page two

I know the established paperwork procedures can be violated if someone with enough authority dictates it. We did that with the IR system when the FWC hardware "Tiger Team" was established. If changes are not made to allow us to accomplish work in a reasonable amount of time, then the O-ring investigation task force will never have the potency necessary to resolve the problems in a timely manner.

S. R. Stein

(Source: *Report I*, 252-3)

ACTIVITY REPORT

The team generally has been experiencing trouble from the business as usual attitude from supporting organizations. Part of this is due to lack of understanding of how important this task team activity is and the rest is due to pure operating procedure inertia which prevents timely results to a specific request.

The team met with Joe Kilminster on 10/3/85 to discuss this problem. He wanted specific examples which he was given and he simply concluded that it was every team members responsibility to flag problems that occurred to organizational supervision and work to remove the road block by getting the required support to solve the problem. The problem was further explained to require almost full time nursing of each task to insure it is taken to completion by a support group. Joe simply agreed and said we should then nurse every task we have.

He plain doesn't understand that there are not enough people to do that kind of nursing of each task, but he doesn't seem to mind directing that the task never-the-less gets done. For example, the team just found out that when we submit a request to purchase an item, that it goes through approximately 6 to 8 people <u>before</u> a purchase order is written and the item actually ordered.

The vendors we are working with on seals and spacer rings have responded to our requests in a timely manner yet we (MTI) cannot get a purchase order to them in a timely manner. Our lab has been waiting for a function generator since 9-25-85. The paperwork authorizing the purchase was finished by engineering on 9-24-85 and placed into the system. We have yet to receive the requested item. This type of

page 1

In this activity report, Roger Boisjoly expresses his frustration with the slow progress of and lack of management attention to the seal task force.

(Source: *Report I*, 254)

example is typical and results in lost resources that had been planned to do test work for us in a timely manner.

I for one resent working at full capacity all week long and then being required to support activity on the weekend that could have been accomplished during the week. I might add that even NASA perceives that the team is being blocked in its engineering efforts to accomplish its tasks. NASA is sending an engineering representative to stay with us starting Oct 14th. We feel that this is the direct result of their feeling that we (MTI) are not responding quickly enough on the seal problem.

I should add that several of the team members requested that we be given a specific manufacturing engineer, quality engineer, safety engineer and 4 to 6 technicians to allow us to do our tests on a non-interference basis with the rest of the system. This request was deemed not necessary when Joe decided that the merging of the task approach was directed.

Finally, the basic problem boils down to the fact that ALL MTI problems have #1 priority and that upper management apparently feels that the SRM program is ours for sure and the customer be damned.

Roger M Boisjoly
Roger Boisjoly 10/4/85

page 2

(Source: *Report I*, 255)

Marshall internal memorandum in the fall of 1985

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama
35812

SEP 5 1985

EA01

TO: SA01/L. M. Mulloy

FROM: EA01/J. E. Kingsbury

SUBJECT: O-ring Joint Seals

I am most anxious to be briefed on plans for improving the SRM O-ring seals. Specifically, I want to review plans which lead to flight qualifications and the attendant schedules. I have been apprised of general ongoing activities but these do not appear to carry the priority which I attach to this situation. I consider the o-ring seal problem on the SRM to require priority attention of both Morton Thiokol/Wasatch and MSFC. Please arrange such a briefing no later than September 13, 1985. From my point of view, this can be accomplished by telecon with Morton Thiokol. I would hope such a briefing could be done in two hours or less.

