U.S. Department
of Transportation
United States
Coast Guard

MARINE CASUALTY REPORT

Capsizing and Sinking
Of The
MOBILE OFFSHORE DRILLING UNIT
ROWAN GORILLA I
In The North Atlantic Ocean
On
15 December 1988

U.S COAST GUARD

MARINE BOARD OF INVESTIGATION REPORT

AND

COMMANDANT'S ACTION

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16. Abstract

This report examines the circumstances surrounding the capsizing and sinking of the Mobile Offshore Drilling Unit (MODU) ROWAN GORILLA I in the North Atlantic ocean on 15 December 1988. Although there were no deaths or injuries to personnel, the MODU was a total loss.

The Commandant concurred with the Board of Investigation's determination that the primary cause of the capsizing/sinking was uncontrolled downflooding into an unknown number of compartments of the vessel, resulting in the loss of positive buoyancy.

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CAPSIZING AND SINKING
OF THE MOBILE OFFSHORE DRILLING UNIT
ROWAN GORILLA I IN THE
NORTH ATLANTIC OCEAN, ON 15 DECEMBER 1988

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16732

MAY 18 1992

Commandant's Action

on

The Marine Board of Investigation convened to investigate the circumstances surrounding the capsizing and sinking of the Mobile Offshore Drilling Unit (MODU) ROWAN GORILLA I in the North Atlantic Ocean on 15 December 1988 with no loss of life or personal injuries

The report of the Marine Board of Investigation convened to investigate the subject casualty has been reviewed and the record, including the findings of fact, conclusions and recommendations, is approved subject to the following comments.

CAUSE OF THE CASUALTY

I concur with the Board's conclusion that the apparent cause of the casualty was uncontrolled downflooding into an unknown number of compartments of the vessel, resulting in the loss of positive buoyancy. Contributing causes include the suspected flooding of preload tanks 14 and 15 and the port thruster room from through-hull fractures, and damage to tank vents, hatches and other through-deck fittings caused by equipment and deck cargo broken loose by boarding seas.

COMMENTS ON CONCLUSIONS

Conclusion 4: The through hull fractures that occurred in way of the after preload tanks and thruster rooms during both open ocean transits of the ROWAN GORILLA I in December 1983 and 1988 indicate that the current U.S. Coast Guard and American Bureau of Shipping (ABS) structural standards may not be adequate for self-elevating MODUs while in the afloat condition. The current regulations do not address requirements for designers to consider the effects of stresses that may be imparted on the hull of a jack-up by the oscillations of the legs caused by the dynamic motions of the unit.

Comment: I partially concur with this conclusion. I do not agree that the present ABS standards are inadequate for self-elevating MODU's while in the afloat condition. Section 3.9.1 of the present ABS rules states in part that "...Sufficient conditions representative of all modes of operation are to be considered to determine critical cases..." Section 3.9.9 indicates that "...The type and extent of the fatigue analysis will be dependent on the intended mode and areas of operation to be considered in the unit's design." In the case of the ROWAN GORILLA I, this would have included towing in environmental conditions representative of the North Atlantic Ocean in the winter.

Existing Coast Guard standards for MODU's (46 CFR 108.113), however, are somewhat outdated because they are based upon 1978 ABS MODU standards. These differ in some areas from present ABS standards. Due to changing priorities within the Coast Guard as a result of the 1990 Oil Pollution Act the project entitled "Adoption of the 1989 Revision of the International Maritime Organization's (IMO's) MODU Code, as the Basis for Major Revision of Title 46, CFR, Subchapter I-A, MODU Regulations," (CGD 83-071a) was withdrawn from the docket. The Coast Guard intends to redocket this project which will update Subchapter I-A regulations by bringing them into conformity with the recently revised IMO MODU Code. At that time, 46 CFR 108.113 will also be revised to reflect the latest ABS structural standards.

Conclusion 5: Although it is recognized that while the largest percentage of a jack-up's service life is spent in the elevated condition, the designer's contention that the greatest stress on the legs and hull of a unit occurs while in the elevated condition may be incorrect. This is supported by the fact that there are no known records or evidence of any stress related fractures occurring to the ROWAN GORILLA I while in the elevated condition. The Marathon Letourneau Vice-President made this determination about leg/hull stress while designing the unit.

Comment: I partially concur with this conclusion. The critical mode of structural failure is dependent on many factors and may vary from one design to another. It is possible that the elevated condition does result in the greatest leg and hull stresses for this design under the assumed environmental conditions. The cracks that were first discovered during the unit's maiden ocean transit in 1983 might well have propagated from preexisting discontinuities in the steel or weldment. Similarly, the cracks that were detected before this casualty may have propagated from fatigue cracking or stress-corrosion cracking that initiated while in the elevated mode. Such damage could occur even at relatively low stress levels. Most of the fatigue life of a structure is during the crack initiation phase. As a fatigue crack grows during the crack propagation phase, increasingly lower stress levels are needed to sustain crack propagation. This is consistent with Marathon Letourneau's

determination that the greatest stresses for this unit occur in the elevated mode, and that the cracks grew from undetectable size to over a foot in length during the course of the towing operation.

Conclusion 6: There is evidence that indicates the current U.S. Coast Guard stability standards may not be adequate for jack-up MODUs while in the afloat condition. The 70 and 100 knot wind intact stability criteria is applied to a unit in static condition. The criteria does not take into account the combined dynamic effects of winds and waves, as they naturally occur, upon the stability of the vessel. Compliance with the intact stability criteria often results in a particularly stiff vessel that does not have natural motions which are compatible with prevailing sea states. As such, the response of the ROWAN GORILLA I to the heavy seas encountered caused significant green water on deck.

Comment: I do not concur with this conclusion. Nothing in the findings of fact indicates that the unit had an intact stability problem. Only when the unit began flooding was it in danger of capsizing. While the intact stability criteria is applied to the unit in a static condition, the 40% required margin of energy in the righting moment curve is intended to account for the dynamics of the unit caused by the sea state. This criteria has been an internationally agreed upon standard since 1979. There have been no casualties involving MODUs designed to this standard directly attributable to inadequate intact stability. As analysis techniques become more advanced, it may be possible to refine the criteria to better account for the relative motions between the wave surface and the unit. Until that time, the existing stability criteria provides an acceptable margin of safety.

Conclusion 9: The bilge/eductor system may not have been capable of handling the extent of flooding of the internal compartments. The system's limited capacity and intended service for (removing) small amounts of water from internal spaces apparently was inadequate to dewater and control the progressive flooding.

Comment: I concur with this conclusion. 46 CFR 56.50-50 states that the "bilge pumping system shall be capable of operation under all practicable conditions after a casualty whether the ship is upright or listed." The vessel is designed to survive both intact and damage stability conditions in meeting the stability criteria. However, the bilge system is not designed to remove water in large volumes as may occur in a casualty, but rather is intended to remove comparatively small amounts resulting from sources such as packing gland seepage, sweating, machinery fluid leakage, etc. Removal of these fluids enhances stability by minimizing free surface in the bilges. The bilge system can, however, serve to pump spaces after the ingress of water is stopped following a casualty.

Conclusion 41: Although the legs were in the storm position with tip of the can 25' below the hull, the combined effects of the winds and seas resulted in causing dynamic motions that exceeded the limits of the leg design.

Comment: I do not concur with this conclusion. There is no evidence indicating a failure of any of the legs of the ROWAN GORILLA I. The facts indicate that portions of the supporting hull structure failed. From the facts presented, it cannot be determined if the supporting hull structure failed (i.e., cracks initiated) as a result of dynamic motion of the legs while in the afloat mode. It is possible that cracks undetectable by visual examination existed prior to the ocean tow and were propagated by stresses within the design limits of the structure.

Conclusion 42: The fractures that occurred to the stern area of the ROWAN GORILLA I during the 1983 and 1988 tows appear to be related to an existing design problem. The design of the supporting leg structure did not adequately account for the transmission of stress due to the oscillating motion of the legs in the afloat mode. The actual design was based on the assumption that the greatest stress on the leg supporting structure was experienced in the elevated mode.

Comment: I partially concur with this conclusion. The cracks occurred in a location that would typically experience high levels of stress during severe environmental conditions in either the afloat or elevated mode. Further detailed design analysis of these areas is necessary to determine the critical mode of a failure and the location of stress concentrations where cracks are likely to initiate. This will be brought to the attention of the owners and ABS.

Conclusion 45: ...The U.S. Coast Guard's proposed MODU licensing and manning regulations require that an individual who is well versed in marine skills related to moving a MODU, and, who has satisfactorily demonstrated these skills, will be aboard as Offshore Installation Manager, i.e., person-in-charge during this evolution. This person need not be a specialist and could be a regular crew member, provided the individual has satisfied the minimum requirements.

Comments: I concur with this conclusion. 46 CFR 15.520 became effective on 1 January 1991. This regulation requires that a MODU underway, other than a drill ship or self-propelled MODU, be under the command of an individual licensed as Offshore Installation Manager endorsed for service specifically on that type MODU.

ACTION ON RECOMMENDATIONS

Recommendation 1: It is recommended that the Coast Guard and all classification societies reevaluate their current standards for strength of self-elevating MODUs while afloat. The sinkings of the ROWAN GORILLA I, DAN PRINCE, and KEY BISCAYNE all occurred in storm conditions less severe than what they were theoretically designed to withstand while afloat. The safety margins afforded by the statically applied empirical formulas are apparently not effective to ensure the seaworthiness of these vessels.

Action: I partially concur with the recommendation. Although the three units mentioned were in less severe storm conditions than what they were theoretically designed to withstand, none of the casualties was caused by a catastrophic structural failure or by loss of stability while the unit remained intact. The primary cause of all three casualties was progressive flooding of below deck spaces due to downflooding through damaged deck closures.

I do agree that the Coast Guard standards for MODU's need reevaluation. As mentioned in my comments on conclusion 4, this will be accomplished through a regulatory project to update the MODU regulations in 46 CFR 108.

Recommendation 2: It is recommended that the Coast Guard, ABS, and MODU designers combine to form a study on these issues, similar to the one that evaluated stability of semi-submersible MODUs after the loss of the Ocean Ranger.

Action: I concur with the intent of this recommendation. The Coast Guard is represented on the ABS Special Committee on Mobile Offshore Drilling Units, which is responsible for initiating modifications to the ABS Rules for Building and Classing MODUs. Both the ABS and the Coast Guard continually work to improve the design criteria in these rules. The Coast Guard will bring these recommendations to the attention of the Committee for consideration.

Recommendation 3: It is recommended that in the interim, owners and operators of jack-ups voluntarily limit the amount of cargo that is carried on deck during ocean tows, and advise towing companies that jack-ups should be towed in a manner to limit the amount of green water on deck and lessen the wave loading on the hull structure and minimize the afloat motions of the unit.

Action: I concur with the intent of this recommendation. The Coast Guard provided the findings of this casualty investigation to the Towing Safety Advisory Committee (TSAC), the National Offshore Safety Advisory Committee (NOSAC), and the International Association of Drilling Contractors (IADC) and recommended that they jointly develop guidelines for ocean tows of MODU's for the

use of all major tow operators, rig owners and contractors. A guideline booklet addressing securing arrangements of cargo carried on deck was accepted by NOSAC and distributed in Navigation and Vessel Inspection Circular 11-91 on 16 July 1991.

This casualty, like the DAN PRINCE, and the KEY BISCAYNE, has shown that there is a common cause associated with these casualties and points to a need to continue to develop these guidelines for the safe towing of jack-up units. USCG, NOSAC, TSAC and IADC should jointly further develop these guidelines to address the minimum number and power of tugs needed to maintain control of the unit under adverse environmental conditions and the manner in which MODUS should be towed to limit the amount of green water on deck and lessen the wave loading on the hull structure.

Recommendation 4: It is recommended that the Coast Guard require secondary means of gauging the condition of all tanks, voids, and spaces on all jack-up units where only sounding tubes allowing access through the exposed deck are currently fitted.

Action: I do not concur with this recommendation. I do not consider a requirement for a secondary means of gauging the condition of all spaces necessary. An acceptable standard for tank gauging and detection of water in spaces is the 1989 Code for the Construction and Equipment of Mobile Offshore Drilling Units (IMO MODU Code). Section 4.8.1 (Bilge pumping arrangements) states in part that..."Means should be provided to detect the presence of water in such compartments which are adjacent to the sea or adjacent to tanks containing liquids and in void compartments which through which pipes conveying liquids pass." Voids and other spaces not adjacent to the sea or that have little likelihood of becoming flooded, such as internal voids, need not be fitted with gauging or other detection devices.

Recommendation 8: It is recommended that the Coast Guard require the immediate retrofit of external canopy lights on all existing lifesaving capsules not so equipped.

Action: I concur with this recommendation. We will consider requiring the retrofit of canopy lights on existing lifeboats in drafting our NPRM entitled "Subchapter W, Lifesaving Equipment for Large Inspected Vessels, including MODU's and Offshore Supply Vessels," CGD84-069.

Recommendation 9: It is recommended that the Coast Guard revise the lifesaving capsule capacity standards to account for the additional space requirements for persons wearing exposure suits.

Action: I concur with the intent of this recommendation. Coast Guard approval of lifeboats is based on international standards under the 1983 SOLAS Amendments and IMO Resolution A.521. Therefore, the Coast Guard, as the U.S. representative to IMO, will propose that the IMO Lifesaving, Search and Rescue Subcommittee make appropriate amendments to SOLAS.

Recommendation 10: That owners and operators of jack-ups voluntarily limit the number of persons exposed to the potential dangers of an open ocean tow by reducing the number of riding personnel to the minimum number required to maintain the units while under ocean tow.

Action: I concur with this recommendation. Dissemination of this report through TSAC, NOSAC and IADC, as discussed in my comments on recommendation 3, will effectively bring this recommendation to the attention of owners and operators.

Recommendation 11: It is recommended that the Coast Guard consider establishing performance based requirements in Outer Continental Shelf Lands Act (OCSLA) Regulations, 33 CFR, Subchapter N, to require formal personal survival training for all persons working offshore. The United States is the only principal OCS nation in the northern hemisphere that does not mandate such training. The existing requirements for regularly scheduled fire, lifeboat, and exposure suit drills do not adequately provide for consistent, safe, minimum levels of training. The regulations, as foreseen, would set a minimum acceptable level of personal survival training and be self-administered by the industry.

Action: I concur with the intent of this recommendation. 46 CFR Subparts 10.470, 10.472, and 10.474 already require the offshore installation manager, the barge supervisor, and the ballast control officer, respectively, to receive this training. They subsequently apply this training in conducting the weekly drills required by 46 CFR Subparts 109.213 and 109.215. The drills acquaint the crew with the emergency procedures and equipment unique to that MODU and are equivalent to the emergency training provided on other types of Coast Guard inspected vessels in ocean service. While I feel it would be beneficial for MODU operators to voluntarily provide formal survival training for all crewmembers, further regulations are not necessary.

Recommendation 12: That the U.S. Coast Guard officially recognize Mr. [redacted] the Rig Superintendent of the ROWAN GORILLA I, and Captain [redacted], the Captain of the SMIT LONDON, for their timely actions and decisions leading to the abandonment of the ROWAN GORILLA I, and the subsequent safe recovery of all crewmembers. For their actions, they are heartily commended by the Marine Board.

Recommendation 13: That the U.S. Coast Guard officially recognize the outstanding performance of the crews of AURORA Rescue 110, 114, and 115 from Greenwood Base, Canadian Forces, in guiding the SMIT LONDON through the darkness to maintain safe contact with the capsule. For their actions they are heartily commended by the Marine Board.

