Society of Petroleum Engineers

SPE Technical Report

Getting to Zero and Beyond: The Path Forward

Improving Safety in the Oil and Gas Industry

March 2018

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The authors wish to thank all the contributors and peer reviewers for their time, effort, and contribution to this report.

This report represents the consensus viewpoint of subject matter experts and is intended to provide useful guidance to SPE members, the industry, and public.

Foreword

Following Lord Cullen's review of this report, he provided the following message to the oil and gas industry:

> *Operations in the oil and gas industry necessarily have to rely on the actions of members of the workforce. Their actions may be influenced—with implications for safety—by a number of things such as the design of equipment, the organisation, the working environment, and the competence and attitude of individuals. It follows that the management of safety has to include assessing human factors and taking them into account. The implications of human factors for safety must be fully realised.*
>
> —Lord Cullen of Whitekirk KT, 22 June 2017

Lord Cullen of Whitekirk KT conducted the public inquiry into the Piper Alpha disaster. He continues to share guidance, wisdom, and support for safe and reliable operations across the global oil and gas industry. His insights and contributions are valued and respected among the industry, its leaders, and oil and gas workers. The authors wish to convey appreciation to him for his leadership and contribution to the understanding that human factors is a necessary element to achieving zero harm.

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1.0 Executive Summary

Between 2009 and 2016, the Society of Petroleum Engineers (SPE) facilitated a series of global sessions to develop ideas for the advancement of health, safety, and the environment (HSE) in the industry. These sessions brought together more than 850 leaders representing diverse disciplines from across the oil and gas industry, government, and academia to discuss a simple question: How can the oil and gas industry achieve zero harm?

The diverse group of participants generated many valuable ideas for a "step change" in performance, and they precipitated alignment around a vision of safety, specifically the expectation of zero harm. The participants agreed that achieving zero harm was possible, but given the oil and gas industry's varied cultures and risk tolerance, it was necessary to collaboratively identify the methods for attaining zero. It was widely agreed that the effort must begin with the industry's most valuable resource, its people, and the elements of human factors in particular, including the factors that influence the interaction of people with each other, with the facilities and equipment, and with the management systems and working practices used to organize and manage the way work is carried out within the industry.

This report is a compilation of the discussions from the SPE sessions, and serves to expand on these discussions to identify and evaluate those elements that may aid the industry in removing obstacles to achieving the expectation of zero harm by exploring current thinking and views, understanding experiences and learnings from other industries that are mature in the application of human factors, and suggesting next steps for both the industry and individual companies.

Specific recommendations for the industry discussed in this report include

- Define a safety vision in which zero is an attainable expectation today, not a future goal.
- Learn from other industries that are mature in human factors with the express intent to progress the application of human factors across the oil and gas industry.
- De-emphasize lagging performance indicators (injury rates) and use more leading indicators to ensure a progressive and preventative focus on the effectiveness of safeguards and risk reduction.
- Establish a no-risk-to-sharing culture—a commitment of collaboration—across the industry with the intent to overcome perceived risks and competition barriers.
- Remove barriers to open sharing of lessons learned from major incidents, high-potential near-misses, and projects during which the work, although complex and with considerable risk, was executed without incidents.
- Collaborate with regulators to ensure they can match the best minds in industry so that competent discussions about risk-management strategies are occurring.

Recommendations for individual companies include

- Realize an interdependent HSE culture demonstrated by a commitment to a collaborative environment and consistent safety culture at the worksite regardless of company position (operator, service company, specialty contractor).
- Achieve operational ownership of HSE.
- Ensure sustainable HSE leadership.

This report is an output of the previously approved technical report *Assessing the Processes, Tools, and Value of Sharing and Learning From Offshore E&P Safety Related Data* (SPE Technical Reports Committee 2016,

SPE-182847-TR), and it also builds on the published technical report *The Human Factor: Process Safety and Culture* (SPE Technical Reports Committee 2014, SPE-170575-TR).

Additionally, this report serves as a catalyst to jump start SPE's recently approved safety and environment strategy. Specifically, it supports the strategic objective of "Strengthen[ing] HSSE-SR integration into other SPE disciplines" as well as SPE's 2013–17 strategic plan goal:

> *Promote safety and environmental protection as high priorities with our membership. Over the past two decades, industry has become far more cognizant of the far-reaching environmental and social consequences of its activities. While many companies have very strong safety and environmental programs, several recent incidents have reinforced public and government skepticism of industry's focus on these issues. SPE should emphasize safety, the environment, and sustainability to its members as a complement to current corporate efforts. Ensuring that environmental and social responsibility is part of SPE programming may provide opportunities to improve awareness and perception.*

2.0 Introduction

For me, the idea is to shun the incremental and go for the leap.
–Jack Welch, Chief Executive Officer of General Electric, 1973–2001

The oil and gas industry was started by visionaries and wildcatters who foresaw a brighter future and were willing to scrap the status quo and take steps to achieve their vision. For the industry to reposition itself for the future today, it needs an injection of the same willingness to cast aside some strongly held legacy beliefs and practices and take the next leap forward—achieving zero harm.

Rod Gutierrez, PhD, Global Leader—Culture and Change Management for DuPont Sustainable Solutions, has written that the concept of zero has encouraged industries to move away from simply minimizing risks through engineering out hazards toward actively engaging people for an overall improvement to workplace health and safety outcomes (Gutierrez 2015):

> *But however positive this advancement, it is important to consider what comes next. What if we are to shift our point of reference, so that zero harm was no longer the goal, but rather simply the beginning of sustained workplace health and safety? By reconfiguring the scale that we apply to workplace health and safety, by no longer considering zero as a final objective but rather a starting point, a minimum standard, we allow for the opportunity to initiate comprehensive and meaningful outcomes*.

The concept of zero harm is not a new one in the oil and gas industry, which has for more than two decades set HSE goals that are focused on the reduction of incidents with the ultimate intended outcome that no one be hurt and no releases occur. However, the challenge for decades has been the alignment of industry on an effective pathway to achieve these goals. To attain zero harm, a step change in thinking, performance, and alignment around HSE is required across the industry. 2016 SPE President Nathan Meehan stated, "This trend in performance improvement over the past decade has plateaued. We need a breakthrough" (Meehan 2015).

It is acknowledged that some believe directing attention toward achieving zero harm can lead to a detrimental focus on incidents and injuries that may lead to underreporting of incidents, gaming of statistics, manipulation of incident definitions, and overly aggressive injury case management. Sidney Dekker has argued against zero being a goal. However, his explanation of it as a vision perhaps best illustrates what it can represent (Dekker 2013):

> *A zero vision is a commitment. It is a modernist commitment, inspired by Enlightenment thinking, that is driven by the moral appeal of not wanting to do harm and making the world a better place. It is also driven by the modernist belief that progress is always possible, that we can continually improve, always make things better*.

Between 2009 and 2016, SPE facilitated a series of global sessions to develop ideas for the continued improvement of HSE in the industry. These sessions brought together leaders representing diverse disciplines from across the industry, government, and academia to discuss a simple question: How can the oil and gas industry achieve zero harm?

The participants of the SPE sessions identified that achieving and sustaining zero harm relies on the industry's people and the factors that influence the interaction of people with each other, with the facilities

and equipment, and with the management systems and working practices used to organize and manage the way work is carried out within the industry. These criteria are described as human factors; identified by the SPE session participants as the priority component for the industry's success in meeting an expectation of zero harm.

In addition, ensuring an industrywide commitment to the expectation of zero harm and integrating elements of human factors to improve human performance were recognized as important steps for the evolution of oil and gas companies to becoming high-reliability organizations (HROs) (Weick and Sutcliffe 2001). An evaluation of the characteristics of HROs and how they can be applied to oil and gas drilling organizations found that numerous HRO attributes, including human factors, readily align with the challenges that exist in drilling operations and that impact performance (Thorogood 2013).

There was agreement among the session participants that the output from the SPE Getting to Zero sessions should form a part of the continuing dialogue within the industry concerning an industry-driven expectation of zero harm. To this point of the discussions, achieving zero has included both personal and process safety. It is recognized that there are different applications required for each, and as the discussions continue, delineating application of the discussed principles will occur as appropriate.

In keeping with the agreement and expectations from the sessions, this report includes information and decisions from the SPE sessions and aims to continue the dialogue concerning the participants' prioritized items identified as essential for the industry to achieve and sustain zero harm.

3.0 How Did We Get Here: The Road to Stavanger

千里之行，始於足下 *(The journey of a thousand miles begins with a single step.)*
–*Tao Te Ching,* Lao Tzu, Chinese philosopher, 604–531 BC

Many in the oil and gas industry today recognize HSE as adding business and shareholder value. Likewise, leaders in HROs recognize HSE as essential and fundamental to short-term and long-term sustainable success. In fact, the impact of poor HSE practices can drive companies out of business. HSE performance becomes an integral part of our ethical, legal, and social responsibility to our employees, customers, contractors, the communities in which we work, and to the future of our planet.

In 2009, while HSE performance in the industry was improving, it was recognized that a step change would be needed to achieve noticeable improvement and to better align the industry toward eliminating incidents and unplanned events. The concept of "getting to zero" was suggested as a focus, and in 2010, SPE sponsored a Forum Series titled Getting to Zero—An Incident-Free Workplace: How Do We Get There? in Park City, Utah, USA. The forum was attended by 43 participants from six countries representing 37 organizations. The discussions included

- Defining zero
- Discerning the role of management systems and metrics
- Understanding and developing an effective safety culture to support zero harm
- Identifying stakeholders and their roles
- Mitigating risk from work processes

The forum stimulated considerable interest and discussion within SPE and across the industry. To encourage further dialogue, an SPE workshop titled Continuing the Journey to Zero was held in 2011 in San Antonio, Texas, USA; 90 attendees from 10 countries representing 55 organizations participated. The workshop focused on sharing of information and expanding the discussion beyond traditional HSE topics and the oil and gas industry.

The workshop highlights included

- *Learning from outside the oil and gas industry* is a significant opportunity, specifically from the nuclear, aviation, and aerospace industries, which are regularly recognized as HROs.
- *Human factors engineering* is an essential component for creating an incident-free workplace.
- *Behavior of senior leaders* is crucial to revealing critical lessons.
- *Self-reporting,* where an individual can make notification about errors or mistakes without fear of retribution, is essential.
- *Removing blame and encouraging absolute honesty and openness* are critical success factors in investigation and identification of root causes of incidents.
- *Leading indicators* remain an elusive but much sought after component of an incident-free workplace. There remains no one solution, and continued work is needed to develop universally accepted leading indicators.
- *Lagging indicators* still play an essential role in understanding the overall performance of an entity by providing critical information in dissecting the causes of systemic failures.
- *The general public's view of the oil and gas industry* is driven by its worst performer. Therefore, the implications of poor performance affect all industry participants.

