Understanding the Macondo Well Failures

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There is plentiful evidence to indicate the Macondo well failures developed because of a cascade of poor decisions involving poor tradeoffs made by all of the organizations with primary responsibilities for the Macondo well project. Critical things were compromised for the wrong reasons in the wrong ways at the wrong times. From the outset, the hazards, uncertainties, and risks were not properly assessed or managed. The likelihoods and consequences of the disastrous failures were dramatically underestimated. As a result, preventative preparations, emergency response, containment, and clean-up processes were woefully inadequate.

The Macondo well disasters involve a specific group of people and organizations. However, these disasters transcend this specific group of people and organizations. It involves a national and international industrial – governmental enterprise that in the last several decades has embarked on a series of extremely challenging undertakings whose risks and rewards are substantially greater than those previously undertaken. The environments of ultra-deep water combined with those of high pressure – high temperature (HPHT) reservoirs are extremely challenging and unforgiving. The complexities of the sub-sea and surface 'hardware' systems are like those of space exploration systems. There are similar complexities in the human systems involving complex interactions between industry, government, the public, and the advocates for the environment. When these complex hardware and human systems are deployed rapidly into unforgiving environments without appropriate 'safeguards' one should expect a disaster sooner or later. That is what happened during the Macondo well project.

The available evidence (e.g., well permitting documentation and regulations) clearly shows the responsibilities for the Macondo well developments reside with BP (British Petroleum) and the MMS (Minerals Management Service). As lease holder, BP is responsible for the quality and reliability of the operations. BP is responsible for the stewardship of these public resources vis-à-vis the public trust as well as the protection of the environment. As the Federal regulator and trustee of the public resources, the MMS bears primary responsibility for proper oversight of the operations of BP. The experiences since 20 April 2010 clearly show BP and the MMS failed to adequately assess and manage the risks associated with the Macondo project.

The oil and gas – energy - industry is a complex risk industry whose existence depends on properly and consistently assessing and managing risks. In the early days of offshore oil and gas developments, most of the risks were addressed in the school of hard knocks. Most of the time, there was success. Sometimes, there were failures. Learning was rapid. There were collaborative – supportive interactions between the industry owner – operators and the service industry contractors. Organizations and people really cared about what they were doing and why they were doing it.

In these early days, the government (Federal, State, local) functions associated with the industrial operations primarily focused on leasing public hydrocarbon resources and receiving leasing income and royalties. But, as the industry advanced offshore, it became apparent that stronger government regulatory functions were needed to address the increasing risks and rewards. This evolutionary

process was punctuated in 1969 by the Santa Barbara blowout and spill. The blowout developed because of flaws in the design of the well drilling and completion system. It became painfully clear that the industries abilities to stop the blowout, contain the escaping hydrocarbons, and clean-up were woefully inadequate. This experience was repeated by a blowout the following year at the Bay Marchand facilities in the Gulf of Mexico – to the west of the Macondo location. The blowout developed during well work-over operations. The experience again demonstrated that blowout control, containment, and clean-up were woefully inadequate.

In the 1970s, as the governmental regulatory processes became more engaged in industry activities, there was substantial 'push back' by industry. As would be expected, an industry that had largely functioned successfully without governmental regulatory 'interference' did not see this development as positive. A largely combative industry and government enterprise developed. Due to the significant technological work of the industry – management, operations, engineering, research – the industry was able to exert major influences on the majority of critical industry - governmental regulatory developments. This was the age of industry self-regulation.

I had my first experiences with British Petroleum (now BP) in the North Sea developments of the 1970s. At this time, British Petroleum had a world-class team of engineers and operating personnel who were backed up by a very substantial research and development enterprise.

The 1980s saw rapid growth in the operations in the Gulf of Mexico and around the world. The industry achieved remarkable records in drilling deeper wells and in drilling and production operations in deeper water and in the arctic. While the growth was rapid, it was founded on more than 100 years of surface-based onshore and offshore operations. In was during this decade that research work intensified to develop sub-sea and floating exploration and production systems. The government regulatory and research activities also rapidly developed during this decade. This was an extremely active decade that saw unprecedented collaboration between industry and the MMS, not only in the U.S., but also internationally.

