This paper examines the human and organizational failures that have plagued the design and construction of the new east span of the San Francisco-Oakland Bay Bridge, drawing comparisons to the failures of the New Orleans Flood Defense System before and during Hurricane Katrina. It also suggests what lessons can be learned from the successes of “high reliability organizations,” so that more integrity and reliability can be built into the leadership and decision-making processes of future projects of this magnitude.

Introduction

“You have met the enemy and it is yourselves.”¹ Former Governor Pete Wilson uttered these words in 1997, criticizing the eight years of delays, in-fighting and indecision that had surrounded the construction of the new east span of the Bay Bridge. Now, ten years later—seventeen years after the 1989 Loma Prieta earthquake exposed the seismic vulnerabilities of one of the busiest bridges in the U.S.—the Bay Area still does not have a new bridge.

Human beings are the weakest link in otherwise high-functioning systems. Some estimates show that human error contributes to 80% of “high consequence compromises in quality” that often prove fatal to organizations.² Engineers commonly argue that there is no such thing as a natural disaster, only man-made catastrophes. The most tangible, recent illustration of human factors’ destructive power is Hurricane Katrina. Despite ample meteorological research and years of first-hand experience with hurricanes in the Gulf Coast, Louisiana was not prepared to face the category three storm that hit New Orleans on August 29, 2005. One of the most glaring failures during Katrina was the New Orleans Flood Defense System (NOFDS), which completely crumbled under the power of the hurricane’s storm surge.

²Robert Bea, Presentation to Prof. Farber’s Disasters and the Law class on 1/22/07.
We are doomed to repeat history when we fail to learn from disasters.\textsuperscript{3} Effective disaster preparation requires organizations to learn not only from their own history and experiences, but also the experiences of others.\textsuperscript{4} There are several warning signs that the construction of the new east span of the Bay Bridge is traveling down the same ignorant and potentially destructive path as the NOFDS had traversed in constructing the New Orleans levee system.

There are volumes to be learned from both failing systems, such as the NOFDS, as well as successful systems, known as high-reliability organizations (HRO’s). Why has the Bay Area, which is at the forefront of scientific and technological innovation and a leader in progressive, forward-thinking values, struggled so much to build a bridge? This paper examines some of the human errors that have plagued the construction of the new Bay Bridge. It also suggests how to apply lessons learned from the successes of HRO’s on one hand, and the failures of the NOFDS during Hurricane Katrina on the other, to build integrity and reliability into the decision-making processes, and ultimately the safety, of the new east span of the Bay Bridge that is currently under construction.

Section A describes “high reliability organizations” in more detail, underscoring the particular qualities that allow these organizations to operate in highly volatile environments with relatively few accidents. Section B outlines the human and organizational errors that lead to the destruction of the New Orleans Flood Defense System during Hurricane Katrina. A timeline of the new Bay Bridge construction is provided in Section C, highlighting a sample of the numerous conflicts, dragged-out decisions, and bureaucratic disorganization that has delayed the bridge’s construction for almost eighteen years. Finally, Section D draws comparisons between the construction of the failed NOFDS and the construction of the Bay Bridge, taking note of why the

\textsuperscript{3} Daniel Farber et al., Reinventing Flood Control, 81 TULANE LAW REVIEW ____ (in press).
\textsuperscript{4} Id. at 9.
Bay Area might have reason to be wary of the competence of those in charge and the ultimate safety of the bridge.

A. Features of High Reliability Organizations

High reliability organizations (HRO’s) work in highly complex and uncertain environments, yet they consistently avoid catastrophe.\(^5\) HRO’s conduct relatively error-free operations over a long period of time, making consistently good decisions that result in high quality and reliable operations.\(^6\) They seek “perfection but never expect to achieve it. They demand complete safety but never expect it. They dread surprise, but always anticipate it.”\(^7\)

Substantial research has been conducted in the world of catastrophes, examining, among other things, why certain organizations—HRO’s—always seem to “beat the odds” and suffer few accidents.\(^8\) The discussion below highlights only a few of HROs’ many qualities—the particular qualities that would have been and could still be useful to the Bay Bridge construction.

