The Incommensurability of 'Faster, Better, Cheaper': NASA's Rhetorical Bind

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Abstract

Ideally, decisions in technical organizations are made on the basis of science; in reality, these decisions are frequently subject to, and outweighed by, political or economic pressures. This phenomenon may be illuminated by examining project management from the perspective of systems theory. In this paper, I discuss project management within the context of systems theory, using NASA's losses of the Mars Polar Lander and the Mars Climate Orbiter as examples. NASA uses the "Faster, Better, Cheaper" (FBC) approach to project management. However, this approach embodies goals that are incommensurable: "Faster" is a political goal; "Better" is a scientific goal; and "Cheaper" is an economic goal. NASA thus faces a rhetorical bind, in which its ostensible goal, "better," becomes subordinate to the goals of "faster" or "cheaper." *Keywords: project management, systems theory, Mars Polar Lander, Mars Climate Orbiter*

1. Introduction

Pinning down the distinction between science and technology has been a notoriously difficult task, one that has been attempted by numerous scholars. Over the course of technology studies, this distinction has changed from one based on the specific role of each—discover versus apply—to one based on the specific goal of each—knowing versus making. In the old view, science makes discoveries and creates knowledge; technology applies those discoveries. In the new view, the goal of science is an abstract form of knowing, that of technology a more concrete knowing how. Edwin Layton has explained this latter characterization as follows: "Scientists favor very idealized theories for maximum understanding; engineers must build a bridge between pure theory and concrete, complex artifacts in the real world" [1]. Embedded as it is in the "real world," engineering is subject to external forces:

> Engineering knowledge reflects the fact that design does not take place for its own sake and in isolation. Artifactual design is a social activity directed at a practical set of goals intended to serve human beings in some direct way. As such, it is intimately bound up with economic, military, social, personal, and environmental needs and constraints. [2]

Thus from the viewpoint of goals, science can be defined as an activity directed toward establishing general theories of knowledge, engineering as an activity constrained by social forces and directed toward achieving practical goals.

In this paper, I explore the implications of the latter definition from the perspective of systems theory. First, I summarize Niklas Luhmann's description of contemporary society, noting its emphasis on the goals of three social systems—politics, science, and the economy. Next, I show how NASA's project management approach, "Faster, Better, Cheaper," mimics the goals of these systems. Finally, I offer a brief analysis of the discourse surrounding NASA's losses of the Mars Polar Lander (MPL) and the Mars Climate Orbiter (MCO).

2. Luhmann's Systems Theory

Luhmann maintains that modern society does not have a hierarchy or a center and periphery; rather, it is comprised of distinct social systems, each of which performs a specific operation [3]. These social systems are differentiated by means of two parameters: a binary code and a program. The binary code of a social system is its defining value and counter-value pair; its program defines the criteria for suitable or correct operations within the system. While the binary code of a social system is immutable or closed, its program is variable or open. Thus a social system can adapt to its environment, although only within the constraints of its code. Furthermore, as the elements of the social systems are communicative acts, this adaptation occurs through communication. Luhmann's description of each system thus allows for both its structure (its code and program) and its process (communication).

Using this schema, Luhmann describes several social systems, three of which are summarized here. Using his descriptions, the goal of each system can also be identified.

2.1. The Political System

The political system is based on a binary scheme of the holding or not holding of public office. The program is the public's selection of the office holders as well as the programs according to which the government will operate. The political system is closed with respect to who holds office; however, it is open with respect to popular will. In other words, while an individual either holds office or does not, the public may change its opinion. This system encompasses political power, which, according to Luhmann, addresses the question of who is or is not entitled to execute collectively binding decisions. Therefore, the goal of the political system is power.

2.2. The Scientific System

Science is differentiated by a binary scheme of truth or falsity. Its program, or the criteria determining suitable operations, consists of scientific theories. The scientific social system is closed with respect to its methods, which require that results be expressed in terms of truth or falsity. The system is open with respect to its theories, which are applied externally. Luhmann restricts the application of science's code of truth and falsity to the acquisition of new knowledge. The goal of science is thus the acquisition of knowledge.

