Safety, Efficiency, and Productivity: Conflict or Cooperative? 
The BP Deepwater Horizon Accident 

Personal Observations

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BP Deepwater Horizon Accident
April 20, 2010
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11 workers lost their lives and 16 others were seriously injured.

The flow continued for nearly 3 months before the well could be completely killed, during which time, nearly 5 million barrels of oil spilled into the gulf.
National Academy of Engineering/National Research Council (NAE/NRC) Committee

Committee for Analysis of Causes of the Deepwater Horizon Explosion, Fire, and Oil Spill to Identify Measures to Prevent Similar Accidents in the Future
Disclaimer

When you speak, we’d ask that you note the following in any written statement or as you answer questions orally:

• 1) Our final report was released to the public on December 14, 2011. The committee of which I was a member has been disbanded; we are not continuing to work on the Deepwater Horizon blowout. Free copies of our report (pdf) are available at www.nap.edu.

• 2) When you are answering a question, please make clear when you are speaking based on the committee’s report and when you are answering based on your own personal experience and expertise. You may need to do this more than once during a public Q & A session. It is particularly important to do this clearly when – in your answer to a single question – you wish to speak about both what the report found and your own personal views or experience.
Committee’s Origin and Tasks

Origin: Request from U.S. Department of Interior Secretary Salazar

Study Tasks: Examine probable causes of the Deepwater Horizon incident in order to identify measures for preventing similar harm in the future.

Committee Composition: 15 Members with expertise in geophysics, petroleum engineering, marine systems, accident investigations, safety systems, risk analysis, human factors and organizational behavior

Process: Consensus report with peer review
NAE/NRC Committee’s BP *DWH* Report

Macondo Well—*Deepwater Horizon* Blowout: Lessons for Improving Offshore Drilling Safety

Released on Dec 14, 2011
The blowout of the Macondo well on April 20, 2010, led to enormous consequences for the individuals involved in the drilling operations, and for their families. Eleven workers on the Deepwater Horizon drilling rig lost their lives and 16 others were seriously injured. There were also enormous consequences for the companies involved in the drilling operations, to the Gulf of Mexico environment, and to the economy of the region and beyond.

Macondo Well-Deepwater Horizon Blowout examines the causes of the blowout and provides a series of recommendations, for both the oil and gas industry and government regulators, intended to reduce the likelihood and impact of any future losses of well control during offshore drilling. This book discusses ultimate responsibility and accountability for well integrity and safety of offshore equipment, formal system safety education and training of personnel engaged in offshore drilling, and guidelines that should be established so that well designs incorporate protection against the various credible risks associated with the drilling and abandonment process. This book will be of interest to professionals in the oil and gas industry, government decision makers, environmental advocacy groups, and others who seek an understanding of the processes involved in order to ensure safety in undertakings of this nature.
The Deepwater Horizon
The Deepwater Horizon Rig

Mobile Offshore Drilling Unit (MODU)

Figure 3.1 shows the basic dimensions of the Deepwater Horizon while drilling. The rig was 256 feet wide (from port to starboard) and 396 feet long (from bow to stern). The main deck sat 61 feet above the water’s surface while drilling, with the drill floor another 15 feet above that. The derrick was 244 feet tall, towering a total of 320 feet above the ocean while drilling.
Deepwater Horizon’s Org Chart
Two different Transocean employees were in charge of the rig at different times. Captain Curt Kuchta, Transocean’s master, was in charge when the rig was moving from location to location.

Once the rig arrived at a given site and began drilling or drilling-related operations, Jimmy Harrell, Transocean’s offshore installation manager (OIM), took over.
Most Important **Technical** Contributing Causes of the DWH Accident

- Well design; Narrow drilling margins
- Cementing:
  - Cement material
  - *Long string instead of a liner*
  - Number of centralizers
- NPT Misinterpretation
- BOP Failure
- Alarm Systems
- Mud-Gas Separator
Once well control was lost, the large quantities of gaseous hydrocarbons released onto the rig, exacerbated by low wind velocity and questionable venting selection, made ignition all but inevitable.
Personal Observations
The ‘HOT’ Model, Safety Culture &
Major Subsystems of a Complex, Large-scale Technological System
(e.g., a nuclear power plant, refinery, chemical processing plant, hospital, or an offshore platform)
Interactive Effect

Human

Organization

Technology

Volume of Output
"Safety is not proprietary."