Workshop participants developed and endorsed "Getting to Zero" vision and mission statements **(Fig. 1)** that introduced a human-factors approach to safety and sought to be both understandable and inspiring.

> ***"Getting to ZERO"***
> **A Vision Statement**
> As a member of SPE, "Safety **IS** my way of Life" at work, home, and in my community. Safety is fully integrated into work knowledge, skills, and abilities, regardless of my position or responsibility in the organization.
>
> As a core value, I am accountable for my safety and the safety of my coworkers, family, and friends. Indeed, I believe every employee associated with the Petroleum Industry is equally accountable for their own safety as well as the safety of those with whom they work and live.
>
> I passionately believe ZERO injuries/incidents is achievable because "SAFETY **IS** MY WAY OF LIFE."
>
> **A Mission Statement**
> The success of our business depends on my Safety Ethic to properly plan my work; to ensure my tools are available, maintained, and safely utilized; to know the hazards of my work and control or eliminate exposure to them; to follow all procedures safely; to *"STOP WORK"* when I deem it is necessary; to immediately report all near-misses and accidents; and to make safety improvement suggestions when warranted.

Fig. 1—SPE Getting to Zero session participants' vision and mission statements, generated as a work product from 2010 SPE Forum Series Getting to Zero—An Incident-Free Workplace: How Do We Get There?

Following these two events, the SPE Health, Safety, Security, Environment, and Social Responsibility (HSSE-SR) Advisory Committee accepted responsibility for further broadening the discussion. In preparation for the 2016 SPE International Conference and Exhibition on HSSE-SR in Stavanger, a series of interactive sessions was conducted. These sessions began in 2015 and were held across the globe (including North America, South America, Europe, Asia, and the Middle East), with the last session organized in Stavanger in conjunction with the April 2016 SPE conference.

More than 750 participants from numerous disciplines and organizations joined the global sessions. (See Appendix 7.2 for information on the participants' organizational affiliations and employment demographics.) The sessions integrated both in-person and live-webinar formats, encouraging active participation including question-and-answer sessions and real-time polling of participants. The discussions focused on three questions:

- Is getting to zero achievable?
- What are the most critical (organizational) values to achieving zero?
- What issues to achieving zero exist that require additional effort and time to understand and resolve?

Nearly 70% of the participants agreed that achieving an expectation of zero harm was possible for the industry, with approximately 20% recognizing it may be possible. Additionally, participants identified that the current HSE culture and risk tolerance across the industry were likely the most significant factors in positioning the industry to regard zero as an achievable expectation.

Participants prioritized five organizational values that define culture and impact the ability of the industry to achieve an expectation of zero harm **(Fig. 2).**

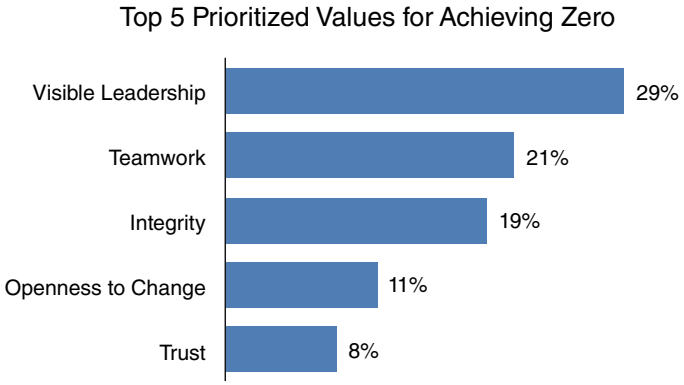

Fig. 2—SPE Getting to Zero sessions participant responses to survey question: Select five values that you believe are critical to achieving a safety vision of "getting to zero."

Participants also identified five obstacles (listed in priority as defined by the participants) that require attention in the near term if the industry is to achieve an expectation of zero harm:

- Insufficient alignment and application of human factors
- Misalignment and confusion on the expectation of zero harm
- Ineffective leadership development
- Inaccurate identification and management of risk
- Market pressure and recent industry downturn

Participants overwhelmingly agreed that the evolution of the industry's HSE culture and risk-tolerance maturities were driving forces in the recognition that human factors are pivotal and a required pathway for the industry to achieve an expectation of zero harm.

4.0 It's All About Us: Human Factors

A person who never made a mistake never tried anything new.
–Albert Einstein

Across industries, the efforts to improve safety performance or achieve a state of operational excellence have followed a generally consistent path. The initial reaction to reducing incidents was to focus on needed improvements in engineering designs. For example, improving drill-rig designs, engineering blast-proof control rooms, and/or incorporating process safety engineering into the design of offshore platforms. Once there was better-designed and -built equipment, the focus was on how the equipment was operated and managed, thus the development and evolution of management systems.

> *Management System: The framework of processes used by the managers and the workforce at all levels in a company's organization to plan, direct and execute activities* (IOGP 2014).

Initially designed as an internally focused framework of processes and procedures, management systems evolved over time to also include an external focus—integrating supplier and customer networks.

The progression to improve safety performance does not stop there. HROs and forward-looking oil and gas companies and service providers have embarked on the third critical component—people. Consensus at the SPE Getting to Zero sessions was that ensuring a safe work environment requires not only technical and procedural improvements, but also close consideration of cultural and behavioral aspects, including human factors.

Poor and inconsistent human performance continues to be an issue that impacts the oil and gas industry's safety performance. Similar incidents occur across the industry with familiar root causes labeled as human error. This "cause" aligns with the simple cause/effect relationship the industry has historically relied upon, but which has not achieved the desired outcome of lack of recurrence. A genuine step change in HSE performance is not going to occur until the industry catches up with the thinking and commitment found in other high-hazard industries and HROs. In the case of incidents, investigations and root-cause analysis must include evaluation and explanation of the conditions or events that led to human error.

Human error is often mistakenly categorized as human factors, when in fact, the application of human factors—understanding why people do what they do—is essential to the creation of a safe workplace. This includes elements of human factors inclusive of neuroscience and social science.

As was identified by the SPE Getting to Zero session participants, the oil and gas industry needs to demonstrate a consistent commitment regarding human factors. Part of the struggle has been the multiple definitions of human factors presented within the industry. These multiple definitions have led to misunderstandings of core issues that lead to the inability to design processes and "tools" that make a difference for the frontline worker. The concepts and discussions of the SPE Getting to Zero sessions and the authors of this report rely on the International Association of Oil and Gas Producers (IOGP) definition of human factors (IOGP 2005):

> *The interaction of individuals with each other, with facilities and equipment, and with management systems.*

If the oil and gas industry is to achieve the needed step change in culture, risk management, and performance to embrace and realize an expectation of zero harm, it is worthwhile to understand more about human-factor elements **(Fig. 3).** Specifically, how they may be and are being applied across the oil and gas industry and how HROs and other industries changed, learned, and worked together to fulfill the expectation of zero harm in their operations.

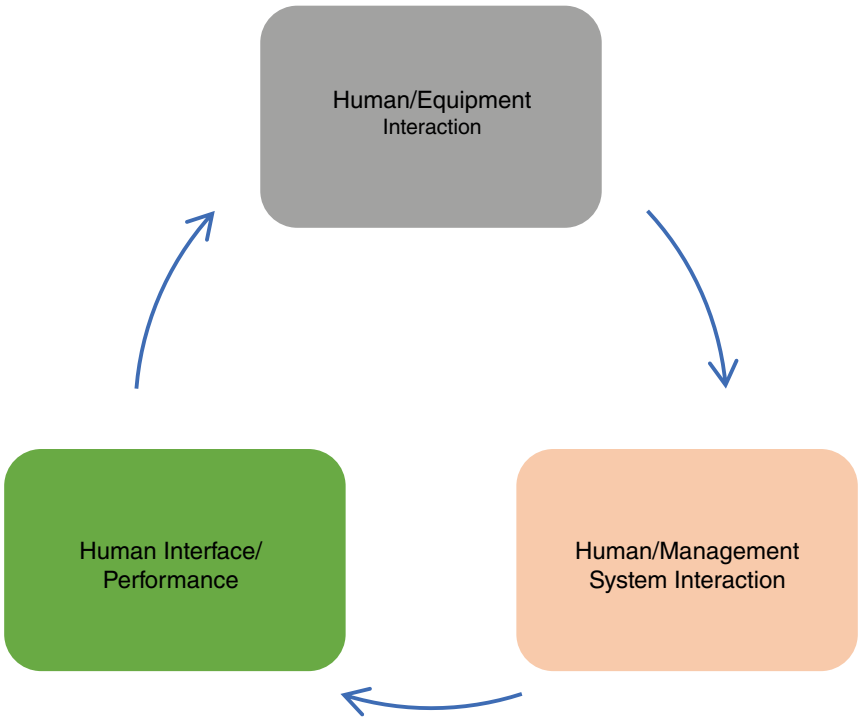

Fig. 3—Human-factors elements.

4.1 Human/Equipment Interaction

Addressing human/equipment interaction requires mastering three categories:

- Identification of human actions that are critical to safety
- Review of legacy-equipment incident data with proper human-factors causal analysis to identify opportunities to improve equipment design
- Incorporation of error-reducing strategies and questions during risk assessments

Identifying human actions that are critical to safety places emphasis on operating activities that, if not performed in accordance with the procedure, could result in a major loss. The nuclear industry, through the Nuclear Regulatory Commission (NRC), handles this category through their human-factors-engineering (HFE) programs. The "major loss" concern includes damage to the nuclear reactor core. The goal of the programs is to minimize the likelihood of human error and ensure that personnel can detect and recover from any errors that may occur.

The NRC conducts a review for every plant-design application to verify that the applicant has

- Identified specific important human actions tied to human factors

- Considered error mechanisms for important human actions in designing the human-factors aspects of equipment and the facility

Through a combination of probabilistic and deterministic risk analyses, the HFE programs identify which human actions are most important to safety for a specific facility design, and use the information to prioritize and assign efforts and resources to developing solutions to prevent human error.

It is important to recognize that the nuclear industry is a highly regulated industry with consistent approaches used worldwide and in which the industry and regulators share and communicate on best practices. Although not a perfect alignment to the oil and gas industry, there is much to learn from the human-factors programs the nuclear industry has developed and implemented for critical tasks. To this end, research has been conducted to bridge the nuclear industry's human-reliability analysis (HRA) methods to oil and gas operations (Boring and Øien 2014). This research illustrates how the concepts and learnings about human factors can transcend industries and operational boundaries.

Identifying opportunities to improve equipment design involves determining causal factors that can be traced back to suboptimal equipment design or user/equipment interfaces. Initial emphasis is placed on thorough reviews and analyses of lessons learned from legacy predecessor or comparable equipment to help identify and eliminate characteristics in the new equipment that

- Require excessive cognitive, physical, or sensory skills or high aptitudes
- Involve complex fault location or workload-intensive tasks
- Necessitate excessive training
- Result in frequent or critical errors

The nuclear industry, commercial aviation, and the US Department of Defense (DOD) have extensive human-factors user-centered equipment design requirements focused on physical human-performance considerations, human cognitive behavior, and industrial design.

