Exposing Single-Loop Learning and the TFW Virus: A Case Study of the Columbia Accident Investigation

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Abstract

Like the cultures of many organizations, NASA's organizational culture during the space shuttle era was entrenched in the TFW virus, a system of dysfunctional behaviors driven by values and underlying assumptions adapted from industrial giants: Taylor, Fayol, and Weber. In 2003, the Columbia space shuttle was destroyed while re-entering the earth's atmosphere, resulting in the loss of human life. The Columbia Accident Investigation Board attributed this tragedy to NASA's dysfunctional organizational culture, which espoused the value of safety but approached work with "faster, better, cheaper" expectations and practices. By exploring the intersection of socio-economic theory and Argyris' theory of organizational dysfunction, this paper examines how NASA's culture perpetuated the TFW virus through a vicious cycle of single-loop learning, a dysfunction that was exposed, following the disaster, by the Columbia Accident Investigation Board.

Key words: single-loop learning, TFW virus, organizational culture, Model I, socio-cognitive process, mental model, espoused values, underlying assumptions, Socio-Economic Approach to Management, Columbia space shuttle disaster, NASA culture.

Socio-economic theory declares that the social health and the economic health of an organization are positively related (Savall, 2010), both essential for organization effectiveness. This theory is supported by ISEOR's more than 40 years of research and practice of the Socio-Economic Approach to Management (SEAM) (Savall & Zardet, 2008, 2011, 2013). Yet, many American and Western organizations tend to have an unbalanced focus on strategies for efficiency, which they believe will produce financial gain (Savall & Zardet, 2013), neglecting the human aspect of organizations. Paradoxically, this imbalance generates risk and other hidden costs, often impeding the financial profitability—and sometimes even the viability—of the organization (Conbere & Heorhiadi, 2011; Savall & Zardet, 2008, 2011, 2013), a phenomenon that played out at NASA.

This paper examines how NASA's culture perpetuated a vicious cycle of dysfunction that ultimately resulted in the Columbia space shuttle disaster and the loss of human life. To provide a foundation for examining this case study, the intersection of socio-economic theory and Chris Argyris' (1998, 2000, 2004, 2010; Argyris & Schön, 1996) "Model I" theory of organizational dysfunction will first be explored.

Model I values

In Model I organizational cultures, "what people say" is inconsistent with "what they do" (Argyris, 1998, 2010; Conbere & Heorhiadi, 2006; Palmer, 2011; Schein, 2009). "The Model I socio-cognitive process includes thought-behavior patterns characterized by a dance of deception and contradiction. Such a dance is evident not only in social interaction between ourselves and other people but also internally within ourselves, through the contradiction between our real values and the values that we espouse" (Friesenborg, 2015, p. 32).

"What people say" is driven by their espoused values, which align with cultural ideals. "What people do" reflects their *real* values (Friesenborg, 2015). With the Model I socio-cognitive process (Argyris, 2000, 2004, 2010; Argyris & Schön, 1996), individuals' *real* values are focused not on cultural ideals but, instead, on their own egocentric desires and goals (Bandura, 2002; Kitayama, Duffy, & Uchida, 2007). Individuals may not recognize the inconsistency between "what they say" and "what they do" because their self-centered real values may be veiled by the idealistic values they claim to have (Friesenborg, 2015; Hofstede & Hofstede, 2005; Schein, 2009).

The contradiction between espoused and real values is not limited to organizational cultures. In fact, it is evident at the societal level. Argyris' (2000, 2004) research found Model I to be the prevailing type of culture in Western organizations, and the Model I socio-cognitive process has been posited as the "cultural default" in Western societies (Edmondson, 1996; Friesenborg, 2015). Through acculturation, individuals learn values from other people within the social systems with which they most closely identify (Hofstede & Hofstede, 2005; Kitayama et al., 2007; Oyserman & Lee, 2008). In this way, people also learn the dance between espousing cultural ideals rather than their admitting their egocentric desires and goals (Argyris, 2000, 2004, 2006; Conbere & Heorhiadi, 2006), and they develop a blindness to the contradiction (Argyris, 1998; Argyris & Schön, 1996; Conbere & Heorhiadi, 2006; Schein, 2009). Through this blindness, individuals tend to develop underlying assumptions about other people's motivations and circumstances, assumptions that go untested (Argyris, 2000, 2004, 2006, 2010; Argyris & Schön, 1996; Edmondson, 1996; Palmer, 2011). The contradiction between real and espoused values and the blindness about this contradiction fit the analogy of a virus, which Savall (2010) used to explain organizational dysfunction.

TFW virus: Perpetuating untested assumptions. SEAM recognizes the prevalence of a phenomenon that Savall (2010) called the "TFW virus," which perpetuates untested assumptions about maximizing human productivity. The TFW virus is named after Frederick Taylor, Henri Fayol, and Max Weber, Industrial Era theorists whose renown is explained in Table 1.

Table 1
Theorists whose Work Influenced the TFW Virus

Theorist	Nationality	Profession	Theory
Frederick Taylor (1856-1915)	American	Engineer	Founded the theory of scientific management, based on maximizing worker efficiency by removing design and decision-making from front-line workers' roles. Contributed to the creation of the Harvard Business School.
Henri Fayol (1841-1925)	French	Engineer	Founded the theory of administration, focusing on division of labor, specialization of tasks, and norms for obeying the chain of command.
Max Weber (1864-1920)	German	Sociologist	Founded the theory of bureaucracy, emphasizing order through an organizational hierarchy with defined rules, as well as norms for obeying the rules.

Source: Heorhiadi, Conbere, & Hazelbaker, 2014.

The theories of Taylor, Fayol, and Weber shaped the Western management approach. Evolving from these theories, the modern primary business model focuses on maximizing profit Heorhiadi et al., 2014). The core underlying assumptions of the model outlined in Table 2.

Table 2
Core Underlying Assumptions of the TFW Virus

Category	Core Underlying Assumption
Assumptions about cost:	Labor is an expense, and profit is—almost exclusively— dependent on the efficiency of labor.
Assumptions about work functions:	Efficiency is maximized by depersonalizing and commoditizing employees' work through: (a) separation of labor, with the removal of decision-making from workers' roles; and (b) hyper-specialization of work roles into narrow, routine, mindless tasks.
Assumptions about work behavior:	To create a labor commodity, managers should control workers, and workers must obey managers.
Assumptions about work structure:	Creating a hierarchy of command and control will help managers control employees and will provide employees with a structure for mindless obedience.

Sources: Heorhiadi et al., 2014; Savall, 2010.

NASA case study: Model I values. During, and even pre-dating, the space shuttle era from 1981 to 2011 (NASA, 2016), NASA's organizational culture reflected Model I values and the TFW virus. The Columbia space shuttle launched on January 16, 2003. The launch appeared to occur as planned, without serious incident. However, a piece of tile with a chunk of insulating foam—approximately the size of a briefcase—had broken away from Columbia's external fuel tank during the space shuttle launch. The insulating foam was designed to protect the fuel tank as the shuttle passed through the earth's fiery atmosphere. Just 81.9 seconds after Columbia's launch, the briefcase-sized chunk of insulating foam pulled away from the area where the fuel tank attached to the shuttle. This breakage was recognized, and the U.S. Department of Defense offered to use its satellite spy cameras to examine the extent of the damage while the Columbia was in flight, but NASA managers dismissed the issue. Without further investigation, NASA would not identify, until it was too late, that when the tile with the chunk of foam insulation broke away, it pierced the space shuttle orbiter's left wing. Not only was a portion of the fuel tank unprotected but also the pierced left wing was fatally exposed (Dreifus, 2003; Hammond & Mayfield, 2004; Howell, 2013; NASA, 2003).