2.3. The Economic System

According to Luhmann, the economy is based on a binary scheme of payment and nonpayment. Although the original basis of the economic system was the ownership or non-ownership of property, the modern economic system is one in which payment mediates economic operations. The program of prices, which are determined by what people are willing to pay, regulates the suitability or correctness of the economy's operations. Luhmann claims that the economy must maintain a balance between profitability and the provision of work. Therefore, the goal of the economic system can be described as prosperity.

The social systems of politics, science, and the economy are shown in Table 1.

Table 1. Luhmann's social systems.

System	Politics	Science	Economy
Code	Office Held / Not Held	True / False	Payment / Nonpayment
Program	Popular Will	Theories	Prices
Goal	Power	Knowledge	Prosperity

In summary, the three social systems can be described in terms of their respective structures and goals. Moreover, those structures and goals dictate the acceptable communication within each system.

2.4. Communicating within the Systems

As a system can only adapt to its environment within the constraints of its binary code, each system's goal both implies and limits the arguments that can be used within the system. Arguments within the political system are directed toward achieving power and center on issues of public office and government programs. Arguments within the scientific system are directed toward producing new knowledge and center on issues of the truth of results. Finally, arguments within the economic system are directed toward sustaining prosperity and center on issues of payment.

While Luhmann's descriptions of the social systems are interesting, it is the mimicking of those systems by NASA's project management approach that is enlightening. In the next sections I define that approach and show how it mimics the goals of the social systems.

3. "Faster, Better, Cheaper"

NASA implemented the "Faster, Better, Cheaper" (FBC) approach to project management in 1992 at the instigation of then new NASA Administrator Daniel Goldin. Goldin charged NASA as follows:

> …tell us how we can implement our missions in a more cost-effective manner. How can we do everything better, faster, cheaper, without compromising safety? [4]

According to one report, the goal of FBC is "to shorten development times, reduce cost, and increase the scientific return by flying more missions in less time" [5]. Another refers to FBC succinctly as schedule, content, and cost [6]. A more comprehensive definition has been provided by the Mars Program Independent Assessment Team (MPIAT), which identifies five main objectives of FBC as implemented by NASA:

1. Create Smaller Spacecraft—More Frequent Missions
2. Reduce Cycle Time
3. Utilize New Technology
4. Accept Prudent Risk Where Warranted by Return
5. Utilize Proven Engineering and Management Practices to Maximize Mission Success [4]

Each of these objectives is discussed below.

3.1. Smaller Crafts, More Frequent Missions

The first objective of FBC is to create smaller spacecrafts and launch more frequent missions. This objective has a dual purpose: (1) to increase participation by scientists and the public and (2) to distribute risk over a larger number of smaller missions. In addition, launching missions more frequently allows for the more timely integration of new knowledge and technology.

3.2. Faster Cycle Times

The second objective of FBC is to reduce cycle time. This objective is carefully qualified by the MPIAT, which maintains that faster does not consist of the arbitrary reduction of development and implementation time. Rather, it consists of the reduction of cycle time by eliminating inefficiency and redundancy.

3.3. Newer Technology

The third objective of FBC advocates the use of new technology in NASA missions. As described by the MPIAT, this objective has several purposes. Specifically, the use of new technology serves to increase the scientific return of missions, reduce spacecraft size and overall mission cost, and increase public interest in the program.

3.4. Prudent Risks

As defined by the MPIAT, the fourth objective of FBC enjoins that prudent risks be accepted where they are warranted by scientific return. The MPIAT cautions that the value of the potential scientific return should be carefully weighed against any additional risks.