It was during the mid-1980s, I had my first experiences as a contractor working for BP in their U.S. based operations with Sohio in the U.S. Beaufort Sea North Slope developments. The Sohio - BP operations mirrored some of my earlier experiences with BP in the North Sea activities. However, there was a noticeable and notable decline in the BP technical and research superiority. In addition, significant changes had developed in the industry owner/operator and service company relationships. The previous collaborative enterprise turned into much more severe and demanding enterprises. Industrial cost-cutting combined with degradation in cooperation and collaboration with service industry contractors and subcontractors became industry norms. During this time, my work focused primarily on risk assessment and management (RAM) associated with the Sohio-BP arctic exploration and production systems. Several of my colleagues and I were invited to BP headquarters in London to conduct workshops for their board of directors on the principles of RAM. In the main, these experiences with Sohio - BP were positive.

The MMS operations during the 1980s and 1990s made major positive transitions. There were good developments in the MMS as it engaged with other international governmental regulatory agencies. The MMS had a substantial and flourishing research and development program that actively collaborated with industry in joint industry-government projects. As would be expected, tensions between the MMS regulatory functions and the industrial operations functions were particularly evident at the local operating level. Many of these tensions were founded in the MMS

internal conflicts between encouraging industrial developments and constructively challenging and overseeing these developments. Frequently, the MMS was caught between 'a rock (industry) and a hard place (Federal Administration).' It was also obvious that the MMS was 'out gunned' – they did not have sufficient qualified and experienced personnel and funding to constructively challenge and oversee the industrial activities and operations. Many of the progressive developments brought forward by the MMS were rejected and defeated by the industry.

By the 1990s, the move to deepwater floating exploration and production subsea operations in the Gulf of Mexico was in full swing. The deepwater reservoirs proved to be highly productive – and expensive to develop. It was during this time that BP acquired a number of U.S. based companies, including Arco (Vastar) and Amoco, and initiated its operations as BP Americas. Before the 1990s, I had developed many highly regarded colleagues in both Arco and Amoco. Both companies had significant advanced management, engineering, operations, research, and development activities. Arco and Amoco actively participated in joint industry – government development projects. They were leaders in Gulf of Mexico exploration and development operations. The largely combative industry – government environment of the 1970s transitioned to a reasonably cooperative – collaborative environment during the 1990s.

It was during this time of mergers that significant changes became evident in the Arco and Amoco – BP operations in the U.S. The U.S. based research enterprises of Arco and Amoco diminished and finally disappeared. The other unsettling trend was one in which Amoco – Arco – BP operations, engineering, and research superiority was subjugated to management (on time, on budget) superiority. There always had been – and I think will be – tensions between these two industrial 'requirements' – quality and reliability in operations (protection) versus productivity, growth and profitability (production). Previous painful experience clearly indicated when the tensions between these frequently conflicting activities became unbalanced, then failures developed. I personally participated in several projects in the Gulf of Mexico offshore operations that produced major failures when the drives for increased production were allowed to become out of balance with the drives to achieve adequate protection. When operations and engineering could not prove something was unsafe, then it was presumed that the something was safe. Even when confronted with results from disciplined quantitative engineering risk analyses that indicated excessive risks, management chose to take those risks to increase production. This imbalance proved to be disastrous when management decision makers did not fully appreciate the risks that were being taken – they 'discounted' the risk likelihoods and consequences – and when the systems were challenged, they failed.

