US Liftboat Trinity II
Engineering Design, Risk Assessment and Ethics

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Abstract: *On Thursday, September 8, 2011 the US Liftboat, Trinity II, experienced damage to the stern jacking leg from heavy weather associated with Hurricane Nate. Listing badly, the crew decided their best course of action was to abandon ship. A detailed review of the Trinity II's history revealed that it was previously owned by an engineering company providing offshore risk and hazard assessment services. This same company sold the Trinity II "as is" despite numerous design deficiencies. These design deficiencies were known in engineering circles.* ***This paper discusses the Trinity II's deficiencies and the ethical duties of a registered engineering company to correct deficiencies and to inform unaware future owners*** *of deficiencies in a highly complex engineered structure such as a liftboat.*

Photo of the adrift *Trinity II*, taken while Mexican Navy personnel boarded the vessel.

INTRODUCTION

On Thursday, September 8, 2011 at about 12:00CDT the US Liftboat, *Trinity II,* experienced damage to the stern jacking leg from heavy weather associated with Hurricane Nate. The Trinity II had three jacking legs, one at the stern and two at the bow, one on each side, SEE Figure 1 below:

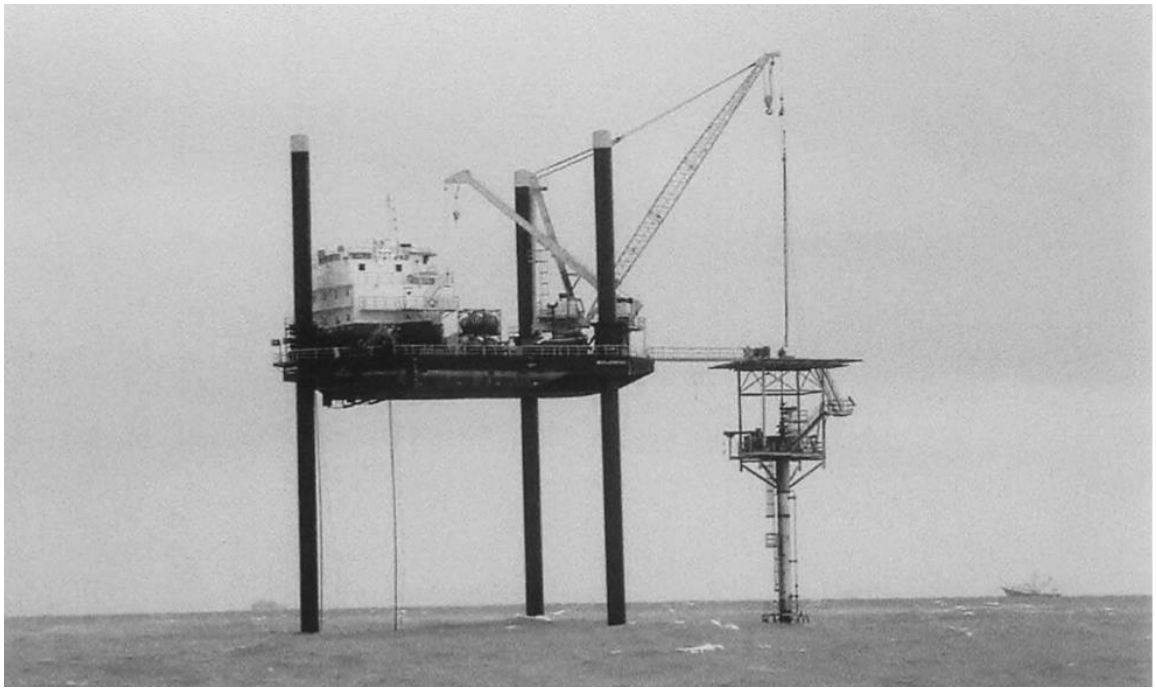

Figure 1. File photograph, provided by Company C, showing the Trinity II jacked up during operations.[1]

Listing badly, the crew decided their best course of action was to abandon ship. A detailed review of the Trinity II's history revealed that it was previously owned by an engineering company that sold it to Company C "as is" despite numerous design deficiencies. This paper discusses the Trinity II's deficiencies and the duties of a registered engineering company to correct these deficiencies and to inform unaware future owners.

[1] NTSB Accident Report,, NTSB/MAR-13/01, P132013-106633, Personnel Abandonment of Weather-Damaged US Liftboat *Trinity II,* with Loss of Life Bay of Campeche, Gulf of Mexico, September 8, September 8, 2011.