The Three Mile Island Commission, the Federal Aviation Administration (FAA), and the Deepwater Horizon Commission are resources for recommended equipment design improvements from major incidents. Examples from these include

- Equipment reviews from the point of view of providing information to operators to help them avoid making human-factors errors that escalate a situation and to cope with accidents when they occur (President's Commission 1979)
- Provision of monitoring instruments and equipment to record continuously all critical plant measurements and conditions (President's Commission 1979)
- Computer technology that clearly displays key measurements relevant to potential conditions, together with diagnostic warnings of conditions for operators and shift supervisors (FAA 1995)
- Grouping of key measurements, including distinct warning signals, on a single panel for use by the operator, with a duplicate panel available in the shift supervisor's office (Presidential Commission 2011)

Some of the preceding reports are nearly four decades old. The relevance of that illustrates why and when other industries (and HROs) expanded their understanding of the people/equipment element of human factors and in some cases embarked upon a commitment to integrate human-factor elements across their industries.

The analysis of incidents and equipment downtime focused on human factors can reveal important clues for opportunities to improve equipment design and eliminate future human error. However, determining a causal factor regarding human factors from an incident is only one step. Other contributing factors must be identified to comprehend the total complexity of the breakdown in human and system performance.

Incorporating human-error-reducing questions and strategies into early risk-assessment activities is the third category in the human/equipment interaction element. HROs use error-reducing design questions and strategies during quantitative and qualitative risk assessments. For example, *MIL-STD-46855A, Department of Defense Standard Practice: Human Engineering Requirements for Military Systems, Equipment, and Facilities* (2011) provides the foundation for asking such critical questions during the early design stages. The questions in that resource require specificity in the answers beyond just "yes" and "no" and include the following:

- Have human roles, interfaces, and workloads been fully identified and analyzed?
- Are tasks designed to be within human capabilities and limitations?
- Will the design provide adequate decision support to minimize situations where humans may rationalize away information or data that is problematic, unclear, or ambiguous, or which does not meet with what the team believes (or wants to believe) is the actual state of an operation?
- Are job aids, training, or references required? Is their availability timely?
- Have human/system interface design incompatibilities been corrected by changing the design or restructuring the tasks to ensure that degraded human performance does not result in degraded system performance?
- Have critical tasks and steps been thoroughly defined? Are they understood? Can these tasks be performed reliably? (For example, avoidance of distractions or ensuring alertness—lack of fatigue.)
- Has equipment been designed to support performance of critical tasks in terms of use of automation, user interface design, and equipment layout?
- Has equipment design considered increasing sensitivity to weak signals and enabling a culture that rewards mindfulness when performing any critical activity?
- Have lessons learned regarding operability and maintenance from similar equipment designs been considered in the design of the new equipment?

Organizations often begin by defining tasks that have fatality or serious injury potentially in advance and put prevention or mitigation elements in place before performing the task. The oil and gas industry has examples of these strategies being implemented. A global integrated oil company used human factors to address human errors in potential major-accident hazard events. High-risk tasks were identified and prioritized to include significant safety, environmental, and/or operational risks. The prioritized tasks were part of an initial effort, and once the process was implemented, benefits were noted, leading to expansion of the process across the company. In addition, educating the workforce in human factors resulted in operating sites having significantly more robust work instructions that were better understood. Therefore, hazard awareness was improved and personnel were more confident in challenging activities of which they were unsure and were quicker to identify potential anomalies (Petrie and Rosbrook 2015).

Further efforts toward improving human performance include identification and discussion of types of errors based on performance modes: skill-based; rule-based; and knowledge-based (Rasmussen 1983). Organizations that are advanced in human factors consider how an individual's traits and characteristics further impact performance-mode behaviors. Recognizing that each personality has a different risk awareness and tolerance level and applying necessary adjustments are actions that provide notable results in performance for many organizations. As an example, a global drilling company used a personality identifier process to enhance

communication, applied leadership, personal and team development, and risk awareness and mitigation. The impact in safety performance was notable, and from a pilot application, a global implementation was planned (Barakat et al. 2010).

These examples represent the beginning stages of how human-error reducing strategies are effectively being implemented. The obvious next step is to begin the process of integrating these efforts across the industry, not just within individual companies.

4.2 Human/Management System Interaction

The second of the three key relationships is between the worker and the management system (operating or safety). Management systems provide direction and guidance for people, the organization, and contractors on how to operate. When the effectiveness of a management system fails, the results can be catastrophic.

In 1996, 110 people were killed when their DC-9 aircraft, flown by ValuJet, crashed shortly after takeoff from Miami International Airport. The National Transportation Safety Board (NTSB) concluded that a fire had started in the cargo hold of the DC-9, cutting through the flight controls and rendering the aircraft uncontrollable by the flight crew. The fire was linked to hazardous cargo that the contract service company had not properly prepared or presented to ValuJet before it was loaded onto the aircraft. The NTSB determined that contributing to the incident was ValuJet's failure to oversee its contract maintenance program to ensure compliance with maintenance, maintenance training, and hazardous-materials requirements and practices.

In the oil and gas industry, Piper Alpha had a similar effect, setting in motion the evolution of the safety-case and safety-management systems. In 2010, Transocean and the *Deepwater Horizon* management systems were rendered ineffective in preventing or responding to the flow of hydrocarbons in the riser and subsequent explosion and fire. The United States Coast Guard (USCG) accident report stated (USCG 2011):

> *The Safety Management System failed to provide proper risk assessment, adequate maintenance and material condition, and process safety adherence. The Flag State and USCG did not identify these system failures in time to ensure the safety of the vessel.*

These fatal incidents highlight the importance of the relationship between management systems and human factors. Safety-management systems in and of themselves are not the answer, but the discipline of human factors helps to uncover gaps in management systems, helping to ensure their effectiveness.

One of the key elements within a management system is a detailed set of specific and mandated operating procedures. These procedures indicate to the human operator the way the organization intends to have various tasks performed. The intent of operating procedures is to ensure the following and, ultimately, to deliver a predictable outcome:

- Provide guidance to the worker to ensure logical, efficient, safe, and predictable means of carrying out work
- Reduce the variability of work
- Deliver clear expectations
- Define boundaries of acceptability of work

HROs have procedures that are designed to prevent errors, are standardized in format, and function to ensure that they are followed by workers throughout their industries, regardless of company affiliation. Performance mode thinking, as an aspect of human factors, helps to create procedures that consider the factors that produce errors and attempts to eliminate them when procedures are created.

In the oil and gas industry, differences exist in contractors' operating procedures that sometimes exhibit little consistency. Such nonstandardized work processes lead to deviations by individuals and crews and difficulty in training people as they move from one location or company to another. These deviations continue to occur in the oil and gas industry and are typically masked on a contractor's mishap report under the label "not following procedures," which does not cite proper corrective actions other than "follow the procedures" to prevent similar incidents. Furthermore, the more routine the work becomes for a worker, the more apt the worker is to drift from the original/mentored way of conducting work. This effect is known as procedural drift, an adaptation of practical drift (Snook 2000), the search to establish why formal safety procedures may not ensure system safety.

There is a concern that the industry is exposed to workers who learn their craft and reapply knowledge from each other more than from formal/procedural training (Caldwell and Hinton 2015). This approach to conducting work has left a large variable in the output of the work and highlights the development of workers as the single point of failure in the management system.

The nuclear and commercial aviation industries provide an interesting counterpoint to this approach. These industries developed detailed, standardized, step-by-step operating procedures to help prevent human error during routine work, where most incidents occur in the oil and gas industry. These highly detailed operating procedures became the foundation of the safety or operational management system for each organization in their industry and created a step change in safety. Today, operating procedures are the cornerstone of any corporate management system throughout these industries because they are used for training, investigation, quality control, auditing, continuous improvement, and organizational learning.

There are efforts underway within the oil and gas industry to change the course. An oil and gas service provider designed a system of checklists for operating perforating guns with a goal of lowering their misfire rate. Although the project was initially identified as an operational enhancement and not specifically a safety improvement, the focus on risk (misfire) reduction provided improvements in safety, reliability, and operations. Perforating-gun checklists were designed to catch human errors during the process of rebuilding the guns. Three months after crews were trained on how to use the checklists and with more than 1,600 gun runs, the results were staggering. With a measured operational improvement of 74% within a few months and a quarterly savings of more than USD 18 million, the service provider declared the project a tremendous success. Three years later, the teams that received the checklists and training realized reliability improvements of more than 300% (Dingee 2015).

The importance of the worker to their management system cannot be overstated. Company management systems in the oil and gas industry have been in a constant state of overhaul and revision for the last 20 years to improve safety culture and organizational performance. This is because humans govern and accomplish all the activities necessary to control the risk of incidents. Not only do humans unintentionally make errors in executing a process that can result in an incident, they also make errors by creating deficiencies in the design and implementation of management systems. We are prone to making errors in all areas of management systems such as authorities, accountabilities, procedures, feedback, proof documents, and continual

improvement provisions. Human factors is a means to systematically validate the efficiency and effectiveness (quality) of our management systems.

4.3 Human Interface/Performance

An important characteristic of HROs is their recognition of the importance of human performance and decision making. The nuclear, aviation, and medical industries and the DOD continue to invest in the understanding of human-performance concepts. They apply how people make decisions and implement practices to consciously identify where opportunities may exist to reduce human error. They accomplish this by ensuring that effective procedural guidance or engineering features are in place to mitigate deficiencies in human performance and decision making. While the research and applied literature on this topic is extensive, going back many years, a detailed review of the literature is beyond the intent of this report. Some key examples and learnings for the design of equipment and practices that consider human performance and decision making include

- Ensuring critical equipment and operations to support the human decision-making process
- Examination of past incidents and development of specific learnings that are then fed back into the design of doctrine, equipment, and standards, including better incident reporting and investigations
- Ensuring competence on decision-making strategies for teams and within the organization

Opportunities for critical equipment and operations to support situational awareness and decision making are regularly found in HROs. Nuclear power plants have numerous alarms and indicators to communicate operating parameters that are out of limits or need attention. In commercial aircraft, ground warning proximity alarms are present to warn pilots when they are too close to the ground. Ideally, through design, warnings and alarms are thoughtfully integrated into the overall systems that support operator's situational awareness.

In the oil and gas industry, proximity alarms or detectors are in place as an alert to high-hazard, "red zone" conditions (for example, potential exposure to hydrogen sulfide or alerting a driller of the potential interference with the traveling block). Thus, the industry is not starting from scratch in introducing this type of technology. However, the challenge is to ensure that the desired outcome to increase an operator's situational awareness is occurring and to improve the human interface with these tools.