Changing Business as Usual

The Deepwater Horizon blowout, explosion, and oil spill did not have to happen. Previous chapters have explained the immediate and root causes for why they nonetheless did. The American public, government, and the oil and gas industry need to understand what went wrong so they can pursue the changes required to prevent such devastating accidents from recurring.

This chapter examines how petroleum companies have been managing the risks associated with finding and producing oil and how they can do it better, individually and as a responsible industry overall. The record shows that without effective government oversight, the offshore oil and gas industry will not adequately reduce the risk of accidents, nor prepare effectively to respond in emergencies. However, government oversight, alone, cannot reduce those risks to the full extent possible. Government oversight (see Chapter 9) must be accompanied by the oil and gas industry's internal reinvention: sweeping reforms that accomplish no less than a fundamental transformation of its safety culture. Only through such a demonstrated transformation will industry—in the aftermath of the Deepwater Horizon disaster—truly earn the privilege of access to the nation's energy resources located on federal properties.

Even as Deepwater Horizon burned, oil from the blown-out well begins to spread across the Gulf. Preventing such disasters in the future will take more effective government oversight. Most crucial, however, will be the oil and gas industry's commitment to fundamentally transform its own safety culture.

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resulted in “a number of serious releases,” but had ultimately declined to do so “(f)or a variety of reasons—including cost pressures” and BP’s ability to take advantage of “the existence of an exemption under [U.S. Environmental Protection Agency] air regulations. . . .”"14

The Safety Board’s report on Texas City noted that “while most attention was focused on the injury rate, the overall safety culture and process safety management program had serious deficiencies. Despite numerous previous fatalities at the Texas City refinery (28 deaths in the 80 years prior to the 2005 disaster) and many hazardous material releases, BP did not take effective steps to stem the growing risks of a catastrophic event.” The report added, “Cost-cutting and failure to invest in the 1990s by Amoco (who merged with BP in 1998) and then BP left the Texas City refinery vulnerable to a catastrophe. BP targeted budget cuts of 22 percent in 1999 and another 22 percent in 2002, even though much of the refinery’s infrastructure and process equipment were in disrepair. Also, operator training and staffing were downsized.”16

The Safety Board further singled what it characterized as the “organisational causes embedded in the refinery’s culture,” including:

- “BP Texas City lacked a reporting and learning culture. Reporting bad news was not encouraged, and often Texas City managers did not effectively investigate incidents or take appropriate corrective action.”
- “BP Group lacked focus on controlling major hazard risk. BP management paid attention to, measured, and rewarded personal safety rather than process safety.”
- “BP Group and Texas City managers provided ineffective leadership and oversight. BP management did not implement adequate safety oversight, provide needed human and economic resources, or consistently model adherence to safety rules and procedures.”
- “BP Group and Texas City did not effectively evaluate the safety implications of major organisational, personnel, and policy changes.”17

At the Chemical Safety Board’s instigation, BP established its own independent panel to review its safety procedures and find ways to improve them.18 That panel, chaired by former U.S. Secretary of State James Baker III, issued its report a few months before the Chemical Board report in 2007. The Baker panel was no more charitable in its assessment. The panel found that BP management had not distinguished between occupational safety—concern over slips, sprains, and other workplace accidents—and process safety: hazard analysis, design for safety, material verification, equipment maintenance, and process-change reporting. And the panel further concluded that BP was not investing leadership and other resources in managing the highest risks.19

The Baker panel especially faulted BP for failing to learn the lessons of Orangemouth by repeating them in the events leading up to the Texas City refinery explosion. According to the panel, “in its response to Orangemouth, BP missed an opportunity to make and sustain company-wide changes that would have resulted in safer workplaces for its employees and contractors.”10 Underscoring the depth of the organisational problem facing BP the panel
singled out for criticism BP’s overall approach to accident analysis. "BP’s investigation system has not instituted effective root cause analysis procedures to identify systemic causal factors."21