BACKGROUND

In February 2011, the 78.5-foot-long US Liftboat Trinity II was chartered by Geokinetics, Inc. ("Geokinetics"), a geophysical services company headquartered in Houston, Texas, from Company C, of New Iberia, Louisiana. Geokinetics had chartered the Trinity II, along with several other vessels, to seismically explore petroleum reserves in the Bay of Campeche in the southern Gulf of Mexico as shown in Figure 2 below. Petroleos Mexicanos (PEMEX), Mexico's state-owned petroleum company, had contracted Geokinetics to conduct the seismic work.[2]

Figure 2. Satellite image by the National Aeronautics and Space Administration (NASA) Showing the Bay of Campeche and location of the Trinity II.

[2] NTSB Accident Report,, NTSB/MAR-13/01, P132013-106633, Personnel Abandonment of Weather-Damaged US Liftboat *Trinity II*, with Loss of Life Bay of Campeche, Gulf of Mexico, September 8, September 8, 2011.

Later that year on Sunday evening, September 4, 2011, the crew received a weather report forecasting the possibility of a surface low pressure system forming nearby. The winds and seas increased on Monday, September 5. On Tuesday morning, September 6, the National Hurricane Center (NHC) reported a 20 percent probability that the surface low pressure system, which was stationary and centered north-northeast of the *Trinity II*, would strengthen. Weather reports that evening predicted 3 to 6 foot seas by Wednesday morning (actual wave height at *Trinity II's* location were already at or above 5 feet, Trinity II's sea state limit). The crew jacked up the *Trinity II* three times to stay clear of the waves that evening.

The next day, Wednesday, September 7, forecasts indicated a 70 percent chance of further system development and 8 to 10 foot seas, indicating the crew would not be able to jack down and move the vessel for another couple of days. Geokinetics also stopped operations because of the weather. At this stage, the personnel's intent was still to ride out the storm on board the liftboat.

On Wednesday afternoon, the weather system with 50 mph winds was now a tropical storm, named "Nate." The rough seas were hitting the *Trinity II's* jacking legs. The legs, which had penetrated approximately 10 feet into the seafloor before the onset of the storm, began to sink deeper.

On Wednesday evening, the wind and seas increased further, and the radio controller at Geokinetics in Frontera asked the watchstanders of the three remaining vessels that had not returned to port (including the *Trinity II)* to check in every 15-20 minutes. The master told investigators that, at about this point, he concluded that it was necessary to consider evacuating the *Trinity II* personnel, and he related this need to Geokinetics in Frontera. The master of the *Mermaid Vigilance,* which was the intended standby vessel and a few miles away at that point,

replied that he would try to turn his vessel around to head to the *Trinity II*, but that the rough waves made it difficult to do so.

Later Wednesday night, the master of the standby vessel, *Mermaid Vigilance*, reported that he would not be able to assist the *Trinity II* due to the sea state and storm related damage. During the night into Thursday, September 8, the *Trinity II* master gathered together the crew and the contractors to review emergency procedures.

On Thursday, September 8, 2011 at about 12:00CDT, the *Trinity II* experienced damage to the stern jacking leg from heavy weather associated with Hurricane Nate. A satellite image of Hurricane Nate, September 9, 2011, is shown in Figure 3 below:

