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Failures of the Deepwater Horizon Semi-Submersible Drilling Unit

The following are preliminary insights into the failures of the Deepwater Horizon Drilling Unit on and after April 20, 2010. The insights are based upon more than 400 hours of analyses of currently available data provided by approximately 50 informants.

Statement of Robert Bea, Professor, UC Berkeley Department of Civil and Environmental Engineering

Summary

Based upon the evidence I have been able to gather, develop and analyze, this disaster was preventable had existing progressive guidelines and practices been followed. Some of these guidelines are implemented internationally where the same industry players, including BP PLC, operate. Moreover, other existing U.S. guidelines that were simply waived by the responsible regulatory authority could have prevented this incident.

The information available to me so far indicates that BP PLC and the Department of Interior's Minerals Management Service (MMS) failed to properly assess and manage the natural hazards in a prudent manner. Consequently, the public, resources and environment were and are being severely punished.

Lessee – BP PLC

As the lessee, BP PLC bears the primary responsibilities for operational Quality (serviceability, safety, compatibility, durability), Reliability (likelihood of realizing desirable Quality) and Stewardship of the exploration of these public resources vis-à-vis the public trust, as well as for the protection of the environment in relation to its operations.

Regulatory – DOI MMS

As the federal regulator and owner of the water bottom subject to this incident, the DOI MMS bears the primary responsibility for oversight of the operations of BP PLC. This responsibility primarily includes assuring that adequate and acceptable Quality and Reliability factors and goals (e.g. factors of safety) for the subject development and exploration of the operation are implemented. Furthermore, the same adequate and acceptable Quality and Reliability factors and goals need to be implemented, maintained and inspected for the life-cycle of the involved equipment used in the subject operations (concept, design, construction, operation, maintenance, decommissioning).

How Did This Happen?

The environment in which the oil drilling took place – 5,000 feet below the ocean's surface – is extremely hazardous. The hazards are comparable to that of exploration on the Moon and Mars. USCG Admiral Thad Allen described this underwater environment as the “Tyranny of Depth and Distance.” I would add “Darkness.” These are the natural hazards presented by the pressures, forces and movements of the water and the seafloor, and by the extremely low and high temperatures of the deep ocean environment.

Previous studies of more than 600 catastrophic failures – costing more than US $1 billion – have led to a simple equation to describe these catastrophes: A + B = C. “A” represents natural hazards. “B” represents human fallibilities, such as acquiescence, indifference, ignorance, hubris, arrogance, greed and sloth. “C” is catastrophe, which will happen sooner or later.

These studies show that approximately 80% of the catastrophic failures are rooted in “Extrinsic Uncertainties,” such as human and organizational performance, knowledge acquisition and utilization. The remaining 20% of the failures are rooted in “Intrinsic Uncertainties,” which include natural variables and analytical model limitations. Approximately 80% of these failures develop during the system operating and maintenance phases. The studies show that more than 60% develop during the design phase, including concept development. Based on the information currently available to me, the failures of the Deepwater Horizon drilling unit is an excellent example these findings.

The evidence I have collected to date shows that BP PLC and the DOI MMS failed to:

- properly evaluate and manage the likelihoods of failure (Pfs),
- properly evaluate and manage the consequences of failure (Cfs),
- abide by the legal Standards of Care established by law and by good industrial practices, and the agency’s and industry’s failure to follow these standards as stewards of the public trust, and
- properly apply the National Environmental Protection Act, and other environmental and public leasing laws and regulatory programs, such as the Outer Continental Shelf Lands Act, including numerous consultation, information and reporting requirements

Seven Steps Leading to Containment Failure (Blowout, Pf)

Based on the information available to me thus far, I believe the Deepwater Horizon failure developed due to:

- improper well design (configuration of well tubulars)
- improper cement design (segmented discontinuous cement sheath)
- flawed Quality Assurance and Quality Control (QA / QC) – no cement bond logs, ineffective oversight of operations
- bad decision making – removing the pressure barrier – displacing the drilling mud with sea water 8,000 feet below the drill deck
- loss of situational awareness – early warning signs not properly detected, analyzed or corrected (repeated major gas kicks, lost drilling tools, including evidence of damaged parts of the Blow Out Preventer [BOP] during drilling and/or cementing, lost circulation, changes in mud volume and drill string weight)
- improper operating procedures – premature off-loading of the drilling mud (weight material not available at critical time)
- flawed design and maintenance of the final line of defense – including the shear rams of the Blow Out Preventer (BOP).

From the information I have seen and analyzed, the failures by BP PLC and DOI MMS can be characterized as follows:

- drilling and well completion operations did not meet industry standards,
- operations were “Faster” and “Cheaper,” but not “Better” – the operation records clearly show excessive economic and schedule pressures resulting in compromises in the Quality and Reliability of this high-end deepwater oil and gas development system, and thus ignoring the Pfs; and
- the involved parties did not anticipate a blowout and, accordingly, did not develop effective, collaborative and constructive interactions to ensure that the Cfs needed in case of a blowout would be available.

