Transportation Research Board
Special Report 321

Strengthening the Safety Culture of the Offshore Oil and Gas Industry

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Strengthening the Safety Culture of the Offshore Oil and Gas Industry

Committee on U.S. Offshore Oil and Gas Industry Safety Culture: A Framing Study

Transportation Research Board

Marine Board

Board on Human-Systems Integration
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Preface

Since the term "safety culture" was coined after the Chernobyl disaster in Ukraine almost 30 years ago, it has been cited as a factor in many other catastrophic accidents worldwide, including the Macondo well blowout/*Deepwater Horizon* explosion and oil spill of 2010. That accident represents the worst environmental disaster in the history of the United States and an enduring reminder of the hazards of offshore oil and gas exploration and production and the serious consequences of accidents offshore. Since it occurred, it has been the subject of several investigations and studies. It also has spurred action from the government and the offshore oil and gas industry aimed at improving safety culture and safety within the industry, including a number of initiatives and new regulations issued after 2011. However, more work remains to be done to effect positive change in the safety culture of the entire U.S. offshore oil and gas industry.

In this context, the National Academies of Sciences, Engineering, and Medicine convened the Committee on U.S. Offshore Oil and Gas Industry Safety Culture to study safety culture and safety in the offshore oil and gas industry and prepare this report. The objective of the committee's efforts was to assist the offshore industry, government, and other stakeholders in strengthening the industry's safety culture. The committee members were selected for their expertise in the areas of industrial and organizational psychology, safety program management, safety culture, high-reliability organizations, offshore industry operations, industrial safety, safety regulations and policy, human factors and applied cognition, and organizational change (for biographical information on the committee members, see page 154).

This study was initiated in March 2014. The committee held five meetings, made four site visits, and held several information-gathering sessions with various members of the offshore oil and gas industry to gather the information needed to carry out the study. We are grateful for the valuable information and insights provided by Charlie Williams II (Center for Offshore Safety [COS]); Doug Morris and Staci Atkins (Bureau of Safety and Environmental Enforcement [BSEE]); Jeff Wiese (formerly with the Pipeline and Hazardous Materials Safety Administration [PHMSA]); RDML Paul F. Thomas (U.S. Coast Guard [USCG]); Andy Eckel (Chevron); Joel Plauche (Fieldwood Energy); David Hensel (Ensco); Ricky Britt (Danos); Kevin Graham (M&H); Steve Arendt (ABS Consulting); John Coryell (Conoco/DuPont, retired); Thor Gunnar Dahle, Elise Jorunn Tharaldsen, and Irene Dahle (Petroleum Safety Authority Norway [PSA]); James Ellis (formerly with the Institute of Nuclear Power Operations [INPO]); Tom Krause (BST); Billie Garde (Clifford & Garde); Mark Steinhilber (California State Lands Commission [CSLC]); Capt. Jason Neubauer (USCG); Christopher Hart (National Transportation Safety Board [NTSB]); Lois Epstein (The Wilderness Society); and David Hammer (WWL-TV New Orleans). We also benefited greatly from our interactions with the training staff and trainees at the Shell Robert Training Center in Robert, Louisiana, and the PetroSkills Oil and Gas Training Facility and the Diamond Offshore Drilling Training and Simulation Center, both in Katy, Texas; with personnel at the Shell Drilling Real Time Operations Center in Houston, Texas; and with third-party inspectors with the Offshore Technical Compliance, LLC.

The committee also is grateful for the assistance provided by the staff of the National Academies of Sciences, Engineering, and Medicine. We particularly wish to acknowledge the support of Stephen Godwin, Camilla Y. Ables, Beverly Huey, Amelia Mathis, and Mark Hutchins.

Finally, I thank all the members of the study committee for their efforts throughout the study and the preparation of this report.

Nancy Tippins, PhD, *Chair*
Committee on U.S. Offshore Oil and Gas Safety Culture

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This study was performed under the overall supervision of Stephen R. Godwin, Director, Studies and Special Programs, Transportation Research Board. The committee acknowledges the work and support of Camilla Y. Ables, who served as study director and assisted the committee in the preparation of its report, and Beverly Huey, who assisted in the early phases of the project. The committee also acknowledges the work and support of Karen Febey, Senior Report Review Officer, who managed the report review process. Rona Briere edited the report and Alisa Decatur, provided word processing support. Jennifer J. Weeks prepared the manuscript for prepublication web posting, and Juanita Green managed the book production and design, under the supervision of Javy Awan, Director of Publications. Amelia Mathis assisted with meeting arrangements and communications with committee members.

A draft version of this report was reviewed by individuals chosen for their diverse perspectives and technical expertise in accordance with the procedures of the Report Review Committee (RRC). The report review was managed by Karen Febey, Senior Report Review Officer for the Transportation Research Board. The purpose of this independent review is to provide candid and critical comments that will assist the National Academies of Sciences, Engineering, and Medicine in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. The committee thanks the following individuals for their review of this report:

Ken Arnold, Independent Consultant, Houston, Texas
Khalid Aziz, Stanford University (emeritus)
Michael Baram, Boston University School of Law, Emeritus
Dennis Bley, Buttonwood Consulting, Inc., Albuquerque, New Mexico
Mark Fleming, Saint Mary's University (Canada)
Patrick Hudson, Delft University of Technology (Netherlands) (emeritus)
Craig Philip, Vanderbilt University
Edgar Schein, Massachusetts Institute of Technology (emeritus)

Although the above reviewers provided constructive comments and suggestions, they were not asked to endorse the report's conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Susan Hanson, Clark University (emerita), and Robert Frosch, Harvard University. They were responsible for making certain that an independent examination of this report was conducted in accordance with institutional procedures and that all review comments received full consideration. Responsibility for the final content of this report rests entirely with the authoring committee and the National Academies of Sciences, Engineering, and Medicine.

Acronyms and Abbreviations

ABS	American Bureau of Shipping
AER	after event review
ANPRM	Advance Notice of Proposed Rulemaking
APD	Application for Permit to Drill
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
BSEE	Bureau of Safety and Environmental Enforcement
BV	Bureau Veritas
CCPS	Center for Chemical Process Safety
CFR	Code of Federal Regulations
COS	Center for Offshore Safety
DNV	Det Norske Veritas
DOI	Department of the Interior
DOT	Department of Transportation
DWOP	Deepwater Operations Plans
EIA	Energy Information Administration
FR	*Federal Register*
HCA	high-consequence area
HSE	health, safety, and environment
HSQE	health, safety, quality, and environmental
IACS	International Association of Classification Societies
IADC	International Association of Drilling Contractors
IAEA	International Atomic Energy Agency
ILO	International Labor Organization
IMO	International Maritime Organization
INPO	Institute of Nuclear Power Operations
IOGP	International Association of Oil & Gas Producers
IRF	International Regulators' Forum
ISM	International Safety Management
ISO	International Organisation for Standardization
MMS	Minerals Management Service
MOA	memorandum of agreement
MODU	mobile offshore drilling unit
MOU	memorandum of understanding
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NPRM	Notice of Proposed Rulemaking
NRC	National Research Council
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act

OMB	Office of Management and Budget
OOC	Offshore Operators Committee
OSHA	Occupational Safety and Health Administration
OTA	Office of Technology Assessment
PHMSA	Pipeline and Hazardous Materials Safety Administration
PSA	Petroleum Safety Authority (Norway)
PSMS	pipeline safety management system
PTP	Prevention Through People
RP	Recommended Practice
SEMP	Safety and Environmental Management Program
SEMS	safety and environmental management systems
SLA	Submerged Lands Act
SPE	Society of Petroleum Engineers
USCG	United States Coast Guard
USDOT	United States Department of Transportation
USGS	United States Geological Survey
U.S. NRC	United States Nuclear Regulatory Commission

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Appendixes

Summary

The offshore oil and gas industry in the Gulf of Mexico is among the most developed in the world; it provides thousands of jobs in the Gulf Coast region and meets a sizable portion of the energy requirements of the United States. In the Gulf of Mexico as of November 2015, 33 mobile offshore drilling units (MODUs)[1] were operating in water at depths of up to 10,000 feet, and more than 2,500 platforms[2] were operating in shallow water. In 2013, federal offshore oil and natural gas production in the Gulf of Mexico accounted for 17 percent and 5 percent of total U.S. crude oil and dry gas production, respectively. According to a February 2016 report of the U.S. Energy Information Administration (EIA), oil production in the Gulf is expected to account for 18 percent and 21 percent of total forecast U.S. crude oil production in 2016 and 2017, respectively, even as oil prices remain low. The EIA projects that the Gulf of Mexico will produce an average of 1.63 million barrels per day (b/d) in 2016 and 1.79 million b/d in 2017.

Although drilling and producing oil and gas are intrinsically hazardous activities, the early history of the offshore oil and gas industry demonstrates priority given to production over safety as a result of constant pressure to recoup the huge investments made in leases, structures, equipment, and personnel as rapidly as possible. It was only in the late 1960s, after a string of high-profile disasters, a growing number of injury lawsuits, and increased media scrutiny and public demand for worker and environmental safety, that the industry and the government decided to make offshore operations safer by way of improved work practices, technologies, designs, and regulations.

Inconsistencies in the collection and reporting of information about accidents and injuries in the early days of the industry make it difficult to determine accurately whether incident rates and safety culture improved after these changes were instituted. However, reports based on incomplete data appear to indicate that the introduction of new regulations and practices in the 1960s and 1970s improved the offshore industry's occupational safety record in the Gulf of Mexico.

Between the late 1990s and 2009, the offshore industry suffered damages due to hurricanes, and nonfatal and fatal accidents continued to occur, but the industry had not experienced a catastrophic accident in many years. This trend ended in April 2010 when the Macondo well blew out, leading to an explosion and fire on the *Deepwater Horizon* drilling rig. This incident resulted in 11 deaths and 17 injuries and spilled an estimated 3.19 million barrels of oil into the Gulf of Mexico, causing immense marine and coastal damage. The economic impact of the incident totaled $8.7 billion in lost revenue, profits, and wages, as well as the loss of about 22,000 jobs; BP also had to pay at least $30 billion to cover fines, penalties, operational response, and liabilities. The blowout and spill, which caused the worst oil pollution in U.S. history, also put the safety of offshore drilling and production under tremendous public scrutiny.

The Chemical Safety Board attributed the accident to " a complex combination of deficiencies: process safety safeguards and inadequate management systems and processes meant to ensure safeguard effectiveness, human and organizational factors that created an environment

[1] MODUs are facilities used for drilling and exploration activities. The term refers to drilling vessels, semisubmersibles, submersibles, jack-ups, and similar facilities that can be moved without substantial effort.
[2] A platform (also referred to as an oil platform, offshore platform, or oil rig) is a large structure equipped with facilities and equipment for drilling wells, extracting and processing oil and natural gas, or temporarily storing oil prior to its transfer to shore for refining and marketing. Most platforms also have facilities to house workers.

ripe for error, organizational culture focused more on personal safety and behavioral observations than on major accident prevention, and a regulatory regime unable to deliver the necessary oversight for the high-risk activities involved in deepwater exploration, drilling, and production." Other reviews of the accident—performed by the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (2011), the National Academy of Engineering and National Research Council (2011), and the U.S. Coast Guard (n.d.) and the Bureau of Ocean Energy Management, Regulation and Enforcement (2011) Joint Investigation Team —also identified the need for reforms to transform the safety culture of the offshore oil and gas industry.

DEFINITION OF SAFETY CULTURE

The term *safety culture* was coined by the International Nuclear Safety Advisory Group during its investigation of the Chernobyl power plant accident in 1986. Since then, the definition of safety culture and the identification of the factors that strengthen such a culture have evolved. At its core, however, safety culture remains an aspect of the larger organizational culture, encompassing the organization's values, beliefs, attitudes, norms, practices, competencies, and behaviors regarding safety. The Nuclear Regulatory Commission defines safety culture as "the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment." Based on this definition, the Bureau of Safety and Environmental Enforcement (BSEE), one of the regulators of the offshore oil and gas industry, issued its *Safety Culture Policy Statement* in May 2013 to promote safety culture in the industry. The policy defined safety culture as "the core values and behaviors of all members of an organization that reflect a commitment to conduct business in a manner that protects people and the environment" and articulated nine characteristics or elements of a robust safety culture:

- Leadership commitment to safety values and actions,
- Respectful work environment,
- Environment for raising concerns,
- Effective safety and environmental communication,
- Personal accountability,
- Inquiring attitude,
- Hazard identification and risk management,
- Work processes, and
- Continuous improvement.

Although there exists no single definitive set of elements that constitute safety culture, the various versions of those elements overlap considerably. Those articulated by BSEE mirror those identified in major scholarly reviews of safety culture research and leading frameworks in other industries and are grounded in empirical research. Given their theoretical and research foundations, these elements represent the best available information about effective strategies for establishing and strengthening a safety culture and thus are particularly useful for the offshore industry.

Recommendation 2.1[3]: The committee recommends that the offshore industry and government regulators adopt the BSEE definition of safety culture and its essential elements as a guide for assessment and practice.

BARRIERS TO STRENGTHENING A SAFETY CULTURE

Immediately after the 2010 *Deepwater Horizon* blowout and oil spill, the American Petroleum Institute created the Center for Offshore Safety, whose focus is on improving safety in the U.S. Outer Continental Shelf and addressing the offshore industry's need to strengthen its safety culture. BSEE also made compliance with the Safety and Environmental Management Systems (SEMS) rule, which previously had been voluntary, compulsory, and subsequently released its *Safety Culture Policy Statement*. As a result of several barriers, however, these and other recent initiatives are not sufficient to transform the industry's safety culture.

Leadership commitment to strengthening and sustaining safety culture varies among organizations in the offshore industry. Senior leaders and owners of organizations vary in their understanding of, commitment to, and engagement with the need to strengthen and sustain a strong safety culture. Leaders who reward productivity but do not consistently recognize safety performance or send intentional or unintentional messages that safety is not a priority, is too expensive, or is an effort made only to comply with regulations create an environment in which a strong safety culture (and safety) cannot be properly maintained or strengthened.

The offshore industry is fragmented and diverse. Complex offshore operations take place under many different organizational arrangements that involve a mix of large and small companies that vary as to their internal resources for safety initiatives and their cultural values around safety. In addition, many segments of the industry have a diverse and multicultural workforce composed of employees with differing safety attitudes and practices and varied educational backgrounds. Moreover, the cyclic nature of the offshore oil and gas industry translates to frequent reductions in experienced staff during downturns and subsequent employment and training of relatively inexperienced workers during upturns. Multiple relationships also exist among operators, contractors, and subcontractors on offshore rigs and platforms that can diffuse responsibility for safety and make consistent practices difficult to implement. Because of their differing safety perspectives and economic interests, offshore oil and gas companies do not all belong to a single industry association that speaks with one voice regarding safety. The fragmented nature of the industry, heterogeneity among companies, and diversity among employees make it a challenge to set consistent goals and implement them through industry-wide agreements.

The offshore industry's safety culture is still developing. The offshore industry is gradually changing from one with a risk-taking attitude to one in which anyone can raise a safety concern or stop work on a job because of safety issues. As with many industries, however, a blaming culture still exists in the offshore industry, as well as a lack of systems thinking that results in focusing on the immediate proximal causes of a safety failure (such as human error) rather than system causes, including culture.

Regulators need competence in safety culture. For BSEE and other regulators, traditional safety oversight has consisted of inspecting offshore installations to ensure compliance with a set of prescribed regulations. However, merely being in regulatory

[3] The committee's recommendations are numbered according to the chapter of the main text in which they appear.

compliance will not ensure safe offshore operations. Responsible companies and progressive regulators realize the need to go beyond regulatory compliance by embracing safety in a holistic manner. One challenge for all regulators is changing the mind-set of inspectors from inspecting for compliance to advocating safety culture. To this end, inspectors' skill set will need to be developed such that they are able to help offshore companies implement a safety culture philosophy. The SEMS requirements instituted after the *Deepwater Horizon* accident are intended to shift the focus of the industry's safety efforts from meeting minimum standards to striving for continuous improvement—a shift that is proving to be challenging for industry and regulators alike.

RECOMMENDATIONS FOR STRENGTHENING AND SUSTAINING A SAFETY CULTURE IN THE OFFSHORE OIL AND GAS INDUSTRY

In response to its charge, the committee offers the following recommendations for strengthening and sustaining a safety culture in the offshore oil and gas industry, along with a list of topics on which further research is needed to fill knowledge gaps with respect to strengthening, assessing, improving, and sustaining safety culture.

Recommendations for the Industry

Collective and Collaborative Action

Recommendation 6.2.1: Industry leaders should encourage collective and collaborative actions to effect change in an industry as fragmented as the offshore oil and gas industry.

Historically, the industry has not offered its vision for the type of regulatory system it supports. The industry should begin with a vision statement and a strategy for safety leadership. This vision should include a description of the regulatory system that best enables the accomplishment of these objectives, encourages continuous improvement, and enhances safety culture. While each company is responsible for its own safety performance, the industry as a whole should be collectively committed to a culture that provides the best opportunity for maintaining a safe working environment.

Recommendation 4.1: The offshore oil and gas industry, in concert with federal regulators, should take steps to define the optimal mix of regulations and voluntary activities needed to foster a strong safety culture throughout the industry, including contractors.

To this end, the following specific steps should be taken: required participation in an independent industry organization dedicated to safety leadership and achievement; collaboration between regulators and operators, contractors, and subcontractors in designing a safety system for all levels of all organizations in the offshore industry; and adaptation or implementation of an evidence-based decision-making process regarding safety that entails reporting of accurate and complete data, analysis of causes as well as trends, and sharing of data across the industry and the regulators. In these efforts, it is essential that industry and regulators go beyond ideas and possibilities to develop concrete plans for execution.

Recommendation 6.3.1: The industry as a whole should create additional guidance for establishing safety culture expectations and responsibilities among operators, contractors, and subcontractors. Regulators should assist in these efforts and ensure consistency.

Once the industry has agreed upon steps to take to achieve safety and environmental goals, all organizations involved, including operators, contractors, and subcontractors, should be responsible for developing their own strategies for executing this overall plan. In addition, the industry should decide which guidelines should be made mandatory for participants in offshore oil and gas exploration and production. To set industry-wide safety goals and expectations, the industry will first need to determine how operators, contractors, subcontractors can best be represented in an independent safety organization and what membership requirements should be imposed for working offshore.

An Independent Entity Dedicated Solely to Offshore Safety

Safety is included in the charters of a number of industry associations, but advocacy to support and promote their members is their primary focus, not identifying weaknesses and concerns relative to safety. Some associations have actively opposed past efforts to enhance offshore safety. Hence, the public may not always trust their claim that promoting safety or assessing safety performance is their first priority.

Recommendation 4.4: The U.S. offshore industry should implement the recommendation of the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling for an independent organization whose sole focus would be safety and protection against pollution, with no advocacy role. The Center for Offshore Safety (COS), although a strong, positive step in this direction, is nonetheless organized within the American Petroleum Institute (API) and therefore not independent of that organization's industry-advocacy role. COS should be independent of API and membership in COS should be a key element of the fitness-to-operate criteria for all organizations, including operators, contractors, and subcontractors, working in the offshore industry.

Regulatory agencies should support this requirement for participation in a single industry-wide safety organization. This would be one way for an independent Center for Offshore Safety, whose membership currently includes the larger offshore operators, independent drillers, and service companies, to expand its base of participants, engage the entire offshore industry, and secure sufficient financial resources to pursue safety culture initiatives.

Safety Management Systems

Recently, the American Petroleum Industry's Recommended Practice 1173 was revised by the pipeline industry with participation from the pipeline safety regulator, and it now includes elements that encourage companies to fully integrate safety culture considerations into their management programs.

Recommendation 4.7: The committee recommends that the American Petroleum Industry's Recommended Practice 75 Committee include a chapter on safety culture in the revised edition of this document, which is currently being drafted.

Assessment of Safety Culture

Assessment of safety culture is important because it helps companies identify strengths, weaknesses and gaps, and potential improvements; without assessment, it is virtually impossible to detect and reinforce gradual changes that may be beneficial to safety.

Recommendation 5.1.1: Operators and contractors should assess their safety cultures regularly as part of a management system.

Recommendation 5.1.2: The committee strongly recommends that companies use multiple assessment methods, including, in particular, both leading and lagging indicators and both quantitative and qualitative indicators of safety culture. Companies should also apply a mix of indicators, including some that are more standard across the industry to facilitate ease of use and comparison across organizations, and some that are tailored to the specific needs and concerns of their organization.

Assessment of safety culture requires objectivity, expertise, and sensitivity to context. For some organizations, the process may require outside help initially, but having self-assessment and self-reflection capabilities is ideal as it creates a sense of ownership and accountability and encourages broad participation in the safety assessment process.

Recommendation 5.2.1: Organizations that operate in the Outer Continental Shelf should consider their capabilities and priorities in determining to what extent they will rely on internal versus external expertise for assessment of safety culture. When feasible, organizations should seek to acquire internal expertise over time so they can manage the process, interpret results, and increase their ownership and the relevance of the assessments and their results.

Implementation of Change

Successful culture change is a long-term effort, entailing considerable uncertainties and investments.

Recommendation 6.1: Company senior leadership needs to commit to and be personally engaged in a long and uncertain safety culture journey. Senior leaders should ensure that their organizations take advantage of resources available from other companies, industry groups, and regulators in strengthening their own safety cultures.

Recommendations for Regulators

Use of Safety Management Principles to Improve Safety Performance

The regulators of the offshore industry (i.e., Minerals Management Service/BSEE, the U.S. Coast Guard), and some industry representatives recognized in the 1990s that offshore industry safety programs needed to go beyond detailed prescriptive equipment regulations. Yet most offshore inspectors continue to focus on prescriptive equipment regulations, following a standard checklist and inspecting all operators in the same manner regardless of their safety records.

Recommendation 4.3: Regulators should make greater use of risk principles in determining inspection frequencies and methods, such that operators with good performance records are subject to less frequent or less detailed inspections. Inspectors should consider shifting from traditional compliance inspections to inspections that follow the safety management approach outlined in the Safety and Environmental Management Systems standard. Audit results should be considered in developing inspection programs and their schedules.

Data Collection and Availability

A commonly noted problem in studying accidents in the offshore oil and gas industry is the lack of complete and accurate data related to accidents and near misses.

Recommendation 4.2.1: Regulators, with help from industry, should define the critical factors necessary for understanding the precursors to accidents, determine what data need to be submitted to which regulatory agencies, and establish mechanisms for regular collection of those data.

Currently, BSEE accident and incident data are available to the public, but inspection data are not publicly accessible.

Recommendation 4.2.2: Because accident, incident, and inspection data all are needed to identify and understand safety risks and corrective actions, the committee recommends full transparency such that regulators make all these data readily available to the public in a timely way, taking into consideration applicable confidentiality requirements. Summaries of voluntarily reported near misses or hazardous events, absent information that should be kept confidential, such as company names and facility identifiers, should also be released.

Safety Culture Champions

The nine characteristics or elements of an effective safety culture that BSEE released in 2013 are not well known in the industry, and BSEE lacks the means to move the entire offshore industry closer to these desired characteristics.

Recommendation 4.5: The Secretary of the Interior, in cooperation with the Commandant of the U.S. Coast Guard, should seek prominent leaders in the offshore industry to champion the nine characteristics of an effective safety culture identified by BSEE, develop

guidance for safety culture assessment and improvement, and facilitate information exchange and sharing of experiences in promoting safety culture.

Memoranda of Understanding on Promoting Safety Culture

The three regulatory agencies that oversee aspects of the offshore oil and gas industry—BSEE, the U.S. Coast Guard (USCG), and the Pipeline and Hazardous Materials Safety Administration (PHMSA)—all have initiatives related to promoting and enhancing safety culture but have no formal agreement to work cooperatively on advancing safety culture.

Recommendation 4.8: BSEE, the U.S. Coast Guard, and the Pipeline and Hazardous Materials Safety Administration should develop memorandums of understanding specifically addressing the concepts of and implementation plans for offshore safety culture and defining accountabilities among the three regulators.

Assessment and Improvement of Safety Culture

Currently, a considerable imbalance favors traditional compliance activities by regulators rather than activities designed to help strengthen offshore safety culture, and the current offshore compliance culture reflects this imbalance. Influencing safety culture in positive ways will require new and different initiatives by regulators. Goals for offshore safety culture shared between the industry and regulators would help define new safety culture activities, such as coaching, sharing lessons learned, and independently assessing offshore safety culture.

Recommendation 5.1.4: The committee recommends that BSEE and other regulators of the offshore industry strengthen their capabilities in the area of safety culture assessment by bolstering their expertise in safety culture through appropriate hiring and training and/or partnering with industry or third-party organizations. These bolstered capabilities would enable regulators to offer advice, training, tools, and guidelines to the industry as it conducts self-analysis.

Recommendation 5.1.5: The offshore industry should work collectively on the challenges of developing a safety culture. BSEE should support this effort by serving as a clearinghouse for and a facilitator of industry-level exchanges of lessons learned and benchmarking.

Future Research Directions

Regulatory agencies, industry organizations, and other participants in the offshore industry need to work together to facilitate research and information sharing so as to advance knowledge and practice. The committee's detailed recommendations for specific areas of research illustrate knowledge gaps in

- Ensuring sufficient competence in an organization's leadership and workforce to create and sustain an effective safety culture;
- Assessing, and sustaining safety culture in different types of offshore organizations (e.g., smaller operators, contractors, regulators);

- Developing industry-level data on safety outcomes, near misses, and safety culture measures that can be shared and compared across organizations over time;
- Sharing information and lessons learned across companies in a fragmented and diverse industry;
- Encouraging decision makers to enhance safety efforts; and
- Developing or identifying strategies for enhancing safety culture and determining the features of safety culture that have the most impact on safety outcomes.

1

Introduction

For many decades, the U.S. federal government has leased portions of the U.S. Outer Continental Shelf (OCS), mainly the Gulf of Mexico and Alaska regions, to companies for the exploration, development, and production of oil and gas. According to the Minerals Management Service, which was reorganized and ultimately replaced in 2011 by the *Bureau of Ocean Energy Management* (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE), more than 50,000 wells have been drilled in the Gulf of Mexico since 1947.

Offshore regulation and company operations are conducted pursuant to the Outer Continental Shelf Lands Act (OCSLA) and several other laws that establish the salient institutional framework, procedures, and regulatory means and the decision criteria for their implementation. With regard to the safety of operations, OCSLA mandates rulemaking and enforcement by the U.S. Department of the Interior, assigns offshore workplace safety responsibilities to the U.S. Coast Guard, requires cost-benefit analysis in safety-related rulemaking, and authorizes adoption of industry standards. It is within this framework that improvements to the safety of offshore oil and gas operations are considered in this report.

Aside from supplying oil and gas to meet U.S. domestic needs, the offshore oil and gas exploration activities in the OCS also contribute considerably to the U.S. economy. In 2009 alone, for example, offshore companies paid the U.S. government $6 billion in royalties on the sale of oil and gas produced in federal waters and provided 150,000 jobs (GAO 2010; Baram 2011). Royalties and payments collected by the Department of the Interior from oil and gas companies amounted to approximately $48 billion from 2009 through 2013 (GAO 2015, 94). Since 2010, leases in the OCS have been the source of approximately 2 billion barrels of oil and 6.2 trillion cubic feet of natural gas, accounting for more than 19 percent of U.S. oil production and about 5 percent of U.S. natural gas production.[1] At the same time, however, offshore oil and gas operations in the OCS (and elsewhere in the world) are highly complex and pose the risk of injury or death to workers, explosions, blowouts, and oil spills with associated contamination of the marine environment.

STUDY ORIGINS

In 2013, an assistant U.S. district attorney in charge of negotiating a settlement with a private oil and gas company operating in the Gulf of Mexico contacted BSEE about addressing the causes of accidents and spills in the offshore oil and gas industry. BSEE staff referred her to the National Academies of Sciences, Engineering, and Medicine because of efforts under way at the Marine Board to develop a project on safety culture in the offshore industry. The study was supported with funds designated for the National Academy of Sciences as a community service

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[1] Statement of Lars Herbst, Regional Director, BSEE, DOI before the Committee on Natural Resources, U.S. House of Representatives. https://www.doi.gov/ocl/energy-production. Accessed January 26, 2016.

payment arising out of a plea agreement entered into between the United States Attorney's Office for the Eastern District of Louisiana and Helmerich & Payne International Drilling Company.

STUDY CHARGE AND APPROACH

This study was carried out in accordance with the statement of task presented in Box 1-1. As part of its information gathering-activities, the study committee held five meetings, met with representatives of the different sectors of the offshore oil and gas industry, and visited offshore oil and gas training and operations centers in Robert, Louisiana, and Houston, Texas. At its first meeting in April 2014, the committee met with representatives of BSEE, the Center for Offshore Safety (COS), and the Pipeline and Hazardous Materials Safety Administration (PHMSA) and learned about each agency's perspectives on addressing safety in the U.S. offshore oil and gas industry. The committee's second meeting was held in August, 2014, its third in October 2014, its fourth in January 2015, and its fifth in May 2015. The speakers and the agendas for the open sessions of the committee meetings are provided in Appendix A.

Box 1-1

Statement of Task

In this project, an ad hoc committee will conduct a study to aid industry, government, and other stakeholder efforts to strengthen the offshore industry safety culture. The committee will gather information from safety culture experts, members of the industry, regulators, workers, and the public in order to identify the essential characteristics of a strong safety culture, barriers to achieving a strong safety culture in the offshore industry, and possible ways of overcoming these challenges. The committee will also identify potential strategies to measure and assess company and industry safety culture effectively. The role of the regulators in achieving a proper safety culture will also be considered.

Because of the complexity of both the subject and the industry, the committee may not be able to answer all of the questions about the offshore industry safety culture that will be raised during the course of the study. However, based on information gathered, literature reviews, lessons learned from implementing safety culture in other industries, and expert judgment, the committee will identify options for improving and promoting a safety culture for industry, regulators, and policy makers to consider. The committee will also identify and recommend specific areas of research and research projects to address gaps in knowledge identified through this process.

STUDY CONTEXT

The Offshore Work Environment

The industry's advance from shallow water into deep water (500-1,499 meters) and ultra-deep water (1,500 meters or more), while crucial to meeting the nation's demand for oil and gas, has increased the dangers to a workforce already engaged in an intrinsically hazardous occupation. Offshore drilling and production platforms in deep and deeper waters, where complex operations using increasingly sophisticated technology/equipment are regularly performed and increase opportunities for human and organizational error, are among the most extreme workplaces in the world. They are exposed to adverse marine conditions and are remote, reachable only by helicopter or boat, features that introduce additional hazards into the work environment.

Workplaces in the offshore environment vary as different types of structures are employed in oil and gas drilling and production in shallow water, deep water, and ultra-deepwater. The types of offshore structures include conventional fixed platform, compliant tower, vertically moored tension leg and mini-tension leg platform, spar, semisubmersible, floating production, storage and offloading facility, and subsea completion and tie-back to host facility. These structures differ in the types of equipment and technology they employ.

Operations required for offshore oil and gas drilling and production are not performed by a single company; instead, operators work with drillers and various contractors for the critical aspects of these operations. These workers can vary in knowledge, skills, and abilities as well as primary language and culture. By current estimates, about 75 operators, 17 drilling contractors, and more than 1,000 contractors/subcontractors provide support to offshore drilling, production, and construction activities in the Gulf of Mexico. Contractors vary in size and financial resources; some are one-person specialized companies, while others have several thousand employees. Safe operations among this complex blend of workforces from different companies operating on the same platform require effective contracts. The contract can establish standards and expectations, and it is typically accompanied by a bridging document that specifies the responsibilities of each company for the various aspects of drilling operations and sets forth emergency procedures that operators and their contractors are expected to follow. As drilling operations move into deeper water and become more complex, specifying responsibilities for safety and liability through contracts and bridging documents has become a greater challenge.

Offshore work environments vary depending on many factors, such as the type and size of facility or vessel and the technology and equipment on board; the mechanical and structural integrity of the facility or vessel; the number of companies involved in the operations and their goals related to profitability; the capabilities and cultural mix of personnel; the operations performed; the leadership style of managers; and the policies, procedures, culture, and financial resources of the operators, contractors, and subcontractors. All of these factors and the complex relationships among operators, contractors, and subcontractors can have profound impacts on the propagation of strong safety culture offshore (NAE and NRC 2011).

Some production platforms have full operations around the clock, while others operate in a "run and maintain" mode, which means they are visited daily or a few times a week for monitoring. Small platforms may have as few as two people aboard, while large platforms and floating production facilities may have between 75 and 150 people aboard depending on the complexity of the equipment and operations. The smaller platforms usually have day crews only, but the larger ones may have larger day crews and some night crews. Mobile offshore drilling units, which move from site to site to conduct well-drilling operations, may have 50 to 125 people aboard.

For long stretches of time, platform workers operate equipment to extract flammable hydrocarbons at high pressure. Shifts are typically 12 hours long. Many people work 14 days on and 14 days off, but schedules vary, with some crews working 14 days on and 7 days off, while others work 21 on and 14 off. Some workers may work overtime, but it is unusual for them to do so on an ongoing basis.

Job performance is contingent on a number of factors. The skill sets required for performance—electrical, instrumentation, mechanical, maintenance, health and safety and environment, drilling, mud engineering, technician, general labor, etc.—are task dependent, and some require company, industry, or regulatory certification. In some situations, critical operations, such as drilling, well servicing, welding, and diving construction, require management and regulatory approval before work can begin. Various kinds of training are mandated by BSEE regulations. In addition, companies may require additional training. Training is provided by the operators and service companies, using either internal or external resources.

Each shift usually begins with a handover meeting from one crew to another (day to night and vice versa) that includes a toolbox safety meeting—a group discussion that focuses on a particular safety issue and is geared specifically to the workers who will undertake a specific task. In addition, supervisors may hold meetings, or members of a skill group (mechanics, welders, etc.) may be assembled to discuss work. After these meetings, employees pursue their individual work activities with varying amounts of supervision and autonomy. In some situations, employees are virtually on their own and are expected to do their jobs with minimal guidance from managers. In other situations, supervisors are present and direct the work.

Fatal and Nonfatal Injuries

The nature of the work and the conditions under which work is performed in the OCS result in a substantial number of accidents that are sometimes accompanied by injuries and/or deaths. According to the BSEE annual report of 2014, a total of 43 deaths occurred in the OCS (Gulf of Mexico and Pacific OCS combined) between 2007 and 2014, with 2010 having seen the largest number of deaths (12 total, 11 resulting from to the *Deepwater Horizon* accident) and 2014 having seen the fewest (only 1 fatality). For this time period, the leading causes of fatalities offshore were explosions/fires (44 percent), lifting (16 percent), helicopter accidents (12 percent), and diving (9 percent). The other causes were falls (during construction), personnel transfer, man falling overboard, electrocution, and accidents involving support vessel-anchor (see Figure 1-1).

In terms of nonfatal injuries, the average number per year in the OCS (Gulf of Mexico and Pacific OCS combined) was 303 between 2007 and 2014 (BSEE 2014). Investigations of injuries reported in 2013 and 2014 revealed that 39 percent were due to human engineering problems (issues related to the human-machine interface, poor working environments, system complexity, and non-fault-tolerant systems), and 32 percent were caused by problems in work direction (related to planning, site preparation, selection of workers, and supervision for a specific job or task). The BSEE annual report of 2014 does not indicate the causes of 29 percent of the nonfatal injuries that occurred offshore in 2013-2014.

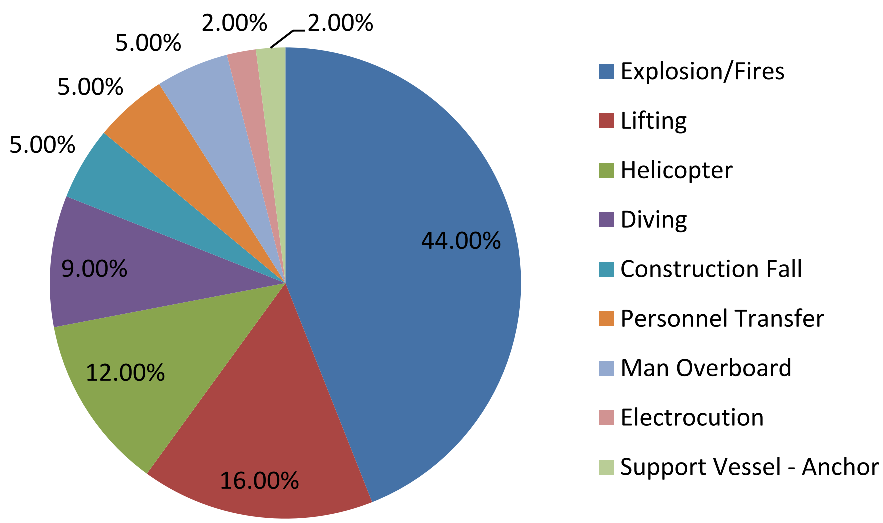

FIGURE 1-1 Causes of fatalities in the Outer Continental Shelf, 2007 to 2014.
SOURCE: Adapted from BSEE (2014).

In terms of nonfatal injuries, the average number per year in the OCS (Gulf of Mexico and Pacific OCS combined) was 303 between 2007 and 2014 (BSEE 2014). Investigations of injuries reported in 2013 and 2014 revealed that 39 percent were due to human engineering problems (issues related to the human-machine interface, poor working environments, system complexity, and non-fault-tolerant systems), and 32 percent were caused by problems in work direction (related to planning, site preparation, selection of workers, and supervision for a specific job or task). The BSEE annual report of 2014 does not indicate the causes of 29 percent of the nonfatal injuries that occurred offshore in 2013-2014.

Low-Frequency, High-Consequence Events and Their Causes and Impacts

The infrequent accidents that can cause massive oil spills and environmental damage (i.e., low-probability, high-consequence events) receive the most public attention and become the subject of investigation and analysis. The scale and consequence of such events worldwide is illustrated by four major accidents: the Santa Barbara oil spill of 1969, the *Piper Alpha* explosion in the North Sea in 1988, the Montara blowout/fire and oil spill in the Timor Sea in 2009, and the Macondo blowout/*Deepwater Horizon* fire and oil spill in 2010 (summarized in Table 1-1):

- The Santa Barbara oil spill of 1969 was the largest oil spill in history in U.S. waters at that time and today ranks third in the amount of oil spilled, after the *Deepwater Horizon* and *Exxon Valdez*[2] spills (Clarke and Hemphill 2002). The investigation into the Santa Barbara accident indicated that the spill occurred as a result of a blowout caused by immense pressure in

[2] The *Exxon Valdez* oil spill occurred when the tanker ran aground on Bligh Reef in Prince William Sound, Alaska on March 1989, spilling more than 11 million gallons of crude oil.

the well and a large volume of oil and gas being released simultaneously (Clarke and Hemphill 2002).

- The *Piper Alpha* accident in 1998 caused more fatalities than any incident in the history of offshore oil and gas operations and was considered the costliest man-made disaster at that time (Lloyd's n. d.). In November 1988, Britain's Lord Cullen conducted a formal inquiry into the *Piper Alpha* accident for the British government. In his report, he identified two factors that contributed to the severity of the accident: human error and flaws in the design of the oil production platform (Cullen 1990).
- The Montara oil spill of 2009 occurred after a blowout and fire on the Montara wellhead platform, located in a remote area of the Timor Sea; 69 workers were evacuated from the rig.[3] The formal inquiry conducted by the Australian government found that the immediate cause of the Montara blowout was failure of the cementing job done by Halliburton. The inquiry also found, however, that the company's systems and processes were deficient, many of the workers were not capable of performing their jobs, and the regulatory regime was inadequate.
- The *Deepwater Horizon* blowout and spill in 2010, which caused the worst oil pollution disaster to date in U.S. history, was investigated by the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling (National Commission), appointed by President Obama shortly after the accident occurred. The commission identified the cause of the blowout as a series of mistakes made by the owner (BP), the operator (Transocean), and the contractor that performed the cementing job (Halliburton)—mistakes viewed as indicative of systematic failures in risk management that call into question the safety culture of the offshore oil and gas industry (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011).

Although these four major accidents in the global oil and gas industry in the last 50 years had different specific causes, they highlight the lack of an effective safety system for ensuring that equipment is working properly and that workers are aware of safety risks and will take corrective action as needed.

The committee chose these four accidents to illustrate the severity of loss and damage that offshore accidents can cause. Other major accidents (e.g., the fire on platform C at Main Pass 41 and the blowout and fire at Bay Marchand, both occurring in 1970) have not been as catastrophic as these four. In combination with the Santa Barbara oil spill, however, they led to changes in regulations and in the way the industry regarded safety and in the environment (Arnold 2015). In 2011, the National Commission reached the following conclusion:

> Most, if not all, of the failures at Macondo can be traced back to underlying failures of management and communication. Better management of decision-making processes within BP and other companies, better communication within and between BP and its contractors, and effective training of key engineering and rig personnel would have prevented the Macondo incident. BP and other operators must have effective systems in place for integrating the various corporate cultures, internal procedures, and decision making protocols of the many different contractors involved in a deepwater well.

[3] http://www.theoildrum.com/node/7193. Accessed September 4, 2015.

TABLE 1-1 Four Major Offshore Accidents and Their Impacts

Date/Name/Location	Casualties/Injuries, Environmental Impacts, and Claims of Illness by Emergency Responders and Cleanup Workers	Cost
January 29, 1969 Santa Barbara/ Union Oil Company platform 21A located 6 miles off the coast of Summerland	Human casualties: none Oil spilled: 80,000 barrels total[a] Environmental effects: 800 square miles of ocean affected; 35 miles of coastline coated with oil up to 6 inches thick (Friends of California Archives 2014) Nearly 3,700 birds confirmed dead (NOAA 2014) A large number of seals and dolphins removed from the shoreline; spilled oil killed fish and intertidal invertebrates, damaged kelp forests, and displaced populations of endangered birds (Friends of California Archives 2014)	Cleanup costs exceeded $4.5 million in 1969 dollars (Friends of California Archives 2014) $6.5 million awarded to owners of beachfront homes, apartments, hotels, and motels (County of Santa Barbara Planning and Development Energy Division n.d.) $1.3 million awarded to commercial and recreational boat owners and nautical suppliers for property damage and loss of revenue (County of Santa Barbara Planning and Development Energy Division n.d.) $9.5 million paid by Union Oil to the state of California, the county of Santa Barbara, and the cities of Santa Barbara and Carpinteria for loss of property (County of Santa Barbara Planning and Development Energy Division n.d.)
July 6, 1988 *Piper Alpha* offshore drilling platform operated by Occidental Petroleum in the U.K. North Sea	Human casualties: 167 fatalities among men aboard the platform; 2 fatalities among men on a rescue ship	Total insured loss: $3.4 billion (Center of Risk for Health Care Research and Practice n.d.)
August 21, 2009 Montara platform/ West Atlas rig operated by PTTEPAA Australia in the Timor Sea	Human casualties: none Oil spilled: 30,000 barrels total[b]	$170 million spent on oil and gas leak until November 3 (Sonti 2009)
April 20, 2010 Macondo/*Deepwater Horizon* platform operated by BP in the Gulf of Mexico	Human casualties: 11 fatalities; 17 injured Oil spilled: 3.19 million barrels (Schwartz 2015) Environmental effects: 650 miles of coastline oiled in Louisiana, 174 miles in Florida, 159 miles in Mississippi, and 90 miles in Alabama (Reuters 2012) More than 8,000 birds, sea turtles, and marine mammals found injured or dead in the 6 months after the spill; Long-term damage caused by the oil and the nearly 2 million gallons (7.6 million liters) of chemical dispersants used on the spill may not be known for years (National Wildlife Federation n.d.):	Cost to BP (Reuters, 2012):$13.9 billion (individual liability); $14 billion (operational response); $4.5 to 17.6 billion (civil penalties); $5 to $15 billion (criminal penalties);$5 billion (environmental damage) Estimated economic impact on U.S. Gulf fisheries (over 7 years) (Sumaila et al. 2012): $8.7 billion; Loss of about 22,000 jobs in fisheries-related sectors

[a] http://www.bsee.gov/BSEE-Newsroom/Offshore-Stats-and-Facts/Pacific-Region/Pacific-Facts-and-Figures/#How_much_oil_is_spilled_or__leaked__from_OCS. Accessed September 4, 2015.
[b] http://www.theoildrum.com/node/7193.