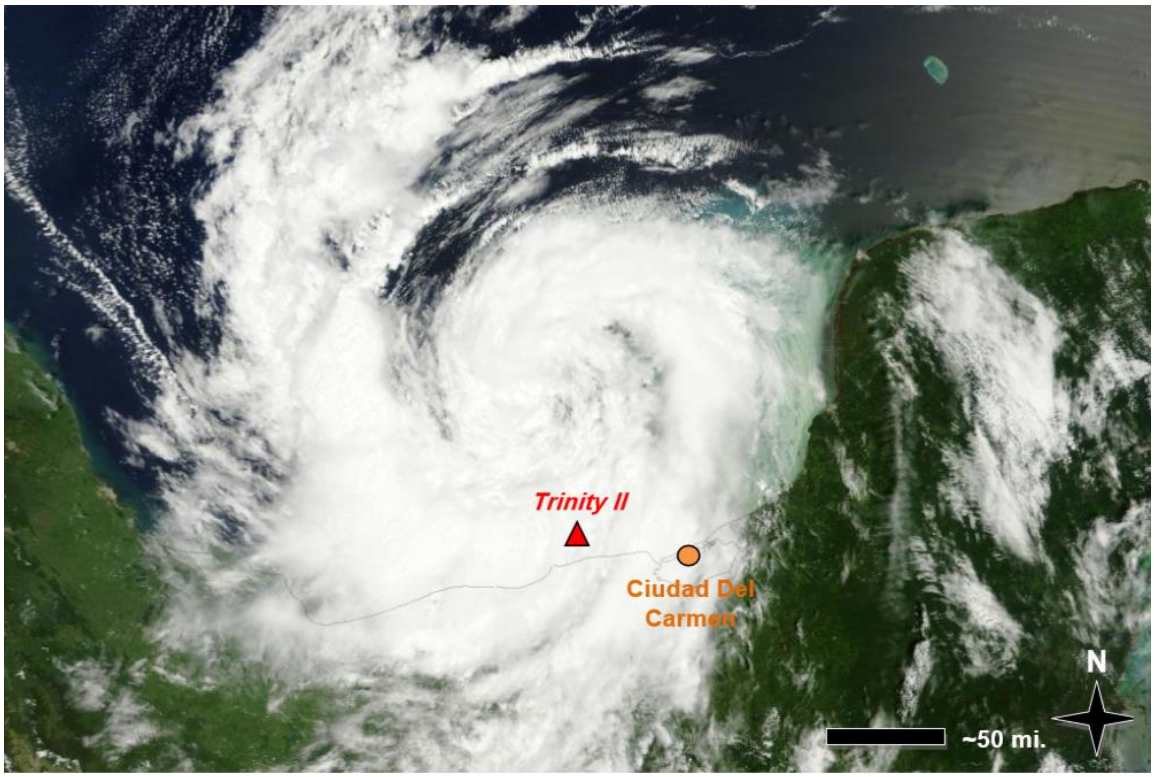

Figure 3. Satellite image by the National Aeronautics and Space Administration (NASA), Tropical Storm Nate over the Bay of Campeche, September 9, 2011.

Trinity II was carrying 10 crew members and contractors while operating in the southern part of the Bay of Campeche, 15 nautical miles north of Frontera, Mexico. The stern leg hydraulic

pressure reached a maximum of 6000 psi and bound up. The vessel couldn't jack up any higher and had about a 20-foot air gap. The vessel took a series of waves, the last which caused the stern leg to fail. Fearing the Trinity II would flip over and the 10 crew members would perish, the Master ordered the crew to abandon ship when seas began to crash across the deck. Both liferafts were lost to winds. The crew entered the water in lifejackets and clung to a 12-person lifefloat where they were exposed to elements for 3 days before being rescued. Four of the crew perished and six survived the accident with serious injuries.

PRIOR OWNERSHIP

Reports and studies performed before the Trinity II was sold by Company B to Company C, indicated that the legs of liftboats like the Trinity II should have been significantly strengthened. As a liftboat fleet operator and registered engineering company in the State of Texas, Company B should have been aware of these reports and should have performed standard risk assessments that would have indicated the same upgrades were necessary.

Standard risk assessments would have also revealed that the evacuation equipment on the Trinity II was inadequate and the evacuation plan in the Operations Manual provided by Company B to Company C was inadequate.

Further, as a registered engineering company, the Texas engineering code of ethics mandates that Company B inform Company C of these deficiencies. Company B failed to make the necessary structural and evacuation equipment upgrades, as well as inform Company C of these deficiencies. Instead they sold the Trinity II “as is.”

TIMELINE

To assist in understanding the contributing design and ethics causes of the incident, a timeline of the Trinity II's history was assembled from the NTSB report, crew statements and court records. The timeline is given below:

1982 Subject Vessel built by Blue Streak Industries.
1982 Blue Streak Industries sells Subject Vessel to Three Cross Venture.
1990 (Feb) W.P. Stewart Ref 1: Liftboat Leg Strength Structural Analysis, Interim Report.
1990 (Apr) W.P. Stewart Ref 2: Liftboat Leg Strength Structural Analysis, Variation of K-Factors and Variation of Leg Diameter/Wall Thickness.
1991 **(Jul) W.P. Stewart's Final Report: Liftboat Leg Strength Structural Analysis,** *cites 46 major casualties identified, out of an estimated fleet of 250 liftboats from 1980-1987, a casualty rate of 18% (30% of total casualties caused by leg failure).*[3]
1995 Company A purchases the Subject Vessel.
1999 Company B merges with Company A, the largest owner and operator of liftboats in the region.[4]
2009 (Nov 24th) Company C purchases the Subject Vessel from Company B.[5]
2011 (Sept 8th) Accident (stern jacking leg failed on Subject Vessel and the crew abandons ship).