Prudhoe Bay pipeline leak. In March 2000—one year after the Texas City refinery explosion and one year before the Chemical Safety Board report on it—BP had yet another significant industrial accident. Its network of pipelines in Prudhoe Bay, Alaska, leaked 212,322 gallons of oil into the fragile tundra environment—the worst spill ever recorded on the North slope.22 The leak went undetected for as long as five days.23 Upon analysis, the pipes were found to have been poorly maintained and inspected.24 BP paid more than $20 million in fines and restitution.25

Progress in follow-up on the safety recommendations. The Baker panel report contained 10 recommendations “intended to promote significant, sustained improvements in BP’s process safety performance.”26 Recommendation nine advocated that BP establish an independent expert to monitor and report on its progress in executing the panel’s other recommendations in its U.S. refineries, in refining management, and at the BP board and executive management levels.27 In the executive summary of the third annual report of the panel, covering January–December 2009, he remarked that:

Delivery against milestones related to implementation of the Recommendations remains a critical performance objective for the U.S. refineries. Virtually all of the milestones in the U.S. Refining’s 2000 plans were delivered on schedule.

"While significant gaps have been closed and most of the new systems, processes, standards, and practices required for continued process safety improvements have been developed, much work remains to be done to fully implement them. BP must now demonstrate improved capability for systematic management of these systems, processes, standards, and practices so it can accelerate the overall pace of implementing the Recommendations."28

The independent expert also noted, apropos of the Baker panel report’s final recommendation that BP use the lessons learned from the Texas City tragedy to transform the company into a recognized industry leader in process safety management:

BP is striving to transform the company into a recognized industry leader in process safety... and... has made significant improvements each year in response to all Recommendations. However, much work remains to fully implement the Recommendations... BP will be an industry leader when its process safety performance is superior to that of its peers, and its peers recognize BP as a true leader to emulate.29

In recent years in the Gulf of Mexico, BP’s safety offshore drilling record was reportedly excellent.30

Deepwater Horizon

BP’s safety culture failed on the night of April 20, 2010, as reflected in the actions of BP personnel on- and offshore and in the actions of BP’s contractors. As described in Chapter 4, BP, Halliburton, and Transocean did not adequately identify or address risks of an accident—not in the well design, cementing, or temporary abandonment procedures. Their management systems were marked by poor communications among BP, Transocean, and Halliburton employees regarding the risks associated with decisions being made. The decisionmaking process on the rig was excessively compartmentalized, so individuals on the rig frequently made critical decisions without fully appreciating just how essential the decisions were to well safety—singly and in combination. As a result, officials made a series of decisions that proved to be at odds with one another, and high-level decisionmaking was characterized by risk aversion—ultimately without full appreciation of the associated risks.

BP conducted its own accident investigation of Deepwater Horizon, but once again kept its scope extremely narrow.31 Professor Najmeh Mehdikhah of the University of Southern California, Los Angeles—a member of the separate National Academy of Engineering committee investigating the oil spill—criticized BP’s accident report for neglecting to “address human performance issues and organizational factors which, in any major accident investigation, constitute major contributing factors.” He added that BP’s investigation also ignored factors such as fatigue, long shifts, and the company’s poor safety culture.32

Upon reading the BP report, this Commission’s Chief Scientific and Engineering Advisor, Richard Sears, commented: “It appeared that for the accident happened at 0:46 p.m. on April 20, whereas in some ways, the blowout began in early 2000 when they initially designed the well.”33

The Culture on the Rig

BP was operator of the Macondo well and in that capacity had both the overall responsibility for everything that went on and was in the best position to promote a culture of safety. However, a number of other contractors involved on the rig, including in the actions of its two significant contractors, Halliburton and Transocean. But the extensive involvement of those contractors in the mistakes that caused the Macondo well blowout underscores the compelling need for a fundamental shift in industry culture that extends beyond BP. As described in Chapter 2, offshore drilling and energy production involve a complex interrelationship among companies. No single company—not even at the major integrated oil companies—performs the full panoply of activities required for oil and gas drilling. All contract out for the services of other companies for critical aspects of their operations. For this same reason, whatever the specific contractual relationships, operating safety in this environment clearly demands a safety culture that encompasses every element of the extended drilling services, and operating industry.