THE IMPORTANCE OF SAFETY CULTURE

Reports produced by National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (2011), the National Academy of Engineering and National Research Council (2011), and the U.S. Coast Guard (n.d.) and the Bureau of Ocean Energy Management, Regulation and Enforcement (2011) Joint Investigation Team all emphasize that compliance with government regulations alone is insufficient to create and maintain a safe working environment offshore and that a fundamental transformation of the offshore oil and gas industry's safety culture is needed to reduce the risk of offshore accidents. Yet while the importance of establishing a safe working environment is widely acknowledged, strengthening offshore safety culture and reducing incidents across the industry needs to be a continuous improvement effort. In November 2012, an explosion and fire on an oil platform owned by Black Elk Energy Offshore Operations LLC killed three workers. While the third-party investigation of this accident, funded by Black Elk, focused blame on the contractor's pipe-welding operation,[4] a federal investigation found that Black Elk had failed "to establish an effective safety culture and communicate risks and precautions to its contractor."[5]

Because of the U.S. demand for energy, substantial oil and gas exploration and production operations are likely to continue offshore despite the current downturn in crude oil prices. Thus, the safety of workers and avoidance of major catastrophes will remain significant concerns of the industry, its regulators, and the public until a vision for creating and sustaining a safer working environment is developed, executed, and shared by all parties.

ORGANIZATION OF THE REPORT

This report consists of six chapters. Chapter 2 defines safety culture, explains why such a culture is difficult to achieve, and identifies its essential elements. Chapter 3 details the history of developments and safety efforts in the offshore oil and gas industry. Chapter 4 describes safety regulations and safety management and safety culture initiatives both domestically and abroad, and suggests what is needed to advance safety culture. Chapter 5 focuses on assessment and measurement of safety culture. Finally Chapter 6 examines how change in offshore safety culture can be implemented. The committee's findings, conclusions, and recommendations are presented at the end of Chapters 2–6. Knowledge gaps and research needs are identified in Chapters 2, 5, and 6.

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Abbreviations

BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
BSEE	Bureau of Safety and Environmental Enforcement
DOI	U.S. Department of the Interior

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[4] http://fuelfix.com/blog/2013/08/21/black-elk-commissioned-investigation-blames-contractors-for-fatal-platform-explosion/?cmpid=eefl#8547101=0. Accessed January 27, 2016.
[5] http://fuelfix.com/blog/2013/11/04/feds-blame-poor-decisions-and-communication-for-lethal-blast/#8547101=0. Accessed January 27, 2016.

GAO	U.S. Government Accountability Office
NAE	National Academy of Engineering
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
TRB	Transportation Research Board
USCG	U. S. Coast Guard

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Safety Culture

Safety culture has become an increasing focus of conversation and research since the late 1980s particularly after a series of organizational disasters including the U.S. Space Shuttle *Columbia* explosion in 2003, the Fukushima Daiichi nuclear plant meltdown in Japan in 2011[1], and the South Korean *Sewol Ferry* capsizing in 2014. The term *safety culture* is often invoked in the offshore oil and gas industry as well, having been used to explain disasters from the *Piper Alpha* accident (1988) to the *Deepwater Horizon* blowout and spill (2010) (see Chapter 1). Investigations into these disasters frequently have identified their cause as a culture that insufficiently prioritized safe and reliable performance relative to other objectives, such as efficiency or shareholder value (e.g., Cullen 1990; CAIB 2003; BP U.S. Refineries Independent Safety Review Panel 2007; CSB 2007; Montara Commission of Inquiry 2010; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011). Independent investigations of both the BP Texas City onshore refinery and BP *Deepwater Horizon* catastrophes found that the safety culture in each instance was deficient—a deficiency that led to the tragic loss of life and, in the case of *Deepwater Horizon*, nearly led to the economic collapse of one of the world's largest corporations (BP). This focus on safety culture appears to be increasing. In 2009, it was estimated that the number of papers referencing safety culture had increased to more than 2,250 (Silbey 2009, 341).

DEFINITION OF SAFETY CULTURE

To understand safety culture, one must have a working understanding of organizational culture. Organizational culture is typically thought to consist of artifacts (e.g., surface aspects that are easy to discern, such as dress), espoused beliefs and values, and basic underlying assumptions (i.e., unconscious, taken-for-granted beliefs and values) that are learned by a group as it solves its problems of external adaptation and internal integration (Schein 2004). Values consist of what members believe is important in their organization—for example, whether production is more important than safety. Norms are the behaviors expected by people who are important to one and one's work (Mearns and Flin 1999). For example, the offshore oil and gas industry in the Western world is often characterized as having organizational cultures that are male-oriented, macho, rough and tough, and "can do" (Wright 1994).

Organizational culture is not static, but is a dynamic characteristic of the organization as enacted among people and between people and organizational systems. In other words, it is a dynamic phenomenon that surrounds members of the organization at all times and is constantly enacted through their interactions with each other and shaped by leaders' behavior and organizational structures, routines, rules, and norms (Schein 2010; Blazsin and Guldenmund 2015). The dynamic cycle of culture enactment and refinement consists of experimentation, interaction (and the development of shared understandings), institutionalization (translation into

[1] Both the nuclear power utility and its regulator had deficient safety cultures (NRC 2014, 238.)

norms and behaviors), and internalization (transformation into basic assumptions) (Berger and Luckmann 1966).

Organizational culture is not unitary, but differs systematically across subgroups (Schein 2010). For example, professions (e.g., engineering) and subunits (e.g., a specific organizational department) often evince distinctive cultures. Similarly, subcultures exist within hierarchical levels of an organization, meaning that senior executives, middle managers, engineers, and front-line workers may have distinctive cultures, including their views regarding safety (Schein 1996). Research consistently finds that senior executives tend to view an organization's safety culture as stronger relative to the perceptions of middle managers and front-line employees (Sexton et al. 2000; Singer et al. 2009). The enacted, multifaceted, and pervasive nature of organizational culture means it is something an organization *is* and is challenging to change deliberately, rather than something an organization *has* that can be changed directly and readily (Schein 2010).

Organizational culture reflects the shared, tacit assumptions that have come to be taken for granted and that determine members' daily behavior. The subset of assumptions about safety in an organization can be loosely labeled safety culture (Schein 2010), encompassing the organization's values, beliefs, attitudes, social norms, rules, practices, competencies, and behaviors regarding safety (Mearns and Flin 1999). In other words, safety culture can be characterized as the actions taken and decisions made when no one is watching. More formally, Uttal (1983, 66) defines safety culture as "shared values (*what is important*) and beliefs (*how things work*) that interact with an organization's structures and control systems to produce behavioral norms (*the way we do things around here*)." Silbey (2009, 343) notes that in engineering and management scholarship, safety culture is referred to as "a set of stable, commonly shared practices in which all members of an organization learn from errors to minimize risk and maximize safety when performing organizational tasks." The U.K. Health and Safety Commission (HSC 1993, 23) defines safety culture as "the product of individual and group values, attitudes, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety programs." The U.S. Nuclear Regulatory Commission defines safety culture as "the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure protection of people and the environment" (NRC Final Safety Culture Policy Statement 76 FR 34773, June 14, 2011). Finally, the Bureau of Safety and Environmental Enforcement (BSEE) defines safety culture as "the core values and behaviors of all members of an organization that reflect a commitment to conduct business in a manner that protects people and the environment" (BSEE Final Safety Culture Policy Statement 78 FR 27419, May 10, 2013).

Across the above definitions, safety culture reflects the extent to which an organization's culture understands and accepts that safety comes first, with a majority of organizational members directing their attention and efforts toward its improvement (Vogus et al. 2010). A primary, albeit often implicit, assumption is that the workforce's choice between being efficient (i.e., productive) and being thorough (i.e., safe and reliable) and its more general attitudes and behavior toward safety are a function of the organization's prevailing safety culture (Guldenmund 2000). Supporting this assumption is consistent evidence from multiple meta-analyses indicating that safety culture consistently influences safety-related behaviors (increasing compliance with safety rules and participation in safety efforts), as well as personal and process safety (reducing accidents and injuries) (Clarke 2006; Christian et al. 2009; Beus et al. 2010). Recent research in the offshore oil and gas industry likewise has found safety culture (particularly staff attitudes and perceptions regarding safety) to be associated with fewer hydrocarbon leaks (Vinnem et al. 2010; Kongsvik et al. 2011).

Safety culture is an ongoing accomplishment; it requires sustained effort and continuous adaptation throughout the entire organization (Vogus et al. 2010). Consequently, an organization's safety culture, like its broader organizational culture, is a function of changes to which the organization has adapted over time (e.g., changes in leadership, government regulation, competitor actions, mergers and acquisitions, reorganizations) and is reflected in its structure (Schein 2004). This view of safety culture belies the popular belief that "a safety culture can only be achieved through some awesome transformation," such as a catastrophic organizational accident (Reason 1997, 192). Instead, changes in response to catastrophe are often short-lived because a safety culture "emerges gradually from the persistent and successful application of practical and down-to-earth measures" (Reason 1997, 192). In other words, strengthening safety culture (i.e., placing priority on safety relative to other goals) results from careful practice, leadership attention, and sustained effort. Others have cautioned that bottom-up behavioral change programs instituted to improve safety culture (see DeJoy 2005) should not shift the responsibility for safety from management to workers, nor should behavioral change be used as a less costly substitute for top-down investments in improvements that would make facilities and operations safe (Baram and Schoebel 2007; Silbey 2009).

The panel[2] that investigated the BP Texas City disaster provides yet another view. According to this view, an organization's culture is enacted and refined through actions taken by all members of the organization, but top management is especially critical (CSB 2007) because "no matter what regulatory system is used, safe operations ultimately depend on the commitment to systems safety by the people involved at all levels within the organization" (NAE and NRC 2011, 116). Top management creates the context and sets the tone for that commitment.

Amalberti (2013) argues that the specific forms of safety culture vary and that industries differ in the vision of safety culture they espouse. He describes a "resilient" model that handles high levels of risk with individual autonomy and expertise (e.g., seafishing skippers, the early airline industry). The "HRO[3]" model (e.g., firefighting, the merchant marine, oil exploration, and chemical manufacturing) blends resilient action with more formal role structures designed to ensure constant attention to risks, flexible detection of and recovery from problems, and regular collective learning and improvement. Finally, the "ultra-safe systems" model (e.g., commercial airline and nuclear power industries) relies on prevention through design (e.g., procedures and standards for normal and abnormal conditions) and training to avoid exposing operators to exceptional risks.

It is also important to note what safety culture is not. The term is often confounded with compliance and rule following, but a strong safety culture entails organizational members viewing safety as intrinsically important. Specifically in the oil and gas industry (Antonsen et al. 2012), a rule- and standardization-focused approach can be inimical to a strong safety culture and organizational capabilities for handling and resolving crises. Rules also can contribute to misleading mind-sets of invulnerability (Wicks 2001), acting as "mock bureaucracies" (Hynes and Prasad 1997) that are neither respected nor enforced (Gherardi 2006, 183). Moreover, an emphasis on rule following can hinder the engagement of those most practiced at recognizing risks and anomalies in operational processes—the front-line people who are most closely associated with complex technical systems and are aware of their inherent risks (Vaughan 1996,

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[2] Also referred to as the Baker Panel or the BP U.S. Refineries Independent Safety Review Panel.
[3] High-reliability organization.

228). Instead, safety culture is characterized by managers and people on the front lines making the right choice every time, even when environmental conditions are difficult, when time constraints are tight, and when no one is looking. In other words, safety culture is not built or sustained solely through such formal means as punishment of individuals for incidents of noncompliance and rewards for compliance, public declarations by the chief executive officer and human resources department, or perfunctory discussions of safety in formal notices or safety minutes. Safety culture is something leadership must fully embrace and the entire organization must commit to, engage in, and execute every day.

As noted earlier, safety culture is characterized by subcultures for different groups (e.g., departments, professions). In gas distribution, for example, Blazsin and Guldenmund (2015) found that distinctive subgroups of employees—field workers, front-line supervisors, and network supervisors—experience the organizational safety culture differently and manage the ambiguity of safety policy and the uncertainty of work situations in their own ways. Mearns and colleagues (1998) similarly found considerable variation in safety subcultures among U.K. offshore workers, depending on their age, occupation, seniority, shift, and prior accident experience. Subcultures are likely to be especially prevalent on offshore oil rigs given the array of contractors typically working the rig. That is, the culture of an oil rig is more likely to be a function of the varied contractors and specific workers than of the multinational oil company that commissioned the drilling. Thus, even more so than in the typical organization, the number of subcultures offshore makes change especially difficult. Chapter 6 further identifies the barriers to cultural change and practices, as well as processes for overcoming them to build and strengthen an organization’s safety culture.

As with all the definitions of safety culture given above, as well as the characteristics of strong safety cultures outlined below, the committee’s concept of safety culture encompasses both the personal safety of workers and process safety, as well as the prevention of harmful events and resilient responses to accidents and emergencies (Amalberti, 2013).

Finally, it is important to distinguish between safety culture and safety climate. Organizational culture is often contrasted with organizational climate, with the latter typically seen as being expressed in specific and identifiable practices such that it captures “surface features” of organizational culture (Denison 1996; Flin et al. 2006). Similarly, safety climate is the shared perception among members of an organization of the priority of acting safely based on shared assessments of the behaviors expected, rewarded, and supported by the organization and its supervisors and managers (Zohar 2003). Safety climate also is a snapshot of the workforce’s current perceptions regarding the perceived status of safety in the organization (Mearns and Flin 1999). Members of the organization draw inferences about safety climate based on the pattern of managerial actions in choosing between competing priorities (i.e., production and safety) because these actions indicate the differences between formally declared and enforced policy and practice (Zohar 2003, 2010). Irrespective of formal policy, for example, whenever safety issues are ignored or made contingent on production pressures, workers will infer low safety priority and a weak safety climate (Zohar 2008; see Wright 1994, for an example from the offshore oil and gas industry). Thus, the safety climate of an organization sends signals regarding the underlying assumptions and values animating its safety culture.

WHY A STRONG SAFETY CULTURE IS DIFFICULT TO ACHIEVE

Safety culture is elusive both conceptually and empirically because safety itself presents many distinct challenges for organizations. First, safety demands seeing what is not there—an accident in the making (Perin 2005). In this way, it is an "ever-receding chimera, observable only when it ceases to exist" (Silbey 2009, 358). This makes a strong safety culture difficult to manage and sustain because people have difficulty knowing the mistakes they did not make but could have, which means they have a limited sense of the actual level of safety and what produces it.

Safety also is difficult to sustain because feedback on system safety is often discontinuous and indirect (March et al. 1991). It is discontinuous because recorded accidents, incidents, and even near misses are relatively rare events, and indirect because these data reflect a system only at a particular moment in time without necessarily indicating its intrinsic resistance to operational hazards (Reason et al. 1998). As a result, safe performance relies on making the unthinkable thinkable, the invisible apparent, such that accidents in the making can be detected more readily (Perin 2005), and producing a "dynamic nonevent" through patterns of practice that entail continual small adjustments (Weick 1987).

As noted, an organization's primary goals (e.g., production) compete or may be perceived as competing with safety (Carroll and Rudolph 2006). In this dynamic, production is seen as an acute problem that needs to be addressed immediately, and safety as a more chronic concern (Woods 2005). With a chronic as opposed to an acute concern, it is easier for complacency to set in and for resources to be diverted to more pressing matters. In fact, the failure to assess risk holistically and take mitigation measures has been implicated in the Macondo well incident (NAE and NRC 2011). Moreover, safety often is encouraged by "outsiders" (e.g., regulators, citizens' groups, media) or safety specialists, who may be seen as interfering with (and not understanding) the organization's legitimate service and production work (Carroll and Rudolph 2006; Dekker 2014). Thus, both research and theory suggest that institutionalizing safety as a priority and value is both elusive and uniquely challenging.

In practical terms, organizations often wrestle with the inevitable (at least in the short term) tension between safety and production goals. This conflict frequently results in heuristics—such as "ALARP" (keeping risks as low as reasonably practicable) and "ASSIB" (and still stay in business)—that amplify the challenge of strengthening safety culture. A strong safety culture, of necessity, accentuates technological and economic feasibility in promoting continuous improvement.

In recognition of these difficulties, organizations such as the Campbell Institute have attempted to create incentives designed to help rebalance some of the trade-offs between safety and production and to illustrate how organizations can balance strong safety culture with high economic performance. Specifically, the Robert W. Campbell Award[4] recognizes organizations that achieve business excellence through the integration of environmental, health, and safety management into their ongoing business operations. The characteristics of these organizations illustrate some of the traits of a strong safety culture: the entire organization (CEO to front-line workers) makes safety a priority relative to business performance, effective practices and processes for safety permeate the organization across geography and hierarchical levels, leading (maintenance, near misses) and lagging (incidents) indicators of safety performance are actively

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[4] The Robert W. Campbell Award is the most prestigious award in environmental, health and safety management worldwide.

measured, and training of and investment in employees to deliver safe performance are continuous.

As interest in safety culture has grown, the concept has been subjected to strong critique, often from researchers in political science and sociology. For example, Perrow (1984) argues that the pursuit of a safety culture in such industries as offshore oil and gas is quixotic, as absolute safety is impossible in complex systems that inevitably produce accidents, even though many operators may exhibit excellent safety records over a number of years. Others have argued that culture is not readily changed to pursue specific goals (e.g., reducing accidents and injuries [Silbey 2009]), a topic addressed directly in Chapter 6.

The next section identifies practices and processes that strengthen strong safety culture. The BSEE safety culture taxonomy is presented as the guiding framework for this report, and the research support for each of its nine factors is reviewed.

ELEMENTS OF A STRONG SAFETY CULTURE

Many reviews have focused on safety culture in particular industries in various countries, including oil and gas (NEB 2014), chemicals (AIChE 2005), health care (AHRQ and HHS 2004; The Health Foundation 2011), occupational safety (European Agency for Safety and Health at Work 2011), radiation (Reiman and Pletikainen 2010), energy (EFCOG/DOE 2009), and nuclear power (IAEA 2008; U.S. NRC 2011). The academic literature also contains many reviews of safety culture that summarize its recurring elements based on survey research.

For the offshore industry, Cox and Cheyne (2000) include measures of nine dimensions in their safety climate assessment toolkit. In the nuclear power industry, the Institute of Nuclear Power Operations (INPO 2013) and the U.S. Nuclear Regulatory Commission (U.S. NRC 2011) have standardized their concept of a strong safety culture to include ten "traits" of a healthy safety culture and an assessment process using a safety climate survey. INPO and U.S. NRC divide these traits into three categories: (1) management commitment to safety—leadership safety values and actions, decision making, and respectful work environment; (2) individual commitment to safety—personal accountability, questioning attitude, and effective safety communication; and (3) management systems—continuous learning, problem identification and resolution, environment for raising concerns, and work processes. In health care, The Health Foundation (2011) used survey data to identify eleven overlapping attributes of safety culture. And following the Columbia space shuttle accident, Behavioral Science Technology used a survey instrument previously developed with the National Aeronautics and Space Administration (NASA) (2005), that includes eleven organizational, team, and safety based dimensions.

In the academic literature, Flin and colleagues (2000) reviewed 18 safety climate scales and concluded that five dimensions emerge consistently: management priorities, safety policies and systems, risk attitudes, work pressure, and competence. Similarly, Christian and colleagues (2009) identify seven dimensions of safety culture. Reason (1997) outlines how a safety culture is a function of practices and processes that arise from the interaction of four subcultures or cultural features: reporting culture (an environment for raising concerns), just culture (people are treated with respect and fairness and not blamed for what is beyond their control), informed culture (appreciative of knowledge and expertise), and learning culture (that makes changes as needed). Westrum (2004) and Hudson (2007) describe a safety culture "ladder" with differing forms of culture that increase in complexity and ability to produce safe performance:

pathological (power oriented), reactive, bureaucratic or calculative (rule oriented), proactive, and generative (learning oriented). Research on high-reliability organizations (Roberts 1990; LaPorte and Consolini 1991; Weick and Sutcliffe 2007) focuses broadly on what differentiates organizations that operate successfully in high-hazard industries, but include a strong focus on cultural features such as preoccupation with failure, reluctance to simplify interpretations, sensitivity to operations, commitment to resilience, and deference to expertise.

The INPO/U.S. NRC taxonomy mirrors academic categorizations of the attributes of strong safety cultures as (1) enabling (leaders' actions to make safety a priority and make it safe to take interpersonal risks), (2) enacting (translating priorities into concrete actions and practices by front-line employees), and (3) elaborating (structured reflection on and refinement of organizational practices, processes, and behaviors) (Vogus et al. 2010; Singer and Vogus 2013). Enabling maps to management commitment to safety, enacting to individual commitment to safety, and elaborating to management systems.

The Bureau of Safety and Environmental Enforcement Taxonomy as Common Ground

Although, as reflected in the above overview, there is no formally agreed-upon approach to defining the elements of a strong safety culture, the committee believes the offshore industry needs to reach consensus on a workable, shared direction forward that can be modified following further research and practical experience. Indeed, looking across the various conceptualizations of safety culture, one can see common sets of practices and processes. Therefore, the committee chose to structure this discussion of the elements of a strong safety culture around those identified as essential by BSEE (summarized in Box 2-1). The BSEE taxonomy mirrors leading scholarly reviews of safety culture research and leading frameworks in other industries, is grounded in empirical research, is supported by a key regulator, and is useful for the offshore industry.

In developing its list of nine essential elements, BSEE relied heavily on the attributes of safety culture ("traits of a healthy safety culture") identified for the nuclear power industry (U.S. NRC 2011; INPO 2013; NRC 2014). The nuclear power industry itself had derived those attributes from the work of Reason (1997), Weick and Sutcliffe (2007), and others. In short, although there is no single definitive set of essential elements of safety culture, the various taxonomies that have been developed display a great deal of overlap and commonality.

Table 2-1 compares the leading conceptualizations of the practices and processes of a strong safety culture summarized above against the nine elements identified by BSEE (Box 2-1). In many cases, these other concepts overlap with and support the BSEE elements. Additional concepts that do not appear to fit within the BSEE framework are included in a final row of Table 2-1 as "other."

The elements identified by BSEE can also be categorized in accordance with the academic taxonomy outline above (Vogus et al. 2010; Singer and Vogus 2013) as factors enabling a safety culture/management commitment to safety (leadership commitment to safety values and actions, respectful work environment, environment for raising concerns, and effective environmental and safety communication); enacting a safety culture/individual commitment to

Box 2-1

Nine Essential Elements of a Strong Safety Culture Identified by the Bureau of Safety and Environmental Enforcement (BSEE)

The nine essential elements of a strong safety culture identified by BSEE are as follows:

- **Leadership commitment to safety values and actions—**Leaders demonstrate a commitment to safety and environmental stewardship in their decisions and behaviors. Leaders visibly demonstrate this commitment through how they allocate resources within the organization and prioritize safety relative to production.
- **Respectful work environment—**Trust and respect permeate the organization, with a focus on teamwork and collaboration.
- **Environment for raising concerns—**A work environment is maintained in which personnel feel free to raise safety and environmental concerns without fear of retaliation, intimidation, harassment, or discrimination.
- **Effective safety and environmental communication—**Communications maintain a focus on safety and environmental stewardship. Knowledge and experience are shared throughout the organization.
- **Personal accountability—**All individuals take personal responsibility for process and personal safety, as well as environmental stewardship.
- **Inquiring attitude—**Individuals avoid complacency and continuously consider and review existing conditions and activities in order to identify discrepancies that might result in error or inappropriate action. Workers are expected to question work practices as part of everyday conversations without hesitation.
- **Hazard identification and risk management—**Issues potentially impacting safety and environmental stewardship are promptly identified, fully evaluated, and promptly addressed or corrected commensurate with their significance.
- **Work processes—**The process of planning and controlling work activities is implemented in a manner that maintains so that safety and environmental stewardship are maintained while ensuring use of the correct equipment, used in the correct way, for the correct work.
- **Continuous improvement—**Opportunities to learn about ways to ensure safety and environmental stewardship are sought out and implemented.

SOURCE: BSEE, 2013.

TABLE 2-1 Comparison of Safety Culture Attributes

BSEE (See Box 2-1)	Institute of Nuclear Power Operations (INPO) (2013)/U.S. Nuclear Regulatory Commission (U.S. NRC) (2011)	Pipeline and Hazardous Materials Safety Administration (PHMSA) (2015)	Flin et al. (2000)	Christian et al. (2009)	Cox and Cheyne (2000)	The Health Foundation (2011)	Reason (1997)	Research on High-Reliability Organizations*
Leadership commitment to safety values and actions	Leadership committed to safety; decision making reflects safety first	Leadership committed to safety; safety has priority over other demands	Leadership committed to safety	Management commitment to safety	Leadership committed to safety; safety is a priority	Leadership committed to safety		
Respectful work environment	Trust permeates the organization	Mutual trust between employees and organization		Teamwork, human resource practices, supervisor support, and internal group processes (e.g., peer support for safety)	Frontline involvement in safety	Teamwork (e.g., people support each other), work environment (e.g., people speak up freely and receive feedback), organizational factors (e.g., management support)	Just culture	Deference to the expertise with the specific safety issue, not to formal authority
Environment for raising concerns		Organization is fair and consistent in responding to safety concerns		Internal group processes (e.g., peer support for safety)	Supportive environment for speaking up about safety	Speaking up	Reporting culture	Reluctance to simplify
Effective environmental and safety communication		Open communication across the organization			Communication	Communication and feedback	Informed culture	

Personal accountability	Everyone personally responsible for safety	Clearly defined accountability; employers feel personally responsible			Everyone involved in safety			Deference to the expertise with the specific safety issue, not to formal authority
Inquiring attitude	Questioning attitude cultivated						Reporting and informed culture	Preoccupation with failure (seeking potential threats to safety system)
Hazard identification and risk management	Technology recognized as complex and difficult to manage; safety undergoes constant examination		Risk attitude	Perceived job risk; safety attributes and behaviors	Risk appreciation	Risk perception	Informed culture	Preoccupation with failure (seeking potential threats to safety system)
Work processes	Safety undergoes constant examination	Safety training and resources available	Safety systems limit work pressures to trade off safety for productivity	Safety systems limit work pressures to trade off safety for productivity	Safety rules are followed and not sacrificed for productivity	Safety systems limit job demands to trade off safety for productivity		Sensitivity to operations
Continuous improvement	Organizational learning is embraced	Continuous learning					Learning culture	Commitment to resilience
Other		Safety training and resources available	Workforce competence					

*Includes Roberts (1990); LaPorte and Consolini (1991); Weick and Sutcliffe (2007).

safety (personal accountability and inquiring attitude); and elaborating a safety culture/management commitment to safety (hazard identification and risk management, work processes, and continuous improvement). It should also be noted that the nine elements of a strong safety culture identified by BSEE do not explicitly include the competence of the workforce that is noted in the "Other" row of Table 2-1. For example, the International Atomic Energy Agency (IAEA 2002) found that participants at one of its meetings considered the key elements of safety culture to be top management commitment to safety, sufficient competent staff, and open communication. Similarly, the INPO and U.S. NRC consider competence to be inherent in continuous learning (W. E. Carnes, Myrtle Beach, SC, personal communication, September, 2015). The American Petroleum Institute's Recommended Practice 1173 also explicitly states that "investment in building competency, like continuous learning, builds trust and confidence that management cares about safety, their employees and contractor personnel, and the public" (API 2014, 23). After deliberating, the committee decided not to expand BSEE's list of nine elements, but rather to emphasize that competence underlies all of these elements. Specific practices that help foster such competence are discussed in the section below on work processes.

Next we review research corresponding to each of the nine elements characteristic of a strong safety culture outlined above.

Research Evidence on BSEE's Nine Essential Elements of a Strong Safety Culture

Research on safety culture across industries supports each of the nine essential elements of a strong safety culture identified by BSEE.

Leadership Commitment to Safety Values and Actions

Research on safety culture in multiple industries has found that leaders and their actions play an especially crucial role through their commitment to safety values and actions, the practices they institute to foster a respectful work environment conducive to raising safety concerns, and their engagement in consistent safety communication. The value of such leadership is especially evident in high-hazard operations that face low-frequency, high-consequence events, such as the U.S. Navy's nuclear submarine fleet (Bierly and Spender 1995). More specifically, the intensity with which safety is pursued is a function of leaders' emphasizing safety through personal practices, such as safety rounding (Thomas et al. 2005); through their leadership style (Yun et al. 2005); through their incident command skills (Crichton et al. 2005); and through their commitment to safety and its priority relative to other goals (Zohar 2002). When employees observe a leader implementing and engaging in practices that make safety a priority, they are more likely to do so as well. As noted earlier, a safety culture is also dynamic, and it relies on well-developed processes of collective reflection and organizational learning to help institutionalize safer practices (Reason 1997). These leader and organizational practices inform action on the front lines that is characterized by high levels of personal accountability and inquiring attitudes focused on identifying hazards and managing their risks through action and changes to work processes. These practices also subject safety performance (both good and bad) to careful analysis and corrective action (i.e., continuous improvement). Stated differently, a safety culture is strengthened and sustained by leader and organizational practices that enable such a culture, by front-line enactments, and by elaboration through structured reflection and refinement (Vogus et al. 2010; Singer and Vogus 2013). We review this body of research next.

Leaders single out and draw attention to safety and make it possible for employees to apply this focus on safety to their everyday work. Evidence suggests that leaders enable safer practices on the front lines in at least two ways: first, by demonstrating commitment and attention to safety (e.g., through safety communication [Hofmann and Stetzer 1998; Katz-Navon et al. 2005]), and second, by creating respectful work environments that spur a willingness to raise concerns such that all workers feel safe in speaking up and act in ways that improve safety (as seen, for example, by Paul O'Neil's action to emphasize and reinforce safety at ALCOA [Duhigg 2012]).

In sum, the value leaders place on safety significantly influences how employees view its importance. Specifically, employees base their perceptions of safety culture, in part, on leaders' commitment to safety (e.g., through safety practices, procedures, and other investments in safety), the priority they place on safety relative to other goals, and their dissemination of safety information (Katz-Navon et al. 2005). For example, commitment to safety will be low when a supervisor disregards safety procedures whenever production falls behind schedule or punishes people for mistakes (Zohar 2000; Carroll and Quijada 2004). As noted earlier, however, aspects of safety are frequently in conflict with other goals that the organization rewards and supports (Zohar 1980). Thus, a safety culture and a safety climate rely on consistent managerial action, as evidenced by research in the offshore oil and gas industry (Kongsvik et al. 2011), as well as leading meta-analyses of safety culture (e.g., Clarke 2006; Beus et al. 2010).

Respectful Work Environment

Formal organizational practices can increase the attention paid to safety and instill a respectful work environment conducive to safety and the ability to raise safety concerns without fear of punitive action. A respectful work environment has been found to be especially necessary offshore, where the traditional "macho" culture can inhibit disclosure and learning (Ely and Meyerson 2010). Such practices as safety rounds or visits by leaders to front-line facilities (e.g., oil rigs) to discuss safety issues and concerns with operators can be especially valuable (Singer and Tucker 2014). These discussions are then documented and translated into action plans that are fed back to the front lines.

Safety rounds are intended to build and sustain good relations between organizational leaders and front-line workers, promote conversations to identify hazards, and gather information to enhance decision making regarding safety. Emerging evidence indicates that safety rounds do indeed strengthen safety culture by, for example, drawing attention to safety when managers visit the front lines. Two studies in health care settings found that safety rounds increased the perception that leaders viewed safety as a high priority, were committed to safety, and were responsive to safety issues identified by workers on the front lines (Thomas et al. 2005; Frankel et al. 2008). Direct observation of front-line work, coupled with safety forums, can further highlight and emphasize the priority of safety concerns (Tucker et al. 2008). Virginia Mason Medical Center, like leading organizations in other industries, such as ALCOA and DuPont (Duhigg 2012), conducts safety rounds during which leaders ask staff to describe specific events in the previous few days that resulted in harm, caused a near miss, or impaired their ability to do their work (Spear 2005). The leaders reinforce their commitment to the front-line workers and enhance a safety culture by creating a safety alert process that allows any employee to immediately halt any process likely to cause harm to a patient and that requires a "drop and run" commitment from more senior leaders (e.g., vice presidents) to respond immediately to these issues (Spear 2005).

Environment for Raising Concerns

Leaders shape safety culture by empowering employees to speak up and resolve threats to safety by correcting erroneous procedures or system flaws promptly. Research illustrates how leaders empower employees to raise concerns by creating psychological safety—the belief that it is safe to take interpersonal risks (Edmondson 1999). Leaders create psychological safety by changing the way in which mistakes are discussed—avoiding threatening terms such as "errors" and "investigations" in favor of more psychologically neutral terms such as "accidents" and "analysis" (Edmondson 2004). Leaders also create psychological safety by actively appreciating others' contributions (Nembhard and Edmondson 2006), soliciting their input, and pardoning employees who make and share unintentional mistakes (Edmondson 1996). Nembhard and Edmondson (2006) found that leaders' inclusiveness (i.e., soliciting the input of front-line employees) reduced status differences and was associated with higher levels of psychological safety, which in turn enabled greater engagement in improvement initiatives designed to remove hazards that threatened safety in neonatal intensive care units. Likewise, Tucker (2007) found that higher levels of psychological safety enabled front-line employees to suggest potential solutions for common work system failures to their managers and experiment systematically with those solutions. Empowerment and an effective environment for raising concerns also rely on adequate resources with which to act; when leaders provide front-line employees with such resources, safer outcomes result (Shortell et al. 1994). In short, an empowering leadership style allows employees to think, apply their knowledge (e.g., speak up), and learn by doing and can lead to both greater learning and safer performance (Yun et al. 2005; Ely and Meyerson 2010).

Effective Safety and Environmental Communication

When leaders personally commit to safety and make it a high priority, their actions lead to more open communication regarding safety issues and increase the likelihood of internal attributions for safety incidents so that future incidents can be avoided by making changes, thus creating the conditions for learning from error (Hofmann and Stetzer 1998). When leaders make safety a priority and safety information is actively and widely disseminated, employees are more likely to report errors (Naveh et al. 2006) and incidents (Weingart et al. 2004). In contrast, a poor safety climate (e.g., high performance pressure, failure to disseminate safety information) encourages employees to deviate from safety procedures and remain silent when others act unsafely (Hofmann and Stetzer 1996).

In other words, leaders aid the development of safety culture when they engage directly in safety-related interactions with subordinates by consistently communicating safety messages, disseminating safety information, and showing how a commitment to safety is practiced in daily functioning (Barling et al. 2002; Zohar 2002), as well as modeling an openness to learning (Ely and Meyerson 2010). When leaders direct attention to safety culture, front-line workers can understand more clearly the specifics of safer practice (Zohar 2000; Carroll and Quijada 2004). Consequently, these actions by leaders have been shown to increase safety motivation (i.e., willingness to exert effort), participation in voluntary safety activities (e.g., helping coworkers with safety-related issues), and reporting of errors by employees (Naveh et al. 2006; Neal and Griffin 2006).

Personal Accountability and Inquiring Attitude

Enactment of a safety culture depends on front-line employees' willingness to disclose errors and near misses and to otherwise communicate their ideas and concerns upward in the organization to improve work processes (Carroll and Edmondson 2002; Stern et al. 2008; Tangirala and Ramanujam 2008). Leaders foster an inquiring attitude to identify causes of safety problems, and encourage workers' personal commitment to and accountability for identifying hazards and improving work processes. Unfortunately, front-line employees often are reluctant to report errors, especially errors of commission (Henriksen and Dayton 2006), because they fear of reprisal (Edmondson 1996). For example, Blatt and colleagues (2006) found that medical residents spoke up in only 14 percent of cases of reliability lapses (i.e., errors). Of even greater concern, residents spoke up only 39 percent of the time when there was a known, specific opportunity to prevent patient harm (Blatt et al. 2006). These instances of employee silence directly affect work outcomes by reducing managerial access to critical work-related information. They often result from a fear of reprisal and other risks of speaking up (Edmondson 1996; Blatt et al. 2006; Tangirala and Ramanujam 2008) and from the fact that errors resulting from taking action often carry a heavier penalty relative to those resulting from inaction (Henriksen and Dayton 2006). In the offshore oil and gas industry, prior research has found these conditions to be especially common. Instead of raising concerns when conditions are unsafe, workers are expected by site managers to cut corners whenever production falls behind schedule, despite official claims to the contrary (Paté-Cornell 1990; Wright 1994), although there are some notable exceptions (e.g., Ely and Meyerson 2010).

By contrast, when the right conditions are present (e.g., leader commitment, an environment for raising concerns, a respectful work environment), speaking up and listening have an impact on safety and reflect a strong safety culture. First, speaking up helps improve safety and safety culture by revealing latent and manifest hazards and by making it possible to discuss, learn from, and collectively avoid the same errors in the future (Edmondson 1996). Naveh and colleagues (2006) also found that higher levels of error reporting were a key component of a well-developed safety culture. Second, Schulman (1993) found that promoting the orderly challenge of operating routines through regular meetings was a key feature of the highly reliable performance of a nuclear power plant (see Knox et al. 1999, for similar examples from health care). Third, speaking up provides a constructive foundation for the development of corrective action. Consistently speaking up and raising concerns in work units expands a repertoire of shared experiences regarding what does and does not work (Edmondson 2003). In military units, related improvements in relationships between supervisors and front-line staff also foster safety culture in the form of greater personal accountability as employees expand the definition of their safety role (i.e., viewing safety as part of, not an add-on to, their role [Hofmann et al. 2003]). Likewise, better relationships between supervisors and subordinates in manufacturing facilities enhance safety culture by producing open and constructive communication about safety and errors that allows employees to learn from incidents and increase their commitment to safety (Hofmann and Morgeson 1999). Such high-quality relationships also help sustain the chronic unease needed to maintain a strong safety culture and correspondingly safe performance (Flin and Fruhen 2015).

Hazard Identification and Risk Management

Management research shows that accurate hazard identification and risk management result from pooling diverse viewpoints such that participants can share what they know and learn through interaction (Weick and Westley 1996). Specifically, valuing stories and storytelling fosters disseminating and refreshing knowledge through interaction so that all participants know more about the risks they face and the errors that may result, and realize that they and their peers have the ability to handle those errors that do occur because others have previously handled similar errors (Weick 1987). In other words, storytelling creates a coherent structure through which gaps and inconsistencies that pose threats to the system can be readily detected (Weick and Browning 1986). Additional tools, such as root-cause/first-cause analysis teams, incident reviews, and other forms of self-analysis, are evident in industries such as nuclear power and chemical processing as means of providing deeper understanding of organizational systems that reveal leverage points, suggest new interventions, and strengthen safety culture and safety performance (Carroll 1998). The absence of such practices and processes for systematically and holistically assessing risk and managing the identified hazards has been associated with disasters in the offshore oil and gas industry such as the *Deepwater Horizon* incident (NAE and NRC 2011).

Actions taken in an attempt to resolve threats often consist of individual workarounds that allow work to continue despite poor work systems (Tucker and Edmondson 2003; Tucker 2004). But truly resolving threats requires mobilizing the resources needed to address their underlying causes (Tucker and Edmondson 2003; Faraj and Xiao 2006). Patching of ineffective work systems occurs offshore and is, in part, a function of not paying sufficient attention to early indicators of larger problems (e.g., blowouts [Skogdalen et al. 2011]). When leaders commit to making safety a priority and integrating it into the organization’s daily functioning (as described above), front-line employees are able to prevent, solve, and learn collectively from problems and reduce the incidence of errors and other safety issues (Singer et al. 2009). Effective problem solving also relies on a combination of preventive actions that avoid problems and adaptive actions that redress problems. Problem solving behaviors (e.g., seeking feedback, using a structured problem-solving process) have been shown to lead to the successful adoption of new practices that improve safety and prevent future errors across industries (MacDuffie 1997; Tucker et al. 2007). In the face of nonroutine problems in aviation and in nuclear power control rooms, for example, quickly prioritizing and shifting tasks among team members to balance demands leads to better and safer performance (Waller 1999; Waller et al. 2004). Faraj and Xiao (2006) found that quickly engaging in practices of dialogic coordination by diagnosing a condition and calling on experts to determine reasonable approaches and relevant factors being missed resulted in more effective and safer outcomes. In other words, all forms of resources need to be made available and usable (i.e., sanctioned and supported by leadership).

Mindful organizing, a set of behaviors observed in high-reliability organizations (e.g., aircraft carrier flight decks [Rochlin et al. 1987]; air traffic control [LaPorte and Consolini 1991]; and nuclear power control rooms [Schulman 1993]), represents an inquiring attitude focused on hazard identification, risk management, and personal accountability. Mindful organizing is a process by which front-line employees come to understand the situation they face and their collective capabilities for managing it (Weick et al. 1999; Weick and Sutcliffe 2006, 2007). Mindful organizing consists of five interrelated organizational processes: preoccupation with failure, reluctance to simplify interpretations, sensitivity to operations, commitment to resilience, and deference to expertise (Weick et al. 1999). Preoccupation with failure is chronic wariness that drives analysis of possible vulnerabilities and treats any failure or near miss as an indicator of potentially larger problems (LaPorte and Consolini 1991; Weick and Sutcliffe 2007; Flin and Fruhen 2015). Reluctance to simplify interpretations means actively questioning received wisdom and seeking differing opinions and viewpoints to better uncover blind spots and avoid complacency (Schulman 1993; Fiol and O'Connor 2003; Weick and Sutcliffe 2007). Sensitivity to operations denotes creating and maintaining a current, integrated understanding of operations and where expertise resides (Weick et al. 1999). Commitment to resilience involves growing employee and organizational capabilities to adapt, improvise, and learn in order to better recover from unexpected events (van Dyck et al. 2005). Finally, deference to expertise occurs when decisions migrate to the people with the greatest expertise in handling the problem at hand, regardless of formal rank (Roberts et al. 1994).

Research suggests that interacting in ways that are more mindful contributes to strengthening safety culture (Vogus et al. 2010; Singer and Vogus 2013). In addition to the above-cited studies of aircraft carriers and nuclear power control rooms supporting the components of mindful organizing, a multiyear qualitative study of a pediatric intensive care unit (Roberts et al. 2005; Madsen et al. 2006) found that introducing practices that embraced mindful organizing (and the enactment of safety culture) led to earlier detection of potential threats to safety. Staff regularly discussed what they might be missing that would jeopardize safety (preoccupation with failure). Regular in-service training helped employees better understand their work and more readily question their assumptions and hypotheses (reluctance to simplify). Collaborative rounding by the entire care team helped create a shared understanding of potential threats to safety throughout the unit (sensitivity to operations). Frequent and inclusive postevent debriefings illustrated new and varied ways for participants to respond to and recover from unexpected events (commitment to resilience). Finally, the person with the most experience and expertise in a specific domain (e.g., a patient) made the final decision about the course of action (deference to expertise). Together these ongoing enactments of mindful organizing were associated with improved safety performance (Roberts et al. 2005; Madsen et al. 2006). Similarly Vogus and Sutcliffe (2007) found that higher levels of mindful organizing in hospital nursing units were associated with safer performance (i.e., fewer errors) over time. These practices also have been noted in a fire incident command system (Bigley and Roberts 2001) and wildland firefighting (Weick and Sutcliffe 2007), and their absence has contributed to failures of platform supply vessels (Sandhåland et al. 2015).

Work Processes

Assuring that work activities are planned and managed with safety as a priority and carried out by competent, skilled people in an effective way is essential to strengthening safety culture. Work processes are both important to a stronger safety culture and organizationally challenging because they often entail significant resource commitments (e.g., equipment, training). Consequently, they serve as an important sign of leaders' and the organization's tangible commitment to safety (Zohar 1980; Katz-Navon et al. 2005) and enhance organizational (and employee) capabilities. A willingness to invest in equipment, training, and otherwise sound work processes also reflects management that is focused on avoiding future problems such as lost-time injuries, mechanical breakdowns due to equipment failure, and other errors. A longer-term view of performance allows for these investments to enhance productivity rather than merely create costs.

Building the knowledge, skills, and abilities of the workforce has been shown to foster safety culture and safety performance. Leaders need to know that their workforce possesses the ability to do the work and do it safely (i.e., without injury to themselves or harm to the organization). Investments in training and related organizational practices influence perceptions of safety culture and personal safety outcomes (Zacharatos et al. 2005). Training, especially continuous training that simulates a range of possible scenarios, including low-frequency, high-consequence events, has long been a part of nearly error-free high-reliability organizations (Rochlin et al. 1987; LaPorte and Consolini 1991). Selection and training for interpersonal skills paired with empowerment of front-line employees has been shown to enhance the quality of workplace interactions, mindful organizing, and safety (Vogus and Iacobucci In Press). In other words, high-reliability organizations build the capacity to recognize and respond swiftly to potential hazards (Weick et al. 1999). Also important is demonstrating a commitment to safety by designing in adequate time for safety briefings, stop-work orders, and audits (e.g., Pisano et al. 2001). Assurances that contractors operating at a facility are doing the same further strengthens the safety culture.