3.5. Proven Practices

The fifth objective of FBC is the utilization of proven engineering and management practices to maximize mission success. With respect to this objective, MPIAT emphasizes the importance of relying on proven practices as well as experienced management. Specifically, the MPIAT recommends that clear lines of authority and responsibility be established; that competent, efficient, independent reviews of projects be conducted; and that risks be evaluated thoroughly.

3.6. Managing FBC

Based on the definition provided in the MPIAT report, the "Faster, Better, Cheaper" approach to project management is directed toward several objectives. First, "Faster" enjoins that cycle time be reduced and that new knowledge and technology be integrated quickly. "Better" enjoins that scientific return be maximized and that new technology be exploited. "Cheaper" enjoins that mission costs be reduced.

In addition, there are two objectives not clearly articulated in the phrase "Faster, Better, Cheaper." The first is that risk must be recognized, evaluated, and managed; the second is that public interest and participation in the program be engaged. While these objectives appear to fall outside the scope of FBC, they also reflect system goals, as will be shown in the next section. An analysis of the MPIAT report and other assessments of the Mars failures illustrates the parallels between all five of the objectives of FBC and the goals of the political, scientific, and economic systems as defined by Luhmann.

4. Parallel Goals

It can be shown that each objective of the FBC approach to project management mimics a particular social system. Furthermore, as the goal of each social system serves as both a source of and a set of constraints on arguments, to be effective, communication within a technical organization such as NASA must use a specific set of arguments derived from and directed toward those system goals.

In the next few sections, I briefly show how the teams investigating the failed Mars missions did use specific arguments that conformed to the structures and goals of the political, scientific, and economic systems described above. I also examine how the two objectives of risk management and public engagement, while not explicitly articulated in the phrase "Faster, Better, Cheaper," serve to achieve a system goal as well.

4.1. Faster, or Political Expediency

According to the MPIAT, the "Faster" component of FBC refers to the reduction of mission cycle time and the timely integration of new knowledge and technology. However, the impetus behind this emphasis on schedule has a political as well as a scientific component.

Historically, the success of NASA has been tied to the status of the United States as a leader in space exploration. This link is reflected in several of the reports investigating the Mars failures. For example, the FBC TASK team, in its report on NASA's implementation of FBC, states, "NASA must continue to improve its performance if NASA is to stay a world leader," characterizing NASA's corporate history as a "national asset" and linking its success to the nation's competitive advantage [5]. The MPIAT describes NASA's technical expertise in deep space exploration similarly as a "national resource" [4].

In the introduction to its report on project management at NASA, the Mars Climate Orbiter Mishap Investigation Board (MCO MIB) emphasizes the importance of "preserv[ing] NASA as a national resource and perpetuat[ing] its legacy of success in innovative scientific and technological undertakings" [6]. The MCO MIB casts this legacy in global terms as well, stating that NASA's successes have "inspired the nation and the world" [6].

Thus the "Faster" component of FBC contains an element of political expediency, which mandates that the U.S. retain its scientific and technological superiority in an era of rapid development. "Faster" can be interpreted as a reflection of national pride in the U.S.'s scientific and technological achievements, embodying the political system's goal of power.

4.2. Better, or Scientific Fruitfulness

The "Better" component of FBC, as described by the MPIAT, refers to the maximization of scientific return and the utilization of new technology. This component is the most straightforward, as it is scientific and technological advancement that most obviously describes NASA's mission.

The MCO MIB explicitly states, "Technology is the *better* part of the 'Faster, Better, Cheaper' paradigm" [6]. In fact, the MCO MIB designates this component as primary, "The ultimate objective of most NASA missions is to accomplish scientific and/or technical research" [6]. A successful mission is one that by definition has a high scientific return.

Like most of NASA's missions, the objective of the Mars program is scientific discovery: "Throughout history, people have pondered whether there is life beyond Earth" [4]. Furthermore, the three Mars missions described by the MPIAT as successful all demonstrated a high scientific return. The Mars Global Surveyor had "a high science return"; the Mars Pathfinder accomplished "limited but exciting Mars science results"; and Deep Space 1 demonstrated twelve new technologies [4].