ENGINEERING ETHICS

The NTSB report blames the incident on a lack of planning by the operators and improper use of the available lifesaving equipment. The report failed to address the deficiency of the Trinity II's design and operating procedures (integral to the design), as well as the ethical obligations of those who were aware of those deficiencies.[6] It is widely known and understood across the broad field of engineering that engineers are expected to protect the health, safety and welfare of the

[3] W.P. Stewart, P.E., Liftboat Leg Strength Structural Analysis, Final Report July 1991.
[4] Company B's company history found on Company B's website (Accessed Aug 20, 2015).
[5] Decl of Company B's employee, Exh B: Bill of Sale
[6] NTSB Accident Report, NTSB/MAR-13/01, P132013-106633, Personnel Abandonment of Weather-Damaged US Liftboat *Trinity II*, with Loss of Life Bay of Campeche, Gulf of Mexico, September 8, September 8, 2011.

public in the practice of their profession. While details of ethical codes vary, protecting the public (including workers) is the paramount principle agreed upon by state engineering boards, professional engineering committees, and is a standard of practice in the engineering industry.[7,8,9]

Company B, one of the prior owners of the Trinity II, was licensed by the Texas Board of Professional Engineers as a firm fulfilling the requirements to offer and perform engineering services in the State of Texas on August 21, 2009. The term of this license would have extended through the time Company B sold the Subject Vessel to Company C.[10,11] As a licensee, Company B agreed to abide by the act and rules of the Texas Board of Professional Engineers.[12]

Engineering ethics extend beyond the scope of protecting the public. The code of ethics for the National Society of Professional Engineers states:

> *"The services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct."*

Rules of practice include "If engineers' judgement is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate." Texas Laws and Rules go further by stating:

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[7] The State of Texas, Texas Engineering Practice Act and Rules Concerning the Practice of Engineering and Professional Engineering Licensure.
[8] Louisiana Revised Statutes, Title 46 – Professional and Occupational Standards, Part LXI. Professional Engineers and Land Surveyors.
[9] Engineering Ethics – Concepts, Viewpoints, Cases and Codes, 2nd Edition, 2008.
[10] Company B's website with license posted from Texas Board of Professional Engineers.
[11] *According to the Texas Board of Professional Engineers, Company B was licensed on August 21, 2009. The firm's license became inactive in June 2015 as their designated licensed engineer no longer lists Company B as his primary employer.*
[12] The State of Texas, Texas Engineering Practice Act and Rules Concerning the Practice of Engineering and Professional Engineering Licensure.

"Engineers should strive to make affected parties aware of the engineers' professional concerns regarding particular actions or projects, and of the consequences of engineering decisions or judgements that are overruled or disregarded."

During its ownership of the Subject Vessel, Company B was a significant player in the field of liftboats. In 1995 Company B purchased Company A, the owner of the Subject Vessel and the "largest owner and operator of liftboats in the region."[13] Company A, as a leader in the liftboat industry, and Company B, a multi-billion dollar company, was aware or should have been aware of W.P. Stewart's Report issued to the US Coast Guard in 1991 that demonstrated the deficiencies and dangers associated with older liftboat designs and which also set a standard for the specification for the design and build of new liftboats.[14]

Company B's document states:

"(Company B) is a registered engineering company that provides technical solutions for all types of offshore and marine applications including emergency and non-emergency support services."[15]

A registered engineering company offering the breadth and depth of services in the highly technical field of offshore and marine applications has the duty of understanding the risk, rules and regulations that apply to its services and products including the products that it sells as a "fleet operator."[16]

During the sale of the Subject Vessel, Company B failed to notify the buyer, Company C, that the Subject Vessel was inadequately designed and posed an unreasonable risk of harm when

[13] About/history found on Company B's website (Accessed Aug 20, 2015)
[14] Liftboat Leg Strength Structural Analysis, by W.P. Stewart, Stewart Technology Associates, for the U.S. Coast Guard, Report No. CG-D-05-91, July 1991.
[15] Company B's "At-a-glance" found on Company B's website.
[16] Deposition of Jeremy Parfait, June 1, 2015, Attorney for defendant Company B refers to Company B's liftboats as a "fleet," page/lines 17:21 and 182:19 for example.

used for its intended purposes. Company C did not have engineers on staff and its crew were unaware of design flaws associated with the liftboat.