“\textit{HRO’s aggressively seek to know what they don’t know.}”\(^9\) HRO’s understand that there is no perfect world. Even the brightest scientists and sharpest engineers are unable to anticipate everything. Even the most sophisticated of systems can crumble to unanticipated catastrophes. Understanding this imperfection, HRO’s design systems that consider the world of unknowables, while simultaneously striving to learn all they can about potential hazards.\(^10\) They employ process auditing, a structured system of continuous checks and balances intended to

\(^{5}\) Karlene Roberts, \textit{High Reliability Organizations and System of Organizations: Getting from Here to There}, PowerPoint Presentation to Prof. Farber’s Disasters and the Law class on 1/29/07.

\(^{6}\) \textit{Id.}


\(^{9}\) \textit{Id.}

\(^{10}\) \textit{Id. at 72}
catch problems in the system. They follow up every audit with aggressive tweaking and adapting and add each lesson learned to an organizational memory bank. HRO’s strive to know each and every risk that exists and build redundancies (also called “overdesign”) into their systems to ensure that, when the inevitable unknowable occurs, they will have as many safeguards as possible in place to mitigate a potential disaster. Non-HRO’s, on the other hand, suffer from hubris. They turn a blind eye to what they do not know. They reject early warning signs of potential hazards and ignore surfacing risks.

**HRO’s reward safety and reliability over performance and efficiency.** “When organizations focus on today’s profits without consideration of tomorrow’s problems, the likelihood of accidents increases.” HRO’s strive to find that balance between efficiency and profit on one side, and safety and reliability on the other. To realize that balance and achieve a true culture of safety, they have to practice what they preach. If safety and reliability are the defining values of their organizations, HRO’s create reward systems that measure and incentivize those values. “Rewarding for performance and asking for safety” will not work. Focusing on success over safety is often fatal.

**HRO’s have hierarchy without bureaucracy.** Hierarchy and bureaucracy are commonly, yet incorrectly, used interchangeably—they are not synonyms. In a thoughtfully constructed hierarchy, “authority is widely delegated, while the chain of command is preserved and secured.” At the top of a hierarchy is one centralized leader, who

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11 Roberts, slide no. 4.
12 Id.
13 Roberts & Bea, supra note 8, at 73.
14 Id.
15 Id.
16 Id. at 74
17 Id. at 75
“absorbs the primary risks of managing the enterprise and then delegates authority and accountability to others to accomplish the more delimited but still complicated and important tasks. The leader in his or her role represents the organization as a whole and integrates the actions of its different divisions.”19 In a true hierarchy, decisions are not made by the people with the most power, but the people with the most expertise. Bureaucracies, on the other hand, suffer from a lack of leadership and an excess of rigid policies and procedures. The “leaders” in a bureaucracy “do not manage the risks … cannot delegate authority to others…[and] rely on disorganizing politics. Checks and balances replace … unity of command; rules replace roles; and politics ultimately drive out team work.”20

**B. The Failure of the New Orleans Flood Defense System During Hurricane Katrina**

It is now well-accepted that the failure of the New Orleans Flood Defense System (NOFDS) during Hurricane Katrina was not caused by the enormous magnitude of the storm alone, but rather in conjunction with numerous human and organizational errors that plagued the construction of the New Orleans levee system.21 Construction of the flood protection system began in 1965 after Hurricane Betsy devastated the Gulf Coast, causing Lake Pontchartrain to flood New Orleans. The project was to be completed within thirteen years at a cost under $90 million.22 However, forty years and $700 million later, the levee system was still unfinished; and what had been constructed was fundamentally flawed.23

The most fundamental structural defects in the NOFDS were the levees being built on unstable soil and the floodwalls not being high enough, despite engineers’ knowledge of the
potentially “treacherous nature” of the underlying soil and the need for higher floodwalls. In addition, the margin of safety was set too low: the system was not designed to protect against “the most severe combination of meteorological conditions reasonably expected.” These risks were well-known facts among officials, yet nothing was done to revise the original design to combat these greater known threats. Simply put, the key organizations failed to detect, evaluate and correct the potential problems which were so plainly laid out in history and current research.

Several underlying organizational flaws enabled the NOFDS to traverse down such a blind, unwarranted path in its construction:

*Lack of Foresight and Risk Assessment.* First and foremost was a complete lack of foresight and a serious underestimation of the risks of a hurricane surge. For years, scientists had predicted the occurrence of a hurricane that would have catastrophic flooding effects on New Orleans. Yet, the adequacy of the Flood Protection System was not questioned; potential hazards were not identified; strengthening New Orleans’ defensive measures was not prioritized. The USACE did not follow the standard engineering practices in building the levees.

