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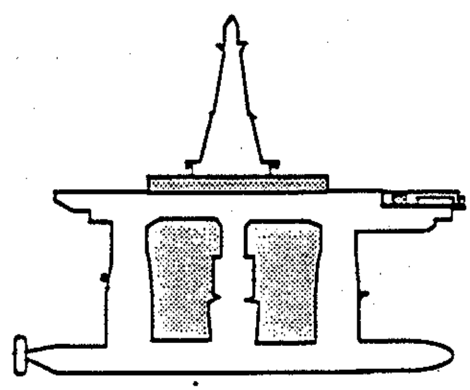
# Evacuation of Offshore Platforms Due to Severe Weather Conditions

Report to

U.S. Minerals Management Service

Offshore Technology & Research Branch

Herndon, Virginia



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# 1. INTRODUCTION

With over three thousand offshore oil platforms in operation in the Gulf of Mexico the annual occurrence of severe hurricanes is destined to cause complications. The decision to evacuate an offshore platform due to severe weather is a complicated matter due to the inaccuracies of hurricane forecasts as well as management pressures to not evacuate unless absolutely necessary. Indecisiveness may result which can lead to catastrophes as weather conditions deteriorate and evacuation becomes impossible. This indecisiveness or even the decision to continue operations has resulted in several crises.

The sinking of the Glomar Java Sea resulted from ARCO and Global Marine management choosing not to evacuate when the opportunity was available. This resulted in the loss of all 81 crew members. The managers involved based their decision on the fact that evacuation would delay the work schedule. [1]

To avoid potential catastrophes such as this, decision criteria must be established for platform evacuations. In addition, the construction of an effective evacuation model will aid in the evacuation time of multiple installations. This is critical in the Gulf of Mexico where low predictable, high severity storms can result in quickly deteriorating weather conditions. A timely evacuation must be implemented using the often limited transportation facilities available to the platform, while the decision to evacuate relies on unpredictable weather forecasts. The net effect can be a shortage of time and personnel left unsupported offshore.

## 2. ACCIDENTS IN THE OFFSHORE INDUSTRY

Offshore oil and gas extraction operations drill deeper and farther offshore, operational hazards simultaneously increase in the severer environments. Using fixed, floating, and jack-up drilling units the industry must consider the physical limitations and historical experiences of each type to implement safety procedures and regulations to prevent losses and deaths.

The operations of oil platforms are highly sensitive to the weather conditions. If management is to make an effective decision on operations based on the weather forecast, risk analysis is a tool based upon the past field experiences and also upon the feelings of an expert in the field when hard data is unavailable. As the offshore oil industry is a recently new field the data on accidents is scare and often incomplete and inaccurate. To get a basis on which to analyze the risks of operations and evacuations a study should be made of the recorded accidents which resulted in sufficient loss of capital or human life.

An overall view of the loss rates of an entire platform or drilling units is a good start. The worldwide loss rate of installations, started in a report by the US. National Research Council is shown below.

*Table 2.1 Comparison of Offshore Operations Failure Probabilities* [2,3]

| | |
|---|---|
| Semisubmersibles | $5 \times 10^{-3}$ per installation per year |
| Fixed installations | $1 \times 10^{-3}$ per installation per year[4] |
| Registered Fishing Vessels | $1 \times 10^{-2}$ per ship per year |
| Merchant Shipping | $3.4 \times 10^{-3}$ per ship per year[5] |

These data are highly applicable to the US. GOM as a majority of the fixed installation losses occurred here due to hurricane forces overcoming designed loads, while the Semisubmersibles rate is applicable worldwide. The North Sea, on the other hand, with higher design standards, has an expected loss rate to be lower than the value started above for fixed platforms. The history of failure rate is shown in Figure 2.1. For a platform life of 25 years there is a significant chance of evacuation due to platform failure at roughly 10%.[6] The history of platform loss can be of use to risk analysis by dividing the chance of loss down into the specific causes of the initiating event. To further clarify the issue the fixed and jack-up structures have been separated. This study of severe accidents by cause is shown in Figure 2.2 and 2.3. These accidents can then be rated by the number of lives lost to give priorities on which to improve hazardous aspects of operation. A separate study is shown in Table 2.2 in which the accidents are described by cause of event and effect on lives lost. Another useful tool for risk analysis is the well documented cases of losses of human life.

*Figure 2.1 History of Reliability of Offshore Platforms in the Gulf of Mexico Subjected to Hurricanes 1950-1981*

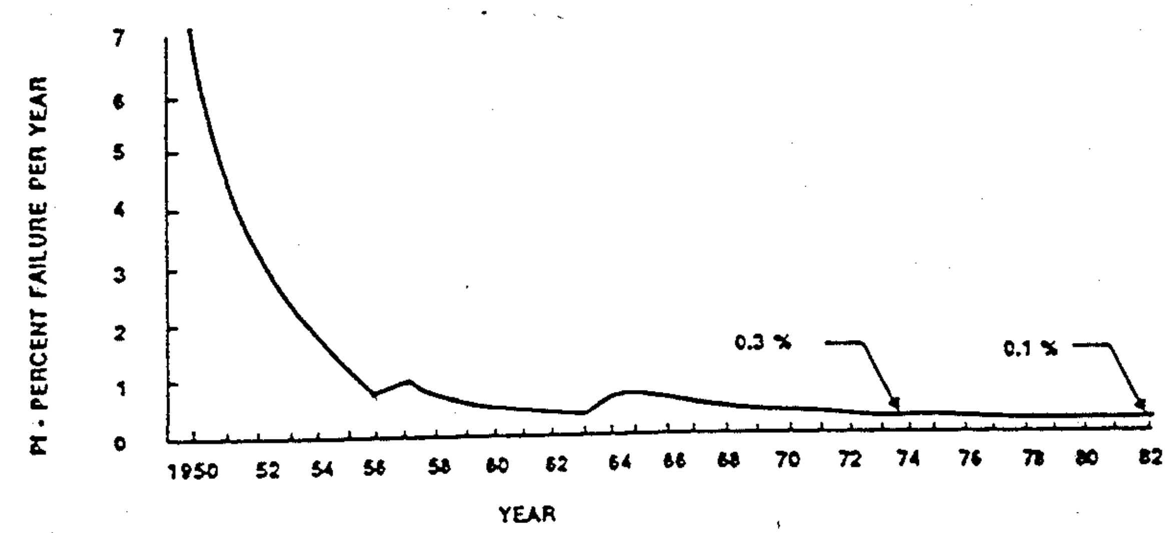


*Figure 2.2 Severe Accidents Worldwide of Fixed Structures*

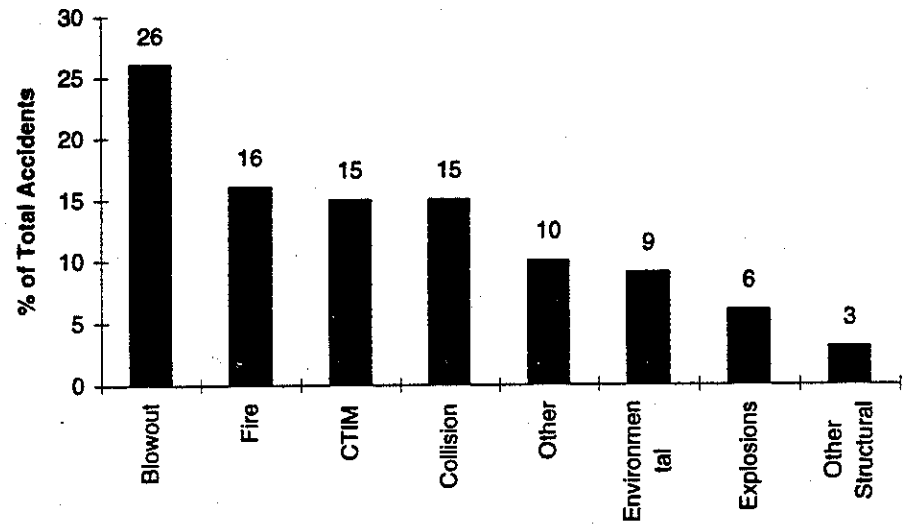



*Figure 2.3 Severe Accidents Worldwide of Jack Up Structures*

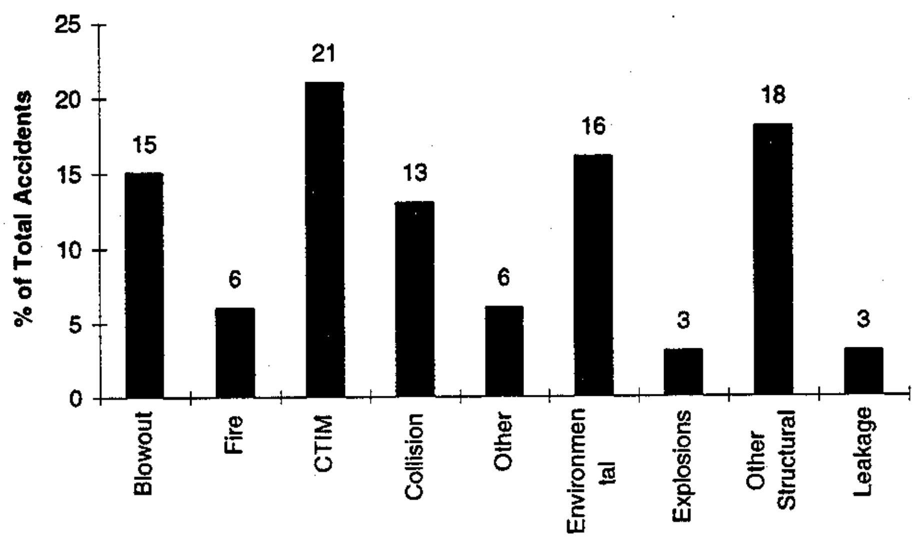


*Table 2.2 GOM Fatal Accidents 1970-79*

| | Events | Percent | Fatalities | Percent |
|---|---|---|---|---|
| <u>By Operation</u> | | | | |
| Drilling | 55 | 47 | 79 | 42 |
| Completion | 15 | 13 | 25 | 13 |
| Construction | 2 | 2 | 2 | 2 |
| Production | 42 | 36 | 77 | 41 |
| Abandonment | 2 | 2 | 4 | 2 |
| | | | | |
| <u>By Type of Accident</u> | | | | |
| Fire/Explosion | 14 | 12 | 36 | 19 |
| Machine or Equipment Failure | 39 | 34 | 51 | 27 |
| Personal | 5 | 4 | 14 | 17 |
| Vessel Mishap | 5 | 4 | 14 | 7 |
| Helicopter Crash | 4 | 3 | 31 | 17 |
| Blowout | 1 | 1 | 1 | 1 |
| Wave | 3 | 3 | 4 | 2 |
| Unknown | 6 | 5 | 6 | 3 |
| | | | | |
| <u>By Primary Cause</u> | | | | |
| Mechanical | 50 | 43 | 76 | 41 |
| Human | 47 | 41 | 81 | 43 |
| Natural Event | 4 | 3 | 5 | 3 |
| Unknown | 15 | 13 | 25 | 13 |

As most accidents in the oil industry are poorly documented the best alternative is the record of deaths by cause. The goal of all risk analysts, in the end, is to improve the overall safety of the working environment which in turn reduces the number of fatalities. The FAFR, fatal accident frequency rate, is a widely used description of risk to life due to occupation or type of activity engaged in. This value associated with the offshore oil industry can then be compared to other activities or occupations to get a reasonable assessment of the exposure to risk, see Table 2.3. The FAFR involved in individual activities of operations, diving, evacuations, etc. can then be separated to determine the high risk activities which can be avoided or improved to enhance safety.

***Table 2.3 Fatality Likelihood's of UK Business Man, Construction Worker and Offshore Platform Worker***

| Activity | | Fatality Likelihood ($x\ 10^{-4}$ per year) |
|---|---|---|
| **UK Business Man** | | |
| Background (Disease, etc.) | | 21 |
| Commuting | | 6 |
| Work (Office) | | 1 |
| Recreation | | 2 |
| Vacation | | 1 |
| | Total | 31 |
| **UK Construction Worker** | | |
| Background (Disease, etc.) | | 21 |
| Commuting | | 4 |
| Work (Office) | | 18 |
| Recreation | | 2 |
| Vacation | | 1 |
| | Total | 46 |
| **UK Offshore Platform Worker** | | |
| Background (Disease, etc.) | | 20 |
| Commuting | | 11 |
| Work (Office) | | 13 |
| Recreation | | 1 |
| Vacation | | 1 |
| | Total | 46 |

## 2.1 Evacuation Accidents

Numerous accidents have occurred worldwide with various degree of intensity and success in evacuation. Below is an incomplete list of, mainly, mobile offshore drilling unit(MODU) accidents involved in evacuation procedures.

*Table 2.4 Accidents in the Offshore Industry*

1. 1966, SEA GEM, North Sea, 13 men died during evacuation.

2. 1971, PANINTOIL II, Persian Gulf, jack-up, damaged by storm necessitating evacuation of crew of 55, 32 by helicopter, 23 by escape capsule (1 type Whittaker), no dead, no injured.

3. 1973, DIAMOND-M, Gulf of Mexico, jack-up, blowout, evacuation by 1 type of Whittaker capsule, 27 evacuated from rig and four more picked up later, no deaths, some injuries in incident (not as a result from evacuation method).

4. 1975, EKOFISK ALPHA, North Sea, 3 men died during evacuation.

5. 1976, DEEP SEA DRILLER, North Sea, semi-submersible ran aground in heavy seas, evacuation by TEMPSC (Harding) of entire crew of 50, 6 died when lifeboat overturned, 17 injured. The six fatalities were holding onto the outside of the TEMPSC, when it overturned.

6. 1976, OCEAN EXPRESS, Gulf of Mexico, jack-up, sank in storm, evacuation; 35 in tow survival capsules (both Whittaker), 1 by helicopter, 13 died of suffocation when capsule carrying 20 overturned during attempted pickup, number of injured unknown.

7. 1977, POOL RIG 22, Gulf of Mexico, jack-up, blowout, evacuation in tow type Whittaker capsules (28 in one, 13 in other), no dead or injured.

8. 1979, BOHIA 2, off China, MODU, capsized in storm, 72 lives lost.

9. 1980, ALEXANDER KIELLAND, North Sea, semi-submersible, capsized due to broken leg, evacuation by TEMPSC (5 'Harding' boats were attempted to be launched carrying an estimated total of about 185 men), by raft and by personnel basket, 123 died, may of these in the attempt to use TEMPSC.

10. 1982, OCEAN RANGER , off Newfoundland, semi-submersible, capsized in storm, evacuation probably attempted by TEMPSC (Watercraft and Harding); all 84 men died.

11. 1983, KEY BISCAYNE, off West Australia, MODU, capsized in heavy weather while under tow, no lives lost.

12. 1985, GLOMAR JAVA SEA, South China Sea, MODU, sank in typhoon LEX while operating, 81 lives lost.

13. 1985, ODECO PLATFORM 86A, GOM, fixed platform, experienced structural failure during Hurricane Juan and collapsed into the water, 5 men were washed overboard and rescued by U.S. Coast Guard, no lives lost.

14. 1988, ROWAN GORILLA I, off eastern Canada, MODU, sank during a storm while under tow, no lives lost.

15. 1989, SEACREST, Gulf of Thailand, MODU, sank in typhoon while operating, 91 lives lost.

16. 1989, INTEROCEAN II, Southern North Sea, MODU, capsized after breaking towline in heavy weather, no lives lost.

17. 1990, WEST GAMMA, Southern North Sea, MODU, capsized in heavy weather while under tow, no lives lost.

This list only includes the major, manned, offshore accidents involved in adverse weather conditions. Numerous other accidents have occurred in the GOM due to hurricanes which involve fixed platforms that have collapsed, moored MODU's that have their anchors dragged, over pipelines, 10 to 20 miles, or have broken their mooring lines only to be washed into fixed platforms.[7,8]

Obviously, the risks associated with evacuation procedures are dependent upon the method of evacuation and especially upon the weather conditions. Evacuations, if enough alert time is available and conditions are favorable, normally use helicopters as the main transportation method accepting personnel off of the platform heli-deck. If insufficient time is available and weather conditions permitting transfer of personnel to the stand-by-vessel(SBV) can be a likely alternative. Another alternative is to use Totally Enclosed Motor Propelled Survival Craft (TEMPSC), an enclosed life boat which is lowered to the sea by winches. If evacuation is immanent another alternative is the use of knotted ropes or chutes to inflatable life boats or, the last resort, jumping to the sea.