In addition to breaking professional codes of conduct, Company B failed to live up to its own company standards. Company B's Marine Division Policy in the Subject Vessel's Marine Operation manual states:

> *"(Company B's Marine Division) Safety & Environment Policy mandates that all marine activities be conducted in such a manner that the safety, health and wellbeing of employees, subcontractors, customers, and other persons on the worksite is given first priority…"*[17]

Furthermore, Company B's failure to maintain its status as a licensed firm indicates its continued negligence in complying with state codes by continuing to offer engineering services without being registered as a professional engineering company by the state of Texas or Louisiana. (Company B is a Louisiana LLC with a principal office located in Houston, Texas.)[18]

RISK ASSESSMENT / HAZARD ANALYSIS

Company A/Company B failed to conduct appropriate risk assessment or hazard analysis on the Subject Vessel over the 14-year period that it owned the vessel. Performing a risk assessment of offshore engineered vessels and structures had been a routine part of the engineering standard of care by the time Company B sold the subject liftboat, based on the author's experience and engineering literature.[19] The process of risk assessment has always been a straightforward

[17] Company B's Marine Operations Manual, 22 September 2005.
[18] *According to the Texas Board of Professional Engineers, Company B was licensed on August 21, 2009. The firm's license became inactive in June 2015 as their designated licensed engineer no longer lists Superior as his primary employer.*
[19] Risk Management: With Applications from the Offshore Petroleum Industry (Springer Series in Reliability Engineering), by Terje Aven and Jan-Erik Vinnem, 2007.

task of evaluating and mitigating risk as described in the flow diagram from International Standard 17776:[20]

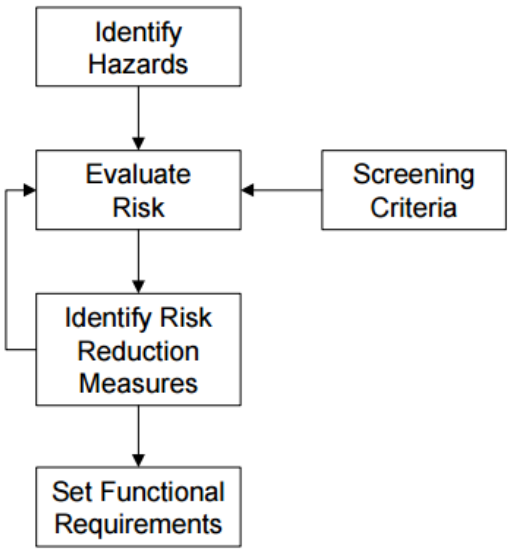

Figure 4. Risk and hazard assessment flow diagram from International Standard 17776.[21]

Design and risk assessment methods are typically in common use a decade or more before appearing in textbooks and regulations to encourage those lagging behind to perform proper assessments. In 2006, the American Petroleum Institute issued recommended practice 95J, "Gulf of Mexico Jackup Operations for Hurricane Season"[22] where it recommended the development and maintenance of an Emergency Evacuation Plan (EEP). In 2008, the American Petroleum Institute issued an addendum on risk assessment to its recommended practice API-RP-2SK, "Design and Analysis of Stationkeeping Systems for Floating Structures." This recommended

[20] International Standard 17776: 2000, Petroleum and natural gas industries -- Offshore production installations -- Guidelines on tools and techniques for hazard identification and risk assessment.
[21] International Standard 17776: 2000, Petroleum and natural gas industries -- Offshore production installations -- Guidelines on tools and techniques for hazard identification and risk assessment.
[22] API Recommended Practice 95J, First Edition, Gulf of Mexico Jackup Operations for Hurricane Season, June 2006.

practice, like the International Standard 17776, provided guidance to perform a straightforward risk analysis and subsequent mitigation of risk.

According to Company B's website in 2009, such assessments were expected as part of its commitment to quality (emphasis added):

> *"(Company B) is committed to quality in all parts of its business. Our corporate expectations require management to ensure mechanical and operational integrity through the development of preventive maintenance programs, mechanical integrity procedures, employee training and tracking systems to ensure completion of action items from risk assessments, hazard analyses and audits."*[23]

The liftboat study performed by Stewart for the U.S. Coast Guard,[24] noted numerous cases of leg failures in storm conditions and concludes the thickness and yield strength for liftboats should be greater. A competent risk assessment of the Trinity II would have resulted in replacing the Trinity II legs with legs having a greater thickness and strength. This did not happen, nor did Company B inform Company C of these studies.