Recommendation 14: That the U.S. Coast Guard officially recognize Mr. [redacted] and his inspectors from the Ship Safety Division, Canadian Coast Guard, for their timely intercession regarding reinstallation of the 36 person lifesaving capsules in their davits. Their actions prevented the ROWAN GORILLA I from departing Halifax without any primary lifesaving equipment on station and saved the crew from having to abandon the unit only with exposure suits for protection.

Action: I concur with recommendations 12, 13 and 14 and have directed Commander, First Coast Guard District to initiate appropriate awards action.

[redacted]

J. W. KIME
Admiral, U. S. Coast Guard
COMMANDANT

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United States Coast Guard

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16732/ROWAN GORILLA I
29 March 1990

From: Marine Board of Investigation

To: Commandant (G-MMI)

Subject: Mobile Offshore Drilling Unit (MODU) ROWAN GORILLA I, O.N. 662033; capsizing and sinking in the North Atlantic Ocean on 15 December 1988, with no loss of life or personal injury

FINDINGS OF FACT

1. Summary

The self-elevating MODU ROWAN GORILLA I capsized and sank on 15 December 1988, at position 39°56'N, 52°54'W, approximately 500 nautical miles southeast of Halifax, Nova Scotia. The ROWAN GORILLA I had departed Halifax on 8 December 1988 under tow by the M/V SMIT LONDON. The tow encountered the effects of several severe winter North Atlantic storms during the period 12 to 15 December 1988. The effects of the storms caused the hull to fracture in way of several preload tanks and the towing wire to part. While adrift, boarding seas caused downflooding and loss of stability, forcing abandonment of the unit and, ultimately, its total loss. Unless otherwise indicated in this report, all stated times are local time.

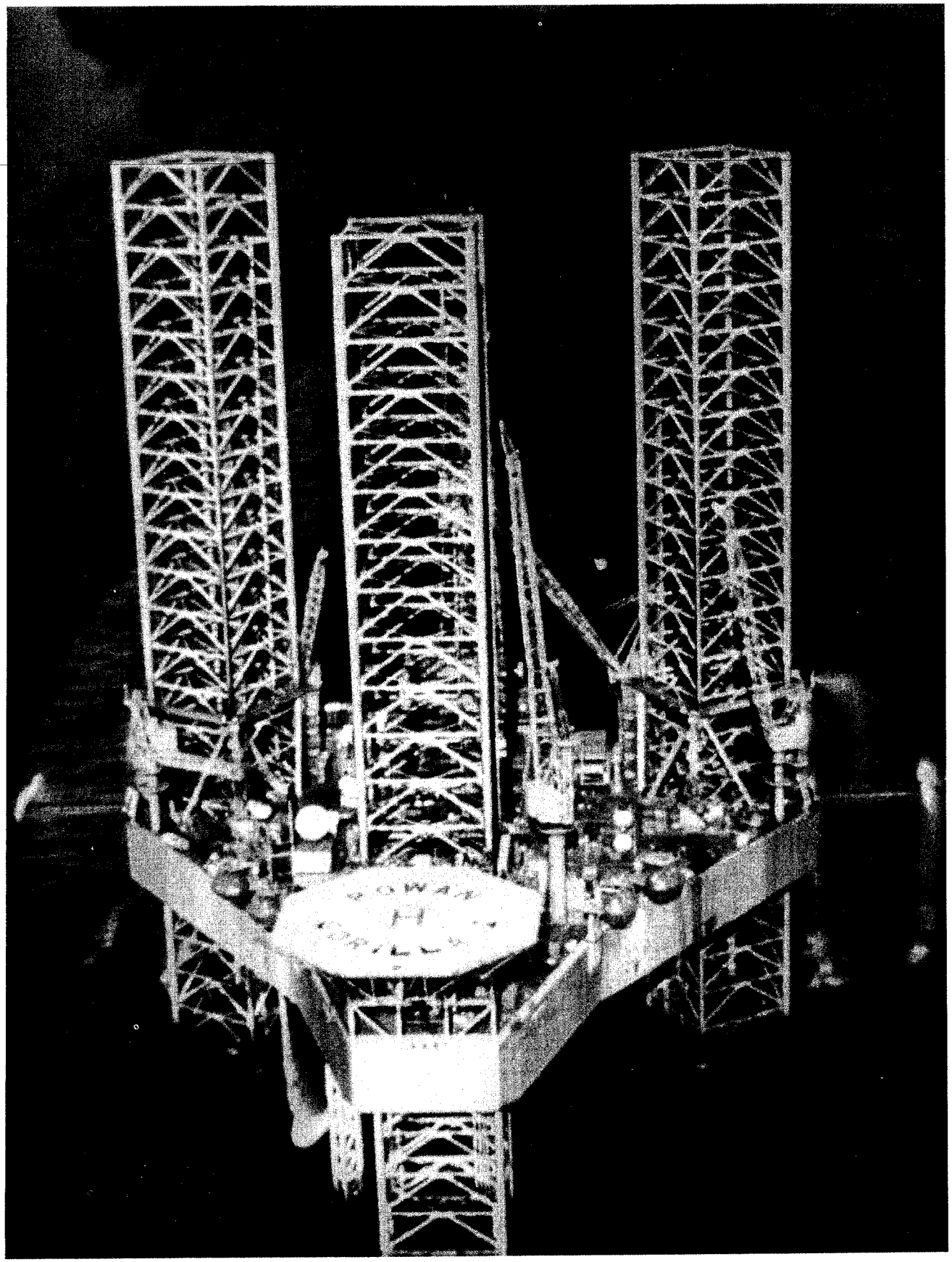
2. Vessel Data

a. Name:	ROWAN GORILLA I
Official Number:	662033
Registry:	United States
Service:	MODU
Homeport:	Houston, Texas
Owner/Operator:	Rowan Companies Inc.
	Suite 1900
	5051 Westheimer
	Houston, Texas
Gross Tons:	13,190
Net Tons:	12,417

Length:	297'
Route Permitted:	Oceans
Total Persons Allowed:	80
Propulsion:	Non-self propelled (Propulsion Assist)
Date Built:	9 December, 1983
Place Built:	Vicksburg, Mississippi
Certificate of Inspection:	Issued 10 December 1987 by U.S. Coast Guard Marine Safety Office, Boston, Massachusetts, at Dartmouth, Nova Scotia
Mid-Period Examination:	Completed 11 November 1988 by Marine Safety Office, Boston, Massachusetts at Halifax, Nova Scotia
Hull Examination:	Completed 11 November 1988
Loadline:	American Bureau of Shipping (ABS) provisional load line issued at Halifax, Nova Scotia on 2 December 1988

b.

Name:	SMIT LONDON
Official Number:	710746
Call Sign:	C6CJ8
Registry:	Bahamas
Service:	Towing
Homeport:	Nassau
Owner:	Smit Internationale
Operators:	Smit Tak B.J.
Gross Tons:	2,273.4
Net Tons:	376.68
Length (registered):	245.47'
Propulsion:	Motor
Horsepower (indicated):	22,000
Date Build:	1975
Place Build:	Holland
Crew:	19
Classification:	Lloyds Registry



3. **Principal Personnel Interviewed During the Investigation**

a. [redacted] age [redacted], was employed by Smit Tak as master of the SMIT LONDON. Captain [redacted] had 28 years of sea-going experience, all with Smit Internationale. He held dual Dutch and Bahamian licenses as Master of Towing Vessels. Captain [redacted] had been serving in the capacity of master since 1973. He had served as master of the SMIT LONDON since 20 October 1988.

b. [redacted] age [redacted] was employed by Smit Tak as a tow rider assigned to the SMIT LONDON. Mr. [redacted] had approximately 40 years of sea-going experience, 35 years with Smit Internationale. As a tow rider, it was Mr. [redacted] function to serve as an intermediary between the master of the SMIT LONDON and the person-in-charge of the ROWAN GORILLA I. In the event of a towline failure, Mr. [redacted] would supervise reconnection of the ROWAN GORILLA I to the SMIT LONDON.

c. [redacted] was employed by Smit Tak as chief engineer of the SMIT LONDON. Mr. [redacted] had 29 years of sea-going experience, 26 years of which was with Smit Internationale. He held dual Dutch and Bahamian licenses as Chief Engineer of Towing Vessels and had been serving in the capacity of chief engineer since 1971, with two and one-half years experience as chief engineer on the SMIT LONDON or sister vessels.

d. [redacted] age [redacted] Holland was employed by Smit Tak as second officer aboard the SMIT LONDON. Mr. [redacted] had 11 years of sea-going experience, all with Smit Internationale. He had served on the SMIT LONDON for two weeks prior to the casualty. He held dual Dutch and Bahamian licenses as Third Officer of Motor Ships, Unlimited, and Second Officer of Towing Vessels.

e. [redacted] was employed by Smit Tak as second engineer aboard the SMIT LONDON. Mr. [redacted] held dual Dutch and Bahamian licenses as Second Engineer, Motor Ships. He had four years of sea-going experience, all with Smit Internationale.

f. [redacted] age [redacted] was employed by Smit Tak as an apprentice mate/engineer aboard the SMIT LONDON. He had five months of sea-going experience, all with Smit Internationale.

g. [redacted] age [redacted] was employed by Rowan Companies as the rig manager of the ROWAN GORILLA I for four years. Mr. [redacted] had been employed by Rowan for 13 years in various capacities including barge engineer, driller, toolpusher, and rig superintendent aboard various Rowan MODUs.

h. [redacted] age [redacted] was employed by Rowan Companies as rig superintendent, or person-in-charge, aboard the ROWAN GORILLA I at the time of the casualty. Mr. [redacted] held a U.S. Coast Guard Merchant Mariner's Document (MMD) for the position of Able Seaman, Mobile Offshore Unit, Wiper, and Stewards Department. He had been employed by Rowan in various capacities for over 12 years. In 1983, he transferred from Rowan's land based drilling operations to the marine (offshore) division. Mr. [redacted] was assigned to the ROWAN GORILLA I while it was under construction as a driller. He subsequently was promoted to toolpusher and ultimately rig superintendent in the fall of 1985. All of this service was aboard the ROWAN GORILLA I.

i. [redacted] age [redacted] was employed by Rowan Companies as the alternate rig superintendent aboard the ROWAN GORILLA I. Mr. [redacted] was a Canadian citizen. He held a U.S. Coast Guard MMD for the position of Able Seaman, Mobile Offshore Unit. Mr. [redacted] was not aboard the ROWAN GORILLA I at the time of the casualty, but had been the person-in-charge of the unit while it was prepared for towing, departing the unit just prior to it leaving Halifax, Nova Scotia. Mr. [redacted] had 11 years of service on MODUs. He was employed by Rowan Companies in 1981 and had been continuously assigned to the ROWAN GORILLA I since 1983.

j. [redacted] age [redacted] was employed by Rowan Companies as senior barge engineer aboard the ROWAN GORILLA I. He was a Canadian citizen and did not hold any U.S. Coast Guard Documents or licenses. He was employed part-time by Rowan Companies in 1981 and 1982 and joined the ROWAN GORILLA I full-time as a barge engineer trainee in 1983 while the rig was under construction.

k. [redacted] was employed by Rowan Companies as rig electrician aboard the ROWAN GORILLA I. He was a Canadian citizen and did not hold any U.S. documents or licenses. He had seven years experience aboard the unit in various maintenance capacities, the most recent three as rig electrician.

l. [redacted] age [redacted] was employed by Rowan Companies as rig mechanic aboard the ROWAN GORILLA I. He had five and one half years experience on MODUs, all with Rowan Companies.

m. [redacted] age [redacted] was the Officer in Charge of the Halifax Rescue Coordination Center, Canadian Department of National Defense.

n. [redacted] was employed by Marathon Letourneau Marine Company as Vice-President of Engineering. He had been continuously employed by Marathon Letourneau since 1972 and was the Manager of Engineering during the design period of the ROWAN GORILLA I.

o. [redacted] was employed by Rowan Companies as Vice-President of Rowan Drill, a wholly owned subsidiary of Rowan Companies which operated the ROWAN GORILLA I. Mr. [redacted] had been employed by Rowan Companies for 14 years in various capacities including barge engineer, toolpusher, rig manager, project manager during construction of the ROWAN GORILLA I, and Canadian area manager.

4. The ROWAN GORILLA I

The ROWAN GORILLA I was a self-elevating MODU, commonly referred to as a "jack-up" drilling rig. Construction of the unit (Marathon Hull 200) commenced in the Marathon Letourneau yard, Vicksburg, Mississippi, in 1982. It was completed and initially certificated by the U.S. Coast Guard on 9 December 1983. In addition to being constructed in accordance with U.S. Coast Guard regulations for MODUs, 46 Code of Federal Regulations (CFR) Subchapter IA, the unit was built in accordance with the 1980 American Bureau of Shipping (ABS) Rules for Building and Classing Offshore Drilling Units and the United Kingdom Department of Energy (DEN) regulations for offshore installations.

The ROWAN GORILLA I (See Figure 1) had a triangular shaped hull with overall dimensions 297'L x 292'W x 30'D. The unit was equipped with three truss type spud legs, 504' long. Each leg was capable of independent operation. The unit was fitted with a quarters module aft of the forward leg and a drill floor/derrick structure between the two after legs, capable of being cantilevered off the stern. The full load line displacement of the unit was 19,419.4 long tons at a maximum draft of 16.5'. The ROWAN GORILLA I and its four sister rigs were some of the largest units of their type ever constructed. Three of the remaining units are owned by Rowan Companies and one by Transworld Drilling, U.K.

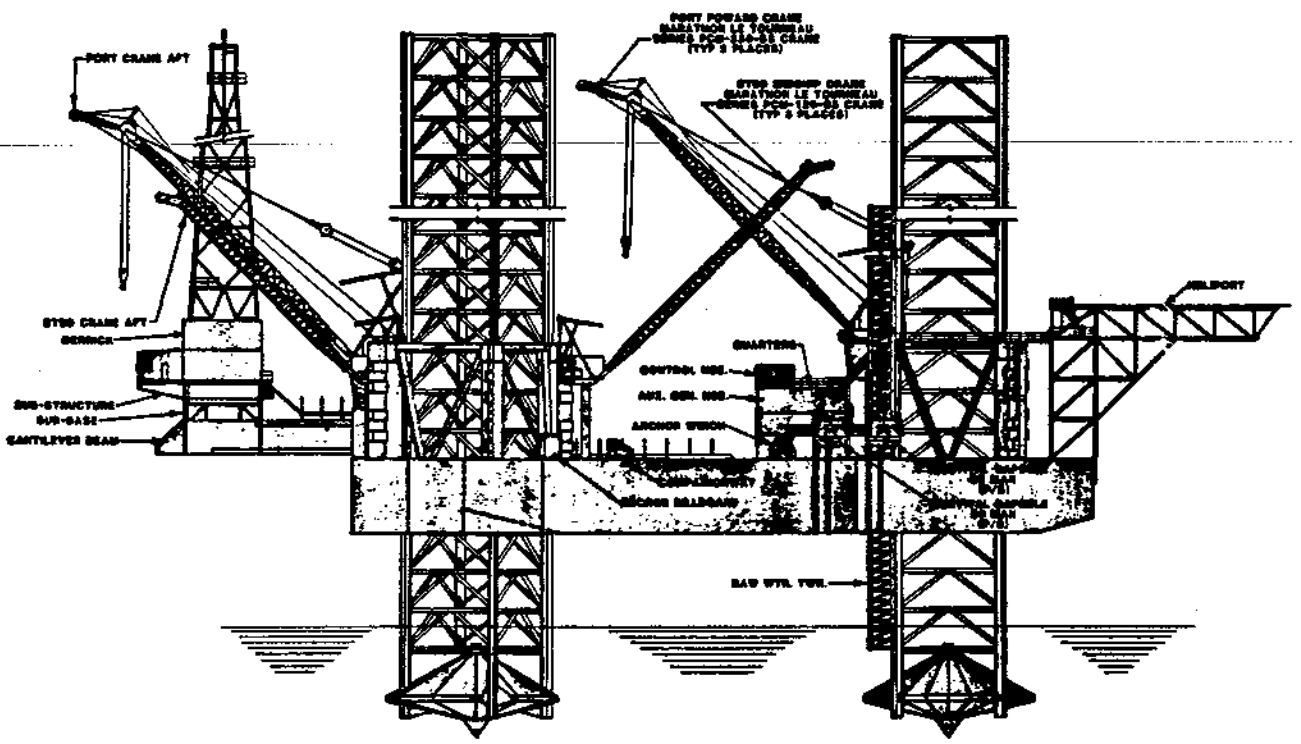


Figure 1

5. **Initial tow of the ROWAN GORILLA I**

Upon the completion of the ROWAN GORILLA I, Rowan Companies decided to move it to offshore eastern Canada to engage in drilling operations for various Canadian interests. A survey was conducted by a representative from J.K. Tynan International, Marine Surveyors in November 1983 to ascertain the suitability of the towing arrangement for the transit to eastern Canada from Belle Chasse, Louisiana. The J.K. Tynan surveyor made a number of recommendations concerning the tow which correlated with the rig's operating manual. Two towing vessels were employed to move the ROWAN GORILLA I, having an aggregate brake horse power (BHP) of 21,760. The survey report recommended a minimum continuous BHP of 20,000. The recommendation also called for a 6' high breakwater to be fitted "along forward and each side of the house between forward leg and aft end of accommodation house."