*Organizational Failures.* “The organizational – institutional systems lacked centralized and focused responsibility and authority for providing adequate flood protection.” Naturally, there was some basic organizational structure to the construction of the levee system: the USACE was responsible for designing and constructing the levee system; and upon completion, responsibility for the daily operation and maintenance of the levees was handed over to state and...

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24 Farber et al., supra note 3, at 7.
25 Heerden et al., supra note 22, at 6.
26 Id.
27 Farber et al., supra note 3, at 6.
28 Heerden et al., supra note 22, at vi.
However, both the USACE and the state and local agencies were being pushed and pulled by a multiplicity of surrounding forces, the USACE incorporating input from the Department of Defense and Congress, and the state and local agencies responding to the needs of municipal government, industry and the general public. Each of these outside constraining influences had a different agenda and “vastly different means, methods, and resources that evolved in different ways and at different times.” The result of having “so many chefs in the kitchen” was a system that lacked communication, knowledge, real leadership, and clear goals.

**Failures of Diligence and Management.** As referenced earlier, the original flood protection system was to be built in thirteen years for less than $90 million. Forty years and $700 million later, the flood protection system was still incomplete. The Team Louisiana Report likened the progress of the levee system construction to the operation of a “1965 flood control museum.”

**Trade Offs.** “A history of flawed decisions and trade-offs proved to be fatal to the ability of the system to perform adequately.” Compromises in the safety and integrity of the flood protection system originated from ill-conceived “fundamental design criteria” developed for the system. Ever-surfacing design alternatives stalled progress and lead to more defects. The resulting “piecemeal” construction of the levee system allowed for even more flaws and deficiencies to work their way into the system. “Efficiency was traded for quality, reliability, and effectiveness. Superiority … was traded for mediocrity and getting along.”

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30 Id. at 618.
31 Id.
32 Heerden et al., supra note 22, at ii.
33 Id.
34 R. B. Seed et al., supra note 22, at viii.
35 Id.
There were also critical flaws in the funding scheme and resource allocation, and a complete lack of synthesis among the many key players and organizations involved. Simply put, the pieces never came together.

C. The Bay Bridge: An Abbreviated History

The San Francisco-Oakland Bay Bridge first opened to traffic on November 12, 1936, six months earlier than predicted and at a cost of $77 million (what would be $984 million in 2002); the bridge toll was 65 cents each way ($8.30 today). Measuring 4.5 miles long, the bridge made history, representing the largest disbursement of public funds for a single structure at that time. While a symbol of progress and innovation upon its opening, today’s engineers wince at the thought of the bridge’s design. Although the engineers who designed the bridge lived through the 1906 earthquake, they made no consideration of seismic safety in designing the bridge, focusing instead on the threat of wind. Earthquakes were considered “an act of “God,” untouchable and incapable of prevention or mitigation.

The seismic vulnerability of the bridge became all too apparent on October 17, 1989, when the Loma Prieta earthquake struck the Bay Area. The earthquake, centered in Santa Cruz and measuring 7.1 on the Richter scale, caused 62 deaths and $5.6 billion in damaged property. During the earthquake, a 50-foot section of the upper deck weighing 250 tons collapsed, subsequently causing the lower deck below it to collapse as well, causing one death. The

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37 Vorderbrueggen and Peele, supra note 1.
38 Id.
39 Id.
40 Id.
41 Id.
42 Pollak, supra note 36, at 3.
43 Id. at 4.
collapse was largely attributed to the poor soil conditions underneath the bridge. The bridge was built using 60-70 foot-long wood pilings that sit largely on top of sand and remaining rubble from the 1906 earthquake. Over time, the soil mixture became saturated with water and increasingly susceptible to liquefaction (when soil strength is compromised by earthquake motion). Thus, when the Loma Prieta earthquake struck, the unstable soil underneath shifted a full foot—a shift that the rigid and inflexible design of the Bay Bridge could not withstand.