However, nowhere is the emphasis on science and technology more apparent than in NASA's press kits:

> Mars Polar Lander will advance our understanding of Mars' current water resources by digging into the enigmatic layered terrain near one of its poles for the first time. Instruments on the lander will analyze surface materials, frost, weather patterns and interactions between the surface and atmosphere to better understand how the climate of Mars has changed over time. [7]

The "Better" component of FBC thus refers to the goal of scientific and technological discovery manifested by NASA. No interpretation is necessary to see the reflection of the scientific goal of knowledge in NASA's project management approach.

4.2. Cheaper, or Economic Cost-Effectiveness

Finally, the MPIAT maintains that the "Cheaper" component of FBC refers to the cost-effectiveness of NASA's missions. While this objective is primarily economic, it also contains an element of politics. Specifically, NASA is a federally funded entity and as such its economics is intertwined with national politics.

According to the MCO MIB, NASA's original adoption of FBC occurred in response to federal funding constraints: "The 'Faster, Better, Cheaper' paradigm has enabled NASA to respond to the national mandate to do more with less" [6]. And the FBC TASK team asserts, in capital, boldface letters, "WE MUST DRIVE DOWN THE COST OF LAUNCH! THIS MUST BE A MAJOR NATIONAL PRIORITY" [5].

The impact of economic constraints is apparent in all of the Mars reports. The Mars '98 project, responsible for both the MCO and the MPL, attempted to develop two spacecrafts for the same amount of money that was spent on the Mars Pathfinder [4, 8]. In fact, the project was "underfunded by at least 30 percent," leading the MPIAT to classify inadequate funding as the dominant problem leading to both Mars mission failures. Similarly, the MCO MIB stated that the Mars Surveyor Program agreed to significant cuts in resources (both monetary and personnel) for the MCO in comparison with previous Mars missions [6].

The "Cheaper" component of FBC thus encompasses the economic component of NASA's project management approach. In addition, its emphasis on issues of cost-effectiveness reflects the economic system's emphasis on prosperity.

To summarize, the reports reveal parallels between "Faster" and the political goal of expediency, "Better" and the scientific goal of fruitfulness, and "Cheaper" and the economic goal of cost-effectiveness. The two additional objectives of risk management and public engagement correspond to a system goal as well.

4.4. Risk and the Public, or Public Relations

Given the parallels drawn above, the assumption can be made that the objectives of risk management and public engagement may also reflect system goals. In fact, I contend that they reflect one system goal in particular: politics. Specifically, I would argue that the necessity of managing risk is in part a political concern stemming from the emphasis on public engagement.

From the viewpoint of politics, the importance of the two remaining objectives is easily understood. Ultimately, NASA's continued existence depends on the willingness of the public and its elected officials to subsidize an inherently costly endeavor. Engaging the public's interest and participation in space exploration is crucial to NASA's success. Accordingly, the importance of engaging and maintaining public interest is an ongoing theme in the reports.

The MPIAT cautions that exclusive access to data by scientists must be carefully balanced with public affairs needs, stating that a crucial aspect of satisfying public interest in a highly visible mission is the prompt release of data [4]. And the MPIAT bases part of its assessment of mission success on public relations. It claims that the Mars Pathfinder was "an unprecedented public relations success," as evidenced by the record number of visits to its website: over half a billion [4]. The Mars Program Office, according to the MPIAT, requires very high visibility because of the importance of Mars exploration as both "an established national goal" and "an engaging program of enormous public interest" [4].

The MCO MIB attributes the increase in public interest to the increased frequency of missions. However, it also notes the downside of that increased interest:

> While [the increase in the number of missions] has delivered the desired results—heightening public interest in our missions and increasing public understanding of our scientific advances—it has also made NASA's failures more visible, along with our successes. [6]

Thus risk management takes on increased importance. In addition to its legitimacy as a management tool for complex projects, risk assessment serves to increase the success rate of missions and correspondingly maintain public interest in those missions. The dual purpose served by risk management justifies the suggestion by the MCO MIB that it be considered the fourth dimension of a project, in conjunction with schedule, content, and cost [6].