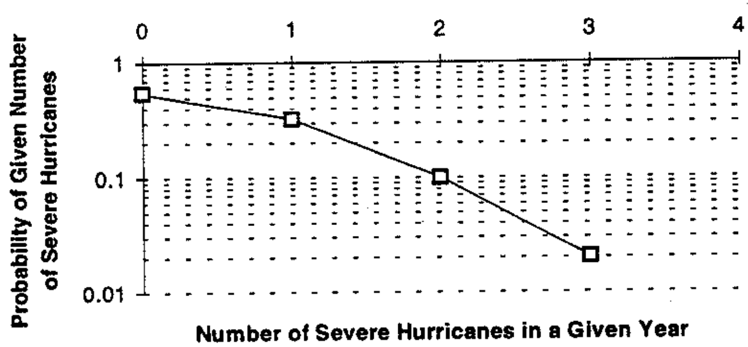
# 3. HURRICANES

## 3.1 Introduction

The main problem associated with operations in the Gulf of Mexico are the widely varying weather conditions. Winter presents some moderates storms. Then, a mild Spring and Summer are followed by Hurricane season with most activity from mid August to late September early November. This time of year exposes operations to unpredictable high intense cyclones. As a result, hurricanes have caused many disasters in the gulf over the last several years.

The number of hurricanes experienced in a season is highly variable. As the hurricanes develop in the mid Atlantic as a tropical depression and increase or decrease in intensity while headed for the eastern seaboard of the US., the variations in sea temperature, humidity, and weather fronts effect the intensity and direction of the hurricane. As a result, the number of severe hurricanes that actually affect the Gulf of Mexico can only be estimated by a probability based on past occurrence. This probability is shown in Figure 4.1. The chance of two severe hurricane events in a season (10 percent) validates the need for evacuation evaluation.

*Figure 3.1 Annual Number of Severe Hurricanes*



### 3.2 Intensity Scales

The intensity of a hurricane is very difficult to describe accurately, therefore scales of estimating the intensity have been developed. The main scale is the Beaufort Wind force scale which describes differing levels of wind speeds. This scale has been implemented to describe the fully arisen sea state associated with these winds. This scale assumes the required fetch and duration of wind is attainable, but for hurricanes this may not be so. This scale is presented in Table 3.1. The other scale, a more simplified one, describes only hurricane conditions. The Saffir/Simpson Damage-Potential Scale is shown in Table 3.2. This scale is used to predict the amount of damage the hurricane will cause when it meets land. This scale is used by the US. National Weather Service to give public-safety officials an estimate of the hurricanes damage potential due to winds and storm-surges. Finally, an estimate of the hurricane's severity can be related to the Beaufort scale.[9]

*Table 3.1 Fully Arisen Sea State Scale*

| Sea State | Beaufort Wind Force | Description | Wind Velocity (knots) | Wave Height Average (feet) | Wave Height Significant (feet) |
|---|---|---|---|---|---|
| | U | Calm | 0 | 0 | 0 |
| 0 | 1 | Light airs | 2 | 0.04 | 0.01 |
| | 2 | Light breeze | 5.0 | 0.3 | 0.5 |
| | 3 | Gentle | 8.5 | 0.8 | 1.3 |
| | | breeze | 10.0 | 1.1 | 1.8 |
| 2 | 4 | Moderate | 12.0 | 1.6 | 2.6 |
| | | breeze | 13.5 | 2.1 | 3.3 |
| | | | 14.0 | 2.3 | 3.6 |
| 3 | | | 16.0 | 2.9 | 4.7 |
| | | | 18.0 | 3.7 | 5.9 |
| 4 | 5 | Fresh | 19.0 | 4.1 | 6.6 |
| | | breeze | 20.0 | 4.6 | 7.3 |
| 5 | | | 22.0 | 8.9 | 14.3 |
| | 6 | Strong | 24.0 | 6.6 | 10.5 |
| | | breeze | 24.5 | 6.8 | 10.9 |
| 6 | | | 26.0 | 7.7 | 12.3 |
| | | | 28.0 | 8.9 | 14.3 |
| | 7 | Moderate | 30.0 | 10.3 | 16.4 |
| | | gale | 30.5 | 10.6 | 16.9 |
| | | | 32.0 | 11.6 | 18.6 |
| 7 | | | 34.0 | 13.1 | 21.0 |
| | 8 | Fresh | 36.0 | 14.8 | 23.6 |
| | | gale | 37.0 | 15.6 | 24.9 |
| | | | 38.0 | 15.6 | 24.9 |
| | | | 40.0 | 18.2 | 29.1 |
| 8 | 9 | Strong | 42.0 | 20.1 | 32.1 |
| | | gale | 44.0 | 22.0 | 35.2 |
| | | | 46.0 | 24.1 | 38.5 |
| | 10 | Whole | 48.0 | 26.2 | 41.9 |
| | | gale | 50.0 | 28.4 | 45.5 |
| | | | 51.5 | 30.2 | 48.3 |
| | | | 52.0 | 30.8 | 49.2 |
| | | | 54.0 | 33.2 | 53.1 |
| 9 | 11 | Storm | 56.0 | 35.7 | 57.1 |
| | | | 59.5 | 40.3 | 64.4 |
| | 12 | Hurricane | > 64 | > 46.6 | 74.5 |

*Table 3.2 Saffir/Simpson Damage-Potential Scale*

| Scale Number (Category) | Central Pressure Millibars | Inches | Winds Knots | Storm Surge Feet | Damage |
|---|---|---|---|---|---|
| 1 | >980 | >28.94 | 71-91 | 4-5 | Minimal |
| 2 | 965-979 | 28.50-28.91 | 92-105 | 6-8 | Moderate |
| 3 | 945-964 | 27.91-28.47 | 106-124 | 9-12 | Extensive |
| 4 | 920-944 | 27.17-27.88 | 125-148 | 13-18 | Extreme |
| 5 | <920 | <27.17 | >148 | >18 | Catastrophic |

*Table 3.3 Storm Intensity Levels and Descriptions*

| Weather Condition | Beaufort Scale | Significant Wave Height |
|---|---|---|
| Calm | Force 3 and less | < 0.5m |
| Moderate | Force 4 to 7 | 0.5-3.3m |
| Severe | Force 8 and above | >3.3m |

### 3.3 Forecasting

In the time span of operation in the GOM significant improvements in the science of weather forecasting have occurred, but cost-cutting by the industries has resulted in lower fees paid for forecasting services.[10] Less time for an individual platform's forecast results reducing accuracy which has raised risks associated with weather.

The science of meteorology requires much atmospheric data to be gathered worldwide. Many land based observation stations contribute information vital to forecasting, but oceanic atmospheric data can only be accurately described by satellite imagery. These data then can be analyzed by computers which, from numerical modeling, can give a most likely scenario of weather conditions. Individual differences in the numerical models can produce varying forecasts as seen in Figure 3.2,3.3,3.4. For a medium range weather forecast (2-5 days ahead) a cut-off time must be specified at which the current weather data must be analyzed. This cut-off time can produce variations in the forecast just by differences in the starting conditions. To get a general consensus of the possible scenarios several runs can be made and analyzed for a trend in which a most likely case can be seen. The human forecaster should view several predictions and assess a broad trend. The forecaster then should give his predictions with a clear statement of his level of confidence, and he should state any possible deviations which could affect operations for a specific platform in a specific area.

*Figure 3.2 Surface Analysis at 0001 GMT 13 November 1985*

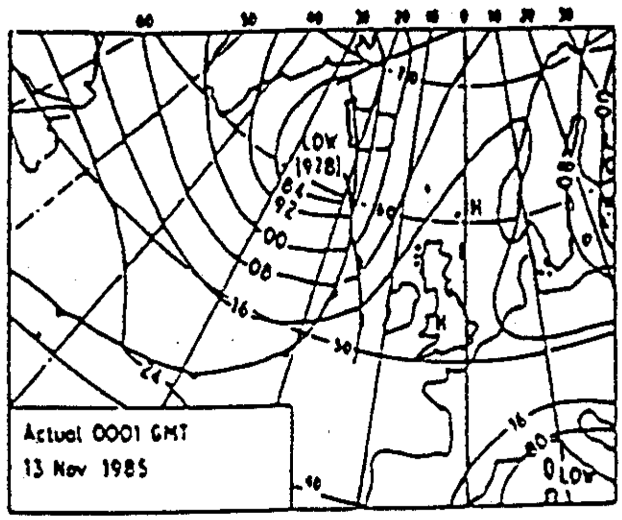



*Figure 3.3 132-Hour Surface Forecasts for 1200 GMT 18 November 1985*

Based on Two of the Major Numerical Models

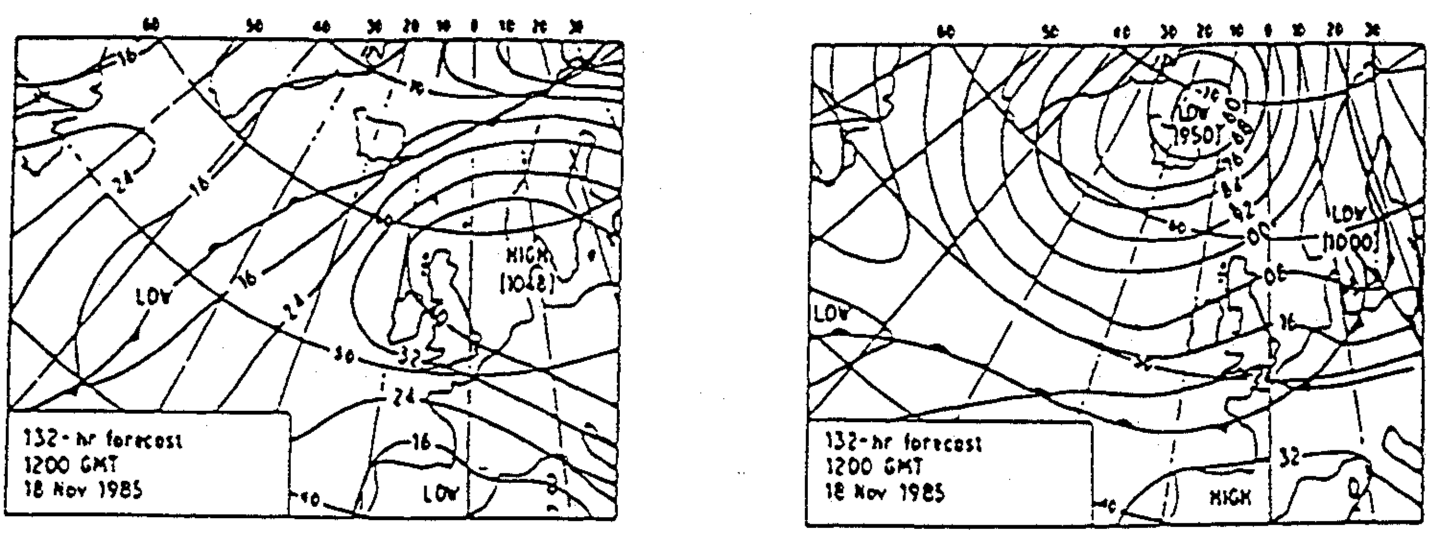
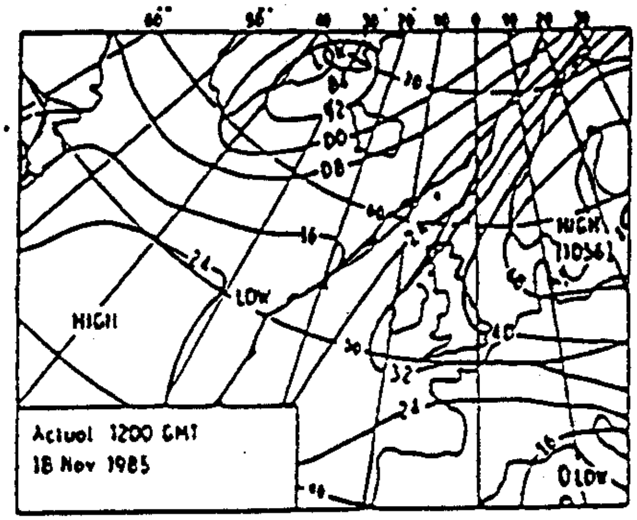


*Figure 3.4 Verifying Surface Analysis for 1200 GMT 18 November 1985*




As of recently, the cost-cutting of the industry has resulted in less accurate forecast. In the late 1960s and early 1970s adequate fees were allocated to meteorological organizations which produced good quality services. Proper levels of staff were devoted to each industry's operations and the limits of weather conditions in which the operations could be performed. As the mid-1970s through mid-1980s came about, competitions in the forecasting business led to reduction of fees which led to a slight reduction in the amount of time and staff allocated to each forecast. Presently, the fees paid for weather services has dropped even lower, not even considering inflation. Thus, the meteorological services are producing computer forecasts for 20 to 30 specific areas every 12 hours without knowledge of operations[11]. These forecasts lack a level of confidence assessment, a statement of possible variations, and a general lack of knowledge of the industries present operations, i.e. production, construction, transportation, etc. This lack of information to the industry can result in tragedies as weather conditions quickly deteriorate. This is especially valid for the towing of MODU's.

The transportation of mobile offshore drilling units (MODU) is greatly influenced by weather conditions. During the towing a company may only request the normal 12 hourly forecast, which can result in tragedy as the MODU is towed unknowingly into a storm. One forecast may predict a storm well off the track of the MODU's course, but with these quick inaccurate forecasts, the storm may deviate into the MODU's course. Also, predictions of wind and wave levels may be acceptable for the tow, but without an estimate of possible fluctuations the actual winds and waves could exceed the towing limits. These possibilities may be able to describe the recent accidents in the offshore industry.[12]

With all the variables associated with hurricanes, the ability to predict the location, speed, and intensity is a very inaccurate science. The US. Weather Service and the National Hurricane Center with all their recourses combines are still unable at this time to forecast the hurricane to any degree of accuracy. A normal forecast advisory is shown in Table 3.4. As seen in the advisory the Hurricane Center reports on the degree of accuracy of their present forecast, But not presented in the advisory is the 12, 24, and 72 hour forecast error.

***Table 3.4 MARINE ADVISORY ISSUED BY THE NATIONAL HURRICANE CENTER AT 0400 GMT ON 22 SEPTEMBER 1975[13]***

STORM CENTER LOCATED NEAR LATITUDE 24.2 NORTH LONGITUDE 89.2 WEST AT 22/0400Z. POSITION ACCURATE WITHIN 20 MILES.

PRESENT MOVEMENT TOWARD THE NORTH-NORTHWEST OR 340 DEGREES AT 11 KT.
MAX SUSTAINED WINDS OF 45 KT NEAR CENTER.
RAD OF 34 KT WINDS 100NE 50SE 50SW 100NW QUAD.
RAD OF SEAS 15 FT OR HIGHER 100NE 50SE 50SW 100NW QUAD.
REPEAT CENTER LOCATED 24.2N 89.2W AT 22/0400Z.

12 HOUR FCST VALID 22/1200Z LATITUDE 26.5N LONGITUDE 89.3W
MAX SUSTAINED WINDS OF 55 KT NEAR CENTER WITH GUSTS TO 70 KT.
24 HOUR FCST VALID 23/000Z LATITUDE 28.0N LONGITUDE 88.9W.
MAX SUSTAINED WINDS OF 70 KT NEAR CENTER WITH GUSTS TO 90 KT.
RADIUS OF 50 KT WINDS 50NE 25SE 25SW 50NW QUAD.

As many variables are involved in the creation, movement, and strength of a hurricane even the seemingly simple prediction of the present location of the hurricane becomes a complex problem. Satellite images and data buoys are the main information source for the prediction of hurricane location and intensity, but these information sources take time to process the data. This down time causes the main problem of exact location. To forecast the hurricane 12 or 24 hours the current data which is already inaccurate must be used as a basis for the prediction. As a result of the time lag and the variations of the hurricanes forward speed, heading, and intensity forecasts are not highly accurate. As seen in Figure 3.5 a hurricane's forward speed can be estimated from a probability based on past observations. Because of this uncertainty in the forward speed and direction of heading the associated forecast track error for the Hurricane Center 1992 predictions are shown in Figure3.6,3.7.