During the following two weeks, Columbia astronauts Commander Rick Husband, Michael Anderson, Kalpana Chawla, Laura Clark, David Brown, William McCool, and Ilan Ramon conducted approximately 80 scientific experiments in space (Howell, 2013), unaware of the tragedy that awaited them. All seven astronauts aboard the Columbia perished.

The seriousness of Columbia's vulnerability was unknown until February 1, 2003, when, following the completion of their mission, the Columbia crew attempted to reenter the earth's atmosphere. Atmospheric gases and fiery heat penetrated the hole in the orbiter's left wing, instantly engulfing and decimating the Columbia space shuttle, raining debris over Louisiana and Texas (Dreifus, 2003; Hammond & Mayfield, 2004; Howell, 2013; NASA, 2003).

Following the disaster, the Columbia Accident Investigation Board (CAIB) was formed to investigate. The Board examined the path and timeline of Columbia's course and its demise. CAIB identified a system of misguided protocols and attributed the cause of these faulty protocols to the systemic dysfunction of NASA's organizational culture. The Columbia Accident Investigation Board reported the following conclusions (NASA, 2003):

- In our view, the NASA organizational culture had as much to do with this accident as the foam" (p. 97).
- "NASA's original briefings to the Board on its safety programs espoused a risk-averse philosophy that empowered any employee to stop an operation at the mere glimmer of a problem" (p. 177).
- "Unfortunately, NASA's view of its safety culture in those briefings did not reflect reality" (p. 177).

Contradiction between espoused and real values. NASA's organizational culture had repeatedly ignored safety hazards, in an effort to hurry projects toward completion, both on-time and on-budget. The organizational culture was rife with contradictions between the values that NASA espoused and the values reflected in people's behaviors (Dreifus, 2003; Hammond & Mayfield, 2004; Howell, 2013; NASA, 2003).

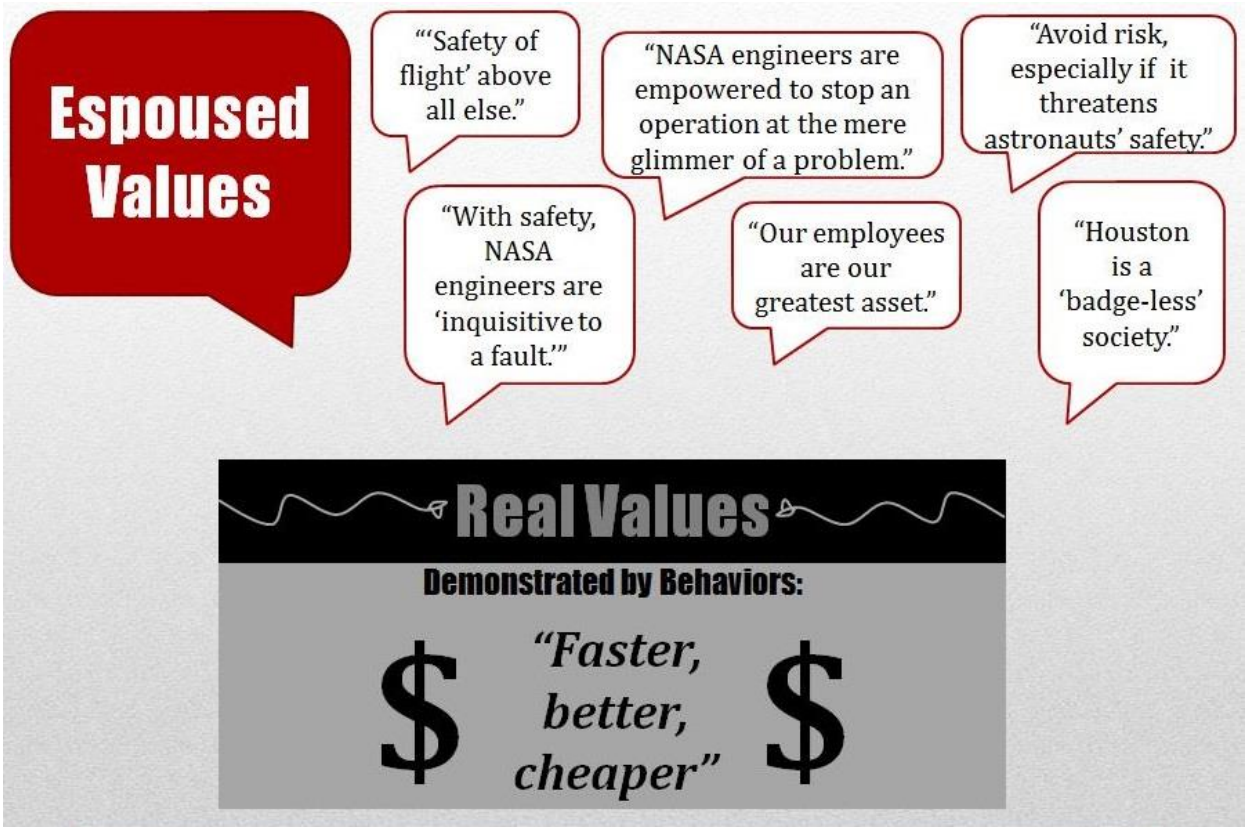

Figure 1. Model I values: NASA's contradiction between espoused and real values, leading to the Columbia space shuttle disaster.

The Columbia Accident Investigation Board Report included findings that NASA paid lip-service to the following values (Dreifus, 2003; Hammond & Mayfield, 2004; Howell, 2013; NASA, 2003):

- "'Safety of flight' above all else."
- "With safety, NASA engineers are 'inquisitive to a fault.'"
- "NASA engineers are empowered to stop an operation at the mere glimmer of a problem."
- "Our employees are our greatest asset."
- "Avoid risk, especially if it threatens astronauts' safety."
- "Houston is a 'badge-less' society" meaning that everyone at NASA has a voice, regardless of position, title, or station.

Each of these espoused values points to cultural ideals and industry safety standards. However, the Columbia Accident Investigation Board found that, in reality, NASA's behaviors were inconsistent with these espoused values. NASA espoused astronaut safety, but behaviors were not driven by a commitment to safety. Instead, decisions and actions were dictated by a "faster, better, cheaper" philosophy (NASA, 2003, p. 103).

Famed astronaut Sally Ride, who served on the Columbia Accident Investigation Board, said:

> Faster, better, cheaper, when applied to the human space program, was not a productive concept. It was a false economy. It's very difficult to have all three simultaneously. Pick your favorite two. With human space flight, you'd better add the word 'safety' in there too because if upper management is going 'faster, better, cheaper,' that percolates down and it puts the emphasis on meeting schedules and improving the way that you do things and on cost. And over the years, it provides the impression that budget and schedule are the most important things. (Dreifus, 2003, p. D2)

NASA espoused "safety above all else," which aligned with cultural ideals and industry safety standards. This espoused value was contradicted, though, by routine behaviors within the organizational culture. "Safety above all else" conflicted with real values for a "faster, better, cheaper" space program. NASA espoused "safety above all else," but cost savings was the real value demonstrated by behaviors within the organizational culture (Dreifus, 2003; Hammond & Mayfield, 2004; Howell, 2013; NASA, 2003).

Insufficient freedom to disagree. Years earlier, NASA recognized insulating foam as a critical safety measure for space shuttle design. By the space shuttle era, despite the organizational culture continually espousing "flight safety" values, NASA managers and engineers minimized the threat and did not push for a resolution when they observed the occasional tendency for the insulating foam to separate from the space shuttle during lift-off (Hammond & Mayfield, 2004).