Just a few weeks after the quake, California Gov. George Deukmejian created an independent board, comprised of seismic and bridge experts, to investigate the damage to the east span of the bridge. Eight months later, he assembled the Seismic Advisory Board to work with Caltrans on issues of seismic safety. And thus began the painstaking and politically-tangled process of designing and building the new Bay Bridge, now seventeen years in the making, with no sight of completion until at least 2013.

**Abbreviated Timeline of the East Span Design and Construction:**


| October, 1989 | Loma Prieta earthquake strikes the Bay Area, causing 62 deaths and $5.6 billion in damaged property. |
| May, 1990 | *Competing Against Time* is released by an independent expert panel, encouraging the government to make Bay Bridge retrofitting a higher priority. |
| September, 1992 | UC Berkeley Team, lead by Dr. Astaneh and commissioned by Caltrans, reports that Caltrans could retrofit the east span for $150-200 million. At the time of the report’s release, Caltrans faced a major “retrofit backlog,” including over 2,300 vulnerable highway overpasses, and the bay bridge retrofit was put on the back burner. Estimated Cost: $150-200 million Estimated Opening: TBA |

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45 Id.
47 Id.
### January, 1994
The 6.7 Northridge earthquake strikes the Los Angeles area, causing major structural damage to several freeways. Southern California quickly unites and fixes the freeways in just a few months.

### Summer 1995
The Seismic Advisory Board, convened by Caltrans, proposes that the east span should be entirely rebuilt instead of retrofitted, due to cost and safety concerns.  
**Estimated Cost:** $650 million  
**Estimated Opening:** TBA

### 1996
Caltrans begins researching the feasibility of an east span replacement. At the end of the year, both the Seismic Advisory Board and an Independent Peer Review Panel “strongly recommend” a replacement bridge over retrofitting. A leading Caltrans engineer urges Caltrans to “proceed immediately” with the construction of the replacement span.  
**Estimated Cost:** $1.3 billion  
**Estimated Opening:** 2004

### March, 1996
The beginning of a 5-year dispute between the Navy and Caltrans erupts, first concerning the impact the Bay Bridge project will have on historic buildings on Yerba Buena Island.

### February, 1997
Gov. Pete Wilson declares that the east span will be rebuilt as an “elevated skyway” instead of retrofitted. Giving in to local demands, Gov. Wilson hands over control of the bridge design to the Metropolitan Transportation Commission. A dispute arises between Northern and Southern California regarding the funding of the replacement.

### July, 1997
MTC makes 17 design recommendations, but suggests that the choice of design should be delayed until Caltrans takes each design proposal to the “30% completion stage.” This marks the beginning of what will be a 9-year conflict over bridge design.

### August, 1997
Funding agreement reached: Half of the money for the replacement will come from a $1 toll increase; the remaining half will come from a combination of State highway funds, the Seismic Retrofit Bond Act of 1996, and other surplus bonds.

### June 1998
MTC selects the controversial “self-anchored suspension” design for the new east span replacement.  
**Estimated Cost:** $1.4 billion  
**Estimated Opening:** 2004

### May, 2000
After 5 years and 3 White House interventions, the dispute with the Navy is finally resolved after the White House commands the Navy to give up the disputed land on Yerba Buena Island to Caltrans.

### January, 2002
Groundbreaking ceremony marks the beginning of construction on the east span replacement.  
**Estimated Cost:** $2.6 billion  
**Estimated Opening:** 2007
June, 2002 | Estimated opening date pushed back from 2007 to 2009.
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November, 2003 | Total cost for east span replacement rises to $3 billion.
May, 2004 | Caltrans receives only one bid to build the controversial self-anchored suspension portion of the bridge. At $1.8 billion, the bid more than doubled the most recent projection of $733 million for the tower’s construction. Gov. Schwarzenegger rejects the bid. Est. Cost: $5.5 billion  
Estimated Opening: 2011
June, 2005 | The original funding agreement is revised and the State raises the Bay Bridge toll to $4. Bay Area drivers now paying for 80% of the replacement project.
April, 2006 | Contractor Selected for construction of east span tower.  
**Estimated Cost:** $6.3 billion  
**Estimated Opening:** 2013

The timeline above speaks for itself. Arguably, the two most significant sources of delay were the five-year dispute between the Navy and Caltrans and the never-ending conflicts over the bridge design. A California State Auditor report indicates that the Navy’s repeated refusals to cooperate delayed the design and environmental process by two years alone. The dispute concerned the effects that the new bridge’s alignment on Yerba Buena Island would have on plans for the island’s historic preservation. The Navy stance’s against the design of the bridge was so strong that it refused to admit Caltrans engineers onto the island to collect soil samples in preparation for the bridge’s construction. The conflict came to an end after the White House intervened in spring of 2000.