*Figure 3.5 Average Distribution of a Hurricane's Forward Speed*

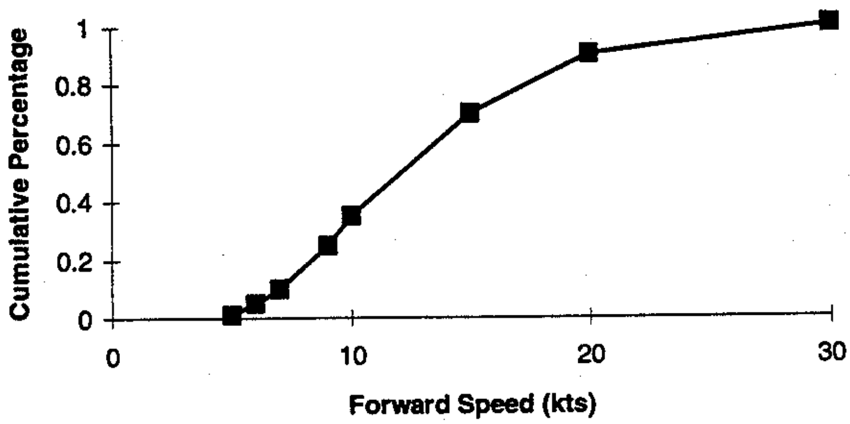


*Figure 3.6 Official Track Error Atlantic Ocean, 1992*

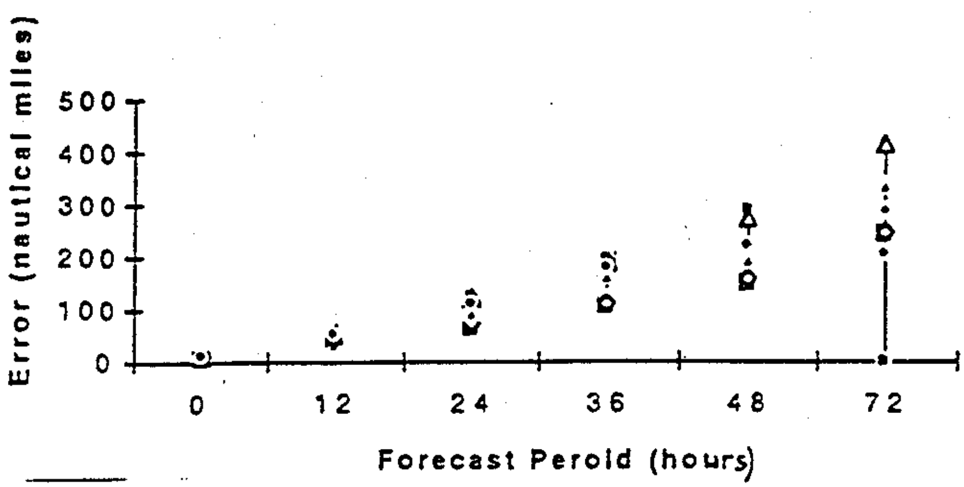
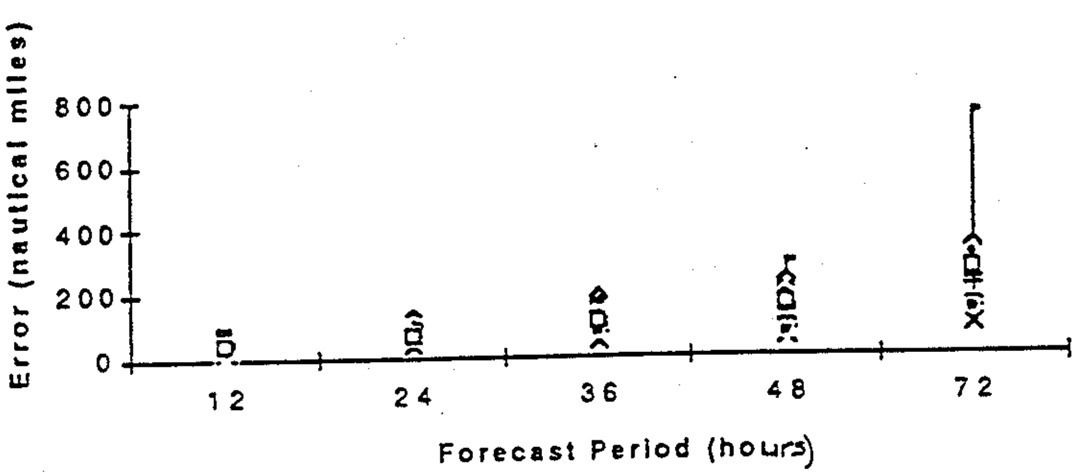



*Figure 3.7 Official Track Forecast Error Eastern Pacific, 1992*




### 3.4 Hurricane Alleys

Cooper investigated the possibility of the existence of hurricane alleys, areas of the gulf where hurricane intensities are recurrently high. Basing the investigation on the gulf water temperature stratification layer and hurricane theory, Cooper presented a preliminary report which determined two alleys which are roughly 20% more intense than elsewhere.[14] This corresponds to a 3-4 m wave height difference than the rest of the GOM using the existing API criteria RP2A.[15]

The first aspect of the report was to find a correlation between intensity and water temperature. Since a good estimate of a hurricanes intensity is the central pressure index(CPI), the barometric pressure difference between the eye and the surrounding atmosphere, the CPI is used as a direct intensity measurement.[16] Figure 3.8 plots the CPI of 100 hurricanes with respect to location in the Gulf of Mexico. Hurricane experts have known for several decades that hurricane intensity is closely related to sea surface temperature (SST).[17] This is because the hurricane is a Carnot cycle engine fueled but the difference between the SST and the air temperature, Figure 3.9. In the hurricane, air spirals from a toward the storm center at point c acquiring entropy from the ocean surface of temperature $T_s$. The air then ascends adiabatically from point c flowing outward near the storm top to some large radius at point o. At this point, the excess entropy is radiated to the lower stratosphere at temperature $T_o$.[18] Ideally, the warmer the SST, within 100 km of the eye, the more intense the hurricane. Severe hurricanes stir up the subsurface waters, thus drawing cooler waters to the surface which can weaken the hurricane, Figure 3.10. It is important to note that if the hurricane has a high translation speed the ocean response has less effect on the storm severity. For slower hurricanes, if the mixing layer is deep enough the cooler waters can be the order of a degree or two, on the other hand if the layer is shallow much cooler water will reach the surface. Cooper prepared a graph of the CPI verses the water temperature at 60 meter depth to see if a correlation existed, he received a 0.6 correlation.[19] Thus, a warm, deep mixing layer seems beneficial to the intensity of the hurricane by providing fuel to its Carnot engine, but the intensity may lag changes in SST by more than a day. A map of the water temperature at a certain depth, Figure 3.11 shows excellent correlation to Figure 3.8. Figure 3.11 depicts two areas of two areas of warm waters designated by $H_e$ and $H_w$ which originate from the Loop Current and its eddies which bring warm Caribbean water into the Gulf.[20]

*Figure 3.8 Spatial Variation of Central Pressure Deficit (mb) in the GOM 1900-1989*

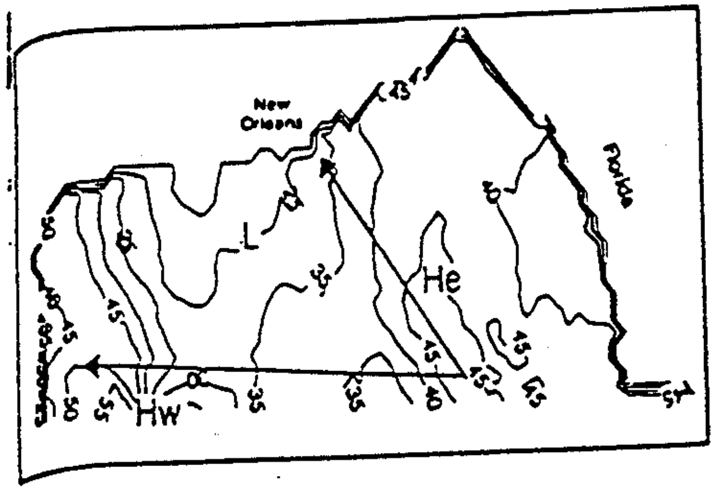



*Figure 3.9 Cross Section of A Hurricane Illustrating the Carnot Cycle*

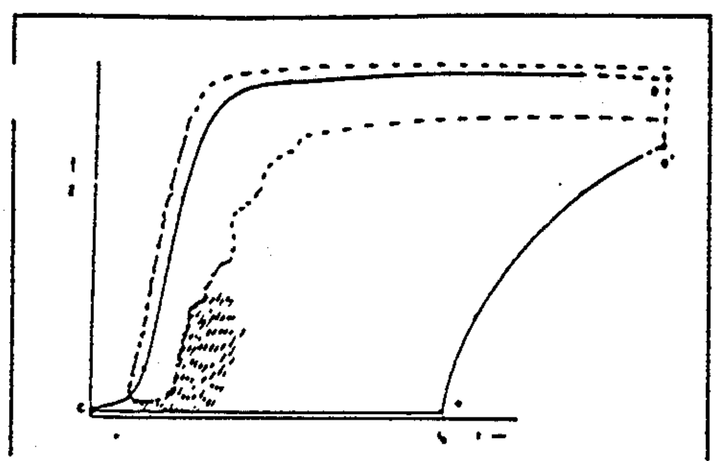


*Figure 3.10 Gulf Water Temperature Profile Before and After a Hurricane*

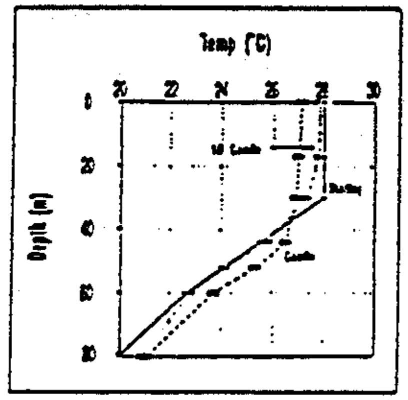
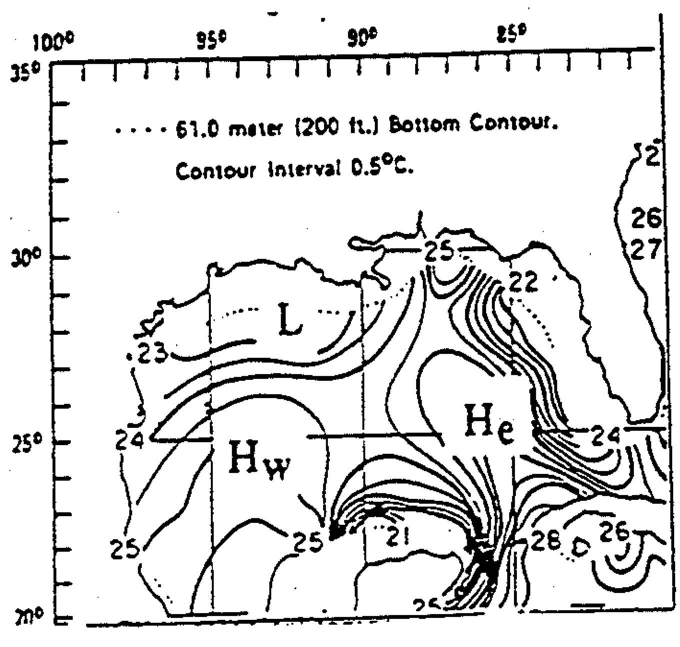


*Figure 3.11 Water Temperature Distribution at 60m during September in GOM*




Most of the largest hurricanes come into the Gulf of Mexico through the Yucatan Channel between Mexico and Cuba as seen in Figures 3.12,3.13. This is to be expected as a hurricane looses much of its strength by crossing over land as the wind is reduced by obstructions and land friction. Also, the loss of moisture from the ocean leaves the hurricane without a fuel source. The hurricane then continues its wandering path through the Gulf until it hits land and eventually dissipates. An interesting side note, previous work suggests a hurricanes track can be influenced by SST.[21,22] Therefore, the Gulfs mixing-layer temperature and depth provide an invaluable aid to prediction of hurricane intensity and maybe even heading, but a lack of data and processing speed can undermine its accuracy. Even as a basic guide, the existence of hurricane alleys can aid in the evacuation of offshore and onshore personnel.

*Figure 3.12 Tracks of 5 Largest Hurricanes*

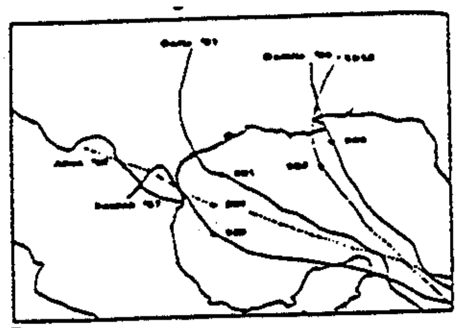
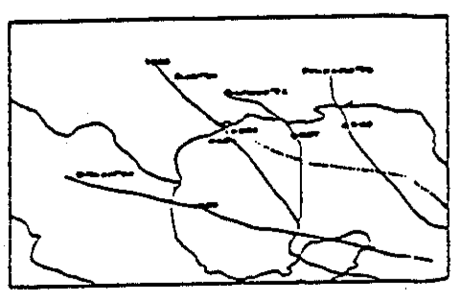


*Figure 3.13 Tracks of 5th-10th Largest Hurricanes*



## 3.5 Wind and Wave Profiles

Several models have been developed based on past observations of hurricanes to predict the associated wind and wave profiles. These models incorporate a basic parameter of the hurricane such as barometric pressure at the center, and wave profiles at that time.

As the barometric pressure of the hurricane can change at any time due to variations in the sea, or atmosphere, these models can only be used with care. Examples of the predicted wind and wave profiles are compared to real profiles in Appendix 1.

### *3.6 Locally Generated Tropical Storms*

Another problem associated with operations in the GOM is the occurrence of locally generated tropical storms (LGTS). These storms can materialize quickly and without warning. With time the storm generates strength the same way as a hurricane extracting energy from the warm gulf waters. The problem with these storms is their lack of predictability and strength can cause hazardous operating conditions when none are expected.

Evacuation from a platform due to the locally generated storms is not a normal activity. Since the strength of the storm is much less than that of a hurricane the crew on the rig normally rides out the storm on the platform. With the quick onset of the storm and the short duration an evacuation would feasibly be more hazardous than non evacuation. Obviously, if the current operations of the rig are highly dependent upon weather conditions the onset of the storm should be prepared for by curtailing operations until the event is over.

# 4. HELICOPTERS

Easily the most widely used method of transportation of personnel and equipment for offshore platforms are helicopters. Independent companies such as Petroleum Helicopters Inc. (PHI) support the oil companies with operations offshore. Many successful personnel evacuations have taken place due to impending hurricanes.[23] A breakdown of the amount of evacuations done by helicopters is shown below.

***Table 4.1 Amounts and Types of Helicopter Use***[24]

47% of evacuations worldwide have involve helicopters
79% of evacuation in the North Sea have involved helicopters
During Storm Conditions
64% of storm evacuations worldwide
88% of storm evacuations in the North Sea

On the other hand, normal transportation operations with helicopters have resulted in fatal accidents. Table 4.2 lists some of the fatal helicopter accidents in the North sea in a ten year period. One such recent accident, the Cormorant Alpha platform crashed of a Bristow helicopter in the North Sea in 13 meters seas and 60 knot winds, resulted in 11 deaths.[25] This recent accident has brought an inquiry into the safety aspects and operating regulations of offshore helicopters. Similar lists of fatal accidents exist for other areas of the world, including the Gulf of Mexico.

*Table 4.2 Fatal Helicopter Ditching Incidents*

North Sea

| Year | Aircraft Type | Country | Deaths |
|---|---|---|---|
| 1973 | S61 | Norway | 4 |
| 1974 | S61 | Netherlands | 6 |
| 1976 | S61 | UK | 1 |
| 1977 | S61 | Norway | 12 |
| 1978 | S61 | Norway | 18 |
| 1981 | Bell 212 | UK | 1 |
| 1981 | Wessex | UK | 13 |
| | | Total | 55 |

## 4.1 Regulations

Presently there are several regulations regarding the operations of helicopters that may or may not be followed by the oil companies.[26] One such statutory regulation is that the platform's standby vessel be informed when a helicopter operations are to take place. Some companies have even stricter regulations such as Shell Expro's HLO manual which states the standby vessel should come within 500 meters downwind of the platform during take-offs. Other regulations require the use of survival suits as well as lifejackets. New recommendations have come about from the recent Cormorant crash. Below is a list of the recommendations by Sheriff Alexander Jessop of the Aberdeen court of the United Kingdom.[27]

*Table 4.3 Safety Recommendations for Helicopter Operations*

- Use of survival suits on all shuttle flights
- Specifications of survival suits, lifejackets, and safety equipment
- Emergency lighting in helicopters
- Operation of door-jettison equipment when a helicopter is inverted in water
- Deployment of floatation bags on helicopters
- Mounting of helicopters life rafts
- Use of cordless headsets by pilots (a Cromorant victim was trapped by a headset cord wrapped around his neck)
- Restriction of helicopter operations in severe weather
- Adequacy of infield helicopter search and rescue facilities
- The position of standby vessels when shuttle flights are in progress

## 4.2 Helicopter Types

Since the offshore industry is made up of many different companies there are several different types and makes of helicopters used for transportation. Table 4.4 lists some of the major types of helicopters. Other specifications are listed in Appendix 2.

*Table 4.4 Helicopter Specifications*

| Type | Average Cruise Speed | Max Range | Passengers |
|---|---|---|---|
| Boelkow 105 CBS | 117 kts | 234 nm | 4 |
| Sikkorsky S-76 | 130 kts | 348 nm | 12 |
| Aerospatiale AS 355F-1 | 117 kts | 335 nm | 5 |
| Bell 412 | 117 kts | 252 nm | 11-13 |
| Bell 206L-1 II | 113 kts | 270 nm | 6 |
| Bell 206B-III | 104 kts | 260 nm | 4 |
| Bell 212 | 100 kts | 245 nm | 11 |

## 4.3 Performance in Adverse Weather

### 4.3.1 Risks

To effectively evaluate the performance and risks of helicopter operations in adverse weather conditions it is necessary to gather any accident data available. This data is hard to come by and is frequently inaccurate, incomplete, and unorganized. A report by Technica on the safety of helicopter operations gave a overall failure rate of 0.0001 per trip based on historical records.[28] One of the problems with available accident data is the frequency of power line collisions. This is not applicable to the offshore industry, thus, it is an over-estimate by approximately 10 percent of the real risk involved Figure 4.1. A report done by Trident Marine Services, Table 4.5,4.6, provides a comprehensive estimate of the probability of accidents and failures of offshore helicopter operations. One of the problems of this data is that the information covers all ranges of operating conditions, and specific operations in severe weather will subsequently have a much higher risk associated with it. This problem is applicable to Figure 4.1.[29] Another source, the U.S. Naval Safety Center has a computer data base on all types of Navy accidents. This data covers all types of accidents from fatalities to first aid in all types of weather conditions over a sixteen year period. Figure 4.2 shows severe accidents of Navy helicopters with respect to weather conditions. Obviously, this provides a scenario in which the weather conditions can be used to predict the risk of helicopter operations, but the only problem with this information is the lack of operating times, or a base upon which to estimate an associated risk.