Therefore, risk management and public engagement also reflect the political goal of power, specifically with respect to the reliance of politics on public opinion for regulating its correct operation. Assuming that this analysis is sound, three of the five main objectives identified by the MPIAT mimic the goal of the political system. Of the remaining two objectives, cost-effectiveness appears to contain a political element as well. Hence politics dominates the objectives, a dominance reflected in the discourse.

4.5. Dominating the Discourse

In several of the reports, the tension between political and scientific goals is readily apparent. The FBC TASK report states that for NASA to remain credible, it was necessary that it "treat cost and schedule as important as Mission performance" [5]. In its report, the MPIAT describes the interface between NASA Headquarters and the entity responsible for the Mars missions, Jet Propulsion Laboratory (JPL), as ineffective. Specifically, what NASA Headquarters considered program objectives, mission requirements, and constraints were viewed by JPL as non-negotiable mandates [4]. JPL, fearful of losing the contract, did not express concerns about programmatic constraints to NASA Headquarters and NASA Headquarters, in turn, appeared non-receptive to bad news. The MPIAT summarizes, "JPL did not want to antagonize the customer. NASA Headquarters was rigid in adhering to unrealistic constraints" [4].

There is also a precarious balance between economic and scientific goals. The MCO MIB maintains that scoping out the expected costs for mission success "should be accomplished independently of any predefined dollar cap" [6]. Similarly, the MPIAT concludes that the Mars program "had inadequate resources to accomplish the requirements" [4]. As NASA's economic constraints are federally driven, it appears that politics dominates NASA operations in that realm as well.

So as might be expected, the three components of FBC conflict with each other. It is this conflict that comprises NASA's rhetorical bind.

5. NASA's Rhetorical Bind

NASA's rhetorical bind lies in the fact that its project management approach mimics the goals of three incommensurable social systems. The problems with FBC have been well documented. According to the MCO MIB, while the goal of FBC is "to enhance innovation, productivity, and cost-effectiveness," many NASA programs have pursued the "Faster" and "Cheaper" components at the expense of managing risk [6].

Heightened risk resulting from shortened schedules and reduced costs was a major factor in the failed Mars missions. In the next sections, I discuss those failures, again focusing on the investigative reports produced.

5.1. Mars Mission Failures

In mid-1999, Administrator Goldin tasked Tony Spears, retired Project Manager for the Mars Pathfinder mission, to study NASA's implementation of FBC and assess its best practices. The FBC TASK team, which conducted sessions and workshops from July 1999 through February 2000, released its report on March 13, 2000 [5].

During that same time period, two Mars missions failed. The MCO failed to achieve orbit around Mars on September 23, 1999, the result of a navigation error attributed to the use of incorrect units in spacecraft operating data [4, 6, 9]. The MPL presumably crashed onto Mars' surface on December 3, 1999, due to a premature shutdown of the engines during descent [4, 9].

Several independent teams investigated the Mars failures, in the process of which they closely examined NASA's use of FBC. The MCO MIB released its report on NASA's project management approach on March 13, 2000 [6]. The MPIAT reviewed both mission failures, releasing its report on March 14, 2000 [4, 7]. And the JPL Special Review Board released its report on the loss of the MPL on March 22, 2000 [8]. One notable aspect of these reports is that they found no pre-established definition for FBC.