Work processes that contribute to an effective safety culture also reflect operational discipline. For example, a hallmark of high-reliability organizations is that they combine a disciplined set of cognitive processes (described above as mindful organizing [e.g., Weick et al. 1999]) with carefully designed and executed work processes. In other words, they are rigorously disciplined at following established process steps.

Continuous Improvement

Continuous improvement entails a sustained effort to pinpoint subtle details and uncover capabilities that have gone unrecognized and develop these revealed capabilities in the pursuit of safer performance. Management research has identified practices for instilling a continuous improvement orientation through structured learning practices such as after event reviews (AERs). AERs are collective guided discussions of past experience that direct learners to understand the specific causes of their failures and successes and thereby derive performance-enhancing lessons (Popper and Lipshitz 1998; Ellis et al. 2006). In other words, when people engage in AERs, they elaborate experiential data, taking special note of unexpected failure, disruption, or significant differences between expectations and reality (Ellis and Davidi 2005). AERs have been studied extensively in military settings, such as the Israeli Defense Force Air Force. There is evidence of the value of structured learning and AER-like activities in other high-hazard industries, including offshore oil and gas production and air traffic control (Ely and Meyerson 2010; Mearns et al. 2013). AERs are most informative when they occur immediately after the event and include all who took part in the operation. Their structured format guides participants in jointly constructing a comprehensive representation that integrates their individual interpretations (Ron et al. 2006). Elaborating is most fruitful when feedback is exchanged without defensiveness and when the review is continued until a shared understanding has been achieved (Popper and Lipshitz 1998; Ron et al. 2006).

Recent research has indicated that AERs also can be powerful vehicles for elaborating success, especially when success may be a near failure in disguise (Ellis and Davidi 2005). In elaborating success, AERs probe the internal logic of the mental model of task performance to identify potential misalignment between specific actions and the conditions under which they were executed (Ellis et al. 2006).

Helpful reflection also occurs through regular (daily) debriefing sessions that analyze whether the day's work met all its requirements and objectives and determine whether it has yielded lessons for subsequent operations (Vashdi et al. 2007). Questions asked include what happened, why it happened, and can be learned so the operation can be done better next time.

A recurring theme is that continuous improvement furthers safety culture when front-line employees reflect on small but important problems (e.g., having to correct someone else's mistake, missing materials, inadequate staff), experience a heightened sense of efficacy, and develop greater trust in the organization's leadership. Their reflections strengthen the other essential elements of safety culture discussed above by communicating upward to managers and others in positions to fix the systems (Tucker 2007).

Structured learning practices also help foster continuous improvement of safety culture by altering other practices. AERs reinforce such behaviors as mindful organizing. In focusing on failures, they reinforce a preoccupation with failure. When people volunteer detailed accounts of what happened, they counter the tendency to simplify interpretations. An AER by definition is sensitive to operations while enabling a more resilient repertoire of responses and greater clarity about the importance of expertise. Front-line system elaborations such as these reinforce safety communication, an inquiring attitude, collective efficacy, and personal accountability (Tucker 2007). Lastly, research on AERs has shown that improvement through lessons learned often diffuses throughout the organization (Ron et al. 2006), creating the coherence and shared perceptions that constitute safety culture.

Continuous improvement through structured learning practices also helps make the work environment more respectful, encourages raising concerns, and enhances work processes such as cross-checking orders. These practices support leaders' provision of concrete and actionable feedback (Vashdi et al. 2007) and cross-functional (e.g., operators and engineers) communication (Edmondson 2003), as well as improvements to work processes such that the right materials are in the right place at the right time (Vashdi et al. 2007). For example, debriefing practices in surgical teams led to changes in the ways procedures were structured and teams were staffed, which then led to more success in implementing new technology and improved safety (Pisano et al. 2001).

Finally, AERs can simultaneously reinforce a commitment to safety values and actions and an environment for raising concerns. For example, AERs reinforce psychological safety by treating errors and near misses as legitimate inputs to learning (Lipshitz et al. 2002). At the same time, AERs produce a better understanding of acts that cannot be tolerated and therefore reinforce personal accountability. Leaders accomplish this by implementing specific "red rules" that must be followed at all times. Deviations from these rules bring work to an immediate halt until compliance is achieved (Dekker 2007). Not only do AERs clarify "never" acts formalized by "red rules," but they also create a context of greater accountability for leaders and peers. However, additional accountability does not mean additional "blaming and shaming," but rather reinforcing the idea of shared accountability to keep everyone on a safe path (Popper and Lipshitz 1998).

Conclusion

The nine elements of a strong safety culture discussed above and substantiated by research findings need to be considered together. For example, the disciplined execution of work processes is aided substantially by leaders' commitment to safety. Similarly, continuous improvement depends on a respectful work environment in which employees are encouraged to raise concerns. Overall, while the committee embraces the BSEE elements of a strong safety culture, such cultures do not merely exist within organizations; rather, they are negotiated and revised frequently with various stakeholders. Unless stakeholders are aware of safety culture practices and engaged in their execution, meaningful changes are unlikely to be achieved. Consequently, the committee also recognizes the importance of promoting transparency and engagement with relevant stakeholders to stimulate their participation in continuously strengthening the safety culture.

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Despite the many definitions of safety culture, overall consistency across industries regarding the essential elements of such a culture enables the establishment of norms to facilitate clear communication across systems and industries.

A robust safety culture permeates an entire organization. Accordingly, safety culture needs to flow from the top of the organization (whether operator, contractor, or subcontractor) to all the workers in offshore locations, including contractor and subcontractor staff, while being supported by regulators.

Safety culture is not a destination. It needs to continuously adapt, evolve, and be reinforced. Creating a strong safety culture requires alignment, effort, resources, and time.

Research demonstrates that safety culture is significantly enabled by all leaders' commitment to safety, actions that reflect broad personal accountability for safety, consistent safety communication, an attitude of inquiry throughout the organization, diligent hazard identification and swift management of identified hazards, and a respectful work environment that encourages raising concerns and addressing unsafe conditions.

A strong safety culture is reinforced and sustained by structured learning practices focused on continuous improvement.

Recommendation 2.1: The committee recommends that the offshore industry and government regulators adopt the Bureau of Safety and Environmental Enforcement (BSEE) definition of safety culture and its essential elements as a guide for assessment and practice.

DIRECTIONS FOR FUTURE RESEARCH

Although research supports each of the nine elements of a strong safety culture reviewed in this chapter, further research is needed on the relative importance of each element. This research would best be conducted in partnership among regulators (e.g., BSEE), industry (e.g., the Center for Offshore Safety), and academic researchers and combine primary data collection (e.g., qualitative and survey data) with statistical analysis. Important questions to be addressed include the following:

- Do aspects of an effective safety culture matter differentially for different types of organizations (e.g., operators, contractors, and large and small companies)?
- Do aspects of an effective safety culture matter differentially for different outcomes, including personal safety, design safety, and process safety and leading and lagging indicators (e.g., gas releases)?
- In terms of low-frequency, high-consequence events, how is it possible to identify whether an organization is close to the safety envelope (i.e., the point at which a disaster becomes more likely)?
- What are the best practices (e.g., recruiting, hiring, training) for ensuring that an organization has sufficient competence in its leadership and workforce to create and sustain an effective safety culture?
- Do operations comprising multiple organizations have a safety record that is consistent with the weakest safety culture? the strongest?

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Abbreviations

AHRQ	Agency for Healthcare Research and Quality
AIChE	American Institute of Chemical Engineers
API	American Petroleum Institute
BSEE	Bureau of Safety and Environmental Enforcement
CAIB	Columbia Accident Investigation Board
CSB	U.S. Chemical Safety Board
DOE	U.S. Department of Energy
EFCOG	Energy Facility Contractors Group
GAO	U.S. Government Accountability Office
HHS	U.S. Department of Health and Human Services
HSC	Health and Safety Commission
IAEA	International Atomic Energy Agency
INPO	Institute of Nuclear Power Operators
NAE	National Academy of Engineering
NASA	National Aeronautics and Space Administration
NEB	National Energy Board of Canada
NRC	National Research Council
PHMSA	Pipeline and Hazardous Materials Safety Administration
U.S. NRC	U.S. Nuclear Regulatory Commission

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3

History of the Development of and Safety Efforts in the Offshore Oil and Gas Industry

This chapter provides a brief history of the development of the offshore oil and gas industry and the safety efforts made since its inception. The discussion draws heavily on *Wake-Up Call: Accidents and Safety Provision in the Gulf of Mexico Offshore Industry* (Priest 2008a). The reader is also referred to the report of the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling (2011, Ch. 2) for additional accounts of the history of the offshore oil and gas industry in the United States.

1890s TO 1940s: COASTLINE AND OFFSHORE OIL AND GAS EXPLORATION

As the offshore oil and gas industry expanded to the U.S. coastline and Outer Continental Shelf (OCS) in the 1890s, oil wells were drilled in the ocean from wooden piers attached to the shore. As drilling moved farther from the shore, drilling from piers became impossible. Moveable barges were used in the 1930s, and by 1938, the first free-standing structure had been placed in the Gulf of Mexico 1.5 miles offshore for the purpose of drilling for oil (Pratt et al. 1997). As the demand for gas and oil products continued to increase during and after World War II, these free-standing structures were placed in deeper waters. In 1947, the first well to be out of sight of land was built on a platform 12 miles off the coast of Louisiana (Priest 2008b). By 1949, there were 11 oil and gas fields with 44 exploratory wells (NOIA 2015) in the Gulf of Mexico.

The early years of offshore drilling were characterized by extremes of both reward and risk in an environment in which very little legislation and regulation existed. During this period the industry undertook few safety initiatives. While companies were able to find and produce oil and gas profitably, they also faced a number of hazards that resulted from trying to adapt land-drilling methods offshore, fitting complex drilling and production facilities onto small platforms, using untested designs and procedures, and handling dangerous equipment and flammable materials, all in an adverse marine environment that frequently exposed workers and equipment to high winds and waves as well as corrosive salt water. In addition, high operational costs intensified pressure to surmount these challenges within the shortest time possible (Priest 2008a).

1950s TO 1960s: THE DANGERS AND CHALLENGES OF MOVING FARTHER OFFSHORE

Offshore oil and gas exploration was halted for a time when California, Texas, and Louisiana challenged a 1945 proclamation made by President Truman that granted authority over the subsoil of the U.S. Continental Shelf to the federal government (Penney 2008). The states' challenge prompted the U.S. Department of Justice to file suits against them. The legal disputes ended when the U.S. Supreme Court ruled against California in 1947 and against Louisiana and Texas in 1950. In May 1953, Congress passed two pieces of compromise legislation that put an end to the debate over federal and state jurisdiction on the Continental Shelf: (1) the Submerged

Lands Act (SLA), which validated all state leases that had been awarded prior to the issuance of the Supreme Court's decision against California, Texas, and Louisiana and reserved to the states all land within 3 nautical miles (nmi) of their shores[1]; and (2) the Outer Continental Shelf Lands Act (OCSLA), which placed all offshore lands beyond the 3 nmi limit under federal jurisdiction and gave the Department of the Interior the authority to issue leases (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling n.d.). Offshore drilling resumed after the legal disputes were settled and the SLA and OCSLA were signed by President Eisenhower.

In 1954, the Department of the Interior's Bureau of Land Management held the first federal lease sale for offshore drilling in New Orleans, while the U.S. Geological Survey's (USGS) Conservation Division established a new office to supervise drilling operations and collect revenues (Priest 2008c). Oil companies explored and developed their new leased lands by using services from the preexisting onshore Gulf Coast oil service sector, creating a distinct offshore industry sector that utilized services in marine geophysical surveying, offshore engineering and construction, transportation (boats and helicopters), diving, and mobile drilling (Priest 2007).

During this period, new discoveries, such as giant salt dome fields off the coast of Louisiana, prompted companies to move their operations farther into the Gulf and support the development of equipment that would facilitate oil exploration in deeper waters. The use of mobile drilling units progressed rapidly. In 1954, a drilling contractor used a submersible drilling barge rig with a hull that could rest submerged on the seafloor in 30 feet of water and be refloated and relocated. Other drilling operators tested jack-up rigs that positioned the rig's legs on the ocean floor and jacked the drilling equipment up above the water's surface, making drilling possible in water deeper than 100 feet. By 1957, 23 mobile rigs were operational along the Gulf Coast, and 11 more rigs were under construction (Calvert 1957a).

As in preceding decades, every phase of early offshore exploration entailed safety hazards that could lead to accidents resulting in death or injury to people and damage to equipment and the environment. The deployment of land-based technologies, equipment, and practices in the marine environment as well as the use of new technologies untested for offshore use persisted and continued to heighten the risk of offshore drilling operations. Platforms were built without full consideration for worker safety, and often had decks crammed with equipment and crew quarters situated near dangerous equipment and compressor buildings.[2] Pipe, drilling mud, cement, and chemicals were moved using brute strength instead of automated tools such as large cranes, lift pallets, and forklifts (Priest 2008a, 142).

In addition, the pressure to drill wells, install platforms, and bring production online as quickly as possible to recoup the huge investment in leases, structures, equipment, and personnel did not abate. In this work environment, some operators and contractors did not make safety a high priority and sometimes cut corners (Priest 2008a, 144). Others may simply not have known how to create a safe working environment.

In the exploration phase, marine seismic work proved to be particularly dangerous. The dynamite explosions used to generate the sound necessary to identify geological structures beneath the ocean floor resulted in a number of problems, ranging from headaches due to breathing in the fumes from an explosion (Shell News 1939, 15) to deaths and injuries due to onboard explosions (premature ignition), particularly when crews tried to speed up operations

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[1] For Texas and the west coast of Florida, 3 marine leagues (approximately 10 nmi).

[2] K. Arnold, personal communication, interview by Tyler Priest, Houston, Texas, May 10, 2004.

(Priest 2008a, 140). In addition, explosions could create large craters in the mud floor, into which unsuspecting workers carrying heavy loads could fall and have difficulty getting out.[3]

Between the late 1940s and mid-1950s, transportation for personnel created another significant hazard, especially during inclement weather. The use of ladders, ropes, cargo baskets, and swing ropes to move personnel from boats to the platform or between different levels of the platform led to falls that produced injuries (Priest 2008a, 141). Helicopters, which were introduced in 1948 but were not widely used until the mid-1950s, provided a more economical and time-efficient means of transferring crews to offshore rigs; however, they were not without risks (Priest 2008a, 141). Helicopter accidents occurred during bad weather and at night, and when they did, multiple fatalities usually resulted. USGS's monthly engineering reports from the 1950s to the1960s listed multiple deadly helicopter crashes. In 1958 alone, 14 reported fatalities resulted from helicopter accidents in the Gulf of Mexico OCS.[4]

In addition, several mobile drilling vessel disasters occurred in the early days of offshore exploration and drilling. From 1955 to1957, four drilling vessels overturned, resulting in the loss of 13 lives. In the worst of these accidents, 9 people died when the Golden Meadow Drilling Company's *Mister K* capsized off the South Pass of the Mississippi River in April 1957. Two weeks later, the Glasscock Drilling Company's jack-up *Mr. Gus* capsized, killing 1 person.[5] Many operators blamed human error for these accidents; however, many academic researchers (e.g., Reason 1990; Shappell and Wiegmann 2001; Dekker 2002) believe the attribution of accidents to human error is too simplistic and fails to take into account issues of equipment design, training, and supervision. For example, it was evident that these mobile drilling vessels, especially the jack-ups, had design flaws that contributed to their instability (Calvert 1957b).

Well control incidents can occur in the course of drilling for oil and gas, and they can be especially disastrous for those who work on the platform and for the surrounding environment when blowouts occur. However, most well control incidents do not result in fatalities or injuries, and the ability to regain control quickly determines the severity of the accident and the extent of its consequences. Despite offshore operators' early use of blowout-prevention systems, some blowouts still occurred in the Gulf, resulting in fires, explosions, deaths, property damage, and environmental pollution (Priest 2008a, 141).

Diving, which had become an essential part of offshore operations by the late 1950s, was also a dangerous activity. Divers took part in the construction, installation, repair, maintenance (such as removal of marine growth), and salvage of offshore platforms and pipelines, and they were asked to dive to greater depths for longer periods of time with minimal training. Unusual and extreme environmental conditions offshore posed challenges even to experienced divers, and new recruits whose primary occupation was not diving were often asked to dive after receiving little training (Priest 2008a, 142).

Although safe operations were a clear problem with many of the common offshore practices, safety was not always emphasized, particularly when untested equipment was employed or pressure to move operations forward rapidly increased. While offshore workers usually received some training in safe operating practices, they were not necessarily trained to manage safety or to manage change safely (Priest 2008a, 144).

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[3] N. Constant, personal communication, interview by Diane Austin, July 23, 2001.

[4] U.S.G.S., "Monthly Engineering Reports," Gulf Coast Region, Volumes 109–160,1954–1966, Record Group 57, Records of the U.S. Geological Survey, Conservation Division, Oil and Gas Leasing Branch, National Archives and Records Administration (NARA), College Park, Maryland.

[5] Oil Rig Disasters. http://home.versatel.nl/the_sims/rig/index.htm. Accessed August 24, 2015.

In most organizations, safety programs were basic and simple. Each company defined what “safe” meant. The better ones learned from their own and others’ mishaps, blowouts, and accidental deaths and worked to improve technologies for drilling, blowout prevention, and production (Priest 2008a, 144).

During this period, the industry’s minimalist approach to safety remained mostly unchanged, and government regulation and oversight also were minimal. Federal regulations addressing specific equipment and procedures were implemented incrementally. Between 1958 and 1960, the USGS issued OCS Orders 2 through 5, which specified procedures for drilling, plugging and abandoning wells, determining well production rates, and installing subsurface safety devices or storm chokes (Priest 2008a, 144). In July 1959, USGS released an order for facility inspectors to file a report on each facility they inspected, noting the deficiencies and actions taken. Enforcement by USGS was sporadic, however, and most installations were inspected only annually and in some cases less frequently because the agency lacked funding and staffing for this work (Priest 2008a, 144).

Because of inconsistencies in the reporting requirements for minor and major accidents, fatalities, and minor injuries, data on fatalities and major accidents were generally more complete than data on minor accidents and injuries. Hence it is difficult to determine trends for all types of accidents and injuries offshore during this period.

Despite the lack of complete records on injuries, specific catastrophic accidents and numerous injuries likely had many causes, ranging from workers’ carelessness and desire to display their physical capability to ropes and cables breaking and objects being dropped (Priest 2008a, 142). In 1965, a jump in the rate of accidents prompted Lloyd’s of London to increase global insurance rates on most types of drilling vessels. In addition to insurance fees, operators had to bear the costs of uninsured exposures such as downtime and lost production (Priest 2008a, 145). More broadly, between 1950 and 1968 there were approximately 150 working mobile units worldwide, and 30 major rig mishaps and about the same number of minor accidents occurred on these structures (Howe 1968, 51–52). At the same time, there remained no legal requirements anywhere in the world for the overall performance and safety of mobile offshore drilling units (Priest 2008a, 146).

1965 TO 1990: IMPROVING THE SAFETY OF OFFSHORE OPERATIONS

During this period, the industry’s ability to solve design and equipment problems at a steady pace allowed it to overcome some of the challenges of working in the marine environment. At the same time, diving contractors were compelled by diver safety groups and union organizers to address safety and formed the Association of Diving Contractors. Ultimately, union efforts failed to organize the divers in the Gulf of Mexico, but the union’s organizing actions helped improve safety standards and technologies in the 1970s and provided the impetus for the creation of new USCG regulations. In addition, diving injuries and fatalities forced operators to require proof of insurance from their diving contractors and focused both operators and diving contractors on reducing accidents (Priest 2008a, 148).

A number of accidents also occurred in the Pacific OCS and the Gulf of Mexico during this time, with serious consequences (see also Chapter 1). In 1969, a blowout in the Santa Barbara Channel, California, spilled 80,000 barrels of oil and spurred a national environmental movement that helped effect the passage of the National Environmental Policy Act (Priest 2008a, 146). Two accidents in 1970 rendered it the worst year up to that point in the history of the U.S. OCS regulatory program. A blowout and fire on a platform in Main Pass block 41, offshore Louisiana, in February spilled an estimated 1,000 barrels of crude oil per day for 3 weeks. Although there were no fatalities, more than 30,000 barrels of oil in total were spilled. Another blowout occurred on a production platform during wireline operations in the South Timbalier block 26-Bay Marchand area, offshore Louisiana, in December. The accident polluted the environment, harmed wildlife, killed 4 men, and injured 37.

Major accidents also occurred outside of the United States. The *Sea Gem* jack-up drilling vessel disaster in the British sector of the North Sea in 1965 killed 13 people.[6] In 1979, a blowout occurred on the *Ixtoc 1* well in Mexico's Bay of Campeche, which caused approximately 3.5 million barrels of oil to spill into the water (the largest industry spill prior to the *Deepwater Horizon* spill in 2010).[7] The 1980 capsizing of the *Alexander Kielland* semisubmersible drilling rig in the North Sea killed 123 people.[8] The 1982 sinking of the *Ocean Ranger* semisubmersible platform off Newfoundland killed 84 people.[9] And the 1988 explosion and fire at the *Piper Alpha* platform in the North Sea resulted in the deaths of 167 workers.[10]

While the immediate causes of these accidents were found to be material/design failure (e.g., *Sea Gem* collapse [Burke 2013] and *Alexander Kielland* capsizing [Officer of the Watch, 2013]), other factors also were implicated in these accidents, including faulty material (e.g., the Santa Barbara accident was caused by insufficient protective casing [Clarke and Hemphill 2002]), process failure (e.g., failure in the circulation of drilling mud caused the *Ixtoc 1* accident in Mexico's Bay of Campeche [Woods Hole Oceanographic Institution 2014]), human factors, and the lack of safety management systems and a work environment that failed to promote safe work practices and behaviors. In some cases, the integrity of the material or equipment had not been properly inspected, and repair or replacement had not been carried out (e.g., *Sea Gem*, South Timbalier block 26-Bay Marchand [Donovan 2010]). In other cases, personnel failed to monitor operations (e.g., South Timbalier block 26-Bay Marchand) and follow safe operating practices and procedures (e.g., Santa Barbara blowout), or performed work without considering standards for safe operations (e.g., *Piper Alpha* [NASA 2013]).

Thus the lack of safety systems and human error were the causes of many of these accidents. Minimal regulatory oversight also may have contributed to a lack of attention to safety on the part of companies working on the OCS during the late 1960s and early 1970s (Arnold 2015). In addition, the focus in most organizations was on personal safety and safe use of equipment, rather than process safety. Some companies, however, began adopting safety practices in the late 1960s, such as high-pressure sensors, shut-in[11] valves, and emergency shutdown systems, while some started keeping records of lost-time accidents and recordable incidents. However, the safety devices being employed were not reliable or tested frequently until the OCS orders were issued in the early 1970s (Arnold 2015).

During this period, studies of drilling processes emphasized the need to improve safety on offshore rigs. In 1985, a report on a study on Arctic and deepwater drilling, conducted by the Congressional Office of Technology Assessment (OTA 1985), called attention to the safety risks

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[6] http://home.versatel.nl/the_sims/rig/seagem.htm. Accessed March 22, 2016.
[7] http://home.versatel.nl/the_sims/rig/ixtoc1.htm. Accessed March 22, 2016.
[8] http://home.versatel.nl/the_sims/rig/alk.htm. Accessed March 22, 2016.
[9] http://home.versatel.nl/the_sims/rig/o-ranger.htm. Accessed March 22, 2016.
[10] http://home.versatel.nl/the_sims/rig/pipera.htm. Accessed March 22, 2016.
[11] The term "shut-in" is commonly used in the oil and gas industry.

of operating in harsh environments and remote locations. The report underscored the need for new approaches that would prevent work-related injuries and fatalities while adapting to the hazards of the Arctic and deepwater environments. The report also noted that at the time, there were no regulatory requirements for submitting integrated safety plans addressing technical, managerial, and other aspects of offshore safety operations and that "insufficient funding by the federal government may result in inadequate rig safety inspections and monitoring efforts" (OTA 1985, 7). Regulatory agencies such as USGS were underfunded and understaffed. In 1969, for example, the USGS Gulf of Mexico Region had only 12 people overseeing more than 1,500 platforms (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011).

The high-profile blowout incidents noted above, a growing number of injury lawsuits, increased media scrutiny, and public demand for worker and environmental safety led to efforts on the part of the industry and the federal government to improve regulations, work practices, technologies, and designs so as to make offshore operations safer. The Department of the Interior expanded and strengthened its regulatory program by rewriting most OCS orders addressing operations in the early 1970s. The new OCS orders required that additional safety features be installed on platforms and pipelines. Subsurface safety valves, for example, which were introduced in 1954 but were not widely used because of costs and operational problems, were required on all producing wells (OCS Order 5-3) for the first time in 1973. There were also new requirements related to process safety. These included the testing of safety devices prior to and when in use, and the use of defined processes for the control of drilling and casing operations, preapproved plans and details of the equipment used for exploration and development drilling, and revised practices and procedures for platform installation and operation. USGS also hired more inspectors and engineers to enforce the new regulations, instituted a more systematic inspection program, and used government-provided transportation to conduct inspections instead of relying on the operators to take inspectors to rigs (Priest 2008a, 147).

In addition, the Department of Justice filed suit against a number of major oil and gas companies that were responsible for accidents or committed safety violations, ultimately obtaining judgments against them (Reifel 1976). In a single case, one operator of record was fined $1 million for its failure to maintain safety devices, including safety chokes (Priest 2008a, 146)—a fine that was considered significant at that time.

In the early 1970s, the industry tried using a new approach to improve safety offshore, involving collaboration between the industry and USGS. The Offshore Operators Committee and the American Petroleum Institute's (API) Offshore Safety and Anti-Pollution Equipment Committee provided input for the revision of OCS orders and also drafted a new set of API Recommended Practices for selecting, installing, and testing various types of safety devices and platform designs (Arnold et al. 1989). Offshore operators, with the help of API, consultants, academics, and suppliers, also instituted changes in the required training programs for offshore operator and contractor personnel, which resulted in increased worker retention and morale and contributed to the improvement of company and industry safety records (Pace and Turner 1974). The series of catastrophic accidents that occurred in 1969 and 1970 also spurred a series of major studies by the NRC Marine Board and USGS, which resulted in more changes to the OCS regulatory program.

In addition to the revised OCS orders and improved technologies and platform designs, other activities focused the industry's attention on safety. The U.S. Coast Guard (USCG) and USGS began enforcing new regulations addressing issues related to occupational safety for personnel. In 1972, Lloyd's Register of Shipping published its first *Rules for the Construction and Classification of Mobile Offshore Units*. In 1973, the American Bureau of Shipping (ABS) revised its *Rules for Building and Classing Offshore Mobile Drilling Units*, based on a wide range of more rigorous tests of mobile drilling designs (Priest 2008a, 148). In the early 1970s, the ABS rules, which had first been published in 1968, were incorporated into USCG's regulatory requirements for mobile offshore drilling units and OCS Order No. 2, which addresses drilling from fixed platforms and mobile drilling units and is enforced by USGS (Lovie 1976).

Reporting of minor accidents and minor injuries remained inconsistent during this period, but reporting of major accidents was done consistently, and as required by the OCSLA, the Department of the Interior and USCG investigated deaths, serious injuries, fires, and oil spills of more than 200 barrels. The likelihood that accidents were underreported in the 1970s is high, however, in part because of the vagueness of the regulatory requirements for reporting injuries, including ambiguity as to what injuries operators and leaseholders should report. Some companies reported only what they legally had to report (i.e., only major incidents). In addition, from 1985 until well into the 1990s, some oil and gas companies did not consider accidents resulting in lost workdays but not fatalities or major damage to assets to be serious incidents that had to be reported to the Mineral Management Service (MMS).[12] A voluntary survey of operators conducted as part of an MMS/USCG industry performance study revealed that of the 507 lost workday cases in 1997 reported in the survey, only 83 (or 16 percent) were shared with the MMS (Federal Register 2003; Priest 2008a, 149).

Through the different trade associations (e.g., the Offshore Operators Committee, API, the International Association of Drilling Contractors [IADC]) the offshore industry reviewed the major accidents to determine their nontechnological causes and to identify appropriate preventive measures. By most accounts, most of the major accidents had been caused not by technological problems or failure to comply with industry safety standards but by human error resulting from insufficient training and supervision, rote reliance on regulations, and poor operating practices (Priest 2008a, 150). Industry was in agreement that realizing significant improvements in safety would require renewed commitment to better training, more supervision and oversight at work sites, less reliance on simply complying with regulations to achieve a safe working environment, and greater focus on enhanced operating practices and procedures. Safety awareness was driven by safety technicians who were assigned to the rigs starting in the late 1970s, which helped reduce incidents involving personnel safety, especially those related to slips, trips, falls, and hand injuries.

1990s: PROMOTING OFFSHORE SAFETY AND ENVIRONMENTAL PROTECTION

In the 1990s, more geographically promising areas in deep water were discovered with the aid of new technology for acquiring multidirectional seismic data and computer processing 3-D seismic images. With the discovery of these deepwater fields that could yield vast amounts of oil, the introduction of new-generation drilling vessels, and advances in drilling technology, the industry began to explore the deeper waters of the Gulf of Mexico—a venture that paid off when millions of barrels of oil were recovered (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011).

[12] The Minerals Management Service (MMS) assumed USGS's responsibilities for offshore oil and gas regulation in 1982.

From 1950 to 1990, the offshore industry focused most of its safety improvement efforts on equipment design and operational considerations, and the government enacted prescriptive regulations (Velez 1998, 5). During the same period and continuing into the 2000s, most accidents offshore were attributed to human error, a narrow perspective that ignored the role of systems and culture. Most in the industry believed that this persistent trend of accidents caused by human error was the result of the difficulty and stressfulness of the work; the environment (e.g., darkness, heat, cold, noise); and long work shifts (e.g., 7 days on/7 days off work schedules and some up to 28 days on/14 days off) that led to worker exhaustion, which can take a toll on human performance and predispose workers to accidents that cause injury. Aside from the problem of underreporting of minor incidents by some companies, the industry's reliance on lost-time incident rates as an indicator of the level of safety emphasized personal safety indicators, which in turn lacked causal explanations (Wilkinson 2012). Rather, the causes of lapses in personal safety could be attributed to many factors, including the worker's failure to follow procedures or pressure from the worker's management to complete a task too quickly.

Although many still attributed accidents to human error in the 1990s, the industry and regulators continued to focus on equipment design and safety and production and drilling practices and procedures. They also began to expand their perspectives on safety to focus on the management systems and process safety of the entire facility. Consideration of process safety goes beyond personal safety and equipment design to analyze the causes of accidents, particularly catastrophes. The focus is on the interrelationships among the components of entire systems, including workers, supervisors, equipment, training, safety procedures, work rules, and so on, with measures being used to monitor systems, track progress, and provide early warning of potentially dangerous situations.

Also characteristic of this period was a decline in the presence of major operators in large areas of the Gulf of Mexico and growth in the number of smaller, independent operators. Many accidents during this period continued to involve entry-level workers, a problem that was probably exacerbated by the "increasing turnover rate in the offshore labor market, the growing use of contract personnel, and the emergence of smaller, independent operators without the necessary organizational structure for managing safety" (Priest 2008a, 150).

The hiring of more contractors and subcontractors by both major and independent operators posed an additional safety concern because it led to the presence of more players in a given location with differing understandings of the elements of safety culture, including safety procedures, work conditions, and decision-making responsibilities. The growing use of contractors and subcontractors also created uncertainty over who had legal responsibility when work was being performed and raised new questions about how to specify safety responsibilities and liability in contract text. One legal concern was whether contracts was to specify in detail how work was to be carried out because a resulting accident could shift liability from the contractor to the operator. A different approach was to specify the safety responsibilities of the parties in contract terms and conditions, with the expectation that reducing adverse events would lower liability for all parties. Some operators also began following up to ensure contractor compliance and screening potential contractors according to their past safety performance as a way of selecting those that would be willing and able to work to the operator's safety standards.

Although there was concern about the takeover of mature properties, rigs, and equipment by small independent operators, a study sponsored by MMS suggested that independents, on average, had marginally better safety and environmental records relative to the major operators

(Pulsipher et al. 1998). This study, however, did not address questions about underreporting of minor incidents.

As one way to address safety offshore, MMS proposed a performance-based safety approach emphasizing corporate and human responsibility. This approach is exemplified by the Safety and Environmental Management Program (SEMP), introduced in 1991 to shift companies from a compliance mentality to a focus on the association of human error and organizational influences with accidents occurring in the workplace and on the application of continuous improvement principles in offshore safety management (Arnold 2015; Priest 2008a, 150).

As in the previous decades, the safety improvements the offshore industry during this period cannot be fully evaluated because of insufficient data, a problem that had long been known (OTA 1985). Baram (2014) attributes the lack of a comprehensive database that could fill this gap to the decades-long inability of the primary offshore regulators (MMS and USCG) to collect data in systematically from all parties involved offshore—operators, independents, contractors, and subcontractors—which limited the ability to analyze trends and help the industry make continuous and timely improvements in offshore safety.

A follow-up to the SEMP designed to address these data inadequacies is the OCS Performance Measures Program, created by representatives of the regulators (MMS and USCG) and the oil and gas industry to help operators and contractors determine how the SEMP affects their operational safety and environmental performance. In addition to assessing the effects of the SEMP within a company, the performance measures are used to monitor the industry's OCS-wide operating performance by aggregating the performance data reported by all operating companies to generate an annual safety and environmental performance profile. This profile allows an operating company to weigh its individual performance against industry-wide performance (Beittel and Atkins 2000), and also enables regulators, industry, and the public to assess offshore performance trends. See Chapter 4 for additional information about the SEMP, API Recommended Practice 75, and the OCS Performance Measures Program.

2000s TO THE PRESENT: DEEPWATER DISCOVERIES AND EXPLORATIONS AND THE AFTERMATH OF A CATASTROPHIC BLOWOUT

In the early 2000s, operators found 11 major oil fields located in 7,000 feet of water or deeper. Offshore oil exploration shifted to the deeper and older strata, called the "Lower Tertiary," that some believe could yield 3 to 15 billion barrels of hydrocarbons. Exploration, however, did not proceed without complications. A major challenge for all such projects included the need for more advanced equipment that would make it possible to see at depths of up to 10,000 ft well enough to operate and manipulate equipment remotely on the seafloor, as well as for blowout preventers made of higher-strength materials and capable of operating at deeper water depths, where reservoir conditions are more intense (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011). As the industry advanced into the deep waters of the Gulf, accidents continued to occur. Overall, however, there was a downward trend in rates of recordable and lost workday incidents across all segments of the offshore industry (production, construction, drilling etc.). From 2000 to 2009, according to Bureau of Safety and Environmental Enforcement (BSEE n.d.-a) data, recordable incident rates fell from 1.97 to 0.46, and lost workday incident rates fell from 0.75 to 0.25 (per 200,000 man hours or 100 person years; see Figure 3-1). In addition, a series of hurricanes battered the Gulf Coast in 2002, 2004, and 2005.

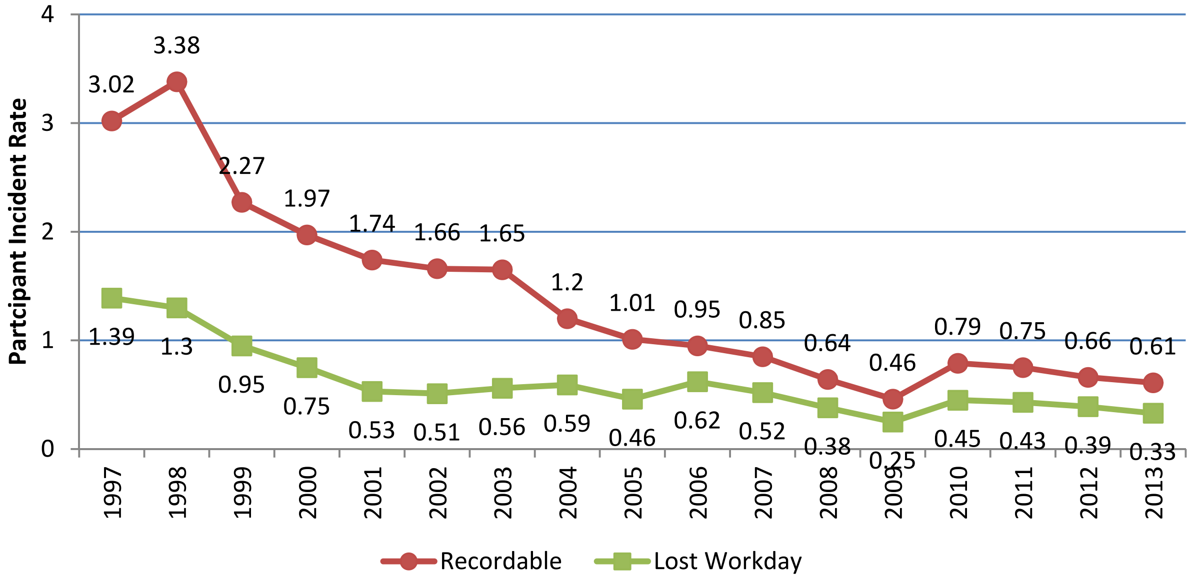

FIGURE 3-1 Recordable and lost workday/days away/restricted or transfer rate (DART) case incident rates[13] for combined operations, 1997 to 2013. [SOURCE: Adapted from BSEE (n.d. -a)]**.**

Many underwater pipelines, vessels, and platforms were either badly damaged or completely destroyed. However, it did not take long for the industry to recover from the hurricane damage and resume drilling in deeper waters and producing oil and gas. By 2010, 19 reservoirs had been discovered in the "Lower Tertiary," 14 of which contained at least 100 million barrels of oil equivalent (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011, 51).

Prior to 2010, the offshore oil and gas industry had not experienced a catastrophic accident in many years. That trend ended on April 20, 2010, when a blowout occurred that led to an explosion and fire on the Transocean *Deepwater Horizon* drilling rig. The blowout was caused by the loss of well control while BP, the operator, was in the process of temporarily abandoning a well it was working in approximately 5,100 feet of water. Eleven of the 126 crewmembers died in the incident, many others were injured, and all personnel had to evacuate the rig. The rig sank in about 48 hours, and oil from the well continued to flow for weeks unimpeded by the blowout preventer. This incident resulted in an estimated 3.19[14] million barrels spilled, the largest ever oil spill in U.S. waters, and activation of the largest ever oil spill response operation. Many attempts were made using different tactics before the well flow was stopped on July 15, 2010, using a capping stack. Prior to this event, it was difficult for many in the industry to imagine an accident that would result in a major spill, loss of lives, injuries, and the sinking of the rig. The likelihood of such an event was very low, but it had major consequences.

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[13] Number of incidents per 200,000 man-hours worked.
[14] Volume determined by the court.

The Need for a Strong Safety Culture

The government's response to the *Deepwater Horizon* incident was swift. Immediately after the incident, President Obama charged the secretary of the Department of the Interior to deliver a report on the accident, with recommendations for improving safety, within 30 days. The secretary asked IADC and API to convene a task force to make those recommendations and also asked the National Academy of Engineering to assemble experts to peer review the secretary's report.

On May 22, 2010, President Obama announced the creation of an independent, nonpartisan group—the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling—to conduct a thorough and impartial analysis of the causes of the oil spill within 6 months and provide recommendations for improving the nation's ability to respond to spills and making offshore energy production safer. The National Commission's objective was to provide the President, policy makers, industry, and the American people with a clear, accessible, accurate, and fair account of the largest oil spill in U.S history, including what the context for the well itself was, how the explosion and oil spill happened, and how industry and government responded to an unprecedented emergency. At the end of its investigation, the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (2011) concluded that safety culture was one area in which significant change was needed. (See Box 3-1 for a list of the National Commission's findings related to safety culture.)

The National Commission reached several important conclusions regarding safety. Among those conclusions were the following. First, a sound and cohesive safety culture throughout the industry is necessary to further reduce the likelihood of very low-frequency incidents that have very high consequences. Safety management system frameworks, such as those described in API Recommended Practice 75 and the Safety and Environmental Management Systems (SEMS) standard, prescribe some of the processes necessary to strengthen a safety culture, but leadership at all levels of the organization, from CEO, to first-level field supervisor, to entry-level employee or contractor, is essential for their successful implementation. Second, the oil and gas industry needs to change its focus from regulatory compliance to implementation of a comprehensive safety system if it is to maintain personnel safety, process safety, and safety leadership at all levels of an organization. The National Commission's report also points out that the regulatory agencies need to provide support for efforts to meet this objective.

The systems approach reflected in the National Commission's conclusions requires actions that ensure a balanced, well-implemented safety culture with appropriate safety policies, procedures, work plans, and behaviors. To this end, BSEE has determined that OCS operators must use SEMS as the foundation for their safety management systems (see Chapter 4 for more detail on SEMS).

In 2010, the Chemical Safety Board also began its investigation of the *Deepwater Horizon* accident. In its report, it attributes the accident to " a complex combination of deficiencies: process safety safeguards and inadequate management systems and processes meant to ensure safeguard effectiveness, human and organizational factors that created an environment ripe for error, organizational culture focused more on personal safety and behavioral observations than on major accident prevention, and a regulatory regime unable to deliver the necessary oversight for the high-risk activities involved in deepwater exploration, drilling, and production" (CSB 2015).

Box 3-1

Findings of the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling

- The explosive loss of the Macondo well could have been prevented.
- The immediate causes of the Macondo well blowout can be traced to a series of identifiable mistakes made by BP, Halliburton, and Transocean that reveal such systematic failures in risk management that they place in doubt the safety culture of the entire industry.
- Deepwater energy exploration and production, particularly at the frontiers of experience, involve risks for which neither industry nor government has been adequately prepared, but for which they can and must be prepared in the future.
- To assure human safety and environmental protection, regulatory oversight of leasing, energy exploration, and production requires reforms even beyond those significant reforms already initiated since the Macondo disaster. Fundamental reform will be needed in both the structure of those in charge of regulatory oversight and their internal decision making process to ensure their political autonomy, technical expertise, and full consideration of environmental protection concerns.
- Because regulatory oversight alone will not be sufficient to ensure adequate safety, the oil and gas industry will need to take its own, unilateral steps to increase dramatically safety throughout the industry, including self-policing mechanisms that supplement governmental enforcement.

SOURCE: Excerpted from the report of the National Commission on the BP *Deepwater Horizon* Spill and Offshore Drilling (2011).

The investigations into the *Deepwater Horizon* all reached the conclusion that a lack of process safety and deficient safety culture were primary causes of the accident. That conclusion signaled a significant change in the attribution of the causes of such catastrophic accidents. Instead of focusing on individual behavior, these reports emphasize the importance of looking more broadly at the systems designed to promote safety and the culture that supports safe working behaviors.

BSEE Initiatives after the Deepwater Horizon Blowout and Spill

Safety and Environmental Management Systems (SEMS) Rule and SEMS II

BSEE issued the original Workplace Safety Rule (also known as the SEMS rule) in October 2010 as a way to improve safety of offshore operations. BSEE subsequently revised the SEMS rule, and a new rule, called SEMS II, became effective on June 4, 2013 (BSEE n.d-c). (See Chapter 4 for a more detailed discussion of SEMS and SEMS II.)

BSEE Safety Culture Policy

On May 9, 2013, BSEE released its final *Safety Culture Policy Statement* as part of its commitment to promoting offshore safety. The policy statement includes BSEE's definition of safety culture as "the core values and behaviors of all members of an organization that reflect a commitment to conduct business in a manner that protects people and the environment," as well as the nine elements of a strong safety culture discussed in Chapter 2. The policy statement also describes BSEE's regulatory approach to leading the offshore oil and gas industry beyond checklist inspection toward a systemic, comprehensive program for achieving compliance. During the release of the policy statement, then BSEE Director James Watson emphasized the following:

> The human factor is the critical element in offshore safety. Prescriptive regulations can reduce risks to worker safety and the environment, but they alone are not enough. Everyone working in the offshore industry must adhere to a set of core values that places safety above all else.[15]

Industry Safety Initiative: Creation of the Center for Offshore Safety (COS)

Industry's response to the *Deepwater Horizon* accident also was swift. In 2011, the Center for Offshore Safety (COS), an industry-sponsored organization funded through API, was created to focus exclusively on offshore safety on the U.S. OCS. The objective of the COS is "to serve the U.S. offshore oil and gas industry with the purpose of adopting standards of excellence to ensure continuous improvement in safety and offshore operational integrity."[16] Initially, only deepwater operators were members, with contractors and other service providers (such as consultants and engineering firms) being associate members. In early 2015, COS opened membership to all companies operating on the U.S. OCS. As of November 2015, COS members included 14 operators, 6 drilling contractors, and 10 service/equipment providers.[17] (See Chapter 4 for additional discussion of COS, its accomplishments to date regarding safety culture, and recommended changes for the future.)