*Figure 4.1 U.S. Helicopter Accidents*

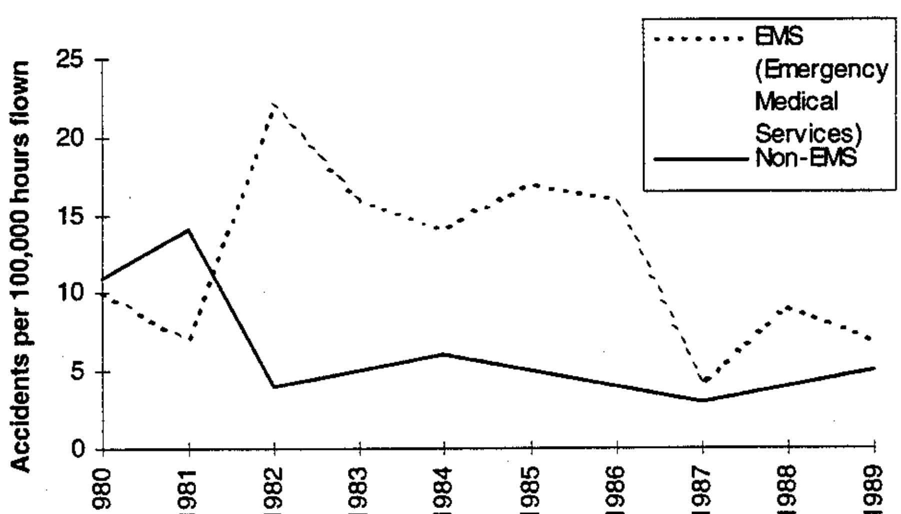


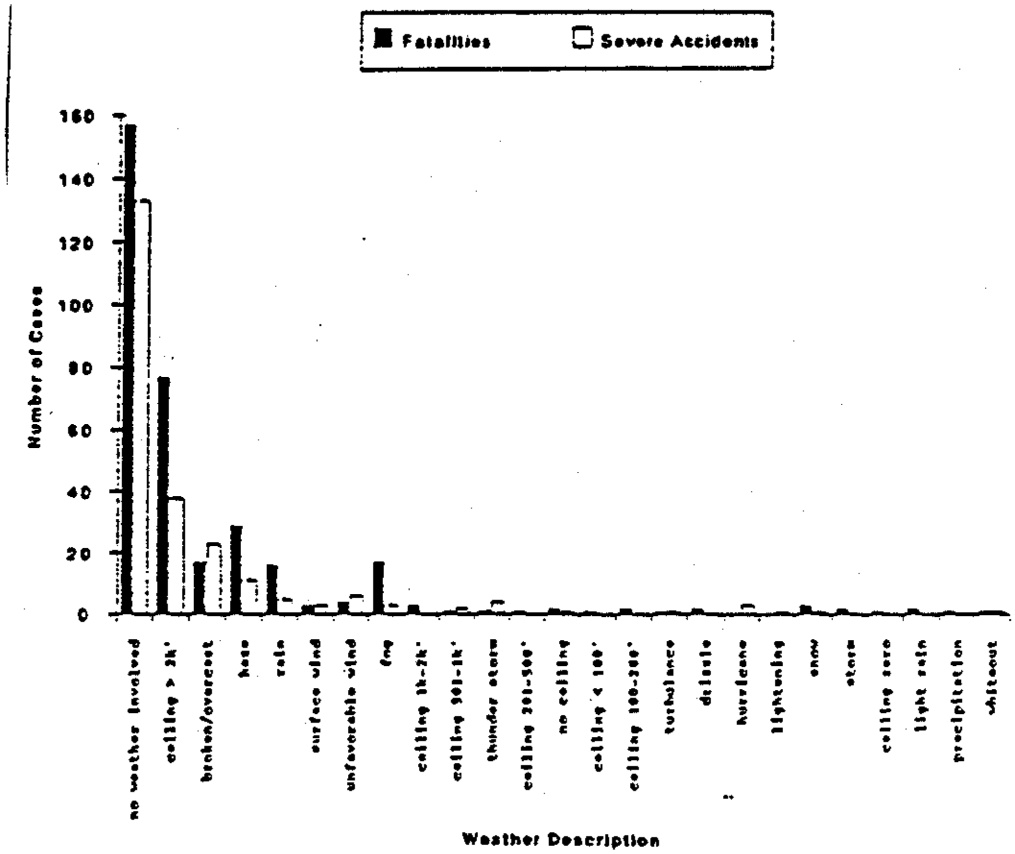
*Table 4.5 Helicopter Accidents*

| | N. Sea 1985 -90 per Year | GOM 1986-90 per Year |
|---|---|---|
| In Flight | | |
| Total | 0.83 | 2.20 |
| Major | 2.17 | 0.40 |
| Minor | 0.67 | 0.40 |
| Start Up | | |
| Total | 0.00 | |
| Major | 1.17 | |
| Minor | 1.50 | |
| Fatalities (total) | | 8 |
| Crew | 4 | |
| Passengers | 47 | |
| Fatal Accidents | 2 | |
| F.A./Stage | 8.81 E-7 | 7.60 E-7 |
| F.A./Hr | 2.08 E-6 | 2.59 E-6 |

*Table 4.6 Helicopter Data*

| | N. Sea 1985-90 | GOM 1986-90 |
|---|---|---|
| No. in Service | 177 | 626 |
| Hours Flown | 159,922 | 540,210 |
| Flight Stages | 378,212 | 1,841,066 |
| Aircraft Kkm | 33,033 | |
| Passenger Kkm | 370,292 | |
| Passenger | 2,811,883 | 3,601,424 |
| Ave Speed km/hr | 207.0 | |
| km/stage | 87.0 | |
| pass. km/AC km | 11.2 | |
| pass. km/pass carried | 132.0 | |
| Pass./stage | 7.2 | 2.0 |
| Time/stage mins. | 25.0 | 18.0 |
| Fatal Accidents | 2.0 | 7? |
| Fatalities | | |
| crew | 4.0 | 5.0 |
| passengers | 47.0 | 6.0 |

*Figure 4.2 Navy Helicopter Severe Accidents 1977-1993*




### 4.3.2 Operating Limits

For an individual type of helicopter a specific definition of an operating limit does not exist. Obviously, there is a vertical ceiling limit for helicopters, but the limits for take-off and landing are harder to define. Wind conditions can prevent engine start around 35 to 45 knots.[30] For personnel transfer the helicopter would not have to shut down therefore, the limit is pushed up higher. If an ideal wind existed the helicopter could ideally land and take off at wind speeds near its cruising air speed. But nature provides no ideal scenarios and gusts are the cause of problems. The landings present the most difficulties while two estimates of the limit have provided 60 knots.[31]

# 5. STAND BY VESSELS

British regulations require a manned platform to have a support vessel within a five nautical mile radius.[32] These stand by vessels (SBV) have a multiservice capacity of evacuation, fire control, rescue, blow out control, pollution pickup, and many other daily operations. These SBV are normally well equipped for evacuation as the wounded and healthy all can be accommodated. The vessels can take on a full load of passengers and still survive severe weather conditions. Therefore, it seems that the most favorable evacuation method would be the SBV. This may be the case for calm weather evacuations as the major problem with the SBV is the transfer of personnel to the ship. There are several ways of transferring personnel, but they are all largely dependent upon the weather conditions.

## *5.1 Personnel Transfer*

There are two main methods for personnel to get to an attendant vessel, but neither are in common use in the north Sea, where SBVs are most prevalent:

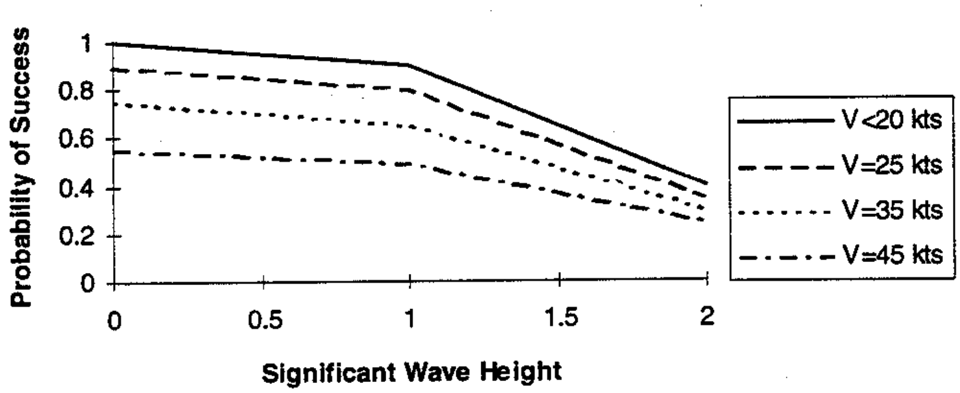
- Personnel transfer basket. This involves the use of a crane with a basket attached which is loaded on the platform and swung out to the waiting vessel.
- Swing ropes located under the platform in which the personnel swing to the vessel deck.

Both of these methods are highly dependent upon the wind and wave conditions.

## *5.2 Transfer Basket*

The transfer basket is a simple effective way to transfer personnel to a SBV. A normal basket can hold approximately 4 personnel and in mild weather can be accomplished in less than 3 to 4 minutes.[33] If foreseen an evacuation in mild weather can quickly and safety be accomplished with relatively no probability of an accident occurring. As the weather conditions deteriorate the chances of an accident increase quickly, and the use of a transfer basket can chances of an accident increase quickly, and the effective transfer basket can become a hazardous activity. First, an evaluation of the effect of wind speed alone upon the basket should be considered. As the basket can be on the end of a 50 to 70 foot cable while being lowered to the deck of the ship below the gusts of wind can whip the basket back and forth. This movement alone can make the transfer a very hazardous task. If the wave conditions are then taken into considerations the limit of an effective transfer by basket are lowered drastically. The wave state determines the vertical and horizontal movements of the vessel, thus, as the waves become larger the motions are greater and the chance of safely landing the basket on the deck gently are slim. The accidents associated with personnel baskets are most commonly caused by the impact of the ship and the basket. Broken bones, crushing, and men overboard can all be caused by the ship rising out of a wave trough and crashing into the basket hanging above. Therefore, combining the wind and wave conditions the limits if successful transfer are reduced to mild weather conditions as seen in Figure 5.1.

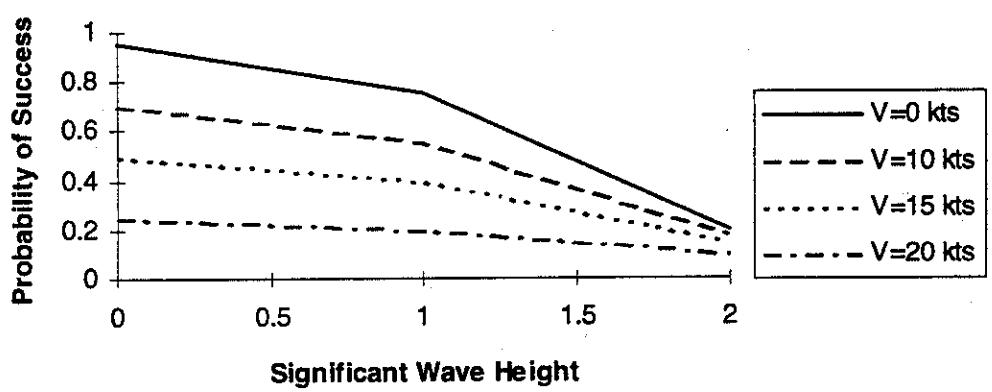
***Figure 5.1 Personnel Transfer from Fixed Platform to Vessel by Basket***



### *5.3 Swinging Rope*

The swinging rope method of personnel transfer is a hazardous activity to non experienced personnel even in mild weather states. The principle behind the rope swing is that the man stands at the edge of the platform holding onto a rope that is hanging from the platform and then he swings out over to the other vessel, and lets go when he gets there. This method can result in a quick transfer or quick transfer, but can be dangerous if someone drops into the water between the vessel and platform. The successful use of a rope swing is highly dependent upon the wave conditions as well as the wind state. The wind can prevent the person from reaching his destination and stand him between the two. The waves make the transfer hazardous to even the skilled transfer person. As the vessel pitches, heaves, sways, and rolls the man must time the swing perfectly so that he is not too low on the rope or too far from his destination. Quantifying these risks can only be done by gathering information from an expert, the rig worker, and finding a limit. This has been done with conversations with an expert in the field who gathered information from the workers.[34] The result is shown in Figure 5.2.

*Figure 5.2 Personnel Transfer from Fixed Platform to Vessel by Swinging Rope*

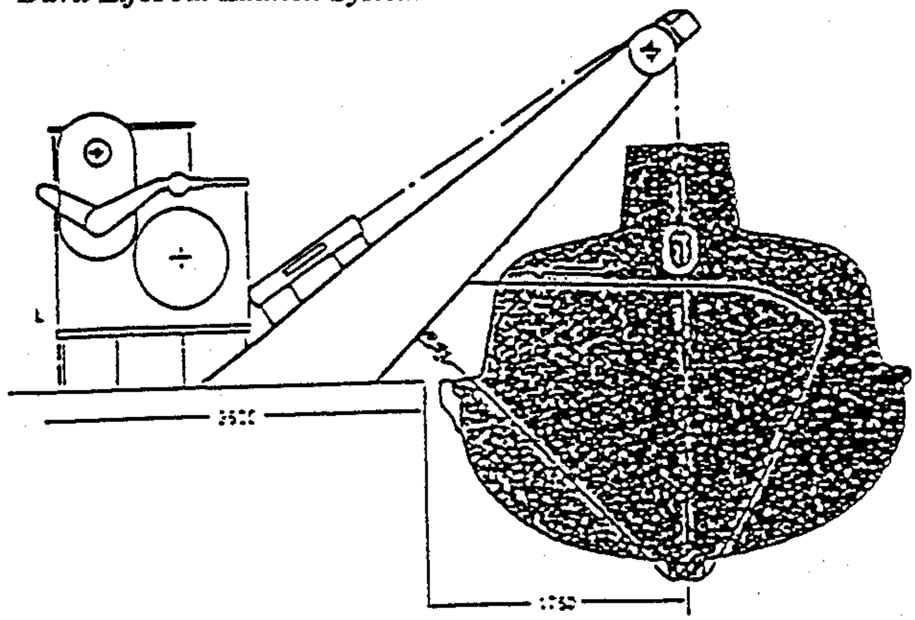


# 6. TEMPSC

In an emergency situation, when the need to evacuate is immanent, and helicopter and vessel evacuation methods are unavailable or too time consuming, the Total Enclosed Motor Propelled Survival Craft can be used. The TEMPSC is basically an enclosed, often self-righting, lifeboat which is lowered from the platform deck to the water below. In mild weather conditions the TEMPSC is an effective evacuation method for many types of accidents. As weather conditions become more severe the expected success rate of evacuation in a TEMPSC drops. In some conditions, such as an ignited sea surface blowout, the TEMPSC offers the only safe evacuation route.

There are several types of TEMPSC on the market currently with obvious differences, but the overall characteristics are all basically the same. The main crafts used in the offshore industry are the Harding, Whittaker, and the Watercraft.[35] The boats are located at the operation deck level and are stationed on several sides of the platform, see Figure 6.1. Once loaded the boats are lowered to the water surface by use of cranes. Some lowering system use one cable (which can result in twisting of the TEMPSC in severe weather but have a better chance of successful release once in the water) while others use two cables which reduces twisting (but can lead to additional release problems). Once the boat enters the water a release liver is pulled and the boat is left to its own power to accelerated away from the platform. Depending upon weather conditions the boats may be towed by other vessels and then unloaded or unloaded on site onto a vessel or helicopter. This sequence of events is explored in greater detail in the next section for analyses of problem areas.

*Figure 6.1 Davit Lifeboat Launch System*



### 6.1 Evacuation Steps

Table 6.1 lists the steps I a normal evacuation by TEMPSC.[36]

*Table 6.1 Evacuation Sequence*

1. Muster alarm goes off.
2. Personnel make way to Boat Stations
3. Personnel are accounted for at Boat Stations
4. Order given to evacuate by survival craft
5. Craft prepared to launch
6. Embarkation
7. Lowering mechanism activated
8. Craft descends under control to near sea level
9. Craft descends final distance to sea level
10. Craft release gear activated successfully
11. Craft moves away from platform
12. Craft remains intact while awaiting pick up
13. Personnel recovered successfully from survival craft
14. Recovery unit returns personnel to shore

Each step listed above includes a risk associated with the activity involved, and these failure modes can be analyzed to find the causes which can then be eliminated or reduced.37

Step 1. Muster alarm goes off.