5.2. Indefinite Definition

When reporting on its review of the failures of the MCO and the MPL, the MPIAT stated, "the team could not find an established definition of FBC" [4]. The lack of a clear definition is also notable in the final report submitted by the FBC TASK team. One of the team's objectives was to "define FBC and develop rules of engagement" [5]. The FBC TASK team held a series of interviews and workshops, finally producing the following vague definition:

1. FBC is simply attempting to improve performance by being more efficient and innovative, and it applies to everything and everybody.
2. There's an intangible element[,] there is a team spirit associated with doing FBC, and people are the most important ingredient. [5]

Furthermore, although the MPIAT concluded that FBC is effective when properly implemented, it noted that NASA, JPL, and Lockheed Martin Astronautics (LMA)

> …have not documented the policies and procedures that make up their FBC approach; therefore, the process is not repeatable. Rather, project managers have their own and sometimes different interpretations. [4]

The Mars missions relied on a project management approach that was never clearly defined.

In addition to the definitional problem, the reports show that the relative priority of the FBC components has produced confusion, a confusion that can be attributed to the fact that the goals are incommensurable.

5.3. Incommensurable Goals

The FBC TASK report describes some of the debates over the definition of FBC as follows: "Should the Better go before Faster and Cheaper? Or is [it] the other way around? Another argument was that you could pick two, but you can't have all three" [5].

This confusion played out in the Mars mission failures. The MCO MIB found that the MCO project management team "appeared more focused on meeting mission cost and schedule objectives and did not adequately focus on mission risk" [6]. Similarly, the MPIAT found that, under pressure to comply with both cost and schedule constraints, JPL and LMA cut too many corners, particularly with respect to testing [4].

The public discourse concerning the loss of the MPL also illustrated the incommensurability between the goals of expediency, fruitfulness, and cost-effectiveness. In addition, that discourse exhibited a shift from scientific to economic to political arguments. It is noteworthy that the issue remained unresolved until it entered the political system.

Prior to launch, the discourse was primarily scientific, focusing on potential gains in knowledge:

> …[in 1996] public interest became regalvanized by the possibility of past or present life [on Mars]. The key to understanding whether life could have evolved on Mars, many scientists believe, is understanding the history of water on the planet. [7]

After loss of contact with the MPL, the discourse turned to economic concerns, specifically the efficacy of FBC:

> Despite what he said were 'problems' with 'faster, better, cheaper,' [NASA Administrator Dan] Goldin defended his philosophy of more missions for less money. … Back-to-back Mars mission failures this fall have prompted questions about the efficacy of the cost-cutting creed. [10]

After the loss of the MPL was confirmed, the discourse entered the political system, where it was eventually resolved:

> In general, the MPIAT observed that Mars exploration is an important national goal that should continue. The panel gave a thumbs-up to NASA decisions to proceed with a 2001 orbiter, and not to fly the 2001 lander… . [11]

NASA faces a rhetorical bind because its incommensurable goals are reflected in its project management approach. The goal that ostensibly impels NASA, knowledge gain, is frequently superseded by the goals inherent in NASA's political mandate, expediency and cost-effectiveness. FBC fails not only to define those goals but also to clarify their respective priorities. Recognizing these problems, the boards made several recommendations.

5.4. Board Recommendations

If, as I've argued, FBC simply mimics the goals of the political, scientific, and economic systems, with the former dominating, the question arises as to whether its inherent problems can be resolved. The investigative boards made several recommendations relevant to the problems with FBC.

One of the three points raised in the conclusion of the MPIAT's report emphasized the importance of defining the framework and direction of the Mars Program, a request that directly pertains to more clearly defining the objectives of FBC. The MPIAT offered the following questions for consideration:

> What does NASA want to accomplish in the long run? What should the products be for science, for human exploration, for technology, and for the public imagination? What are the near-term and long-term budget targets? [4]

Answers to these critical questions would resolve the definitional problem with FBC.

However, the underlying problem, according to the reports from the FBC TASK and the MCO MIB, is inadequate resources. The FBC TASK report, which in general supports the continued use of FBC, says,

> …it takes a Project Manager with good judgment and courage to declare under pressure that the Project is not doable for the available resources. [5]

The conclusion of the report submitted by the MCO MIB is more to the point.