Nothing can trump the delaying power of the bridge’s design controversy, however. While the Bay Bridge reopened to traffic only a month after the Loma Prieta earthquake, it took Caltrans six years just to decide that the east span should be rebuilt instead of retrofitted. Caltrans spent the first four or five years grappling with how to seismically retrofit a 60-year old bridge.

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[50] Id.
structure that presented numerous complications.\textsuperscript{52} It was not until 1995 that Caltrans’ Seismic Advisory Board suggested that it look into completely rebuilding the bridge instead of retrofitting.\textsuperscript{53} This replacement recommendation spawned another three years of debate concerning the safety, costs, timelines and aesthetics of the retrofit and replacement options. Then, after Gov. Wilson finally declared that the east span was to be rebuilt, it took another nine years to select the final design of the east span. Should the new bridge be a simple, utilitarian viaduct (criticized by many as a “floating freeway overpass”)? Or should the bridge have an aesthetically-pleasing “world class design,” albeit at a higher cost? Who will pay for the aesthetic enhancements? These nine years were marked by political manipulation and flip-flopping, an allegedly fraudulent design competition wrought with conflicts of interest, and a dizzying number of reports from numerous advisory panels addressing costs, safety, and timeline.\textsuperscript{54}

D. “A Ticking Time Bomb”: Will the new Bay Bridge Suffer the Same Fate as NOFDS?

The construction of the Bay Bridge has arguably suffered from all of the organizational failures that plagued the construction and lead to the ultimate demise of the New Orleans Flood

\textsuperscript{52} Id.
\textsuperscript{53} Pollak, supra note 36, at 5.
Defense System. This section will focus specifically on the failures of risk assessment, trade-offs, organization, diligence and management.

1. Failures of Risk Assessment

The new east span of the Bay Bridge will be the tallest single-tower self-anchored suspension span in the world.\(^{55}\) The design presents huge challenges, incorporating engineering structures and techniques never before used in a seismic area like the Bay Area. The new span will consist of a skyway, including two side-by-side, elevated roadways which will join a 525-foot tower close to Yerba Buena Island.\(^{56}\) Traditional suspension bridges are built with two main cables, connected to smaller “suspending cables,” which hold up the roadbed and anchor to separate structures in the ground.\(^{57}\) The new self-anchored suspension bridge will use only one main cable, which will not anchor to solid ground, but rather anchor to the east deck and loop under the freeway at the span’s west end (see Appendix for design diagrams).\(^{58}\) Proponents of the new bridge design highlight the flexibility the bridge will have during an earthquake. The structural rigidity of the current east span was a major contributing factor in the collapse of the 50-foot section of roadway during the Loma Prieta Quake.\(^{59}\) Although the new east span will have only one main tower, the tower itself will be “comprised of four separate legs connected by ‘linker beams.’”\(^{60}\) The linker beams will “distort and absorb” the bulk of the shock produced by a massive earthquake as well as prevent “catastrophic damage” to the bridge’s main structure.\(^{61}\)

The new design has its share of critics, however, the most out-spoken of which is Dr. Abolhassan Astaneh, a UC Berkeley professor of structural engineering. Astaneh claims the new

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\(^{55}\) Caltrans, [www.baybridgeinfo.org](http://www.baybridgeinfo.org).
\(^{56}\) Id.
\(^{57}\) Id.
\(^{58}\) Id.
\(^{59}\) Glen Martin, *supra* note 44.
\(^{60}\) Caltrans, [www.baybridgeinfo.org](http://www.baybridgeinfo.org).
\(^{61}\) Id.
design will actually make the bridge more vulnerable to earthquakes. He believes that having only one tower, even if designed of four separate support beams, exposes the bridge to greater seismic susceptibility than the traditional bridge, which has even-numbered towers. The single tower’s vulnerability is further increased because it is anchored to itself. “The bridge is essentially holding itself up … It’s like anchoring a ship to itself, not the sea bottom.” Astaneh also argues that the new bridge will be vulnerable to acts of terrorism. After conducting limited computer modeling analyses, he concluded that even a “relatively small car bomb at the right spot” might cause the entire east span to crumble.