Failure: 1. Alarm inoperable

Cause: power supply failure
broken alarm
alarm turned off
alarm sensitivity too low

2. Alarm unseen or unheard
operation noise too loud
personnel inattentive

3. Personnel ignore alarm
ignorance
'Cry wolf' syndrome

Step 2. Personnel make way to Boat Stations

1. Obstructions to escape routes
smoke or fire hazards
platform modifications
lighting inadequate

Step 3. Personnel accounted for at Boat Stations

1. Human error
congestion of personnel in area
stress

Step 4. Order given to evacuate by survival craft

1. Delay in decision
management pressure
uncertainty

2. Wrong decision
HOE
inaccurate or incomplete information

Step 5. Craft prepared for launch

1. Engine can not be started hydraulically or manually
inspection, testing neglected
poor design leads to visual problems
water spray system frozen

2. Sea water cocks are jammed shut
corrosion
testing neglected

3. Damaged craft
initiating accident
inspection, maintenance neglected

Step 6. Embarkation

1. Access to boat blocked
2. Craft descends before completely loaded

Step 7. Lowering mechanism activated

1. Released pin jammed
2. Brake cables breaks, jams, or blows away in wind
   - inspection, maintenance program neglected
   - strength reduced by initial accident
3. Brake lever jammed
   - fallen obstacle
4. Platform or MODU listing
   - structural failure

Step 8. Craft descends under control to near sea level

1. Lowering system fails and descent stops
   - brake or launch mechanism jams
   - brake cable breaks or blows away
2. Uncontrollable descent results in crash into water
   - release hood opens
   - winch brake fails to control descent
   - cable, shackles, or splices break
3. Craft hits structure due to wind forces
   - platform or MODU list angle
   - manual brake put on too suddenly

Step 9. Craft descends final distance to sea level

1. Inadvertent operations of release gear
   - human error
2. Waves push craft into structure
   - release gear breakage
   - craft released at wave crest

Step 10. Craft release gear activated successfully

1. Unable to operate release gear
   - lever jammed
   - entanglement in cable
2. Craft twisted
   - wind and wave forces

and recovery. (Note: Many of the deaths on both the Alexander Kielland and the Ocean Ranger were totally un-related to TEMPSC failures.)

***Table 6.2 TEMPSC Accidents***

| | | | |
|---|---|---|---|
| 1976 | *Deep Sea Driller* | 6 killed | Harding |
| | engine failed to start, craft capsized | | |
| 1976 | Ocean Express | 13 killed | Whittaker |
| | craft capsized | | |
| 1980 | Alexander Kielland | 123 killed | Harding |
| | 2 craft damage or unavailable; 3 craft lowered to sea level but unable to released - dashed to bits; craft capsized due to men climbing on. | | |
| 1982 | Ocean Ranger | 84 killed | Harding and Watercraft |
| | craft capsized, craft capsized during pickup attempt. | | |

The TEMPSC launch success rates are dependent upon numerous variables such as the orientation of the boat to the platform, the location of the boat with respect to wind and current direction, the ability of the captain, and reliability of release and lowering equipment. Thus, a wide range of success rates have resulted.

In analyzing the risks associated with TEMPSC evacuations there are uncontrollable variables, but there are also risks that can be reduced by improvements in installation, inspection, and design. One of the main problems of TEMPSC is their location on the platform. The boats should be placed on at least three sides of the platform to allow for quick access as well as launching on the downwind or down current side to avoid collision into the platform. Several other conditions should be met to improve safety of evacuations. The first criteria for placement should consider the hazards of equipment or operations in the vicinity. The boat should not be placed next to the high pressure gas storage tanks for instance. Equally important is the ease of access. Escape routes on the outside and inside of the modules should be well lit, free of obstructions, and large enough for several personnel to pass. This will aid in the time response of personnel to muster stations and allow injured to be carried as well. Finally, the TEMPSC must have adequate horizontal clearance of the platform legs. This may be the most important of the three. As the boat is lowered the wind can push it into the legs causing damage before the boat even hits the water. The dynamics of TEMPSC lowering has been studied in several reports and Figure 6.2 presents a likely variation in position. Further clearance is required for a boat launched parallel to the platform than one launched pointing away as the parallel boat must maneuver itself to accelerate away from the platform while the perpendicular boat can just move away. Figure 6.3 graphs the probability of collision of two differently oriented boats launched in a current. Besides the TEMPSC location and orientation other improvements in performance can aid in safety.

*Figure 6.2 Trajectory of Lifeboat During Descent*[39]

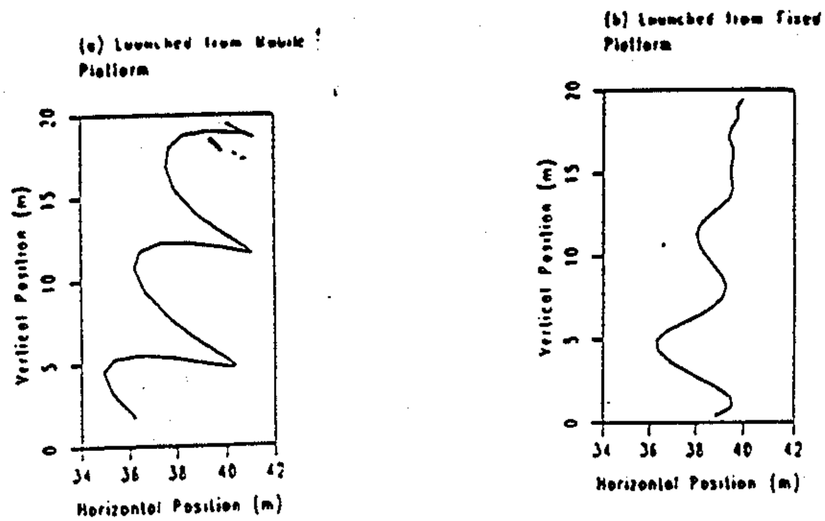
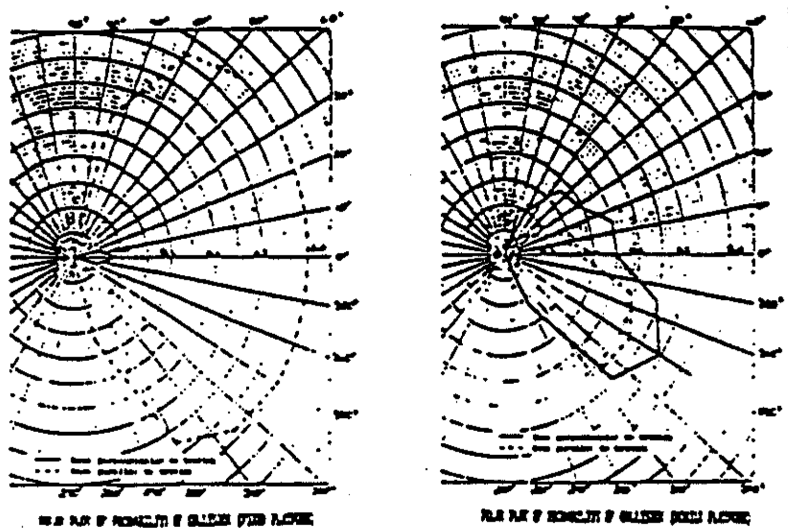


*Figure 6.3 Probability of Collision of TEMPSC into Platform*[40]



## 6.3 Free Fall TEMPSC

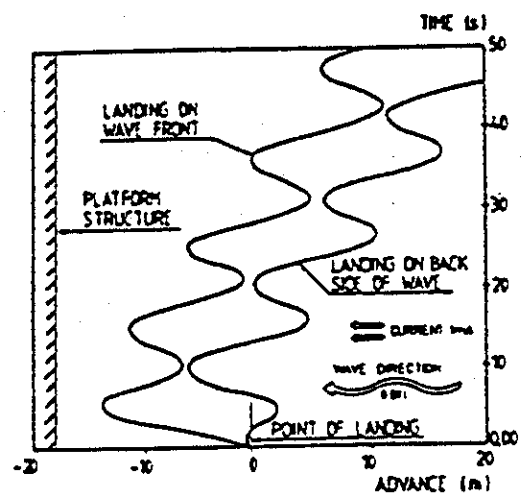
Free fall TEMPSCs get around some of the problems associated with a standard falls launched boat. As one of the major problems with TEMPSC is the reliability of lowering and release mechanism, a good idea would be to eliminate them all together. Free fall boats incorporate this idea, but with the elimination of one risk comes together. The forces on the boat from free fall present not only problems to the integrity of the boat but also to the integrity of personnel inside. A normal platform in the GOM would have a lower deck elevation of at least 60 feet, in the North Sea a value of 90 feet may be expected. With a free fall of this magnitude a quick deceleration on impact results which can present forces on the human body over its limits, thus after some personnel may require medical attention. This should not be a problem for a properly designed boat in calm conditions, but can become an issue in wave conditions. If timed correctly the boat can land perfectly on the back side of a wave which can reduce the impact as well as aid in the acceleration away from the platform. On the other hand, the boat may land on the front side of incoming wave which can cause larger impact forces as well as orientation problems. The outlook seems bright for free fall TEMPSCs. One such boat, the Lifescape

125, boasts significant improvements in all areas of weather conditions as seen in Table 6.3. The craft is designed to accelerate 125 men away from a platform from a 30 meter free fall landing on the front side of an incoming Beaufort scale 8 wave while fighting a 1 m/s current, see Figure 6.4.[41]

***Table 6.3 Comparison of Success Rates***[42]

| WEATHER CONDITION | | | SUCCESS RATE % | | | |
|---|---|---|---|---|---|---|
| Type | Severity Bf | Frequency % | Prob. distr. acc. wind rose | | Into the wind | |
| | | | LIFESCAPE | CONV. | LIFESCAPE | CONV. |
| Calm | < 3 | 28 | 96 | 97 | 96 | 88 |
| Moderate | 4 - 7 | 61 | 94 | 80 | 94 | 32 |
| Severe | > 7 | 11 | 91 | 46 | 82 | 1 |
| Average all weathers | | | 94 | 81 | 93 | 45 |

***Figure 6.4 Time History of Lifescape Acceleration Ability***




## 7. EVACUATION DECISIONS BASED ON UNCERTAINTIES

The evacuation decision is a highly complicated task which is compounded by uncertainties in weather forecasts, management pressures to continue operation unless absolutely necessary, and lack of communications. The weather forecasts have increased in accuracy over the years, but the amount of money spent for accurate forecasts has decreased to the point of two estimated predictions per day.[43] Management pressures to continue operations has led to several accidents such as the *Glomar Java Sea.* ARCO and

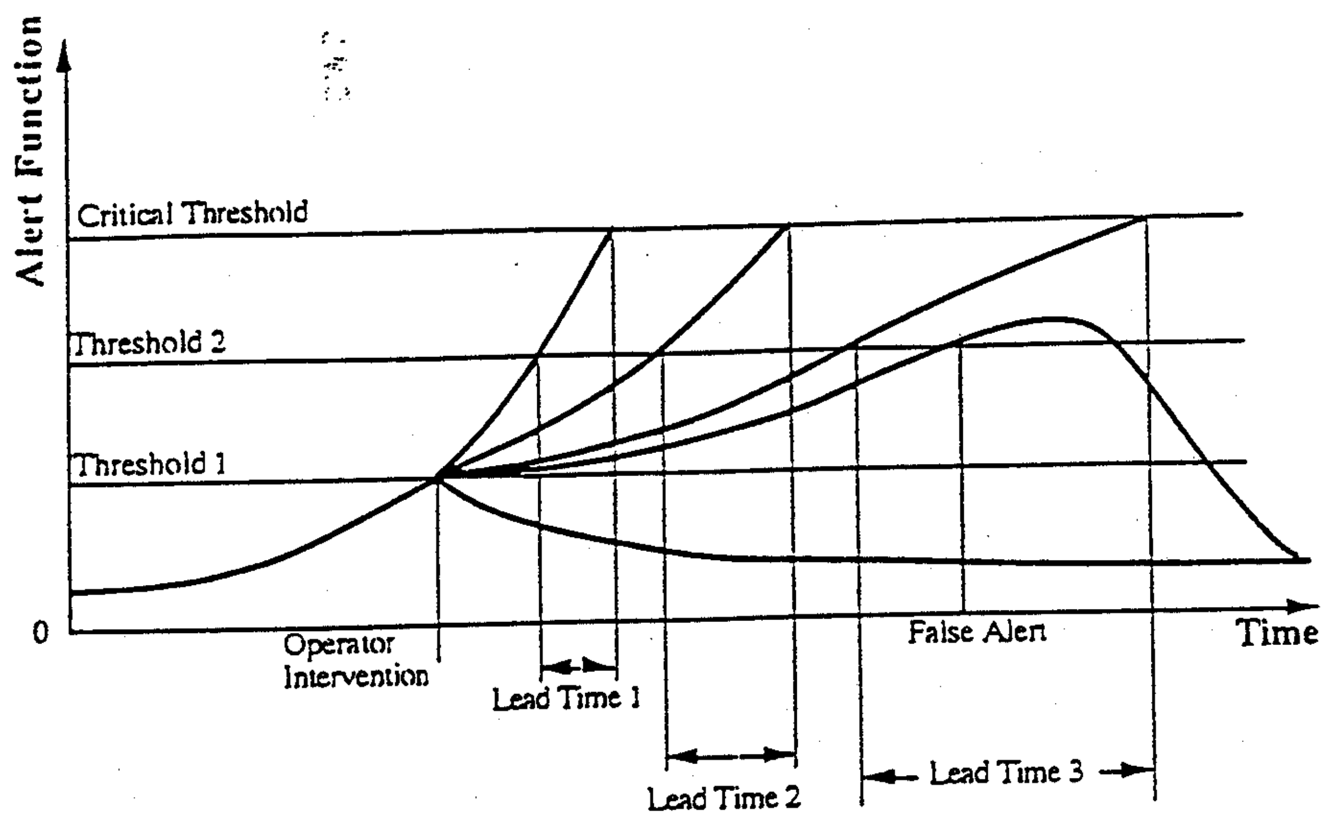
Global Marine made the decision to not evacuate non-essential personnel to avoid incurred costs and delays in work schedule. This Human Organization Error (HOE) in judgment resulted in the loss of all 82 crew members.[44,45] Communication problems can be traces to Gross HOE which from ignorance or lack of initiative to gather information on the part of personnel and management can lead to disasters. The drill ship Seacrest was lost while operating in the Gulf of Thailand in an area where typhoons were not normally observed. Their lack of knowledge of an incoming typhoon resulted in the loss of 91 men, with only 6 survivors.[46]

### *7.1 Early Warning Systems*

An effective way to eliminate the problems associated with uncertainties is to provide a limit at which a decision must be made. This warning level provides enough leeway for the uncertainties to be accounted for, but at the same time is not too sensitive to promote excessive false alarms. This is not to say that false alarms will never occur, just that numerous false alarms are avoided. The effective early warning system therefore must provide sufficient lead time before the situation becomes critical, but it must be insensitive to less than critical situations.