Three Steps to the Failure to Respond (Containment, Clean-up, Secure, Cf)

My analysis of the facts developed to date show that BP PLC and the DOI MMS did not develop or implement effective measures for:

- well control after loss of containment – blowout
- capturing the loss of control materials (gases, oil, water)
- clean-up of the loss of control materials in the open ocean (booms, skimmers, burning, dispersants)

Because BP PLC and the DOI MMS believed that the potential Cfs were “insignificant,” they were not prepared for the failures associated with the Deepwater Horizon operations, both in prevention and containment. The consequences of these deeply flawed assessments and decisions were catastrophic to life, property, resources, the industry, and the environment. As this incident continues to unfold, it is clear that BP PLC and the DOI MMS had no effective plans, measures or preparations for mitigating the Cfs.

The developing record shows that BP PLC and the DOI MMS had ineffective QA/QC of BP PLC plans, operations and maintenance. Diligent and effective efforts are required to correctly detect, analyze and rectify important flaws during the life-cycle of “cutting edge” systems and operations.

Violation of The Laws of Public Resource Development

From the information I have seen and analyzed to date, I believe BP PLC and the DOI MMS did not:

- properly or effectively assess and manage the Risks (Pfs and Cfs) associated with the development of precious and vital public resources. Pfs and Cfs were not acceptable to the U.S. public and environment. This appears to be a violation of the public trust held by the MMS and the corresponding assurances of the industry
- satisfy the legal Standard of Care (SOC) in design, construction, operation, and maintenance of a unique deepwater drilling and development system (due diligence was not demonstrated)
- meet the requirements of, inter alia, the National Environmental Protection Act (NEPA), and the Outer Continental Shelf Lands Act (OCSLA)
- act in the best interest of the public, which might be categorized as an issue subject to the “public trust doctrine.”

In summary, this catastrophic failure appears to have resulted from multiple violations of the laws of public resource development, and its proper regulatory oversight.

How Can This Be Prevented?

The likelihood of such failures as the Deepwater Horizon explosion and the subsequent containment and clean-up operations can be reduced to desirable and acceptable levels by developing and implementing a leading, collaborative and diligent Life-Cycle Risk Based Management (LC RBM) government and industrial regime to explore and develop a precious and vital public resource – offshore oil and gas reserves (life-cycle Safety Case regime).

The industrial LC RBM should be based on Pfs and Cfs assessed using qualitative and quantitative methods that develop and maintain Pfs and Cfs that are acceptable to the public, government and comply with the legal SOC, NEPA, OCSLA, and the Public Trust in general. Proactive, Reactive, and Interactive methods must be used to assure development of acceptable and desirable Pfs and Cfs during the life-cycle of the activities. These methods are founded on continuous effective efforts to reduce the likelihoods and severity of malfunctions, and increase the likelihoods of effective detection, analysis and correction of malfunctions.

The OCS Lessees and the DOI MMS should develop and sustain:

- a technically superior, challenging, collaborative, and diligent program of life-cycle QA/QC based on effective and timely detection, analysis and correction of defects and flaws
- High Reliability Organizations that effectively practice High Reliability Management (planning, organizing, leading, controlling) in all segments of the operations. This will require organizational Commitment (to develop acceptable Pfs and Cfs throughout the life-cycle), Capabilities (technical and managerial superiority), Cognizance (awareness of hazards and uncertainties that threaten acceptable Pfs and Cfs through the life-cycle), Culture (balancing production and protection), and Counting (development of acceptable costs, benefits, and profitability)
- programs of international industry – government – academia collaborative Research and Development projects and Public Outreach to help educate the public
- long term collaborations with international regulatory agencies to enable realization of continuous improvements and implementation of best practices in regulations of deepwater oil and gas exploration and production
- effective deepwater oil and gas development Technology Delivery System (TDS) that effectively engages the public interests, the responsibilities of the governments (of, by, and for the people), the technology of industry and commerce and the stewardship of the environment.

These recommendations do not address the hardware, equipment and structural elements associated with ultra deepwater exploration and production developments – the “engineering technical” elements associated with these systems. These recommendations are based upon analyses of the performance of previous systems summarized earlier. The primary challenge that must be addressed as a first priority are the human and organizational aspects. Experience clearly shows that if we are able to develop the “right stuff” – High Reliability Organizations and Management, then systems (comprised of hardware, structures, operating personnel, operating and oversight organizations, procedures, cultures, and interfaces among the foregoing) that have acceptable reliability and quality characteristics will be realized. We must have the right stuff to realize the right things.

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