Astaneh is not alone in his concerns. Prof. Manabu Ito (Tokyo University) and T.Y. Lin (UC Berkeley) have both aired their concerns about the bridge, commenting that the bridge is “not … a rational structure” and is a “monument to engineering stupidity, respectively. Perhaps more disconcerting is the report from the U.S. Army Corps of Engineers (USACE). In 2000, Caltrans commissioned the USACE to evaluate the various proposals for the bridge, including both retrofit and replacement options. Although USACE ultimately gave its approval to the self-anchored suspension design, their final evaluation could “hardly be classified as a ringing endorsement.” Take, for example, this excerpt from its final evaluation:

“Question 4, Part 1. Is the currently proposed replacement alternative seismically safe?

Conclusion: It is the COE Team’s opinion that Caltrans’ design team is moving along a path to design a bridge that meets the seismic performance established by the SAB and EDAP … Data shows intent to meet the seismic design and performance criteria.”

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63 Id.
64 Id.
65 Id.
66 Id.
This evaluation is far from reassuring. But even assuming that Caltrans had undoubtedly met the standard seismic performance criteria, would that give the Bay Area genuine assurance that the new Bay Bridge could withstand the next “Big One”? It is questionable, given that Caltrans’ seismic performance requirements are not in line with the “Maximum Credible Earthquake” safety standard (MCE). MCE evaluates a bridge design in terms of its ability to withstand the greatest seismic motion that is possible at a given location. (Scientists predict that an earthquake as severe as an 8.0 on the Richter scale is possible in the area.) Instead, Caltrans has adopted a “Safety Evaluation Earthquake” model (SEE), which places more emphasis on the probability of a major earthquake striking the Bay Area during the bridge’s estimated 150-year lifetime, not the earthquake’s magnitude.

Looking for further signs of assurance in the USACE report only leads to more doubts. The Army engineers made no statement regarding which model was better, nor did they discuss the self-anchored suspension design (SAS) in comparison with other design proposals. In fact, when asked to rate “On a scale from A to F weighing seismic safety reliability … how would you rate … the proposed [SAS] East Span replacement?” the USACE responded: “The rating requested in this question is outside the current scope of work.”

Furthermore, the USACE report found that the SAS bridge design did not meet the original “lifeline criteria” initially proposed for the new structure. Lifeline criteria are “above average standards for bridge construction.” A bridge meeting lifeline criteria could “accommodate emergency response vehicles and heavy equipment immediately following a

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68 Id.
69 Russell, supra note 53.
70 U.S.A.C.E., supra note 60, at Appendix 6.
71 Id.
72 Id. at Appendix 2, p. 3.
maximum credibility earthquake.” The USACE report indicates that when Caltrans opted to use the SEE model instead of the MCE model, the initial proposal for incorporating lifeline criteria into the bridge’s design was consequently “relaxed” to just a “no-collapse” standard.

A high reliability organization would respond to these concerns, in its quest to know all it can, with a thorough round of tests and research. Even though Dr. Astaneh is not a high rung in the Bay Bridge hierarchy (if in the hierarchy at all), an HRO would acknowledge his expertise and experiences and “humor him” by conducting tests of the bridge design under the conditions Astaneh believes will be catastrophic.

Instead of deferring to expertise and safety, Caltrans responded with name-calling and unsubstantiated assurances. According to Dan McElhinney, Caltrans Chief Deputy Director, Astaneh’s criticisms were more “sour grapes” than valid safety concerns, as Astaneh had submitted a design proposal for the new bridge that was rejected. McElhinney has repeatedly assured that “many engineers” support the new span’s design and that Caltrans has done its best to design a structure that “considers possible attacks on the bridge” (emphasis added). The bridge “should protect against seismic events and terrorism” (emphasis added). McElhinney refused to identify which particular blast and seismic tests were used during the design phase. Herb Rothman, principal design engineer of the new suspension span, was much more up-front on the issue: “We didn’t design for blast,” he admitted. An HRO would incorporate these known terrorist vulnerabilities, and any other possible threats under the sun, into the span’s