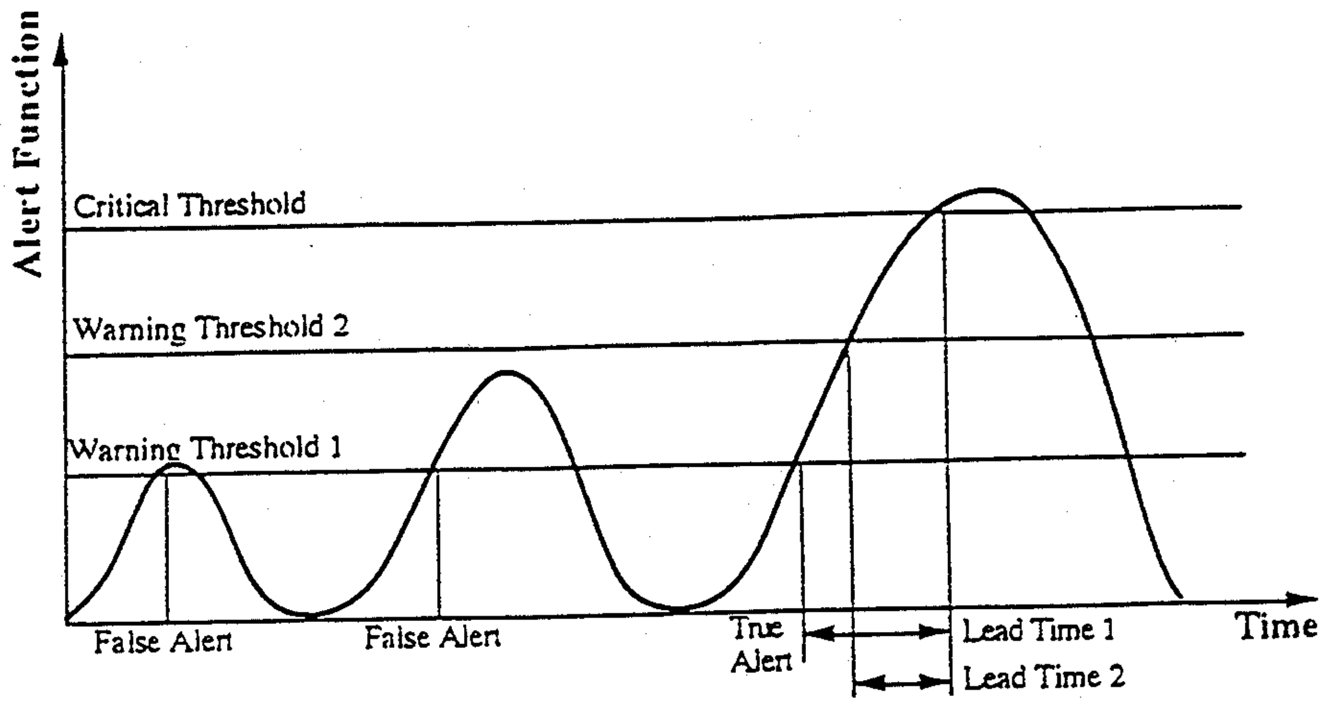
One example of an effective warning system is the fire alarm. If too sensitive many false alarms will occur and a cry wolf scenario will result: that is when a true alarm occurs the personnel may voluntarily ignore it based on previous experiences. If the alarm is not sensitive enough there will be insufficient lead time to response to the situation before it becomes critical. If operator intervention is possible to deter the situation from becoming critical a graphical representation can be seen in Figure 7.1.[47] One implication of the operator intervention is that his actions can result in compounding of the event from human error which can result in catastrophe.[48]

*Figure 7.1 Operator Intervention EWS*




From another perspective, as no operator intervention can affect the weather the alert function is unaffected, see Figure 7.2. The major decision in the warning system is the determination of the warning threshold limit. Consider the case of tropical generated storms in the GOM. These storms develop quickly and sometimes result in no evacuation of platforms as their intensity is within the design criteria for the platforms. To avoid false alarms for these storms, the warning threshold must be above this intensity level. For the case of hurricane of high intensity, the platforms are not designed to withstand these storm conditions, therefore the platforms must be evacuated before the hurricanes arrives. Thus, the warning threshold should be just above the tropical generated storm intensity limits to allow for sufficient lead time for evacuation. As the intensities of storms are easily descried by the central pressure index (CPI), a logical warning threshold would be based on this scale.

*Figure 7.2 Early Warning System*

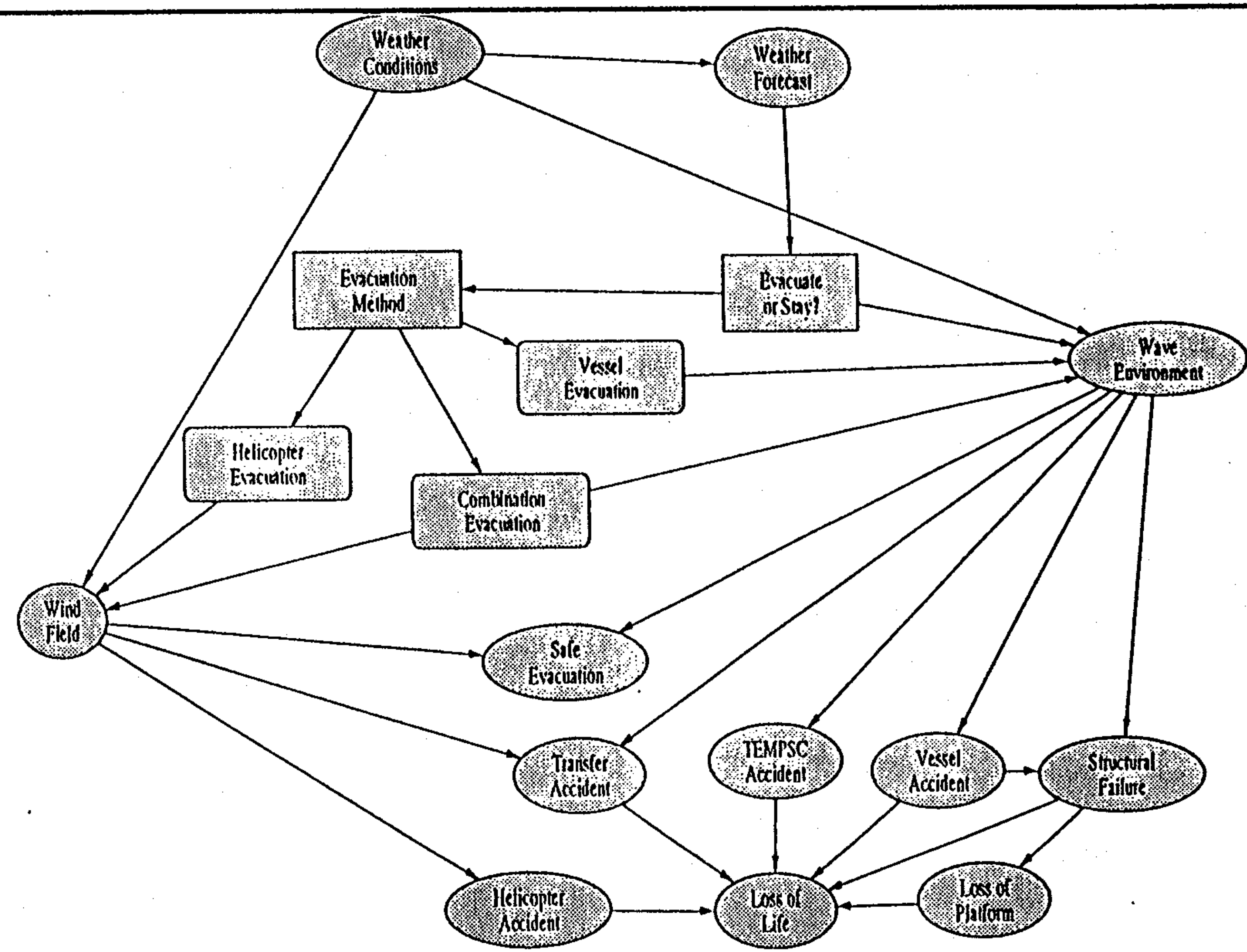


# 8. EVACUATION MODELS

An excellent way to determine the effects of weather upon the evacuation decision is the use of influence diagrams. These diagrams give a model of the cause and effects associated with the weather upon the successful of evacuations. With the aid of these models, the decision of evacuation can be analyzed to predict the possible outcomes, and the main causes of these outcomes.

Figure 8.1 is a graphical representation of such a model. This diagram includes the methods of transportation for evacuations, the wind and wave effects upon their success, as well as the accidents associated with each. The model represents a fixed platform facing a storm. The management may or may not know of the incoming storm. Each box or oval represent specific steps in the evacuation. The rectangles represent decision nodes, the ovals represent probability distributions, and the rounded rectangles represent decisions on the evacuation method. The model can also be applied to a moored unit facing a storm.

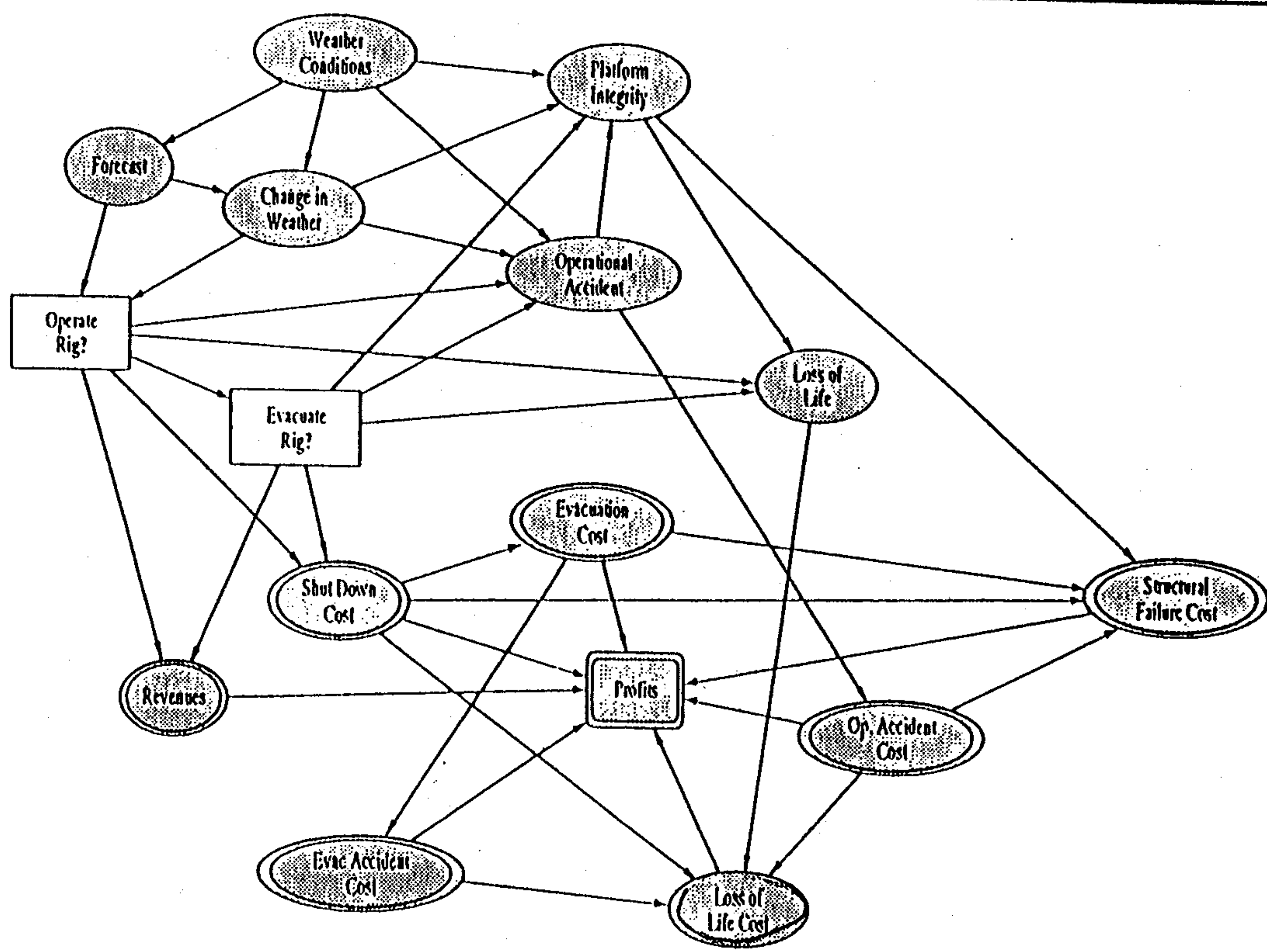
Figure 3.1 Evacuation Methods Model



Another way to model the decision is to use the cost associated with each outcome so that management can see the monetary effects of their decision. Figure 8.2 is such a model. In this model the above nodes are still valid, but the double lined values represent the costs, and the double lined rounded rectangle represents the final expected cost.

With the knowledge of each of the node's associated probability distributions, the total likelihood of each event can be extracted. From this the costs associated with each outcome can be implemented to reach a cost analysis of evacuation. This would give management a base on which their decisions can be analyzed with prior knowledge of the expected outcomes. This would help reduce the amount of HOE effects as the decision would be the most logical given the information at that time.

Figure 8.2 Evacuation Costs Model



# 9. CONCLUSIONS

The first step in the evacuation decision is the knowledge that a decision must be made. The uncertainties associated with weather forecasts present the first obstacle. With the use of an effective early warning system, the time limit on the decision can be assessed. The warning threshold for an early warning system based on a storms central pressure must ignore the minor tropical generated storms while quickly screening the hurricanes. With a data base of CPI's of hurricanes and LGTS a limit can be chosen based on a platform's design wave and wind loads. With prior knowledge of the risks associated with certain outcomes a logical decision can be made. Thus, the management can foresee the probabilities of an accident for each evacuation method. Finally, the use of influence diagrams can show the causes of the accidents and the results of certain decisions. The need for an effective decision model is obvious in the wake of numerous accidents in severe weather conditions.

**Recommendations**

1. more money allocated for forecasting and more forecasts during critical operations
2. free fall TEMPSC research and development
3. training of personnel in evacuation steps
4. warning limit established
5. evacuation of non-essential personnel at first warning
6. if stranded - remain on platform unless absolutely necessary - total platform failure
7. Communication and cooperation between corporations
8. improve helicopter regulations
9. inspection of TEMPSC regularly

[1] National Transportation Safety Board. *Capsizing and Sinking of the United States Drillship Glomar Java Sea in the South China Sea 65 Nautical Miles South-Southwest of Hainan Island*, Peoples Republic of China, October 25, 1983. NTSB/NAR-87/02.

[2] Committee on Assessment of Safety of OCS Activities; Marine Board Assembly of Engineering, National Research Council, *Safety and Offshore Oil*, Washington D.C., 1981.

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[4] NRC, Ibid.

[5] Lloyds, Ibid.

[6] Tecnica, *Risk Assessment of Emergency Evacuation from Offshore Installations*, p. 20, November 1983.

[7] U.S. Department of the Interior, Minerals Management Service, *Investigation of October 27-28, 1985, Structural Failure*, 1987.

[8] Bea, R.G., Conversation, 12 February, 1993.

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[14] Cooper, C.K., "A Preliminary Case of the Existence of Hurricane Alleys in the Gulf of Mexico," *Proceedings, 24th Annual Offshore Technology Conference*, Houston TX, May 1991.

[15] Cooper, Ibid.

[16] Cooper, Ibid.

[17] Emanuel, K.A., "Toward a General Theory of Hurricanes," *American Scientist*, Vol. 76, 1988.

[18] Cooper, Ibid.

[19] Cooper, Ibid.

[20] Cooper, Ibid.

[21] Brand, S., The Effects on a Tropical Cyclone of Cooler Surface Waters Due to Upwelling and Mixing Produced by a Prior Tropical Cyclone, *Journal of Applied Meteorology*, Vol. 10, 1971.

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[23] Technica, Ibid. 117.

[24] Technica, Ibid. 117.

[25] *Lloyd's List*, "Pilot to Blame for Cormorant Crash - Court," April 7, 1993.

[26] *Lloyds List*, "Shell 'Ignored Regulations,'" April 7, 1993.

[27] *Lloyds List*, "Urgent Helicopter Safety Review Recommended," April 7, 1993.

[28] Technica, Ibid. 125.

[29] Dodd, Robert S., "Emergency Medical Service: Helicopter Crash Safety," *FAA Aviation Safety Journal*, Vol. 2, No. 4, U.S. Dept. of Transportation.

[30] Trident Marine Services

[31] Trident Marine Services, PHI

[32] Daniel, John Jeremy Sykes, Stand-By Rescue Ships - Their Roles and the Factors Involved in Performing Them, *Proceedings of the Offshore Technology Conference*, 4374, 1982.

[33] Webster, W.C., Conversation on 6 March 1993.

[34] Webster, Ibid.

[35] Technica, Ibid. 113.

[36] Technica, Ibid. 31.

[37] Technica, Ibid. 31-42.

[38] Technica, Ibid.

[39] Lou, Young, J.C. Trickey, C.E. James, R.L. Jack, "Lifeboat Launch Simulation and Its Application to Safety Assessment," *Proceedings of the Offshore Technology Conference*, 6929, 1992.

[40] Lou, Ibid.

[41] Bengtsson, B., "An Offshore Evacuation System: A Safe Haven and an Emergency Control Center," *Proceedings of the Offshore Technology Conference*, 5077, 1985.

[42] Bengtsson, Ibid.

[43] Lynagh, Ibid.

[44] National Transportation Safety Board. *Capsizing and Sinking of the United States Drillship Glomar Java Sea in the South China Sea 65 Nautical Miles South-Southwest of Hainan Island, Peoples Republic of China*, October 25, 1983. NTSB/MAR-87/02.

[45] Bre, R.G., *Reliability Based Design Criteria for Coastal and Ocean Structures*, National Committee on Coastal and Ocean Engineering, The Institute of Engineers, Australia, 1990, 150.

[46] Noble Denton Accident Database.