The Columbia Accident Investigation Board questioned why NASA engineers did not voice concern. CAIB found that for NASA to avoid upsetting its schedule and budget for space shuttle launches, unwritten cultural norms had been established to inhibit people from speaking-up and insisting that threats to safety be addressed. Instead, NASA engineers were expected to silently follow the chain of command. Unwritten rules prevented people from voicing their observations of safety hazards. These cultural norms served as a vehicle to serve NASA managers' real values, driving their goals for a "faster, better, cheaper" space program (Dreifus, 2003; Hammond & Mayfield, 2004; Howell, 2013; NASA, 2003).

The failure to take action to ensure safety is largely attributable to the TFW virus and its unbalanced focus on cost savings. As outlined in Table 3, NASA's core underlying assumptions leading to the Columbia space shuttle disaster provided evidence of the TFW virus.

Table 3
NASA's Core Underlying Assumptions Leading to the Columbia Space Shuttle Disaster: Evidence of the TFW Virus

Category	Core Underlying Assumption
Assumptions about cost:	Labor is an expense and profit is almost exclusively dependent on the efficiency of labor (*i.e.*, "faster, better, cheaper" [NASA, 2003, p. 103]). The "magical thinking" that NASA could slash its budgets yet continue ambitious initiatives through existing programs (*e.g.*, the Human Space Flight Program), as well as add new programs (*e.g.*, the costly Space Station Program), is, almost exclusively, dependent on the belief that labor can be increasingly efficient.
Assumptions about work functions:	Efficiency is maximized by depersonalizing and commoditizing employees' work through separation of labor. This separation included the removal of decision-making from NASA engineers, preventing them from reexamination of flight safety hazards without permission.
Assumptions about work behavior:	To create a labor commodity, NASA managers controlled NASA engineers, and the engineers were expected to silently obey managers. NASA engineers were silenced from voicing safety hazards and calling for further examination or mitigation of those safety hazards, which could delay space shuttle launch schedules and increase cost.
Assumptions about work structure:	A hierarchy of command and control was established for NASA managers to control NASA engineers, providing engineers with a structure for mindless obedience.

Sources: Conbere & Heorhiadi, 2016; Dreifus, 2003; Hammond & Mayfield, 2004; Heorhiadi et al., 2014; Howell, 2013; NASA, 2003; Savall, 2010.

Failure to learn from the 1986 Challenger disaster. The TFW virus was evident at NASA long before the Columbia disaster. In 1986, the space shuttle Challenger exploded shortly after lift-off, due to structural failure in the "O-ring" seals, which allowed hot gases to make contact with a fuel tank. All seven lives aboard the Challenger were lost. Following the Challenger disaster, President Reagan formed the Presidential Commission on the Space Shuttle Challenger Accident, which became known as "the Rogers Commission," named after Commission Chairman William Rogers, a former Secretary of State. The Rogers Commission

report cited both structural and management failures (Argyris, 1990; NASA, 2003). The Columbia Accident Investigation Board report (NASA, 2003) referenced the Rogers Commission's report:

> The Rogers Commission concluded "the decision to launch the *Challenger* was flawed." Communication failures, incomplete and misleading information, and poor management judgments all figured in a decision-making process that permitted, in the words of the Commission, "internal flight safety problems to bypass key Shuttle managers." As a result, if those making the launch decision "had known all the facts, it is highly unlikely that they would have decided to launch." Far from meticulously guarding against potential problems, the Commission found that NASA had required "a contractor to provide that it was not safe to launch, rather than proving it was safe." (NASA, 2003, p. 100)

Argyris (1990) analyzed how NASA's organizational culture contributed to the 1986 Challenger disaster. He examined the Rogers Commission's report, which concluded that NASA had the appropriate organizational structures, regulations, policies, and practices in place to prevent safety threats of this magnitude, and the problem was that "people who were capable of recognizing and reporting safety problems did not do so" (p. 37). However, Argyris disagreed. In reviewing the transcript of NASA employees' testimony to the Rogers Commission, he found that budgets and launch schedules were the priority and that engineers who voiced safety hazards were ignored. The Rogers Commission reported:

> The engineers could not understand why their recommendation was going to be reversed. They spoke out again and again to make their position clear: "When Arnie realized he wasn't getting through, he just stopped…I also stopped when it was apparent that I couldn't get anybody to listen." (Presidential Commission, 1986, as cited by Argyris, 1990, p. 39)

NASA's organizational dysfunctions, which CAIB later attributed to the 2003 Columbia disaster, were also noted by Argyris (1990) in his analysis of the Challenger disaster, through review of the Rogers Commission testimony. The organizational dysfunctions attributed to the Columbia disaster were also evident in NASA's culture leading to the Challenger disaster in 1986. Yet, NASA failed to learn from the devastating outcome of the Challenger disaster. The contradiction between NASA's espoused and real values continued, and people were blind to NASA's severe neglect of flight safety protocols (NASA, 2003).

Often rooted in self-oriented desires and goals for power or self-preservation, these deep underlying assumptions guided the behavior of NASA managers and silenced NASA engineers

from speaking-up. The conflict between the "safety above all else" espoused values and the real values of "faster, better, cheaper" practices for cost savings—while risking human safety—is an indicator of a dysfunctional organizational culture (Argyris, 1998; Argyris & Schön, 1996; Conbere & Heorhiadi, 2006; Edmondson, 1996; Schein, 2009). This indicator is revealed by a contradiction between what people in an organization say (*i.e.*, their espoused values) and what they do (*i.e.*, their routine behaviors).

Model I behaviors

Though the theories of Taylor, Fayol, and Weber were developed over a century ago, today's predominant business model is still strongly indebted to the 20th century model that evolved from their theories (Savall, 2010). TFW assumptions are still evident in today's business practices (Heorhiadi et al., 2014), such as:

- Referring to employees as "human capital";
- Implementing management-controlled lean interventions for work efficiency, waste reduction, and cost savings; and
- Restructuring and downsizing to reduce labor expense, typically without reducing the expectations for the organization's output. These and other business practices are extensions of Model I behaviors driven by TFW assumptions.

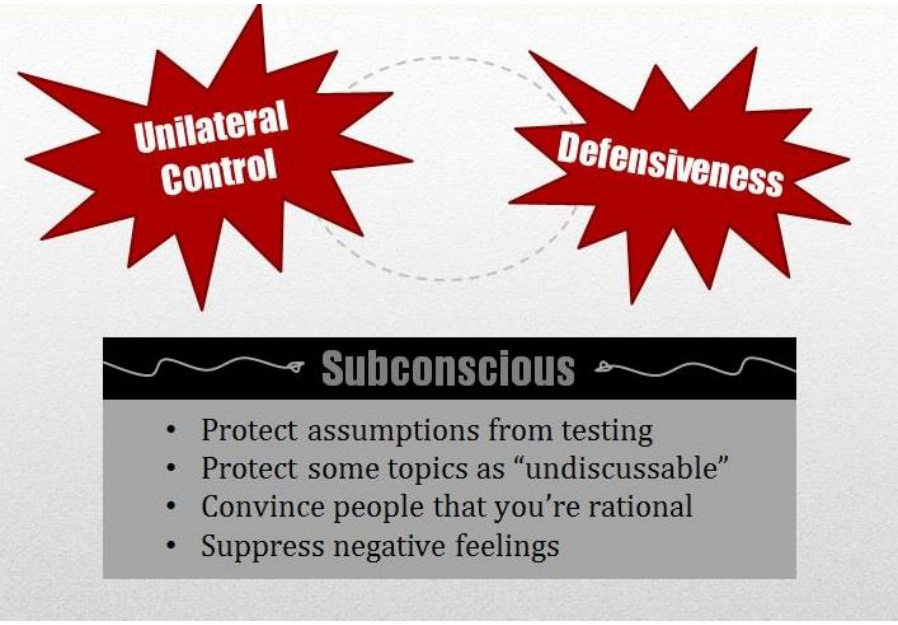

Figure 2. Model I behaviors.