The second category involves further examination of past incidents and development of specific learnings that are then fed back into the design of doctrine, equipment, and standards. All too often, safety investigations begin and end with the individual who committed the "unsafe act," and unless it is a high-potential event or one that attracts external attention, the rigor to go beyond "who committed the unsafe act" is not consistently applied. Safety investigations must go beyond typically stated causal factors such as employee incompetence, failure to follow procedures, failure to recognize risk, failure to maintain situational awareness, failure to maintain vigilance, fatigue, or just human error. HROs conduct investigations to determine why or how the human made the decision that preceded their action (the error). Understanding why the team or the individual made certain decisions is critical to learning how to prevent human error.

As an example of how learnings from industry incidents are leading to improvements, a drilling company, in consideration of the role human factors has had in oilfield incidents, revised their well-control manual. Well control presents complex and diverse challenges that can create a high-stress environment; therefore, the company decided to introduce human factors into the management of well-control incidents. Their journey of

development included identifying the specific human-factor elements relevant to well-control processes and tasks and consideration of how to successfully implement significant change in an industry generally resistant to change (Odgaard and Morton 2017).

The third category addresses training on decision-making strategies for teams and within the organization. The DOD, commercial aviation, and other industries have been conducting training in this area, including

- Training for individuals and teams on how to improve workers' situational awareness.
- Teaching and communicating decision-making strategies across organizations. The purpose is to improve awareness that human decision making is impacted by cognitive biases. Further, the learning environment helps teams and individuals consider the need to be cognizant and to look for mitigations and improvements.
- Increasing use of simulators and virtual environments to help improve situational awareness and decision making by the crew.

Crew-resource-management (CRM) training is a recognized tool for improving team decision making. Within CRM, the emphasis is on human interpersonal behavior. These are the personal and social resource skills that complement technical skills that contribute to safe and efficient task performance (Flin et al. 2008).

The commercial aviation industry is viewed as an industry leader in recognizing the importance of interpersonal skills or CRM training to ensure its safety record. CRM training covers skills, such as leadership, communication, assertiveness, team-building and cooperation, and conflict resolution, that are central to optimizing interpersonal effectiveness. The goal of this training is to increase situational awareness that aids in making better team decisions. Most programs include scenario-based training within flight simulators to enhance effectiveness of the learning experience.

In the oil and gas industry, follow-up reports from multiple incidents in the petroleum industry have included indications that interpersonal factors contributed to individuals (1) not sharing and using information that was available to them or (2) not effectively challenging decisions that they believed were wrong.

Therefore, the industry has started considering training for their workers regarding decision making and cognitive bias in courses typically called "nontechnical skills training." In 2014, IOGP released two publications—OGP 501 and OGP 502—that identify a training syllabus and instructor guidance for CRM customized to the needs of well-operations teams that are performing drilling, completions, intervention, and workover operations.

The impact of nontechnical factors on HSE performance and operational execution was evaluated by a global oil company's drilling team. The 14-month, two-rig program was designed to assess and improve human-factors awareness and modify team behaviors using the application of CRM and other methods used by HROs with a goal of achieving perfect or near-perfect operations—hurt-free and spill-free—while improving performance efficiency. The application of CRM principles was reported to produce significant days of perfect HSE performance and improved operational execution (Morris et al. 2016).

Continuing the application of CRM for all job categories will enable the industry to address yet another element of human factors—the engagement and interpersonal skills we rely on as we achieve the expectation of zero harm.

As was identified at the SPE sessions, human factors is an important element in the evaluation and management of risk within the industry. The US Department of Energy (DOE) sums it up best (US DOE 2009):

> *It is not easy to anticipate exactly how trivial conditions can influence individual performance. Error-provoking aspects of facility design, procedures, processes, and human nature exist everywhere. No matter how efficiently equipment functions; how good the training, supervision, and procedures; and how well the best worker, engineer, or manager performs his or her duties,* people cannot perform better than the organization supporting them. *Human error is caused not only by normal human fallibility, but also by incompatible management and leadership practices and organizational weaknesses in work processes and values. Therefore, defense-in-depth with respect to the human element is needed to improve the resilience of programmatic systems and to drive down human error and events*.

5.0 Achieving a Culture of Perfection Led From the Top

Oil and gas companies will never be "High Reliability Organizations" if they rely on campaigns to change hearts and minds on the operational frontline. Instead, they must identify the obvious precursors to catastrophe and get serious about eliminating them – led firmly from the top.
–Andrew Hopkins, 2014

Zero harm as an expectation will require a cultural adjustment for the industry. Patrick Hudson's Safety Culture Maturity Model (Hudson 2001) is a recognized framework used by organizations to assess and understand their culture. For the 2015–16 SPE Getting to Zero sessions, the Hudson model was adapted to evaluate HSE culture and risk tolerance **(Fig. 4).**

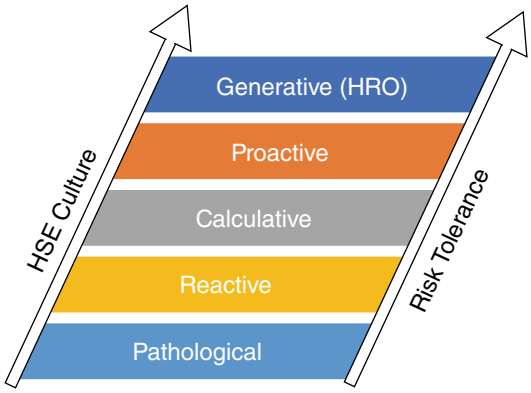

Fig. 4—Culture/risk tolerance adaptation of Hudson's Safety Culture Maturity Model.

Participants at the SPE Getting to Zero sessions identified that an evolution to a generative mindset is emerging within their companies, for both HSE culture and risk tolerance **(Fig 5).** Specifically,

- Two-thirds (69%) identified their organizations as having a proactive/generative HSE cultural mindset: 50% proactive/19% generative.
- Three-quarters (78%) identified their organizations as having a risk-tolerance mindset of being naturally proactive/generative: 72% proactive/6% generative.

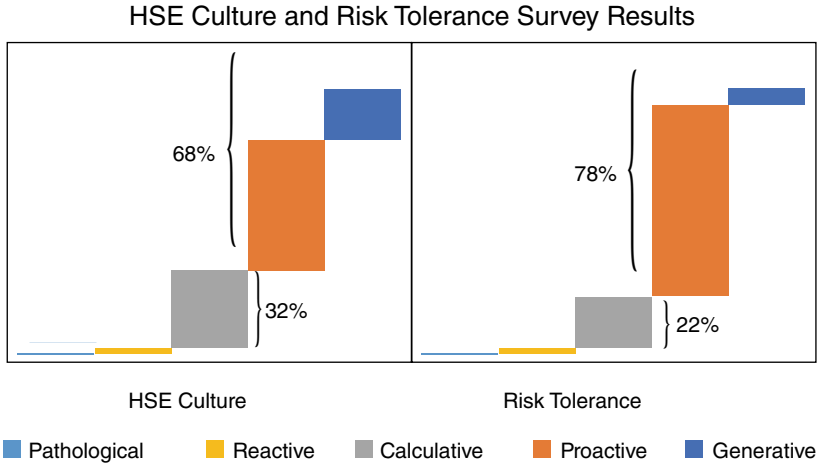

Fig. 5—HSE culture and risk tolerance survey results from SPE Getting to Zero sessions.

Although the more than 750 session participants represented a diverse cross section of the industry, the authors are not concluding that the survey unequivocally defines where the oil and gas industry is on its evolutionary journey to a generative mindset. Rather, the authors attest that the results represent insight into the industry's desire and the direction in which the industry is moving on attributes that are essential for achieving zero as an expectation.

Also indicative of the culture across the industry of the ability to achieve an expectation of zero harm are the present attention and action that are being given to incidents. As a frame of reference, incidents are categorized as fatalities, lost-time injuries, medical cases, first-aid, high-potential, and near-miss. When asked what level of safety incidents trigger their company's incident analysis and attention, the participants reported the following **(Fig. 6):**

- More than one-third of the session participants identified that in their organizations all incidents receive analysis and attention regardless of outcome severity.
- For nearly one-half of the participants, high-potential incidents initiate action in their organizations.
- The small remainder of participants limit their analysis and attention to traditional incident metrics (that is, fatalities, lost time, medical cases, and first aids).

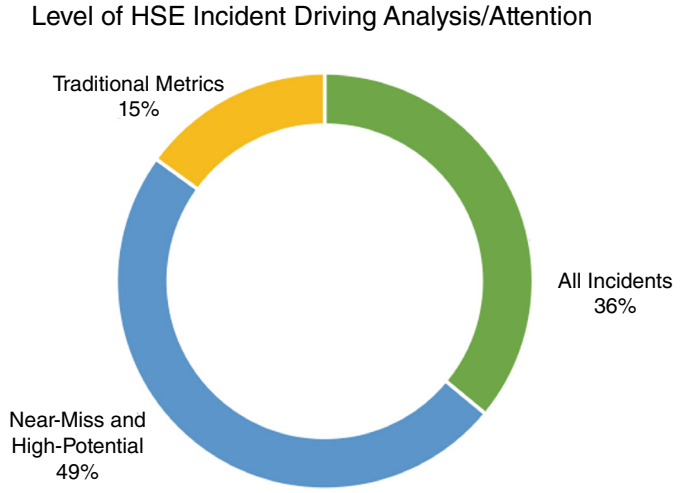

Fig. 6—Management of HSE incidents—survey results from SPE Getting to Zero sessions.

When session participants were queried regarding their company's state of cultural readiness to embrace zero as possible, the results were notable.

- 2% expressed no desire to pursue, and just 16% cited a present lack of leadership commitment or limitations in their present means to manage HSE as what was holding them back.
- 33% indicated it may take some time and clarity as to "how" they would embrace zero as possible.
- Nearly one-half (49%) responded that they are actively working now or are ready to join others in the pursuit.

Most encouraging are the organizational behaviors cited during the SPE Getting to Zero sessions that underpin these positive percentages. More organizations now genuinely believe safety is critical to business success and that their safety systems are essential, using effectiveness methodologies to ensure their efficacy. For

many, safety is a fundamental part of the organization's core culture, not a discretionary add-on or someone else's responsibility.

Organizational and personal accountability mindsets are now more prevalent, causing pre-emptive challenge of conditions and behaviors, because the recognition and perception of risk have increased and tolerance for risk has decreased. This supports Patrick Hudson's research that organizations shift their tolerance/perception of risk as they evolve upward on his culture ladder (Hudson 2001).

To continue this cultural evolution across the entire industry, the critical component to instilling and ensuring the necessary change rests with leadership behaviors. Andrew Hopkins states, "a company may expend huge resources trying to change the way operators, foremen, and supervisory staff think and feel about safety, but a far more effective approach is to instill a culture of *This is the way we do things around here*. This approach focuses on what people do, not on what they think." And, says Hopkins, "what people do is something company leadership can indeed control, while what people think is neither here nor there" (DecomWorld 2014).