CONCLUSION

Offshore operations, equipment, and workplaces, as well as the workforce and the relationships among operators, contractors, and subcontractors, are complex. There can be no simple description of the "workplace" offshore. Rather, workplaces offshore vary according to many factors, some of which raise significant safety challenges. For example, the workplace may be defined by the type of mobile offshore drilling unit and the types of equipment onboard, as well as by the amounts and types of technology employed, with substantial differences between the more hazardous drilling operations and the more or less steady-state production operations. In

[15] http://www.bsee.gov/BSEE-Newsroom/Press-Releases/2013/BSEE-Announces-Final-Safety-Culture-Policy-Statement/. Accessed April 26, 2016.
[16] http://www.centerforoffshoresafety.org/main.html. Accessed March 22, 2016.
[17] http://www.centerforoffshoresafety.org/membership.html. Accessed November 20, 2015.

addition, offshore workplaces vary significantly in their workforces, with workers differing in knowledge, skills, and abilities, as well as primary language and culture.

The growth of small independents in the Gulf of Mexico over the last two decades, moreover, has led to increased reliance on contractors and subcontractors with specialized skills, adding to the diversity of the workforce. For drilling operations on deepwater mobile offshore drilling units, in particular, the numbers and types of contractors and subcontractors on the same unit, the financial resources of each, and their goals related to profitability play critical roles in defining the safety culture of an operator, which in turn affects the culture in the workplace. These diverse workforces certainly complicate an operator's ability to instill a consistent safety culture in the workplace. According to Priest (2008, 151), "The greater use of contracting by majors but especially independents has created uncertainty over the location of legitimate authority and decision-making, and bred ignorance about work conditions and the responsibilities of personnel and confusion over safety procedures." Elements of Priest's assessment from 2008 can be seen in the string of mistakes and errors made on the *Deepwater Horizon* that led to the 2010 blowout and explosion, as well as in the chaos and confusion that occurred in the aftermath as managers argued about safety procedures and authority to engage the blowout preventer and disconnect from the riser.

In the span of almost 80 years, from the time when the first free-standing structure was installed in the Gulf of Mexico in 1937, the U.S. offshore oil and gas industry has gone from extracting oil and gas from the seabed a mile and a half offshore in 14 feet of water to drilling 35,000 feet under the sea, out to 200 miles offshore in 10,000 feet of water. In November 2015, 33 mobile offshore drilling units and more than 2,500 platforms were operating from shallow water and out to 10,000 feet of water in the Gulf of Mexico (Baker Hughes n.d.; BSEE n.d.-b). According to a February 2016 report of the Energy Information Administration (EIA),[18] oil production in the Gulf of Mexico is expected to account for 18 percent and 21 percent of the total forecast U.S. crude oil production in 2016 and 2017, respectively, even as oil prices remain low. EIA projects that the Gulf of Mexico will produce an average of 1.63 million barrels per day (b/d) in 2016 and 1.79 million b/d in 2017.

The history of accidents and spills in the Gulf of Mexico and elsewhere in the world highlights the need for every company doing business offshore to implement a safety system and adopt a strong safety culture as a corporate value. This need is further highlighted by the introduction of new technologies offshore, which bring their own sets of challenges, require specific training and expertise, and often require greater collaboration among all workers in the same facility or vessel. To protect workers, the public, equipment, and the environment, the industry and regulators need to work together to define minimum standards for compliance and to facilitate the exchange of information necessary to maintaining a strong safety culture.

FINDINGS AND CONCLUSIONS

The number and severity of accidents that have occurred on the OCS indicate that the oil and gas industry can be a dangerous business. While significant improvements in safety performance have been achieved over the past 40 years, unique logistical, oceanographic, operational, and economic challenges complicate deepwater exploration and development. These challenges require that continuous improvement in the management of process and personal safety be a

[18] https://www.eia.gov/todayinenergy/detail.cfm?id=25012. Accessed February 26, 2016.

priority among operators and contractors. The number and variety of contractors operating on a single facility can further increase the challenges associated with maintaining a common safety culture, effectively managing personnel, and executing the responsibility of maintaining safe working conditions.

High-impact accidents have very low probability. Although accidents, such as the Deepwater Horizon blowout, with extensive repercussions are unlikely, they can have severe consequences for individuals, the people in the communities that support the oil and gas industry, the assets of the operator and its contractors, the environment, and the industry as a whole when they do occur.

Regulatory actions such as SEMS, SEMS II, and BSEE's Safety Culture Policy reflect regulators' awareness of the importance of safety management and safety culture in preventing catastrophic accidents. However, having safety management systems is necessary, but not sufficient, to having a robust safety culture.

The establishment of COS by industry leaders and the increased number of new and updated standards and recommended practices indicates these leaders' concern about the safety culture of the organizations that work offshore and their desire to provide tools that can assist them in implementing safety systems and processes. Yet while leaders in the offshore oil and gas industry have begun addressing safety culture, not all industry participants have done so. Necessary next steps are participation in COS by all offshore companies and a wider and deeper commitment to improving safety culture throughout the industry.

REFERENCES

Abbreviations

BSEE	Bureau of Safety and Environmental Enforcement
CSB	U.S. Chemical Safety Board
NASA	National Aeronautics and Space Administration
NOIA	National Ocean Industries Association
OTA	Office of Technology Assessment

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U.S. Offshore Safety Regulation Pertaining to Safety Culture

No regulatory framework for offshore oil and gas operations existed until the 1950s, when growing concerns regarding offshore jurisdiction led to the passage of two key pieces of legislation. The Submerged Lands Act (SLA) of 1953 granted the federal government the title to and ownership of submerged lands making up the majority of the continental margin, while the Outer Continental Shelf Lands Act (OCSLA) of that same year is the principal law governing oil and gas exploration and production activities on subsea lands beyond state boundaries out to the limit of U.S. jurisdiction of mineral rights (EIA 2005). Beyond that limit, these activities are governed by international law or by the laws of another sovereign country.

The OCSLA gave authority to the Department of the Interior (DOI) and the U.S. Coast Guard (USCG) to implement certain safety and environmental regulations according to each organization's capabilities and expertise. Other acts—the Natural Gas Pipeline Safety Act of 1968, the Hazardous Liquid Pipeline Safety Act of 1979, and the Pipeline Safety Act of 1992—extended some regulatory authority to the U.S. Department of Transportation (USDOT). Today, the capabilities and expertise for permitting and inspecting oil and gas wells and production (including producer pipelines) reside in DOI's Bureau of Safety and Environmental Enforcement (BSEE), which was created in 2011 after the Minerals Management Service (MMS) was reorganized,[1] and assumed MMS's responsibilities for safety and environmental enforcement. The capabilities and expertise for certifying and inspecting floating offshore units and marine operations reside in USCG, which is now under the Department of Homeland Security. The capabilities and expertise for offshore transportation pipelines reside in the Pipeline and Hazardous Materials Safety Administration (PHMSA), created within USDOT in 2004. BSEE is the only one of the three agencies focused on permitting and inspecting oil and gas wells and production on the U.S. Outer Continental Shelf (OCS); USCG regulates nearly all maritime activities; and PHMSA regulates pipelines both on- and offshore. It should be noted that these federal agencies have little authority or responsibility over oil and gas activities that occur completely within a state's jurisdiction.

Certain commonalities exist within BSEE, USCG, and PHMSA. Each employs professionals with backgrounds closely associated with the industry it regulates. Each has a staff of engineers who review and approve plans and a field-based staff of inspectors who physically check compliance at individual federally permitted work sites. Additionally, BSEE and USCG have safety management auditors, and PHMSA is developing a safety management audit program and will require safety auditors.

Each of the three agencies charges fees that are based roughly on the daily cost of its regulatory activities. Fees collected by USCG go to the general U.S. Treasury, while BSEE fees augment its annual budget. Additionally, BSEE receives annual appropriations from Congress for such expenses as overhead, policy development, rent, and training. The USCG and PHMSA programs are funded through annual appropriations. None of these agencies is responsible for collecting U.S. royalties—a responsibility that resides within the Office of Natural Resource

[1] In the reorganization, in May 2010, MMS was split into three agencies: the Bureau of Ocean Energy Management, BSEE, and the Office of Natural Resources Revenue.

Revenue, another agency of DOI, which has an agreement with BSEE to support measurement of oil and gas production. Each agency minimizes its dependence on industry-provided logistics and accommodations to the extent possible. For example, BSEE and USCG share government-contracted offshore helicopter services and minimize inspectors' overnight stays in offshore facilities and consumption of industry-provided food.

None of the three agencies is authorized to advocate for the industry it regulates. That said, all of the agencies have a duty as outlined in the OCSLA to facilitate U.S. oil and gas production within the bounds of human and environmental safety. Each agency enforces prescriptive standards with similar but distinct processes and penalties. All have a dedicated staff for accident investigations and have historically participated jointly in investigations when warranted by circumstances. When deficiencies with respect to regulatory requirements are found, each agency has the authority to assess civil penalties. If evidence of criminal violations is found, the agencies refer that information to the Department of Justice for further investigation and potential prosecution. All agencies cooperate with the Department of Justice in the criminal investigations.

All three agencies use some form of risk-based approach for both strategic and tactical resource allocation for new work, such as development of regulations, and for daily assignment of inspectors. Each is influenced by lessons from previous major accidents and also monitors risk indicators such as personal injuries, spills, temporary loss of vessel or well control, introduction of new technologies, and known end-of-life-cycle operations. Each relies on industry-developed technical standards. Agency technical experts participate on standards development committees of industry associations such as the American Petroleum Institute (API)[2] and the International Association of Drilling Contractors (IADC), professional organizations such as the American Society of Mechanical Engineers (ASME), or international classification societies[3] such as the American Bureau of Shipping (ABS). Each agency references finalized industry standards throughout its regulations. However, because the industry consensus process differs from the public consensus process defined in the Administrative Procedures Act, agency regulations often augment industry standards with additional requirements resulting from external studies and public comments.

The OCSLA assigns responsibility for the safety and health of offshore workers to USCG, the principal federal agency in matters of safety and health on the OCS. BSEE also has some safety and health regulations applicable to OCS operations. The Occupational Safety and Health Administration (OSHA) retains responsibility for any matters related to worker safety and health for which neither USCG nor BSEE has requirements. USCG and OSHA responsibilities are clearly specified in a USCG/OSHA memorandum of understanding (MOU) dated December 19, 1979. According to Baram (2014), "OCSLA does not create any special role for labor unions or workers in its offshore safety regime," but it gives USCG authority to "review any allegation from any person of a violation of safety regulation."

When accidents or events that threaten people or equipment occur in the offshore industry, BSEE, USCG, and PHMSA all have roles and duties designed to mitigate loss of life, damage to the environment, and loss of offshore oil and gas production. Hurricane preparedness and response are well practiced and coordinated in the Gulf of Mexico because of the frequency

[2] API is a trade association that was founded during World War I.

[3] A classification society is an organization outside of the government whose primary purposes are to develop technical standards for the construction and operation of ships and offshore structures and to evaluate the extent to which ships and offshore structures meet those standards.

of hurricanes in the area. Responses to other incidents and accidents are less practiced but are still addressed in contingency plans and memorandums of agreement (MOAs) among the agencies.

All of the federal agencies involved in the offshore oil and gas industry and the industry itself have pursued a number of initiatives intended to improve the industry's safety record and help strengthen its safety culture. This chapter highlights the most prominent of these initiatives. The MMS and BSEE initiatives are summarized in Table 4-1. The remainder of this chapter reviews in turn federal safety management and safety culture initiatives, and international regulation of offshore oil and gas operations. It then considers approaches for advancing safety culture. The final section presents findings, conclusions, and recommendations.

TABLE 4-1 Milestones in the Development of the Mineral Management Service (MMS)/Bureau of Safety and Environmental Enforcement (BSEE) Safety and Environmental Management Systems (SEMS) Program and Safety Culture Policy

Year	Initiative	Significance
1990	Cullen Report on the *Piper Alpha* tragedy (1988, U.K. sector of the North Sea) published	Cullen called for a goal-setting regulatory regime that would emphasize management systems and safety case analyses. MMS studied Cullen's findings and began considering different regulatory approaches.
1990	The report *Alternatives for Inspecting Outer Continental Shelf Operations* released by the National Research Council	The report recommends that MMS refocus its regulatory program to increase the emphasis on human and organizational factors and management systems.
1991	MMS *Federal Register* Notice issued	MMS announced the safety and environmental management program (SEMP) concept and its intention to investigate alternative strategies for promoting safety and environmental protection.
1993	American Petroleum Institute (API) Recommended Practice (RP) 75 published	MMS participated in the development of RP 75, which was the first safety and environmental management standard for offshore oil and gas operations.
1996	MMS begins collecting SEMS performance measures data	The objective of this data collection effort was to measure industry progress in developing and evaluating SEMP programs.
1997	MMS begins conducting annual performance reviews of Outer Continental Shelf (OCS) operators	SEMP implementation was a topic of these face-to-face reviews.
1998-2000	SEMP Performance Measures Workshops held	MMS and industry discussed progress in implementing SEMP and reviewed performance data.
2002	SEMP changed to SEMS	This change was made in recognition of the comprehensive and systematic management approach required.
2004	API RP 75 update published	The update incorporated provisions to enhance environmental management.
2006	MMS publishes SEMS Advance Notice of Proposed Rulemaking (ANPRM)	MMS requested input on the direction of the regulatory program and the next steps in implementing SEMS.

(*continued*)

TABLE 4 (*continued*) **Milestones in the Development of the Mineral Management Service (MMS)/Bureau of Safety and Environmental Enforcement (BSEE) Safety and Environmental Management Systems (SEMS) Program and Safety Culture Policy**

Year	Initiative	Significance
2009	MMS publishes SEMS Notice of Proposed Rulemaking (NPRM) and convenes public meeting	In its first mandatory SEMS proposal, MMS proposed a limited SEMS program consisting of four elements—mechanical integrity, operating procedures, hazards analysis, and management of change.
2010	MMS publishes SEMS Final Rule	The SEMS Final Rule was published 3 months after the flow from the Macondo well had been stopped. It required SEMS programs that address all 12 elements of RP 75.
2011-2015	Center for Offshore Safety (COS)* provides SEMS support	COS developed auditing protocols and auditor accreditation programs.
2012	The report *Evaluating the Effectiveness of Offshore Safety and Environmental Management Systems* released by the National Academies' Transportation Research Board	The report considers methods for evaluating the effectiveness of safety management systems and emphasizes safety culture.
2012	BSEE publishes draft *Safety Culture Policy Statement*	The draft *Safety Culture Policy Statement* listed nine elements of a robust safety culture and requested comments.
2013	BSEE publishes SEMS II	This SEMS update promoted employee participation and empowerment. It also added a requirement for audits by accredited third parties
2013	BSEE publishes final *Safety Culture Policy Statement*	This was the first safety culture policy statement for oil and gas operations.in U.S. offshore waters.
2013	API committee initiates update to RP 75	The committee begins considering the addition of safety culture elements.
2015	A Pipeline and Hazardous Materials Safety Administration (PHMSA) and API committee publishes RP 1173	The goal of API RP 1173, which establishes requirements for pipeline safety management systems (PSMSs), is to provide a framework for reviewing an existing or developing and implementing a new PSMS.

* COS is a unit of API that was established in 2010 after the *Deepwater Horizon* incident.

FEDERAL SAFETY MANAGEMENT AND SAFETY CULTURE INITIATIVES

The three federal regulatory authorities with responsibility for offshore safety and environmental management (BSEE, USCG, and PHMSA) have long recognized that improved safety performance in the offshore oil and gas industry requires more than compliance with prescriptive standards. Each agency addresses the larger issues of safety culture in similar but not identical ways.

Department of Interior Regulatory Programs for the Outer Continental Shelf

The Safety and Environmental Management Program (SEMP)

In 1990, the National Research Council's (NRC) Committee on Alternatives for Inspection of Outer Continental Shelf Operations (NRC, 1990) completed a report for MMS that considered strategies for enhancing safety in the offshore industry and increasing the effectiveness of the OCS regulatory program. The NRC committee recommended that MMS refocus its regulatory program to increase the emphasis on human and organizational factors and management systems. MMS also was influenced by international developments, including the United Kingdom's regulatory reforms following the *Piper Alpha* tragedy and Norway's transition to a risk-based regulatory system.

In a 1991 *Federal Register* Notice, MMS announced its intent to consider new safety regulations in the form of the Safety and Environmental Management Program (SEMP). Central to the SEMP concept was the recognition that responsibility for safety rests with operators. Because safety performance, as reflected in casualty data, had reached a plateau, MMS believed that further gains were dependent on management and cultural improvements. MMS could not inspect safety into a company's culture; instead, it advocated a program to encourage a culture in which safety is integral to the way the industry does business, and all employees in each company, from roustabouts in the field to executives in the board room, make a total commitment to achieving safety. The goal of SEMP was to help sustain this type of culture in the offshore industry.

The American Petroleum Institute's Recommended Practice 75 (API RP 75)

For many years, MMS's approach to promoting safety and environmental protection involved prescriptive rules, review and approval of plans and permits, and inspection/enforcement. MMS's 1991 *Federal Register* Notice announced the agency's intention to investigate alternative strategies for promoting safety and protecting the environment and requested public input. Most respondents asked MMS to defer publishing SEMP regulations so the industry could develop a voluntary approach. Consistent with the objective of encouraging safety leadership by the industry, MMS accepted this recommendation. API, with MMS participation, subsequently developed and in 1993 published API RP 75, *Recommended Practices for Development of a Safety and Environmental Management Program for Outer Continental Shelf (OCS) Operations and Facilities*, and a companion hazards analysis document (API RP 14J).

After the publication of API RP 75, MMS worked with industry representatives to develop prototype plans for instituting a safety management system and auditing protocols that would assist those companies that had limited experience with safety management systems. A series of six workshops on performance measures and SEMP concepts, which were open to anyone in the industry, was held from 1998 to 2000 to focus attention on continuous improvement and effective administration of safety management systems. These safety management systems were viewed as a means of addressing human and organizational factors and enhancing safety culture.

The OCS Performance Data Survey

In 1996, MMS began collecting safety performance data that were submitted voluntarily by offshore operators. These data supplemented the required incident reports that MMS was already receiving. The voluntary submittals included incident rates normalized by hours worked and National Pollutant Discharge Elimination System (NPDES) discharge noncompliance rates. In 1997, MMS began conducting annual performance reviews of every offshore operator.[4] These mandatory performance reviews examined the operator's compliance with safety regulations and incident record, assessed its progress in implementing SEMP, and addressed topics of concern such as hurricane preparedness and crane safety.

In 2002, in response to a request by MMS, members of API and the Offshore Operators Committee (OOC) formed a steering committee to examine how the environmental component of API RP 75 could be enhanced. In response to the steering committee's suggestion, API expanded RP 75 to incorporate concepts from International Organisation for Standardization (ISO) 14001-Environmental Management Systems.[5] Thereafter, the MMS SEMP program became known as Safety and Environmental Management Systems (SEMS) in recognition of the comprehensive and systematic management approach that is required.

In 2000, enthusiasm for the voluntary SEMP/SEMS program began to wane, as evidenced by the decline in industry participation in a survey that was part of the OCS Performance Program (see Figure 4-1). This trend continued through the decade. As a result, MMS determined that additional action was needed to ensure that all operators were fully committed to comprehensive safety and environmental management programs.

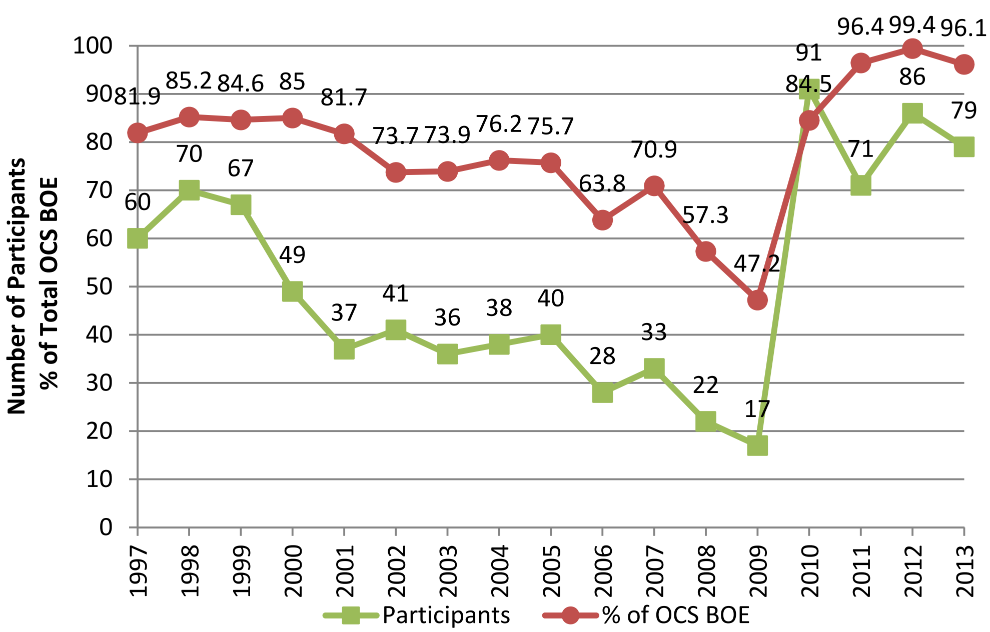

FIGURE 4-1 Number of participants in the Outer Continental Shelf Performance Data Survey, 1997 to 2013. Note: OCS = Outer Continental Shelf; BOE = barrel of oil equivalent. SOURCE: Adapted from BSEE (n.d.-a).

[4] https://www.gpo.gov/fdsys/pkg/FR-2006-05-22/html/E6-7790.htm. Accessed March 22, 2016.
[5] https://www.gpo.gov/fdsys/pkg/FR-2006-05-22/html/E6-7790.htm. Accessed March 22, 2016.

In 2006, MMS published an Advance Notice of Proposed Rulemaking (ANPRM) to seek public input on the direction of the regulatory program and the next steps in implementing SEMS. In the *Federal Register* (30 Code of Federal Regulations [CFR] Part 250, May 22, 2006), MMS offered the industry three options[6]:

1. Keep the Current Regulatory Program—continue the current program, which is largely based on overarching performance-based regulations supplemented by specific prescriptive safety and environmental regulations and requirements when necessary. The use of API RP 75, while encouraged, is strictly voluntary.
2. A Mandatory Limited SEMS Approach—continue the current regulatory program and add the four critical SEMS elements—hazard analysis, management of change, operating procedures, and mechanical integrity.
3. A Complete SEMS Approach—implement a new performance-based, comprehensive safety and environmental management approach. The MMS would develop performance-based regulations that address the 12 elements from API RP 75 and additional elements similar in nature to those detailed in Section 4 of ISO 14001[7].

While option 1 (maintenance of the current regulatory program) was voluntary, options 2 and 3 incorporated mandatory components. Consistent with their view that the OCS safety record was good and continuing to improve, OOC and API supported option 1 (status quo), indicating that the industry was not prepared to embrace mandatory SEMS requirements or a SEMS-based regulatory system. Other commenters, however, most notably offshore safety regulators from Norway, Australia, and the Netherlands, recommended a complete SEMS approach; they argued that SEMS should be fully, not partially implemented (option 2) because a total systems approach embracing all the SEMS elements (option 3) was needed to be successful in advancing safety in the offshore industry.

In the ANPRM, MMS also suggested the possibility of a SEMS pilot program in which a limited number of companies with outstanding performance records, as demonstrated by their incident and compliance data, could manage their operations under a comprehensive SEMS program (essentially option 3). For the duration of this pilot, participating companies would operate under a separate regulatory regime with fewer prescriptive requirements. The intent of the pilot program was threefold: (1) to determine whether SEMS should be expanded beyond a voluntary regulatory program, (2) to provide MMS with experience in auditing and using SEMS to advance safety and environmental protection, and (3) to determine whether SEMS is practical for the oil and gas industry as a whole or only specific companies.

Only one company, a major international producer, expressed interest in the pilot and the opportunity for reduced oversight (i.e., fewer inspections and approvals for pilot participants) and greater responsibility. In light of the limited industry interest and internal uncertainty, however, MMS did not pursue the SEMS pilot program.

After a 3-year period of information gathering and a continued decline in industry participation in the OCS Performance Data Survey, MMS published a Notice of Proposed Rulemaking (NPRM) (74 *Federal Register* [FR] 28639, June 17, 2009) for a limited, but mandatory, SEMS program consisting of four elements—mechanical integrity, operating

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[6] Excerpted from http://www.gpo.gov/fdsys/pkg/FR-2006-05-22/html/E6-7790.htm.
[7] ISO 14001 specifies the requirements of an environmental management system for small to large organizations. Section 4 contains environmental management system requirements.

procedures, hazards analysis, and management of change. In response to industry requests, MMS also convened a public meeting on September 2, 2009, in New Orleans to discuss the proposed rule. In their written and oral comments, API and OOC continued to oppose mandatory SEMS requirements and reiterated their position that the industry's safety record was excellent and improving.

The following API and OOC comment, which was submitted to DOI/MMS just 7 months prior to the *Deepwater Horizon* accident and was based on limited incident data, demonstrated a limited understanding of the importance of safety management in minimizing process safety risks during drilling operations (well control)[8]:

> OOC and API examined the 33 MMS Accident Panel Investigation Reports that were used as part of the justification for imposing a mandatory SEMS program. We noted that 14 of the 33 incidents (42%) were related to loss of well control events. While several of these events could be attributed in part to mechanical integrity issues, it was difficult for us to understand how a mandatory SEMS program would have prevented or otherwise changed the outcome of these specific events.

Most of those well control incidents were in fact related to the absence or failure of management systems and would have been prevented with more effective risk assessment, operating procedures, and project execution.

The API and OOC comment suggests a continued focus on compliance and a limited understanding of the connection between management systems and well control. In a subsequent comment, these organizations appeared to assert that well plans and MMS Application for Permit to Drill (APD) approvals were sufficient to ensure well control[9]:

> Well control is one of the cornerstones of any successful oil and gas exploration and production program. Both offshore operator well planning and MMS application of permit to drill (APD) reviews and approvals focus on ensuring that operator drilling programs maintain well control at all times. It is difficult to understand how a mandatory SEMS program will significantly influence what is already a vital and highly scrutinized activity.

This comment was submitted to DOI/MMS on September 15, 2009, 25 days after the Montara well blowout in the Timor Sea, which continued for another 50 days.

After the Montara blowout, many of the public statements from the U.S. oil and gas industry were focused on explaining why a Montara-like blowout could not happen in the United States, rather than expressing the industry's intent to learn more about the Montara incident and its causes and share that knowledge across the industry. Indeed, such an incident did subsequently happen in the U.S. OCS in the form of the *Deepwater Horizon* accident,[10] with much worse consequences. The root causes of Montara and Macondo well blowouts were

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[8] Excerpted from http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-05963.pdf. Accessed October 19, 2015.

[9] Excerpted from http://www.mdl2179trialdocs.com/releases/release201302281700004/TREX-05963.pdf. Accessed October 19, 2015.

[10] This accident occurred as a result of the Macondo well blowout and the explosion of the *Deepwater Horizon* rig.

similar. Had industry paid more attention to understanding and responding to the findings of the Montara inquiry, during which the management failures involved were discussed in great detail, the suspension of the Macondo well might have been managed better with less damage.

Final SEMS Rule: Mandatory SEMS Requirement

On October 15, 2010, 3 months after flow from the Macondo well had been stopped, the interim DOI regulator, the Bureau of Ocean Energy Management Regulation and Enforcement (BOEMRE[11]), published the Final SEMS Rule. The rule required operators to implement a SEMS program addressing all elements of RP 75 by November 15, 2011, and to submit their first completed SEMS audit to the new DOI regulator (BSEE) by November 15, 2013. More than 20 years after MMS had introduced SEMS (then referred to as SEMP), a mandatory SEMS requirement had finally been established. While it is impossible to say what would have happened if that accident had not occurred, many believe that SEMS would not be mandatory today were it not for that accident. The case study in Box 4-1 illustrates some of the weaknesses in the industry's collective safety culture: leadership, hazard identification and risk management, work processes, continuous improvement, and communication.

In 2012, the Transportation Research Board (TRB) published a follow-up report to the NRC (1990) report that had helped initiate the SEMS concept, The 2012 TRB report considers methods for evaluating the effectiveness of safety management systems. It also includes important comments regarding the development of a proper safety culture. Particularly noteworthy are the report's first two conclusions, which specifically address safety culture:

> Conclusion 1: If BSEE's goal is, as it should be, to encourage a culture of safety so that individuals know the safety aspects of their actions and are motivated to think about safety, then the agency will need to evolve an evaluation system for SEMS that emphasizes the evaluation of attitudes and actions rather than documentation and paperwork. All of the elements of SEMS must be addressed, but it is much more important that those who are actually doing the work understand and implement SEMS than it is that SEMS documentation be verified with a checklist.
>
> Conclusion 2: A SEMS program that contains all the elements laid out in the SEMS regulation is necessary but not sufficient for creating a culture of safety. An organization's safety culture will reduce risk; SEMS is but a means to that end.
>
> a. A culture of safety must be supported throughout the organization—from the top to the bottom—to be effective.
>
> b. A culture of safety only exists where the work occurs. If it does not actually drive the actions that people take, then it is only theoretical.
>
> Merely following a strict interpretation of a minimal SEMS program will not guarantee safe operations offshore. An effective SEMS program cannot rely on checklist compliance; the program must become ingrained in the operation's

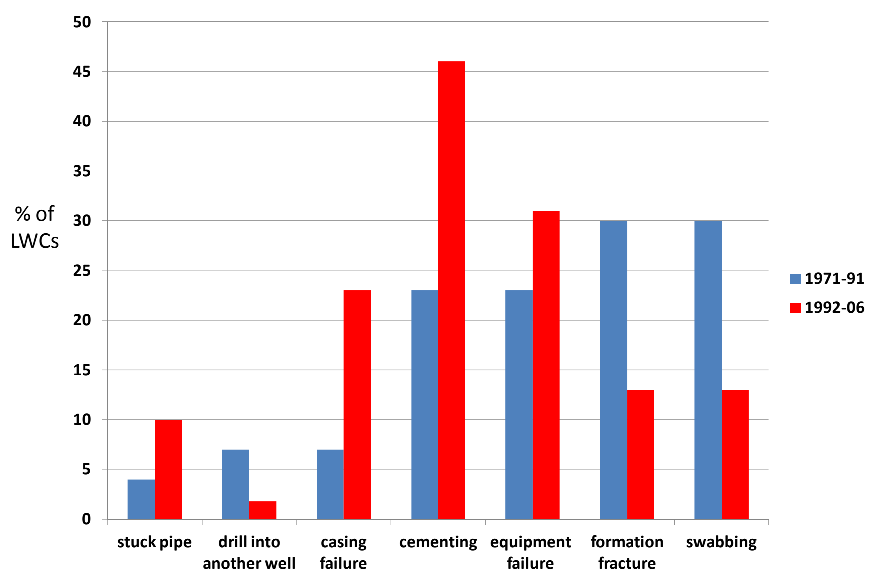
[11] BOEMRE, which replaced MMS, was replaced on October 1, 2011 by the Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE) as part of a major reorganization.

management structure to be successful. The tenets of SEMS must be fully acknowledged and accepted by workers and be motivated from the top. Only then can an effective culture of safety be established and grow.

Box 4-1

Cementing Standards

Among well control incidents occurring during 1971 to 1991 and 1992 to 2006, the greatest problem area was cementing operations. In 2000, the Minerals Management service (MMS) requested that the American Petroleum Institute (API) develop a cementing standard addressing the zonal isolation issues associated with many well control incidents. This project was repeatedly delayed, and the standard (Recommended Practice [RP] 65-2) was not issued until after the *Deepwater Horizon* accident in April 2010. RP 65-2 (issued in May 2010) and the revised version (Standard [S] 65-2) (issued in December 2010) effectively address the zonal isolation issues that were the root causes of the Montara and Macondo well blowouts in 2009 and 2010, respectively.



Factors that contributed to loss of well control (LWC) from 1971 to 1991 and from 1992 to 2006.

SOURCE: http://drillingcontractor.org/dcpi/dc-julyaug07/DC_July07_MMSBlowouts.pdf; Danenberger 1993.

This guidance from the TRB report is reflected in a subsequent BSEE rule known as SEMS II (effective as of June 4, 2013), which promotes employee participation and the empowerment of field-level personnel. (See Box 4-2 for a list of SEMS II requirements.) The rule also adds a requirement for audits by accredited third parties. This requirement is not entirely consistent with the TRB (2012) report, which emphasizes that the primary responsibility for auditing lies with operators and states that "a properly conducted, truly independent internal audit is potentially more effective than an independent third-party audit, as it reinforces ownership of the safety culture" (92). This committee concurs with that position. As discussed in the TRB (2012) report, both internal and third-party audits have their advantages, and operators should be responsible for determining the auditing approach that is most effective for their facilities and organization. The focus of regulators should be on assessing the quality and effectiveness of the audits, their findings, and follow-up actions.

Box 4-2

Bureau of Safety and Environmental Enforcement (BSEE)
Safety and Environmental Management Systems (SEMS II)

The SEMS II final rule expanded and revised the existing 30 Code of Federal Regulations (CFR) Part 250, Subpart S, regulations for SEMS and added several new requirements. Operators were required to integrate these new requirements into their existing SEMS program. The additional safety requirements contained in this final rule that were not covered in previous regulations included

- developing and implementing a stop work authority that creates procedures and authorizes any and all offshore industry personnel who witness an imminent risk or dangerous activity to stop work.
- developing and implementing an ultimate work authority that requires offshore industry operators to clearly define who has the ultimate work authority on a facility for operational safety and decision-making at any given time.
- requiring an employee participation plan that provides an environment that promotes participation by offshore industry employees as well as their management to eliminate or mitigate safety hazards.
- establishing guidelines for reporting unsafe working conditions that enable offshore industry personnel to report possible violations of safety, environmental regulations requirements, and threats of danger directly to BSEE.
- establishing additional requirements for conducting a job safety analysis.
- requiring that the team lead for an audit be independent and represent an accredited audit service provider.

SOURCE: Excerpted from BSEE (n.d. –b).

Consistent with SEMS II, the Center for Offshore Safety (COS), a unit of API that was established after the *Deepwater Horizon* accident, developed audit protocols, auditor accreditation programs, and guidance documents to facilitate the administration of SEMS. COS also gathers performance data that could improve risk assessments and promote continuous improvement. While COS is making important contributions to offshore safety, its affiliation with API, which is known for its public advocacy programs, raises questions about COS's objectivity, credibility, and motives. A COS that was independent from API would more likely be recognized as a safety leader in the United States and internationally. In addition, COS's influence is limited by the extent of its membership at this point in time. Initially, COS membership was open to deepwater operators only; however, when that restriction was lifted and membership was broadened to all organizations, independent companies with shelf operations elected not to join COS because of the cost of membership. As a result, COS membership is currently limited to 13 operating companies, most of which are major international producers. Although COS provides programs for accrediting auditors and gathering safety performance data, it is possible to comply fully with SEMS without being a member of COS.

The Final Incident Reporting Rule

When MMS published the ANPRM seeking public input on SEMS in 2006, a related and complementary regulatory action was taken when MMS published the final incident reporting rule on April 17, 2006. Because prior reporting requirements were not sufficiently specific, particularly with regard to less serious accidents, MMS was concerned that some incidents were not being properly reported. The intent of the new reporting rule was to improve the consistency and reliability of incident data so that trends could be better assessed and problem areas more readily identified.

During the public comment period, API and OOC strongly opposed the revised reporting rule. They thought the rule was overly prescriptive and burdensome,[12] and they questioned how the information would be used (71 FR 73 [April 17, 2006]). In response, MMS stated that incident reporting requirements had to be highly prescriptive to ensure consistency and comparability, and that the information would be used to assess the need for standards or regulatory changes, determine research needs, and identify unsafe procedures. MMS also said that these data would be available for free to the industry, which has no comprehensive incident data system. MMS expected the data to be of great assistance to the oil and gas industry in developing risk assessments and continuously improving their safety programs.

A marked spike in the numbers of injuries, fires, and crane incidents after the publication of the new rule suggested that the reporting of these incidents had been incomplete in previous years.

Gas Release Incident Reporting

Another requirement that MMS considered was the reporting of gas release incidents, which are important leading indicators of process safety issues. This type of data was already being collected and analyzed by safety regulators in the United Kingdom, Norway, Australia, the Netherlands, Brazil, Canada, and elsewhere. Despite the international consensus in support of analyzing gas release incident data, however, API and OOC strongly objected to their collection

[12] http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/incidents/AC57-4-17-06-pdf.

and elevated their concerns about this and other provisions in the reporting rule to the Office of Management and Budget (OMB). Although MMS was generally successful in making its case before OMB, ultimately the gas release reporting requirement was compromised—only gas releases that initiate an equipment or process shutdown had to be reported. As a result, BSEE is still unable to assess gas release data in a meaningful manner and cannot compare such data for the United States with those from other countries.

Deepwater Operations Plans (DWOP) Program

Another important development during the "voluntary SEMS era" of the 1990s and 2000s was the Deepwater Operations Plans (DWOP) program (30 CFR, Subpart B § 250.285 to § 250.295). In the absence of regulations and industry standards for deepwater production facilities, MMS had to assess projects in a more holistic manner. DWOP, which are analogous to safety cases and are dependent on comprehensive risk and barrier assessments, became the primary means of regulating deepwater development projects. The DWOP program has been extremely successful; since its implementation in 1995, more than 6 billion barrels of oil and 17 billion cubic feet[13] of gas have been produced from deepwater (greater than 1,000 ft) facilities with only one fatality (a crane incident) and no significant pollution incidents.[14] Through 2013, 1,271 DWOP had been approved for 410 deepwater projects.[15]

In contrast with deepwater production facilities, deepwater drilling operations have been regulated in a more traditional manner, and their performance record has not been exceptional. The overall fatality rate for deepwater wells has been higher than that for shelf drilling—0.0072 versus 0.0048 fatalities per well (see Table 4-2). The higher fatality rate per well may be attributable in part to the added time required to drill deepwater wells and the greater complexity of these operations. However, one would expect these time and complexity factors to be offset somewhat by the use of newer equipment and assignment of the best personnel to costly deepwater projects.

TABLE 4-2 Fatality Rates for Deepwater Versus Shelf Drilling (from the 1950s Through 2013)

Drilling Type	Drilling Fatalities[a]	Wells Drilled[b]	Fatalities/Well
Deepwater	31	4,315	0.0072
Shelf	229	47,789	0.0048

[a]Figures calculated using data from http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Listing-and-Status-of-Accident-Investigations.
[b]Figures calculated using data from http://www.data.bsee.gov/homepg/data_center/well/borehole/master.asp.

[13] https://www.data.bsee.gov/homepg/data_center/production/production/summary.asp. Accessed September 25, 2015.
[14]Information obtained from BSEE incident and production data. http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Listing-and-Status-of-Accident-Investigations. Accessed October 19, 2015.
[15] Information from the presentation of Mike Conner, BSEE, at the 2014 BSEE Standards Workshop that was held in NOLA, January 28–29, 2014.

With regard to process safety, the deepwater drilling record was quite good prior to the Macondo incident. On average, losses of well control occurred at a rate of 1 incident per 499 deepwater wells drilled during 1992-2006, compared with 1 per 370 wells drilled on the shelf. No fatalities were associated with any of these deepwater wells.[16] However, a disaster like Macondo would likely have been prevented with a more holistic assessment of risks, barrier management practices, and operational controls, as practiced in the DWOP program.

BSEE's Safety Culture Policy Statement

SEMS is now an integral part of an ongoing effort by BSEE to emphasize the role of management systems and human and organizational factors in maintaining a safe working environment. Consistent with these objectives, BSEE released a draft *Safety Culture Policy Statement* on December 20, 2012. This policy statement appeared to be a positive message that all parties could embrace. Despite assurances from BSEE that no safety culture regulation was being proposed or considered, however, OOC raised concerns that the draft policy statement could lead to new regulations. OOC commented that MMS had reneged on its commitment to voluntary SEMS, even though SEMS was a voluntary program for 20 years despite inconsistent industry participation, implying that BSEE could do the same with respect to its safety culture policy. In letter sent to BSEE dated March 20, 2013, OOC also cast doubt on the effectiveness of mandated safety culture regulations by criticizing the pioneering safety culture program of the Petroleum Safety Authority of Norway:

> As can be seen from the Petroleum Safety Authority Norway (PSA) experience, mandating a safety culture may not always achieve the desired results.

This comment is puzzling because PSA is highly respected in Norway and internationally; the Norwegian offshore industry has an outstanding safety record; and PSA's safety culture program has widespread support in the Norwegian oil and gas industry. BSEE's final *Safety Culture Policy Statement*, published on May 9, 2013, outlined the agency's approach to safety culture, provided a common definition of safety culture, and informed the offshore community about BSEE's safety expectations. In issuing the policy statement, BSEE noted its commitment to a regulatory approach designed to lead the offshore oil and gas industry beyond checklist inspections toward a systemic, comprehensive safety regime. The BSEE definition of safety culture and BSEE's nine characteristics of a robust safety culture are discussed in Chapter 2.

A Vision for Appropriate Regulation

Since 1990, the regulatory agencies and industry groups have undertaken a number of initiatives to advance safety in the oil and gas industry (those of MMS/BSEE are summarized in Table 4-1). While the SEMS and safety culture initiatives are important steps, as is the BSEE initiative to establish a voluntary near-miss reporting program called the SafeOCS, which was formally launched on May 5, 2015, the implications of these actions for the broader regulatory program remain unclear. A "prescribe, approve, and inspect" culture is still deeply rooted in the industry and the regulatory agencies. Most of the regulatory changes in the immediate aftermath of the

[16] http://drillingcontractor.org/dcpi/dc-julyaug07/DC_July07_MMSBlowouts.pdf.

Deepwater Horizon accident reinforced this traditional compliance culture instead of emphasizing management systems, risk assessment, operator responsibility, and safety culture. The 2010 BOEMRE Drilling Safety Rule (75 FR 198 [October 14, 2010]) produced prescriptive operating requirements and more regulatory reviews and approvals. The companion SEMS rule was an add-on to the regulatory program rather than its new centerpiece. There was no apparent change in the fundamental regulatory philosophy, and most of the regulators' resources continued to be dedicated to sustaining the traditional "prescribe, approve, and inspect" programs.

The challenge for BSEE is to identify the path forward that would be most effective in achieving and sustaining outstanding safety and environmental performance. To meet this challenge, several questions must be answered:

- Is the traditional regulatory program conducive to safety leadership, personal accountability, teamwork, dialogue, risk-free reporting, dialogue, and other characteristics of an advanced safety culture?
- Should BSEE transition to a SEMS-based regulatory program with prescriptive requirements only as necessary to monitor and assess performance?
- Should the DWOP approach be expanded to other complex operations, such as deepwater and Arctic drilling?

For those who favor greater emphasis on safety management systems and culture, the BSEE SEMS program has offered some encouragement. While BSEE's mission statement mentions only "vigorous regulatory oversight and enforcement," its vision statement now emphasizes innovation, culture, risk reduction, and collaboration:

> BSEE Mission: BSEE works to promote safety, protect the environment, and conserve resources offshore through vigorous regulatory oversight and enforcement.
>
> BSEE Vision: We will expand our role as a world leader in safety and environmental stewardship. With innovative regulatory approaches and appropriate collaboration with industry, we will foster a culture of risk reduction and compliance among operators that results in reducing the risk of accidents and spills and an enhanced ability to respond to those that do occur with prompt and appropriate regulatory action. We will serve as a model for other regulatory agencies and international peers and attract the best graduates and experts in engineering and technology through our unrivaled training and expertise.