The tow departed Belle Chasse on 12 December 1983. The tow was relatively uneventful until 19 December when the towing wire of one of the tugs parted at approximate position 36°29'N, 70°44'W. At that time, winds were reported at 35-40 knots and, waves with swells to 12',

causing a three and one half degree maximum single amplitude roll over a five second period. Only minor damage was reported while shipping seas over the bow and port side. The towing wire was reconnected on the morning of 20 December and the tow again proceeded normally.

On 23 December, at approximate position 41°N, 64°23'W, a towing wire parted again. Winds were reported at 40-50 knots, with swells to 15'. A maximum roll of ten degrees in a ten second period was reported during the day. Attempts to reconnect the towing wire were ineffective until just after midnight on 24 December. During this time, it was reported that the after end of the rig came around toward the seas causing waves to board over the stern. The following damage was reported in the unit's logs. The shale shaker bulkhead buckled; "numerous objects were smashed and moved on deck"; and cracks were discovered on the port after bulkhead of the port thruster room and starboard after bulkhead of the starboard thruster room, "admitting water with each working of the legs." Additionally, voids 5 and 10 were found to contain water and preload tanks 10A, 14 and 16 all had between one inch and one foot more water in them than previously reported. Due to heavy motions, the person-in-charge moved the ROWAN GORILLA I's legs from ocean towing position one (tip of spud cans 12.9' below the hull) to ocean towing position two (tip of spud cans 25.0' below the hull) to dampen the leg motions.

During the 24th, further investigation determined the existence of cracks in preload tanks 14, 16, and 17 open to the sea. The fractures in preload tanks 16 and 17 were in way of the thruster tunnels. The additional water in numbers 5 and 10 voids was believed to have entered via the deck vents.

On 25 December, a towing wire parted for the third time at position 43°07'N, 63°08'W. Winds were blowing at 50-55 knots with seas running to a maximum of four feet. The tow was soon reconnected and additional fractures were discovered in preload tank 15. From this time on, the tow was again uneventful until it concluded at St. Margaret's Bay, Nova Scotia, on 27 December 1983.

Coast Guard documentation of the damage incurred on the initial tow is only minimal. A review of the MSO Boston file of the ROWAN GORILLA I revealed only a copy of a proposed repair survey prepared by Mr. [redacted], a Marathon-Letourneau naval architect, and signed by the attending inspector. There is no indication of a "Notice of Vessel Casualty" report CG-2692 or a "Notice of Structural Failure" report, CG-2752A prepared or submitted by Rowan Companies and the attending Coast Guard inspector, respectively.

Repairs generally consisted of arresting, gouging and rewelding the fractures in the shell plating and common bulkheads of preload tanks 14, 15, 16, and 17 and the addition of gussets for stress relief in way of the thruster tunnels. Apparently both Rowan and Marathon disregarded the

statement of the person in charge of the ROWAN GORILLA I who reported that the working of the legs was contributing to the stress cracking of the thruster room bulkheads. There is no indication that Rowan Companies either commissioned, or Marathon Letourneau ever conducted any type of engineering study to pinpoint the exact cause of the hull fractures and determine a permanent solution. Additionally, it appears that they either dismissed or overlooked the fact that most of the damage occurred after the unit's stern had been subject to wave impingement,even though the leg motions may not have exceeded the design limitations.

After repairs, the ROWAN GORILLA I operated in Canadian waters for several contractors. It was moved on an intermittent basis, approximately eight to ten times. All the moves were short field relocations. No information was discovered during this investigation to indicate that any other significant structural problems occurred between the time the rig arrived in Canada and departed on its ill-fated December 1988 voyage.

6. Preparations for the December 1988 Tow

By the fall of 1988, offshore drilling activity had diminished to the point where Rowan Companies decided to relocate the ROWAN GORILLA I outside of eastern Canada. The rig had already been idle for a number of months and, according to the testimony of Rowan personnel, the long term prospectus for employment in that area was not particularly good.

In October, 1988, Rowan Companies contracted Noble Denton and Associates, Inc. to survey the unit prior to its tow from Halifax, Nova Scotia to Trinidad, West Indies. The Noble Denton survey included detailed information consisting of towing modes; recommended crew levels; towing arrangement; stability; position of cantilever, derrick and legs; water tight integrity; pumping arrangements; securing equipment on deck; critical motions under tow; and damage control equipment. The survey recommendations were fully consistent with the unit's U.S. Coast Guard approved operating manual. The survey recommended towage of the unit by a sea-going salvage tug of approximately 22,000 Indicated Horsepower (IHP). It further recommended that the tow take place in fair weather, on receipt of a favorable forecast which considered the long range out look. The Noble Denton survey report made no mention of the fitting of a temporary breakwater to the forward part of the unit as recommended in the J.K. Tynan survey for the initial tow.

The ROWAN GORILLA I had a valid U.S. Coast Guard Certificate of Inspection issued by Marine Safety Office (MSO) Boston, Massachusetts on 10 December 1987. Concurrent with the preparations for the tow, personnel from MSO Boston conducted a mid-period examination and a special underwater inspection in lieu of drydocking. The examinations were completed on 11 November 1988 with no outstanding deficiencies

noted. Additionally, the American Bureau of Shipping (ABS) completed examinations as part of special survey number one. These examinations consisted of the annual hull, load line, and drydock equivalent surveys and were completed with no outstanding requirements. The ABS surveyor issued a provisional loadline certificate dated 2 December 1988.

Throughout November and early December, 1988, preparations were made for the rig move. These preparations were directly supervised by the two rig superintendents or persons-in-charge of the ROWAN GORILLA I, [redacted] and [redacted]. Messrs. [redacted] and [redacted] alternated 14 day work shifts as person-in-charge. As rig manager of the ROWAN GORILLA I, Mr. [redacted] had overall responsibility for the rig move preparations. During questioning, the Marine Board noted that while all three men had extensive MODU experience, particularly with jack-ups, the overwhelming majority of this experience pertained to the industrial or drilling operations as opposed to traditional maritime functions.

Although it was initially anticipated that the ROWAN GORILLA I would be moved to Trinidad, Rowan Companies was unable to finalize a contract in that area. As is generally typical in the offshore drilling industry, Rowan personnel continued to market the unit. This resulted in several additional prospective contracts in the North Sea area.

About mid-November, Rowan Companies officials in Houston determined that there was sufficient possibility of a contract to move the rig from Halifax to the North Sea area. Rowan contacted Smit Tak concerning towing services. Smit Tak operated three of the world's most powerful ocean salvage tugs, each singularly capable of meeting the horsepower requirements for the tow.

Mr. [redacted] was the person-in-charge aboard the ROWAN GORILLA I when the final decision was made to move the unit. He stated that while the preparations for the move were underway for some time, he was informed of the actual departure date only about a week or week and a half prior to getting underway. Mr [redacted] further stated that he completed securing the unit in accordance with the Noble Denton survey. However, he indicated that he made no reference to the unit's operations manual, although he presumed the unit's barge engineers were using the manual to calculate its stability.

The ROWAN GORILLA I was designed to carry all of the equipment necessary to engage in drilling operations. Specific locations and devices are provided to permit secure stowage for much of the equipment during a tow. However, generally speaking, jack-ups are designed to spend the majority of their service life in the elevated condition. Consequently, there are some items that required relocation

for protection against storm damage during long open ocean tows. It is also common for drilling contractors to take extra supplies and equipment when a unit is deployed overseas. Most large items are stored on any available open deck space.

Mr. [redacted] indicated that miscellaneous cargo was stowed on the unit's main deck between the accommodations deck house and the stern. The tubular goods (drill pipe) were stowed in the center and starboard pipe racks. They were bulkheaded off on the ends with steel H-beams and heavy wood planking and were intermittently bound with chain binders. Just aft of the center pipe rack, five or six small steel containers were secured to the deck with welded steel angle. A Schlumberger trailer was secured in the same fashion along side the containers. Two well test skids and the Texas deck were stowed on the port pipe rack and were secured with welded stanchions and chain binders. The Texas deck was actually a pair of removable walkways that were normally attached between the main deck and the rig floor. Finally, the two flare booms were removed from their normal outboard positions and secured to the starboard pipe rack in the same fashion as the well test skids.

The cantilever was skidded in to its normal towing position, forward of the after legs, and locked in place. Heavy blowout prevention equipment was mounted on test stumps located near the stern and bolted in place. A number of smaller drilling related items were secured to the drill floor. The travelling block and top drive unit were locked in their customary stowed position, at the base of the derrick near the drill floor. Below decks, large storage shelves were planked over with heavy plywood.

During the preparations for the tow, Mr. [redacted] received word from Mr. [redacted] that Rowan's area manager in the United Kingdom had requested that all four totally enclosed lifesaving capsules be removed from their davits and stowed on top of the quarters. The MODU was equipped with one 36 and one 50 person capsule per side, adjacent to and slightly forward of the quarters. Mr. [redacted] complied with the directions he had received and relocated all four to the top of the quarters.

Co-incidental with the rig move, Rowan Companies requested that the Canadian Coast Guard perform an inspection pursuant to maintaining the unit's Letter of Compliance on 6 December. Two Canadian Coast Guard inspectors came aboard the unit to conduct the inspection. They noted the removal of the lifesaving capsules, and, upon returning to their office, brought the matter to the attention of Mr. [redacted], Regional Superintendent of Technical Services, Ship Safety, Canadian Coast Guard.. Mr. [redacted] immediately called Mr. [redacted] and questioned him as to whether or not he had received permission from the U.S. Coast Guard to remove the capsules. Mr. [redacted] called Mr. [redacted] who in turn contacted Mr. [redacted], Vice President of Rowan Drill in Houston. Mr.

[redacted] emphatically stated that the capsule never should have been removed. Mr. [redacted] notified Mr. [redacted] and the two 36 person capsules were reconnected to the davits. The two 50 person capsules, however, were left secured to the top of the quarters.

Mr. [redacted] arrived on the unit on 7 December. A Noble Denton surveyor was also aboard to examine the final securing of the rig for sea. Mr. [redacted] and Mr. [redacted] discussed some last minute instructions made by the Noble Denton surveyor and jointly examined the preparations accomplished to that point.

The M/V SMIT LONDON arrived in Halifax on 6 December. Captain [redacted] master of the SMIT LONDON stated that his crew prepared the towing arrangement on 7 December. The vessel was equipped with two constant tension winch systems, each consisting of two friction drums and a storage reel. The bollard pull on each unit was 180 metric tons. Both the Captain and Chief Engineer stated that the towing machinery was in excellent operating condition. The starboard winch was selected for the tow. During his testimony, the Captain stated he had not towed a MODU while serving as master, but had experience in towing MODUs across the Atlantic as a mate. He further stated he had considerable experience crossing the Atlantic, with or without tows, and had never experienced a towing wire failure while serving as master.

The crew assembled a towing arrangement that consisted of 4,225' of nine inch diameter braided steel wire with a breaking load of 372 tons. An intermediate 180' double stretcher of 21" diameter synthetic fiber rope, with a breaking load of 735 tons was fitted between the towing wire and the 195', eight and one half inch diameter pennant wire with a 316 ton breaking load. The stretcher served as a spring between the towing wire and pennant. The connecting shackles had a breaking load of 375 tons. Late in the evening of 7 December the towing wire was attached to the permanently installed towing bridle on the ROWAN GORILLA I. This bridle was made of three and one half inch diameter chain fastened to a heavy steel triangle known as a fish plate. Additionally, the SMIT LONDON crew secured an emergency line between the bridle and the rig to permit retrieval of the bridle if the towing wire parted. Review of the towing wire certificate indicated it had been manufactured in late 1986 and according to the captain, had only been used sparingly since its installation on the tug in the late summer of 1988.

Early on 8 December, the Noble Denton surveyor completed his examination of the towing preparations made by the Rowan crew and made a final check of the towing arrangement. A certificate of approval for the tow was delivered to Mr. [redacted] Mr. [redacted] and Captain [redacted] Mr. [redacted] departed the unit at approximately the same time.

In conjunction with the final preparations for the move the Senior Barge Engineer aboard the ROWAN GORILLA I, made the final stability calculations. He employed an Apple 2E Computer utilizing a spread sheet type stability program called "STAZ" and needed only to enter the weights and locations of the variable load (non-permanent equipment and liquids) on the unit. The program calculated the vertical center of gravity (VCG), longitudinal center of gravity (LCG), and transverse center of gravity (TCG) for the unit. The Senior Barge Engineer ran the calculations assuming the legs to be in the normal towing position with the tip of spud cans 12.9' below the hull. The stability condition of the rig just prior to its departure from Halifax was as follows:

Displacement	18,852.83 long tons
VCG (with free surface, measured from the hull base line)	85.59'
LCG (forward of the center-line of the aft legs)	65.64'
TCG (minus denotes to port, measured from the hull centerline)	-.10'

These calculations were all within the parameters for an open ocean transit as allowed by the unit's Coast Guard approved operations manual.

The Senior Barge Engineer stated that the calculated draft was 16'2". The Rig Superintendent recalled that the draft was 16'3" forward and 16'8" aft due to the Noble Denton recommendation that the rig be trimmed by the stern. The maximum draft permitted was 16'6" measured at the midships Plimsol (loadline) mark.

7. The Riding Crew

The Noble Denton report recommended at least 15 persons be aboard the ROWAN GORILLA I during the tow. Rowan determined that the crew would be 26 persons. Additionally, Smit Tak would transfer one crewman from the tug to the unit as the towing observer. This individual would report to the captain of the SMIT LONDON concerning the condition of the tow and provide the necessary experience to direct the reconnecting of the tow in event of a breakaway.