Two additional significant hazards are identified in Company B's operations manual[25] provided to Company C and appear in the Liftboat study performed by Stewart for the U.S. Coast Guard.[26] The two significant risks identified are:

i) The lift boat cannot jack back down if wave heights are greater than 6 ft. Thus, if storm predictions indicating the crew can ride out a storm turn out to be

[23] http://web.archive.org/web/20081220145936/ - Company B's "About" (Accessed 08/20/2015)
[24] Liftboat Leg Strength Structural Analysis, by W.P. Stewart, Stewart Technology Associates, for the U.S. Coast Guard, Report No. CG-D-05-91, July 1991, and cited references. OTC 6611 Observed Storm Stability of Jackup Boats (Liftboats) W.P. Stewart, Stewart Technology Assocs.; V.G. Rapoport, Marine Soil Consultants; and M. Oser, Otis Engineering Corp. 1991.
[25] Company B's Marine Operations Manual, 22 September 2005.
[26] Liftboat Leg Strength Structural Analysis, by W.P. Stewart, Stewart Technology Associates, for the U.S. Coast Guard, Report No. CG-D-05-91, July 1991, and cited references.

significantly incorrect (on the low side for wind and wave height), the crew can end up in the situation where they must abandon ship as rescuers are reluctant to act.[27]

ii) Evacuation by Life Raft is likely to be difficult as noted in section 7.9.2 Evacuation by Lift Raft, where it is stated (emphasis added):[28]

> (d) Launch and board the life rafts if possible
>
> (e) Jumping into the water is a last resort option. For additional information, see ¶*11.6.5 Water Entry Survival.*

Had a rudimentary risk assessment or hazard analysis, been performed, the hazards identified as deficiencies resulting in the Subject accident would have been identified and corrected. The operational trap - attempting to ride out a storm with predicted wind speeds and wave heights below the liftboat's rating, and then experiencing wind speeds and wave heights greater than the rating – would have been more explicitly described in the operations manual. Further, given this operational trap, the life rafts should have been replaced by enclosed capsule style lifeboats or Total Enclosed Motor Propelled Survival Craft (TEMPSC) with location transponders pre-installed. Exemplar capsule style lifeboats have been available for decades and exhibits on Survival Systems International's website since 2009.[29]

[27] Liftboat Leg Strength Structural Analysis, by W.P. Stewart, Stewart Technology Associates, for the U.S. Coast Guard, Report No. CG-D-05-91, July 1991, pg vi and 3.
[28] Company B's Marine Operations Manual, 22 September 2005, pg 7-13.
[29] https://web.archive.org/web/20090714232538/.

Figure 5. Capsule style lifeboats exhibited on Survival Systems International's website since 2009.[30]

The evacuation plan should also have prescribed the setting up of guide/safety lines from the liftboat main cabin to the TEMPSC's as a storm worsens.

Evaluation and continually improving of evacuation and evacuation methods should be part of any offshore risk assessment. Weather is the main problem associated with operation in the Gulf of Mexico; particularly widely varying conditions and difficulty in estimating and characterizing storms.[31] Unfortunately, Company B failed to perform this task. In his declaration, Operations Manager for Company B from approximately 1995 to 2012 stated that the operations

[30] https://web.archive.org/web/20090714232538/.
http://www.survivalsystemsinternational.com/prod_capsules_21.html.
[31] Evacuation of Offshore Platforms Due to Severe Weather Conditions, Report to U.S Minerals Management Service Offshore Technology & Research Branch, Herndon, Virginia, by Jay Christman and R.G. Bea, Department of Naval Architecture and Offshore Engineering University of California, Berkeley, December 1994.

manual: "...would have been present on the bridge of the Liftboat when Company B sold the Liftboat to Company C in 2009. Company B could not and did not change any of the conditions or parameters for the Lifeboat while it owned the vessel."[32] The idea that Company B could not perform a standard risk assessment and update the liftboats equipment and procedures is absurd. Coast Guard and MMS requirement are minimums, not maximum requirements. Operation manual excerpts regarding evacuation such as "Launch and board the life rafts if possible" clearly show a disregard for safety and human life that is contrary to the ethics of engineering.

CONCLUSIONS

At a minimum, these risks should have been explicitly transmitted to a buyer and new owner. A liftboat is a complex, highly engineered structural vessel. Known risks should be explicitly disclosed, as required by engineering ethics cited by numerous states and engineering organizations, regardless of the engineering knowledge of the new user to minimize the possibility of injuries and fatalities to future crew members.

[32] Declaration Company B's Operations Manager, dated 2-14-2014.