Untested assumptions, including those that are TFW-inspired, are formed through a value system driven by egocentric desires and goals. These values and untested assumptions fuel

dysfunctional behaviors. In his research, Argyris (1990, 1998, 2000, 2004, 2006, 2010; Argyris & Schön, 1996) found two overarching behaviors to be prevalent in organizations: (a) unilateral control; and (b) defensiveness.

In Model I cultures, individuals or factions engage in divisive behaviors with each other, as they compete for unilateral control. Unilateral control is pursued by vying for influence or recognition (Argyris, 1998, 2000, 2004, 2006, 2010; Argyris & Schön, 1996), building social capital (Bandura, 2002), or threatening or punishing people through either aggressive or passive-aggressive tactics (Argyris, 1998, 2000, 2004, 2006, 2010; Argyris & Schön, 1996).

Defensive behavior is exhibited in response to embarrassment or either real or perceived threats to oneself, one's espoused values, or other people or things that are important to the individual. The individual may respond by blaming or demonstrating "fancy footwork," deflecting blame and redirecting it to others (Argyris, 2000; Conbere & Heorhiadi, 2006; Mezirow, 2003; Palmer 2004, 2011).

To protect TFW-inspired assumptions and Model I's dysfunctional behaviors from scrutiny, individuals employ subconscious strategies, including preventing underlying assumptions from being tested and protecting some topics as "undiscussable." Threats to these strategies result in defensive behavior, along with attempts to convince others that their behavior is rational, supported by suppressing negative feelings (Argyris, 1990, 1998, 2000, 2004, 2006, 2010; Argyris & Schön, 1996).

NASA case study: Model I behaviors. Both controlling and defensive behaviors were evident at NASA. Prior to the Columbia disaster, between 1981 and 2002, 13 space flights sustained significant foam loss or damage to the space shuttle's thermal protection system. Because those cases did not result in serious injury to astronauts, NASA's culture developed a "normalization of deviance," a phrase coined by Diane Vaughn in her book about the Challenger disaster (Hammond & Mayfield, 2004, p. 10) to explain how people become comfortable with undesirable risks or outcomes: (a) if people experience them often enough; and (b) if those experiences do not result in serious consequences. The risks no longer cause alarm. At NASA, foam strikes had become routine, and until the Columbia disaster, none of the incidents had resulted in severe consequences (NASA, 2003). CAIB's report explained:

> The attitudes and decision-making of Shuttle Program managers and engineers during the events leading up to this accident were clearly overconfident and often bureaucratic in nature. They deferred to layered and cumbersome regulations rather than the fundamentals of safety. The Shuttle Program's safety culture is straining to hold together the vestiges of a once robust systems safety program. (NASA, 2003, p. 177)

As a result, when NASA engineers communicated plans to reexamine the potential for foam strikes to negatively impact flight safety, their plans were terminated by management. As evidence of "normalization of deviance," NASA management cited that such examination was unnecessary. NASA's culture was driven by "faster, better, cheaper" values, bowing to political pressures for cost savings and deadlines for high-profile space shuttle launches (Dreifus, 2003; Hammond & Mayfield, 2004; Howell, 2013; NASA, 2003). The unwritten expectations were, "Do what you're told, and do not question or challenge decisions made through the chain of command."

Defensive behaviors were evident, in additional to unilateral control. In the interest of "faster, better, cheaper," the assumption that foam strikes would not cause serious injury was an assumption that NASA managers protected. While NASA deeply espoused astronaut safety, NASA managers maintained the "foam strikes pose no danger" assumption as undiscussable and protected this assumption from being tested. Based on the Columbia Accident Investigation Board's conclusions, Hammond and Mayfield (2004) explained, "…The engineers had identified the 'mere glimmer of a problem.' However, in direct contrast to NASA's stated value that all employees were empowered to stop the operation, the engineers were cut out of the decision-making process by higher-level managers intent on meeting the schedule" (p. 16). NASA's dysfunctional values and behaviors generated costly outcomes.

Model I outcomes

Dysfunctional behaviors yield a snowballing-effect of dysfunctional outcomes, beginning with the six dysfunctions identified by Savall and Zardet (2008; Savall, Zardet, & Bonnet, 2008). These six dysfunctions are related to: working conditions; work organization; communication, coordination, or cooperation; time management; integrated training; and strategic implementation.[1] In response to encountering these dysfunctions in the workplace, people react by internalizing pain and frustration, as the problem escalates. Subconsciously, they demonstrate "skilled unawareness" to their own role in contributing to the problem (Argyris, 2000, 2004, 2006, 2010; Ford, 1999; Palmer, 2011), resistance to productive learning and change (Ford, 1999; Kimball, 2011; Mezirow, 2003), and self-fulfilling prophesy (Argyris, 2000, 2004, 2006, 2010; Argyris & Schön, 1996; Ford, 1999).

As the dysfunctional outcomes continue to snowball, symptoms of the dysfunctions are produced. Symptoms include: absenteeism, occupational injury or disease, staff turnover, non-

[1] Note: This paper is not intended to provide a comprehensive explanation of the individual dysfunctions, symptoms, and hidden costs identified by socio-economic theory. To explore these further, please see Savall (2010) or Savall et al. (2008).

quality, or direct productivity gaps. These symptoms result in hidden costs: excess salary, lost time, over-consumption (*i.e.*, duplication of work), non-production, risk, and squandered human potential. These hidden costs are not listed on financial statements (Conbere & Heorhiadi, 2011; Savall, 2010; Savall & Zardet, 2008; Savall et al., 2008) and are, instead, shrouded by the Model I system. The result is squandered economic potential, a direct contradiction to the #1 value of typical American organizations: economic profitability.