J. E. Kingsbury
Director
Science and Engineering

EE01 Rec'd SEP 5 1985
Action/
Suspense
File
Copies to Dr. Littles

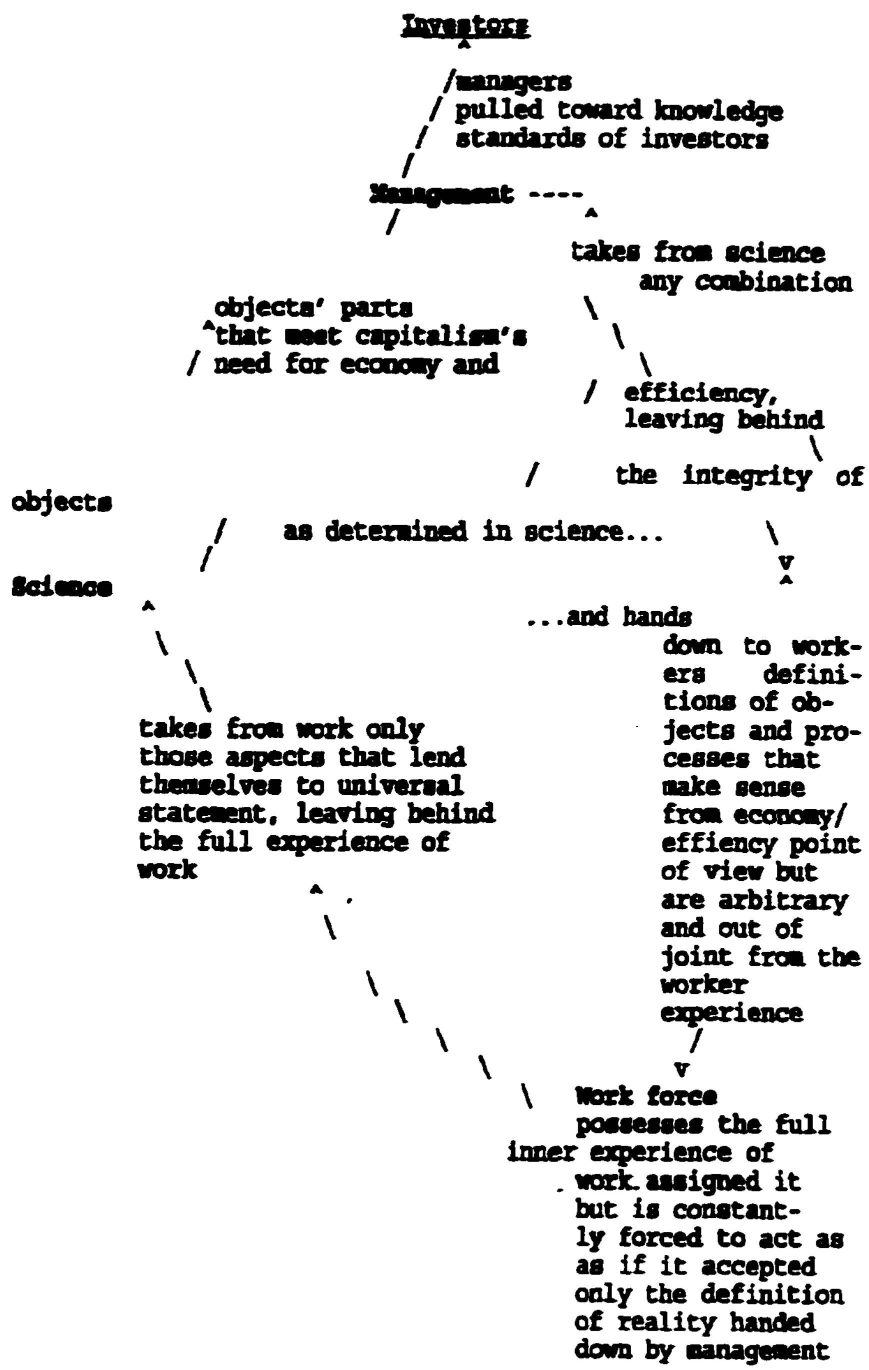
cc:
SA01/Mr. Lindstrom
SA01/Dr. Lovingood
EA01/Mr. Hardy
EE01/Dr. Littles 4301/600
EE11/Mr. Horton
EP01/Mr. McCool
EH01/Mr. Schwinghamer

cc
(EE11/Mr. Smith)

In this memorandum, J. E. Kingsbury informs Lawrence Mulloy that he places high priority on the O-ring seal problem and desires additional information on plans for improving the situation.

(Source: *Report I*, 256)

Fig. 2: Knowledge Taken and Left Behind by Leading Groups



(Source: "Why Management Reforms Fail: A Knowledge Analytic" by David Carnevale and Ralph Hummel. A Conference Paper Presented to the Oklahoma Political Science Association, November 1996, 63)