> ***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, encompassing the organization's values, beliefs, attitudes, social norms, rules, practices, competencies, and behaviors regarding safety* (National Academy of Sciences 2016).

The 2016 National Academy of Sciences *Strengthening the Safety Culture of the Offshore Oil and Gas Industry* report identified that safety culture is elusive, both conceptually and empirically, because safety itself presents many distinct challenges for organizations, including the following:

- Issues that negatively impact oil and gas production are perceived by the organization as an acute problem that needs to be addressed immediately, while safety is viewed as a more chronic concern that competes, often unsuccessfully, with production for resources, attention, and real commitment.
- Safety demands seeing and preventing an incident in the making. Therefore, a strong safety culture is often difficult to manage and sustain because people have difficulty knowing the mistakes they did not make but could have.
- Feedback on system safety is often discontinuous because recorded accidents, incidents, and even near-misses are relatively rare. Further, it is indirect because the data reflect a system only at a moment in time without necessarily indicating its intrinsic resistance to operational hazards.

Members of senior management have been identified as critical drivers in setting the priorities within an organization (O'Dea and Flin 2003). The higher the individual is in an organization, the greater their potential to influence organizational outcomes through their behaviors and actions. Managers have a direct effect on establishing the culture of the organization and the safety climate—employees' behaviors—in the workplace. The model described by O'Dea and Flin (2003) demonstrates that senior managers have a direct impact on the HSE attitudes and behaviors of middle managers, and middle managers in turn have the same impact on supervisors. Because of this influence, the importance of effective HSE leadership by senior managers and middle managers becomes apparent. They have a critical role in creating positive HSE attitudes and behaviors throughout an organization. It becomes very clear how important HSE leadership by senior managers is in ensuring that safety remains on par with other business priorities such as profitability and productivity.

Some error-prone behaviors can become self-reinforcing if leaders do not continually emphasize the importance of safe behaviors and practices. For example, if a procedural shortcut or using an incorrect tool saves time and does not result in an incident or near-miss, the positive consequence of the error-prone behavior can easily reinforce the behavior, and, over time, this type of occurrence can become part of the culture of the organization.

Two tragic and memorable lessons in cultural deviation resulting from commitment to schedule and delivery are the tragedies at the National Aeronautics and Space Administration (NASA)—the loss of the *Challenger* and *Columbia* crews. These failures were defined as examples of "normalization of deviance," meaning people within the organization became so accustomed to a deviant behavior that they did not consider it as deviant, even though they far exceeded their own rules for safe performance (Wilcutt and Bell 2014).

As explained by Diane Vaughan (Vaughan 2016):

> *In many cases the various pieces of hardware and systems that ultimately fail, "talk" to us in some manner before the failure. As leaders, we need to decide whether to listen to the hardware and fix it (or control it), or rationalize the risk and continue operations. Before* Challenger's *fatal flight, NASA had seen erosion of the Solid Rocket Booster O-rings on previous flights. Likewise, before the loss of* Columbia*, NASA had seen multiple pieces of foam liberated from the external tank and strike the vehicle. In both cases, the decision was made to accept the risk of flying with these failure modes. For a short time, the flights were successful, and so we congratulated ourselves on making the right decision. Unfortunately, the risk still existed and we paid the consequences.*

Finding ways to translate learnings from other industries into action in the oil and gas industry has not been easy. An oil and gas service provider enlisted leaders as HSE owners by developing an HSE leadership program for senior managers (Breitsprecher et al. 2014). The program used findings from previous psychological research on the role of managerial leadership in determining workplace safety outcomes, and applied the antecedent-behavior-consequence (ABC) model (see Appendix 7.3). The aim of the program was to increase HSE leadership by senior and middle managers and thereby accelerate the development of a strong HSE culture. The scope of the HSE leadership program was to increase managers' and senior managers' operational ownership of HSE and provide "line of sight" as to what effective HSE leadership is and how to apply it to daily activities.

The first phase of success was commitment from senior management outside the HSE function to endorse the HSE leadership program. If this commitment was not present and the training was not perceived to be integral to the business, the participants in the course would not recognize the importance of the training. Further, the goal of achieving a strong culture through operational ownership of HSE would be undermined.

To ensure this critical aspect of success, a series of executive sessions was conducted for the executive leadership teams of the organization to ensure their commitment and involvement in the program. Members of the executive leadership team were active participants in the sessions and defined their expectations for participants following their completion of the program.

The program's effectiveness was realized at various levels of the company. The executive leadership awareness and commitment drove an increase in their level of accountability and ownership. The direct reports of

those attending the leadership sessions reported an increased awareness and improved HSE behaviors. The participants themselves were the instigators of the cultural change of their supervisors and their subordinates. In summary, the results demonstrated that the HSE leadership program had a positive impact on the operational ownership of HSE.

Programs like the one described in the preceding have been implemented with varying levels of success in several oil and gas companies. In each case, the impact/success of the program was directly related to the level of senior-operational-management involvement in the process. In short, effective and engaged leadership matters.

6.0 Where Do We Go From Here? Next Steps

"If a problem is too difficult to solve, enlarge it."
–Dwight D. Eisenhower

The takeaway from President Eisenhower's words is that we should be thinking about managing HSE as a subset of a larger human-factors question that can then be enlarged to become part of the organizational development of HROs. Or, seen another way, as we get HSE and human factors right, we move closer to managing risk throughout our organizations—and our industry—to get everything right.

Despite year-by-year improvements in personal-injury rates, fatal incidents in certain areas continue at unacceptable levels. In 2016, IOGP members reported 29 fatal incidents resulting in 50 employee fatalities (IOGP 2017).

High-profile incidents, such as *Exxon-Valdez*, *Deepwater Horizon*, and the Lac-Mégantic rail disaster, have led the industry to focus increasingly on process safety and systems engineering. While needing to maintain high investment in occupational safety programs, the industry also is investing more than ever in the prevention of "low-frequency, high-severity" incidents—those rare, but disastrous events that can cause devastating harm to people, communities, and ecosystems. With this investment, focus on "high-frequency, low-severity" incidents sometimes suffers.

So, when faced with these challenges, the industry's alignment on an expectation of zero harm must encompass managing its risks as a high-reliability industry, and given this goal, there are many opportunities for companies to focus their efforts to drive them toward implementing generative characteristics common to HROs.

In generating next steps for continuing both the discussions and actions required to achieve and sustain zero harm, the authors considered the output of the SPE Getting to Zero sessions and developments that have ensued since the sessions. These recommendations are provided below. In addition, during the process of peer review and public comment for the report, the reviewers provided additional topics for consideration by the industry. The authors believe the reviewers' recommendations are additive to the discussion and have included them in the Afterword found in Appendix 7.4.

What Do We Do as an Industry?

1. **Shift from "zero as a goal" to "zero as an expectation."** In the 1990s, leading companies in our industry defined a goal of zero harm (for example, Exxon's "Nobody Gets Hurt," Shell's "Goal Zero," and BP's "No accidents, no injuries, and no harm to the environment"); the ultimate outcome of these efforts would be that no one is hurt and no releases occur. These goal-driven visions forced a step change in the reduction of injuries and spills, but despite these improvements, catastrophic incidents—fatal injuries and major releases—occur in our industry at a persistent frequency today.

   To eliminate catastrophic events in the oil and gas industry, we need to revise our vision of zero. Defining zero harm as a goal implies that we can set incremental safety performance targets; it acknowledges that our operations will harm today. Further, this thinking can lead to a detrimental focus on incidents and injuries that may lead to under-reporting of incidents, gaming of statistics, manipulation of incident

definitions, and overly aggressive injury case management. A goal of zero suggests an unattainable numerical target of perfection. Rather, we need to think of zero harm as an expectation at each and every moment. We need to acknowledge the risks in our industry, and at the same time, we need to expect that the people working in our operations will go home safe today.

In the 1950s, the frequency of airplane crashes was so high that many assumed there could never be a market for air transportation to the public; so, the nascent commercial aviation industry did not set a future, ultimate goal of zero plane crashes. Rather, they realized that a single plane crash is one too many and they committed to eliminate catastrophic aviation accidents. They began to expect that every flight could arrive safely. The steep drop in commercial aviation accidents in the 1960s is a testament to this industry's commitment. In the same way, the oil and gas industry can eliminate catastrophic events when we begin to expect zero catastrophic events.

Perhaps this is a nuanced, subtle shift in thinking—from a goal of zero harm to an expectation of zero harm—but the difference between the two is the difference between focusing on future improvement and focusing on safety in the moment. This shift in mindset is imperative to eliminate catastrophic incidents.

If we can agree as an industry that zero harm is an attainable expectation, then we will commit to undertake the necessary step change to ensure that it is attained and sustained.

Individual companies and organizations such as SPE should review their safety visions and workforce safety messaging to clarify that zero harm is not an ultimate goal, but is an immediate expectation.

2. **Continue to progress the application of human factors.** The cultural shift to being proactive, and ultimately to being generative, is causing healthy questioning of how the industry has managed HSE. SPE Getting to Zero session participants characterized that
    - Essentially one-half (49%) of the industry's efforts to manage HSE performance are still very traditional, specifically comprising management systems, standards/procedures, and audits/inspections.
    - Only approximately 11% of companies are using leading indicators.
    - Only 6% are evaluating and using human-factors elements.

    The realization that our present suite of management and mitigation efforts can only yield incremental HSE-performance improvement is profound, particularly when one considers how sacred the traditional approaches have become. The questioning that incremental thinking must be replaced with zero thinking is driving the desire to do something else.

    The industry should standardize on a set of leading indicators that measure the degree to which human factors are being used in our industry. This would necessitate a common view of human factors. During the peer review of this report, it was evident that the views of human factors and their successful application in the oil and gas industry vary considerably across the field of human-factors technical experts. Continuing the discussion and sharing how human factors can be and have been successfully applied across the industry's operations will benefit the entire industry and improve the likelihood that the industry, not just individual companies, will achieve the expectation of zero harm.

    Once we have a common understanding concerning human factors, we can develop a common vocabulary and we can begin to drive a consistent industry culture that will help all companies with considerations

such as resource planning and competencies. We will be able to regularly include human-factors assessments in such things as hazard and operability studies/hazard-identification studies and equivalent tools/processes so we can identify shortcomings in the understanding of the engineered process. Incident investigations and root-cause analysis can include a common set of human-factors attributes that would allow companies to better understand contributing factors in events that go well beyond the often-cited and yet narrow assessment that someone did not follow process or that the event was caused by operator error.