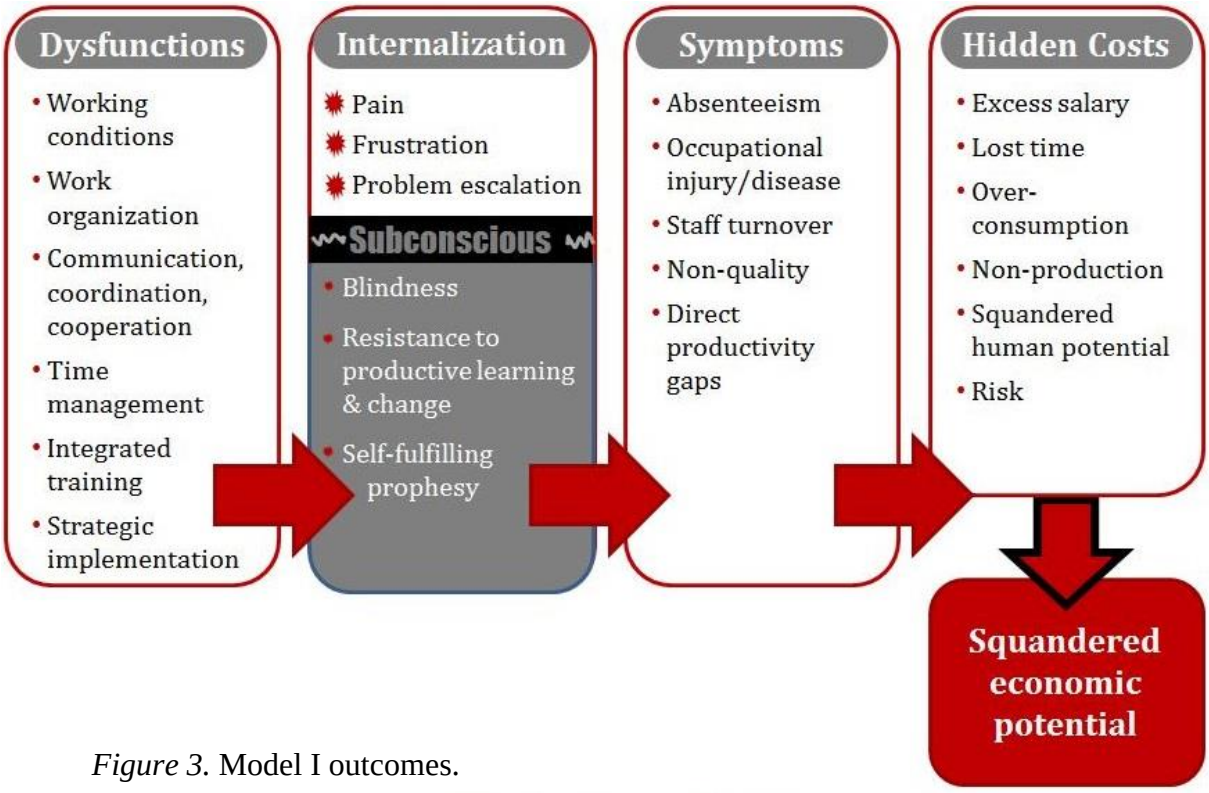

Figure 3. Model I outcomes.

NASA case study: Model I <u>outcomes</u>. Following the Columbia space shuttle disaster, the Columbia Accident Investigation Board concluded that NASA's "faster, better, cheaper" approach to work was inconsistent with its espoused values of "safety above all else." Analyzing CAIB's findings, along with the six organizational dysfunctions identified by Savall (2010; Savall et al., 2008), listed in Figure 3, one may conclude that NASA's major failures produced three primary dysfunctions:

- <u>Working conditions:</u> unsafe working conditions that proved fatal;
- <u>Strategic implementation:</u> "faster, better, cheaper" strategies, in direct contradiction to espoused priorities for flight safety;
- <u>Communication, coordination, and cooperation:</u> destructive patterns of communication, flawed coordination, and lack of cooperation.

These dysfunctions are internalized. Though not explicitly recorded in the literature about the Columbia space shuttle disaster, pain and frustration are typical outcomes in organizational cultures that practice unilateral control and defensiveness, depriving people the freedom to speak-up and disagree. At NASA, other internalized outcomes included people's blindness to the contradiction between their espoused safety values and their real "faster, better, cheaper" values, which they practiced, as well as their resistance to productive learning and change.

These internalized outcomes are presented externally as symptoms. At NASA during the space shuttle era, hampered quality in the space shuttle's design, labeled as "non-quality" in Figure 3, was a major symptom of the dysfunctions. This compromise produced catastrophic risk, a hidden cost that was revealed with the deaths of the Columbia space shuttle's seven astronauts. Another hidden cost was squandered human potential, among: (a) the engineers who were silenced from raising any safety concerns; and (b) the seven astronauts who lost their lives, squandering the impact they could have contributed through both their personal and professional roles and relationships. Secondarily, the disaster posed risk for damaging public opinion and, subsequently, reducing Federal funding for NASA's space programs, jeopardizing NASA's economic potential and perhaps even the agency's viability (Dreifus, 2003; Hammond & Mayfield, 2004; Howell, 2013; NASA, 2003).

Single-loop learning

The Model I values (shown in Figure 1), behaviors (shown in Figure 2), and outcomes (shown in Figure 3), combine to form the system shown in Figure 4.

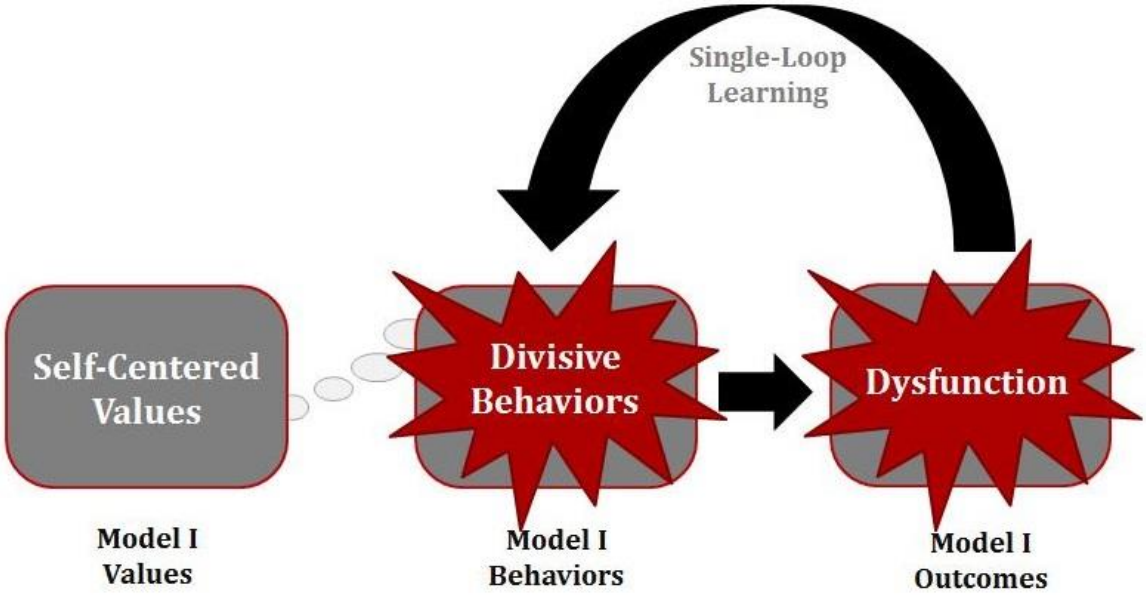

Figure 4. Single-loop learning: A vicious cycle stemming from untested assumptions, including those associated with the TFW virus.

The contradiction between espoused values and real self-centered values drives divisive behaviors, which lead to dysfunctional outcomes. In response to these dysfunctional outcomes, including hidden costs and squandered economic and human potential, people tend to elevate their divisive behaviors, through more defensiveness and more pursuit of unilateral control. This, in turn, elevates the dysfunctional outcomes, creating a vicious cycle of divisive behaviors and dysfunctional outcomes. Argyris (1990, 2000, 2004, 2010; Argyris & Schön, 1996) called this vicious cycle "single-loop learning." Self-centered values, the primary culprit fueling this vicious cycle, remain free from scrutiny because people remain blind to the contradiction between their espoused values and their real self-centered values (Argyris, 1990, 2000, 2004, 2010; Argyris & Schön, 1996; Heorhiadi et al., 2014; Hofstede & Hofstede, 2005; Kitayama et al., 2007; Oyserman & Lee, 2008; Savall, 2010).