The offshore industry as a whole needs to begin by developing its vision of appropriate regulatory oversight and a strategic plan for achieving its safety and environmental objectives. Its vision needs to include a description of the regulatory system that can best enable the accomplishment of these objectives, encourage continuous improvement, and enhance safety culture, while its strategic plan needs to include a strategy for safety leadership. Historically, the industry has opposed most regulatory initiatives but has offered no vision for the type of regulatory system it supports. The industry also needs to demonstrate that it can address fundamental and long-standing management concerns. For example, a technologically advanced industry might be expected to have sophisticated incident data collection and analysis capabilities, which still is not the case. Other concerns, such as the consistency and rigor of industry standards and the absence of an independent safety organization, need to be addressed as well. The industry should begin with a vision statement and a strategy for safety leadership. While each company is responsible for its own safety performance, the industry as a whole needs to be collectively committed to a culture that can provide the best opportunity for creating and maintaining a safe working environment.

The U.S. Coast Guard's Approaches to Offshore Safety Culture

The Prevention Through People (PTP) Program

USCG's approach to addressing safety problems due to human and organizational causes in the offshore and marine industry includes the International Safety Management (ISM) Code and a nonregulatory program called Prevention Through People (PTP). The ISM Code, developed by the International Maritime Organization (IMO),[17] became mandatory for ships in 1998 and for mobile offshore drilling units (MODUs) and offshore support vessels in 2002. It addresses the responsibilities of those who manage and operate ships and MODUs and prescribes international standards for carrying out those responsibilities, including pollution prevention, safely. To this end, the code requires that ships, MODUs, and offshore support vessels have safety management systems. Application of the ISM Code is intended to support and encourage the development of a safety culture in both shipping and offshore operations.

The PTP program is described as "a systematic people-focused approach to reducing casualties and pollution."[18] Developed by USCG in cooperation with the maritime and offshore industry, it is based on the recognition that "safe and profitable operations require the constant and balanced interactions between management, workers, the work environment, and technology."[54] In effect, the program encourages companies to assess their safety culture. The vision of PTP is "to achieve the world's safest, most environmentally sound and cost effective marine operations by emphasizing the role of people in preventing casualties and pollution."[19] USCG and the marine community believe that the PTP vision could achieve a safety culture through the persistent application of five principles: (1) honor the mariner/worker, (2) take a quality approach, (3) seek nonregulatory solutions, (4) share commitment, and (5) manage risk.[20] The program has encouraged the marine and offshore industry to work in concert to improve safety culture and therefore safety performance. One such effort addressed current safety and environmental issues through joint government-industry quality teams that developed practical actions that could be quickly implemented. This model of USCG and industry jointly tackling specific safety issues continues today.

In its review of the PTP program, the NRC's Subcommittee on Coordinated Research and Development Strategies for Human Performance to Improve Marine Operations and Safety (NRC, 1997) stated the following:

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[17] IMO is a United Nations agency that sets global standards for safety, security and environmental performance for the international shipping industry.

[18] http://www.uscg.mil/proceedings/archive/1999/Vol56_1999Special_Issue.pdf. Accessed March 22, 2016.

[19] http://testimony.ost.dot.gov/test/pasttest/97test/kramek1.pdf. Accessed March 25, 2016.

[20] http://www.uscg.mil/proceedings/archive/2000/Vol57_No2_Apr-Jun2000.pdf. Accessed March 22, 2016.

> The PTP program is a bold departure from the traditional use of regulation to address safety issues. The sub-committee believes the PTP concept is extremely valuable, particularly in its balanced approach to risk management and its emphasis on partnership. The PTP program recognizes the need for all participants in the marine transportation system (including government agencies, industry, classification societies, industry associations and mariners) to work cooperatively to increase system effectiveness and safety.

In effect, the NRC committee embraced USCG's approach to improving a safety culture by involving all stakeholders, including government and industry. Combined with USCG's regulatory requirement for safety management systems for ships, MODUs, and offshore support vessels in the ISM Code, the PTP program goes beyond regulation to address the prevention of accidents by focusing on the people who do the work, as well as those who manage at all levels of the organization. In fact, many industry leaders have become "Champions of Prevention through People" and provided guidance to USCG.

It merits noting that the PTP program is inherently different from safety management systems. While the DOI experience reviewed above suggest that safety management systems should be mandatory, safety culture programs are difficult to manage. In fact, external, mandatory regulatory requirements may be antithetical to the concept of safety culture, which must be developed and maintained internally.

QUALSHIPS 21

Another program initiated by USCG to foster safety culture in the shipping industry is QUALSHIPS 21, which recognizes high-quality foreign-flag ships that visit U.S. ports and rewards them for their commitment to safety and quality. In January 2001, USCG implemented this program "to identify high-quality ships and provide incentives to encourage quality operations."[21] For example, ships that meet QUALSHIPS 21 criteria relative to those that do not are inspected less frequently by USCG.

Safety and Environmental Management Systems for Vessels in the OCS

USCG has announced that it is considering developing a SEMS regulation (ANPRM, September 13, 2013, Safety and Environmental Management System Requirements for Vessels on the U.S. Outer Continental Shelf; 33 CFR Parts 140, 141, 142, 143, 144, 145, 146, and 147 [*Federal Register* 2013]) for its segment of the offshore industry. This regulation would be a companion to BSEE's SEMS and SEMS II.

Safety Management and Safety Culture Initiatives of the Pipeline and Hazardous Materials Safety Administration

PHMSA has jurisdiction over a 1.66 million mile pipeline network, a small fraction of which is on the OCS. Jurisdiction over OCS pipelines is divided between BSEE and PHMSA in accordance with a 1996 MOU. As described in the MOU, as well as regulations of BSEE (30 CFR Part 250) and PHMSA (49 CFR parts 192 and 195), PHMSA has jurisdiction over

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[21] http://www.uscg.mil/hq/cgcvc/cvc2/psc/safety/qualship.asp. Accessed March 22, 2016.

transporter-operated OCS pipelines and producer-operated pipelines downstream of the last valve on the last OCS production facility to which the pipeline is connected. Currently, active pipelines on the OCS total 19,117 miles[22]—11,831 miles overseen by USDOT (PHMSA) and 7,286 miles by DOI (BSEE). In 2007, active pipelines on the OCS totaled almost 25,000 miles of active pipeline, almost 25,000 miles, divided about equally between BSEE and PHMSA jurisdiction. The reduction in active pipeline mileage, particularly that overseen by BSEE, reflects the decrease in production and infrastructure in the shallow water areas of the Gulf of Mexico.

BSEE incident data reveal that during the past 10 years (2005-2014), five fatalities have been associated with pipeline operations. Four of the five involved diving operations, while the other fatality occurred when an employee was struck by equipment on a pipe lay barge. According to BSEE spill data for all OCS pipelines, most of the pipeline spills of 50 barrels or more during this 10-year period were associated with hurricane damage (see Table 4-3).

PHMSA's jurisdiction is much broader than the offshore sector. Thus an overview of its regulatory program needs to consider the entire U.S. pipeline network, of which 80 percent is used for gas distribution, 12 percent for gas gathering and transmission, and 7 percent for carrying hazardous liquids (USDOT n.d.). Despite the vast and aging pipeline infrastructure, pipeline safety and spillage records have generally improved over the past two decades. The number of pipeline incidents resulting in major injuries or deaths declined from 65 (yearly average from 1991–2000) to 41 (yearly average from 2001–2010), and the number of liquid pipeline spill incidents, including spills of any amount, declined from 153 in 2002 to 116 in 2011 (USDOT n.d.). However, recent major incidents have demonstrated weaknesses in some operators' safety management systems, including insufficient knowledge of pipeline risk characteristics and inadequate evaluation of options for reducing or mitigating consequences.

Integrity Management Programs for Pipeline Operators

PHMSA and the pipeline industry have applied integrity management principles to advance safety in this complex and diverse industry. "Pipeline Integrity Management in High Consequence Areas" (49 CFR 195.452) outlines a process for evaluating and reducing pipeline

TABLE 4-3 Oil Spills (>50 barrels) from All Department of Interior and U.S. Department of Transportation Pipelines in the U.S. Outer Continental Shelf (OCS) and Their Causes (2005–2014)

Cause /Year	Number of Spills	Volume per Spill (barrels)
Hurricanes Katrina and Rita, 2005	10	50 to 960
Hurricane Ike, 2008	6	55 to 1,316
Human error, external impact, and equipment failure, 2006	1	870
Human error, 2007	1	187.5
Equipment failure, 2009	1	1,500

SOURCE: BSEE n.d. -c.

[22] Bimal Shrestha, BSEE, personal communication, May 29, 2015.

risks.[23] PHMSA conducted a risk management demonstration project in the late 1990s and advised Congress that risk management could indeed supplement the PHMSA regulations, with an emphasis on high-consequence areas (HCAs). HCAs are defined as areas where a pipeline failure would have a significant impact on public safety or the environment; they include populated areas, areas containing drinking water and sensitive ecological resources,[24] and commercially navigable waterways[25]. Subsequently, the Pipeline Safety Improvement Act of 2002 (P.L. 107-355)[26] required PHMSA to develop and issue regulations addressing risk analysis and integrity management programs for pipeline operators (the core elements of integrity management programs are listed in Box 4-3). Consistent with that act, PHMSA has issued regulations and guidance that establish processes for managing pipeline risks. Pipeline operators must prioritize, assess, evaluate, repair and validate the integrity of hazardous liquid or gas pipelines that could, in the event of a leak or failure, affect HCAs.[27] Integrity management programs identify HCAs; integrate construction, operating, and inspection data; analyze risks by pipeline segment; establish corrosion, damage assessment, and repair procedures; and describe continuous improvement programs.

API RP 1173, Pipeline Safety Management System

PHMSA considers an integrity management program to be one of the operational controls within a broader safety management system. Recognizing that comprehensive safety management systems and a strong safety culture are critical to continuous improvement and outstanding safety performance, PHMSA and an API committee issued API RP 1173, specifying pipeline safety management system (PSMS) requirements, in July 2015. The goal was to provide a framework for reviewing an existing or developing and implementing a new PSMS. API RP 1173 provides the flexibility needed to apply it to unique operating environments and varied pipeline systems. Its essential elements include the following:

- Leadership and management commitment;
- Stakeholder engagement;
- Risk management;
- Operational controls;
- Incident investigation, evaluation, and lessons learned;
- Safety assurance;
- Management review and continuous improvement;
- Emergency preparedness and response;
- Competence, awareness, and training; and
- Documentation and recordkeeping.

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[23] http://www.ingaa.org/File.aspx?id=16945. Accessed March 24, 2016.
[24] https://primis.phmsa.dot.gov/comm/FactSheets/FSHCA.htm. Accessed March 24, 2016.
[25] https://primis.phmsa.dot.gov/iim/faqs.htm. Accessed April 29, 2016.
[26] https://www.gpo.gov/fdsys/pkg/PLAW-107publ355/content-detail.html. Accessed March 24, 2016.
[27] https://www.federalregister.gov/articles/2003/12/15/03-30280/pipeline-safety-pipeline-integrity-management-in-high-consequence-areas-gas-transmission-pipelines#h-9. Accessed March 24, 2016.

Box 4-3

Core Elements of Integrity Management Programs for Pipeline Operators

- Identifying all locations where a pipeline failure might impact an HCA.
- Developing a risk-based plan (known as the Baseline Assessment Plan) to conduct integrity assessments on those portions of the pipeline. Integrity assessments are performed by in-line inspection (also referred to as "smart pigging"), hydrostatic pressure testing, direct assessment or other technology that the operator demonstrates can provide an equivalent understanding of the condition of the line pipe.
- Integrating the assessment results with other relevant information to improve the understanding of the pipe's condition.
- Repairing pipeline defects identified through the integrated analysis of the assessment results.
- Conducting a risk analysis to identify the most significant pipeline threats in segments that can affect HCAs. Examples of pipeline threats include corrosion, excavation-induced damage, material defects, and operator errors.
- Identifying additional measures to address the most significant pipeline threats. These measures include actions to prevent and mitigate releases that go beyond repairing the defects discovered through integrity assessment.
- Regularly evaluating all information about the pipeline and its location-specific integrity threats to determine when future assessments should be performed and what methods should be selected to conduct those assessments.
- Periodically evaluating the effectiveness of the integrity management program and identifying improvements to enhance the level of protection.
- Identifying the specific integrity assessment method(s) for each segment that can affect an HCA. These methods must be based on the identification of the most significant integrity threats for the specific segment.

SOURCE: Excerpted from http://www.pipelinesafetyinfo.com/integrity_management_programs. Accessed March 24, 2016.

Building on the RP 75 experience, members of the RP 1173 committee added new elements, most notably safety culture, to the PSMS. RP 1173 includes indicators of a positive safety culture within an organization and also addresses evaluation of a safety culture[28]:

> The pipeline operator shall establish methods to evaluate the safety culture of its organization. Operators shall assess the health of their safety culture using methods that assess employee perception of the safety culture. Methods to assess the perception of the culture include but are not limited to questionnaires,

[28] Excerpted from http://www.pipelinelaw.com/files/2014/09/API-RP-1173.pdf. Accessed October 19, 2015.

> interviews, and focus groups. Policies, operating procedures, continuous vigilance and mindfulness, reporting processes, sharing of lessons learned and employee and contractor engagement support an operator's safety culture. Observations and audits of how each of these are being applied in the daily conduct of operations provide indications of the health of an organization's safety culture, including conformance with policies, adherence to operating procedures, practicing vigilance and mindfulness, utilizing reporting processes, integrating lessons learned and engagement of employees and contractors. Failure in application of these provides an indication of potential deterioration of the safety culture. Management shall review the results and findings of perception assessments, observations and audits and define how to improve application of the supporting attributes.

The elements of safety culture in RP 1173 are similar but not identical to those outlined by BSEE (see Chapter 2). RP 1173 defines safety culture as the shared values, actions, and behaviors that demonstrate a commitment to safety over competing goals and demands. It identifies the critical elements of a strong safety culture as follows:

- Leadership is clearly committed to safety.
- There is open and effective communication across the organization.
- Employees feel personally responsible for safety.
- The organization practices continuous learning.
- The work environment is safety-conscious.
- Reporting systems are clearly defined and nonpunitive.
- Decisions demonstrate that safety has priority over competing demands.
- Mutual trust is fostered between employees and the organization.
- The organization is fair and consistent in responding to safety concerns.
- Training and resources are available to support safety.

The inclusion of the elements of safety culture in RP 1173 will increase attention to the importance of a strong safety culture and encourage companies to integrate cultural considerations fully into their management programs. To date, PHMSA has not incorporated this standard into its regulations, hence operators are not required to conform with it; however, the pipeline industry collaborated in its development and approved it. The RP 75 committee is currently drafting a revision of that standard which offers an opportunity to incorporate a chapter on safety culture and its elements as in RP 1173.

INDUSTRY SELF-REGULATION AND THIRD-PARTY INITIATIVES

Oil and Gas Industry Initiatives

The U.S. offshore industry prides itself on a history of self-regulation. Pioneering companies that ventured offshore, such as Kerr-McGee and Shell Oil, actively participated in standards development through appropriate API committees and through safety programs organized by OOC, IADC, and the Society of Petroleum Engineers (SPE). These industry-led organizations developed the engineering standards and best practices that largely serve as the foundation for offshore exploration and development throughout in the world. For example, most API standards are translated into ISO standards and further referenced by national regulations wherever offshore drilling and production occur. Except for certain API monogram equipment and individual certification services, offshore operators use industry standards themselves as the basis for internal engineering, construction, and operation quality control. Most offshore operators and their contractors employ health, safety, quality, and environmental (HSQE) specialists to verify compliance with industry standards, as well as company policies and contract stipulations.

As discussed in Chapter 2, the offshore industry does not have a common definition of safety culture. Instead, it has focused on safety management practices. Developed years before the 2010 *Deepwater Horizon* accident, API RP 75 prescribes best practices that should be included in a company safety management program and suggests that company HSQE personnel audit records on each offshore platform or rig regularly. After the *Deepwater Horizon* accident, BSEE made API RP 75 mandatory for all offshore operators by incorporating it into the SEMS regulations.

As mentioned in Chapter 3, the industry also responded after the *Deepwater Horizon* accident by establishing COS within API. The focus of COS is on assisting deepwater operators with safety management by developing standardized audit procedures, accreditation programs for auditors, and data sharing mechanisms. The COS Safety and Environmental Management System auditor certification standard has been officially recognized by BSEE.

COS works with industry stakeholders to promote the highest level of safety for the U.S. offshore oil and gas industry through effective leadership, communication, teamwork, utilization of disciplined management systems, and independent third-party auditing and certification. It works to draw lessons learned from successful safety management programs, and to stimulate cooperation and sharing among industry participants to enhance the collective safety management knowledge of the industry and develop tools and good practices based on that knowledge. The agency's responsibilities, mission, and objectives can be found at its website.[29]

Three independent third-party organizations—ABS Quality Evaluations (ABS-QE), Bureau Veritas Certification (BV), and DNV Business Assurance (DNV)—have been fully accredited by COS to conduct SEMS audits for operators and contractors, following the audit protocol established by COS. As accredited audit providers, ABS, BV, and DNV evaluate the implementation and effectiveness of SEMS that can lead to their certification to COS standards.[30]

To date, BSEE has incorporated three COS documents into the new SEMS II rule: the COS-2-01 *Qualification and Competence Requirements for Audit Teams and Auditors Performing Third-party SEMS Audits of Deepwater Operations*, the COS-2-03 *Requirements for Third-party SEMS Auditing and Certification of Deepwater Operations*, and the COS-2-04 *Requirements for Accreditation of Audit Service Providers Performing SEMS Audits and Certification of Deepwater Operations*.[31]

COS could be even more effective in encouraging safety management practices across the industry if its members and associate members represented a larger cross-section of the industry. Barriers to this expansion of membership may include the annual cost of membership

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[29] http://www.centerforoffshoresafety.org. Accessed August 4, 2015.
[30] http://www.centerforoffshoresafety.org/COS-Accreditation-Press-Release-FINAL.pdf. Accessed March 22, 2016.
[31] http://www.centerforoffshoresafety.org/COS-Membership-Expansion.pdf. Accessed March, 22, 2016.

and the requirement to undergo regular SEMS audits and make the data available. There also is a perception of bias because COS is associated with API, which, in addition to its extensive work on industry standards and safety, is also an advocate for operators.

On the third anniversary of the Macondo incident (April 2013), most members of the Oil Spill Commission Action project[32] reiterated that an organization independent of API is needed. Their 2013 report[33] states:

> The industry-sponsored Center for Offshore Safety, which has focused on developing criteria for certifying safety and environmental auditors, holds promise of helping to ensure that the firms involved in offshore drilling perform at the top of their game, but more needs to be done. We continue to believe, however, that if it is to establish widespread credibility the Center when fully operational should become independent of the American Petroleum Institute (API).

Safety Approaches of Other Industries: A Model for the Offshore Industry?

Other industries have taken somewhat different approaches to ensuring safety in their operations from that taken by the offshore industry. The Institute of Nuclear Power Operations (INPO), for example, was founded by the nuclear industry after the partial meltdown of the Three Mile Island nuclear power plant in 1979. Like the *Deepwater Horizon* accident, that incident brought national attention to questions of industry safety and integrity, as well as a severe loss of public trust. The leaders of the nuclear power industry responded to guidance from the Three Mile Island Presidential Commission[34] that it “dramatically change its attitude toward safety and regulations.” The needed changes included a system to set and police its own standards of excellence to ensure effective management and safe operation of nuclear power plants. Shortly after the commission issued its report in 1979, the leaders of the nuclear industry created INPO as a nonprofit organization. INPO’s mission is “to promote the highest levels of safety and reliability—to promote excellence—in the operation of commercial power plants.”[35] The immediate past CEO/president of INPO[36] cited to the committee five key factors that have allowed INPO to be successful:

- CEO engagement,
- A focus on nuclear safety (and nothing else),
- Industry support,
- Accountability, and
- Independence from the boards of the member companies, members (individual member companies), and the regulator.

[32] This commission is an outgrowth of the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling, which, as discussed in previous chapters, President Obama established in response to the explosion of the Macondo well in the Gulf of Mexico on April 20, 2010.
[33] http://oscaction.org/wp-content/uploads/FINAL_OSCA-No2-booklet-Apr-2013_web.pdf.
[34] http://www.threemileisland.org/virtual_museum/pdfs/188.pdf. Accessed March 25, 2016.
[35] http://www.inpo.info/AboutUs.htm. Accessed March 25, 2016.
[36] Admiral James Ellis, U.S. Navy (retired), personal communication, Washington, D.C., October 7, 2014.

The National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling considered the applicability of the INPO model to the offshore oil and gas industry. Citing both similarities and differences between the nuclear power and offshore oil and gas industries, the National Commission made a strong case for a self-regulatory model for the offshore industry based on a modification of nuclear model:

> Like the nuclear power industry in 1979—in the immediate aftermath of the Three Mile Island accident—the nation's oil and gas industry needs now to embrace the potential for an industry safety institute to supplement government oversight of industry operation. Akin to INPO such a new safety institute can provide the nation with assurances of safety necessary to allow the oil and gas industry access to the nation's energy resources on the outer continental shelf.

The National Commission also suggested that the INPO model could serve as the touchstone for the offshore industry, but that to be credible, the industry's institute would need to be completely free from other interests and agendas and separate from API. The institute's success would also depend on industry-wide commitment to rigorous auditing and continuous improvement; in effect, all operators on the COS would have to participate in the institute. COS meets some of these criteria, but it is not independent and does not represent all offshore operators (see Box 4-4 for the COS mission and objectives).

Box 4-4

Center for Offshore Safety: Mission and Objectives

The Center for Offshore Safety is designed to promote the highest level of safety for offshore drilling, completions, and operations through leadership and effective management systems addressing communication, teamwork, and independent third-party auditing and certification. COS will achieve operational excellence by

- Enhancing and continuously improving industry's safety and environmental performance
- Gaining and sustaining public confidence and trust in the oil and gas industry
- Increasing public awareness of the industry's safety and environmental performance
- Stimulating cooperation within industry to share best practices and learn from each other
- Providing a platform for collaboration between industry, the government, and other stakeholders

SOURCE: Excerpted from http://www.centerforoffshoresafety.org/about.html. Accessed April 29, 2016.

In developing COS, organizers considered not only INPO, but also other programs as potential models, including the United Kingdom's Step Change in Safety, the chemical industry's Responsible Care program, for Nuclear Power Operation, OSHA's Voluntary Protection Program, and the Safety Case Regime for international operators.[37] A notable example of a safety organization that COS should also consider is the Center for Chemical Process Safety (CCPS), which was formed by the American Institute of Chemical Engineers, a professional society representing more than 50,000 members in industry, academia, and government. CCPS was formed in 1985 after the 1984 Bhopal gas leak disaster and has since been the leading source of guidelines and other chemical process safety materials.

The Role of Third-Party Organizations

The U.S. government recognizes certain third-party organizations, including classification societies, independent training institutions, and testing laboratories to act on behalf of the government regulators. These are not advocacy organizations, and unlike API and other industry-led organizations, they receive no member contributions. Instead, they rely on fees for service. Some have a not-for-profit status, but they are not charities. For example, the American Bureau of Shipping, a classification society established in 1862, reinvests revenues exceeding expenses back into training, technology, and standards development.

Classification societies are the only third parties employing surveyors and auditors who routinely go offshore to verify compliance with specifications and audit management systems. Unlike the marine transportation industry, in which International Maritime Organization (IMO) standards are applied when audits are conducted, the offshore oil and gas industry does not subscribe to a single worldwide standard. The business model for classification societies depends on minimizing casualties, pollution, and operational downtime for their clients. Classification society engineers, surveyors, and auditors tend to promote higher standards and more thorough oversight of the industry when they perceive that the consequences of an accident scenario have increased.

Currently, USCG recognizes certain classification societies, including the American Bureau of Shipping, for conducting engineering reviews, offshore inspections, and management system audits on its behalf. BSEE recognizes the American Bureau of Shipping and other third parties on a case-by-case basis, to be hired by an offshore operator as a certified verification authority.

INTERNATIONAL REGULATION OF OFFSHORE OIL AND GAS OPERATIONS

Different nations take different approaches to establishing safety in their offshore oil and gas operations. More than 80 nations have established or planned offshore oil and gas safety programs. Their regulatory systems are influenced by their governmental structure, the respective roles of state/provincial and federal authorities, the size and sophistication of the operating companies and contractors, the presence of national oil companies and the manner in which such public entities are regulated, the respective roles of existing agencies, the role of labor organizations, the government's familiarity with the maritime industry, the presence of onshore energy and mineral development activities, cultural factors, and outside influences

[37] COS website FAQs http://www.centerforoffshoresafety.org/faqs.html#No11. Accessed January 19, 2016.

(neighboring countries, foreign assistance programs, trade organizations, and international companies). As is the case with all energy development, countries must balance economic, national security, safety, and environmental considerations in accordance with national policies and legislation. The division of responsibilities for land management, plan approval, permitting, safety regulation, and environmental oversight varies considerably. The synergies and efficiencies associated with a single land management, safety, and environmental authority must be weighed against the importance of independent regulators and the need to prevent conflicts of interest that could compromise safety and environmental programs.

The Shift from Compliance Management to Safety Management

Most early offshore regulatory programs emphasized detailed operating requirements, plan and permit approvals, and compliance inspections. Over the past 30 years, however, the views of offshore safety regulators have evolved significantly. Performance objectives began superseding prescriptive requirements, and the regulatory focus shifted from compliance management to systematic safety management. Instead of just verifying that safety equipment was functioning properly, regulators began verifying that companies had management systems in place to assess risks and ensure that safety systems and operational controls were functioning as intended. Magne Ognedal, safety director of the Norwegian Petroleum Directorate and director of Norway's Petroleum Safety Authority from 2004 until his retirement in 2013, was a leading voice in this evolution of regulatory thinking:

> Many years have passed since we had to admit that writing safe design and operations requirements into our detailed regulations was not the way to go. We realized that the maintenance of detailed regulatory requirements on how to construct safe installations or operate them properly was resource intensive, and that these requirements would sooner or later lag behind best industry practices. Such detailed requirements could even hamper technological development.
>
> So, since 1985 we have systematically worked on revising our detailed regulatory specifications. We introduced a new kind of regulatory portfolio with just a few regulations mainly stating what should be accounted for by the duty holders. Our statutory requirements today describe the goals that should be strived for—not how to achieve them. Only where we find it essential will we specify detailed measures that need to be adhered to by duty holders. To provide predictability, our formal regulations are supported by guidelines that also make reference to industry standards.[38]

Shortly after Norway began transforming its regulatory process, a massive fire and explosion on the *Piper Alpha* platform in the U.K. sector of the North Sea killed 167 workers. The report of Lord Cullen, who headed the *Piper Alpha* inquiry, influenced offshore regulatory programs worldwide. Cullen's findings emphasized management systems and safety case assessments. According to Cullen (1990),

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[38] M. Ognedal, Norwegian Petroleum Directorate and Petroleum Safety Authority, personal communication, January 2010.

> Many current safety regulations are unduly restrictive because they impose solutions rather than objectives. They also are out of date in relation to technological advances. Guidance notes lend themselves to interpretations that discourage alternatives. There is a danger that compliance takes precedence over wider safety considerations and that sound innovations are discouraged.

Cullen's report expresses the view that management systems should describe the safety objectives, the system by which those objectives are to be achieved, the performance standards to be met, and the means by which adherence to those standards is to be monitored. Safety cases should describe potential major hazards on an installation and identify appropriate safety measures. Safety cases should demonstrate that the safety management systems of the company and the installation are adequate to ensure that the design and operation of the platform and its equipment are safe. In addition, Cullen's report recommends setting goals related to safety performance because previous prescriptive approaches had failed.

The report of the International Expert Meeting in Noordwijk, the Netherlands[39] (1997), reinforced Ognedal's and Cullen's views regarding the importance of management systems, performance standards, skilled regulators, and active communication between operators and regulators:

> In many countries the offshore industry is developing faster than the government's ability to regulate them [sic], and the traditional approach to regulation is inhibiting the industry's capacity for innovation and technological change. This is because regulators impose a prescriptive approach, telling the industry exactly what measures it must take and requiring little interpretation on the industry's part. Prescriptive regulations can foster a 'compliance mentality' within industry and discourage the development of new technologies and creative practical solutions. There is also a limit to the extent to which it is possible to add more and more specific prescriptions without this resulting in counterproductive regulatory overload. Under this approach governments also maintain a strict, regular and costly inspection service, which is resource intensive. In contrast, performance standards specify the outcomes to be achieved but not how to achieve them. For this reason, they can accommodate to changes in technology and the creation of new hazards. They also allow firms flexibility to select the least costly or least burdensome means of achieving compliance. On the other hand, because they are sometimes imprecise, performance standards are to that extent more difficult to enforce. The success of performance-based approaches depends on effective goal setting, with active communication and a sophisticated and multidisciplinary skills profile of both the operators and regulating authorities.

Today, offshore regulatory regimes in Norway, Australia, the United Kingdom, New Zealand, and the Netherlands focus on operator safety management systems as opposed to prescriptive regulations. Safety culture has become an important theme for regulators in these countries. In 2002, Norway's Petroleum Safety Authority became the first offshore regulator to stipulate that companies must have a sound health, safety, and environment (HSE) culture. The United States and Canada have adopted elements of this approach (i.e., SEMS in the United

[39] http://embosman.tripod.com/cgi-bin/page0006.htm. Accessed April 29, 2016.

States and management system requirements in Canada) while maintaining their prescriptive regulations.

Norway's petroleum regulations of January 1, 2002, specifying that enterprises must have a sound HSE culture, was the first time a requirement for safety culture was expressed so directly in Norwegian or in international regulations. To help develop safety culture, the Petroleum Safety Authority created a pamphlet[40] intended to be a useful tool for the industry in developing an effective HSE culture. The pamphlet describes the nature and characteristics of a sound HSE culture, suggests methods for understanding an organization's HSE culture, and lists factors that can affect an HSE culture.

International Safety Improvement: Opportunities and Challenges

In 1994, the International Regulators' Forum (IRF) was organized at a meeting during an Offshore Technology Conference in Houston, with the objective of improving offshore safety through cooperative programs and information sharing. Representatives of Canada, Norway, the United Kingdom, and the United States participated in this first meeting. IRF has now grown to include 10 countries—the original four plus Australia, Brazil, Denmark, Mexico, the Netherlands, and New Zealand. Safety culture emerged as the central theme of the 2010 IRF Offshore Safety Conference in Vancouver. Delegates agreed that certain regulatory and management practices are conducive to developing and sustaining a strong and vibrant safety culture. In that regard, IRF's consensus findings and recommendations[41] were as follows:

- Regulatory regimes function most effectively when a single entity has broad safety and pollution prevention responsibility. Gaps, overlap, and confusion are not in the interest of safety or regulatory efficiency.
- The regulator's core responsibilities and objectives must be clearly identified. Managers must minimize distractions so that regulatory personnel can focus on these objectives.
- Safety management and regulatory priorities should be identified through a comprehensive risk assessment program. Training and competency development programs should be updated to reflect the new risk information. Contracting strategies should be reviewed to assess their safety and risk implications.
- Government and industry should promote an improvement mentality, not a compliance mentality. Continuous communication among regulators, operators, contractors, workers, industry associations and public interest groups is essential for continuous improvement.
- Operators and contractors must manage their companies to achieve safety objectives and must continually assess the effectiveness of their management programs. Regulators should challenge industry to resolve potential safety problems rather than seek to resolve the problems for them.

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[40] Pamphlet available online at http://www.ptil.no/getfile.php/z%20Konvertert/Products%20and%20services/Publications/Dokumenter/hescultureny.pdf. Accessed October 19, 2015.

[41] Excerpted from http://www.irfoffshoresafety.com/conferences/2010conference/summary.aspx. Accessed March 25, 2016.

- Regulators should serve as catalysts for learning by distributing information, hosting workshops, participating in research, and identifying gaps in standards and best practices. Wherever possible, the best standards should be identified and applied internationally.
- Accident investigations should be conducted independently and findings should be promptly and broadly distributed. Industry or government should maintain comprehensive and verified incident data bases. Offshore companies should regularly discuss the causes and implications of past accidents with their employees.
- Industry and government cannot rely solely on incident data to identify risks. New indicators must be explored and assessed, particularly for major hazards and safety culture. Worker input is also essential.
- Peer-based audit programs should be considered for both regulators and operators.
- Industry and regulators should make better use of technology for real time monitoring of safety parameters.
- Sustaining outstanding safety performance is critical to the reputation of industry and government. All personnel should be trained to be safety leaders and should be empowered to stop work without blame.
- Industry and government should investigate other actions and programs that might help promote, sustain, and monitor a culture of safety achievement.

IRF remains concerned about safety culture in the offshore oil and gas industry and active in its pursuit of solutions. In a communiqué resulting from its 2015 Conference and General Meeting, IRF announced the formation of a Safety Culture Workgroup, which will "identify five key components of organizational culture that impact safety, and find factors that inspectors may observe in the field that are indicators of strong safety culture."[42]

Internationally, much work remains to be done to enhance the safety culture of the offshore industry. Continuous improvement is dependent on timely, comprehensive, and verified international incident data that can be used to answer important questions, such as the following:

- Where are incidents occurring and why?
- What equipment is failing?
- How effective are standards and training programs?
- Where are improvements needed?

Although IRF, the International Association of Oil and Gas Producers (IOGP), and IADC collect and publish some data, the absence of a comprehensive international data collection system is an obstacle to sustained safety improvement.

International safety improvement may also be constrained by inconsistent standards that are not always timely or sufficiently challenging. IOGP studied 13 offshore safety regulators and found that they referenced 1,142 different standards from 60 different standards development organizations. Only 13 percent of these standards were referenced by 2 or more of these regulators. Three North Sea regulators (from Denmark, Norway, and the United Kingdom) referenced 465 standards, but only 6 of those standards were referenced by all 3 nations. IOGP concluded that there is little harmonization in the use of standards. Timeliness also is a concern

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[42] http://www.irfoffshoresafety.com/conferences/2015conference/2015%20IRF%20AGM%20Communique.pdf. Accessed April 29, 2016.

with respect to both the development and adoption of standards. For example, an important cementing (zonal isolation) standard that might have helped prevent both the Montara and Macondo well blowouts was delayed for a decade before being issued by API in 2010. Concerns also have been expressed about the consensus approach to standards development and the influence of participants who are committed to maintaining the status quo or protecting their company's special interests.

APPROACHES FOR ADVANCING SAFETY CULTURE

How Regulators Can Best Influence Safety Culture in the U.S. OCS

Regulators also help create the conditions that encourage operators, contractors, and subcontractors to do the right thing even when it is difficult (Hudson and Hudson 2015), and thus have the ability to improve safety performance and enhance safety culture.

The committee found that safety consciousness and a bias for action on safety improvements have been trending up since 2010. Incidents are now examined with consideration for management, organizational, and cultural factors as well their immediate causes (i.e., human error, technological deficiencies, poor maintenance, inappropriate training). The industry as a whole appears to have reacted to the *Deepwater Horizon* accident in ways that reinforce a stronger safety culture, although grading the actual safety level of the offshore industry, even on a relative scale with other industries, is difficult.

The offshore regulators have initiated a number of actions intended to improve safety offshore. The committee observed that industry participants have accepted the regulators' actions but view them as enforcement actions rather than actions designed to enhance safety culture. As discussed earlier, the regulatory structure in the United States has focused largely on compliance rather than performance, so the industry's response is to be expected.

Although a fundamental responsibility of the regulators is to implement laws, influencing safety culture in positive ways will require that they undertake new and different initiatives. Goals for offshore safety culture shared between the industry and regulators would help define new activities focused on those goals, such as coaching, sharing lessons learned, and independently assessing the achievement of such a culture. If the offshore oil and gas industry is to go beyond its compliance mind-set, changes in the regulators' policies will be necessary. BSEE, USCG, and PHMSA currently maintain MOUs to document their relationships and responsibilities so as to avoid overlap and optimize limited engineering and inspection resources. A new MOU addressing concepts of and implementation plans for offshore safety culture would help the regulators extend cooperation with the industry. The industry sees its regulators collectively as "the government," but when introducing safety culture initiatives, regulators also will need to assume the role of participants in the effort to strengthen safety cultures across the industry. The respective roles of operators and regulators need to be clearly delineated as well as part of an overarching vision for the regulatory program. Ideally, the role of the regulators is to ensure that the operating companies have systems to optimize their safety performance, not to do their jobs for them.

Alignment with safety culture criteria among all offshore regulators and third-party safety professionals would help industry accept new safety culture initiatives. The transition of regulators and third parties from compliance officials to safety culture models and coaches will require training and time. Joint training and a common evaluation program would appear to be the most efficient and effective way forward. Experienced SEMS managers and auditors would be a logical source for instructors and evaluators of compliance regulators and third-party personnel. Mingling safety compliance professionals and management audit professionals in a training context could also be expected to generate cross-cutting, safety culture-oriented solutions to challenging gaps in industry performance.

Finally, if regulators are to become proficient in supporting safety culture models, it will be essential for both government and industry executives to address the barriers that currently reinforce the compliance/enforcement-only view of government regulators. For example, transparency and sharing of company information are hindered by a fear of legal liability, and dialogue with offshore workers is inhibited by the strict ethics guidelines imposed on government inspectors and engineers.

The Role of Third-Party Organizations

Overhauling the use of responsible third parties, such as the classification societies, could be an effective way for both government and industry to change the current compliance/enforcement-only perception of the regulators. The government regulators could delegate certain day-to-day offshore compliance inspection and auditing functions to third parties while expanding the government's safety oversight and risk management responsibilities.

Elsewhere in the world, classification societies perform most of the compliance and auditing duties that have been reserved for USCG and BSEE in the United States. Regulators in other countries focus on oversight of the classification societies and risk mitigation activities instead of reviewing detailed engineering drawings and conducting equipment inspections and tests themselves. Typically, non-U.S. regulators also rely on the classification societies' internationally accepted rules instead of trying to maintain detailed government regulations.

Classification societies and government regulatory agencies (i.e., BSEE, USCG, and PHMSA) have different rulemaking processes. Classification societies belonging to the International Association of Classification Societies (IACS) have mature rulemaking processes that are supported by the various IACS member societies. Because classification societies' rules are strictly technical in nature, they are updated continually to keep pace with new technology. In contrast, BSEE and USCG government regulations must adhere to the Administrative Procedures Act. Consequently, their updates are less frequent and more administratively complex.

Another benefit of expanding the role of a designated third party would be the potential for the industry to have a trusted advisor that could periodically tell them what they need to hear before they hear it from the regulators. The committee notes that INPO has been highly effective in this role.

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

A Vision for Appropriate Regulation

Historically, the offshore industry has opposed most regulatory initiatives but has offered neither a vision for the type of regulatory system it would support nor plans for fostering a strong safety culture throughout the industry and achieving safety and environmental objectives. The regulators have also been unclear regarding their regulatory philosophy and strategy.

Recommendation 4.1: The oil and gas industry in concert with federal regulators should take steps to define the optimal mix of regulations and voluntary activities needed to foster a strong safety culture throughout the industry, including contractors.

To this end, the following specific steps should be taken:

- Required participation in an independent industry organization dedicated to safety leadership and achievement. The Center for Offshore Safety has made excellent progress in establishing data gathering and SEMS support programs, and could fulfill this role. However, measures should be taken to ensure their independence (see Finding 4.4),
- Collaboration between regulators and operators, contractors, and subcontractors in designing a safety system that instills safety at all levels of all organizations participating in the offshore oil and gas industry and balances the needs of industry and the interests of the public
- Adaptation or implementation of an evidence-based decision-making process regarding safety that entails
  - regular data reporting that is complete and accurate
  - analysis of the data reported to identify causes as well as trends
  - sharing of data across the industry and regulators so that lessons learned can be used to continuously improve the safety of the industry.

In these efforts, it is essential that the industry and regulators go beyond ideas and possibilities to develop concrete plans for execution.

Accident, Incident, and Inspection Data

A commonly noted problem in studying accidents in the offshore oil and gas industry is the lack of complete and accurate data related to accidents and near misses. Currently, BSEE accident and incident data are available to the public, but inspection data are not publicly accessible.

Recommendation 4.2.1: Regulators, with help from industry, should define the critical factors necessary for understanding the precursors to accidents, determine what data need to be submitted to which regulatory agencies, and establish mechanisms for regular collection of those data. In addition, regulators and the industry should review what data need to be made available to the public and take appropriate steps to make those data accessible.

Recommendation 4.2.2: Because accident, incident, and inspection data all are needed to identify and understand safety risks and corrective actions, the committee recommends full transparency such that regulators make all these data readily available to the public in a timely way, taking into consideration applicable confidentiality requirements. Summaries of voluntarily reported near misses or hazardous events, absent information that should be kept confidential, such as company names and facility identifiers, should also be released.

Recommendation 4.2.3: BSEE should issue regular reports summarizing performance trends and safety issues.

Recommendation 4.2.4: BSEE should improve the organization of its incident data to facilitate public access and review. The Pipeline and Hazardous Materials Safety Administration database is a good, user-friendly system that could serve as a model.

The Application of Safety Management Principles to Improve Safety Performance

The Minerals Management Service/BSEE, the U.S. Coast Guard, and some industry representatives recognized in the 1990s that offshore industry safety programs needed to go beyond detailed prescriptive equipment regulations. Accordingly, they initiated programs such as SEMP/SEMS, PTP, and QUALSHIPS 21. Operators are responsible and accountable for ensuring compliance with regulations and operating in accordance with their management systems. BSEE and Coast Guard offshore inspectors verify that operators are fulfilling those responsibilities. However, most offshore inspections focus on prescriptive equipment regulations and follow a standard checklist. Thus, they have a "one-size-fits-all" character regardless of the operator's safety performance, and may inhibit the development of safety culture by promoting a compliance mentality.

Recommendation 4.3: BSEE and the U.S. Coast Guard should provide safety leadership and foster safety culture in the industry by reducing inspection frequencies for companies and facilities with excellent performance and inspection records. Regulators should make greater use of risk principles in determining inspection frequencies and methods, such that operators with good performance records are subject to less frequent or less detailed inspections. Inspectors should consider shifting from traditional compliance inspections to inspections that follow the safety management approach outlined in the Safety and Environmental Management Systems (SEMS) standard. Audit results should be considered in developing inspection programs and their schedules. BSEE and the Bureau of Ocean Energy Management should also consider simplified plan and permit approval processes for operators with outstanding performance and compliance records and transparent SEMS and incident reporting systems.

An Independent Group Dedicated Solely to Offshore Safety

BSEE and USCG deal with many industry associations whose charters include safety (e.g., API, OOC, IADC). However, these organizations also have advocacy responsibilities, and their primary mission is to support and promote their members' interests, not to identify weakness and concerns. As a result, conflicts can arise when advocacy and safety conflict. In addition, the public does not always trust that such industry associations are sincere when they state that safety is their first priority or assess the performance of their members.

Recommendation 4.4: The U.S. offshore industry should implement the recommendation of the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling for an independent organization whose sole focus would be safety and protection against pollution, with no advocacy role. The Center for Offshore Safety, although a strong, positive step in this direction, is nonetheless organized within the American Petroleum Institute (API) and therefore not independent of that organization's industry-advocacy

role. Moreover, the current cost of membership in the Center for Offshore Safety limits participation. COS should be independent of API and membership in COS should be a key element of the fitness-to-operate criteria for all organizations, including operators, contractors, and subcontractors, working in the offshore industry.

The details of who would make membership in a single safety organization mandatory and how that might be accomplished would have to be worked out. For example, would a regulator establish this requirement, or would industry be accountable for making membership a condition for participating in offshore work? Would an operator make membership a requirement for its contractors? Similarly, the process for making membership mandatory would also have to be determined. Would the regulator announce its expectation of membership in an independent safety organization focused on self-improvement and indicate that nonparticipants would be subject to more frequent inspections? Alternatively, the regulator might publish a Notice to Lessees (NTL) requiring all operators to participate in the safety organization; however such an NTL would need to be tied to an existing regulation. The regulator might also revise the qualification regulations for lessees and operators or include a stipulation in all new lease contracts requiring participation in the independent safety organization.

Safety Culture Champions

The nine characteristics of an effective safety culture released by BSEE in 2013 are not well known in the industry, and BSEE lacks the means to move the entire offshore industry closer to these desired characteristics

Recommendation 4.5: The Secretary of the Interior, in cooperation with the Commandant of the U.S. Coast Guard, should seek prominent leaders in the offshore industry to champion the nine characteristics of an effective safety culture identified by BSEE, develop guidance for safety culture assessment and improvement, and facilitate information exchange and sharing of experiences in promoting safety culture.