Transocean, for instance, was a major contractor for the Macondo well and is the world’s largest operator of offshore oil rigs, including the Deepwater Horizon. Transocean personnel made up the largest single contingent on the rig at the time of the accident, and 9 of the 11 men who died on April 20 worked for the company. As described in Chapter 4,
Meshkati’s Observation

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• BP conducted its own accident investigation of Deepwater Horizon, but once again kept its scope extremely narrow. (31) Professor Najmedin Meshkati of the University of Southern California, Los Angeles—a member of the separate National Academy of Engineering committee investigating the oil spill—criticized BP’s accident report for neglecting to “address human performance issues and organizational factors which, in any major accident investigation, constitute major contributing factors.” He added that BP’s investigation also ignored factors such as fatigue, long shifts, and the company’s poor safety culture. (32)
Site Visit – Deepwater Nautilus in the Gulf of Mexico
Deepwater Nautilus
BOP
BOP
BOP
BOP
NAE-NRC BP *DWH* Report’s Specific Findings

• The actions, policies, and procedures of the corporations involved did not provide an effective systems safety approach commensurate with the risks of the Macondo well. The lack of a strong safety culture resulting from a deficient overall systems approach to safety is evident in the multiple flawed decisions that led to the blowout. Industrial management involved with the Macondo well-*Deepwater Horizon* disaster failed to appreciate or plan for the safety challenges presented by the Macondo well. (Finding 5.1. p.77)
Specific Recommendations

Fostering Safety Culture

Summary Recommendation 5.5: Industry should foster an effective safety culture through consistent training, adherence to principles of human factors, system safety and continued measurement through leading indicators. (p.82)
Summary Recommendation 6.25: BSEE and other regulators should foster an effective safety culture through consistent training, adherence to principles of human factors, systems safety, and continued measurement through leading indicators. (p. 96)
Lessons of the Deepwater Horizon

Profits trumped safety and the gulf paid the price.

The latest investigative report on the Deepwater Horizon disaster in the Gulf of Mexico, released Wednesday, is an important reminder of industry’s past shortcomings and a call to vigilance in the future. It could not have come at a more timely moment, just as the Interior Department was completing its first round of new oil-drilling leases in the gulf since the spill.

The report was prepared by the National Academy of Engineering and the National Research Council. It concluded — as had an earlier study by a presidential commission — that the explosion resulted from a series of poor decisions by BP and others, including a major misjudgment involving the ability of the well to withstand serious increases in pressure. The study criticized both the industry and federal regulators for “misjudged trust” in the ability of bottom-connector to seal off wells in an emergency, and called for industry to redesign these devices to make them more reliable in the future.

More broadly, the report said that industry was more focused on drilling and profits than it was on the need for precautions and oversight. It said “the lack of a strong safety culture” was not unique to BP but was shared by its contractors and its regulators in the Interior Department’s former Minerals Management Service.

Since the disaster, the Interior Department has put in place a series of new regulations that dramatically curbed the environmental risk. The new safety culture has been examined and reengineered, and its inspection capabilities have been bolstered. Its new leaders have vowed that its workers will be trained to protect the public and the environment, but the industry is still criticized for its safety culture.

Jim ♦ Wies, a former Navy engineer who directed the new study, said that because of these and other improvements, drilling in the gulf could safely proceed “at the highest levels.” But he warned, rightly, against overconfidence, especially now that drilling in the gulf has resumed and the Interior Department has started leasing new tracts that will be to further exploration.