As I made a career transition from industry to academia in July 1988, I was brought by Occidental Petroleum to Aberdeen, Scotland as a member of an international team to investigate the failure of the Piper Alpha platform. For the next 3 years, the investigation team struggled to understand this disaster. At the end of this experience, I came to understand that for the vast majority of my career I had not understood several important aspects that caused this disaster. These aspects were chiefly focused in the human, organizational, and institutional issues that were instrumental in development of the Piper Alpha platform disaster. This experience was reinforced in 1990 when I headed a joint industry – government sponsored project to investigate the grounding of the Exxon Valdez tanker. The investigation taught many of the same lessons we learned from the failure of the Piper Alpha platform. There were some additional lessons that reinforced what I had learned earlier as a result of the Unocal Santa Barbara platform blowout and the Shell Bay Marchand platform blowouts – the means, methods, and processes to contain and clean up oil in and on the

water were very ineffective. This important part of the consequences of failures could not be effectively mitigated or managed.

The Piper Alpha and Exxon Valdez investigations launched a two decade long series of research, development, and consulting projects that addressed different kinds of failures associated with oil and gas exploration and production systems including platforms, ships, and pipelines. All of these studies were conducted as joint industry – government agency sponsored projects. The different kinds of failures included 'quiet failures' that developed during concept development, design, and construction phases – these were projects that suffered serious project 'over-runs' and frequently showed up in legal proceedings. There were also 'noisy system failures' that developed during construction, operations, and maintenance phases – these were projects that received significant media public and government agency attention. These different kinds of failures sometimes had similar sources; other times they had different sources. These different kinds of failures had very different 'signatures'. The 'quiet' failures generally were sourced in a few people and a few malfunctions of different parts of a particular system. In contrast, the noisy system failures were sourced in many people and organizations and involved a very large number of malfunctions in many parts of the particular system that generally developed over a long period of time. Examples of the noisy system failures that were studied during this time period included the Sleipner A platform sinking (failure during construction), the Texas Tower Number 4 collapse (failure during operation), and the sinking of the Petrobras P36 floating production platform.

During the 1990s, there were increasing signs that the MMS was 'suffering' because there were insufficient resources to keep pace with the industry developments. The MMS did not have enough of the 'right stuff' that could be empowered to do the right things. Changes in administrations and incentives often had notable negative effects on the agencies abilities to do what needed to be done. The gulf between the industry and the MMS widened. Many within the MMS and within industry were concerned with these increasingly negative developments.

It was during the early 2000s that Professor Karlene Roberts and I were invited by BP to come to London to work with CEO John Brown's Executive Committee and BP's U.S. Profit Center Managers (BULs – Business Unit Leaders). Our work focused primarily on 'downstream' facilities and operations (refining, pipelines). During our meetings, BP expressed concerns for three categories of factors. The first area of concern was described as 'clashes of corporate cultures.' The U.S. companies BP acquired (corporate mergers) had very different operating organizations, cultures, procedures and processes than those of BP's U.K. operations. Frequent references were made to the American 'cowboy' culture. I understood that culture because I was a product of that culture. The second category was described as 'loss of core competencies.' They were concerned that as a result of the reductions in personnel that accompanied the mergers, that they no longer had a 'sufficient stock' of experienced personnel. This situation developed as a result of 'early retirements' that were part of the 'right sizing' that accompanied the mergers. There had been dramatic losses in 'experience' in operating and engineering personnel. The research enterprises associated with the merged companies had been eliminated. Heavy reliance was placed on outside consultants and workers in service companies. I understood this concern because I had worked on both sides of the 'desk' – as owner / operator and as consultant / contractor. The third area of concern developed as a result of repeated waves of 'downsizing and outsourcing' intended to reduce costs and improve profitability. Many parts of the organization showed 'brittle tendencies' – when there were serious organizational challenges, the organization was not able to function properly. Subsequent discussions and visits to the U.S. operating facilities confirmed the seriousness of these

three areas of concern. Our work focused on methods and approaches that BP could use to develop and maintain High Reliability Organizations and High Reliability Systems (HROs - HRSs).