Safety Management Systems

SEMS and SEMS II regulations are now part of the regulatory system for the industry. They are still in their embryonic stage, so practices are still emerging. SEMS audit information provided to BSEE by the operators thus far appears to be minimal and insufficient for assessing the success of the safety management scheme. SEMS II requires an independent third-party lead auditor, but this provision does not apply to contractors. USCG has proposed developing SEMS for offshore industry contractors subject to USCG regulatory authority. PHMSA and the pipeline industry have issued a safety management standard, RP 1173, that includes safety culture elements. The inclusion of safety culture elements will encourage companies to fully integrate cultural considerations into their management programs.

Recommendation 4.7: BSEE and USCG should work with operators and contractors to develop a system for capturing meaningful audit results and related information to be submitted to BSEE and the USCG. USCG SEMS requirements should be consistent with those published by BSEE. The committee recommends that the American Petroleum

Institute's Recommended Practice 75 Committee include a chapter on safety culture in the revised version of this document, which is currently being drafted.

Memorandums of Understanding on Promoting Safety Culture

BSEE, USCG, and PHMSA each oversee elements of oil and gas operations on the OCS, and each agency has emphasized the importance of a strong safety culture. However, the three agencies have not formally agreed to work cooperatively regarding offshore safety culture. Existing MOAs and MOUs apply only to prescriptive regulations, investigations, and response.

Recommendation 4.8: BSEE, the U.S. Coast Guard, and the Pipeline and Hazardous Materials Safety Administration should develop memorandums of understanding specifically addressing the concepts of and implementation plans for offshore safety culture and defining accountabilities among the three regulators.

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Abbreviations

EIA	U.S. Energy Information Administration
NRC	National Research Council
TRB	Transportation Research Board
USDOT	U.S. Department of Transportation

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5

Safety Culture Assessment and Measurement

This chapter examines how safety culture is typically assessed, as well as how it should be measured in the offshore oil and gas industry. It begins by restating the definition of safety culture used in this report (see Chapter 2) and, more important, placing safety culture within the context of a larger organizational and institutional system. The measurement of safety culture is not an end in itself, but a means of assessing, understanding, and influencing both safety and the overall mission of the organization. The measurement activity takes place within an existing safety culture and, more generally, within a broader organizational culture and the cultural ecology within which the organization operates (e.g., suppliers, customers, industry groups, professional associations, regulators, governments, the public, markets). Hence, the measurement of safety culture is one step in a set of conversations, decisions, and actions aimed at directing organizations toward safer and more sustainable performance. Given this context, the succeeding sections of this chapter articulate what can and should be assessed and what methods and techniques can be used for assessment. Because the goal is not simply accurate assessment but also improving safety, the discussion of assessment focuses on what is being assessed, how it is assessed, how assessment is used to guide strategy and operations, who should be involved in this process, and how often assessment should occur.

SAFETY CULTURE AND ITS ORGANIZATIONAL CONTEXT

In Chapter 2, safety culture is defined as “the core values and behaviors of all members of an organization that reflect a commitment to conduct business in a manner that protects people and the environment” (BSEE 2013, 7). This definition identifies safety culture as an aspect or facet of the larger organizational or workplace culture, that is, those elements of the organizational culture that pertain to safety, including values, beliefs, assumptions, norms, and practices. Given the complexity of the offshore oil and gas industry, the safety culture concept extends to both companies of various sizes (including business units, divisions, and departments that act like organized entities) and settings or workplaces that demand interdependent activities from individuals working for owners, operators, or service providers.

As discussed in Chapter 2, although safety culture is routinely considered to be a shared property of a company or a workplace, all organizations have some degree of cultural variability. For example, the culture of exploration may have a different approach to risk than the culture of production, even within the same company. Likewise, Mearns and colleagues (1998) found considerable variation in safety subcultures among U.K. offshore workers depending upon seniority, occupation, age, shift, and prior accident experience. For example, offshore engineers may share more cultural elements with other engineering professionals in their country than with operators, managers, and others in their own company (Schein 1996). And the culture on an oil rig may have more to do with the contractors who own the rig and the local culture of the workers than with the organizational culture of the multinational oil company that commissioned the drilling. Across hierarchical levels, moreover, senior executives, middle managers, supervisors, and workers may have very distinct cultures, including their views of safety.

Research consistently finds that as one moves higher up the organizational hierarchy, views of the existing safety culture become more positively biased, because bad news does not readily travel upward (e.g., Sexton et al. 2000; Singer et al. 2009).

Cultural variability within an organization or operation, or within an organization's safety culture, is generally considered a weakness. However, Mearns and colleagues (1998) suggest that a strong, cohesive safety culture may lead to complacency, and retaining cultural variability can be a source of robustness rather than a problem. In a study of organizational culture across multiple industries, Sorensen (2002) found that strength of culture was beneficial in stable environments but not in less predictable environments. The variable nature of culture in organizations informs the discussion below of what should be assessed, how it should be assessed, and who should do the assessing.

ASSESSING AND MANAGING SAFETY CULTURE

The management systems in an organization direct attention toward strategic goals and priorities, one of which is safety. The organization's culture needs to be aligned with and help support and reinforce the management systems, and safety culture is no exception. Thus, neither safety nor culture can be managed independently from the other management systems. Safety, culture, and safety culture need to be understood as part of these management systems and therefore should not be delegated to a stand-alone unit (e.g., a safety culture assessment group) that is not highly integrated with the other core operating systems of the organization (Wears et al. 2005; Dekker 2014).

An analogy can be drawn to the assessment of individual health, in which a single indicator, such as blood pressure or cholesterol level, is of limited utility without an understanding of what interdependent biological systems are involved (e.g., cardiovascular) and how they work, and what interventions are available for managing overall health (e.g., medications, diet, exercise, surgery, meditation). Like health, then, safety is best assessed comprehensively and systematically; each is more than the absence of harm or disease. Both health and safety are a function of the presence of wellness in the form of interrelated system functions, including protective structures and processes (Hofmann and Tetrick 2003). Therefore, meaningful improvement efforts must target multiple interconnected elements of organizational systems (e.g., Beer and Nohria 2000), a point discussed in greater detail in Chapter 6.

Why It Is Important to Measure Safety Culture

Culture, including safety culture, typically is assessed for one of several reasons related to an organization's strategic goals: (1) to respond to institutional pressures to copy successful organizations, please regulators, meet a standard, or demonstrate that improvement efforts are being made; (2) to describe and understand the organization; (3) to make specific improvements (e.g., in safety); or (4) to improve the organization and management more broadly (see Sackmann 2006). Consideration of these reasons suggests different criteria for choosing an assessment approach, such as whether to select a widely accepted tool or to develop one tailored to the organization, or whether to assess safety culture more narrowly or organizational culture more broadly. Among the reasons listed above, this chapter assumes the pragmatic goal of assessing safety culture to improve safety. However, the committee also believes that the assessment process is one input into a much broader conversation regarding organizational and safety culture, formal and informal organizational structures, power, relationships with contractors, and other strategic goals (productivity, cost, quality). With these assumptions in mind, the committee believes it is important for organizations to conduct periodic assessments of their organizational and safety culture for the following five reasons:

- **To move conversation from the vague to the specific—**An assessment moves conversations from vague, general perceptions, or a "sense" of how the organization is doing with respect to safety, toward more focused exploration of what lies behind specific and quantifiable metrics, such as accident rates and injuries. For example, if an assessment reveals that workers perceive a gap between management pronouncements about the importance of safety and management actions that appear to be unsupportive of safety, this finding can trigger a more targeted conversation about what types of management actions (e.g., never committing significant budget dollars to improving safety) are driving this perception and how management can better align its words with its actions.
- **To allow for the tracking of progress—**Without ongoing assessment and communication of its results, employees cannot evaluate the effectiveness of initiatives designed to improve the safety culture and safety management. Regular assessments allow management (and others) to detect and reinforce slow changes in an organization's culture that may be beneficial to safety, as well as to identify and address slow changes that may produce a drift into failure (Dekker 2011).
- **To provide motivation and feedback—**Ongoing assessment allows individuals throughout the organization to receive feedback, set goals, and seek to improve the organization's safety management. It also, if its results are sufficiently communicated, can help close the communication loop when front-line employees have raised safety concerns (or concerns about work and managerial practices that are not specified as related to safety). Even in the absence of tangible progress, it is important for management to communicate to front-line employees that they are being heard and that management is investigating how to address the issues they have raised.
- **To identify strengths, weaknesses and gaps, and potential improvements—**An assessment spanning different subgroups, functions, and operational areas of the organization can provide an opportunity to examine the consistency of the culture and tailor improvement efforts to specific concerns. For example, different interventions will be needed if senior management is viewed as strongly committed to safety, but front-line management frequently trades off safety for more pressing goals, or if front-line management is viewed as being strongly committed to safety, whereas senior management is more focused on financial performance.
- **To provide a leading indicators—**A growing body of research (e.g., Zohar 2010; Morrow et al. 2014) and recent meta-analyses (Christian et al. 2009; Narhgang et al. 2011) show that safety culture can predict both safety behaviors and accidents/injuries. Assessments of safety culture hold promise for providing leading indicators of safety issues that can trigger proactive interventions and serve as complements to lagging indicators, such as incident rates. However, this research has focused on personal safety (e.g., use of personal protective equipment, days away from work) rather than process safety; therefore, more research is needed to explore the relationship between safety culture and process safety.

Approaches to Assessment of Safety Culture

Unfortunately, across both academic research and reports from multiple industries, there is no single agreed-upon approach to assessing organizational and safety culture. Not surprisingly, approaches for assessing safety culture (e.g., IAEA 2002) generally parallel those for assessing organizational culture (e.g., Sackmann 2006). Still because the goals of assessing safety culture tend to be more improvement-oriented and more institutional than those of assessing organizational culture, the most common approaches for safety culture assessment are more pragmatic. This section will briefly examine culture assessment in general and then turn to safety culture assessment in particular, considering both the content and process of the assessment.

Assessments of Organizational Culture

A fundamental difference among approaches to culture assessment is whether each culture is seen as a unique grouping of elements or cultures are scored or categorized on a limited number of dimensions (Sackmann 2006; Guldenmund 2015). Whereas the classic anthropological approach to culture sees each culture as unique from the viewpoint of a cultural insider, that approach is time-consuming and does not lend itself readily to comparisons or recommended improvements (thus really constituting description rather than assessment). In contrast, a number of different models and typologies of organizational culture have been developed over the years, many of which have associated measures, typically on questionnaires (Zohar and Hofmann 2012). Hofstede (1980, 1998) measured national cultures based on five dimensions grounded in the working world: (1) power distance or degree of inequality, (2) uncertainty avoidance, (3) individualism-collectivism, (4) masculinity-femininity (competitiveness and materialism versus relationships and quality of life), and (5) long- versus short-term orientation. Cameron and Quinn (1999) and Denison (2000) used dimensions of internal versus external orientation and flexibility versus stability to define four cultural types. Goffee and Jones (1996, 2001) and Cooke and Szumal (1993, 2000) used other dimensions to create a different set of three or four cultural types.

Variations in the above approaches arise in part from what is meant by culture (Sackmann 2006; Zohar and Hofmann 2012). Some definitions focus on values, some on organizational practices, some on norms and expectations, and others on commonly held beliefs. Some of the cultural dimensions focus on structures (external/internal, flexible/stable), while others focus on social interaction (solidarity/sociability) or behavioral orientations (task/people, promotion/prevention). Some aspects of culture are relatively easy to assess, often by means of self-reported perceptions on a survey (typically called “climate” [e.g., Denison 1996; Guldenmund 2000]). Schein’s (2010) influential model of culture asserts that there are surface features of culture that can be seen and heard, including visible artifacts and communicated values and beliefs, whereas the essence of culture, comprising underlying assumptions, is “deeper” and difficult even for cultural insiders to perceive and articulate.

How Safety Culture Can Be Assessed

To assess safety culture, one must start with a clear concept and then build a set of assessment procedures suited to that concept. A broad concept of safety culture requires a broad set of data for assessment and means for collecting those data, including both quantitative and qualitative approaches. Given the wide range of organization sizes, resources, and work activities involved with safety culture, organizations can be expected to use a great variety of approaches to assess their safety cultures.

There are several established methods for assessing culture, including safety culture. None of these methods is perfect; each has its strengths and weaknesses (see reviews by IAEA 2002; Sackmann 2006). To build on these strengths and compensate for these weaknesses, multiple methods can be used for a given assessment. The various methods are reviewed here in terms of (1) accuracy, and scientific validity, how well the method captures the key aspects of (safety) culture, and (2) practicality, or how much money, time, and scarce expertise is needed to execute the method. Figure 5-1 depicts the methods to be discussed.

Note three issues with respect to this figure. First, proponents of various methods would differ dramatically on where the methods should be placed on the figure, especially in terms of accuracy and scientific validity. Survey proponents argue that ethnographies are subjective and unscientific, while proponents of ethnographies argue that surveys are self-reported answers to possibly misleading questions written and interpreted by cultural outsiders (e.g., Silbey 2009). Second, where a method is placed on the figure depends on the quality of its execution: there are bad ethnographies, bad surveys, and bad interviews. The positioning shown on the figure assumes a version of the method that at least is of "good" quality (i.e., has reasonable validity) as understood by experts in that method. Finally, no scale is given to the axes of the figure because there is no objective quality standard for and little work systematically comparing the methods. Similarly, on the practicality dimension, managers have to judge what expertise they have or can readily contract, given the size and capabilities of their organization, and how much cost can be tolerated.

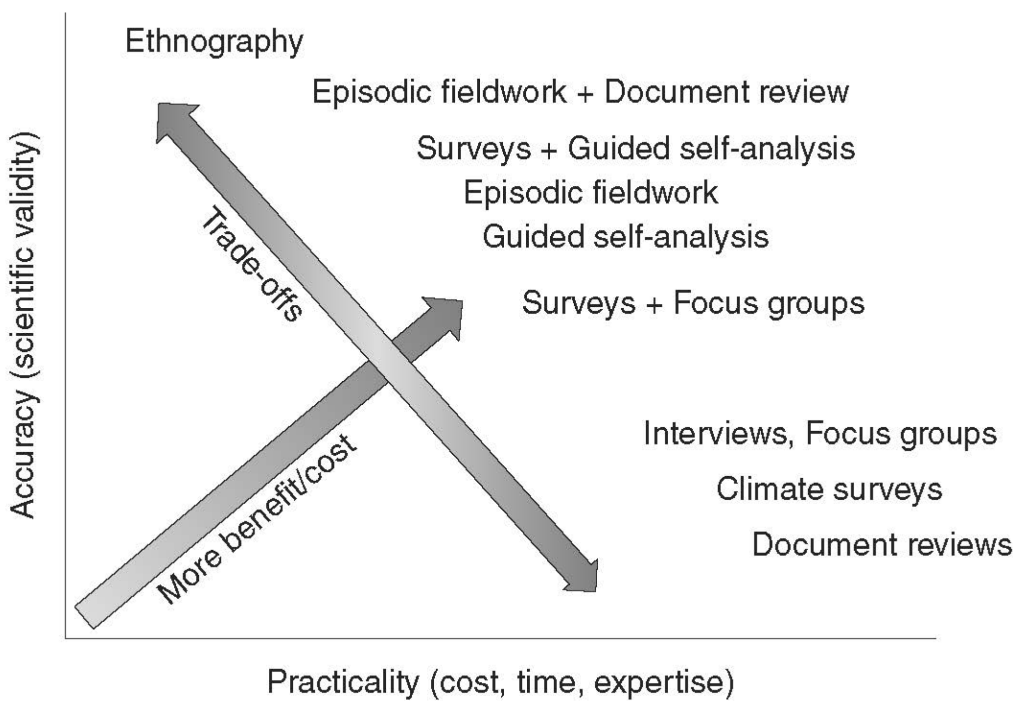

FIGURE 5-1 Methods for assessing safety culture.

The classic method for studying culture is *ethnography*. The method was originated by field anthropologists, who generally spend 1-2 years "living" in a culture, often in a nonindustrialized setting not previously studied systematically. The emphasis is typically on understanding a novel culture, particularly with respect to deriving meanings as insiders ("natives") understand them. Accuracy is assessed in terms of internal coherence and narrative force: Is the ethnographer able to tell a good story that is stimulating and instructive for the reader? Ethnographers observe and ask questions of "key informants" who are willing to share insights with and mentor the researcher. They take detailed notes, often written or rewritten at the end of the day to capture as much as they can remember, and then spend months or years reading their notes to understand what they have seen and heard and decide how best to tell their story. It also is possible to use ethnographic methods in a less intensive way, such as by visiting a site for a week, or making a series of visits to track changes or deepen the investigation. Especially when the setting, work technology, and social arrangements are relatively familiar, such as when the study focuses on an industrial site (factory, drilling rig) with no language barrier, less time may be required to absorb the culture. A representative ethnography in the offshore oil and gas industry is Ely and Meyerson's (2010) study of how one rig went from a "masculine" culture in which accidents and injuries were frequent and little learning took place to a more "feminine" culture that reshaped "gender identity" to focus on learning and safety.

Although it is debatable how accurate ethnographic approaches can be (e.g., most people want to present a positive impression, and replication is unusual and sometimes has been disappointing when attempted), these methods are designed to reveal "deep" culture or basic assumptions and meanings. In the hands of a skilled ethnographer, levels of accuracy and insight (even wisdom) are high. At the same time, reliance on a highly skilled outsider to conduct the ethnography can require considerable time and resources and yield uncertain benefits, which can be frustrating and even prohibitive for managers and regulators. Yet a skilled ethnographer can add a deep understanding of cultural assumptions and interpretations, as well as organizational processes, that potentially can guide regulators in writing and implementing new policy. In particular, such in-depth exploration may lead to more sensible and grounded rules that can be implemented readily across an industry.

Less intensive than ethnography is a set of field-based methods that can be termed *episodic fieldwork*. These methods include combinations of direct observation of work practices by individuals or teams of visitors, interviews of individuals or groups, and analysis of documentation (e.g., U.S. NRC 2014). This method is typically used by internal and external auditors (e.g., quality assurance personnel, regulators), consultants, benchmarking teams, and peer-assist teams. Episodic fieldwork has some advantages over ethnography: it takes less time (although a 2-week visit by a 10-person team is quite intense), and the visitors are typically experts in and familiar with industry terminology and work practices. Hence, they can work more efficiently than an ethnographer who enters a strange new culture, and the team provides diverse viewpoints and can test assumptions, observations, and conclusions. Still, an "outsider" (ethnographer) who resides in the culture for many months may have a better chance of observing the underlying culture, especially those aspects that are part of an industry or local work culture that are taken for granted and invisible to episodic visitors.

Leaders and members of organizations, regulators, and researchers also use *document review* to make sense of and shape an organization's safety culture in three ways—vicarious learning, learning from near misses, and operational refinement. First, documents in the form of reports of inquiries or government investigations into an accident can serve as a source of vicarious learning for other organizations throughout the industry (March et al. 1991). These reports can be important aids to learning as they can be based on a combination of the sources of information discussed in this section (interviews/observation, surveys, documents, and data on accident and error rates).

However, to wait for an accident to occur is to miss the opportunity to uncover weaknesses in organizational defenses before they cause an accident (Reason 1997). Known leading indicators of accidents (i.e., near misses) can serve as sources of vicarious learning (March et al. 1991). This, in part, is what motivates the second use of document review—the use of near-miss reporting systems, such as the Aviation Safety Reporting System[1]—to provide a more comprehensive picture and facilitate learning from a wider range of events. Yet while effective in aviation, such systems are known to underrepresent the frequency and range of errors when applied to other industries (Thomas and Peterson 2003). The Bureau of Safety and Environmental Enforcement (BSEE) has its own voluntary near-miss reporting system—the Safe OCS Voluntary Confidential Near-Miss Reporting System (BSEE 2015). However, this system is relatively new, so whether it will receive sufficient reporting to provide useful insights cannot as yet be known. This second use of document reviews also can include incident reports and investigations, maintenance backlogs, activities of corrective action programs, training processes, human resources and employee health records, notes from management walkarounds, and anything else that would provide insight into the functioning of the organization.

Third, high-reliability organizations use the development and refinement of operational documents and standard operating procedures as occasions for cross-functional conversations to ensure continuing reliability and safety. For example, Schulman (1993) observed processes for negotiation among several departments of a nuclear power plant designed to ensure careful interdepartmental coordination. Soliciting differing departmental viewpoints on documents increases the likelihood that potential issues will be addressed proactively and sufficiently proceduralized so they can be dealt with reliably by all departments. The negotiation process also creates norms of interdependence and collaboration, reduces mindless execution of tasks, and tends to curb “hubris and bullheadedness” among organizational members.

Safety culture and climate[2] *surveys* using questionnaires with rating-scale measures of various cultural attributes have become increasingly popular in recent years, and regulators are requiring such surveys more routinely, especially of organizations suspected of having a weak safety culture. In its review of methods for assessing safety culture, the International Atomic Energy Agency (IAEA) (2002) found that surveys were endorsed as useful and practical more often than any other method. Table 5-1 lists sample survey items, based on items from the Institute of Nuclear Power Operations (INPO) safety culture assessment instrument, that could be used to assess safety culture in the offshore oil and gas industry in terms of the nine elements of a strong safety culture identified by BSEE (2013).

The advantages of culture and climate surveys are that they require relatively little time and money (especially if an off-the-shelf survey is chosen, or modified in minor ways to make it more specific to the organization’s context and needs), can be kept anonymous to encourage candor (although not everyone trusts “anonymous” surveys), and provide quantitative scores, and results can be compared readily across multiple dimensions—time, organizations, departments,

[1] The U.S. Federal Aviation Administration’s (FAA) voluntary confidential reporting system that allows pilots and other airplane crewmembers to report near misses and close calls.

[2] The term “safety climate” denotes shared perceptions of safety-relevant policies, procedures, and practices concerning what the organization rewards, supports, and expects (Guldenmund 2000; see also Chapter 2).

TABLE 5-1 Sample Survey Items for Use in Assessing Safety Culture

BSEE Safety Culture Attribute	Sample Survey Items
Leadership commitment	Leadership frequently communicates the importance of safety. Decision making at this site reflects a conservative approach to safety.
Respectful work environment	People are treated with dignity and respect by leadership. My supervisor responds to questions and concerns in an open and honest manner.
Environment for raising concerns	I can raise safety concerns without fear of retaliation. Dialogue and debate are encouraged when evaluating safety issues.
Safety and environmental communication	There is good communication about safety issues that affect my job. Contractors/vendors understand our expectations for performing work safely.
Personal accountability	It is my responsibility to raise safety concerns. When an important safety decision must be made, I know who is responsible.
Inquiring attitude	Overall, workers maintain a “questioning attitude” and a rigorous approach to problem solving. Personnel do not proceed in the face of uncertainty.
Hazard identification and risk management	Personnel promptly identify and report conditions that can affect safety. Organization weaknesses are identified and resolved.
Work processes	Our procedures are generally up to date and easy to use. My supervisor discusses safety with me before I start work on a new or infrequent job.
Continuous improvement	We adopt innovative ideas to improve safety. This site learns from its mistakes.

NOTE: BSEE = Bureau of Safety and Environmental Enforcement.
SOURCES: For BSEE safety culture attributes, BSEE (2013); for sample survey items, INPO (2013).

locations, or hierarchical levels. Yet many difficulties remain in the application of surveys. The main disadvantage is that responses are self-reports in response to standard questions that may be interpreted in different ways by different respondents, who may or may not be able (or willing) to report on “deeper” levels of culture. Moreover, the meaning of the questions and the factor structure among them are dependent on whether the culture itself is reactive, calculative (rule oriented), or proactive (Hudson 2007). In smaller organizations where anonymity is difficult to maintain or in those with very low levels of trust, it may be difficult to obtain candid replies or a good response rate. Finally, culture and climate surveys can sometimes be treated as the end point of the assessment (“our scores are good enough”) as opposed to a mechanism to guide a substantive conversation about safety (Schein 2013).

Proponents of safety culture and climate surveys argue that the results provide leading indicators of safety problems even better than those derived from near-miss reporting for anticipating and therefore proactively managing safety issues. A growing body of research shows statistically significant and practically meaningful relationships between culture and climate scores and safety statistics (e.g., Morrow et al. 2014). However, many of these studies are correlational, such that the direction of causality is ambiguous (Bergman et al. 2014), and others use personal safety measures (e.g., days away from work, number of injuries) rather than failures of process safety, with some exceptions (e.g., Hofmann and Mark 2006). It is now known that personal safety can be managed successfully with little impact on process or system safety. Process and system safety indicators are more subtle and invisible, based in a confluence of interacting problems or an unanticipated combination of components each functioning as designed (Leveson 2012, 2015). The knowledge and skills needed to manage process and system safety are different from those necessary to ensure personal safety. Indeed, major accident investigations have cautioned that a focus on personal safety and occupational injury statistics can lead to a false sense of security with regard to process safety (HSE 2003; CSB 2007). Fortunately, a growing body of evidence from field experiments shows that specific interventions significantly change perceptions of safety climate and, in turn, improve process safety outcomes (e.g., Zohar 2002; Zohar and Luria 2004; Thomas et al. 2005).

Culture and climate surveys can serve another beneficial function: raising awareness of and creating opportunities for productive conversations about safety. Use of the scores calculated from survey responses to monitor and manage is the most visible and least important aspect of culture assessment and change. Instead, surveys can prompt conversations about and broaden understanding of the organization's safety processes, as well as participation in generating innovative paths forward and continuing conversation to learn from these efforts (Carroll 2015). It is also important to recognize that this learning process can succeed only if senior leaders are engaged, listening, and pushing for improvement; otherwise, the self-analytic activity will come to a halt, leaving behind a residue of cynicism, mistrust, and resistance to change. One example of how leaders can become involved in such activities to foster psychological safety, problem reporting, and meaningful improvement is a front-line improvement system (Singer and Tucker 2014). Such a system pairs mechanisms by which employees can offer suggestions with forums in which leaders and employees process those suggestions and direct collaborative efforts toward change. For example, the comprehensive unit safety program model features processes by which leaders "adopt a unit" and become a more visible presence to enable discussion and action (Pronovost et al. 2004). These examples illustrate how surveys can be combined with other methods to foster more comprehensive data collection and meaningful opportunities to learn.

A method that is not as time- and labor-intensive as ethnography but not as broad-brush or "distant" as surveys is a process that can be called *guided self-analysis*. This method relies primarily on cultural insiders to analyze their own culture through one or more workshops or meetings (hence, self-analysis), while also recognizing the need for skilled facilitation by either an internal specialist or an external consultant (hence, guided). The process engages a cross-section of participants who are knowledgeable about the culture but also have the curiosity and critical thinking skills to step outside their own culture. Individuals who are already bicultural, such as those who have worked in another company or in another part of the same company that has a different culture, may be a good choice as participants. It is desirable to have a diverse group for these discussions, but if the existing culture is low on trust (low psychological safety, high conflict), it may be necessary to have more homogeneous groups within a single hierarchical level and even a single department so as to encourage candid conversation.

It is usually easier to start the discussion with what is readily observable about the organization, such as its espoused values ("What are our goals? Why does this organization exist? What do we care about?") and the ways in which the culture expresses itself in artifacts of technology, physical space, and communication. Questions about the "culture" are often difficult to answer; it is often easier to ask, "What is it like working here?" or "How does this place differ from other places you have worked or other parts of the company?" Schein (2015, 16) suggests "bringing employees of an organization into a room together and asking them to provide some examples of what kinds of things are expected of them, listening carefully for those things on which there is obvious consensus and ignoring things that are clearly individual quickly… brings out what the important elements of a given culture are." It may also be useful to ask about what has changed in the past 5 or 10 years, why it has changed, and in what ways the change is important (see Cooperrider and Whitney [2005] for a discussion of appreciative inquiry as a form of guided self-analysis).

One way to surface cultural assumptions is to explore apparent contradictions between espoused values and observed practices—for example, if an espoused value is "safety is our top priority," but everyday behaviors privilege production and "doing what is necessary to get the work done." When the group has raised apparent contradictions and appears prepared to discuss them, the next step is to explore the contradiction—for example to ask, "Why do we say we value safety but we seem to take actions that value production over safety?" It may be that there are deeper understandings of safety and production that resolve the contradiction in a way that helps understand the culture. Or underlying assumptions about the need to please external audiences, the pressures of short-term incentives, the way managers think, or the lack of resources to invest in work improvements may surface.

Strong research evidence shows that self-analysis strategies for problem detection and resolution have improved safety in a variety of industries. The Israeli Defense Force is renowned for its use of after-event reviews, whereby both successes and failures are probed by all members participating in a mission for possible improvements (e.g., Garvin 2000; Ellis and Davidi 2005). Successes are examined for near-misses and close calls, an approach that has been shown to improve group cohesion and psychological safety in addition to identifying actionable problems (Ron et al. 2006). In health care, many leading organizations use safety rounding, whereby leaders go on the floor to talk with front-line staff about what they see as risks and threats to safety. Prior research has found that safety rounding improves perceptions of safety climate (Thomas et al. 2005); however, actual improvement depends on the consistency and rigor of its implementation, such that surfacing problems is followed up with concrete actions and status updates (Singer and Tucker 2014). After-action reviews and safety rounds that are enacted as a ceremonial duty with no expectation of learning or, even worse, as an opportunity to punish guilty parties and reinforce authority, will create cynicism and resistance to change. Although after-action review and safety rounding focus on problems rather than culture, they illustrate how organizations can establish opportunities for self-analysis through discussion of what people do and why they do it, and thereby bring important facets of culture to light.

Finally, as illustrated in Figure 5-1, the use of *multiple methods* combines the strengths and mitigates the weaknesses of individual methods to achieve a practical mix of benefits without crippling costs. For example, a safety culture or climate survey could be used to provide broad background information and raise questions about dimensions, departments, or hierarchical levels with higher or lower scores. Typically, attention focuses on the lower scores as areas for improvement, but it may be useful to think about the organization's strengths and attempt to learn from its successes. It is essential for interpretation of the meaning of the scores to go beyond numerical averages or the intuitions of a few people preparing the survey report. Many organizations use focus group interviews following a survey to discuss its results and to obtain specific examples and details as to what the responses mean to workers, supervisors, and managers. Some organizations include work observations (as in episodic fieldwork) conducted around the time of the climate survey to add further richness to the data. Then, diverse teams can begin to assemble ideas about how to intervene and how to evaluate whether progress is being made. This process helps elevate concerns so they receive attention, resources needed to address them are available, and steps are taken to gather further information and engage broad participation in sense-making and change initiatives (Weick 1979; Carroll 2015).

Monitoring of safety culture requires more than an assessment every 2 years through a survey. Periodic surveys and audits are most helpful when paired with other, more regular (monthly or quarterly) assessments. Larger organizations often have a "dashboard" of indicators that are used for various management concerns, including productivity, cost, environment, human relations, and safety. For example, the Gulf of Mexico business unit of one large multinational company has a monthly "Process Safety Scorecard" that includes lagging indicators of loss-of-control events (major and minor) and, importantly, leading indicators that include overdue critical equipment inspections and tests, safety system activations, overdue and open process hazard analysis recommendations, number of discrepant material nonconformances, and overdue permanent and temporary management-of-change analyses. The scorecard includes objectives and color coding for status against objectives. Another large multinational has a suite of process safety key performance indicators, including both lagging indicators such as loss of primary containment and fires and leading indicators that include process control overrides, maintenance deviations, canceled inspections, failed assurance tasks, and number of management assessments offshore.

Increasingly, safety culture is a part of such a dashboard, with multiple indicators being examined regularly. These indicators may include codes for safety outcomes, near misses, problem reports, incident investigation results, employee concerns and suggestions, management walkarounds, observations of prejob briefings and after-action reviews, and union concerns. Some of these indicators may be quantitative, others a simple green-yellow-red assessment, and still others qualitative comments. Indicators may assess strengths and positive examples as well as weaknesses and problems. The intent is to keep everyone thinking about safety culture along with other management concerns, and to feed this information into the safety management system for improvement efforts.

As an illustration, one company in the nuclear industry uses the 10 INPO safety culture traits (similar to BSEE's nine attributes) to structure a dashboard of indicators that are examined in a quarterly meeting attended by senior management and 10 middle managers who are designated as subject matter experts, one for each trait. The dashboard is available online through the company intranet to all employees and contractors. For example, "environment for raising concerns" is given a trait health rating (color code and emoticon) calculated by combining the most recent safety culture survey results on the same trait with the most recent indicators from the Employee Concerns Program (number of concerns, average time to close concerns, average satisfaction as rated by the employees who raised the concerns, and percentage of participants who would recommend the program to others). The dashboard's online page for this trait also includes a plan of action for improvement and metrics for tracking plan implementation and results. In addition, the subject matter expert writes a short qualitative narrative describing the strengths and weaknesses of the organization on that trait.

Who Should Assess Safety Culture

As with any aspect of safety, assessment of safety culture requires objectivity, expertise, and sensitivity to context. Some organizations already have the right capabilities and motivation to conduct a safety culture assessment, but many others need assistance from outside auditors, corporate experts, consultants, peer organizations, or industry groups. In some circumstances, external organizations may be more trusted by respondents and therefore elicit more candid responses, and they also may have better access to benchmarking data. Use of existing tools (such as climate surveys widely used in the nuclear industry) offers the advantages of requiring less development and support, as well as facilitating comparisons and industry-level sharing with other organizations using the same tools. However, existing tools have the disadvantages of being generic and therefore less useful in terms of the specific issues and context of an organization; such tools also may instill less sense of ownership of safety culture. Therefore, the long-term goal should be to bring the organization's self-assessment and self-reflection capabilities as close to the work as possible, involving everyone in the safety culture assessment process. Internalizing the capability for gathering and analyzing data on safety culture is especially important in the offshore industry because, as discussed in Chapter 2, offshore organizations vary greatly in size, resources, risks, and sophistication, so it is necessary to tailor safety culture assessment to each organization.

Given that surveys provide only a partial view of the safety culture of an organization, a more comprehensive assessment often engages a team of specialists who use a combination of tools, such as interviews, document reviews, observations, and focus groups. The size and makeup of assessment teams need to flow from the scope and purpose of the undertaking and the complexity of the methods used. Consistent with the finding that multiple cultures exist within organizations (see Chapter 2), a broad, comprehensive understanding of an organization's safety culture (or cultures) will require a range of assessment tools and a diverse assessment team. In a larger organization, this means gathering data from multiple levels (executives, managers, front-line employees) and across functional areas (e.g., drilling, engineering). A more focused investigation of one particular aspect of safety culture (e.g., issues with lockout, tagout procedures) likely will require a much smaller team (or even an individual) using a more limited set of tools.

Regardless of the final composition of the assessment team, it is important for several reasons that the host organization retain ownership of both the process and follow-up actions on the recommendations resulting from the assessment. First, if employees perceive that management has outsourced the safety culture assessment (and perhaps the broader problem) to an outside agency or contractor, they may conclude that the organization is not really serious about the issue. Second, the safety culture assessment ultimately will require some actions and changes within the organization. One of the key factors predicting the success of change initiatives is management commitment (Zohar and Luria 2005). Management's staying involved in and retaining ownership of the assessment process will increase its engagement in and commitment to the process and any resulting recommended changes. Third, assessments that are conducted and evaluated closer to the organization's work processes typically result in more timely feedback and therefore greater flexibility and learning. There is a hierarchy of people and organizations that establish and implement safety plans and evaluate safety processes and performance, from workers to supervisors, safety auditors, middle managers, senior executives, regulators, and legislators (Leveson 2012, 2015). Some safety indicators will be common across many levels of this hierarchy, but more real-time indicators and methods for controlling safety and making improvements are needed for those levels closer to work operations. Finally, only management can ensure that safety culture assessments fit within the organization's broader safety management system (Branch and Olson 2011).

Each organization has to match the strategic scope and complexity of its safety culture assessment to the right balance among local involvement and ownership, local expertise, breadth of perspective, outside expertise, and trust of internal or external parties (see DOE [2012] regarding diversity of background and training of assessment team members). The Nuclear Energy Institute (NEI 2009) has identified three types of assessment teams: internal self-assessment, independent, and third-party. An internal self-assessment team consists of employees from the local site, as well as staff from other locations and headquarters. An independent assessment team has no members from the site being evaluated, but is made up of a mix of staff from other sites and members from outside the organization. A third-party assessment team consists of members exclusively from outside the organization. As noted in a recent report from the Belgian Nuclear Research Centre (2012), however, each potential assessment team approach has strengths and weaknesses, with none emerging as "best."

Employee Participation in the Assessment Process

Effective employee participation is a key component of the safety culture assessment process and successful follow-up actions. A report of the U.K. Health and Safety Executive (HSE 2015) notes that employee involvement is one of the greatest influences on safety culture. Yet despite their critical role, workers may be hesitant to participate. For example, the International Labor Organization (ILO 2011) observes that workers may be hesitant to participate in safety culture assessments because their opinion has not often been valued: "Workers generally know where many of the safety problems are, but since no one asks them their opinion, they resist getting involved in the safety program." In addition, workers may fear that making reports of safety issues or negative comments could jeopardize their job, create conflict in the workplace, increase workload for themselves or their coworkers, and fail to result in improvements. Companies need to build trust in management and provide positive incentives to encourage reporting and participation in the learning process (e.g., Baram 1997).

Baker and colleagues (2007) had to grapple with this hesitancy during its safety culture investigation of BP's U.S. oil refineries. BP created the Baker Panel in response to an urgent recommendation issued by the U.S. Chemical Safety Board in August 2005. Five months earlier, BP's Texas City Refinery had experienced a catastrophic fire and explosions that killed 15 and injured 170. The panel recognized that employees might be hesitant to trust and participate in the panel's safety culture survey, interviews, and meetings. This hurdle was overcome through the production of a video featuring Leo Gerard, president of the United Steelworkers Union, which represented most BP refinery workers, and Carolyn Merritt, chair of the Chemical Safety Board, both of whom urged employees to participate fully in the safety culture assessment activities. In addition, Glenn Erwin, a long-time union leader, was a member of the Baker Panel.

Both the ILO (2011) and Baker and colleagues (2007) reports emphasize that front-line employees need to have a feeling of "psychological safety" (Edmondson 1996, 1999) to be willing to disclose difficult conditions or events without fear of being embarrassed by their peers or punished by their managers. Indeed, this feeling is the foundation of a reporting culture (Reason 1997) and the starting point for improvement (see also Hofmann and Stetzer 1998). Psychological safety can be enhanced by messages from legitimate leaders (e.g., union presidents), as well as by an open, fair, and participative process. For example, the European Agency for Safety and Health at Work (2012) suggests that employee involvement should include union involvement and involve more than informing or consulting activities, stating that "full participation goes beyond consultation; workers and their representatives are also involved in making decisions."

Front-line employees and all key stakeholders also need to stay involved, or at least be informed on an ongoing basis, once the safety culture assessment has been completed. Many organizations fail to communicate the results of the self-assessment back to employees, who are likely to conclude that the assessment was a ceremonial exercise carried out to comply with external demands and that no meaningful changes will result. Indeed, given that respect and communication are key aspects of safety culture, it appears obvious that a safety culture assessment must communicate respectfully with employees both during the information-gathering process and again when results are reported and improvement plans are made. Doing so will not only maintain employee interest and engagement in change efforts, but also shape the culture (Chapter 6) with respect to how management and employees treat each other as part of the same team.

Psychological safety is important not just for front-line employees but for all participants, including senior management. Companies are understandably cautious about producing reports that may expose them to regulatory sanctions and/or legal actions asserting negligence. Making safety a priority entails executives showing leadership by supporting the flow of information necessary for organizational learning, because the cost of hiding problems is likely to be higher in the long run than the cost of facing them as early on as possible.

The safety culture assessment process also serves as an opportunity to engage the organization in a set of conversations and change efforts that can have a major beneficial impact on the culture itself. An effective assessment process brings together a wide range of people to talk about their concerns and opportunities for improvement, and thereby begins to break down the vertical silos and the horizontal barriers in large organizations. The process resulted in the development of personal networks that act as a resource for information flow, interdependent work, and organizational learning. The assessment process can be conducted in a way that informs and engages employees, treats them respectfully and shows sincere interest in what they have to say, and leads to taking collaborative action to achieve small wins (and maybe bigger wins as well). If people are engaged in actively effecting needed changes and those changes are seen and valued as successes, the culture reflects the assumption that this is the way members of the organization work together to improve.

At the same time, the process of assessment raises expectations of improvement, and unless visible change is communicated to the workforce (change in which they ideally have been actively engaged), the process will likely increase cynicism and further entrench the existing culture. If the assessment process is conducted by outsiders who report to management, it may provide the appearance of objectivity, but it also will have the unintended consequence of imbuing the culture with the assumptions (or reinforcing existing assumptions) that insiders are helpless to effect change and that expertise and power reside in top management and external consultants. When safety culture assessment is conducted as a checklist process run by outsiders and imposed on workers, with little communication of results and little visible change, it reinforces the gaps among owners, managers, workers, and contractors and erodes trust.

Role of the Safety Regulator

Just as regulatory authority differs substantially across industries and countries, the role of the regulator in safety culture assessment can be established in more than one way. The U.S. Nuclear Regulatory Commission (U.S. NRC) provides one model for how a safety regulator assesses safety culture. In general, the U.S. NRC does not conduct safety culture assessments, although it reserves the right to do so in special situations. Instead, the U.S. NRC publishes general criteria for assessments (e.g., U.S. NRC 2014).

There are both advantages and disadvantages to having the regulator actually conduct the safety culture assessment. On the plus side, doing so ensures that the assessment will be carried out and conducted in a reasonable and uniform manner and that its results will be shared.

However, this approach also shifts the context from self-initiated learning to reactive oversight and compliance. If there is a true partnership, it may be possible for the regulator to be more proactive without undermining learning by other parties, but in a more adversarial situation, defensive behavior may interfere with the flow of data and the opportunities for learning.

For a regulator such as BSEE to play a greater role in safety culture assessment (for example, serving as a clearinghouse for methods, offering advice, validating quality), the agency must have the capacity—including both the technical expertise and cultural values and assumptions—to perform this role. For example, the U.K. Health and Safety Executive offshore regulator employs senior nontechnical staff trained and experienced in social science. BSEE currently has little expertise in this area but could build such capabilities by hiring experts, training current employees, and/or using external contractors. If the regulator wishes to support a strong and advanced safety culture (a proactive learning culture), the regulator itself should lead the way. A regulator with a calculative culture is likely to instill checklist compliance despite its expressed desires.

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Safety in the offshore industry is a strategic issue that needs to be managed along with operations, costs, human resources, and innovation. Safety management requires assessment of safety outcomes and processes that enable safety, including the attitudes, beliefs, and behaviors of everyone in the organization. Safety culture is not a perfect concept, but its assessment directs attention to how people think, feel, and act, from top leadership to front-line workers. Whether the process actually focuses on culture or on communication, management, leadership, work design, respect, or teamwork probably is not as important as the fact that the people involved are working on these interrelated topics. However, it will be challenging for many organizations (especially smaller ones) to build the capabilities needed to assess safety culture and use the results to draw actionable conclusions consistent with the organization’s overall strategy.

Recommendation 5.1.1: Operators and contractors should assess their safety cultures regularly as part of a management system. To this end, they should discuss salient inputs, even if only abbreviated data and qualitative impressions, at periodic management meetings (weekly, monthly, or quarterly) and as safety culture issues emerge in operations (e.g., incidents, investigations, audits, industry bulletins).

Recommendation 5.1.2: The committee strongly recommends that companies use multiple assessment methods, including, in particular, both leading and lagging indicators and both quantitative and qualitative indicators of safety culture. Companies should also apply a mix of indicators, including some that are more standard across the industry to facilitate ease of use and comparison across organizations, and some that are tailored to the specific needs and concerns of their organization. For example, American Petroleum Institute Recommended Practice 754 (“Process Safety Performance Indicators for the Refining and Petrochemical Industries”) addresses the importance of collecting broad leading and lagging indicators of process safety performance. The American Petroleum Institute could revise this guideline to include safety culture indicators and expand its application beyond onshore refining to include offshore operations. This “dashboard” of indicators could be

examined periodically as part of the standard management process, even if some indicators (such as a full-scale climate survey or external audit) would be collected less frequently than others.

Recommendation 5.1.3: Given the challenges of developing practical and useful indicators of the strength of safety culture for a wide variety of organizations (large and small operators, contractors, regulators), the nine elements of such a culture identified by the Bureau of Safety and Environmental Enforcement (BSEE) should be adopted as a standard or starting point for safety culture assessment. There is little reason for each organization to develop its own safety culture content, and the BSEE elements are sufficiently general and relevant to serve the purpose.