“The lack of strong safety culture”
THE POST-MACONDO WORLD:
Two Years After the Spill
Robin Beckwith, Senior Staff Writer

Offshore petroleum rig, Gulf of Mexico. Photo by Digital Vision.
Drillers Find Themselves in a Tricky Spot at the Human/Machine Interface

Stephen Rassenfosse, JPT Emerging Technology Editor

When describing his company's drilling simulation, Lars Nanseth of Axon Energy Products said experienced rig workers have ended a session drilling a virtual well with skins sealed in sweats. The story told at a trade show booth at the ADCAPE Drilling Conference, held 6-8 March 2013, was one of the indications that being at the controls in the driller's chair is an increasingly complex place to be.

It has never been a simple job. Drillers must balance conflicting demands that can affect everything from the cost of the well to the lives of the crew. They are the critical link between drilling contractors and oil companies, a relationship described as "cooperative antagonism" by management consultant John deWardt of deWardt and Company, writing in Petroleum Engineer.

The growing use of computerized controls led to less unflattering comparisons. Field tests of Schlumberger's Drilling Advisor system reported at the conference found that drilling with computerized controls easily outperformed human control. When the computer was in control, the drill bit penetrated the formation 59% faster than it did with a human operator making the drilling decisions.

Clint Chapman, drilling automation architect at Schlumberger, explained that computer systems can make up for the absence of human operators in critical areas. He said his company's software has data on 12 factors affecting drilling performance, and a drill bit can only follow about five. Drillers working with automation systems do not have a fixed role. The system can control drilling based on the well plan, offer recommendations for the driller to act on, or allow full control by the operator. Issues, such as technical problems, can require the driller to take charge.

Schlumberger was able to drill wells significantly faster using a computer program based on an algorithm it developed. The first four wells were drilled without its rate of penetration optimization (ROPO) system, and the next four were drilled with it.

As the industry gradually moves to computer control for drilling functions, the consensus is that the job of drillers is secure but changing. "All too often, we confuse software-controlled systems with replacing humans," said Clint Chapman, a software specialist at Schlumberger. Computerized drilling control must be adapted to the fact that drilling is a "very deterministic." "We do not know with geology what is next as you would on a factory floor."
Looking Out for Perils

Five characteristics used by high reliability organizations to be mindful of risks:

1. Are preoccupied with failure. A chronic unease something has been missed or shortcomings in safety procedures.
2. Are reluctant to simplify. Diverse checks and balances are part of the reviewing process.
3. Are sensitive to operations. A broad group of people in the organization play close attention to day-to-day work.
4. Cultivate resilience. The organization is set up to respond to surprises.
5. Seek out expertise. Technical decisions are made by experts in the area and work is organized so they can provide meaningful input.

Source: Managing the Unexpected, by KE Weick and KM Sutcliffe.
Global Implications

• About a 30% of the world’s oil production presently comes from offshore projects and it will increase to about 50% in 2015.
Implications for the Gulf of Mexico:

Cuba

Taking it to the Straits

Before the end of the year, Spanish oil firm Repsol YPF plans to begin drilling for oil north of Havana in Cuban waters. In case of a well blowout, it is unclear if U.S. companies could lend equipment or expertise.

Sources: Jorge Piñón, visiting research fellow at Florida International University
Implications for the Gulf of Mexico: Mexico
Conclusion
Safety, Efficiency, and Productivity: Conflict or Cooperative?
A Requirement for Safety Culture:
A Balanced Approach Toward Production and Safety Goals

Inspired by Professor James Reason’s *Human Error* (1990)
An Unbalanced Approach Toward Production and Safety Goals

Equilibrium

Economic/Competitive Schedule Pressure

Political & Regulatory Env.; Senior Management’s Biased Priorities, Policies, and Practices
Technological systems’ failures “Accidents”? or System designers’ ignorance to consider / incorporate HRO Characteristics + Managers’ incompetence + Regulators’ arrogance
A Robust/Stable Technological System
INVESTIGATION REPORT
Final Draft for Board Vote

REFINERY EXPLOSION AND FIRE
(15 Killed, 180 Injured)

KEY ISSUES:
- Safety Culture
- Regulatory Oversight
- Process Safety Metrics
- Human Factors

To Najm
Thanks for your report. Your work is a tremendous cultural insight. It was an inspiration for our work there.

BP
Texas City, Texas
March 23, 2005

Report No. 2005-04-1-TX
March 2007