The TFW virus is perpetuated by single-loop learning. Through single-loop learning, TFW's core assumptions (see Table 2) remain untested. The virus spreads untested assumptions through acculturation and protects them from scrutiny (Argyris, 1990, 2000, 2004, 2010; Argyris & Schön, 1996; Heorhiadi et al., 2014; Hofstede & Hofstede, 2005; Kitayama et al., 2007; Oyserman & Lee, 2008; Savall, 2010). In the case of the Columbia space shuttle disaster, the vicious cycle of divisive behaviors (*i.e.,* unilateral control and defensiveness) and dysfunctional outcomes (*e.g.,* hampered quality in the space shuttle's design; severe flight safety risks; squandered human and economic potential) continued—through single-loop learning—until disaster struck. A disaster of this magnitude, with the deaths of seven astronauts on the world's stage, prompted an investigation by the Columbia Accident Investigation Board. Ultimately, CAIB's report exposed evidence of the TFW virus, perpetuated by a vicious cycle of single-loop learning.

Exposing single-loop learning and the TFW virus

The analysis of NASA's organizational culture and its contribution to the Challenger disaster provide evidence that the TFW virus was already ingrained in NASA's culture in the 1980s, long before the Columbia space shuttle disaster. The TFW virus bred dysfunctions and hidden costs. To understand the root causes of those dysfunctions, one must first understand NASA's history.

NASA's history. In 1961, President Kennedy announced to Congress—and the nation and world—the goal to send an American astronaut safely to the moon by the end of the decade. This goal was driven by the United States' high-pressured political competition with its Cold War adversary, the Soviet Union, which had eclipsed the U.S. in space exploration, embarrassing the U.S. This embarrassment prompted President Kennedy's speech (NASA, 1961).

Cold War symbolism of the space race. In effect, the launch of the U.S. space program was largely motivated by a Model I relationship between the U.S. and the Soviet Union. Modeling the pattern of single-loop learning, the U.S. and USSR were each driven by egocentric values of good versus evil, with each country considering itself the hero and its rival, the villain. These values manifested into a supreme goal to win the space race, a symbol of world power dominance. Goals for scientific exploration and discovery were secondary. During the Cold War relationship between the U.S. and Soviet Union, each nation pursued unilateral control not only through the space race but also through espionage and proxy conflicts, such as the botched Bay of Pigs invasion. Frustration and fear—particularly of nuclear attack—were major outcomes of the Model I process. Through single-loop learning, the Cold War relationship between the U.S. and Soviet Union was characterized by a vicious cycle of vying for unilateral control and exerting defensive behavior, followed by frustration and fear, followed by elevated defensiveness and efforts for unilateral control, as an ongoing cycle.

In 1961, "Kennedy felt great pressure to have the United States 'catch up to and overtake' the Soviet Union in the 'space race'" (NASA, 1961). Americans deeply desired to win the space race. The first and second legs of the race had been won by the Soviet Union, which shocked the world in 1957 by sending into space the first human, cosmonaut Yuri Gagarin, who not only traveled outside the earth's atmosphere but also orbited the earth. Four years later, in 1961, less than three weeks prior to President Kennedy's speech, the U.S. sent the first American—astronaut Alan Shepard—into space, though it was a short suborbital flight, without orbiting the full perimeter of the earth, as Gagarin had done four years prior (NASA, 1961). The crowning achievement would go to the Cold War rival that won the third leg of the race: sending the first person to step foot on the moon, then safely return home. Congress committed significant funding to reach this ambitious goal. In 1961, less than 1% of the Federal budget was allocated to NASA, an allocation that grew to nearly 4% of the Federal budget by 1965 (NASA, 2003).

The effort paid off. On July 20, 1969, Apollo 11's lunar module landed on the moon, and American astronaut Neil Armstrong took "one small step for a man [and] one giant leap for mankind" (NASA, 2014), becoming the first person to walk on the moon. Planting the American flag on the moon was symbolic of the U.S. surpassing the Soviet Union in the space race.

Post-Cold War perceptions and resistance to learn. After its first decade of existence, though, NASA's role became less important in the Cold War struggle. By the mid-1970s, NASA's funding had reverted to the approximate amount allocated by Congress in 1961, less than 1% of the Federal budget. This trend continued after the Cold War thawed in the 1980s. By this time, the space race had been won, and the United States' competition with the Soviet Union had fizzled. NASA no longer symbolized the United States' ticket to win against the Soviet

Union, and Americans were no longer as mesmerized by the idea of space travel. Yet, "NASA personnel maintained a vision of their agency that was rooted in the glories of an earlier time, even as the world, and thus the context within which the agency operated, changed around them" (NASA, 2003, p. 102).

> In the aftermath of the *Challenger* accident, [NASA exhibited]…a resistance to externally imposed changes and an attempt to maintain the internal belief that NASA was still a "perfect place," alone in its ability to execute a program of human space flight…As Human Space Flight Program managers strove to maintain their view of the organization, they lost their ability to accept criticism, leading them to reject the recommendations of many board and blue-ribbon panels, the Rogers Commission among them. (NASA, 2003, p. 102)

After the Challenger disaster, though NASA restructured and appointed new senior leadership at the Johnson, Marshall, and Kennedy Space Centers, the agency's culture and practices remained mostly unchanged (NASA, 2003).

> As a close observer of NASA's organizational culture has observed, "Cultural norms tend to be fairly resilient…The norms bounce back into shape after being stretched or bent. Beliefs held in common throughout the organization resist alteration…By the eve of the *Columbia* accident, institutional practices that were in effect at the time of the *Challenger* accident—such as inadequate concern over deviations from expected performance, a silent safety program, and schedule pressure—had returned to NASA. (NASA, 2003, p. 101)

Constrained budgets. In 1990, the administration of President George H. W. Bush ordered a comprehensive review of NASA and its programs, prompted by structural problems with shuttles and the Hubble Space Telescope. The review concluded that NASA's budget was insufficient to fund all the programs that NASA was attempting to implement. The report explained that "NASA is currently over committed in terms of program obligations relative to resources available—in short, it is trying to do too much, and allowing too little margin for the unexpected" (Report of the Advisory Committee on the Future of the U.S. Space Program, as cited by NASA, 2003, p. 102).

Between 1965 and 1975, NASA's budget was slashed by 59.2%.[2] Budgets increased in the years following the Challenger disaster, but never approached the Federal funding that was

[2] Adjusting for inflation, using the FY2002 value of the U.S. dollar, NASA's budget decreased from $24.696-billion in 1965 to $10.079-billion in 1975 (NASA, 2003).

invested in the space program in 1965. During the decade prior to the 2002 Columbia space shuttle launch, neither President Bill Clinton's or President George W. Bush's administration, nor Congress were interested in developing "a reinvigorated space program" (NASA, 2003, p. 102). This lack of vision resulted in constrained budgets. However, "rather than adjust its ambitions to this new state of affairs, NASA continued to push an ambitious agenda of space science and exploration, including a costly Space Station Program" (NASA, 2003, p. 99).