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73 Id.
74 Id.
75 Martin, supra note 44.
76 Russell, supra note 53.
77 Martin, supra note 44.
78 Id.
design. This method of “overdesign” is an HRO’s precaution against the unknowable, a safeguard against inevitable human and organizational error.\textsuperscript{79}

2. Trade-offs: Did We Swap Safety for Aesthetics?

How did we end up with the highly contested bridge design we have? What baseline criteria were adopted? Frighteningly, no clear criteria can be found. After the seven-year decision was made to completely replace the east span instead of retrofitting it, two basic design proposals surfaced: a “traditional” suspension bridge and a “self-anchored” suspension bridge. The east span advisory panel, comprised of engineers and architects, challenged both designs multiple times. Most of the challenges, however, concerned the bridge’s appearance. Chris Arnold, an architect on the advisory panel recalled the aesthetics/safety “back-and-forth” that occurred at their meetings:

“A lot of the focus on the panel was the idea of a signature span: ‘Let’s get this big, significant thing done.’ … If the engineers had been more insistent about engineering, [the bridge design] might have been different. But they would mumble something, and then the architects would swing back to aesthetics.”\textsuperscript{80}

Up until the very last meeting, the traditional cable-stayed suspension plan was favored by a majority of panelists.\textsuperscript{81} But the weekend before the final meeting, the designers of the self-anchored suspension bridge modified their plans, moving the span’s signature tower closer to Yerba Buena Island (making a more asymmetrical profile) and repositioning the main cable to loop below the deck. This new proposal was a vast departure from their former designs. The innovations used in the new plans had never been tried before and the designers provided few engineering details to back up their work.\textsuperscript{82} But the new design’s “unique appearance” won over the advisory panel, which selected the controversial SAS design by a 12-7 vote in May, 1998.

\textsuperscript{79} Farber at 5.
\textsuperscript{80} King, supra note 48.
\textsuperscript{81} Id.
\textsuperscript{82} Id.
Reflecting on the vote, Arnold believed that “the novelty factor kicked in, especially with the engineers. And everyone was getting a bit tired by then.”

A 2004 report by an Independent Review Team (IRT) commissioned by the State of California reveals exactly what was bargained for in adopting the new, aesthetically-pleasing SAS design. The IRT, comprised of transportation consultants and engineers, strongly recommended that the bridge plans be revised using a traditional cable-stayed bridge, primarily because of the dangerous number of risks and unknowables attached to such an innovative project. First, only a few shipyards exist in the world that are large enough to accommodate the fabrication of the enormous pre-assembled sections the tower requires. The IRT predicted significant delays in reaching initial agreements with a shipyard and in settling the inevitable disputes that will arise. Second, the fabrication of a tower of such size is simply unprecedented. Numerous lengthy delays will occur when the construction team runs into problems building these large pieces using such new technology. Third, the concrete, cables, and even the paint have never been tested for the bridge design. As the IRT summarized, “The single tower SAS of this size and constructed in this environment is a first-of-a-kind bridge … Experience indicates that first-of-a-kind major bridges have a high potential for construction claims, added costs and schedule delays.”

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83 *Id.*
85 *Id.* at 90-91.
86 *Id.* at 101.
3. Organization: Who’s in Charge?

The discussion above, revealing a process rife with indecision, politicking, and questionable tradeoffs, begs the question: “So who’s in charge?” The answer to this simple question is far from straightforward, perhaps best illustrated by the Bay Bridge “hierarchy” diagrams below:

The number of constraining and conflicting influences is clear from first glance. Caltrans’ and the MTC’s inability to juggle the overwhelming number of outside opinions and demands is all too evident in the bridge’s disputed design and the ever-increasing timeline and budget, which is discussed next.