Industry conferences and technical forums provide the opportunity to further the discussion and share broader ideas and actions started by the industry. Examples of these opportunities include

- 2014 SPE Workshop Getting to Grips With Human Factors in Drilling Operations: The main points from the workshop presentations and discussions were summarized in a paper that included practical tools and insights that could be applied to day-to-day operations and additional resources for further reading (Thorogood et al. 2015).
- A panel discussion at the 2017 Offshore Technology Conference included a presentation by a service company about their work in human factors. Their efforts are focused on the underlying organizational and system aspects that support the individual. Using their "What Lies Beneath" approach **(Fig. 7)**, which incorporates human factors, they are embracing a holistic view that is enabling their organization to achieve a step change, not just incremental change, in HSE performance. This will further their cultural advancement toward an HRO (Hinton 2017).

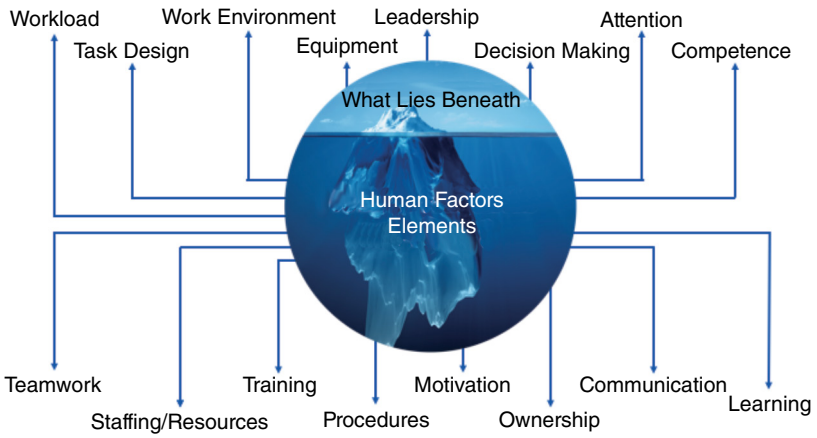

Fig. 7—What-lies-beneath analysis of human-factors elements (Harris and Hinton 2017).

3. **De-emphasize lagging performance indicators and use leading indicators.** As an industry, we have become adept at gathering performance on lagging indicators (events that have occurred) vs. leading indicators (risk-control measures). It is easy to measure safety by counting injuries, but much more complicated to measure (and set targets for) effective controls to reduce or eliminate risk. While the emphasis on lagging indicators has brought significant improvement in recordable injury rates, the pressure exerted by focusing on incidents as a performance measure is yielding diminishing returns, to the point that incident rates are no longer a reliable indicator of a company's safety program (OSHA 2012).

   Goodhart's Law applies here: "Any observed statistical regularity will tend to collapse once pressure is placed upon it for control purposes" (Goodhart 1975). Or in other words, "when a measure becomes a target, it can no longer be used as a measure" (Strathern 1997).

In addition, the longstanding concern that focusing on lagging indicators can drive aberrant behavior, including manipulation of the recording of injuries and pressure on employees not to report, was addressed in OSHA's 2016 update to their Recording and Reporting Occupational Injuries and Illnesses regulation, whereby they explicitly prohibit employers from using incentive programs that would discourage or deter an employee from reporting a work-related injury or illness (OSHA 2016).

Lagging indicators, such as total recordable incident rates, should not be the primary basis to assess safety performance. Instead, to promote a more accurate measure of HSE performance, and to focus the industry's efforts on safeguard effectiveness and risk reduction, we should use a balance of lagging and leading indicators to measure the effectiveness of our programs.

The industry should agree upon an appropriate set of leading indicators. These measures would be the inputs required to reach the desired outcome of eliminating the worst incidents. This demands that we look toward the next evolutionary stage of our performance measurement and emphasizes the need for the industry to focus on expected behaviors rather than outcomes of the process. It is only by collectively setting this expectation that we will establish an industry culture that requires the actions needed to prevent harm, as opposed to accepting the harm that comes from a potentially flawed system.

4. **Optimize collaboration across companies and crews.** The oil and gas industry is made up of numerous operating companies, service companies, vendors, contractors, and subcontractors—all interrelated and all needing to interface seamlessly to operate safely. With a workforce guided by a myriad of safety management systems and processes and procedures unique to each organization, working in alignment—and working safely—is a challenge. We need to improve how our individual companies collaborate with each other.

   Numerous opportunities exist within the oil and gas industry to optimize collaboration. Some believe a rigorous "bridging" process between contract parties remains the single most important tool for collaboration. The process requires the parties to identify, document, and communicate hazards and controls in a bridging document that sets the stage for effective collaboration throughout a project.

   Having said that, better standardization of terms will facilitate sharing. Standardization of HSE requirements can help support better collaboration between different companies working together. When the various parties on a job site are using the same rulebook, they are better able to collaborate. Efforts to standardize HSE requirements are already happening in various ways.
   - Standardization of requirements within a single enterprise streamlines implementation of safety programs between major projects.
   - Standardization of requirements between operators within a single region (such as in the Gulf of Mexico) can simplify training and assurance for vendors working for various operators—including individual workers who may continuously move from platform to platform and operator to operator.
   - Standardization of requirements between projects within a single fabrication yard has potential to streamline differences between adjacent projects that share workers, and improve effectiveness of training and assurance efforts.

   We need to establish and sustain a no-risk-to-sharing culture across the industry, with the goal of overcoming perceived risk and competition barriers. This is paramount to the identification and management of risk. It has been suggested that perhaps industry associations such as IOGP, International Association

of Drilling Contractors (IADC), American Petroleum Institute (API), and the Center for Offshore Safety (COS) need to focus on the barriers to communication rather than more metrics and analysis. Intellectual property boundaries may have to be challenged in terms of advances in HSE technologies that could benefit the entire industry, but are used by only a few.

5. **Remove barriers to open sharing of lessons learned.** There is no use sanitizing the message to the point of uselessness, and being vague dilutes the personal touch. As every soldier knows, war stories are more effective. The industry should be telling the stories, repeatedly, of the iconic incidents relevant to the industry. Likewise, sharing the success stories from jobs and projects successfully operated will enable learning opportunities from well-executed work. Story telling is a powerful way of educating and reinforcing attitudes.

   We must create an environment where incident information can be shared across boundaries without fear of unnecessary regulatory reaction and burden, misunderstanding and mistrust by the public, and frivolous and counterproductive litigation.

One sector of the industry, the geophysical industry, has been successfully sharing lessons learned for more than 60 years. The culture of sharing evolved from a time when the accident rate in the geophysical industry was five times that of the total oil and gas industry (Threadgold 2014). Cooperation between the International Association of Geophysical Contractors (IAGC) and the IOGP Geophysical HSSE Subcommittee to share serious and high-risk near-miss incidents has evolved from a reluctant mindset to one of great enthusiasm, with everyone realizing both organizations and membership are all working toward the same objectives of saving lives and reducing injuries.

In addition, IOGP and IAGC member companies share data on fatal accidents and have assembled a data base of fatalities that have occurred in geophysical operations over three decades, describing some 320 events that led to a total of 522 fatalities. This database gives substantial insight into where the risks are and provides training material for the next generation, avoiding painful reinventing of the wheel (Threadgold et al. 2010).

Because of the geophysical industry sharing of incident information and the fatality database, industry-specific tools focused on supporting effective HSE systems and contract schedules for the geophysical industry have been developed, such as *IOGP Report 432, Managing HSE in a Geophysical Contract* (2016).

Another area in which progress is being made to remove barriers to sharing includes the interagency agreement between the US Department of the Interior's Bureau of Safety and Environment Enforcement (BSEE) and the Bureau of Transportation Statistics (BTS) to develop a confidential near-miss reporting system for use on the Outer Continental Shelf (SPE Technical Reports Committee 2016). Several companies have agreed to participate in the pilot program, from which it is planned that the BSEE and the industry will be able to capture essential information about accident precursors and potential hazards associated with offshore operations.

Other industries have committed to and benefitted from the process of sharing lessons learned, one being Formula One racing. Between 1952 and 1994 (43 years), 47 drivers were killed in Grand Prix championship and test races. In 1994, industry leaders came together and decided to suspend racing until a solution to the fatalities could be realized across the industry. With the commitment that safety was paramount and should

not be left up to the individual teams in the highly competitive environment, common standards and a common approach to safety were established. The results of this action remarkably reduced driver fatalities, with one fatality occurring in Grand Prix championship races in the last 23 years. This tragic occurrence prompted further improvement in track operations and driver-safety systems across the industry.

Our industry needs to adopt a more open, transparent approach to sharing lessons learned from major incidents, high-potential near-misses, and projects where, although complex and with considerable risk, the work was executed without incidents. If we do not share, we hamper our ability to learn from each other.

6. **Collaborate with regulatory authorities.** Andrew Hopkins summarizes the need to get regulators onboard if continued and sustained improvement is to occur across the industry (DecomWorld 2014):

   > *Regulators have a crucial role to play because when they say what "the way things are done around here" must look like, the industry has to listen. To get companies to focus on major hazard risk you need to get the regulators to focus on major hazard risk. In some countries they have already pushed behavior in certain directions, by requiring gas releases to be recorded and reported, for instance. That is a step in the right direction, but a gas release is still too close to a catastrophic event. The further upstream in the causal process you set the precursor event, the better.*
   >
   > *Regulators need to be highly skilled and resourced, and must be able to match the best minds in industry in order to have competent discussions about the risk-management strategies of corporations. In the US, they're not doing that yet. The best practice recognized worldwide is the safety case regime, in use in the UK and Norway.*

   We recognize that certain legal systems can create an underlying adversarial relationship between industry and its regulators, but within this regulatory environment there is room to improve the collaboration and trust, which will lead to greater partnership.

7. **What do we do as individual companies?** The real power to break down silos and barriers to get to zero ultimately resides with the operating companies because they drive contractor behavior in most of the world. This being said, some great risk-management and organizational-development improvements have been driven by individual drilling contractors and service providers.

   A recent SPE paper describes the challenge faced by an oilfield service company expected to deliver high HSE performance on site (Novia and Fernandes 2016):

   > *This expectation [is] sometimes easier said than done when variables outside of the service contractor's control are taken into consideration, such as numerous third parties and their equipment, variances in processes across different companies, and the integrity of well-barriers owned and/or maintained by the operator or other contractors*.