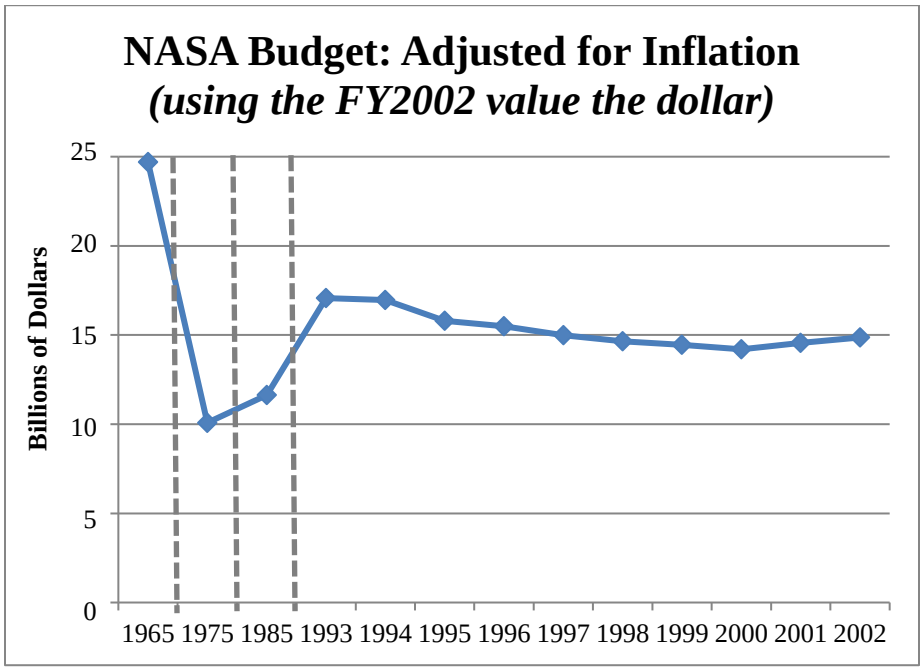

Figure 5. NASA budget: Adjusted for inflation (NASA, 2003, p. 103).

NASA's history—from the glory days of the space race to post-Cold War perceptions, coupled with inadequate budgets to accomplish all NASA's initiatives—led to an organizational environment where the TFW virus flourished. The virus is evident in the "organizational cause statement," in which the Columbia Accident Investigation Board summarized the causes for the Columbia tragedy.

Organizational cause statement. The Columbia Accident Investigation Board report issued the following "organizational cause statement," identifying the chief causes of the Columbia space shuttle disaster:

> The organizational causes of this accident are rooted in the Space Shuttle Program's history and culture, including the original compromises that were required to gain approval for the Shuttle Program, subsequent years of resource constraints, fluctuating priorities, schedule pressures, mischaracterization of the Shuttle as operational rather than

> developmental, and lack of an agreed national vision. Cultural traits and organizational practices detrimental to safety and reliability were allowed to develop, including: reliance on past success as a substitute for sound engineering practices (such as testing to understand why systems were not performing in accordance with requirements/specifications); organizational barriers which prevented effective communication of critical safety information and stifled professional differences of opinion; lack of integrated management across program elements; and the evolution of an informal chain of command and decision-making processes that operated outside the organization's rules. (NASA, 2003, p. 177)

The Columbia Accident Investigation Board attributed the disaster to NASA's (2003) dysfunctional organizational culture. Until the disaster and subsequent investigation, NASA's conflicting espoused and real values remained shrouded from scrutiny. However, the investigation by the Columbia Accident Investigation Board removed that shroud and, through its report, exposed the contradiction between NASA's espoused value of "safety above all else" and its real values reflecting "faster, better, cheaper" priorities for cost savings.

CAIB's identification of the causes of the Columbia space shuttle disaster provided a revelation of NASA's dysfunctional organizational culture (NASA, 2003). Drawing upon the "organizational cause statement's" comprehensive collection of identified causes, the SEAM process targets the *root* causes of the dysfunctions and hidden costs (Conbere & Heorhiadi, 2015).

Root causes of the Columbia space shuttle disaster. Central to SEAM is the identification of root causes. Using the SEAM's analogy of a "causal tree," the trunk and branches of the tree symbolize a flawed organizational culture and its practices, the leaves symbolize the organization's dysfunctions, and sprouting from the leaves are poisonous berries, the "fruit" of the dysfunctions: hidden costs. The roots of the tree represent the underlying causes of the organizational culture and the dysfunctions and hidden costs that it produces. The SEAM analogy of the causal tree corresponds with the pattern of Model I values, behaviors, and outcomes shown in Figures 1-3, along with their combined interrelationship, shown in Figure 4 (Argyris, 1990, 1998, 2000, 2004, 2006, 2010; Argyris & Schön, 1996; Friesenborg, 2015).

In SEAM theory there are five root causes of dysfunction: (a) lack of steering; (b) lack of synchronization; (c) lack of cleaning up; (d) lack of negotiation; and (e) poor information systems. Drawing from the Columbia Accident Investigation Board's report, the following appear to be the root causes NASA's dysfunctional culture, leading to the Columbia space shuttle disaster (see Table 4).

Table 4

Root Causes of NASA's Dysfunctional Culture, Leading to the Columbia Space Shuttle Disaster

Root Cause	Evidence at NASA
Lack of steering	a) Lack of national vision for NASA from the White House and Congress, along with the lack of Federal funding to support that vision; and b) Lack of prioritization and strategic management of NASA's programs and projects by senior management.
Lack of cleaning-up	Failure of NASA's senior management to target NASA's objectives and shrink the scope of programs, in response to constrained budgets. Instead, NASA executed an ambitious slate of programs—continuing existing programs (*e.g.*, the Human Space Flight Program) and adding new programs (*e.g.*, the costly Space Station Program)—despite the financial reality that sustaining this scope of programs *and* maintaining flight safety standards was not feasible.
Poor information systems	Hiring a large number of external consultants to lead essential responsibilities, including those related to flight safety, prevented an effective flow of information throughout NASA.
Lack of negotiation	Disallowing the freedom to disagree: Failure of NASA's senior management to listen to NASA employees, particularly the failure to listen to NASA engineers who identified potential safety hazards and suggested reexamination to mitigate them.

Sources: NASA, 2003.

Lack of steering, lack of cleaning-up, lack of negotiation, and poor information systems are the root causes, upon which all other causes of NASA's dysfunctional culture and the Columbia space shuttle disaster hinged. The Columbia Accident Investigation Board found that NASA's culture failed to change following the Challenger disaster. Evidence of these root causes were cited before and after both the 1986 Challenger disaster and the 2002 Columbia disaster. Central to socio-economic theory and the SEAM process, organizations must address the root causes of their dysfunctions in order to create organizational change. Addressing these three root causes is critical for NASA to overcome its dysfunctions and hidden costs, including flight safety risks and the squandering of human and economic potential.

Conclusion

Foundational to the Socio-Economic Approach to Management is the organization's balance of social and economic values. Socially, SEAM organizations value people, with a primary focus on employees, as well as customers and other stakeholders. Economically, SEAM organizations value financial prosperity. Like NASA during the space shuttle era, most organizations in the U.S. and other Western nations *espouse* both "people values" and financial values. The question is: What are the organization's *real* values, and do they align with the values the organization espouses? To make this determination, a series of questions are posed in Table 5. These questions correspond to the organizational functions identified by Savall (2010) and his colleagues (Savall et al., 2008).

Table 5
Diagnosing Dysfunctional Organizations: A Comparison with SEAM Organizations

Dysfunctional Organizations: Misalignment between Real and Espoused Values	**SEAM Organizations:** Alignment between Real and Espoused Values
<u>Working Conditions:</u> What are the organization's working conditions?	
Dysfunctional organizations provide unsafe or unhealthy working conditions that fail to honor both the humanity of employees and the stewardship of organizational resources. These organizations fail to demonstrate a balance of "people values" and financial values, which the organizations espouse.	SEAM organizations provide safe and healthy working conditions that honor both the humanity of employees and the stewardship of organizational resources, demonstrating a balance of "people values" and financial values, which the organizations espouse.
<u>Work Organization:</u> What is the work organization like?	
In dysfunctional organizations, the organizational structure and the assignment of roles and responsibilities do not support a balance of "people values" and financial values, which the organizations espouse.	In SEAM organizations, the organizational structure and the assignment of roles and responsibilities support the values that SEAM organizations espouse: a balance of "people values" and financial values.
<u>Communication, Coordination, Cooperation (the "3 Cs"):</u> What are the organization's patterns for communicating, coordinating work, and cooperating?	