The Rowan crew was comprised as follows:

Rig superintendent	1
Tool pusher	2
Barge engineer	2
Mechanic	1
Electrician	1
Driller	2
Assistant driller	2
Derrickman	2
Crane operator	2
Motorman	2
Floorhand	4
Welder	1
Catering	4

All were Canadian citizens except the Rig Superintendent (USA) and one Dutch catering person. The Tow Rider was also Dutch. There were sufficient persons aboard to meet the minimum U.S. Coast Guard crew requirements for the unit of two able seamen and one ordinary seaman. However, the Marine Board determined that with the exception of the Tow Rider, none of the other personnel had any significant maritime experience. All the Rowan personnel had attended a formal personal lifesaving training course mandated by Canadian regulations. The course included donning of life jackets and survival suits; inflating and righting of overturned life rafts; boarding life rafts from the water; familiarization and operation of lifesaving craft; and recovering persons from the water. Additionally, the Senior Barge Engineer had attended a course pertaining to the operation of fast rescue craft and enclosed lifeboats.

8. Departure

The decision to depart Halifax harbor was essentially a joint agreement between the Rowan Area Manager and the Captain after a discussion with the Halifax harbor master. Forecasts received on the SMIT LONDON indicated that there would be an approximate 36 hour "window" of good weather. The Captain stated he was receiving regular weather reports from the U.S. National Weather Service. While engaged in drilling operations, in addition to public weather forecasts, Rowan subscribed to a private weather service. However, the Rowan Vice-President stated that while under tow, the unit was not capable of receiving these reports. The Rig Superintendent stated that he presumed the tug would monitor the weather and advise him accordingly. Apparently there was no discussion between Rowan personnel and the Captain about the Noble Denton recommendation that the advice of a long range forecasting service be used for the

duration of the tow. The Captain stated that he knew winter storms generally tracked up the east coast of the United States and over Nova Scotia and considered the 36 hour period to give the tow a good start to get far enough south to avoid severe weather.

9. **The Tow**

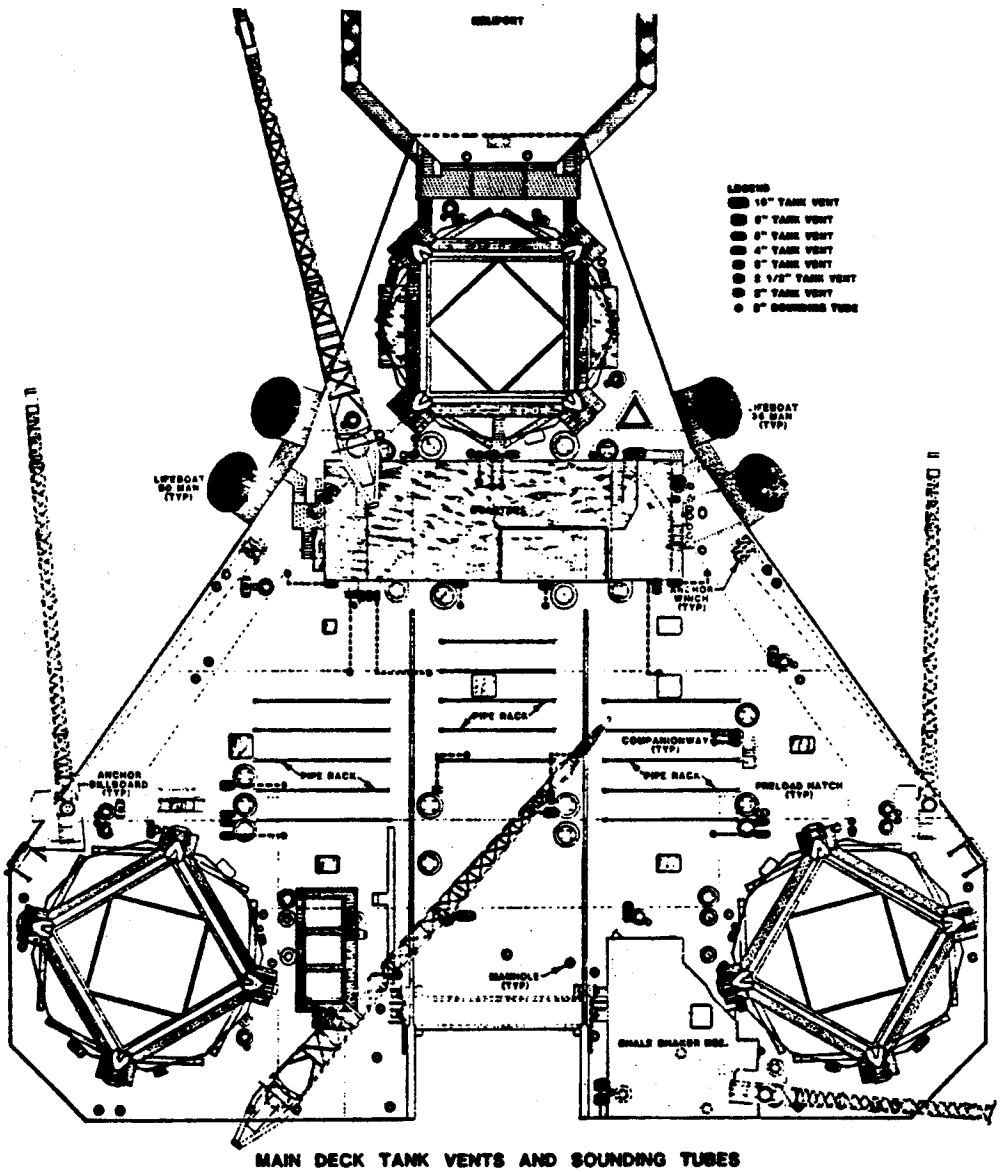
Final connection of the tow occurred at 1050 on 8 December. The ROWAN GORILLA I was still elevated at this time. The Rig Superintendent jacked the rig down, setting the legs in the normal towing position at tip of can 12.9' below the hull. There are clamp bars on the legs at this position which assure the proper can positioning. Actual departure from Halifax was at 1210. Upon clearing the Halifax seabuoy, the Captain set a course of 155°T to intersect the 40°N latitude at a speed of approximately four knots. The Captain indicated that an easterly course along the 40°N latitude would provide a favorable opportunity to avoid severe weather. At departure, the final destination of the tow still had not been determined. This route would facilitate the movement of the tow to either the North Sea or Trinidad.

During the period of 8 to 11 December, the SMIT LONDON log indicated that the tow progressed about 346 miles in a generally south southeasterly direction from Halifax. Winds and seas were moderate and variable, 7-21 knots and 3' to 12', respectively, during this period.

In the early hours of 12 December, the tow had reached a position of 39°57'8N, 56°23'.5'W. The Captain changed course toward the east. Throughout the day winds and seas built to westerly at 28-40 knots and over 20', respectively. At 1700, a new towing wire protector had to be fitted due to chaffing wear at the first towing bar. Towing wire protectors made of a composite material were fitted over the towing wire at each of the towing bars and the transom to prevent chaffing of the towing wire. The towing wire was restrained by the gog wires fitted to constant tension winches installed below the towing bars. At 2100 a gog wire parted. By 2400, pitch and roll of the ROWAN GORILLA I was so severe that the Rig Superintendent lowered the legs to the storm position, tip of can 25' below the hull, to dampen the motion of the unit and minimize the stresses on the rig structure caused by the oscillations of the legs. Throughout 12 December, the waves had been impacting the stern and after quarters of the unit.

By the morning of 13 December, the Captain was aware of a well developed cyclonic storm to the west of his position. Additionally, the forecast warned of a developing storm approaching the tow's proposed track line from the southwest. Forecast winds of this storm were 50 to 65 knots with accompanying seas of 20 to 30 feet. The Captain altered his course to the southeast in an attempt to place more distance between the tow and the storm.

Aboard the ROWAN GORILLA I, one of the crewmen detected flooding in preload tank 14 during a routine sounding. The only means of determining the condition of the preload tanks was through two inch sounding tubes located on the main deck (See figure 2). Secondary or remote means were not provided. The tank was opened and inspected and a vertical fracture was discovered in way of the stern, permitting a steady spray of water to enter the tank. Preload tank 15 was also entered and a horizontal fracture was discovered in way of the stern, though only "weeping". The Rig Superintendent directed that the eductor system take suction on preload tank 14. The Senior Barge Engineer observed the fractures in both tanks. He stated the crack in preload tank 14 seemed to open and close as the stern was struck by waves.



MAIN DECK TANK VENTS AND SOUNDING TUBES

Figure 2

The eductor system (see figure 3) consists of four inch diameter piping and runs to all internal spaces of the unit. During normal operations to elevate the unit, a calculated amount of preload ballast water would be pumped into the tanks to drive the spud cans and legs securely into the seabed. Preload would then be dumped through large skin valves located in the bottom of hull while the unit was slightly elevated. The eductor piping served to strip preload ballast that remained in the tanks. It was not intended to effectively de-ballast large amounts of water from internal spaces.

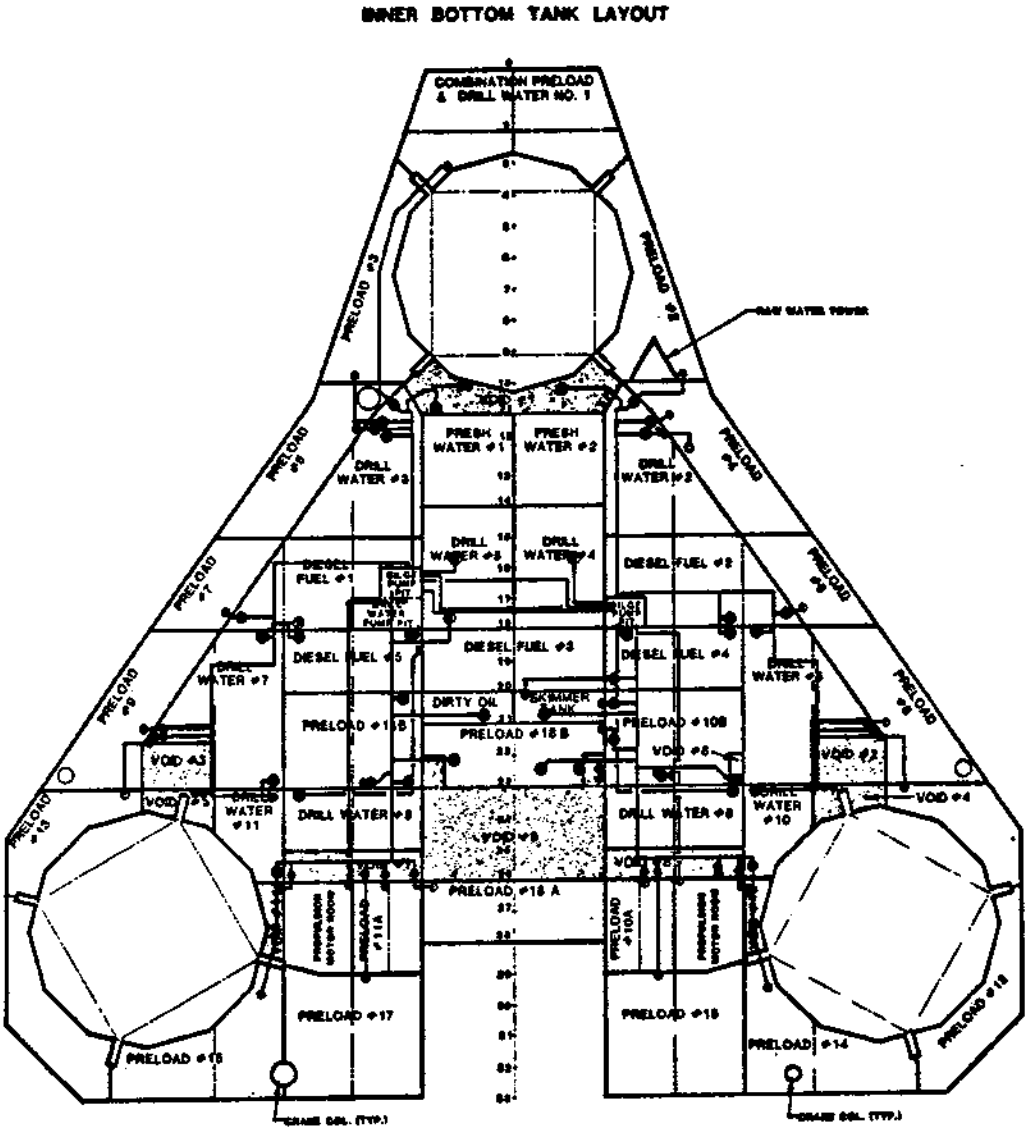


Figure 3

The Rig Superintendent relayed the information regarding the cracking through the Tow Rider to the Captain shortly after he was advised as to the extent of damage. The crew continued to check the unit. Around noon, several small fractures were found radiating from the inboard leg guides of the port and starboard legs. The leg supporting structure in this vicinity is tied to bulkheads located below the main deck, 66' to the port and starboard of centerline, just inboard of the legs.

Aboard the SMIT LONDON, the tow wire was moving to such an extent that between 1015 and 1200, several protectors were worn away and had to be replaced. An additional gog wire was also attached to the towing wire to help minimize movement and reduce chaffing.

The Captain became concerned about the amount of drag the MODU was causing on the tow. Heretofore, the tow had been subject to generally following westerly winds and seas. However, the storm created prevailing easterly winds and seas. Around 1900, the Captain discussed this with the Rig Superintendent. The Rig Superintendent raised the rig's legs back to the towing position in an attempt to help the tow make some forward progress. However, this increased the rig's motions severely, and by 2300, the legs had to be returned to the storm position. Shortly thereafter, facing winds mounting to 50 mph and seas building to 30 feet, the tow could no longer make headway. Concerned with the possibility of the SMIT LONDON being pulled astern and eventually capsized by the unit, the Captain made the decision to turn the tow and run with the seas, altering course as required, until the storm passed.

Also that evening,the Rig Superintendent reached the Rig Manager by radio at his home in Mississippi and advised him of the fractures in the preload tanks. The Rig Manager contacted his Houston office and, in turn, Marathon Letourneau personnel were called regarding a potential repair. Marathon engineers suggested the fabrication and installation of doubler plates. This information was relayed to the Rig Superintendent.

After daylight on 14 December, the Rig Superintendent sent his crew to install the doubler plates in preload tanks 14 and 15. The Senior Barge Engineer and another crewman entered preload tank 14 in an attempt to make repairs. The tow was now on an easterly course with the winds and seas. Throughout the morning, winds increased to 60 knots with waves exceeding 40'. Waves were now routinely breaking over the stern of ROWAN GORILLA I and running into the open preload tank. This forced the two men to abandon their efforts.

The ROWAN GORILLA I had a series of internal passageways and spaces below the main deck which were accessible through a number of hatches and covers installed in the main deck (see figure 4). Crew members on watch reported to the Rig Superintendent that some hatches were leaking. On the afternoon of 14 December, the storm abated

slightly and a work crew went on deck to tighten hatches. However boarding seas over the stern hampered the crews ability to check the tightness of the cover for preload tank 14. This was the last time personnel could safely get on deck to check hatch covers or sound tanks.