   A collaborative environment and consistent safety culture is one in which all workers, regardless of the logo on their coveralls, look out for one another and confront each other as needed to address hazards. Ideally, a low-level laborer at any worksite can exercise "stop work" authority to a supervisor, regardless

of company, and be assured of support from the facility owner (operating company representative). Of course, the ideal state is not the real state at many oil and gas worksites.

a. **Interdependent HSE culture.** If a company has a mature interdependent HSE culture, its employees are more likely to recognize and act on hazardous conditions. The DuPont Bradley HSE culture model **(Fig. 8)** describes the journey to an HSE culture in three phases, moving from a dependent phase, through independence, to an interdependent culture. In the dependent phase, HSE is mainly driven through use of control, discipline, rules, and regulations. As the culture matures, it moves through the independent phase, in which employees begin to take personal responsibility for HSE rather than simply relying on rules and regulations to create a safe work environment. The final—interdependent—phase is characterized by a "peer's keeper" approach that is adopted by all. In this phase, employees do not just look out for their own safety; everyone looks out for each other's safety, and management works collaboratively with employees on HSE matters, feeling comfortable leading or allowing others to lead. People do this because they genuinely care about the safety and well-being of their colleagues. They do it because they want to, not because they have to.

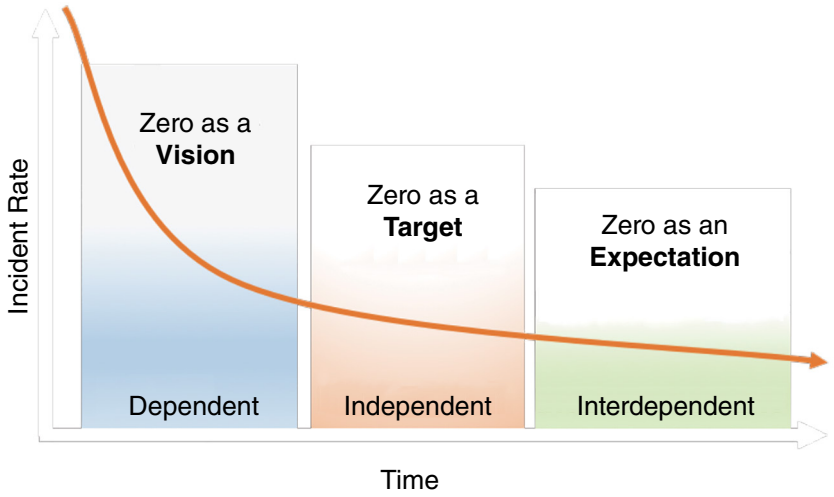

Fig. 8—DuPont Bradley HSE culture modified to include zero.

b. **Operational ownership of HSE.** Interdependence is established by achieving operational ownership of HSE—that is, by employees assuming accountability for HSE performance and maintaining a safe work environment. Operational HSE ownership is characterized by employees looking out for each other, intervening in unsafe acts and conditions, and engaging with HSE to identify and implement risk-mitigating controls and processes. This leads to a collaborative engagement rather than HSE directing and acting as a police force in the organization. Operational ownership, however, must exist at every level of the organization to be successful.

c. **Sustainable HSE leadership.** While operational ownership of HSE leads to all employees assuming accountability for HSE performance, it is essential that senior leaders and managers be a continual driving force in embedding this concept throughout the organization. Senior leadership and managers have a direct effect on establishing the "culture" of the organization and on employee HSE behaviors in the workplace. The behavior of managers, through their influence on employees, can strongly

influence the HSE performance and HSE culture of an organization. Only when senior leadership and managers adopt operational ownership of HSE will the rest of the organization follow.

The oil and gas industry has made great strides in the way we manage HSE. We must continue to evolve our culture so everyone across the industry is empowered and responsible to make the right decisions every time and is supported by the organization and systems to be error free. We must do this in the face of ever-changing market conditions that can form a barrier to HSE commitment and inhibit making the best decisions. Changing how we manage HSE is the next frontier for our industry. How we go about that change will shape the industry and the world it serves far into the future (Hinton 2016).

Zero harm is the expectation and the industry has the bench strength, the fortitude, the commitment, and the resources to make it happen. Let's get going.

7.0 Appendices

7.1 Acronyms

API	American Petroleum Institute
BSEE	Bureau of Safety and Environmental Enforcement
BTS	Bureau of Transportation Statistics
COS	Center for Offshore Safety
CRM	Crew Resource Management
DOD	Department of Defense
DOE	Department of Energy
FAA	Federal Aviation Administration
HFE	Human-Factors Engineering
HRA	Human-Reliability Analysis
HRO	High-Reliability Organization
HSE	Health, Safety, and Environment
HSSE-SR	Health, Safety, Security, Environment, and Social Responsibility
IADC	International Association of Drilling Contractors
IAGC	International Association of Geophysical Contractors
IOGP	International Association of Oil and Gas Producers
NASA	National Aeronautics and Space Administration
NRC	Nuclear Regulatory Commission
NTSB	National Transportation Safety Board
SPE	Society of Petroleum Engineers
USCG	United States Coast Guard

7.2 Participant Demographics for SPE Getting to Zero: The Road to Stavanger Sessions

SPE Getting to Zero: The Road to Stavanger sessions conducted across the globe were attended by more than 750 participants. During the interactive sessions, participants were asked to report their organizational affiliation and their employment position. The results are illustrated by the graphs below.

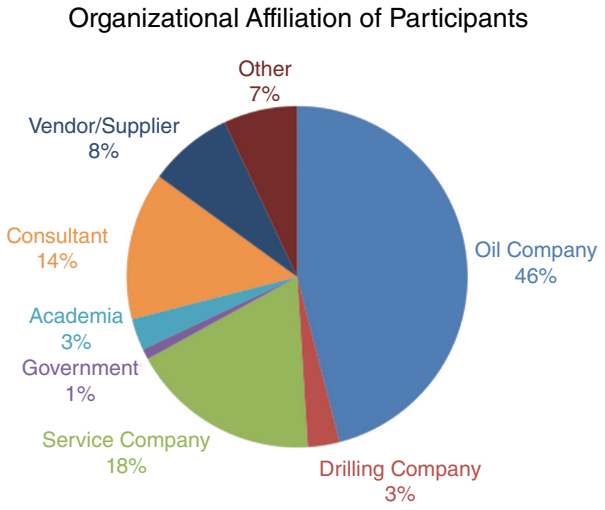

Fig. 9—Organizational affiliation of participants of the SPE Getting to Zero sessions.

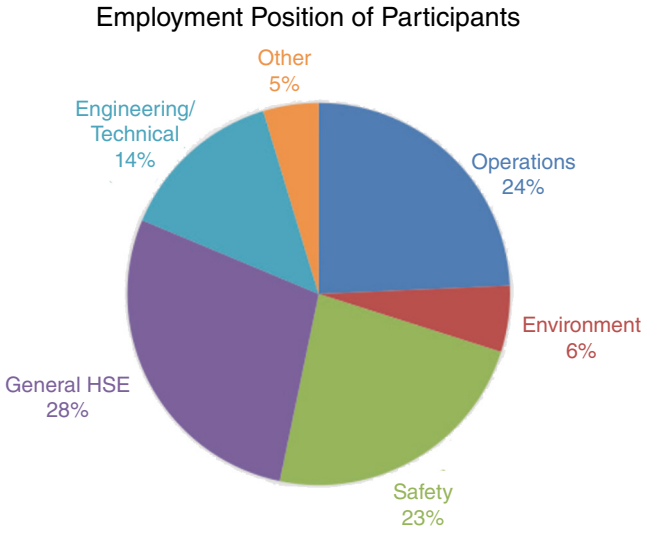

Fig. 10—Employment positions of participants of the SPE Getting to Zero sessions.

7.3 The ABC Model

What does good HSE behavior look like? The ABC model is a methodology well-grounded in empirical research spanning more than 50 years. It is, as its name suggests, made up of three components:

- Antecedents (events that trigger behavior)
- Behaviors (observable acts)
- Consequences (events both positive and negative that follow behavior)

The ABC model enables managers to clearly identify and describe desired HSE behaviors. It replaces vague statements such as "I want to improve my employees' attitudes toward HSE" into more-observable, behavioral terms such as "I want all my direct reports to review risk assessments before the start of a task." These more concrete ways to express successful HSE performance enable managers to be more direct in their HSE leadership. The model also helps managers understand where and how their own behaviors affect HSE behaviors of others. If the managers change their own behaviors regarding setting antecedents and consequences, this changes the HSE behaviors of others and ultimately leads to a positive shift in the organization's HSE culture.

By applying the ABC model and setting timely, certain, and positive consequences for safe behaviors, the manager can outweigh the positive consequence an error-prone behavior might bring the employee. In addition, by setting timely, certain, and negative consequences for error-prone behaviors, the manager gives the employee the incentive to choose the safe behavior over the error-prone behavior. As these safe behaviors are demonstrated and repeated over time by the employee, they are likely to become stronger and more habitual, and as such will assist in creating a strong HSE culture where safe behaviors are chosen over error-prone behaviors.

7.4 Afterword

The peer review and public comments received on this report provided valuable insights. Some of the comments and recommendations were beyond the scope of this report, and the authors believe they merit additional consideration by the industry as the conversation about human factors and achieving zero harm continues.

M. Sam Mannan, Texas A&M University

- Broadening the participation and contribution by all stakeholders (i.e., academia, government, industry, and the public).
  - Academia everywhere should make appropriate curriculum revisions to include concepts of process safety, loss prevention, human-factors engineering, and risk-based decision making. These curriculum changes should cover all engineering disciplines and extend to other disciplines as well, such as the sciences, business, management, industrial psychology, and public policy.
  - Government should make sure that regulations are based on science, data, and risk, and that once a regulation is promulgated, there should be a comprehensive plan for ensuring compliance. Government can and must drive progress by developing and maintaining a national chemical-incident surveillance system.
  - Industry should continue the progress toward adopting new and effective risk-based standards and engineering standards to improve safety performance. In this respect, specific emphasis should be placed on making progress in the human-factors engineering area. We should no longer accept or even allow self-defeating arguments such as "can't fix stupid." Other areas of progress include safety culture, appropriate use of leading and lagging indicators, and wide sharing of lessons learned.
  - The public and public-interest groups should play their own role by engaging with industry and other stakeholders in a constructive dialogue that is based on a deep understanding of "hazard" and "risk." We must realize that often we do not have a choice but to live with the hazards in our midst (because of the associated benefits); however, we do not have to accept unreasonable risks associated with the hazards.

Ron McLeod, Consultant (BHGE, Non-GE)

- The ideas of Barrier Management have become current and very widely used across the oil and gas industry in the past 10 years and more. The UK's Chartered Institute for Ergonomics and Human Factors published guidance on human factors in Barrier Thinking in 2016 and the Center for Chemical Process Safety has a new publication soon to be published that is relevant. This must have a critical place in achieving zero, at least for process safety.

John Thorogood, Drilling Global Consultant

- Expand the discussion to include the current modern-thought leaders in human factors: Kahneman, Hollnagel, Dekker, Leveson, Shorrock, and Woods. Include the following concepts:
  - Kahneman: System 1 and 2 thinking—its impact on decision making and design of procedures
  - Dekker, Hollnagel, Shorrock, Woods:
    - Safety-I vs. Safety-II: people create safety in complex systems
    - Reframing the discussion in terms of human performance as opposed to human error
    - Introducing the essential notion of "work-as-imagined" vs. "work-as-done"
    - Recognizing local rationality vs. situational awareness in post-accident investigation
    - Acknowledging the pernicious influence of hindsight bias in investigations
    - Incorporating the property of resilience
    - Accepting that safety is an emergent property of complex systems

- Leveson: Moving beyond simple linear accident-causation models and thinking in terms of systems that consist of interactions among hardware, computer software, and the operator(s).