4. Failures of Diligence and Management:

The failures of diligence and management that have afflicted the construction of the Bay Bridge are evident from the timeline on pages 9-11. What originally started as a $200 million retrofit proposal, capable of completion in a few years, turned into a seventeen year-ordeal at a cost of $6.3 billion. As early as 1990, engineers were urging Caltrans to propose a timely, but thoughtful solution to retrofitting the Bay Bridge. Without wasting any time, an HRO would have defined its guiding priorities, (safety, in this case) which would inform all future decisions and activities, including the bridge design, timeline, budget, and selection of a central leader who has knowledge and experience in seismic bridge design. Under this centralized leader, the HRO would work diligently to stick to the proposed timeline, keeping in mind the imminence of future earthquakes, but would not be so inflexible as to forge ahead when valid safety concerns arose.

http://www.dot.ca.gov/dist4/eastspans/
Instead, Caltrans let itself get caught up in a web of conflicting interests and bureaucracy. Particularly frustrating were the delays caused by relatively insignificant concerns (at least when compared to safety), including: the inclusion of a pedestrian and/or bike lane, the preservation of historic buildings, and the never-ending back-and-forth on aesthetics. The Bay Bridge construction has seen the terms of four California governors and numerous mayors in both Oakland and San Francisco, all of whom injected their own agendas into the process. In losing sight of the ultimate priority of safety, Caltrans’ also lost its inability to make progress in the midst of conflicting interests. And the result has been a fragmented and potentially dangerous process that has cost the Bay Area billions of dollars.

**Conclusion: Lessons for the Future**

After seventeen years, all of the pieces have been set into place: the final bridge design, an official timeline, a (working) budget, and contractors for each segment of the bridge. At this point, any recommendations for further change would only aggravate what has already been a painstakingly long process, especially in light of the substantial progress that has been made in the east span’s construction thus far. Instead, the thrust of Caltrans’ energy should focus on adhering to the proposed timeline and opening the new bridge on schedule in 2013.

Perhaps the most interesting and useful lesson can be learned from the recent “meltdown” of the MacArthur Maze, which occurred when a tanker carrying 8,600 gallons of gasoline hit a guardrail on the I-580 overpass and exploded, causing the overpass’s giant steel frame to melt.88 With the Interstate 880 and 580 connectors closed, drivers balked at what everyone believed would be an overly lengthy and expensive project. But Caltrans has proved the Bay Area wrong.

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and many local residents are in shock. The I-880 reopened just seven days after the meltdown and the I-580, which suffered significantly more damage, is scheduled to reopen in June.89

What explains Caltrans’ “180 degree” turnaround in taking initiative, prioritizing, and effectiveness? Surely, reconstructing a freeway overpass is relatively much simpler than designing a brand new suspension bridge in a seismically active area. But there is more to it than the engineering alone. Many have pointed to the leadership of Will Kempton, Caltrans’ Director since 2004. Since becoming Director, Kempton has dramatically changed how Caltrans conducts business. Contractors and citizens alike have praised Kempton’s ability stick to timelines and communicate effectively among the myriad organizations with which Caltrans works.90 Kempton assumed the position at Caltrans during the last feud over the east span design in 2004. Since the resolution of that final conflict, construction on the new Bay Bridge has progressed rather smoothly.91 One can only wonder how the design process would have fared under Kempton’s leadership.

There is also something about the MacArthur Maze meltdown that created a very tangible sense of urgency felt by everyone in the Bay Area, from Caltrans and Governor Schwarzenegger to local businesses and commuters. All of a sudden, many people’s daily lives were forced to change, as commuters took alternate routes to work, switched to public transportation, or began working from home. And while most commuters adjusted quickly, everyone was still aware of what needed to be done: fix the MacArthur Maze as soon as possible. And that is happening.

The “maze meltdown” provides this lesson: where there are straightforward priorities and a unity in goals, there is no room for politics. The design process for the new Bay Bridge, on the other hand, was so fraught with compromised goals and a lack of priorities that politics were able

90 Id.
91 Id.
to leak into just about every aspect of the project. With future projects of this magnitude, Caltrans needs to work to unify the community—politicians, businesses, and citizens alike—behind the ultimate priority of safety. While this is surely no easy task, having the centralized leadership of an experienced professional who is willing to take responsibility for the organization’s actions will certainly be a step in establishing that unity.
APPENDIX

Design of the Bay Bridge’s new east span:
(Photo source: Caltrans, see www.baybridgeinfo.org)

View of the self-anchored suspension looking north (Yerba Buena Island is just to the left).

Aerial view of the self-anchored suspension and “skyway,” consisting of two side-by-side freeways.
View of self-anchored suspension from below.

View of self-anchored tower from the bike path (looking towards Yerba Buena Island).