Recommendation 5.1.4: The committee recommends that BSEE and other regulators of the offshore industry strengthen their capabilities in the area of safety culture assessment by bolstering their expertise in safety culture through appropriate hiring and training and/or partnering with industry or third-party organizations. These bolstered capabilities would enable regulators to offer advice, training, tools, and guidelines to the industry as it conducts self-analysis. These capabilities also would enable regulators to act on their safety culture aspirations by, for example, enhancing their audits of safety outcomes, practices, and culture.

Recommendation 5.1.5: Complementing Recommendations 5.1.3 and 5.1.4, the offshore industry should work collectively on the challenges of strengthening a safety culture. BSEE should support this effort by serving as a clearinghouse for and facilitator of industry-level exchanges of lessons learned and benchmarking, thereby helping the industry develop a shared language, shared approaches, appropriate options, and more practical and efficient assessment practices.

Assessment of safety culture requires objectivity, expertise, and sensitivity to context. Some organizations already have the right capabilities and motivation to conduct a safety culture assessment, but many others need outside auditors and experts from corporate staff, consultants, peer organizations, industry groups, or elsewhere. At the same time, however, bringing the self-assessment and self-reflection capabilities as close to the work as possible creates a sense of ownership and accountability and encourages broad participation in assessment process. Internalizing the capability for gathering and analyzing safety culture data is especially important because offshore organizations vary greatly in size, resources, risks, and sophistication, so the assessment process needs to be tailored to the organization.

Recommendation 5.2.1: Organizations that operate in the Outer Continental Shelf should consider their capabilities and priorities in determining to what extent they will rely on internal versus external expertise for assessment of safety culture. When feasible, organizations should seek to acquire internal expertise overtime so they can manage the process, interpret results, and increase their ownership and the relevance of the assessments and their results. Of course, smaller organizations will need outside help from customers, contractors, or industry groups in identifying simple yet useful assessment approaches.

Recommendation 5.2.2: Given that it is management's responsibility to ensure safety, regulators should define their role in terms of monitoring safety culture and encouraging and supporting the management of regulated entities in identifying the expertise and resources and understanding the priorities for operating safely.

The safety culture assessment process is itself a cultural intervention. The process can reinforce a reactive and cynical culture or help the organization move toward a proactive and generative culture. An effective assessment process engages a wide range of participants in coming together to talk about their concerns and opportunities for improvement, and thereby begins to break down the vertical silos and the horizontal barriers in large organizations. If people are engaged in actively effecting changes and those changes are seen and valued as successes, the culture reflects the assumption that this is the way members of the organization work together to improve.

Recommendation 5.3.1: Organizations should treat the safety culture assessment process as an opportunity to enact a strong safety culture based on frequent and open communication, mutual respect, and widespread participation.

Recommendation 5.3.2: Safety culture assessments should include processes for employee feedback and engagement in the development and implementation of appropriate interventions. Assessment should be viewed not as an end in itself but as a means to guide an improvement process. Broad participation is key to any improvement process, and visible improvement motivates continued participation and trust.

A useful safety culture assessment will not only provide a score or overall average but also attend to variability across units, locations, and levels of the organization. The safety culture perceptions of senior managers, middle managers, direct supervisors, and front-line workers typically differ. It is difficult for bad news to travel upward, and natural for senior management to believe that safety culture is stronger than it is perceived to be among front-line workers. Similarly, even a company with a good safety culture may have departments or units that vary in the quality of their safety culture. And at a workplace with many employers, such as a single large offshore installation, the safety cultures of the different companies may differ. It is important to direct attention and resources where they are needed, and therefore important to examine such variations in perceptions of and the quality of safety culture.

Recommendation 5.4.1: Safety culture assessments should be designed and analyzed to capture variation within the organization, including by hierarchical level, work location or department, and employer. Thus the assessment should collect a broad set of indicators from a suitably diverse set of individuals and groups.

Recommendation 5.4.2: Safety culture assessments should include employees, contractors, and any others involved in a work process or at a work site who are the responsibility of the operator or who could affect or be affected by safety culture.

Although a great deal of knowledge about safety culture and its assessment has emerged in the past 30 years, a great deal more remains to be learned.

Recommendation 5.5.1: Regulators, industry organizations, operators, and other participants in the offshore industry should work together to facilitate research and information sharing with respect to safety culture. Priority research topics include the following:

- **Which safety culture assessment approaches are best suited to specific contexts, such as smaller companies with relatively few employees and few resources? Which aspects of safety culture assessment (e.g., specific items from safety climate surveys) are most relevant for specific types of organizations (e.g., contractors, small operators, large operators)?**
- **How can data and lessons learned best be shared across companies in the diverse offshore industry? Who should facilitate this process—an industry group, the regulator, a new consortium? The committee suggests that at this time, the Center for Offshore Safety is best positioned to serve as a partner and facilitator that can earn the trust of all stakeholders.**
- **What are examples of experience in the development of safety culture, especially in a variety of contexts (smaller operators, larger operators, contractors, regulators)? How can these experiences best be compared across countries (e.g., Norway and the United States)? What is the role of infrastructure, such as national legal systems, in enabling or preventing improvements in safety culture?**
- **Can safety cultures be grouped into discernable models or types, such as those described by Westrum (2004; see Chapter 2), Hudson (2007), and Amalberti (2013; see Chapter 2), or do they fall along a single continuum such as that assumed in safety climate measures? If so, what are the key attributes that distinguish the models or types?**

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Abbreviations

BSEE	Bureau of Safety and Environmental Enforcement
CSB	U.S. Chemical Safety and Hazard Investigation Board
DOE	U.S. Department of Energy
HSE	U.K. Health and Safety Executive
IAEA	International Atomic Energy Agency
ILO	International Labor Organization
INPO	Institute of Nuclear Power Operators
NEI	Nuclear Energy Institute
U.S. NRC	U.S. Nuclear Regulatory Commission

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6

Implementing Change in Offshore Safety Culture

The history of change in the offshore oil and gas industry reveals a great deal of progress and innovation over the past decades, especially following the *Piper Alpha* explosion in the North Sea in 1988, but it also shows frustration and delay. While some data indicate a downward trend in recordable and lost workday incident rates offshore (see Chapter 3, Figure 3-1), significant concerns about safety offshore remain as the industry expands drilling in more challenging locations (e.g., deeper waters farther from shore) and transfers marginal assets to smaller, lower-cost operators. These circumstances motivated the priority accorded to having a safety and environmental management system (SEMS), first as a voluntary program, later as a partial requirement, and perhaps in the future as a more extensive requirement. But as argued in Chapters 3 and 4, having SEMS as a management structure needs to be complemented by appropriate safety culture features and leadership behaviors, which are not easy to develop.

Entire fields of study and practice have emerged around change management and implementation science. In a broad set of industries, studies of change initiatives have found that fewer than half meet their goals (Seo et al. 2004). Change plans may take years to craft and more years to implement. For example, it took more than a decade for the American Petroleum Institute (API) to develop and issue an updated cementing standard (issued just after the Macondo blowout) that improved upon existing guidance and recommendations. The culture change process is more like a journey than a project: even highly successful and respected organizations can behave in ways that bring the strength of their safety cultures into question. For example, following the 2009 Montara blowout off the coast of Australia, one defensive reaction by some in the United States was to explain why such an accident could not happen here—and then it did, in the form of 2010 Macondo explosion and oil spill.

Therefore, this chapter focuses on how to implement change in a sustainable way, especially culture change that involves everyone from top to bottom in an organization. It first briefly summarizes change principles from the extensive literature on change, including strategies for culture change, and examines the illustrative cases of the U.S. Navy's SUBSAFE program and one international oil and gas company's safety culture journey. The chapter then turns to the challenges faced by the offshore industry in changing safety culture. Some are general challenges for managing change of any sort, and some are specific to culture change in this particular context. The challenges are described, along with strategies for overcoming them. The final section presents findings and conclusions, as well as recommendations for the industry as a whole and for particular stakeholders (large integrated companies, small operators, regulators).

CHANGE PRINCIPLES

Kotter (2012) offers a relatively simple and generic recipe for change, but it is only a starting point. His recipe involves eight steps in the following sequence: (1) create a sense of urgency; (2) build a guiding coalition; (3) shape a strategic vision and change initiatives; (4) enlist participation; (5) enable action by removing obstacles; (6) generate short-term wins; (7) gather momentum by aligning systems, structures, processes, and people; and (8) institutionalize change with leadership development and culture. By looking behind these steps, one can identify several principles underlying effective change.

First, people have to want change more than they want stability and fear change. Lewin (1947) suggests that change begins with "unfreezing" as people become convinced that current practices are failing. For example, the safety transformation of the Norwegian offshore industry drew its impetus from two major accidents: the Ekofisk Bravo blowout and major oil spill in 1977 and the capsizing of the *Alexander L. Kielland* in 1980, which led to 123 fatalities. Although major accidents provide pressure for change, successful transformation also requires a compelling vision and a practical plan for moving forward that can motivate stakeholders. In every organization, there are forces favoring change and those resisting change. An effective change strategy will strengthen the forces favoring change, such as by connecting the specific change(s) to stakeholder interests (i.e., "What's in it for me?"), while also working to reduce the varied impediments to change, such as limited time and resources and fear of getting fired. Beckhard and Harris (1977) popularized a "change equation" according to which successful change requires:

$$\mathbf{D} \times \mathbf{V} \times \mathbf{F} > \mathbf{R}$$

where:

D is *Dissatisfaction with the current situation* (WHY is this change necessary?);
V is *Vision of what is possible in the future* (WHERE are we going?);
F is *First Steps that are achievable towards the vision* (HOW do we get there?); and
R is *Resistance to change*.

For change to occur, the combination of **D**, **V**, and **F** must be greater than **R**.

Second, different people have different values and different priorities, and to be successful, change has to engage those who are ready for it and to gain the support of those inclined to wait for change (Beckhard and Harris 1977). Although the offshore industry is quite diverse, the major players in deepwater operations and typical shelf (shallow-water) operators already have or could develop and share protocols that could help advance the industry's safety culture. That the change process requires getting individuals with formal authority as well as respected and influential opinion leaders involved early in a guiding coalition, enlisting wider participation, generating small wins, and building momentum suggests that the process is as much a social movement as a "project" to be managed. And the process is never completed, even when change is embedded in cultural practices and beliefs as well as in organizational structures and processes.

Third, because organizations are so complex and its parts so interdependent, it generally is not possible to change one thing at a time. Any change has intended and unintended consequences and reverberations, some of which reinforce the desired change, but some of which interfere with it or raise new challenges. Virtually every change brings surprises that must be dealt with, so the change process is iterative, uneven, and not fully predictable. For example, some companies have built a rotation assignment in safety into the career path to upper levels of management, intending thereby to elevate and reinforce the importance of safety to career advancement. However, if these well-intentioned assignments are taken as required "get your ticket punched" experiences with no intrinsic motivation or accountability, they waste time and resources and, even worse, breed cynicism and degrade the safety culture. Thus, leaders and change agents would do well to heed the saying from Zen Buddhism, "Everything changes; everything is connected; pay attention."

Fourth, change tactics must be appropriate to the context. The same change plan may work in one setting (e.g., a large integrated operator) and not in another (e.g., a small independent operator). Change can be top-down, bottom-up, or middle-up-down. It can be incremental or radical, gradual or sudden, led from within or imposed from outside. Change can focus on incentives and rewards or on mission and purpose, exploiting existing capabilities or building new ones (DiBella and Nevis 1998; Beer and Nohria 2000). In short, change must involve an assessment of the situation, including the strategic goals, the formal organization, the key stakeholders and their interests, the companies involved, the cultural underpinnings, and the iterative reassessments and shifts in direction as the process unfolds (Beckhard and Harris 1977; Brown and Eisenhardt 1997).

Finally, leadership plays a critical role in change. Leaders supply meaningful interpretations, a vision of a better future, a network of interpersonal relationships, and innovative action, but it is not necessary for a single leader to do everything; leadership as a change function is distributed across many individuals (Ancona et al. 2004). Formal leaders, such as the top management team or change project team, bring authority and visibility. Informal leaders, often impossible to identify on the organization chart, provide important role models and network connectors in their organizations whose support or resistance can make or break a change effort.

Jacobs (2013) offers behavioral leadership as a framework for understanding and shaping a culture of effective leader behavior and provides a science-based method for understanding and addressing leadership development that can measurably impact a safety culture. Addressing leadership behaviors and a range of organizational levers in conjunction with effective cross-functional and cross-organizational alignment to enable leadership buy-in can shift collective behavior across an organization toward operational excellence in environment, safety, health, reliability, and productivity.[1]

Deliberate culture change is difficult, but some strategies can be successful (Schein 2010). For example, leaders can leverage a disaster to instigate change. As previously mentioned, the Norwegian offshore industry responded forcefully to two disasters, and Exxon-Mobil made many changes following the *Valdez* oil spill. However, companies do not always change even after a disaster. Another strategy is to bring in people from a culture seen as worthy of emulation: the nuclear power industry hires U.S. Navy captains and admirals, and the oil and gas industry hires people from respected companies such as DuPont. Still another possibility arises if the desired culture already exists within part of the organization, and its leaders can be reassigned and promoted to spread the existing model more widely and signal top management support for culture change. Sending employees on benchmarking trips is a strategy that can provide role models for change, and widespread training can instill or reinforce new behaviors,

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[1] It can be helpful to envision and strive for a "perfect day" with zero incidents. But the concept of "incidents" must be broad enough to include both personal and process safety accidents, near misses, nonconformances, anomalies, and surprises. It is dangerous when organizations focus only on what can be counted, which are typically personal safety accidents, or when workers feel reluctant to report a problem that will spoil a record of many days without an incident.

especially if senior management is visibly involved. Providing resources and encouragement for interdisciplinary problem solving can create new cultural practices and assumptions as people work together in new ways to make desired improvements. Finally, instead of trying to replace all of the old culture, some cultural values and practices can be supported, reinterpreted, and linked to new, desired behaviors. At one nuclear power plant, for example, deeply ingrained concepts of excellence, professional integrity, and safety were reinterpreted to modify the culture (e.g., excellence was now defined as not just knowing everything and having answers but also discovering problems and learning new things [Carroll and Quijada 2007]). Schein (2015, 9) offers this observation:

> If I have learned anything in this field, it is that cultures as a whole don't change; they evolve slowly as bits and pieces of them are changed by systematic change interventions. And these interventions work only when the culture changes are clearly tied to the fixing of some organizational problems linked to performance.

Described below are two examples of culture change, one from the U.S. Navy and one from the oil and gas industry. These examples are intended to highlight effective principles and processes rather than specific actions to be emulated directly.

The SUBSAFE Example

One informative example of a comprehensive safety system embedded in safety culture is the U.S. Navy's SUBSAFE program (Sullivan 2003), created at the insistence of Admiral Rickover immediately following the loss of the nuclear submarine USS *Thresher* in 1963 (Bierly et al. 2014). The purpose of SUBSAFE is quite specific—to maintain hull integrity and operability of crucial submarine systems so as to allow control and recovery. The SUBSAFE program has nothing to do with the safety of the submarine's nuclear reactor or missiles or with slips, trips, and falls. Its success is evident in the safety record of the Navy's submarine fleet: in approximately 50 years prior to the establishment of the SUBSAFE program, 16 submarines were lost to noncombat accidents; in the 50 years following its establishment, no submarine that was part of the SUBSAFE program was lost.

The core of the SUBSAFE program is a comprehensive set of requirements that permeates every aspect of submarine design, construction, operations, and maintenance, including how work is conducted, what materials are used, how every element of work is documented, and how inspections and audits are used to verify compliance with the requirements. Every 10 years, the entire program is evaluated and revised (and small changes are made as needed), so that the program is never viewed as finished or complete. A core element of the program is the certification process that is applied to critical structures, systems, and components. Certification is based strictly on objective quality evidence—a statement of fact, quantitative or qualitative, that documents the deliberate steps taken to comply with requirements. Certification can readily be audited throughout the life of a submarine, and without certification, a submarine cannot be operated. In contrast, industrial plants often operate with known and unknown problems (and lists of promises of work to be done). Therefore, risks are nearly impossible to estimate and manage.

The SUBSAFE program is also designed to address three cultural challenges: ignorance, arrogance, and complacency. Passionate, engaged, and effective leadership is considered the key factor in the constant struggle to overcome these challenges. Leaders actively promote a questioning attitude through critical self-evaluation, a learning orientation (e.g., continuous training, audit philosophy), an assumption that everyone is trying to do the right thing (but it is necessary to verify), and a focus on objective quality evidence rather than opinion. The above cultural challenges also are addressed each year at an annual meeting held on the anniversary of the loss of the *Thresher*, where lessons learned and changes made during the past year are summarized. In addition, a video of the *Thresher* is shown with emotionally laden images of the crew and civilians on board, and relatives of the victims attend and speak of their loss. The heart and soul of the annual meeting is a shared commitment to safety—and to keeping the emotional experience of the *Thresher* accident alive.

The SUBSAFE audit practices and philosophy also are astutely oriented to the realities of a complex organization. Audits of every SUBSAFE-certified ship and every SUBSAFE-certified facility (e.g., shipyards, contractors) are conducted quite frequently to verify compliance with requirements. The audit philosophy encourages learning in a constructive manner, rather than "policing" and punishing the guilty. Consistent with that philosophy, audit teams comprise about 80 percent external auditors from peer facilities (that are also subject to similar audits) and 20 percent personnel from the facility being audited. Continuous communication between the audit team and the personnel in the facility ensures full understanding of identified problems; there is no desire to "catch" or "surprise" people. The compliance verification organization has status and authority equal to that of the program managers and technical authority. Headquarters also is audited, and just like any other part of the SUBSAFE community, its leaders must accept and resolve audit findings.

The SUBSAFE program explicitly recognizes the potential conflict among stakeholders with different goals and gives voice and weight to each of three key roles: (1) the platform program manager is responsible for the design and operation of a particular submarine design or "platform"; (2) the independent technical authority is responsible for providing the necessary technical expertise, such as recommending acceptable designs from which the program manager may choose; and (3) the independent quality assurance and safety authority is responsible for compliance with requirements. None of these actors can make a unilateral decision; designs can move forward only if all three have agreed that their goals are satisfied. This system of checks and balances must be carefully maintained to prevent significant accidents. For example, the investigation of the space shuttle *Columbia* accident found that shuttle program management had gradually acquired power over the supposedly independent safety organization and had program management staff sit in on, then become members of and even chair safety committees that were, by policy, independent of the program organization (CAIB 2003).

In summary, the success of the SUBSAFE program arises not just from its structure as a set of requirements, obsessive documentation of objective quality evidence, roles and responsibilities, audit practices, and so forth, but also from its enacted and reenacted experience with its balance of powers, annual renewal ceremony, audit philosophy and teamwork, and engaged leadership (and much more). The story of the SUBSAFE program illustrates change principles from Kotter (2012) and Schein (2010), among others. The program demonstrates the vital roles played by a clear sense of urgency, leadership at the top, engagement of key stakeholders in a joint improvement effort, measurable success that people cared about, and the program's being embedded within both management structures and cultural values and practices.

The International Oil and Gas Company Example

Each of the major oil and gas companies has its own safety culture story to tell. The committee did not choose the example of this operator for its absolute safety record, which may be no better than that of other operators. However, this story is notable for its long duration, the company's global reach and willingness to share details (e.g., Hudson 2007), and the many lessons this example provides.

Starting in 1986, the company was the sponsor of the research behind Reason's (1990) Swiss cheese model of accident propagation and an early adopter of these new safety concepts. The company made progress in safety but saw less improvement after about 1993. In the early 1990s, the company was implementing safety cases and SEMS-style systems in the post-*Piper Alpha* period and benefited from having strong senior management support for safety initiatives and a psychologist on the core implementation team.

By 1996, there was concern within the company that safety performance had plateaued, and new approaches were needed. In a business improvement workshop, senior management embraced the concept of a workforce intrinsically motivated to be safe; however, the change management team believed that changing the safety culture would be somewhat easier and more acceptable than improving intrinsic motivation, and would have a similar impact on the company's safety performance. After convening researchers and industry experts from several companies, the change team focused on the safety culture development ladder shown in Table 6-1 (Westrum 1991, as revised by Hudson 1997).

The change team conducted interviews in multiple locations to identify aspects of culture that more than 50 percent of respondents could agree represented each step on the ladder. The result was the Hearts and Minds program (a name used by British Army operations in several parts of the world during the mid-20th century), designed to create engagement between workers and managers that would stimulate and signify managerial commitment (from top managers down to supervisors) in the area of health, safety, and environment. The program included an engagement and assessment tool (the most recent version of which asks about where the

TABLE 6-1 Safety Culture Development Ladder

Stage	Concept	Sample Discourse
Pathological	Compliance with statutory requirement. May conceal unfavorable information.	No one cares about safety as long as we are not caught.
Reactive	Respond to accidents. Worry about costs and immediate causes of accidents.	We do a lot about safety every time we have an accident.
Calculative	Focus on objective statistics, number of reports, following rules, hazard analyses.	We have procedures in place to manage all accidents.
Proactive	Investigate the causes, look for trends, benchmark others, audit, try to be the best.	We try to anticipate safety problems before they arise.
Generative	Benchmark inside and outside the industry, full audit system, engage entire workforce and contractors, no compromises	Safety is how we do business around here.

SOURCES: Westrum (1991), as revised by Hudson (1997).

organization could realistically be in 24 months and where it is now) and an evolving set of simple Hearts and Minds tools[2] (e.g., Managing Rule Breaking, Risk Assessment Matrix, Working Safely, Improving Supervision) with associated training and workshop experiences to support use of the tools. The program also was made available by the U.K. Institute (a professional association) for the entire industry to use.

In the mid-2000s, the company had these tools but no shared safety vision or strategy across different business units and locations. After several years of discussion, senior leaders agreed upon Goal Zero, which set the expectation that zero incidents and injuries for employees and contractors was the only acceptable outcome. Goal Zero represented a fundamental shift in mind-set away from viewing the oil and gas industry as inherently dangerous toward leadership recognition of and commitment to good safety performance as essential to good operational performance.

Building on the Hearts and Minds program, the company focused on getting employees and contractors to accept behavioral rules, starting with simple measures to protect personal safety, such as holding handrails, and then shifting to more complex procedures intended to reduce higher-risk (including process safety) exposures. Safety measures were incorporated in all aspects of the business and benchmarked internally and externally to make performance transparent and motivate improvement.

In mid-2009, the company implemented its 12 Life-Saving Rules globally. Five of these rules relate to personal safety, 4 to process safety, and 3 to road safety. Based on an analysis of worldwide fatalities in the prior 10 years, safety leadership estimated that had these rules been in place earlier, compliance with them might have prevented 80 percent of those fatalities. These rules also have been made available to the oil and gas industry through the International Association of Oil & Gas Producers (IOGP Safety Data Subcommittee 2013). At first glance, these rules appear to place the entire burden of maintaining safety on workers; however, they in fact highlight leadership's responsibility to clarify the rules and to establish the conditions that make compliance possible (e.g., having the right equipment available, ensuring that procedures are aligned with rule requirements). Although following these rules became a condition of working for the company and people were terminated for noncompliance, the rules were framed as a means of saving lives and demonstrating care for people: The shared assumption was that if one could not follow the Life-Saving Rules, it would be only a matter of time until one hurt oneself or others.

The broad acceptance and institutionalization of Goal Zero and the Life-Saving Rules provided a new momentum for safety and improved performance. In a major project in Qatar, for example, which took nearly 7 years to construct and employed as many as 50,000 workers, the company achieved outstanding safety performance. Historical performance would have predicted 20 to 30 work-related fatalities; yet this project had only 1. The change in expectations and behaviors led to tangible results (e.g., global fatalities across all company activities dropped from 26 in 2008 to 5 in 2014). However, it merits noting that an effective safety management program does not eliminate all accidents. The structured safety culture development ladder (Table 6-1) suggests that an organization would use the lessons learned from a previous experience to reduce the likelihood of a similar situation in the future. Challenges also remain as leaders discuss (1) how to strengthen process safety (systemic interactions and strength of preventive measures against accidents are more difficult to manage than individual actions), and (2) how to partner

[2] http://www.eimicrosites.org/heartsandminds. Accessed February 15, 2016.

more effectively with contractors and work with industry associations (e.g., IOGP) to set common standards.

Some valuable lessons emerge from this example. First, the journey is lengthy, bumpy, and uncertain. The potential always exists to backslide or for parts of the organization to lag behind. New initiatives took hold in this company but reached a plateau over some years, and leaders had to maintain their commitment and rekindle momentum with innovative concepts and initiatives that came partly from outside and partly from within the company. Even now, there is variability across the company and its contractors. Whereas in 2004 the company was in general working to reach the calculative stage in the safety culture development ladder, people in the company believe many of its parts have now attained the proactive stage. The strategic goal is not necessarily to get everyone to highest stage of the ladder but to keep everyone engaged in assessment and improvement, thereby moving up the ladder within a dynamic business, with a continuously changing workforce, and with heightened societal expectations.

Second, extensive support from and access to top management were critical to make current performance transparent through continual assessment, to acknowledge when performance was unacceptable, and to reenergize the organization when progress began to flag. When leadership is about one step higher on the safety culture ladder than most of the organization, it can provide an effective vision of the future and be a catalyst for change. On the other hand, leadership that is lagging will find it difficult to champion change, while leadership that is too far ahead will have difficulty communicating an understandable message about safety improvement that people believe is achievable and worthy of their commitment.

Third, having in-house social science capability was critical in this company for generating and implementing ideas and marshaling global experts for help. Culture change is a people challenge, requiring the ability to engage and motivate people as well as to understand organizations and cultures.

Fourth, the strategies that move an organization from one step on the safety culture ladder to the next are not the same at each step. Moving from the pathological to the reactive stage requires a decision from the top to take action, which then results in a suite of programs and tools that may or may not be implemented. Moving from reactive to calculative involves actually implementing the programs and tools, although they may have varying utility and impact. Making the programs and tools more effective and improving performance brings the organization to the proactive level. Moving beyond programs and tools, the organization can progress toward the generative stage when it embeds and sustains leadership behaviors that demonstrate engagement and care for people.

CHALLENGES IN CHANGING THE OFFSHORE SAFETY CULTURE

In sum, the safety culture journey requires leadership commitment and engagement; significant time, money, and know-how; appropriate policies and training; and means of ensuring that new values and behaviors are actually in place. At some points in the journey, as was the case with this example company, there was more explicit focus on culture and at other points more explicit focus on structures and rules. In the fragmented, competitive, heterogeneous, and ever-changing offshore oil and gas industry supported by multiple regulators and industry associations, this journey will not be short or straightforward but will present a number of challenges. These challenges are described below, along with approaches to overcoming or at least addressing them:

1. Safety culture is an ambiguous concept that is difficult to measure.

The safety culture concept has existed for more than 25 years (IAEA 1991; Pidgeon 1991), and despite the varying definitions and measures articulated in Chapters 2 and 5, respectively the committee converged on the Bureau of Safety and Environmental Enforcement (BSEE) definition and nine elements as a reasonable starting point for consensus. Even with a high-level working consensus, however, each industry segment and each company has to consider what safety culture means in its context; what behaviors are critical to sustaining such a culture; and how it can implement an effective measurement system, which takes more thought and resources than simply adopting standard tools. In particular, there remains greater emphasis on personal safety, with which the term "safety" is commonly equated, as opposed to process safety. Further, for many in the oil and gas industry, safety culture is equated with having a SEMS. SEMS is essentially a management strategy and tool, with accompanying processes such as goal setting, measurement, and continuous improvement. As such, it is about roles and responsibilities—necessary but not sufficient to ensure a healthy safety culture, which complements SEMS by expanding on why and how to manage safety. Until safety culture is defined in the context of a particular organization, including its employee behaviors and management practices, the concept cannot be specified and assessed, nor can efforts to improve safety culture be effectively managed.

Overcoming the Challenge

One goal of this report is to provide clarity and direction to the offshore industry in its safety culture journey, analogous to what the Norwegian Petroleum and Safety Authority did for its industry in 2002-2003 in articulating a sound health, safety, and environment culture (PSA 2003). The preceding chapters have provided historical context for a useful definition of safety culture and its essential elements and examined ways to assess this culture. Many of the companies in the offshore industry are well under way on this journey and can serve as instructive examples to others. The nuclear power and airline industries also provide helpful role models for many other industries and have exhibited a notable willingness to share information, both within their own and with other industries. For example, these industries have successfully created, implemented, and institutionalized near-miss reporting systems, employee concerns programs, safety climate surveys, and other means of ensuring that information flows upward and is acted upon (a critical element of safety culture).

Amalberti (2013) asserts that very distinct safety models exist in different industries (see Chapter 2): a resilient model based on individual expertise, a high-reliability organization model based on organized expertise and collective learning, and an ultra-safe model based on prevention and supervision. Important for this discussion of improvement strategies, he points out that improvements can be made by a factor of 10 within a particular safety model (e.g., improving better as a high-reliability organization), but the models cannot easily be mixed. Switching to another model (e.g., from high-reliability organization to ultra-safe) requires a "changeover event" (sometimes imposed by regulators after a disaster) that affects the entire profession or industry. In that changeover, some of the gains of the new model are offset by the loss of benefits of the prior model. For example, the culture of aviation shifted from one of resilient, heroic pilots to the ultra-safe model because of technological advances such as electronic air traffic control, automated aircraft, and systematic flight data recording and analysis, as well as economic changes in the airline industry. However, some current pilots struggle to fly a plane designed for computer control, and although accidents are less frequent, some rare accidents reflect the reduction in pilot resilience that characterized the old safety model.

In the offshore industry, each company need not invent its own safety culture policies, practices, and measurement tools, but each has to decide how to translate (and put into practice) the knowledge and tools that come from the experiences of other companies or industry groups into structures and actions that address its own specific needs and goals. The committee believes that the offshore industry can continue to develop safety culture resources and guidance by sharing information through existing collective institutions, such as trade associations, working groups, the Society of Petroleum Engineers (SPE), and the Center for Offshore Safety (COS). Effective sharing will take leadership at the industry level as well as from each organization—the topic of the next challenge described below.

2. Leadership commitment to building and sustaining safety culture varies among organizations.

Senior leaders and owners of organizations in the offshore industry vary in their understanding of, commitment to, and engagement with developing and sustaining a strong safety culture. Although there are pockets of excellence, leadership challenges remain in the areas of setting strategy, deploying initiatives, and meeting business goals while modeling safety as a value. Leaders who reward productivity but do not consistently recognize safety performance, or who send intentional or unintentional messages that safety is less important than production, too expensive, or something the organization addresses to comply with regulations but does not really believe in, create an environment in which safety culture (and safety) erodes. Leadership transitions also can derail an organization's safety culture if new leaders are not carefully oriented as to its importance and do not assume full ownership of its enactment, even when a good system is in place.

Overcoming the Challenge

Leaders can create and communicate a vision that describes safety as a fundamental value of the organization, not just a transient priority. Priorities change, but values endure and become embedded in the organization's culture. For leaders to be committed to maintaining a strong safety culture, they must first believe that the tangible and intangible benefits of doing so far outweigh the costs, as the two case examples described above illustrate. Then, they must provide support and convince others to commit themselves as well. A number of researchers (e.g., Schein 1996) have noted that leaders rarely change the culture of their organization by their comments; instead, a modified culture is the result of collaborative effort on a common problem in which the leader demonstrates his/her values and commitment to safety. People need to envision a compelling future state of safe operations and understand how their own behavior relates to achieving that vision if they are to have a clear sense of their contributions to change and why that change is important. People throughout the organization have to enact safety processes and practices with behaviors that often go beyond written requirements. A clear and engaging picture of leadership's commitment to sustaining a strong safety culture will spur people to action. They will see a future desirable enough to motivate them to change the present to achieve it.

A key attribute of leadership is that leaders go first; employees watch carefully what leaders do and observe whether it matches what they say. Leaders need to be visible role models who live safety as a value, consistently demonstrate the importance of safety-related behaviors, and instill the courage to change. They need to focus not only on getting results but also on getting results in the right way and behaving in a manner consonant with a strong safety culture. Workers, supervisors, and managers will not speak up about safety issues or be willing to stop work unless they believe their leader will support them. Senior leaders may believe they are willing to support these actions, but if there is no precedent for such support (or, worse, a history of negative reactions) and employees are afraid to even try, there will be no opportunity to reinforce safe behaviors. Leaders have to be proactive with their messages and actions and ensure that no learning opportunity goes to waste.

Effective leaders build an emotional connection to the workforce. Establishing an open-door policy or specifying times for employees to visit personally goes a long way toward establishing trust. The commonly used term "management by walking around" describes a leader who frequents all parts of an organization, getting to know the people who make it work and seeing firsthand what is working well and where opportunities for improvement lie. When members of an organization see leaders who are "walking around" and engaging workers by asking them questions (Schein 2013) and offering appropriate assistance, they know these leaders care about what they are doing and how well they are doing it. Leaders also need to communicate about safety so the workforce can connect emotionally to salient events and progress in risk reduction. Such behavior creates an environment in which people see the value leaders place on the safety of people and assets, learn the scope of their authority for dealing with unsafe situations, and are inspired and confident to do the right thing as a matter of practice.

3. The industry is fragmented and diverse.

As discussed in Chapter 1, drilling and production take place under many different organizational arrangements, from huge deepwater rigs with a large onboard staff (e.g., well over 100, including a diverse set of contractors and subcontractors) to small platforms that are unmanned or have just one or two crewmembers. Because of this heterogeneity, as well as competition, it is challenging to set uniform rules, reach industry-level agreements, or even share information. Efforts are under way through COS and BSEE to develop toolkits and guidance documents, but these efforts have not yet engaged the entire offshore industry. For example, not all of the large operators are members of COS, and many independent companies with operations on the Outer Continental Shelf have elected not to join COS.

Persuading each entity in a fragmented industry to embrace safety culture is challenging. As with the organizational heterogeneity noted above, the economic costs and benefits and cultural values around safety vary across the range of operations, such as seismic, drilling, production, construction, and logistics (air and marine). Most larger operators and contractors recognize the benefit of investing in safety in light of the long-term costs to their operations and their corporate reputation of failing to do so. However, smaller operators and small contractors and subcontractors are more varied in their approach to safety. Some have excellent internal communication about safety and a focused and innovative approach to its achievement, while others may maintain a mind-set and practices focused on a minimum level of safety (e.g., less safety training, selection of contractors based on low cost without consideration of their safety records). Those who believe they cannot afford the near-term costs of investments in safety may withhold information regarding unsafe practices and accidents to minimize further costs (in dollars and reputation). Even the most conscientious organizations can be subject to greater pressures to deemphasize safety when projects run late and financial incentives are in jeopardy.

Many parts of the industry have a dispersed and multicultural workforce (see Chapter 1), which creates challenges either within a workplace, among contractors, or between contractors and their customers. Some of the cultural issues are intercultural. For example, some skilled craft workers in the Gulf of Mexico are employees from various national cultures whose languages and safety attitudes and practices may differ, and may not accord with English and U.S. approaches. Some foreign flag drilling rigs move around the world with long-term, non-American crews. These rigs have consistent expertise and a coherent rig culture (which may be very safe), but this culture may vary from that of the operator. Even within a single national culture, such as that of the United States, there exist cultural and status differences among professional groups (e.g., engineers versus operators versus managers [Schein 1996]), hierarchical levels, generations of workers, and local sites.

Overcoming the Challenge

To strengthen and sustain safety culture, a commitment to safety must start at the top. Senior leaders in each company involved in offshore operations and leaders of industry associations (e.g., API, SPE, IOGP, COS) must consistently demonstrate their commitment to safety, aligning their actions with their words. The industry as a whole, led by the more progressive operators, contractors, and industry associations, needs to be thoughtful about extending safety culture to the heterogeneous organizations and workers in the offshore industry. There are many ways to encourage the development of a strong safety culture in the offshore oil and gas industry and share ideas, tools, and approaches, and industry leaders need to determine which of these are most effective and appropriate. Options include encouraging the development of safety leaders throughout the industry; supporting safety standards and values; recognizing effective safety practices; and providing tools, training, and expertise that can be tailored to the needs of diverse organizations. In addition, each organization needs to develop supervisory practices and training programs for offshore workers that are effective regardless of the workers' native language or preexisting attitudes about safety.

Given the many industry groups that are stakeholders in the offshore industry (see Appendix B), a coalition of informed, interested, and respected parties will be needed to influence others to participate. Culture cannot easily be imposed by one organization on another, whether it is large operators telling contractors how to think and act or regulators telling operators; a better strategy is collaborative engagement. Although the regulators have considerable authority and must be part of the change process, they are not well positioned to lead this effort. An inappropriate regulatory approach could result in a compliance mentality and significant resistance; the industry does not want new regulations, but it does want an improved regulatory process that is more effective for all stakeholders and less adversarial. For example, the National Research Council (NRC 1997) report on the U.S. Coast Guard's (USCG) Prevention Through People program praises its "bold departure from the traditional use of regulation to address safety issues…[as] extremely valuable, particularly in its balanced approach to risk management and its emphasis on partnership."

4. The industry safety culture is still developing.

The offshore oil and gas industry has some heritage of risk taking from the onshore oil and gas industry, as well as the mining industry, which celebrated individual heroics rather than teamwork, discipline, rules, and protection of people and the environment. The offshore industry has changed significantly in the past decades, as have many other industries, and as reported in Chapter 3, there are signs that the number of incidents is decreasing. It is more common now for anyone to report safety concerns or to stop a job. But both the heritage of risk taking and the rapid growth and influx of new operators and contractors result in a complex mélange of cultural values and competencies.

In this industry as in many others, there is an existing culture of individual blame for noncompliance with rules. Unfortunately, a blaming culture often works against a reporting culture, so that workers are reluctant to report near misses or small accidents, which can be precursors of larger problems. In addition, problems may be concealed to avoid paperwork; please the boss; receive bonuses; or avoid management attention, peer annoyance, and regulatory enforcement. Even when incidents are reported, those that receive attention are often those involving minor personal injuries, transportation incidents, and spills (because they occur most frequently) rather than gaps in process safety that could be precursors of major accidents.

As in most industries, the oil and gas industry as a whole lacks systems thinking in which the interrelationships among events and practices are considered. Problems may be seen as one-off and each installation as unique. An operator may share lessons learned internally but be less inclined to share them with another operator. There is a tendency to focus on the immediate, proximal causes of an incident (such as human error) rather than systemic causes, including culture. Historically, fixes are devised with little understanding of how they will be implemented and validated or what unintended side effects they might have. Like all industries, the offshore industry continues to learn how to teach and encourage systems thinking (e.g., Leveson 2012), including sharing of lessons learned.

Overcoming the Challenge

Many in the industry recognize the importance of deliberately managing the development and implementation of safety processes organization-wide. Operational excellence and operational discipline are considered key enablers of a strong safety culture. Even before the advent of SEMS, most in the industry had adopted a management system process that promotes goal setting and drives progress toward incident-free operations (including personal and process safety accidents, near misses, and nonconformances). Gaps between current performance and these objectives are usually uncovered during safety culture assessment. Plans are developed for closing the gaps, actions are taken, and results are reviewed for validation and learning purposes. Developing and sustaining a strong safety culture requires each member of the workforce to be competent in and accountable for established safety processes.

Again, leadership is a critical element of culture change and institutionalization. Unfortunately, the image of the confident, successful, "heroic" leader can lead to misperceptions regarding the characteristics of a leader that are necessary to effect culture change (Khurana 2002). Leadership is not so special that only the rare charismatic leader can step forward. Rather, the great majority of successful leaders simply have the courage of their convictions and a willingness to work with people toward a common future. Although senior leadership support is essential, positive safety changes also need to involve field supervisors and workers in the field who are dedicated to safety improvement and equipped with both the authority and resources to pursue it. This is why the term "safety culture" implies commitment and participation throughout the organization.

Competent leaders who are committed to safety can be developed and supported. To this end, organizations need to consider their hiring practices and the training and mentoring needed to become a leader of safety culture. Becoming such a leader also is facilitated by a management system that aligns leaders with business outcomes that reflect safety as a priority and that holds them accountable for long-term performance rather than short-term production goals. It is also easier to lead safety culture when safety processes and standards are well designed, effectively implemented, and well suited to the organization. A complex operation with many possible hazards or an operation in a sensitive environment may require more rigorous processes and standards relative to a less complex operation in another location. It is leadership's responsibility to make these distinctions and apply the appropriate safeguards. It is also leadership's responsibility to ensure the competence of the entire workforce through the hiring and training processes, the assignment of roles and responsibilities, and continual monitoring.

Given the demonstrable progress being made in safety in many parts of the offshore industry, it is desirable to leverage individual successes to accelerate progress throughout the industry. Industry groups and regulators can help disseminate success stories and lessons learned. Operators can encourage and advise their contractors and contractors can encourage and advise their subcontractors, and vice versa. Benchmarking and peer assist visits can facilitate the exchange of knowledge. The offshore industry can look to the success of the nuclear power industry in creating a strong industry-led organization (INPO) to set standards and facilitate knowledge sharing.

5. Regulators have difficulty developing competence in safety culture.

USCG and BSEE are the main agencies with oversight for safety in the offshore industry, although more than 10 other regulators have some safety-related responsibilities offshore. These two organizations have a good working relationship with each other, which was strengthened in 2012 by a new memorandum of understanding.[3] While leaders in both agencies recognize the need to extend their federal role by fostering safety culture in the industry, internal challenges remain with respect to staffing resources.

Developing staff in the regulatory agencies who understand and embrace safety culture and have the credibility and competence to support its improvement in the offshore industry nonetheless poses a challenge. Traditional safety oversight consists of inspecting offshore installations to ensure that they comply with a set of construction, equipment, and operational regulations. These federal regulations have been developed over time to address particular safety and environmental hazards. Offshore operators meeting these standards are considered to be in compliance with federal requirements and therefore free to operate. Federal inspectors are trained to check drill rigs and offshore installations for compliance using standard checklists.

However, responsible companies and progressive regulators realize that just complying with federal requirement will not ensure safe operations; they recognize the need to go beyond compliance by embracing safety holistically. Using a safety management approach is one important aid to establishing or strengthening safety culture. BSEE took an important step to

[3] http://www.bsee.gov/BSEE-Newsroom/BSEE-News-Briefs/2012/BSEE---Coast-Guard-Sign-Memorandum-of-Understanding. Accessed November 2, 2015.

support the development of such an approach to safety (which includes meeting equipment regulations) when it issued the SEMS regulations.[4] USCG is developing companion safety management system regulations. The SEMS regulations are similar to a voluntary industry standard (API Recommended Practice 75) which has been in place for many years.

A challenge for BSEE inspectors is inspecting for compliance with the SEMS regulations. Their prior training in engineering tasks and operational procedures and their experience in identifying equipment issues and uncovering deficiencies have not inculcated in them the mind-set or the skill set needed to advocate for safety culture and help a company implement its safety culture philosophy. Further, the public has its own expectations of safety regulators, which appear to include the levying of heavy sanctions and fines when problems arise, and generally forcing industry compliance through more inspections and penalties.

Overcoming the Challenge

BSEE and USCG leadership needs to focus on recruiting practices and training programs for inspectors in the domain of offshore safety culture. Regulators, including inspectors, need new skills and knowledge to be helpful to those they regulate and be trusted and respected by the industry and the wider public. To be effective, inspectors need to be selected with this role in mind and trained to have competence in developing, implementing, and maintaining safety systems and culture, not just in the appropriate operation of equipment.

To be of assistance to the offshore oil and gas industry, the regulatory approach needs to shift from focusing on compliance and policing to serving as a safety resource that works with industry to help improve safety from a systems perspective. The regulators then will be able to audit programs and assess practices and priorities, not simply inspect for compliance. At the same time, the regulator will need to have at their disposal a wide range of sanctions and rewards, including stiff penalties for those that need correction and reduced oversight and risk-based inspections for those that perform well.

The regulators also can encourage and help the industry organize itself to develop training programs, tools, peer-to-peer sharing and learning practices, standards, and other means of facilitating safety culture. The Nordic model of regulation is a tripartite collaboration among companies, unions, and government. Although the U.S. regulatory approach and legal context are very different, this model offers important lessons about working together for improvement. In the nuclear power industry, INPO has played a critical role in promoting safety by accrediting training programs, developing standards, working to reduce insurance costs for members in compliance, facilitating peer assist visits and personnel exchanges, and pressuring operators that are falling behind (Rees 1994). As regulators shift their role from inspector to safety resource for the industry, the public will need to be informed of the change and educated as to its benefits.

CONCLUSIONS AND RECOMMENDATIONS

Successful culture change is a long-term effort that entails considerable uncertainty and necessary investments and requires sustained commitment from senior leadership. Behaviors and relationships will be disrupted, and the organization needs to be

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[4] The Workplace Safety Rule became effective on November 15, 2010; The SEMS II Rule became effective on June 4, 2013.

supported through the lengthy change process. However, there are many examples of successful culture change in such industries as nuclear power, aviation, the chemical industry, and the military, as well as in the offshore oil and gas industry.