- The academic debate has moved on from HROs to the broader concept of resilience. Resilience is a topic that is the focus of active debate and development and the subject of multiple conferences and books. Resilience is an essential attribute of a safe organization, and safety is the **presence of capabilities** of team members to recognize boundaries of safe operation, maintain control within them, and recover from an excursion if it happens, and these capabilities must be trained and assessed.
- IOGP does what it can in terms of sharing, but its efforts are hampered by lack of contributions from all but a few members and legal constraints on what can be published. The situation in our industry stands in complete contrast to that which prevails in aviation where the obligation to investigate and publish accident reports is an integral part of international treaty obligations. The International Civil Aviation Organization (ICAO) was established by the 1944 Chicago Convention, and ICAO, Annex 13, Aircraft Accident and Incident Investigation was incorporated into the national law of all participating states as the result.

William Robb, Safety Improvers

- A major finding of the report is that to achieve zero harm, the industry must change its thinking away from the goal of zero harm to the expectation of zero harm. This conclusion is based on several conceptual and logical errors.
  - The report implies that the majority of our efforts should be directed at getting people to accept an expectation. What does that mean? Why "accept" an expectation? Why not just "expect?"
  - There is no need to expect or believe that zero harm is possible. We know zero harm has already been achieved by some individuals, some companies, and some countries for a day, a month, a year, and even 5 years. So the report should state: Accept that zero harm is possible because we see it every day.
  - Whether we are conscious of it or not, the goal of every individual worker, supervisor, and manager, is zero harm. The report even states zero as a goal by saying "meeting an expectation of zero harm." Meeting means fulfilling the expectation.
  - The report wants the industry "To eliminate catastrophic events …," but we all know human error and accidents cannot be eliminated, only eliminated for a while.
  - The reason for this flawed conclusion is two-fold. First, the contributors have failed to see (as do many individuals) the distinction between achieving zero and staying at zero forever. Zero is achieved everyday somewhere; the challenge is staying there. So, SPE should change its motto of "Getting to Zero" to "Getting to zero and staying there as long as possible." Second, human beings do not want to set goals that they know cannot be sustained forever. This is what the industry has to grasp. We have to accept the goal of perfection knowing we cannot sustain it forever.
  - Finally, what good is an expectation to anyone? If you expect 100% to achieve zero harm, but do not achieve it, then what?
- It is difficult to understand why this report has been produced and why such a wide-ranging group has come to the conclusions it has. It seems as if they are unaware of the behavioral approaches that have been underway in some parts of the industry for many years. We know for certainty why people do the wrong things for safety: (a) lack of awareness; (b) unintentional, unreasonable pressure; (c) fear; (d) loss of concentration; and (e) wrongly diminishing the risk. There are simple but powerful ways to help people overcome these human traits at all levels, from senior managers to frontline workers. It is to this behavioral approach that SPE should look to help the industry reduce harm.

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7.6 Author and Contributor Biographies

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Andrew Dingee has worked with the oil and gas industry since 2010, where his airline-industry experience has guided him to successfully implement aviation-style checklists and procedures that reduce risk and increase efficiency, saving hundreds of millions of dollars for his clients. Dingee is a 27-year veteran (Lt. Colonel) of the US Marine Corps, where he flew AV8Bs. During his tours, Dingee received more than a dozen awards for outstanding recognition with regards to standardization and safety. In 1999, he was hired at United Airlines and held a variety of safety leadership positions, including Manager of Human Factors. Dingee was nominated for the Flight Safety Foundation Brownlow award. He conducts accident investigations with an emphasis on the human-factor element, designs and delivers courses on threat-error management, reviews Chemical Safety Board accident reports, and develops standardization programs that consist of procedures and checklists that prevent and trap human error. Dingee was the former chair of the SPE Human Factors Technical Section and is a regular speaker at international events. He holds a degree in economics from the University of Illinois.

Colette M. Glencross is a director at True North Concepts Incorporated and serves as an executive adviser to global industries including energy, chemicals, maritime, aviation, and law enforcement. Her areas of focus include enterprise risk management, operational excellence, and organizational effectiveness. Glencross has 25 years in the global oil and gas industry, serving as a registered lobbyist with API, Strategic HSE Manager for Texaco, Senior HSE Director for Baker Hughes, and global adviser. Before her work in the oil and gas industry, she worked in state and local government and in manufacturing. Glencross holds an MSPH degree in environmental science and a BS degree in biology, both from the University of South Florida. She is a published member of SPE.

Tony Zamora is a director for the consulting firm ERM. He has worked for more than 25 years in safety and environmental leadership roles for the oil and gas industry, including Chevron, BP, and Alyeska (the Alaska Pipeline). Zamora has been responsible for HSE operational programs for offshore and onshore operations and delivery of corporate initiatives for safety improvement. His professional interests include safety culture, environmental protection, communication effectiveness, and business-management systems. Zamora holds a BA degree in biology from the University of California at Santa Cruz. He has been an active member of SPE for 10 years.

Phil Grossweiler is a principal consultant at M&H Energy Services, consulting to corporate clients on liquefied-natural-gas (LNG) business strategy, LNG projects, and managing risk in offshore oil and gas operations. He first served as a USCG officer on ships operating in North Atlantic, Greenland, and Russian Arctic regions. Grossweiler worked at Exxon for 25 years with assignments in their US and Norwegian production companies and their Upstream Research and Upstream Development companies. His recent government service included assignments as Chair, Ultra Deepwater Advisory Committee for the US Secretary of Energy on USD 200 million deepwater research and development programs and on the staff of Congresswoman Heather Wilson for support on energy and science policy issues. Grossweiler graduated from the USCG Academy and holds MS degrees in mechanical engineering and naval architecture from Massachusetts Institute of Technology and an MBA degree from Houston Baptist University. He is chairperson of SPE's Human Factors Technical Section.

John M. Karish has held senior-level HSE positions with Ensco and BP Exploration during the past 15 years. Previously, he held various operational drilling, technical auditing, organizational development, and drilling safety positions with BP and its legacy companies in the US and carried out various international assignments. Karish is now pursuing similar interests in a consulting role. He has been very active in both IADC and SPE HSE conferences during the past 15 years, as an author, moderator, panelist, and program committee member. Karish holds a BS degree in petroleum engineering from the University of Pittsburgh.

Tom Knode is the director of HSE for Athlon Solutions. He previously worked for Statoil on contract, with Contek Solutions, and spent 25 years with Halliburton. In his last position with Halliburton, Knode was the director for HSE standards and performance with global responsibility for health and safety technical experts and the HSE management-system documentation. He has developed several HSE leadership workshops for operations leaders, introduced improved means of investigating incidents and sharing lessons learned, and established leading indicators to improve the balanced view of performance. Knode has been active with industry and was the Technical Director of HSSE-SR for SPE from 2008–11, has cochaired five SPE HSE conferences, and coauthored upwards of 20 technical papers and articles, including in *Journal of Petroleum Technology*. He was chair of the OGP Safety Data Task Force for 2 years and also worked on the rewrite of *API RP 76* on contractor management. Knode holds an MS degree in geology from the University of Texas at Arlington and a BS degree in geology from Texas Christian University.

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Lord Cullen of Whitekirk KT was appointed a judge in the Supreme Courts in Scotland in 1986, after 25 years at the bar. He held office as the most senior judge from 2001 until his retirement in 2005. During his time as a judge, Lord Cullen conducted three public inquiries into (1) the Piper Alpha Disaster in 1988, (2) the shootings at Dunblane Primary School in 1996, and (3) the Ladbroke Rail Crash in London in 1999. He is a Privy Counsellor, a life peer, and a knight of the Order of the Thistle. Lord Cullen is a Fellow of the Royal Society of Edinburgh and an Honorary Fellow of the Royal Academy of Engineering.

Michael Bloomfield is the vice president and general manager of Oceaneering Space Systems, a division of Oceaneering that provides space-flight hardware and space suits to NASA. He served 26 years in the US Air Force as a fighter pilot, test pilot, and NASA astronaut. While at NASA, Bloomfield made three trips into space, serving as the commander on his final flight. He also held several management positions at NASA, including Chief of Safety for the Astronaut Office, Chief Instructor Astronaut, and Deputy Director of Flight Crew Operations. In this role, Bloomfield represented the Astronaut Office for the critical go/no-go decisions

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Mary Morahan, former senior HSE manager at Chevron-Texaco, is a partner in the consulting firm of Hire Standard Incorporated in Denver. She has consulted in the global oil and gas industry since 2003 with primary focus on HSE leadership development, incident investigation, management-system development, and HSE performance improvement. Morahan is the coauthor of *Never and Never Again—Lessons from the Frontline.* She holds an MBA degree from the University of Colorado and bachelor's degrees in mathematics, education, and communications from Gustavus Adolphus College in St. Peter, Minnesota.

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Rob Fisher is the president and director of operations for Fisher IT, a Native-American (Cherokee) and veteran-owned business. Before his current role, he spent almost 10 years in the US Navy and 12 years at the South Texas Nuclear Project, where he owned the Human Performance Improvement initiative and the Procedure Program through a difficult plant-recovery time. Fisher has extensive experience in performing event investigations, designing performance improvement systems, designing and improving corrective action programs, designing and running procedure programs, and educating staff. He is a sought-after trainer, and is routinely invited to speak at international, national, and regional conferences on safety, procedures, performance improvement, human performance, and event investigation. Fisher IT has most recently been recognized internationally as instrumental in reducing fatalities and serious/life-altering injuries in high-hazard industries using human-performance and procedure concepts.

Trey Shaffer is a senior partner with ERM based in Houston. He helps clients with a broad range of sustainability, environmental, and safety challenges. In 2014, Shaffer was elected to the SPE International Board of Directors as the HSSE-SR Technical Director and will complete his term in October 2017 at the SPE Annual Technical Conference and Exhibition in San Antonio, Texas, USA. In 2016, he was elected as vice chair of the SPE Gulf Coast Section and will begin his term as chair in August 2017. In 2010, Shaffer was recognized by the SPE Gulf Coast Section and received the Award for Distinguished Contribution to Petroleum Engineering in the area of HSSE-SR. He was the cochair of the 2016 SPE International HSSE-SR Conference in Stavanger. Shaffer supports numerous SPE activities globally and is a frequent speaker on environmental and sustainability topics. He holds a bachelor's degree in environmental design from Texas A&M University.

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SPE Technical Report

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2018