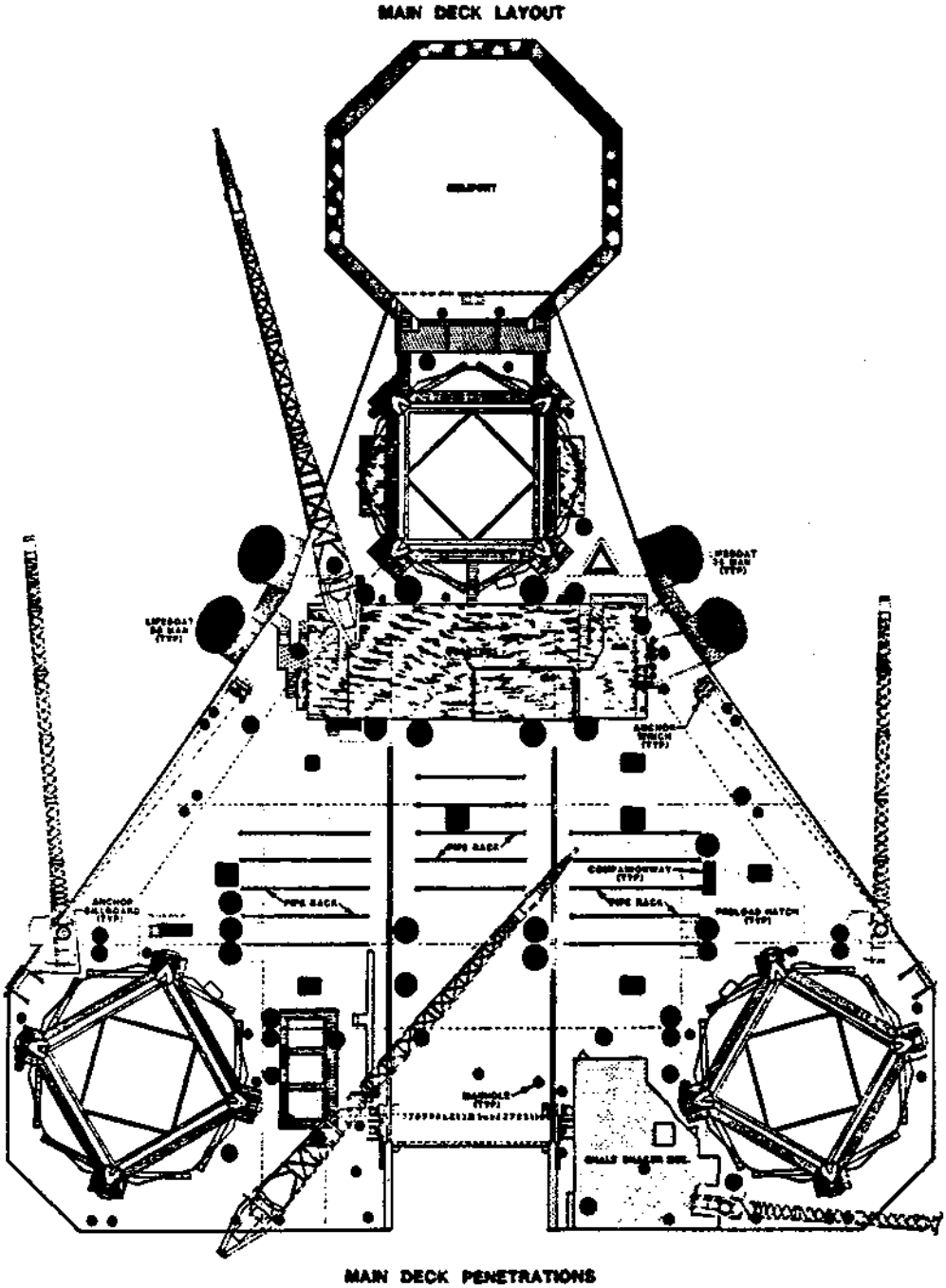


Figure 4

Riding before the elements caused the towing protectors to wear through rapidly as the towing wire slewed across the stern of the SMIT LONDON. By midday, there were not enough protectors to cover all the contact points on the towing bars and stern. At noon, the towing wire was slacked one half of a meter to avoid continuous wearing in one location. By 2300, the last towing protector on the stern was worn through and the towing wire was again slacked one meter. The Captain also stated that one of the gog wires also parted because of weather conditions. Adverse weather conditions made it impossible to dispatch a crewman to reconnect the gog wire. Additionally, the following seas were putting a terrific strain on the towing wire. The Captain testified that the towing wire tension meter fluctuated between zero and 280 (pegged) metric tons as the tow rode over the reported 40'+ waves.

During the evening of 14 December, the Rig Superintendent made his radio report to the Rig Manager. He indicated that the repairs were not made to preload tanks 14 and 15. Additionally, the Rig Manager's notes indicate that the Rig Superintendent reported that the Schlumberger trailer had broken loose and was sliding around the main deck.

At 0220 on 15 December, the towing wire parted, approximately one meter from the stern of the SMIT LONDON, at position 40°00'04 N, 53°59'.84 W. Shortly thereafter, the bridge watch recorded the lowest barometric pressure of the voyage, 971 millibars. Winds surpassed 60 mph and waves over 45' were observed. The 1000 G.M.T. weather report for 15 December indicated a dangerous storm near 40°N, 55°W. The ROWAN GORILLA I was effectively now in the middle of this storm.

Immediately after the towing wire broke, the Rig Superintendent went out on the weather deck adjacent to the control room. He observed several containers that had broken loose and were skidding around, damaging the deck structure. He also observed that the test skids had broken free and knocked the welder's shack loose. The Rig Superintendent could not see specific damage to hull penetrations from his vantage point. He did note that one vent had been bent over and suspected others had been damaged.

Shortly after, the on-deck containers in the center bay broke loose and the roving watch reported that the main deck access cover over the mud pit room was missing. This cover was of a flush deck type. The Rig Superintendent stated he was not sure if the cover was torn off by the containers or lifted off by the hydrostatic suction of the waves as they broke over the deck. Water was pouring into the mud pits rapidly. At great personal risk, two crew members made their way to the shale shaker house on the after starboard stern of the unit. They were able to activate a centrifugal pump to take suction on the mud pits in an effort to

dewater them. Concurrently, water was entering the port compressor compartment via a main deck wireway. The port thruster room was also flooding. The Senior Barge Engineer stated that he could see a leak emanating from the upper thruster room, although he could not pinpoint the source.

Throughout the night, the SMIT LONDON could do nothing but stand by. The rig continued to head in an easterly direction at a speed of five to six knots, running before the wind and seas.

When the towline parted, the ROWAN GORILLA I's port side came up against the winds and seas. Previously, the unit's thrusters had been running to help maneuver it while under tow. On the evening of 14 December, the thrusters had been secured. The Rig Superintendent restarted the thrusters and was successfully able to maneuver the unit. He managed to even get the bow leg of the ROWAN GORILLA I to face into the wind and seas. However, he stated that the unit seemed to pound more and he repositioned the unit with the port after corner facing the seas. This attitude seemed to make for the least pitch and roll of the unit.

Despite the flooding situation, the Rig Superintendent stated that by daybreak on 15 December, he believed the situation was well under control. It appeared they were keeping ahead of the flooding in all the spaces that the crew could monitor. However, as a precaution, he mustered all non-essential personnel in the control room with their survival suits. He had been in contact several times during the night with the Rig Manager to apprise him of the damage. Additionally, he had spoken directly to the Captain of the SMIT LONDON at least once, and the Tow Rider kept in regular contact with the Captain as well.

In the early morning, the Rig Superintendent and Senior Barge Engineer both detected that the ROWAN GORILLA I was getting heavy by the stern. The Rig Superintendent stopped the thrusters which resulted in a less turbulent ride. He requested the Senior Barge Engineer to run a damage stability calculation assuming 16 feet of water in preload tank 14. The Tow Rider was also aware of the increased stern trim and discussed the matter with the Rig Superintendent. The Senior Barge Engineer suggested that pumping out of drill water tanks 8, 9, 10 and 11, which were all full at the time of departure from Halifax, would help the trim (See figure 5). This was accomplished, but the effect was minimal. Both of them suspected that perhaps other stern preload tanks were also flooding. However, there were no means available for them to verify additional flooding as the main deck was now constantly awash from the breaking seas. There was no attempt to establish suction on other preload tanks with the eductor system to determine if they were flooding.

INNER BOTTOM TANK LAYOUT

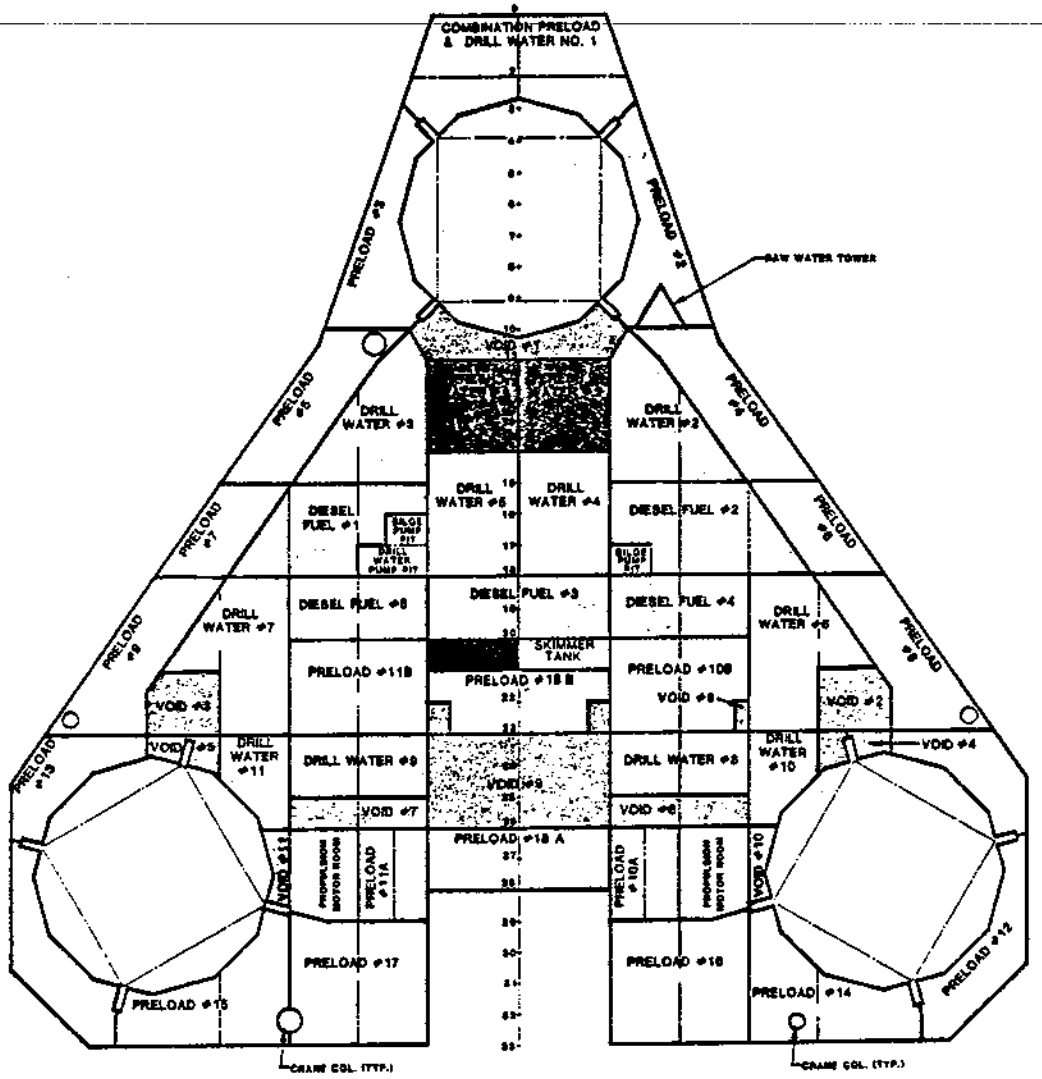


Figure 5

When the ROWAN GORILLA I was visible at daybreak on 15 December, the Captain moved the SMIT LONDON in for a look at the unit. He could see it was pitching, but not slamming, had no list, and appeared to have a two degree trim by the stern. Aboard the rig, the Senior Barge Engineer estimated his trim by the stern to be three to five degrees with a slight starboard list.

By 1000, the Captain could see the ROWAN GORILLA I although he could not clearly determine the extent of trim. He observed that the unit was now considerably heavier by the stern, that is, as it pitched fore and aft, the bow would not immerse as deeply as the stern. The Captain was aware of a report written by a fellow Smit master concerning the sinking of the jack-up DAN PRINCE (LI) in the North Pacific Ocean. The Captain remembered the circumstances of the casualty, i.e., broken tow line, waves breaking over the stern, the rig laying heavy, etc. The Captain retrieved the report from his stateroom, and after review concluded the ROWAN GORILLA I was in imminent danger of sinking.

The Captain immediately ordered his crew to prepare for rescue of the ROWAN GORILLA I crew. He simultaneously confirmed with the Rig Superintendent the present condition of the unit and informed him of his assumption based on the report of the sinking of the DAN PRINCE. The Senior Barge Engineer and Tow Rider also conferred with the Rig Superintendent about the worsening stern trim condition, now approximately six degrees. After weighing all available information, the Rig Superintendent radioed the Canadian Rescue Coordination Center (RCC) in Halifax of a "state of emergency" aboard the ROWAN GORILLA I at 1228.

10. The Abandonment

The majority of the crew were already in or near the controlroom when the Rig Superintendent radioed the Canadian RCC. The few remaining crewmen working below decks were carrying exposure suits with them. In the half-hour following the call, the Rig Superintendent stated the waves continued to build. He estimated wave height to be as much as 50'. Around noon, three 50' waves hit the unit in succession resulting in a solid wall of water, estimated by the Rig Superintendent to be at lease six feet high, strike the quarters, some 100' from the stern. All the equipment on the main deck pipe racks was gone except for the Texas deck, flare booms, and tubular goods. After the series of waves, the Rig Superintendent recalled the trim increased to approximately eight degrees by the stern.

The Rig Superintendent now had ensured that his entire crew was mustered in their survival suits. At approximately 1330, he stated that he observed two waves of about 60' approach the ROWAN GORILLA I. When the first one hit the rig, the trim immediately changed to 12° and the stern of the unit hung dead under the seas. As soon as the second hit the rig, Mr. [redacted] ordered his crew to the starboard life capsule and notified RCC Halifax and the SMIT LONDON that the ROWAN GORILLA I was being abandoned.

Based on the collective testimony of all the witnesses aboard the ROWAN GORILLA I the abandonment went smoothly. All of the crew entered the boat in an orderly fashion and safely strapped in. The Senior Barge Engineer placed himself in the coxwain's position after concurrence by the Rig Superintendent. The Rig Superintendent pulled the releasing gear and the capsule lowered. At one point the capsule bumped the side of the unit and then was waterborne. The releasing gear momentarily hung up but the Senior Barge Engineer freed it by throttling the capsule ahead and astern. The abandonment occurred at 39°59.82'N, 52°57.32'W. During the testimony, the Marine Board noted that despite the tenuous situation, there was no evidence of panic or disorganization by the crew members abandoning the ROWAN GORILLA I. The Rig Superintendent received input from his subordinates and weighed the recommendations correctly. The Marine Board also noted the emphasis the Rig Superintendent placed on the formal training he had received from the required four day lifesaving course which gave him the confidence to abandon the unit under extremely adverse conditions. This confidence, provided by the survival training, was apparent in all the other ROWAN GORILLA I crewmen as well.

Finally, the Marine Board noted that both the Rig Superintendent and the Captain each acknowledged the professionalism and courage displayed by the other.

11. Shore Support

By 14 December, Rowan management had sufficient concern about the ROWAN GORILLA I to contact Marathon Letourneau about the preload tank fractures. As previously mentioned in this report, Marathon recommended plug welds and doubler plates for the fractures in preload tanks 14 and 15. The Rig Superintendent's morning report of 15 December, detailing the damage and adverse trim condition, reached Marathon too late to permit them to offer any guidance to counteract the flooding. The Marine Board noted that one report carries notations to indicate the fractures in preload tanks 14 and 15 and the port thruster room occurred in the same locations where they had appeared during the initial tow to Canada in December 1983.