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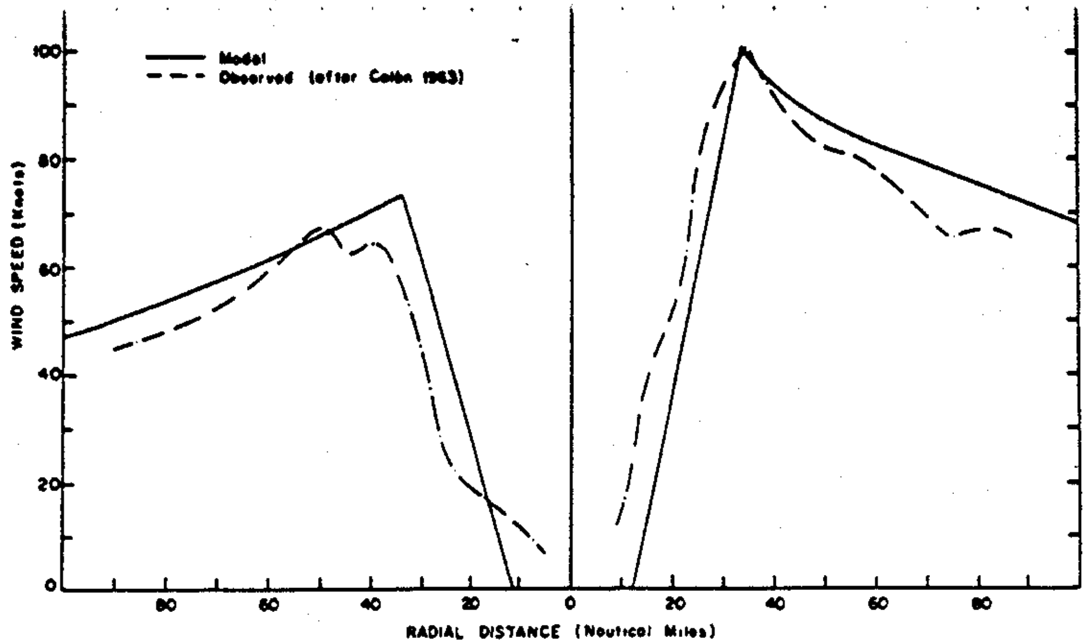
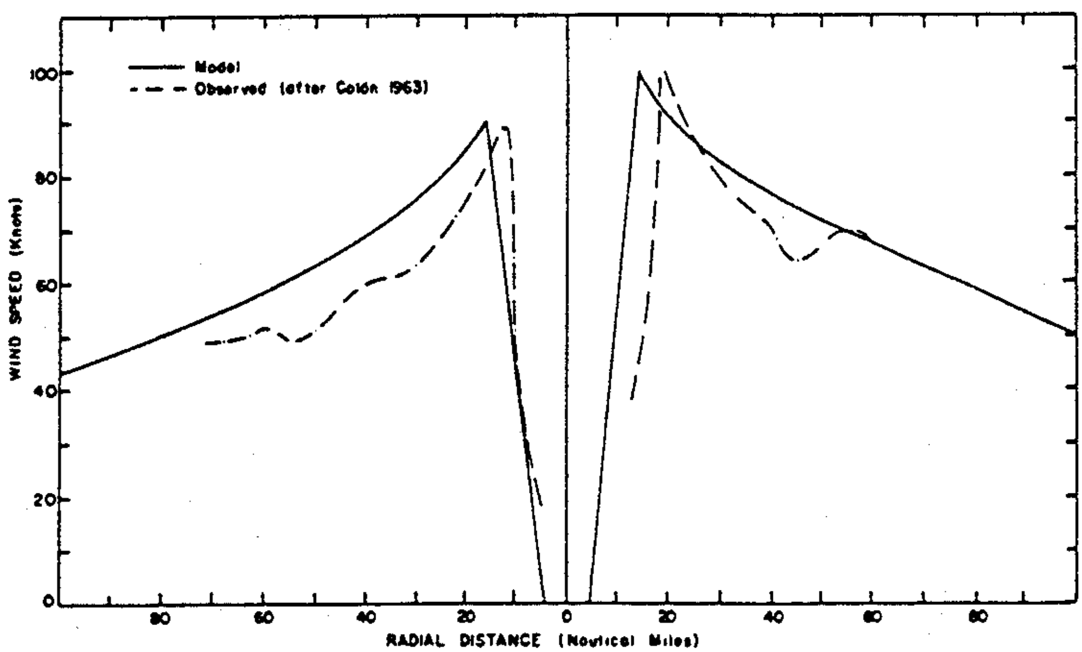
[48] Bea, R.G., *Reliability Based Design Criteria for Coastal and Ocean Structures*, Ibid.

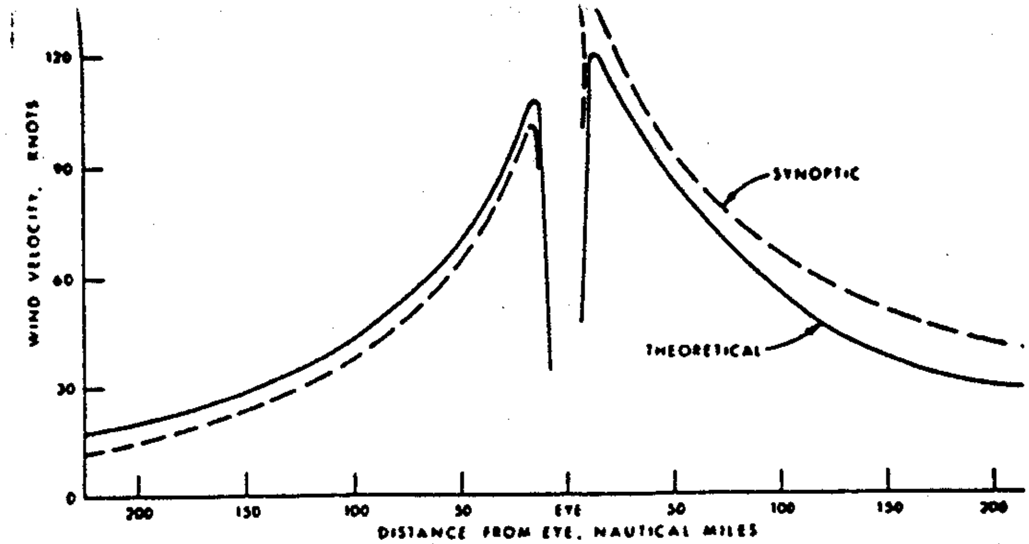
# APPENDIX 1
# WIND AND WAVE PROFILES



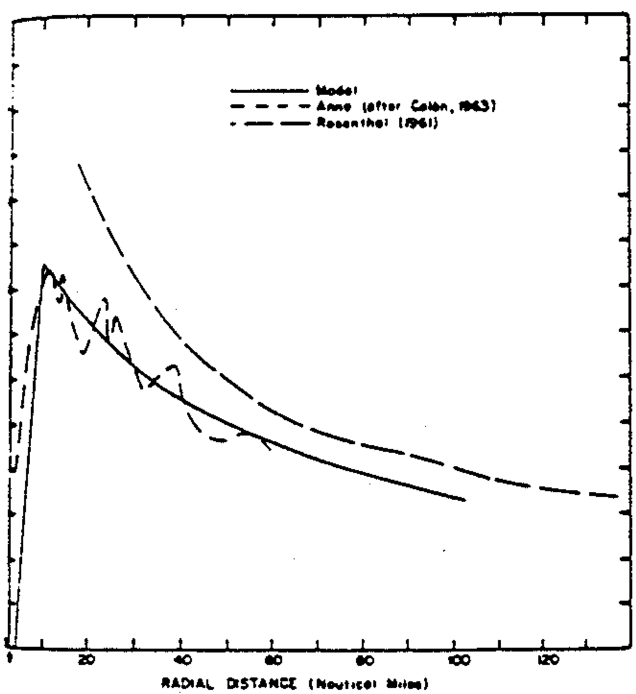

. Wind profiles recorded in hurricane Carla, Sept. 8, 1961.



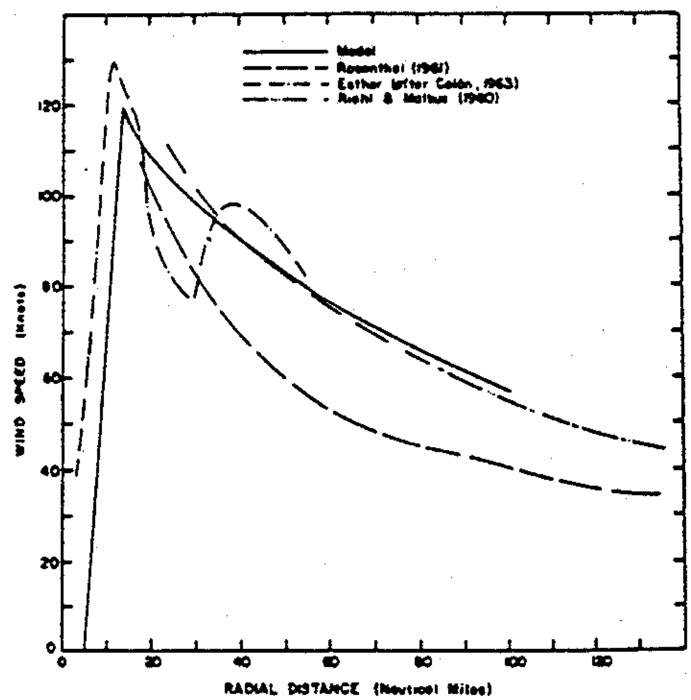

. Wind profiles recorded in hurricane Carla, Sept. 10, 1961.



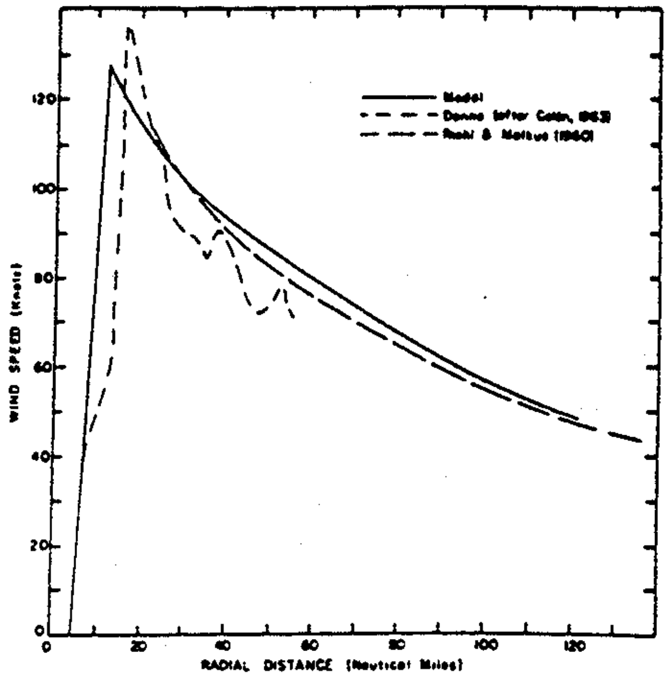

Typical wind profile for hurricane models.



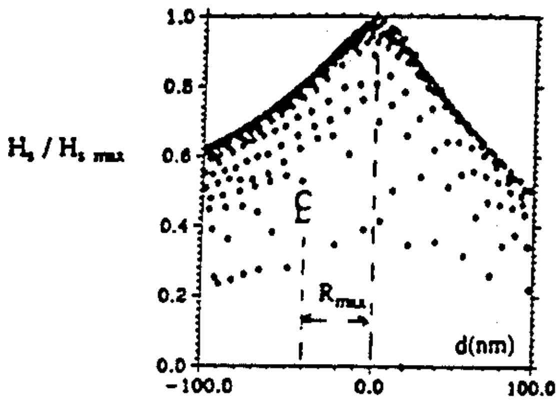

- Comparison of model profile with wind profile recorded in hurricane Anna, July 21, 1961.



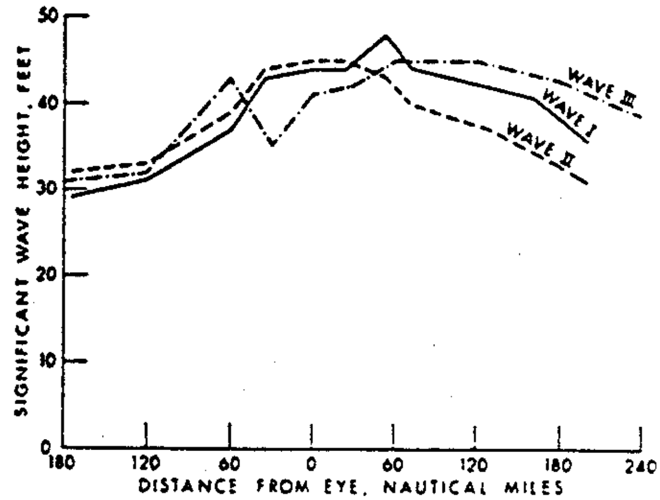

Comparison of model profile with wind profile recorded in hurricane Esther, Sept. 16, 1961.



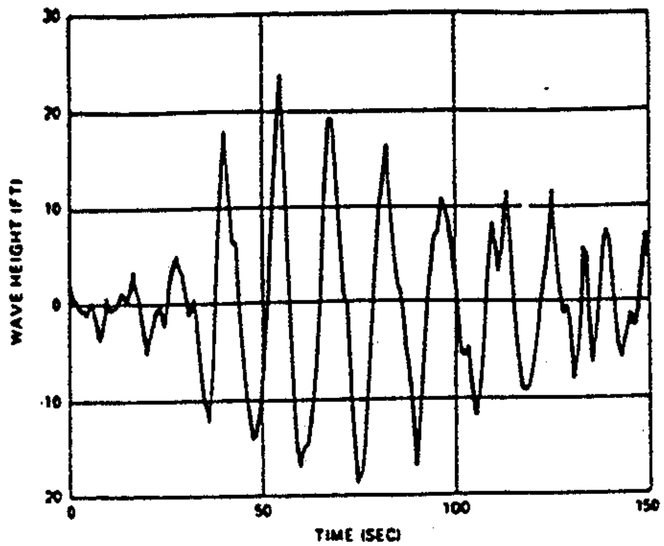

- Comparison of model profile with wind profile recorded in hurricane Donna, Sept. 7, 1960.



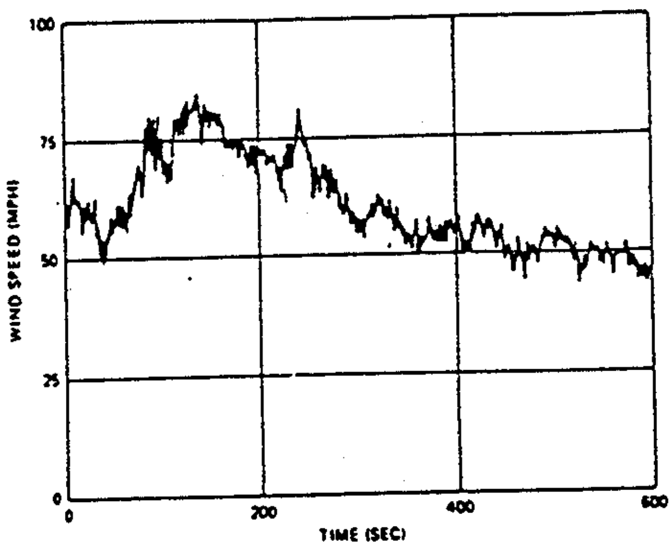

Typical cross-section for the significant wave height for a hurricane (GUMSHOE).



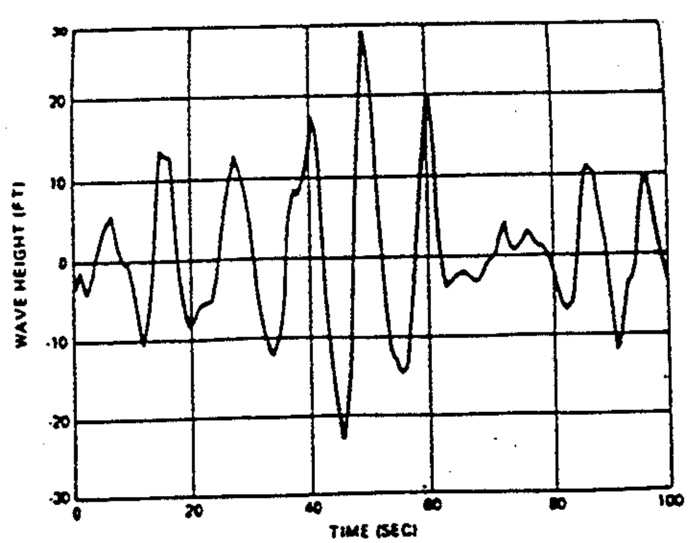

- Significant wave heights for hurricane Carla.