Company senior leadership needs to commit to and be personally engaged in a long and uncertain safety culture journey. Even if they find or hire a champion, they still need to be visibly engaged. Convincing senior leadership to embrace safety culture may involve leveraging industry resources, receiving regulatory encouragement, visiting workplaces personally to view safety problems and useful improvements, benchmarking with other companies, and engaging external help.

Recommendation 6.1: Senior leaders should ensure that their organizations take advantage of resources available from other companies, industry groups, and regulators in strengthening their own safety cultures. Smaller companies can reach out to their larger customers or industry groups to obtain information on establishing or strengthening safety culture and to learn of success stories from those who have created a safe working environment. Safety improvements do not have to cost enormous amounts of money, and they may return substantial benefits in quality, reliability, reputation, hiring and retention, reduced regulatory attention, and performance.

Because the industry is fragmented, it is necessary to work with a coalition of key stakeholders. Compliance by itself is insufficient; proactive collective action is needed from a coalition of willing parties. This is especially likely to be the case in the offshore oil and gas industry given the sheer number of groups charged with its operation and the regulators' limited ability to impose changes. Referring to the safety culture development ladder (Table 6-1), those from reactive and pathological cultures will not appreciate the need for change until they see others change successfully and feel pressure and encouragement to move forward.

Recommendation 6.2.1: Industry leaders should encourage collective and collaborative action to effect change in an industry as fragmented as the offshore oil and gas industry. A starting point is to engage personally and encourage key employees to participate in industry organizations, conferences, benchmarking opportunities, standards-setting groups, pilot projects, and exchanges of information and lessons learned.

Recommendation 6.2.2: Leadership from the Bureau of Safety and Environmental Enforcement (BSEE), the U.S. Coast Guard's (USCG), the American Petroleum Institute (API), the Independent Petroleum Association of America (IPAA), the International Association of Drilling Contractors (IADC), the Pipeline and Hazardous Materials Safety Administration (PHMSA), the Society of Petroleum Engineers (SPE), the International Association of Oil & Gas Producers (IOGP), the Center for Offshore Safety (COS), and others should continue to be involved early in this process. It would help to have a focal organization that is sufficiently independent and can engage the entire industry. There is an opportunity for BSEE

and other regulators to provide encouragement and leadership, but demands from a regulator are likely to be met with resistance from the industry. Regulators can help convene senior industry leaders and experts to craft a vision, provide feedback and encouragement, reinforce well-intentioned actions, and coach from the sidelines.

Recommendation 6.2.3: The industry as a whole should leverage the knowledge and experiences of those organizations that are already moving ahead with safety culture and trying new approaches. In a heterogeneous industry, it is not necessary for every organization to move at the same pace. By increasing awareness and interest among the industry as a whole and sharing lessons learned from early adopters and benchmarking cases, each organization can access learning opportunities and build momentum.

Although the industry is composed of a wide variety of organizations of varying sizes and capabilities, and the work is carried out by combinations of operators and contractors, there are opportunities to find agreement and take steps to improve safety culture industry-wide.

Recommendation 6.3.1: The industry as a whole should create additional guidance for establishing safety culture expectations and responsibilities among operators, contractors, and subcontractors. Regulators should assist in these efforts and ensure consistency.

Recommendation 6.3.2: The industry should work with regulators to consider changes in policy (and laws when necessary, such as modifying any that inhibit information flow between operators and contractors) that would help accelerate improvements in safety culture, including information exchanges, cooperation across operators and contractors, and protection of all personnel from retaliation if they speak up.

As elaborated in Chapter 5, the safety culture assessment process varies considerably from organization to organization. At the industry level and in individual companies, the safety culture assessment and improvement process is still evolving, while benefiting from examples in various industries. Safety culture assessments help identify opportunities for improvement, but also guide and evaluate improvement efforts and provide lessons learned for the development of better safety culture assessment and change tools and practices.

Although a great deal is known about culture change, a great deal more remains to be learned. Offshore safety culture in particular warrants additional research.

Recommendation 6.5.1: Regulatory agencies, industry organizations, operators, and other participants in the offshore industry should work together to facilitate research and information sharing. High-priority research topics include the following:

- **Develop industry-level data that can be shared and compared across organizations and over time, including data not only on safety outcomes but also on near misses and organizational precursors such as safety culture assessments.**
- **Analyze positive cases. What works to generate awareness and interest? How have others encouraged experiments and trials? What arguments for enhanced safety are most compelling to decision makers? What strategies enhance safety culture, and what features of safety culture have the greatest impact on safety outcomes?**
- **Define what contextual factors matter most. If safety culture is a predictable journey of steps or levels, is it possible to articulate those steps and the most effective actions for taking an organization from one step to the next? In particular, are Hudson (2007) and Amalberti (2013) correct that different actions are needed at different stages of safety culture or for different safety models?**
- **Although it is common to hear that companies with fewer resources may manage safety differently from larger companies with higher margins, there is a need for systematic study of the improvement of safety management practices across different kinds of organizations (large, small, operators, contractors, etc.) with differing resource endowments to better understand practical means for building a strong safety culture throughout the offshore industry.**

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Abbreviations

CAIB	Columbia Accident Investigation Board
IAEA	International Atomic Energy Agency
IOGP	International Association of Oil & Gas Producers
NRC	National Research Council
PSA	Petroleum Safety Authority Norway

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Appendix A

Open Session Agendas

FIRST COMMITTEE MEETING
Keck Center of The National Academies
Washington, D.C.

Tuesday, April 29, 2014

10:00 **Welcome, Introductions** (Committee and Guest Speakers)
Nancy Tippins, Committee, Guests

10:15 **Remarks from Doug Morris**, *Chief of Offshore Regulatory Programs, Bureau of Safety and Environmental Enforcement (BSEE)*

10:45 **Coffee Break**

11:00 **Remarks from Charlie Williams II**, *Executive Director, Center for Offshore Safety (COS)*

11:15 **Remarks from Jeff Wiese**, *Assistant Administrator, DOT, Pipeline and Hazardous Materials Safety Administration (PHMSA)*

11:30 **Remarks from Jim Card**, *Vice-Chair, Marine Board*

12:00 **Lunch Break**

1:00 **Committee Discussion with BSEE and COS Reps**

2:00 **Discussion of Safety Culture; How to Advance Safety Culture in the Oil & Gas Industry?**

3:00 **Coffee Break**

3:15 **Continuation of Discussion**

5:00 **Adjourn Open Session**

Wednesday, April 30, 2014

9:00 **Recap Discussion from the Previous Day**
Nancy Tippins, Committee

10:00 **Coffee Break**

10:15 **Discuss Statement of Task and the Committee's Approach to the Study**
Nancy Tippins, Committee

12:00 **End of Open Session**

SECOND COMMITTEE MEETING
Marriott Residence Inn Houston West/Energy Corridor
Houston, Texas

Wednesday, August 27, 2014

Open Session Topics:

- The current state of safety culture in the offshore industry
- Things that the industry and BSEE can do to improve safety culture
- Suggestions for measuring safety of culture in operations
- Safety Culture: Conoco & DuPont Perspective

Guest Speakers:

- US Coast Guard: RDML Paul F. Thomas
- Oil and Gas Operating Companies: Chevron and Fieldwood
- Auditors: M&H, ABS
- Drilling Company: Ensco
- Construction Contractor: Danos
- John Coryell, DuPont Sustainable Solutions

8:15 **Welcome, Introductions**
Nancy Tippins, Committee, Guests

8:30 **U.S. Coast Guard**
RDML Paul F. Thomas, Assistant Commandant for Prevention Policy, USCG

9:15 **Chevron and Fieldwood**
Andy Eckel, Health Environment and Safety Manager, Chevron's North America Exploration and Production Company, Gulf of Mexico Business Unit
Joel Plauche, Manager, Safety, Environmental and Compliance, Fieldwood Energy, LLC

10:45 **Coffee Break**

11:00 **Ensco**
David Hensel, Senior Vice President, Ensco

11:45 **Q & A**

12:00 **Lunch Break**

1:00 **Danos**
Ricky Britt, Operations Director, Production Services Business Unit, Danos

1:45 **M&H and ABS Consulting**
Kevin Graham, Director of Compliance, M&H
Steve Arendt, Vice President, North America Process Industries, ABS Consulting

3:15 **Coffee Break**

3:30 **Safety Culture: Conoco & DuPont Perspective**
John Coryell, Conoco/DuPont (Retired)

4:15 **Q & A**

4:45 **Opportunity for Public Comment**

5:00 **Adjourn Open Session**

THIRD COMMITTEE MEETING
Keck Center of The National Academies
Washington, D.C.

Tuesday, October 7, 2014

8:45 **Welcome, Introductions**
Nancy Tippins (Committee Chair), Committee, and Guests

9:00 ***James Ellis,*** Former President and CEO, Institute of Nuclear Power Operations (INPO)

9:45 ***Tom Krause,*** Founder of Behavioral Science Technology, Inc. (BST); Private Consultant

10:30 **Coffee Break**

10:45 ***Billie Garde,*** Attorney, Clifford & Garde, LLP

11:30 **Q & A**

12:00 **Lunch Break**

1:00 ***Mark Steinhilber,*** Senior Process Safety Engineer & Engineering Supervisor, California State Lands Commission, Mineral Resources Management Division (via WebEx)

1:45 ***Jason Neubauer,*** Chief, Office of Investigations and Casualty Analysis, U.S. Coast Guard

2:30 **Q & A**

3:15 **Coffee Break**

3:30 **Opportunity for Public Comment**

4:00 **Adjourn Open Session**

Wednesday, October 8, 2014

1:00 ***Christopher Hart***, Chair, National Transportation Safety Board (NTSB)

1:45 **Q&A/Public Comment**

2:00 **Adjourn Open Session**

FOURTH COMMITTEE MEETING
Keck Center of The National Academies
Washington, D.C.

Friday, January 30

8:45 **Welcome, Introductions**
Nancy Tippins, Committee, Guests

9:00 **Lois Epstein,** Engineer and Arctic Program Director, The Wilderness Society

9:45 **David Hammer,** Investigative Reporter, WWL-TV New Orleans

10:30 **Q & A/Public Comment**

10:45 **Coffee Break and End of Open Session**

SITE VISITS AND INFORMATION-GATHERING SESSIONS

Monday, August 25, 2014

2:30 PM
Shell Robert Training Center, 23260 Shell Lane, Robert, Louisiana

4:30 PM
PetroSkills Oil and Gas Training Facility, 25403 Katy Mills Parkway, Katy, Texas

Tuesday, August 26, 2014

10:00 AM
Diamond Offshore Drilling Training and Simulation Center (DOTSC), 15415 Katy Freeway, Houston, Texas

2:30 PM
Shell Drilling Real Time Operations Center (ROTC), Dairy Ashford Road, Houston, Texas

Tuesday, October 7, 2014

7:00 AM – Teleconference with PSA Norway

Wednesday, January 7, 2015

10:30 AM – Teleconference with OTC (Third Party Inspectors)

Appendix B

Regulators, Trade Associations, Advisory and Other Groups with Offshore Safety Oversight

Name	**Scope**	**Role/Mission**
		REGULATORS
Alaska Department of Environmental Conservation (ADEC)	Alaska	Conserves, improves, and protects Alaska's natural resources and environment to enhance the health, safety, and economic and social well-being of Alaskans.
Alabama Oil and Gas Board (AL OGB)	Alabama	Prevents waste and promotes the conservation of oil and gas while ensuring the protection of both the environment and the correlative rights of owners.
Bureau of Offshore Energy Management (BOEM)	Federal	Promotes energy independence, environmental protection, and economic development through responsible, science-based management of offshore conventional and renewable energy and marine mineral resources. BOEM is supported by three regional offices in Louisiana, California, and Alaska. These offices manage oil and gas resource evaluations; environmental studies and assessments; and leasing activities, including the review of Exploration Plans and Development Operations and Coordination Documents**,** fair market value determinations, and geological and geophysical permitting.
Bureau of Safety, Environment, and Enforcement (BSEE)	Federal	Promotes safety, protects the environment, and conserves resources offshore through vigorous regulatory oversight and enforcement. • The BSEE Offshore Regulatory Program develops standards and regulations to enhance operational safety and environmental protection for the exploration and development of offshore oil and natural gas on the U.S. Outer Continental Shelf (OCS). • BSEE's regional offices in Louisiana, California, and Alaska are responsible for reviewing and approving Applications for Permit to Drill to ensure that all of the recently implemented enhanced safety requirements are met. • The regional offices are responsible for conducting inspections of drilling rigs and production platforms using multiperson, multidisciplinary inspection teams and issuing Incidents of Non-Compliance and fines for regulatory infractions. • Regional and field operations personnel also investigate accidents and incidents.
California Department of Conservation (CA DOC)	California	Oversees the drilling, operation, maintenance, and plugging and abandonment of oil, natural gas, and geothermal wells. CA DOC's regulatory program emphasizes the wise development of oil, natural gas, and geothermal resources in the state through sound engineering practices that protect the environment, prevent pollution, and ensure public safety.

Chemical Safety Board (CSB)	Federal	Conducts root-cause investigations of chemical accidents at fixed industrial facilities. • The agency does not issue fines or citations, but makes recommendations to plants, regulatory agencies such as the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA), industry organizations, and labor groups. • The agency's board members are appointed by the President and confirmed by the Senate. The agency was designed by Congress to be nonregulatory and independent of other agencies so that its investigations might, where appropriate, review the effectiveness of regulations and regulatory enforcement.
US Department of Transportation - Homeland Security Administration (DOT DHS)	Federal	Monitors pipeline safety, inspects pipelines for compliance with regulations related to pipeline safety, and enforces the regulations. • The federal program for pipeline safety resides primarily within the U.S. Department of Transportation (USDOT), although USDOT’s inspection and enforcement activities rely heavily on partnerships with state pipeline safety agencies. • The federal pipeline security program began with USDOT as well, immediately after the terror attacks of September 11, 2001, but pipeline security authority was subsequently transferred to the Department of Homeland Security (DHS) when the latter department was created.
Federal Aviation Administration (FAA)	Federal	Regulates all U.S.-based aviation, including helicopter transportation offshore, and monitors helicopter-related safety issues and onshore and offshore flight safety.
Louisiana Department of Natural Resources LA (DNR)	Louisiana	Ensures and promotes sustainable and responsible use of the natural resources of the state of Louisiana.
Mississippi Oil and Gas Board (MS OGB)	Mississippi	Promulgates and enforces rules to regulate and promote oil and gas drilling, production, and storage and disposal of nonhazardous oilfield waste in an environmentally safe manner consistent with federal and state regulations.
National Institute for Occupational Safety and Health (NIOSH)	Federal	Develops new knowledge in the field of occupational safety and health and transfers that knowledge into practice. NIOSH has an oil and gas extraction health and safety program that includes a database of fatalities resulting from oil and gas extraction operations onshore and offshore.
National Oceanic and Atmospheric Administration (NOAA)	Federal	Protects life and property; conserves and protects the nation’s natural resources. • As the lead science agency for coastal oil spills, NOAA's Office of Response and Restoration provided mission-critical information to guide the emergency response to the *Deepwater Horizon* oil spill. • NOAA continues to assess the fish, wildlife, and habitat affected by the spill along the coasts of Louisiana, Mississippi, Texas, Alabama, and Florida.

National Transportation Safety Board (NTSB)	Federal	Investigates every civil aviation accident the United States and significant accidents in other modes of transportation—railroad, highway, marine, and pipeline. • Determines the probable cause of the accidents and issues safety recommendations aimed at preventing future accidents. • Carries out special studies concerning transportation safety and coordinates the resources of the federal government and other organizations to provide assistance to victims and their family members impacted by major transportation disasters.
Occupational Safety and Health Administration (OSHA)	Federal	Monitors working conditions at all U.S. work sites and has responsibility for any hazardous working condition for which the U.S. Coast Guard or Minerals Management Service has not yet promulgated a regulation.
Pipeline and Hazardous Materials Safety Administration (PHMSA)	Federal	Protects people and the environment from the risks of hazardous materials transportation by establishing national policy, setting and enforcing standards, educating, and conducting research to prevent incidents; prepares the public and first responders to reduce consequences if an incident does occur.
Texas Railroad Commission (TXRRC) Oil and Gas Division	Texas	Regulates the exploration, production, and transportation of oil and natural gas in Texas. TXRRC's statutory roles are to • prevent waste of the state's natural resources, • protect the correlative rights of different-interest owners, • Prevent pollution, and • provide safety in matters such as hydrogen sulfide.
United States Coast Guard (USCG)	Federal	Improves the safety and security of the offshore oil and gas industry. • Develops and maintains standards, guidance, and regulations for vessels, facilities, and offshore platforms and their operations; develops and maintains regulations and guidance concerning operational pollution prevention, response, and removal. • Prepares national positions with respect to vessel, facility, and platform operations and represents the United States in national and international fora. • Supports and coordinates with classification societies and national professional and industry organizations to foster sound industry standards; recommends, guides, and conducts research and development as a basis for regulations, policy, and guidance toward safe and environmentally sound operating practices by the maritime industry. • Administers the International Convention for Safe Containers and a container certification program involving designation of approval authorities; serves as executive director for the National Offshore Safety Advisory Committee. • Conducts inspections of safety equipment and investigations of incidents causing death or serious injury, fires, and "major" oil spills.

TRADE ASSOCIATIONS		
Association of Diving Contractors (ADC)	Industry-International	Establishes industry-wide safe standards for commercial diving. • ADC provides services and/or support for the conduct of safe underwater operations. • Initially comprising only U.S. domiciled companies, ADC comprises members from the business, educational, and medical communities from around the world.
Association of Oil Pipelines (AOPL)	Industry-U.S.	Represents common carrier crude and petroleum product pipelines, as well as carbon dioxide pipelines, before Congress, regulatory agencies, and the courts; provides coordination and leadership on key industry issues, including pipeline rates and services, pipeline safety initiatives, pipeline security, and the industry's Environmental and Safety Initiative; and acts as an information clearinghouse for the public, the media, and the pipeline industry regarding liquid pipeline issues. AOPL is a nonprofit trade association comprising owners and operators of liquid pipelines.
American Petroleum Institute (API)	Industry-U.S.	API is the only national trade association that represents all aspects of America's oil and natural gas industry. It aims to improve the compatibility of oil and gas operations with the environment while promoting the economic development of energy resources and supplying high-quality products and services to consumers.
Center for Liquefied Natural Gas (CLNG)	Industry-U.S.	Enhances public education and understanding about liquefied natural gas by serving as a clearinghouse for liquefied natural gas information • CLNG is a trade association of liquefied natural gas producers, shippers, terminal operators and developers, and energy trade associations
Center for Offshore Safety (COS)	Industry-U.S.	Promotes safety offshore by • Providing assistance to member companies for their implementation of Center for Offshore Safety (COS) programs, • Ensuring that third-party certification program auditors meet the program's goals and objectives, • Compiling and analyzing key industry safety performance metrics, • Performing coordinating center-sponsored functions designed to facilitate the sharing and learning process • Identifying and promoting opportunities for the industry to continuously improve, and • Developing outreach programs to facilitate communicating with government and external stakeholders.

Helicopter Safety Advisory Conference (HSAC)	Industry-U.S.	Promotes helicopter safety in the U.S. offshore oil and gas industry. • HSAC is a group that represents companies working in the American oil industry. • It identifies issues that affect safety in the Gulf of Mexico and works proactively to address these issues. • It is recognized both nationally and internationally for its efforts to improve communication and safety in the offshore industry. • It has developed and maintained an offshore heliport design guide and offshore Gulf of Mexico sectional charts, increased flight service station facilities and services, and established new flight procedures. • It has also improved coordination of operators, as well as weather forecasting and reporting.
International Association of Drilling Contractors (IADC)	Industry-International	Promotes improvements in health, safety, environmental protection, and training in the oil and gas industry by • Issuing regular safety alerts contributed by its members, describing rig accidents, their causes and corrective actions; • Compiling data on drilling accidents worldwide through its Incident Statistics Program (ISP); • Creating an accreditation system for basic rig floor safety through its HSE RIG PASS program; • Providing a forum to exchange and disseminate best practices; to structure industry performance measures and assist the International Association of Drilling Contractors (IADC) in its promotion and publication efforts; and to serve as a channel for members, government agencies, manufacturers, and customers to interact to improve the performance of the industry in matters relating to occupational safety and health and environmental affairs; • Issuing Health, Safety, and Environment (HSE) Case Guidelines for both mobile offshore drilling units and land drilling units that provide a framework for developing an integrated HSE management system for use in reducing the risks associated with offshore and onshore drilling activities; and • Promoting awareness of training and facilitating the exchange of information regarding suitable training methods and materials benefiting the global drilling and drilling services industries.
International Association of Geophysical Contractors (IAGC)	Industry-International	Provides geophysical services, geophysical data acquisition, seismic data ownership and licensing, geophysical data processing and interpretation, and associated services and products to the oil and gas industry. IAGC's mission is to optimize the business climate and commercial health of the geophysical industry and to promote the conduct of business in a professional, safe, and environmentally responsible manner.

Independent Petroleum Association of America (IPAA)	Industry-U.S.	Advocates its members' views before the U.S. Congress, the administration and federal agencies. • IPAA provides economic and statistical information about the domestic exploration and production industry. • It also develops investment symposia and other business development opportunities for its members.
International Marine Contractor Association (IMCA)	Industry-International	Represents companies and organizations engaged in delivering offshore, marine, and underwater solutions. MCA's core purpose is to improve performance in the marine contracting industry by championing better regulation and enhancing operational integrity.
Independent Petroleum Association of America (IPAA)	Industry-U.S.	Represents the 9,000 independent producers that have no more than $5 million in retail sales of oil and gas in a year or that do not refine more than an average of 75,000 barrels per day of crude oil during a given year.
National Oceans Industry Association (NOIA)	Industry-U.S.	Represents companies that are dedicated to the safe development of offshore energy for the continued growth and security of the United States. • NOIA's membership of more than 300 companies also includes companies involved in or branching out to pursue offshore renewable and alternative energy opportunities. • Members are engaged in the areas of environmental safeguards, equipment supply, gas transmission, navigation, research and technology, shipping, and shipyards.
Offshore Marine Service Association (OMSA)	Industry-U.S.	Fosters, develops, and promotes ideas that advance the common good and the interests of its members with governmental and regulatory bodies across the globe; encourages and advances the highest standards of safety and environmental protection among its member companies
Offshore Operators Committee (OOC)	Industry-U.S.	Represents 151 member companies engaged in drilling and producing hydrocarbon resources in the Gulf of Mexico and the Atlantic Ocean, and provides its member operators with information and technical support that will assist them in conducting their offshore activities in a manner that will promote sound safety and environmental operational practice. OOC's objectives include • Conducting a cooperative effort to become familiar with and to stay informed as to the laws, rules, and regulations adopted or being considered by the various government entities asserting jurisdiction over matters affecting the offshore petroleum industry, and to consult with and advise such governmental entities concerning matters affecting the offshore petroleum industry; • Conducting studies in oceanography, weather forecasting, safety, pollution controls, aid to navigation, and any other matters commonly affecting offshore operations; and • Taking part in cooperative studies and investigations of matters that do not contradict federal or state laws and are not prejudicial to the rights of any of the OOC members when requested by the government agencies.

Petroleum Equipment Suppliers Association (PESA)	Industry-U.S.	Advocates and supports continued achievements in job creation, technological innovation, and economic stability. PESA is the unified voice for the energy industry's service, supply and manufacturing organizations.
Spill Control Association of America (SCAA)	Industry-U.S.	Promotes the interests of all groups within the spill response community. SCAA represents spill response contractors, manufacturers, distributors, consultants, instructors, government and training institutions, and corporations working in the industry.
U.S. Oil and Gas Association (USOGA) and State Groups	Industry-U.S. and States	Advocates for producers of domestic oil and gas. USOGA is composed of four divisions: • The Louisiana Mid-Continent Oil and Gas Association promotes the oil and gas industry in Louisiana and the Gulf of Mexico and represents its members in the Louisiana legislature and the Louisiana congressional delegation and speaks on their behalf to state and federal regulatory agencies, the media, and the general public. • The Oklahoma Oil & Gas Association (OKOGA) is a nonprofit association composed of oil and gas producers, operators, purchasers, pipeline operators, transporters, processors, and service companies that represent a substantial segment of the oil and gas industry within the state of Oklahoma. OKOGA's activities include providing support for legislative and regulatory measures designed to promote the well-being and best interests of the citizens of Oklahoma and a strong and vital petroleum industry within the state of Oklahoma and throughout the United States. • The Texas Oil & Gas Association is a general, multipurpose trade association and is the only organization in Texas that embraces all segments of this industry. Its members include executives of the state's largest energy companies, independent oil and gas producers, refining companies, marketing companies, drilling contractors, consulting engineers, royalty owners, pipeline companies and contractors, transportation companies, equipment and supply firms, well-servicing contractors, oil and gas tax attorneys, insurance companies, banks, and other parties interested in promoting the welfare of the industry. The focal points for the association's activities are legislation, regulation, and public/industry affairs. • The Mississippi/Alabama Division of USOGA is a trade association comprising companies in Mississippi and Alabama that are engaged in oil and gas exploration and production; transportation, refining, and marketing of petroleum products; and natural gas transportation, processing, electricity generation, and distribution. The association's mission is to establish and maintain reasonable statewide public policy regarding legislative and regulatory issues and to work on regional and federal issues that could have a significant impact on the industry.

ADVISORY AND OTHER GROUPS		
USCG National Offshore Safety Advisory Committee (NOSAC)	Industry-U.S.	Advises the Secretary of the Department of Homeland Security, via the Commandant, U.S. Coast Guard, on matters relating to the safety of the offshore mineral and energy industries
BSEE/BOEM Offshore Energy Safety Institute (OESI)	Federal	Provides a forum for dialogue, shared learning, and cooperative research among academia, government, industry, and other nongovernmental organizations in offshore energy-related technologies and activities that ensure safe and environmentally responsible offshore operations.
USCG Towing Safety Advisory Committee (TSAC)	Federal	Serves as a deliberative body that advises the Secretary of Transportation, via the Commandant, U.S. Coast Guard, on matters relating to shallow-draft inland and coastal waterway navigation and towing safety. TSAC members represent the following sectors: • Barge and towing industry; • Offshore mineral and oil supply vessel industry; • Holders of active licensed masters or pilots of towing vessels with experience on the Western Rivers and the Gulf Intracoastal Waterway; • Holders of active licensed masters of towing vessels in offshore service; • Active masters of active ship-docking or harbor-towing vessels; • Licensed or unlicensed towing vessel engineers with formal training and experience; • Port districts, authorities, or terminal operators; • Shippers (of whom at least one shall be engaged in the shipment of oil or hazardous materials by barge); and • General public.

Study Committee Biographical Information

Nancy T. Tippins is a principal consultant at CEB, where she manages the firm's development and execution of strategies related to job analysis, competency development, employee selection, assessment, and leadership development. Dr. Tippins oversees the teams that develop legally and professionally compliant tools, administrative processes, and delivery platforms to meet client staffing, assessment, and succession planning requirements. She also conducts executive assessments and provides expert support in litigation. Dr. Tippins is active in professional affairs. She has a long-standing involvement with the Society for Industrial and Organizational Psychology (SIOP), where she served as president (2000–2001). In addition, she served on the Ad Hoc Committee on the Revision of the *Principles for the Validation and Use of Personnel Selection Procedures* (2003) and co-chairs the current revision committee. She also served on the Joint Committee to revise the *Standards for Educational and Psychological Tests* and represented the United States on the International Organisation for Standardization (ISO) 9000 committee, whose efforts focused on establishing international testing standards. Dr. Tippins is a fellow of SIOP, the American Psychological Association (APA), and the American Psychological Society (APS) and is involved in several private-industry research groups. She received her M.S. and Ph.D. in industrial and organizational psychology from the Georgia Institute of Technology, and holds an M.Ed. in counseling and psychological services from Georgia State University.

Deborah A. Boehm-Davis is dean of the College of Humanities and Social Sciences and university professor in the Psychology Department at George Mason University. Prior to joining the university in 1984, she worked on applied cognitive research at General Electric, the National Aeronautics and Space Administration's (NASA) Ames Research Center and Bell Laboratories. She also served as a senior policy advisor for human factors at the Food and Drug Administration. Dr. Boehm-Davis has served as president of APA's Applied Experimental and Engineering Psychology Division and of the Human Factors and Ergonomics Society. She is an associate editor for *Human Factors*, and serves on the editorial boards of *Theoretical Issues in Ergonomics Science* and the *Journal of Cognitive Engineering and Decision Making*. She is a fellow of APA, the Human Factors and Ergonomics Society, and the International Ergonomics Association. Dr. Boehm-Davis holds an A.B. in psychology from Douglass College, Rutgers-the State University of New Jersey, and M.A. and Ph.D. degrees in cognitive psychology from the University of California, Berkeley.

John S. Carroll is Gordon Kaufman professor of management and a professor of work and organization studies at the Massachusetts Institute of Technology (MIT). He taught in the Psychology Departments of Carnegie-Mellon University and Loyola University of Chicago and was a visiting associate professor at the University of Chicago Graduate School of Business before joining the Sloan School faculty in 1983. His research focuses on individual and group decision making; the relationship between cognition and behavior in organizational contexts; and the processes that link individual, group, and organizational learning. His current projects are examining organizational safety issues in high-hazard industries such as nuclear power, aerospace, and health care; the focus of this work includes leadership, self-analysis and organizational learning, safety culture, communication, and systems thinking. Dr. Carroll has consulted for several organizations in the nuclear power industry on issues of operations, management, and safety culture. He taught in the MIT-BP Operations Academy on issues of group decision making, organizational learning, and process safety. He also advises Sloan MBA teams conducting analyses of organizations undergoing change as part of the "Organization Processes" course. Dr. Carroll has published four books and numerous articles in several areas of social psychology and organization studies. He received a B.A. degree in physics from the MIT, and an M.A. degree in social psychology and as a Ph.D. in social psychology from Harvard University.

Elmer P. (Bud) Danenberger retired from the U.S. Department of the Interior, Minerals Management Service, in January 2010 after a 38-year career at the district, regional, and headquarters levels. From 2004 until his retirement, he served as chief, offshore regulatory programs, with responsibility for safety, environmental, and conservation standards for offshore oil and gas operations; regulatory, enforcement, and engineering programs for oil and gas operations in federal waters; standards, regulations, and monitoring programs for renewable energy and alternative uses of offshore facilities; management of research programs assessing petroleum and renewable energy development capabilities and risks; direction of accident investigations; and coordination of offshore and regulatory activities with oil and gas producers, contractors, federal and state agencies, and international partners. Mr. Danenberger has worked in all four U.S. Outer Continental Shelf (OCS) regions: Gulf of Mexico, Alaska, Pacific, and Atlantic. He served a long-term detail with Petronas, the national oil company of Malaysia, and co-founded the International Regulators' Forum, a network of offshore safety regulatory authorities. He initiated a quantitative rating system to measure safety and pollution prevention performance and co-authored legislation leading to offshore renewable energy and alternative use authority. He has also worked closely with industry officials to address mooring system, structural, and pipeline issues associated with hurricanes. Mr. Danenberger has received numerous awards, including the Department of the Interior's Distinguished Service Award and the U.S. Coast Guard's Meritorious Public Service Award. He earned an M.S. degree in environmental pollution control, with a focus on energy-related environmental issues, mineral economics, and water pollution control, and a B.S. degree in petroleum and natural gas engineering, both from Pennsylvania State University.

David A. Hofmann is professor of organizational behavior at the University of North Carolina's Kenan-Flagler Business School. Dr. Hofmann conducts research on leadership, organizational and work group safety climates, and organizational factors that affect the safety behavior and performance of individual employees. His research has contributed significantly to the scientific foundation for tools used to assess the safety and organizational climates of organizations—such as NASA after the *Columbia* accident—and to help plan interventions for improving safety climate. His research has appeared in the *Academy of Management Journal*, *Academy of Management Review*, the *Journal of Applied Psychology*, the *Journal of Management*, *Organizational Behavior and Human Decision Processes*, and *Personnel Psychology*. Dr. Hofmann has published or has forthcoming numerous book chapters on leadership, safety issues, and multilevel research methods. In 2003, he edited a scholarly book on safety in organizations (*Health and Safety in Organizations: A Multilevel Perspective*), and he has a second edited book forthcoming on *Errors in Organizations*. He has received APA's Decade of Behavior Award and the Society of Human Resource Management's Yoder-Heneman Award, and has been a Fulbright Senior Scholar. Before arriving at the University of North Carolina at Chapel Hill, Dr. Hofmann was a faculty member at Purdue University, Texas A&M University, and Michigan State University. He consults, conducts applied research, and leads executive workshops for a variety of government organizations and private corporations. He served as a member of the National Academy of Engineering's Committee to Analyze the Causes of the Deepwater Horizon Explosion, Fire, and Oil Spill to Identify Measures to Prevent Similar Accidents in the Future. Dr. Hofmann received a Ph.D. in industrial and organizational psychology from Pennsylvania State University.

William C. Hoyle was a senior investigator for the U.S. Chemical Safety and Hazard Investigation Board (CSB). He served as an expert advisor on all aspects of incident investigation, with particular focus on safety culture, high-reliability organizations, international safety best practices, confidential no-blame hazard reporting programs, and safety metrics. He initiated and designed the CSB public hearings on international safety case regimes and process safety indicators; served as an investigator of the *Deepwater Horizon* disaster, with emphasis on regulatory reform and organizational performance/culture; and authored the CSB investigation policies on worker participation, family involvement, and causal analysis. He was a member of the American Petroleum Institute's (API) Pipeline Safety Management Systems Committee, and was an expert advisor on safety culture assessments and process safety for the California Governor's Task Force on Refinery Safety. From 1998 to 2008, he was the investigations manager and before that the recommendations manager at CSB, during which time he directed more than 30 major incident and 2 safety studies; designed and managed CSB's investigation and recommendations programs, including investigator hiring and training; served as a member of the Center for Chemical Process Safety Technical Steering Committee (2000–2002); and advised the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration on BP Alaskan Pipeline safety culture initiatives (2006–2008). Mr. Hoyle retired from CSB in 2008 and worked as an independent safety consultant before returning to CSB in 2010, from which he retired in 2015. Prior to his work at CSB, Mr. Hoyle was a safety specialist, trainer, and process operator at Amoco Oil Company's Salt Lake City Refinery.

Robert Krzywicki was global practice leader of the core employee safety consulting practice for DuPont Sustainable Solutions (DSS) until his retirement in December 2013. Before assuming that position, he was managing director-North America operations for DSS in the North America Region. He had been with DSS for 13 years. Prior to his DSS assignment, Mr. Krzywicki held a variety of safety and operations roles at the site, regional, and corporate levels involving a range of responsibilities, including capital program delivery, safety program management, product development, business development, and business management. Mr. Krzywicki has more than 32 years of experience at the DuPont Company. He represented the company on national committees such as the American National Standards Institute's Construction Users Roundtable, and committees of the Construction Industry Institute and the Joint EU/U.S. Conference on Occupational Safety and Health. He has authored numerous trade journal articles and is a frequent conference speaker. Mr. Krzywicki has worked across a number of industries, including nuclear, engineering/construction, electric utilities, mining, chemical/petrochemical, and oil and gas. He earned a B.S. in mathematics from Randolph-Macon College in 1973.

Todd R. LaPorte is professor emeritus, Department of Political Science, at the University of California, Berkeley (UCB), where he was also associate director of the Institute of Governmental Studies (1973–1988). He received his B.A. from the University of Dubuque (Iowa) (1953), and his M.A. and Ph.D. degrees from Stanford University (1962). He held faculty posts at the University of Southern California and Stanford University, as well as at UCB. Dr. LaPorte teaches and publishes in the areas of organization theory; technology and politics; and the organizational and decision-making dynamics of large, complex, technologically intensive organizations, as well as public attitudes toward advanced technologies and the challenges of governance in a technological society. He was a principal of the Berkeley High-Reliability Organization Project, serving as a member of a multidisciplinary team that studied the organizational aspects of safety-critical systems such as nuclear power, air traffic control, and nuclear aircraft carriers. His research is focused on the evolution of large-scale organizations operating technologies that must have a very high level of operating reliability (nearly failure-free performance) across a number of management generations, as well as the relationship of large-scale technical systems to political legitimacy. This work took him to Los Alamos National Laboratory (1998–2003), where he was involved in examining the institutional challenges of multigeneration nuclear missions. Most recently, Dr. LaPorte has taken up questions of crisis management in the face of new types of threats emerging from the nation's sustained engagement with radical Islam. In a parallel effort, he is examining the institutional evolution of a critical element in the nation's meteorological monitoring capacity and Earth Observation system—the development of the National Polar-orbiter Operational Environmental Satellite System, managed by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Defense (DoD) in cooperation with NASA. He was a fellow at the Woodrow Wilson International Center for Scholars, Smithsonian Institution, and research fellow at Wissenschaftszentrum (Sciences Center) Berlin and the Max Planck Institute for Social Research, Cologne. In 1985, he was elected to the National Academy of Public Administration. He has served on a number of editorial boards and on the steering committee of the Large Technical Systems International Study Group. He has also served on the Secretary of Energy Advisory Board, U.S. Department of Energy (DOE), chairing its Task Force on Radioactive Waste Management, and on the Technical Review Committee, Nuclear Materials Technology Division, Los Alamos National Laboratory. He has consulted with DOE and the Defense Nuclear Facilities Safety Board, and currently is a faculty affiliate, Decision Sciences Division, Los Alamos National Laboratory.

Karlene H. Roberts is professor emeritus at the Walter A. Haas School of Business, University of California at Berkeley. She is also chair of the Center for Catastrophic Risk Management at Berkeley. Since 1984, Dr. Roberts has investigated the design and management of organizations and systems of organizations in which error can result in catastrophic consequences. She has studied both organizations that have failed and those that have succeeded in this category. The sectors and industries in which she has worked include the military, commercial marine transportation, health care, railroads, petroleum production, commercial aviation, banking, and community emergency services. She has consulted in the areas of human resource management, staffing policies, organizational design, and the development of cultures of reliability. Recently, she has consulted with the military, in the health care industry, in software development, in the energy industry, and in the financial and insurance industries. Dr. Roberts testified before the Columbia Accident Investigation Board and recently testified to the U.S. National Transportation

Safety Board. She is a fellow in APA and the Academy of Management. She has contributed to policy formation for the Federal Aviation Administration, the U.S. Coast Guard, the U.S. Navy, the Department of Energy, and the Minerals Management Service of the U.S. Department of the Interior, and she received the 2011 Academy of Management Practice Impact Award. Dr. Roberts earned her bachelor's degree in psychology from Stanford University and her Ph.D. in industrial psychology from the University of California, Berkeley. She also received the docteur honoris causa from the Université Paul Cezanne (Aix Marseilles III).

Peter K. Velez is an independent consultant in the offshore oil and gas industry. Prior to his retirement in late 2012, he was global emergency response manager for Shell International Exploration and Production. Employed at Shell since 1975, his assignments included drilling engineer, civil engineer; division civil engineer; operations superintendent; production superintendent; manager production engineering-Gulf of Mexico; manager, health, safety, and environment-Gulf of Mexico; manager, regulatory affairs; manager, regulatory affairs and incident command for Shell U.S. and Americas; and global security manager. As incident commander for Shell, he has responded to major incidents in the Gulf of Mexico and onshore involving oil spills, hurricanes, fires, and explosions and other events. He has received the U.S. Coast Guard's (USCG) Meritorious Public Service Award and Medal (the highest award to a civilian), API's Distinguished and Meritorious Service Awards, and Offshore Operators Recognition Awards, among others. Mr. Velez was appointed by the secretary of transportation to the USCG National Offshore Safety Advisory Committee, on which he served for 7 years (the last 4 years as chair). He is a member of the board of directors of the Marine Preservation Association (the largest oil spill response organization in the United States). He is active in various trade association groups, including serving as chair of the API Executive Committee on Drilling and Producing Operations, chair of the API Executive Committee on Environmental Conservation, and chair of the Louisiana Health, Safety, and Environment (HSE) Committee. He has been a member of the API Standards Group and API Safety Committee, and chaired the API committee that, with the Minerals Management Service, developed Recommended Practice 75, "Safety and Environmental Management Program for Offshore Operations." Mr. Velez received B.S. (1974) and M.S. (1975) degrees in civil engineering from Rensselaer Polytechnic Institute.

Timothy Vogus is associate professor of management at the Owen Graduate School of Management. He was recently named one of the 50 most influential business professors of 2013, and previously was named one of the Top 40 Business School Professors under 40 by PoetsandQuants.com. He also received the Owen Graduate School of Management Research Productivity Award in 2013. His teaching was recognized with the James A. Webb Jr. Award for Excellence in Teaching in 2007 and 2013. Dr. Vogus previously taught organizational behavior at the University of Michigan's Ross School of Business, and in 2002–2003 received the Gerald and Lillian Dykstra Fellowship for Teaching Excellence. His research specifies the mechanisms through which organizations create and sustain a culture of safety, as well as how they achieve highly reliable (i.e., nearly error-free) performance through mindful organizing—a set of behaviors by which collectives detect and correct errors and unexpected events. Understanding how and under what conditions safety culture and mindful organizing are built is important in explaining why some organizations perform so much better than others. Dr. Vogus is especially interested in these dynamics in health care settings and their effects on the incidence of medical errors at the point of care delivery. He also serves on the editorial board of *Organization Science*.

Before his academic career, Dr. Vogus worked with the Ford Motor Company in the area of human resources and health care management. Prior to that, he was a business process analyst for Andersen Consulting (now Accenture). He received his Ph.D. in management and organizations from the University of Michigan and his B.A. in political economy and Spanish from Michigan State University.

James A. Watson (Admiral, USCG, retired) is president and chief operating officer of the Americas Division of the American Bureau of Shipping. Prior to undertaking this appointment in 2013, ADM Watson was director of the Bureau of Safety and Environmental Enforcement (BSEE). In this position, he was responsible for promoting safety, protecting the environment, and conserving resources through the regulatory oversight and enforcement of offshore operations on the U.S. Outer Continental Shelf. Before joining BSEE, ADM Watson served as USCG's director of prevention policy for marine safety, security, and stewardship, with responsibilities that included commercial vessel safety and security, ports and cargo safety and security, and maritime investigations. Notably, he was designated federal on-scene coordinator for the government-wide response to the Macondo oil spill in the Gulf of Mexico in June 2010. ADM Watson graduated in 1978 from the U.S. Coast Guard Academy with a B.S. degree in marine engineering and earned an M.S. degree from the University of Michigan in mechanical engineering and naval architecture, in addition to a master's degree in strategic studies from the Industrial College of the Armed Forces.

Warner Williams has retired as vice president of Chevron North America Exploration and Production Company's Gulf of Mexico business unit, where he was responsible for Chevron's offshore shelf and deepwater production operations and shelf exploration activities. Mr. Williams received his bachelor's degree in petroleum engineering from the New Mexico Institute of Mining and Technology in 1974 and a master's degree in petroleum engineering from the University of Southern California (USC) in 2013. He joined Chevron as a production engineer in 1974 and progressed through assignments of increasing responsibility. In 1990, he was named manager of engineering training at Chevron's Drilling Technology Center in Houston. In 1992, he became production manager for Chevron Overseas Petroleum Inc. in the Democratic Republic of Congo. In 1994, Mr. Williams was named general manager, production and geothermal operations, for Amoseas Indonesia, a joint venture of Chevron and Texaco. In 1997, he was named general manager of international relations in Washington, D.C., a registered lobbyist, and a year later was appointed general manager of the Southern Africa Strategic business unit for Chevron Overseas Petroleum Inc. In November 2000, Mr. Williams was named to lead the team that merged Chevron's and Texaco's worldwide oil exploration and production assets into the newly formed ChevronTexaco Corp. He was named vice president of health, environment and safety for ChevronTexaco Corp. upon the company's formation in 2001. In 2003, Mr. Williams was named vice president of Chevron's North America Exploration and Production Company's San Joaquin Valley business unit. In this capacity, he was responsible for Chevron's oil and gas production in California. Mr. Williams was named vice president of Chevron's North America Exploration and Production Company in 2008. He also served as president of the Chevron Gulf of Mexico Response Company, LLC. Mr. Williams is active on the boards of the American Association of Blacks in Energy and the Viterbi School Engineering Board of Councilors (University of Southern California). He also serves as a director for the Valley Republic Bank.

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