After this work was completed, in the mid-2000s, I was contacted by BP 'upstream' operations in Houston, Texas. In this case, the primary interest focused on ultra deepwater exploration and production operations in the Gulf of Mexico. The emphasis of our work was on prevention of blowouts (management of rapidly developing crises) and on development of comprehensive life-cycle RAM approaches and strategies. Again, our work focused on methods and approaches that BP could use to develop and maintain HROs and HRSs. It was obvious that many in BP upstream operations were very concerned about the same issues that had developed during our earlier work with the BP downstream operations.

In 2005, an international conference was held in Normandy, France to address HROs and HRSs in a wide variety of 'enterprises' including commercial aviation, nuclear power, fire fighting, health care, and oil and gas operations. BP participated in this conference. Their keynote presentation included a 'play' presented by professional actors who dramatized the principles required to develop and maintain HROs and HRSs. This play had been presented at many of BP's operating centers. A very impressive handbook was produced and distributed to BP employees. While this experience showed that BP was attempting to address this very 'serious business,' other experiences in the U.S. indicated that development and maintenance of HROs and HRSs had not become serious business – the knowledge was not translated to practice. Later that year, the explosions and fires at the Texas City refinery and the almost sinking of the Thunder Horse deepwater production platform in the Gulf of Mexico punctuated these observations. Subsequent difficulties associated with BP pipeline operations in Prudhoe Bay in March 2006 underscored that BP faced some very serious and systemic RAM challenges. While significant resources had been devoted to acquiring the knowledge about RAM, HROs, and HRS, it was painfully evident that this knowledge had not reached the frontlines of BP's operations.

I have asked myself many times: why was there this "failure to learn?" Professor Andrew Hopkins explains this failure as follows: "We shall find that BP's inability to learn is attributable to the structure and functioning of the corporation as a whole." I think Professor Hopkins's explanation is true. But, I think there is more to understand. I start development of this understanding by contending that the structure and functioning of BP is not decidedly different from many other major operators in the Gulf of Mexico. However, there are major differences in how the structure and functioning works and what the workings are intended to achieve. BP's expressions of concerns we heard and saw in the early to mid 2000s are parts of this understanding: corporate cultures, loss of core competencies, results of repeated downsizing and outsourcing, drives for production, growth, and profitability without commensurate growth in protections. Progressive degradations in the regulatory functions, processes, regulations, oversight, and industrial collaborations allowed these 'maladies' to accumulate in BP. Particularly damaging were the poor relationships between BP and its service industry contractors and sub-contractors. Internal BP organizational 'unrest' and turmoil were evident.

At this same time, BP was publicly rewarded for its unprecedented growth, profitability, productivity and accomplishments of its operations. As we found in our earlier studies of system failures, it was apparent BP was rewarding "A" (production and profitability) and hoping for "B" (protection against system failures). BP was rightly proud of the 'safety' record it had achieved. This record was focused on 'worker safety' – prevention of lost time accidents and fatal accidents.

However, it is clear that 'system safety' (prevention and mitigation major system failures) was another matter.

The Macondo well disaster is firmly rooted in a history that goes back at least three decades. The Macondo well disaster followed a well established roadmap of previous system disasters. These system disasters involved a multiplicity of breakdowns that developed over a long period of time. Those at the 'pointed end of the spear of disaster' played their sad roles in the causation of the Macondo well blowout – a cascade of bad decisions, actions, and inactions. Those along the 'shaft of the spear of disaster' had important influences on what happened at the pointed end of the spear. They supplied the power for this disaster. The MMS and BP led organizations, policies, and practices provided the incentives, means, and measures that facilitated what happened at the pointed end of the spear onboard the Deepwater Horizon. The multiple failures that followed the blowout (control, containment, cleanup) have similar sources. The natural hazards associated with this environment (deep open ocean, high temperature-pressure-gas/oil ratio reservoirs, toxic and explosive fluids and gases) combined with human malfunctions (hubris, arrogance, greed, ignorance, indolence) formed the 'perfect storm' of the Macondo well disaster. We failed to manage, and we were managed.