12. Capsule Underway

As soon as the life capsule was free of its falls, the immediate concern was to get away from the rig. Aboard the SMIT LONDON, the Captain observed the capsule being deluged by a huge wave, and thought it would not recover. Seconds later the capsule popped up and the Rig Superintendent asked the Captain via VHF radio for a course to steer away from the rig. The ROWAN GORILLA I, under the force of wind and sea, was still moving approximately due east at five to six knots. The

Captain gave them an initial course of east southeast to minimize the effects of waves. The Captain realized the separation between the capsule and the unit was not opening sufficiently with the east southeast course and advised them to head due south or 90° relative bearing from the rig. This made the capsule subject to beam seas but they were able to maintain this course until the engine quit running 45 minutes after abandonment. By that time, the rig and capsule were sufficiently separated to ensure the safety of the crew.

The SMIT LONDON radioed Halifax RCC to advise them that the rig was abandoned and the crew were all safe in the capsule. The Captain and RCC Halifax mutually agreed that no attempt would be made to recover persons from the capsule until the seas had subsided. The Captain posted multiple lookouts with orders to observe nothing but the capsule. Several other lookouts were assigned to observe the ROWAN GORILLA I. At 1605, the Deck Cadet observed the rig to appear to capsize on its after legs and sink. The ROWAN GORILLA I sank at approximate position 30°56'N, 52°47'W in about 16,000 feet of water. The estimated value of the unit was in excess of $90 million.

Throughout this period, all significant events were being monitored by RCC Halifax. In fact, since the parting of the towline at 0220 on 15 December, RCC had maintained regularly scheduled communications with the ROWAN GORILLA I. RCC Halifax also alerted AMVER to the potential distress situation.

Upon receiving the mayday, RCC Halifax dispatched the Canadian Coast Guard vessel SIR WILLIAM ALEXANDER and the HMCS OTTAWA from port in Halifax and diverted the Canadian Department of Fisheries and Oceans vessel, the LEONARD J. COWLY. The Canadian forces base at Greenwood was alerted and an Aurora, a long range SAR aircraft, similar to a P-3 Orion, was immediately scrambled. By chance, a Canadian forces C-130 was on a return flight to Greenwood at the time of the mayday. It was diverted and reached the capsule at approximately 1630. Approximately 1730, Aurora Rescue 110 arrived on scene and took up station over the capsule.

As darkness fell, the Captain's primary concern became maintaining contact with the capsule without colliding with it. This was particularly difficult due to the fact that the capsule did not have an external light and it was impossible to monitor the capsule on radar because of the sea conditions. The Aurora crews illuminated the capsule with flares throughout the night, allowing the SMIT LONDON to monitor it from a safe distance. Occasionally, the Aurora requested the capsule to shine a flashlight or fire a flare from the top hatch to mark their position. This coordinated effort permitted the Captain to keep the SMIT LONDON in close proximity to the capsule. The Rig Superintendent stated that the

continual presence of the Auroras had a tremendous impact on keeping up the morale of the crew. Rescue 110 was relieved on scene by Rescue 115 at approximately 2300. Rescue 114 relieved 115 at 0430 on 16 December and was subsequently relieved by 110 at approximately 1015.

In addition to the Canadian forces resources, two commercial vessels, the DON JUAN and CLARY, were also diverted to the capsule's position. These vessels arrived in the vicinity early on 16 December and stood by for instructions.

Aboard the capsule, the Rig Superintendent stated everything was relatively calm and uneventful. He made sure that water and seasick pills were distributed . Most of the crew experienced seasickness, although he stated that neither of the two women became ill. Despite the lack of an engine, the helm was regularly relieved to keep the capsule on a course with the waves. All crew members wore exposure suits. Those interviewed indicated that despite the capsule's rating for 36 persons, there was no extra space in the capsule because they were in their exposure suits. The one brief attempt to restart the engine was abandoned due to the inability for persons to move about.

The Rig Superintendent also expressed concern about the lack of a canopy light on the capsule. The log of the SMIT LONDON Indicated several occasions during the night where the capsule was lost for brief periods.

Throughout the night, the crew sang songs or recited procedures learned during their survival training. The crew members interviewed during the hearings stated that each person in the capsule was confident that they would soon be safely rescued.

At daybreak, the Rig Superintendent indicated that he observed the chief steward, a diabetic, to be in a deteriorating state of health. The crew hadn't eaten a regular meal since at least 24 hours before abandonment and the lack of food was affecting his blood sugar levels. Although the food stores in the capsule had been distributed, they were not of any apparent value to the chief steward. The Rig Superintendent reported this situation to the Captain.

RCC Halifax and the Captain had several conversations regarding the recovery of the crew from the capsule. It was tentatively agreed that pick-up would be made by the Sea King helicopter carried aboard the HMCS OTTAWA. However, the Sea King was experiencing mechanical problems and the revised ETA of the vessel was now about 1400. The weather at the capsule had moderated considerably from the day before with seas running only about 15', but conditions were threatening to build again. The Rig Superintendent advised the Captain that the chief steward was

getting progressively sicker and his VHF radio batteries were almost depleted. About 1000, the Captain launched his inflatable Zodiac rescue boat, manned by the Second Mate and Second Engineer, to carry soft drinks, fruit, and batteries to the capsule.

The Captain also had his crew rig a Jacobs ladder to the side of the SMIT LONDON. All his available crew was mustered at this location with lifejackets and lifelines. The Captain correctly assumed that once the Zodiac was by the capsule, the crew would want to transfer. The relative motion between the capsule and the Zodiac was minimal, making for easy transfer from the capsule to the Zodiac. The crew was ferried, three at a time to the SMIT LONDON. A lifeline was tied to each individual and the SMIT LONDON crew rendered assistance as personnel from the capsule climbed the ladder. Transfer commenced at 1100 and was completed at 1157. The approximate position of the pick-up was 39°57'N, 52°32'W.

Once aboard the SMIT LONDON, the chief steward quickly restored his blood sugar levels through food intake and experienced no further ill effects. There were no other injuries to the crew. The abandonment and recovery was a complete success.

13. Aftermath

The SMIT LONDON immediately commenced a return to Halifax. The M/Vs DON JUAN and CLARY were released and Aurora Rescue 110 returned to Greenwood. It was determined that the Canadian vessels enroute to the scene would attempt to recover the capsule. However, the capsule was never located and was presumed at least partially sunk as the access hatches were left open. The SMIT LONDON docked at Halifax at 0700, Sunday, 18 December 1988, and disembarked the ROWAN GORILLA I crew members.

Footnote: Approximately one and a half months after the sinking of the ROWAN GORILLA I, the Marine Board was notified by the Canadian Coast Guard that an inflated liferaft from the rig had been sighted and recovered by a vessel in the North Atlantic. The ROWAN GORILLA I was equipped with four-25 person Beaufort liferafts normally stored on racks hanging over the main deck about amidship and adjacent to the quarters, on both port and starboard sides. These are exposed locations. To prevent loss in transit, two rafts were lashed to the top of the quarters adjacent to the 50 person capsule. The other two, along with the fire fighting equipment normally located forward of the quarters, were secured in the vicinity of the center pipe rack. It is assumed that this gear was washed overboard sometime on 14 or 15 December. The specific storage location of the recovered liferaft remains unknown. It was understood by the Marine Board that the raft was returned to its manufacturer for examination.

14. **Rig Motions**

The following is a table of the roll, pitch, and period of the ROWAN GORILLA I, as extracted from the testimony and exhibits to this investigation. All numbers are maximums for the days and times listed.

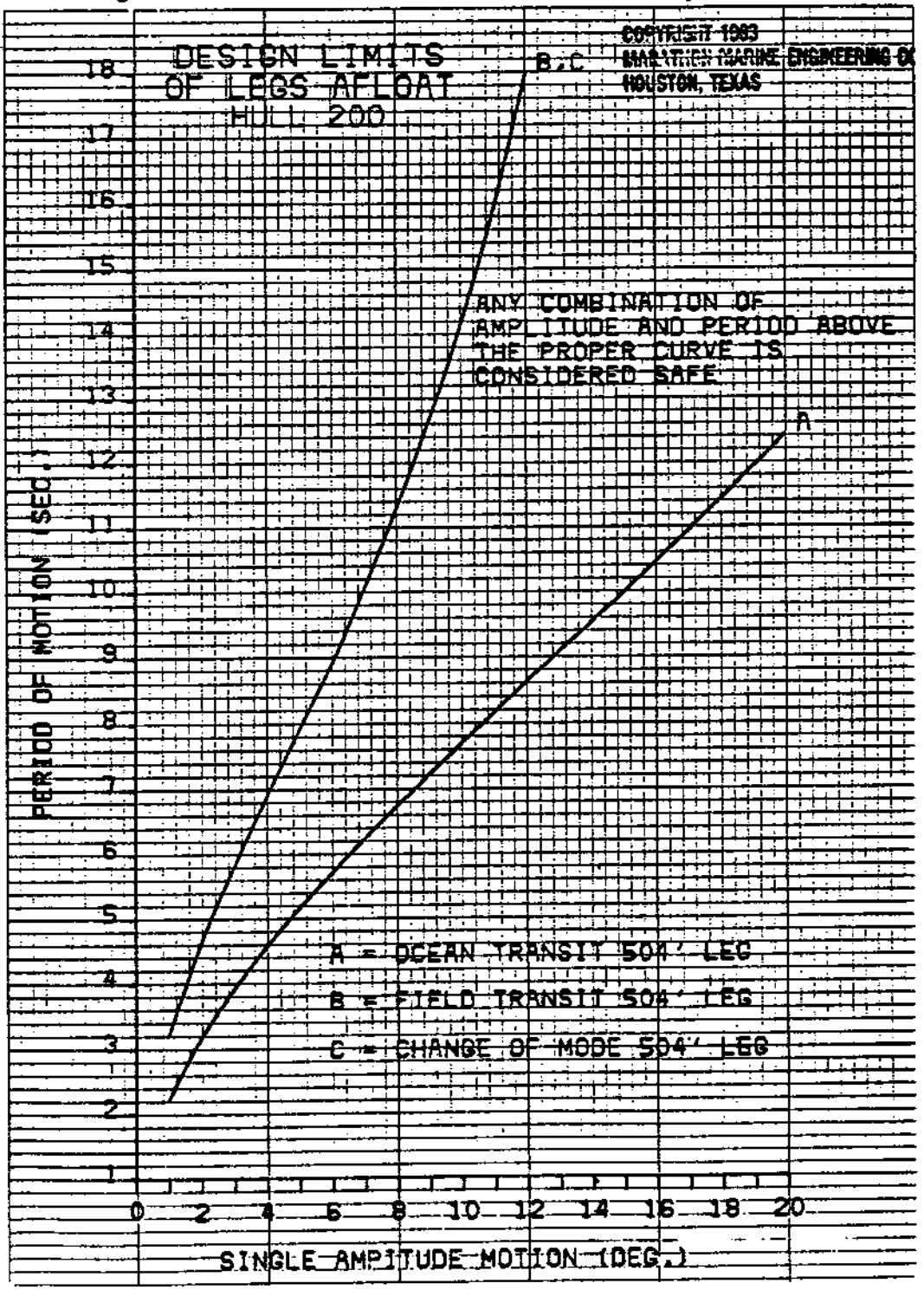


Figure 6

Date	Pitch/Period	Roll/Period
12 December	-	2°/7 seconds
13 December (AM)	-	2.5°/8 seconds
13 December (PM)	3.5°/8 seconds	3.5°/8 seconds
14 December (PM)	5°/6 seconds	7°/5 seconds
15 December (AM)	14°/4-6 seconds 5°/10 seconds (average)	3°/4 seconds

Page 13 of the ROWAN GORILLA I's operations manual is a graph (see figure 6) of the design limits of legs afloat. The curve marked A represents the maximum motions and period permitted for the legs during ocean transit. The combination of motions and period to the right of the line represent conditions that exceed design limits and will likely damage the legs and their supporting structure. The recorded rig motions from the evening of 14 December, to the time of the sinking, generally exceed the design limitations. As noted earlier, the legs were in the approved storm position during this time to limit (dampen) motions.

15. Chain of Command and Communications

The testimony of the Captain, Tow Rider, and Rig Superintendent indicated that from the onset of the voyage clear lines of command and communications were established. The Rig Superintendent retained command of the daily operations of the ROWAN GORILLA I. The Captain of the SMIT LONDON had overall responsibility for the tow. The two communicated at regularly scheduled intervals, initially through the Tow Rider and then directly as the situation deteriorated. After the towing wire parted, the Captain monitored the condition of the rig, offering advice and counsel regarding the maritime aspects with which the Rig Superintendent had limited experience.

16. MODU DAN PRINCE

The self elevating drilling unit DAN PRINCE (LI) sank on 22 October 1980, in the North Pacific Ocean, approximately 600 miles south of Alaska. The rig, under tow of the M/V SMIT NEW YORK, was battered by 60+ knot winds and 45'-50' waves. While being towed into the seas, the helicopter deck forward of the bow leg broke off and severed the towing wire.

The Marine Board reviewed the accident report issued by the Bureau of Maritime Affairs, Republic of Liberia. The DAN PRINCE was a Mitsui/Levingston Class III, independent leg jack-up. At the time of the casualty, the rig was carrying 418' of leg. The Marine Board noted the following pertinent points of the investigation:

a. A number of heavy drilling related items were stored on the main deck.

b. Over a period of four days prior to the towing wire parting, a number of minor fractures occurred as the unit faced increasingly adverse weather conditions. These included small fractures in way of the supports for the port and starboard leg jackhouses.

c. Equipment on deck broke loose and caused damage which impaired the watertight integrity of the hull and quarters house.

d. After the parting of the towing wire, numerous fractures to the hull occurred, the most critical being a 12'-18' crack in the main deck inboard of the port jackhouse. Loose gear on deck smashed vents and holed the access trunk to preload tank 25 causing unobstructed flooding.

e. Flooding in accessible spaces was deemed under control prior to abandoning the unit.

f. A private weather forecasting service employed for the tow predicted moderate weather at its onset. After the tow was underway, the forecast was revised to predict significantly worse weather along the intended course.

g. The unit, constructed in 1976, was built and classed to American Bureau of Shipping (ABS) standards "Maltese Cross" A1, self elevating drilling unit. The minimum required intact afloat stability condition under ABS rules was the 100 knot wind criteria.

h. The report concluded that the DAN PRINCE sank from uncontrolled flooding into the hull. It recommended that wherever possible, temporarily stowages be removed from the unit. Additionally, it recommended that weather patterns along the projected towing track be thoroughly reviewed and all reliable sources of weather forecasting be examined.

17. ROWAN GORILLA I - Design Criteria

The Marine Board interviewed Mr. [redacted], Vice-President of Engineering for Marathon-Letourneau. At the time of the unit's construction, he was the manager of engineering and had overall responsibility for the design of the unit.

The Vice-President stated the unit was designed in accordance with the structural standards of the U.S. Coast Guard, ABS, United Kingdom (UK) Department of Energy (DEN), Canadian Oil and Gas Lands Administration (COGLA), and American Institute of Steel Construction (AISC). The design also fully complied with the U.S. Coast Guard and ABS intact and damage stability requirements.

In designing the unit, two series of model tests were conducted, one for towing resistance at Rice University and one for a qualitative assessment of the selected hull form at the University of Michigan. Neither of these tests considered the effects of any stresses that might be imposed on the hull by oscillations of the legs, resulting from motions of the hull in a seaway.