> In recent years, NASA has been asked to sustain this level of success [achieved with the Mercury, Apollo, Space Shuttle, and Mars Pathfinder missions] while continually cutting costs, personnel and development time. It is the opinion of this Board that these demands have stressed the system to the limit. The set of recommendations described here is the first effort in a series of ongoing "continuous improvement" steps designed to refocus the Agency on the concept of Mission Success First, accompanied by adequate but not excessive resources. [6]

These latter two reports pinpoint the underlying problem with FBC. Given that the goals of expediency, fruitfulness, and cost-effectiveness conflict, and given that the political system dominates, the scientific goals of NASA are frequently outweighed. Faced by a mandate "to do more with less" [6], project managers must maintain a tenuous balance between meeting schedule and cost limitations and accomplishing science. The emphasis placed by the MCO MIB on the concept of Mission Success First serves to explicitly articulate a priority among the three components of the FBC, identifying mission content as the primary objective.

This depiction of the underlying problem brings us back full circle to the earlier definition of engineering as an activity directed toward achieving practical goals while operating under external constraints. Furthermore, the distinction between science and technology appears to play a role as well. Professedly, NASA as an entity undertakes scientific endeavors directed toward establishing new theories of knowledge. However, NASA's external constraints recast this idealized undertaking in practical terms. The investigative reports illustrate both the external constraints placed on engineering and the tension those constraints engender between NASA's scientific and technological goals.

5.5. Balancing Tensions

In addition to the conflict between the components of FBC, there appears to be an underlying tension between the scientific and technological goals of NASA. This tension is also discernible in the reports.

Both the MCO MIB and the MPIAT reports note that the scientific experts were not consistently consulted in decisions affecting mission success. The MCO MIB states that "flight-critical decisions did not adequately involve the mission scientists who had the most knowledge of Mars, the instruments and the mission science objectives" [6]. According to the MPIAT report, the MPL mission exhibited the same problem, in which major decisions were made without consulting the scientists: "The inevitable result was that some of the science eroded" [4].

However, the MPIAT report also asserts the following,

> If technology is the primary objective of a specific mission, science objectives should not conflict with or compromise the achievement of technology objectives. [4]

In contrast, the FBC TASK report cautions that NASA "guard against any effort to shift from basic research to development solely in support of the near term Missions" [5]. These cautions imply a distinction between scientific and technological goals and between long-term and near-term goals, respectively. At least at NASA, the science versus technology dichotomy appears to lie between conducting basic research with long-term implications and developing technology for near-term applications.

NASA is thus faced with an inherent tension between science and technology as well as with the conflicting demands of shortened schedules, reduced budgets, heightened risks, and increased public interest. The FBC approach to project management, rather than being the root cause of the problem, may simply be a mirror of NASA's complex social environment.

6. Conclusion

Much has been made of the problems with FBC and its implementation by NASA. When a mission fails, the investigative boards and the media target FBC as a major contributing factor. While my analysis has confirmed that there have been problems with both defining and prioritizing the three components of FBC, it has also shown that those problems reflect the social environment. Specifically, "Faster, Better, Cheaper" manifests the conflicting demands placed on NASA by the political, scientific, and economic social systems. The impetus for advancing quickly mirrors an era in which national power is intertwined with a country's technological superiority. The impetus for increasing scientific and technological returns reflects an era in which those returns have contributed to practical outcomes. And the impetus for reducing the cost of large-scale scientific and technological undertakings mirrors an era in which more technology is expected for less money.

As stated in the introduction, engineering is a social activity directed toward practical goals intended to serve human beings and, as such, is subject to social constraints. Thus it is not surprising that those social constraints are embedded in the FBC approach to project management. A systems theory analysis facilitates the recognition and comprehension of the influence of the social systems, directing attention to the root cause rather than to the symptom. While the root cause may evade a cure, identifying it may enable engineers to negotiate their conflicting environmental demands and, in the process, to mitigate them.

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