Dysfunctional Organizations: Misalignment between Real and Espoused Values	**SEAM Organizations:** Alignment between Real and Espoused Values
The cultural norms of dysfunctional organizations fail to encourage, expect, or support productive communication, coordination, and cooperation. These organizations fail to demonstrate a balance of "people values" and financial values, which the organizations espouse.	The cultural norms of SEAM organizations encourage, expect, and support productive communication, coordination, and cooperation. SEAM organizations demonstrate a balance of "people values" and financial values, which the organizations espouse.
<u>Time Management:</u> How do people manage their time?	
In dysfunctional organizations, cultural norms fail to encourage, expect, or support productive time management, in a way that honors both the humanity of employees and the stewardship of organizational resources. These organizations fail to demonstrate a balance of "people values" and financial values, which the organizations espouse.	In SEAM organizations, cultural norms encourage, expect, and support productive time management, in a way that honors both the humanity of employees and the stewardship of organizational resources. SEAM organizations demonstrate a balance of "people values" and financial values, which the organizations espouse.
<u>Integrated Training:</u> To what extent do people receive the training and development needed to effectively perform their jobs?	
Dysfunctional organizations fail to encourage, expect, or support learning and development among employees and neglect to provide the training needed for employees to effectively perform their jobs. These organizations fail to demonstrate a balance of "people values" and financial values, which the organizations espouse.	SEAM organizations encourage, expect, and support learning and development among employees and provide the training needed for employees to effectively perform their jobs. SEAM organizations demonstrate a balance of "people values" and financial values, which the organizations espouse.
<u>Strategic Implementation:</u> What are the organization's strategic priorities, how effectively are they executed, and to what extent are the strategic priorities achieved?	
Dysfunctional organizations fail to plan, take action, and accomplish strategic priorities that reflect a balance of "people values" and financial values, which the organizations espouse.	SEAM organizations plan, take action, and accomplish strategic priorities that reflect a balance of "people values" and financial values, which SEAM organizations espouse.

Sources: Conbere & Heorhiadi, 2011; Savall, 2010; Savall et al., 2008.

Collectively, how well organizations perform the six functions, or deal with six dysfunctions, identified by Savall (2010) and his colleagues (Savall et al., 2008) distinguishes either how effective or how dysfunctional the organization is. For Model I organizations, entrenched in the TFW virus, the responses to the questions presented in Table 5 reveal dysfunctions, which snowball to internalization of the dysfunctions, followed by observed symptoms of the underlying dysfunctions, then hidden costs, and finally, squandering of the organization's economic potential (see Figure 3). In contrast, the way that SEAM organizations respond to the questions in Table 5 demonstrates a balance of "people values" and economic values, which the organizations espouse.

Reconciling social and economic values for greater organizational effectiveness. Like NASA during the space shuttle era, most organizations in the U.S. and other Western nations *espouse* a balance of "people values" and economic values, but their actions reveal a skewed focus toward economic values. To mirror cultural ideals, organizations espouse "people values." In reality, though, most organizations are entrenched in the TFW virus and treat people as expendable commodities. Their espoused values and real values do not align. Instead, these organizations' actions reflect their *real* values, which hold little regard for people.

At most organizations, like NASA during the space shuttle era, the human aspects of management are ignored because people are not valued. Former astronaut Sally Ride observed that NASA both espoused and implemented "faster, better, cheaper" practices, while also continuing to espouse "safety above all else." Assuming that all four will be achieved is "magical thinking," a term coined by Conbere & Heorhiadi (2016) to explain espoused expectations that conflict with reality. In reality, NASA could not achieve all four criteria because they represented competing interests at the agency.

NASA's focus was skewed toward cost savings, creating an imbalance that emphasized economic values and devalued people. Safety measures—which cost time and money—did not support the skewed focus on cost savings. By the space shuttle era, NASA had grown comfortable with the possibility of foam strikes, based on the false assumption that foam strikes did not pose severe risk. That false assumption, coupled with values fixated on cost savings and the devaluation of people, predicated the Columbia space shuttle disaster. The fact that safety makes good business sense, as a strategy for mitigating financial risk, was not enough for NASA to overcome the false assumption that potential foam strikes did not pose serious risks.

Organizations falsely assume that the prospect of valuing people directly competes with valuing economic prosperity. Organizations devalue people by considering them a commodity subject to cost savings. Drawing from this assumption, dysfunctional organizations consider

"people values" and economic values as exclusive of one another. The TFW virus perpetuates this false assumption through the vicious cycle of single-loop learning.

Valuing the organization's financial standing *and* valuing people may lead to superior strategies, complementing both values. At NASA, "fast" and cheap" competed with "better" and "safer." This exclusivity need not be the case. An organization can pursue revenue and cost savings, while honoring quality and safety commitments to employees and customers. Production at a SEAM organization may not be quite as "fast" and "cheap" as an organization with a skewed focus on cost savings and little regard for quality and safety. However, an organization that practices both social and economic values may achieve *relative* speed to market and *relative* cost savings, while simultaneously achieving safety and product quality, whereby reducing dysfunctions and hidden costs and leveraging the potential of both people and the organization's financial standing (Savall, 2010; Savall et al., 2008). With SEAM, this collective outcome is the objective for organizational change.

Framework for organizational change. CAIB's report concluded, "It is the Board's opinion that good leadership can direct a culture to adapt to new realities. NASA's culture must change…" (NASA, 2003, p. 225). To create organizational change, first, this vicious cycle of single-loop learning must be interrupted by exposing the TFW virus, beginning with exposing: (a) the root causes of the organization's dysfunctions; and (b) the contradiction between the values the organization espouses and the values reflected by people's behaviors. At NASA, these revelations were accomplished through the Columbia Accident Investigation. Second, the TFW virus must be mitigated by replacing it with an organizational culture that: (a) aligns espoused and real values; (b) equitably values both the organization's financial standing and people; and (c) integrates the use of feedback loops as a cultural norm to ensure that espoused and real values remain aligned, preventing the TFW virus from creeping back into the organizational culture. Whether NASA followed through on this second step toward organizational change, or whether NASA reverted to old patterns as it did following the Challenger disaster, is unknown.

After the Columbia space shuttle disaster, NASA's vicious cycle of single-loop learning was interrupted and evidence of the TFW virus was exposed through CAIB's report, but whether the root causes were thoroughly addressed or whether NASA even had the tools to replace its TFW-infused, Model I culture with a new, healthy, productive culture is unclear. Following the Columbia Accident Investigation Board report, which exposed evidence of the TFW virus and single-loop learning, NASA would have benefited from the structured framework of a SEAM intervention to recreate its organizational culture. In addition to diagnosis and identification of projects to chart a new path forward for the new organizational culture, a SEAM intervention would have provided the opportunity to learn and practice using SEAM tools to sustain that new culture and resist the old patterns of the TFW virus.

"Over four decades, the socio-economic approach to management proved to be the best antidote to the TFW virus" (Conbere & Heorhiadi, 2016, p. 34). SEAM, first, provides a framework for interrupting the vicious cycle of single-loop learning and exposing the TFW virus and, second, integrates tools for creating and sustaining a new culture that values both financial prosperity *and* people, values that are both espoused and reflected in the organization's practices. In SEAM organizations, what people *say* (*i.e.*, their espoused values) and what they *do* (*i.e.*, actions driven by their real values) are aligned. They do not merely espouse that "employees are our greatest asset," but organizational practices also support this claim. Over 40 years of SEAM intervention-research have demonstrated that social and economic values are not mutually exclusive but, instead, mutually essential for organizations to be effective.

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