The Vice-President stated that in designing the unit, it was concluded that the elevated condition of the unit would cause the greatest stress on the hull through the legs, the supporting elevating system, and the associated bulkhead structures. Despite the fractures that occurred to the hull after the initial tow, there were no specific studies regarding the stresses which may have been imparted on the hull by leg motions. The design limits of leg afloat curves account for the maximum allowable motions of the legs, to minimize stress on the legs and their supporting structure only. The curves are based on the ABS standard in "Rules for Building and Classing Mobile

Offshore Drilling Units", 1980, which defines a 15°, ten second single amplitude limit. The Vice-President stated that there was no dynamic analysis conducted on the effects of leg stresses which might be imposed on the hull. When questioned why a dynamic analysis was not done, he stated that the triangular hull design makes development of a computer motions program to evaluate stress virtually impossible, and further stated none was required by the U.S. Coast Guard or ABS.

Additionally, Mr. [redacted] and the Rowan Drill Vice-President stated they saw no correlation between the 1988 fractures and the 1983 fractures since they were not in the same location. This lack of correlation is surprising since on both occasions, the Marine Board noted the fractures occurred in way of the same preload tanks, symmetrically, in way of the 66' off centerline bulkheads which run longitudinally to the stern, just inboard of the port and starboard legs.

18. <u>ROWAN GORILLA I - Stability Study</u>

Due to the flooding that occurred to the unit, the Marine Board requested that Marathon-Letourneau perform some theoretical damage calculations to determine the effects on the unit. The calculations assumed the following intact conditions:

a.	VCG:	83.14' above baseline
b.	LCG:	66.41' forward of centerline of after legs
c.	TCG:	.10' port of centerline
d.	Free Surface Correction:	.21 and 1.4 (longitudinally and transversely)
e.	Displacement:	18,314.5 long tons

The following damage cases, in conjunction with an overturning moment equivalent to a 50 knot beam wind from port and a 50 knot stern wind, were assumed:

a. Flooding of preload tank 14 to the waterline.
b. Flooding of preload tanks 14 and 15 to the waterline.
c. Flooding of preload tanks 14 and 15 and both thruster rooms, to the waterline.

d. Flooding of preload tanks 14 and 15, both thruster rooms, pit room to half depth and compressor room to half depth.
e. Flooding of preload tanks 14 and 15, both thruster rooms, pit room to half depth, compressor room to half depth and shale shaker house completely.

In reviewing the cases, even the most serious damage condition of flooding described in case "e" above does not result in the overturning moment of the wind exceeding the residual righting moment of the unit. However, the flooding of those spaces caused progressive reduction of freeboard to the stern, to less than 10 feet in case "e". This equates to an adverse stern trim of about 3°.

The Rig Superintendent and Senior Barge Engineer both stated on the morning of 15 December the trim by the stern was anywhere between three and six degrees. At six degrees, the stern of the ROWAN GORILLA I would be submerged. With no freeboard and 40'-50' waves boarding from the stern, virtually every tank vent aft of the quarters was constantly under water, potentially permitting downflooding of interior spaces and tanks. The tons of green water on deck adversely affected the righting arm forces, essentially pushing the unit below the seas.

19. U.S. Coast Guard Stability Standards

The U.S. Coast Guard stability standards for self elevating MODUs are contained in Title 46, Code of Federal Regulations (CFR) parts 170 and 174. The Coast Guard intact stability standard for the ROWAN GORILLA I, in a severe storm configuration (tip of can positioned at 25' below the hull), is based on an energy criteria. This criteria calls for the ability of the unit to survive the overturning moment created by the sustained force of a 100 knot wind during a severe storm. The ROWAN GORILLA I complied with this intact stability criteria. In addition, the Coast Guard also requires compliance with a damage stability energy criteria which calls for the ability of the unit to survive the overturning moment created by the sustained force of a 50 knot wind with all compartments located within five feet of the exterior hull, between two

adjacent main watertight bulkheads, the bottom shell, and the upper most continuous deck, flooded. The ROWAN GORILLA I complied with this damage stability criteria.

20. Towing with the Weather

During the initial tow of the ROWAN GORILLA I to Canada in 1983, the parting of the towline and caused the stern of the unit to be brought up against the seas. In his testimony, Mr. [redacted] pointed out that jack-up hulls were built excessively stiff to satisfy the regulatory requirements for intact stability. Consequently, a jack-up's motions are unlike a ship which more readily rolls, pitches, and yaws with the effects of the sea. He further indicated that the unit's best survival position in heavy weather is to place bow into the wind and seas. Otherwise, the unit's sides and stern would take a tremendous pounding, potentially leading to structural damage.

The Marine Board reviewed a study authored by Dr. [redacted] of Noble Denton Limited, U.K. The study concerned the loss of the self-elevating unit KEY BISCAYNE, a Marathon Letourneau class 52 rig. The loss of the rig shared many similarities with that of the DAN PRINCE and ROWAN GORILLA I, i.e., broken towing wire, green water on deck, etc. Dr. [redacted] indicated that his model tests of the KEY BISCAYNE casualty suggested that maintaining the bow of a jack-up into the weather would significantly reduce the amount of green water on deck (by virtue of striking the deck house), which would prevent increased hydrostatic pressure on hatches and accesses, and, lessen the potential for downflooding through openings in the hull. Dr. [redacted] further pointed out through his model tests that impact loads could be reduced on the towing wire, limiting the chance for breakage, and there was little danger of capsizing the tug.

The Captain of the SMIT LONDON, while having extensive general towing experience, apparently had, by his own admission, little experience towing jack-up drilling units.

The U.S. Navy Towing Manual, SL740-AA-Man-010, Section 4-5 contains guidance for towing in heavy weather. In part, this section provides that:

a. "Running before the sea and wind can cause difficulty in steering and keeping the tow astern or in the desired position."

b. "Under more strenuous sea condition, dynamic hawser tensions, when towing down wind, can be significantly higher than when heading into wind and seas at the same speed and power."

c. "Recognize that the tug and tow likely will make negative speed over the ground."

The Marine Board spoke to several individuals with extensive ocean towing experience. While each individual stated the optimum situation would be to proceed into the weather, all indicated, that, based on events as they might actually occur, would consider deviating from the norm.

21. **The ERICA Project**

After the conclusion of formal hearings, the Marine Board received detailed information concerning a joint U.S./Canadian weather project, "Experiment on Rapidly intensifying Cyclones Over the Atlantic" (ERICA). The information was received from Dr. [redacted] Atmospheric Sciences Program, Dalhousie University, Halifax, Nova Scotia.

The report detailed the ongoing ERICA study which has been established in an attempt to accurately forecast the patterns of the large winter mid-latitude storms, known as extratropical cyclones. These storms affect a rough triangular section of the Western North Atlantic, bounded by Cape Hatteras, Southwestern New Foundland and 40°N latitude, and 50°W longitude. Prior to the start of actual observations in the 1986-87 winter season, storm systems dating back to 1965 were researched and documented, including those that contributed to the loss of the MODU OCEAN RANGER (1982) and the significant damage suffered by the P/V QUEEN ELIZABETH II (1978).

Dr. [redacted] indicated that these storms were particularly dangerous in that their growth "is characterized by the rapid fall of surface pressure at the center of the rotating storms, referred to as explosive deepening". The usually strong storms that result are called "bombs."

Dr. [redacted] stated he had made personal observations of a storm between 11 and 14 December 1988, in the vicinity of the tow. The storm was characterized by "intense, rapidly changing wind and water conditions", including "rapid changes in wind direction while the wind speed remained well above 40 knots, and often above 50 knots", while, "chaotic seas were visually observed near the centre (sic), with whitecaps being blown off the waves from one regime by the winds" with "constructive interference between the waves of the two regimes, with mammoth foamy water turrets the result."

The log of the SMIT LONDON, and the testimony of the Captain and Rig Superintendent bear out the occurrence of this phenomenon during 14-15 December.

Dr. [redacted] stated that the long range forecasting of ERICA was not intended for public dissemination, presumably because of its experimental nature, but would have been available to the towing operation through the Maritime Weather Center in Halifax. He contended that if the forecast was obtained either by Rowan or Smit, the tow could have been postponed until after 18 December. This would have allowed a ten day period of good weather, permitting safe passage of the tow through the dangerous triangle of the western North Atlantic.

Finally, Dr. [redacted] suggested that it may be appropriate for designers to consider a design criteria employing testing of the effects of variable winds and waves on a potential hull design.

22. **Rowan's Decision to Depart Halifax**

The Marine Board received a letter from Mr. [redacted] Chairman of the Board and President of Rowan Companies after completion of the formal testimony.

Mr. [redacted] clearly indicated that the decision to move the ROWAN GORILLA I was based on economic factors. The drilling prospectus for offshore Canada was poor, with no operations likely until January 1990. He indicated that the financial burden of keeping the rig stacked in Halifax amounted to more than one million dollars per month for Rowan.

Mr. [redacted] further stated that employment of a "dry tow" was not a consideration because Rowan "anticipated difficulty, in the event of unfavorable weather conditions upon arrival, in unloading the Gorilla I." Additionally, they had moved the ROWAN GORILLA II from Singapore to the North Sea by dry tow. The spud cans were in the water except when it was dead calm, a condition he deemed "totally unsatisfactory" for an Atlantic crossing.

Mr. [redacted] indicated that the wet tow of the ROWAN GORILLA I was carefully planned. He stated "based on our prior experience, the design criteria for the rig, and the experience and advice of Smit and Noble Denton, all steps were taken to make the tow as uneventful as possible. Rowan equipment and personnel had been through numerous storms at sea and had experienced a number of broken tow lines as a result of such storms. It was never believed that we had men and equipment in serious jeopardy until 15 December 1988."

The Marine Board had previously questioned the Rowan Drill Vice-President concerning the possibility of a dry tow for the ROWAN GORILLA I. He had stated that he had seen the jack-up GLOMAR LABRADOR I arrive in Halifax on a dry tow with damage that took three to four weeks to repair. He attributed this damage to the towing vessel getting into heavy seas. When asked if he ever discussed the dynamics and stability of a dry tow situation, the Vice-President indicated he had no first hand knowledge of this method of moving rigs.

23. <u>Employment of a Rig Mover</u>

Both the Rowan Drill Vice-President's testimony and Mr. [redacted] letter emphatically indicated that Rowan Companies would never employ a part-time rig mover on their units. A rig mover is an individual, ostensibly with a Marine background, that comes aboard as person in charge while the unit changes locations. Both indicated that all Rowan's rig superintendents were adequately prepared since they "came through the ranks" vice being hired into the position from outside. They both asserted that the Rig Superintendent aboard the ROWAN GORILLA I had a satisfactory amount of sea-going experience.

CONCLUSIONS

1. The proximate cause of the sinking of the ROWAN GORILLA I was the uncontrolled downflooding into an unknown number of interior spaces of the unit, resulting in the loss of positive buoyancy.

2. Contributing to the cause of the casualty was the suspected flooding of preload tanks 14 and 15 and the port thruster room via through-hull fractures,which occurred when severe stresses were imparted on the hull by the oscillations of the legs. While not directly fatal to the unit, the flooding of these spaces decreased the freeboard at the stern, thereby, increasing the amount of green water taken on deck from boarding seas.

3. Also contributing to the cause of the casualty was the probable damage to tank vents, access hatches, and other through-deck fittings, caused by equipment and deck cargo broken loose by boarding seas. This damage created numerous downflooding points through the main deck. Additionally, it is probable that the hydrostatic pressure imposed by boarding seas further damaged other accesses in the deck, creating additional downflooding points.

4. The through hull fractures that occurred in way of the after preload tanks and thruster rooms during both open ocean transits of the ROWAN GORILLA I in December 1983 and 1988 indicate that the current U.S. Coast Guard and American Bureau of Shipping (ABS) structural standards may not be adequate for self-elevating MODUs while in the afloat condition. The current regulations do not address requirements for designers to consider the effects of stresses that may be imparted on the hull of a jack-up by the oscillations of the legs caused by the dynamic motions of the unit.

5. Although it is recognized that while the largest percentage of a jack-up's service life is spent in the elevated condition, the designer's contention that the greatest stress on the legs and hull of a unit occurs while in the elevated condition, may be incorrect. This is supported by the fact that there are no known records or evidence of any stress related fractures occurring to the ROWAN GORILLA I, while in the elevated condition. The Marathon Letourneau Vice-President of Engineering stated in his testimony that Marathon Letourneau made this determination about leg/hull stress while designing the unit.

6. There is evidence that indicates the current U.S. Coast Guard stability standards may not be adequate for jack-up MODUs while in the afloat condition. The 70 and 100 knot wind intact stability criteria is applied to a unit in a static condition. The criteria does not take into account the combined dynamic effects of winds and

waves, as they naturally occur, upon the stability of the vessel. Compliance with the intact stability criteria often results in a particularly stiff vessel that does not have natural motions which are compatible with prevailing sea states. As such, the response of the ROWAN GORILLA I to the heavy seas encountered, caused significant green water on deck.

7. The carriage of cargo and equipment on the relatively open deck of the ROWAN GORILLA I proved to have the most adverse effect on the unit. The potential forces of boarding seas which dislodged the cargo and equipment were greatly underestimated. Once loose, the damage caused by shifting cargo caused an undetermined number of downflooding points.

8. The lack of a secondary means to sound inaccessible tanks and spaces did not afford the Rig Superintendent the opportunity to fully assess the condition of the ROWAN GORILLA I. While the crew was able to keep ahead of the flooding in the accessible spaces, the increasing adverse trim by the stern indicated progressive flooding in spaces unknown or inaccessible to the crew.

9. The bilge/eductor system may not have been capable of handling the extent of flooding of the internal compartments. The system's limited capacity and intended service for stripping small amounts of water from internal spaces apparently was inadequate to dewater and control the progressive flooding.

10. The Captain's relative unfamiliarity with towing jack-up units may have caused him to turn the tow to navigate with the winds and seas. Towing with the seas caused the failure of the towing wire because of the shock loading on the wire, as described by the U.S. Navy towing manual and the Captain's testimony concerning the towline tension indicator which was rapidly fluctuating between zero and 280 tons.

11. The exposure of the ROWAN GORILLA I's stern to the seas caused that portion of the unit to be exposed to impact loading for which it was not designed. Additionally, the relatively low freeboard of less than 14', when compared to waves in excess of 40', offered no protection from boarding seas. If the bow leg of the unit had been kept into the seas, the quarters module could have shed a considerable amount of water, particularly if temporary breakwaters had been installed as during the December 1983 tow. Even after the towline parted, the ROWAN GORILLA I's thrusters would have been capable of keeping the unit headed into the seas.

12. Rowan Companies took a calculated risk in attempting to tow the unit across the North Atlantic. The Chairman of the Board of Rowan and the Rowan Drill Vice-President specifically mentioned the great amount of open ocean towing experience Rowan Companies personnel had collectively gained during its operating history. However, the ROWAN GORILLA I, on its only other long ocean tow in December 1983, had suffered significant storm damage in the same approximate area where it foundered in December 1988. Rowan Companies apparently failed to draw this parallel. Finally, Rowan Companies appeared to have not fully investigated the employment of a dry tow of the unit.

13. Neither the Captain nor the Rig Superintendent were aware of the negative effect of exposing the stern areas of the ROWAN GORILLA I to the seas. It is difficult to expect that either of them would have intuitively known of the possible consequences. At no point prior to the sinking were they advised of this negative effect by shore-based personnel.

14. Both Rowan Companies and Smit Tak were remiss in not following the Noble Denton towing survey recommendation that the advice of a long range forecasting service be used for the duration of the tow. Rowan Companies appears to have abdicated their responsibility and relied on Smit Tak. The SMIT LONDON apparently only received data and facsimile maps from Environment Canada and the U.S. Weather Service. These forecasts were generally accurate only up to 36 hours. Even without knowledge of the ERICA Project, the intensity of winter North Atlantic storms are generally well known by mariners and more scrutiny could have been exercised to anticipate the weather prior to the unit's departure from Halifax.

15. Although Dr. [redacted] recommended the accurate long-term weather forecast made by ERICA, this information was not public knowledge nor apparently well known to the maritime community.

16. There is evidence of a violation of 46 USC 3313, on the part of Rowan Companies for failing to maintain the unit in accordance with its Certificate of Inspection. The two 50 person lifesaving capsules were removed from their davits and stowed without authorization of the U.S.Coast Guard. Further, if not for the vigilance and intercession of Mr. [redacted] and his Canadian Coast Guard inspectors, the ROWAN GORILLA I would have departed Halifax with all four lifesaving capsules stowed and inoperable. It is not necessary to speculate what might have happened to the crew if this had occurred.

17. Although the crew removed the liferafts from their approved normal stowage positions, it was noted that these exposed positions above the rail on the outboard sides of the hull would have made the rafts easily susceptible to being washed away. The stowage locations for rafts are selected for raft deployment while the unit is in the elevated condition. There is no U.S. Coast Guard regulation pertaining to stowage requirement while under tow.

18. There is no evidence to suggest that the actions of either the U.S. Coast Guard or ABS personnel, who performed required inspections, examinations, and surveys prior to the unit's departure from Halifax, contributed in any manner or fashion to the sinking of the ROWAN GORILLA I.

19. There is evidence of a violation of 46 USC 12110(d), on the part of Rowan Companies for failing to employ a U.S. citizen as person-in-charge of the ROWAN GORILLA I. Mr. [redacted], a Canadian citizen, served as rig superintendent of the ROWAN GORILLA I prior to its departure from Halifax. Rowan Companies was cited by personnel from U.S. Coast Guard Marine Safety Office Boston for the same violation in December 1987. Employment of a foreign national as person-in-charge voided the unit's document.

20. Prior to, and during the voyage, the Captain and the Rig Superintendent established and maintained satisfactory communications between their vessels. There were no language problems.

21. The Captain of the SMIT LONDON and Rowan Companies personnel jointly agreed to commence the tow on 8 December 1988.

22. When the ROWAN GORILLA I departed Halifax, the unit's intact stability was in full compliance with the U.S. Coast Guard approved operations manual. The unit was also in compliance with its loadline.

23. From 8 December to 15 December, the prevailing winds and waves were generally on the stern or stern quarters of the ROWAN GORILLA I.

24. Mr. [redacted] properly positioned the unit's three legs at the severe storm position with the tip of the can 25' below the hull, as appropriate to limit leg stresses.

25. The crew discovered the initial fractures in preload tanks 14 and 15 on the morning of 13 December and last observed them on 14 December. Although, the fractures did not appear severe, it is

reasonable to conclude that they continued to propagate due to the increasing environmental loading and stresses imposed by leg oscillations transmitted to the supporting structure. It is probable that both preload tanks were completely flooded prior to the sinking of the unit.

26. Through continuous loss of towing wire protectors, the towline was subject to chaffing damage on the towing bars and the stern of the SMIT LONDON. When the last towing wire protector on the stern wore through, the wire was slacked one meter. The towing wire, already weakened, failed at this point due to the continual shock loading.

27. The hydrostatic impact of the continuous boarding seas and the effects of sliding cargo and equipment across the deck, created downflooding points through deck hatches and vents. This phenomena was noted by Dr. Denton in his study of the sinking of the jack-up KEY BISCAYNE.

28. Given the severe storm conditions on 15 December, the crew of the SMIT LONDON could not have had a reasonable chance to reconnect the towing wire.

29. The Captain of the SMIT LONDON recognized the perilous condition of the ROWAN GORILLA I. The information he passed to the Rig Superintendent, concerning his observation of the unit and the striking similarities of the DAN PRINCE sinking, accurately predicted the eventual sinking of the unit.

30. The Captain's early warning allowed the Rig Superintendent sufficient time to access the condition of the unit and make a timely decision to abandon the unit.

31. The Senior Barge Engineer and Tow Rider also provided the Rig Superintendent with accurate and timely advice concerning the progressive loss of the unit's stability.

32. The Rig Superintendent correctly made an independent and timely decision to abandon the unit. Though not an expert regarding maritime concepts, he was willing to listen to his subordinates and accept the advice offered by the Captain of the SMIT LONDON, who was more experienced in maritime operations. The absence of panic by the crew may be attributed to the coolness and professionalism displayed by the Rig Superintendent.

33. The orderly abandonment of the crew is a testament to the importance of the formal training they received during the survival course mandated by the Canadian government.

34. Current Coast Guard regulations pertaining to the determination of life capsule personnel capacities do not take into account the wearing of exposure suits by the occupants within the capsule.

35. The cause of the lifesaving capsule engine failure is unknown.

36. The Senior Barge Mover's actions as coxwain of the lifesaving capsule ensured the safety of the crew. His proper actions are another example of the importance of having received formal training as an lifesaving capsule coxwain.

37. Lack of an external light on the lifesaving capsule proved to be a distinct problem in keeping track of it during darkness.

38. The skills, professionalism and stamina of Canadian forces Aurora crews of Rescue 110, 114, and 115 in illuminating the area in the vicinity of the life capsule, throughout the night, in adverse weather conditions, were critical in allowing the SMIT LONDON to remain in close proximity to the life capsule. The Auroras' presence served as a great source of solace to the capsule crew and provided them with the confidence and hope for an early rescue.

39. RCC Halifax reacted to the mayday in a timely and effective manner, mustering air and sea rescue resources and monitoring, directing, and coordinating the rescue.

40. The safe transfer of the crew from the capsule to the SMIT LONDON was facilitated by the employment of the inflatable rescue boat. The use of the inflatable boat as an interface between the tug and the capsule proved beneficial due to its excellent stability characteristics, its ability to ride waves at the same frequency with the capsule, and its "soft" structure that eliminated any possibility that it would be damaged alongside the tug, jeopardizing the recovery of the capsule crew.

41. Although the legs were in the storm position with tip of can 25' below the hull, the combined effects of the winds and seas resulted in causing dynamic motions that exceeded the limits of the leg design.

42. The fractures that occurred to the stern area of the ROWAN GORILLA I during the 1983 and 1988 tows appear to be related to an existing design problem. The design of the supporting leg structure did not adequately account for the transmission of stress due to the oscillating motion of the legs in the afloat mode. The actual design was based on the assumption that the greatest stress on the leg supporting structure was experienced in the elevated mode.

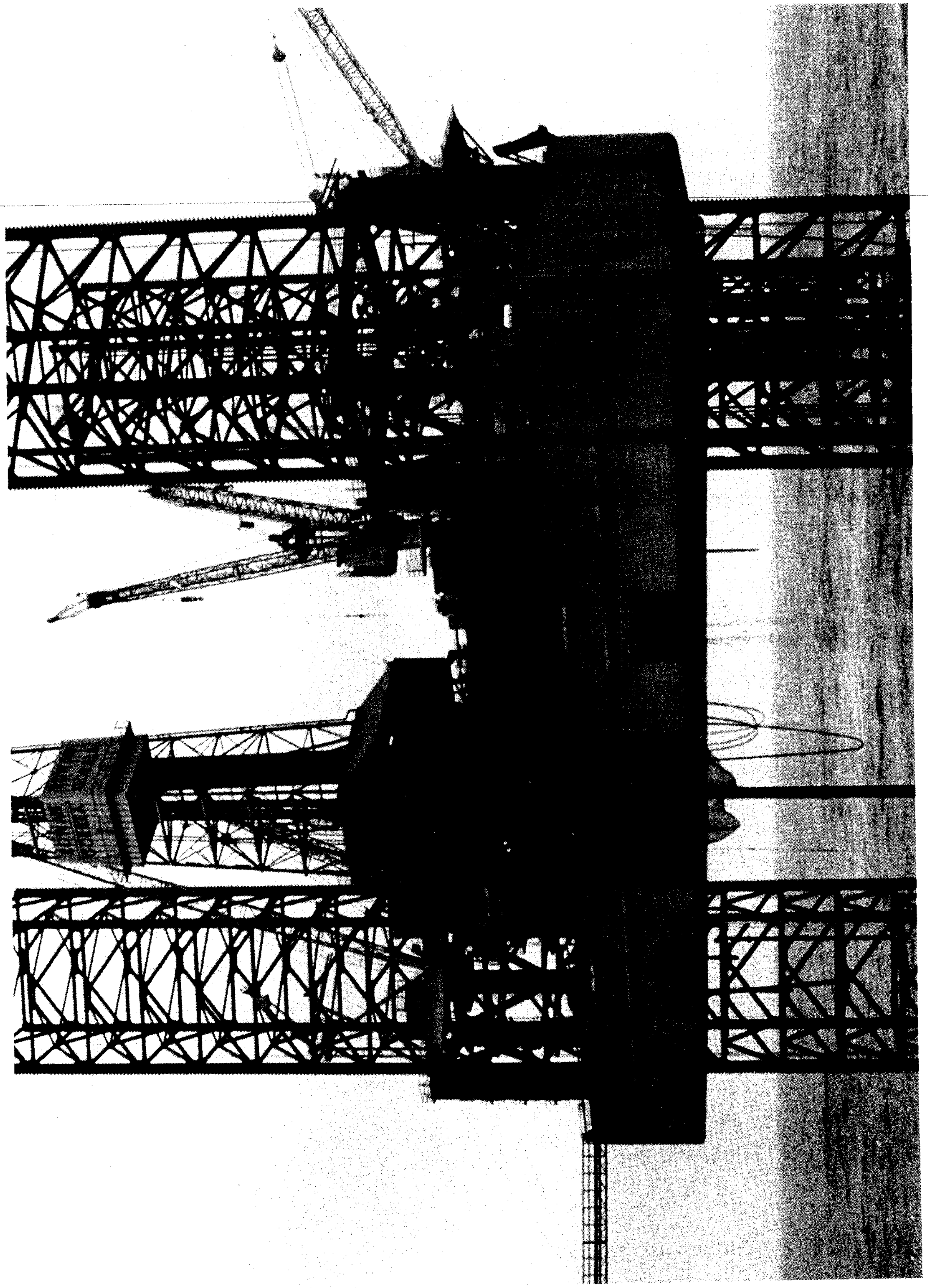
43. Towing any jack-up in adverse weather with following winds and seas places the unit in jeopardy due to the likelihood of significant green water on deck. Green water on deck reduces stability and may cause breaches in the watertight integrity of the deck, resulting in downflooding into the internal compartments of the unit and loss of buoyancy.

44. Given the time of year and the reputation of the North Atlantic Ocean, Rowan Companies should have thoroughly investigated the employment of a heavy lift vessel to move the ROWAN GORILLA I before opting to tow the unit. The Marine Board is unaware of any heavy lift vessels that have foundered while transporting MODUs.

45. The President of Rowan Companies position that his company will not employ a rig mover is not debatable. The U.S. Coast Guard's proposed MODU licensing and manning regulations require that an individual who is well versed in marine skills related to moving a MODU, and, who has satisfactorily demonstrated these skills, will be aboard as Offshore Installation Manager, i.e., person-in-charge during this evolution. This person need not be a specialist and could be a regular crew member, provided the individual has satisfied the minimum requirements.

46. The Marine Board concludes that towing of self elevating units in severe storm conditions can be inherently dangerous. Some may choose to dismiss this, citing the vast numbers of successful trans-oceanic tows of jack-ups that have occurred over the years. However, the Marine Board doubts that many of these tows have been conducted in waters or at times of the year where they were subject to extreme winds and waves. The photograph on the next page clearly illustrates the potential damaging effects of boarding seas on a jack-up unit (not the ROWAN GORILLA I) under tow. Note that this unit's helideck is completely submerged.

If the circumstances surrounding the sinkings of the DAN PRINCE, KEY BISCAYNE, AND ROWAN GORILLA I are ignored by regulatory bodies or parties involved in trans-oceanic tows of jack-ups, the likelihood of reoccurrence of a similar casualty is high. Bearing this in mind, the Marine Board makes the following recommendations.



RECOMMENDATIONS

1. That the U.S. Coast Guard and all classification societies reevaluate their current standards for strength of self-elevating MODUs while afloat. The sinkings of the ROWAN GORILLA I, DAN PRINCE, AND KEY BISCAYNE all occurred in storm conditions less severe than what they were theoretically designed to withstand while afloat. The safety margins afforded by the statically applied empirical formulas are apparently not effective to ensure the seaworthiness of these vessels.

2. That the U.S. Coast Guard, ABS, and MODU designers combine to form a study on these issues, similar to the one that evaluated stability of semi-submersible MODUs after the loss of the Ocean Ranger.

3. That in the interim, owners and operators of jack-ups voluntarily limit the amount of cargo that is carried on deck during ocean tows, and advise towing companies that jack-ups should be towed in a manner to limit the amount of green water on deck and lessen the wave loading on the hull structure and minimize the afloat motions of the unit.

4. That the U.S. Coast Guard require a secondary means of gauging the condition of all tanks, voids, and spaces on all jack-up units where only sounding tubes allowing access through the exposed deck are currently fitted.

5. That owners and operators of jack-ups give full consideration to employing dry tows whenever units are moved to or from areas, where seasonally, bad weather can reasonably be expected to occur.

6. That owners and operators of jack-ups and towing vessels fully consult with all available governmental and private weather sources prior to commencing a tow.

7. That the U.S. Coast Guard initiate civil penalty action against Rowan Companies, Inc. for alleged violations of 46 USC 3313 and 46 USC 12110(d).

8. That the U.S. Coast Guard require the immediate retrofit of external canopy lights on all existing lifesaving capsules, not so equipped.

9. That the U.S. Coast Guard revise the lifesaving capsule capacity standards to account for the additional space requirements for persons wearing exposure suits.

10. That owners and operators of jack-ups voluntarily limit the number of persons exposed to the potential dangers of an open ocean tow by reducing the number of riding personnel to the minimum number required to maintain the units while under ocean tow.

11. That the U.S. Coast Guard consider establishing performance based requirements in the Outer Continental Shelf Lands Act (OCSLA) Regulations, 33 CFR, Subchapter N, to require formal personal survival training for all persons working off shore. The United States is the only principal OCS nation in the northern hemisphere that does not mandate such training. The existing requirements for regularly scheduled fire, lifeboat, and exposure suit drills do not adequately provide for consistent, safe, minimum levels of training. The regulations, as foreseen, would set a minimum acceptable level of personal survival training and be self-administered by the industry.

12. That the U.S. Coast Guard officially recognize Mr. [redacted] the Rig Superintendent of the ROWAN GORILLA I, and Captain Rijnsaardt, the Captain of the SMIT LONDON, for their timely actions and decisions leading to the abandonment of the ROWAN GORILLA I, and the subsequent safe recovery of all crew members. For their actions, they are heartily commended by the Marine Board.

13. That the U.S. Coast Guard officially recognize the outstanding performance of the crews of AURORA Rescue 110, 114, and 115 from Greenwood Base, Canadian Forces, in guiding the SMIT LONDON through the darkness to maintain safe contact with the capsule. For their actions they are heartily commended by the Marine Board.

14. That the U.S. Coast Guard officially recognize Mr. [redacted] and his inspectors from the Ship Safety Division, Canadian Coast Guard, for their timely intercession regarding reinstallation of the 36 person lifesaving capsules in their davits. Their actions prevented the ROWAN GORILLA I from departing Halifax without any primary lifesaving equipment on station and saved the crew from having to abandon the unit only with exposure suits for protection.

15. That this investigation be closed.

[redacted]

LCDR R. R. Prince, USCG
Chairman

[redacted]

LCDR S. T. Ciccalone, USCG
Member Recorder