Hurricane Elena: wave height



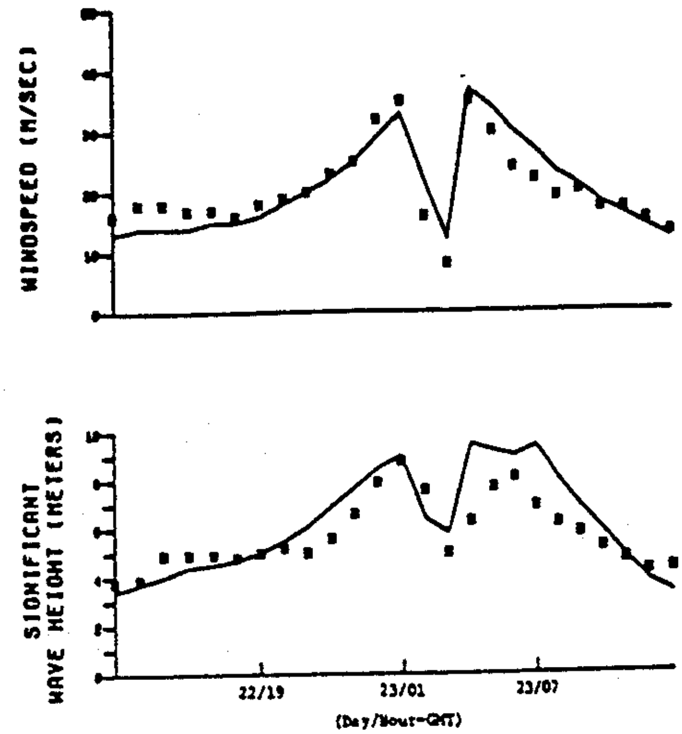

Hurricane Juan: wind speed




Hurricane Juan: wave height

## ELOISE EB-10

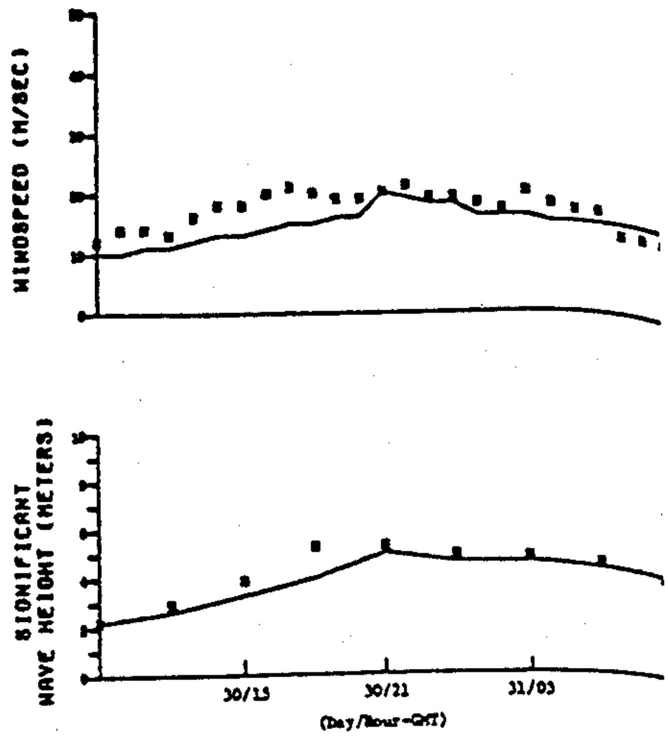
- HINDCAST VALUES
■ MEASURED VALUES




Time histories - September 1975.

## ANITA EB-04

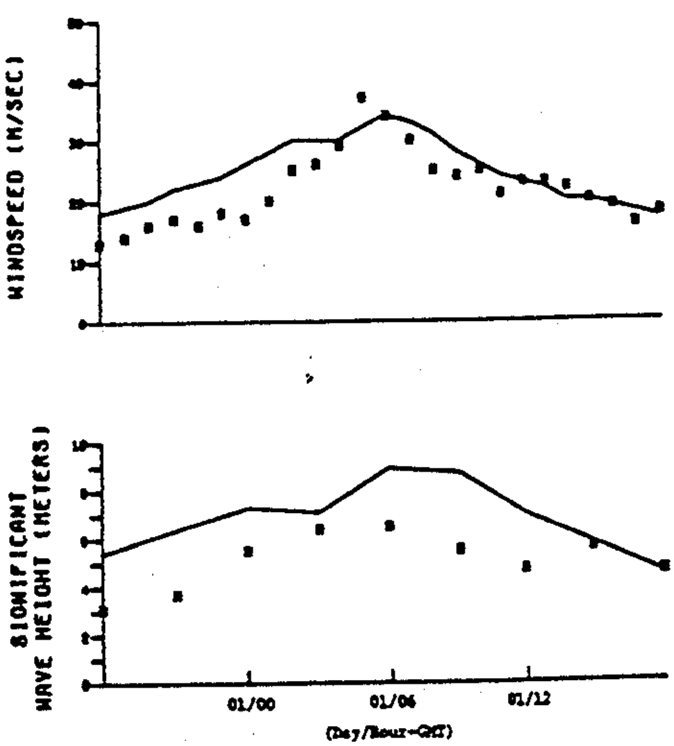
- HINDCAST VALUES
■ MEASURED VALUES




Time histories - August 1977.

## ANITA EB-71

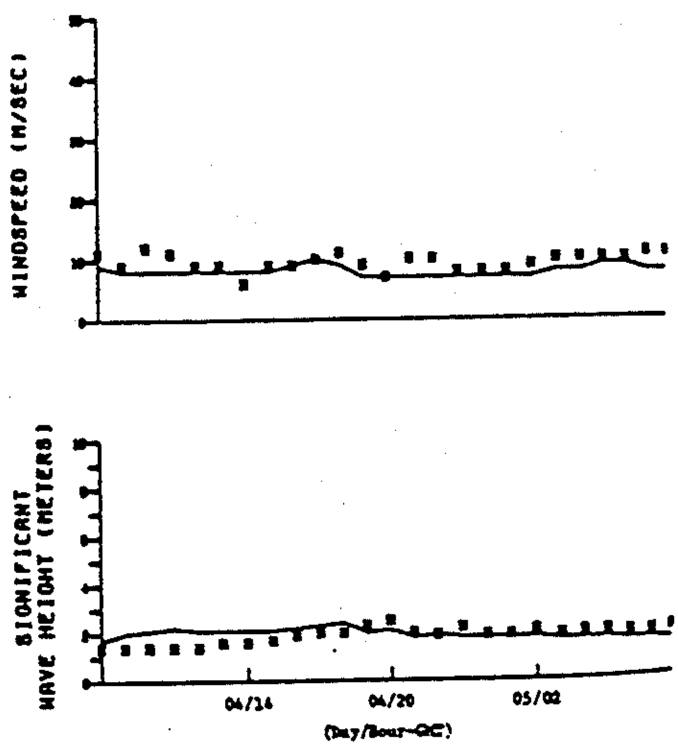
- HINDCAST VALUES
■ MEASURED VALUES



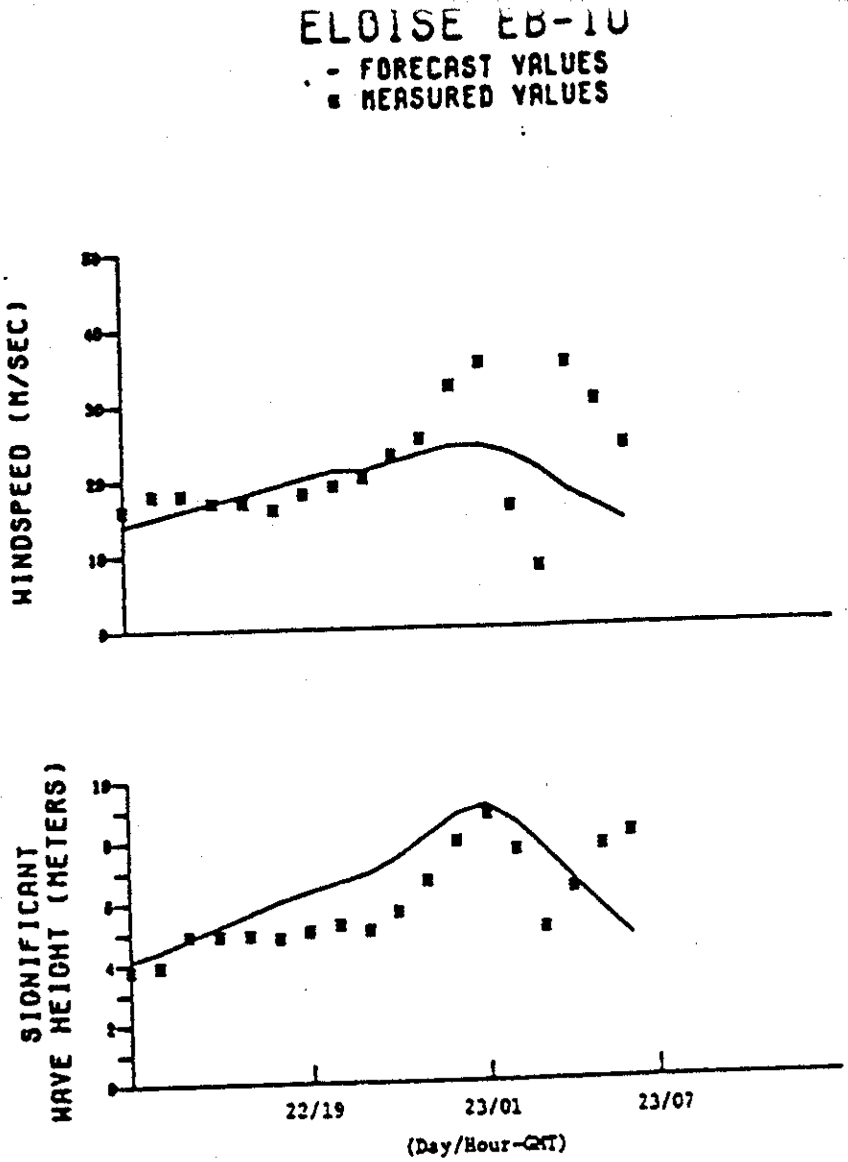

Time histories - September 1977.

## BABE EB-04

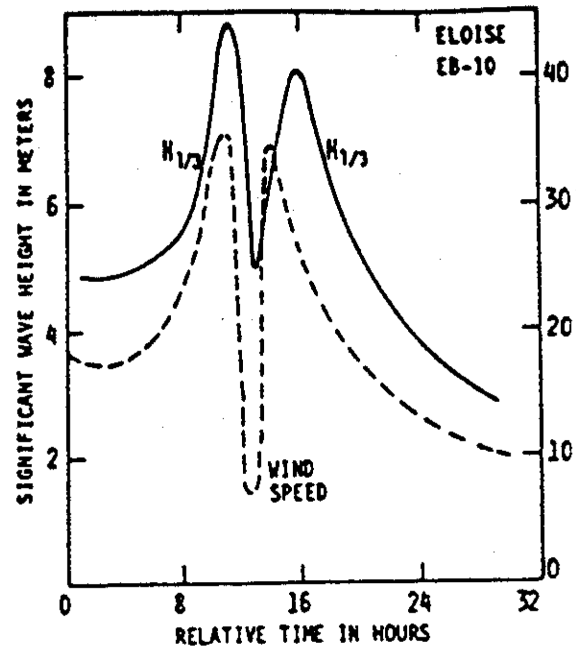
- HINDCAST VALUES
■ MEASURED VALUES



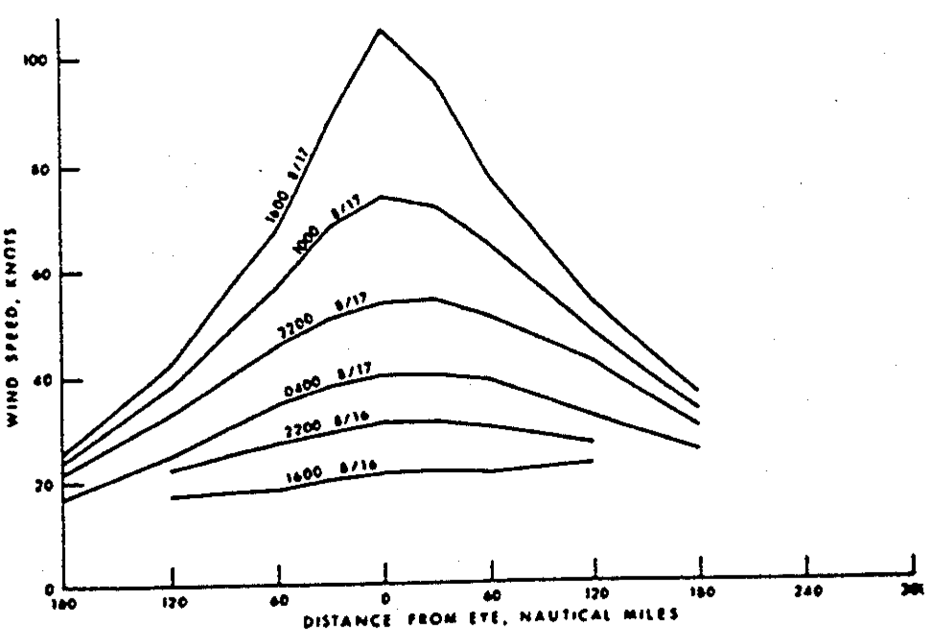

Time histories - September 1977.




Time histories - September 1975.




Variation of significant wave height and w
magnitude for Hurricane Eloise with respect to time




- Wind-time history for hurricane [illegible]

# APPENDIX 2
# HELICOPTER SPECIFICATIONS

PHi Petroleum Helicopters

# GENERAL SPECIFICATIONS

## BOELKOW 105 CBS TWIN-TURBINE HELICOPTER

### DIMENSIONS

| | |
|---|---|
| Length | 38' 10" |
| Width | 8' 2" |
| Height | 9' 11" |
| Main Rotor Dia. | 32' 2" |

### POWER PLANT

Two (2) Allison 250-C20B turbine powered engines developing 840 SHP derated to 690 for take of and cruise.

### LANDING GEAR

Fixed skid type landing gear with pilot activated emergency pop-out float system.

### HELIPORT SIZE

36' x 36' Landing Deck (normal operations)
24' x 24' Landing Deck (restricted operations)

### STANDARD EQUIPMENT

VHF Radio
Loran C Navigation
Life Vests
Cargo hook (optional)
Customer FM Radio (optional)

### CARGO/BAGGAGE

| | |
|---|---|
| Length | 6' 8" |
| Width | 4' |
| Internal Height | 1' 10" |
| Volume | 64 cubic feet |

### SPECIFICATIONS

| | |
|---|---|
| Maximum gross weight | 5,512 lbs. |
| Average basic weight | 3,322 lbs. |
| External sling load | 1,500 lbs. |
| Fuel capacity | 150 gal./1020 lbs. |
| Fuel consumption | 60 gph/408 pph |
| Average cruise speed | 117 kts/135 mph |
| Maximum range | 234 nm/270 miles with 30 min. fuel reserve |
| Passenger seats | 4 passengers plus pilot |

### LOADING INFORMATION

| | |
|---|---|
| Basic weight | 3,322 lbs. |
| Full fuel | 1,020 lbs. |
| Pilot | 180 lbs. |
| Operating weight | 4,522 lbs. |
| Max. gross weight | 5,512 lbs. |
| Minus operating weight | 4,522 lbs. |
| Total payload | 990 lbs. (full fuel) |

### PAYLOAD

Distance vs. Fuel Requirement = Payload & Flight Time

| DISTANCE (Round Trip) | FUEL REQUIRED* | PAYLOAD OUTBOUND | FLIGHT TIME |
|---|---|---|---|
| 234 nm/270 miles | 950 lbs. | 990 lbs. | 2:10 |
| 217 nm/250 miles | 897 lbs. | 1113 lbs. | 1:55 |
| 174 nm/200 miles | 707 lbs. | 1303 lbs. | 1:30 |
| 130 nm/150 miles | 569 lbs. | 1441 lbs. | 1:10 |
| 87 nm/150 miles | 430 lbs. | 1580 lbs. | :50 |
| 44 nm/ 50 miles | 326 lbs. | 1684 lbs. | :25 |

* *Includes 30 min. reserve.*

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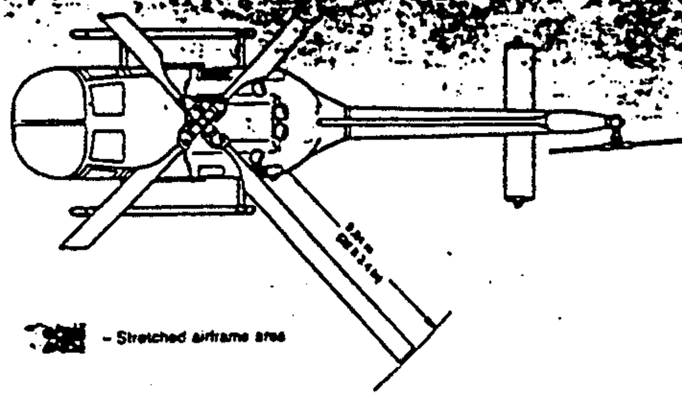
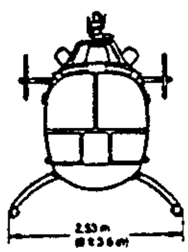
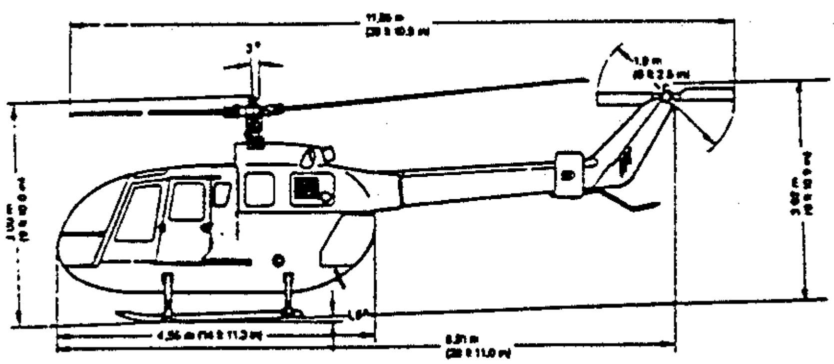
Fax: **(318) 235-7312**

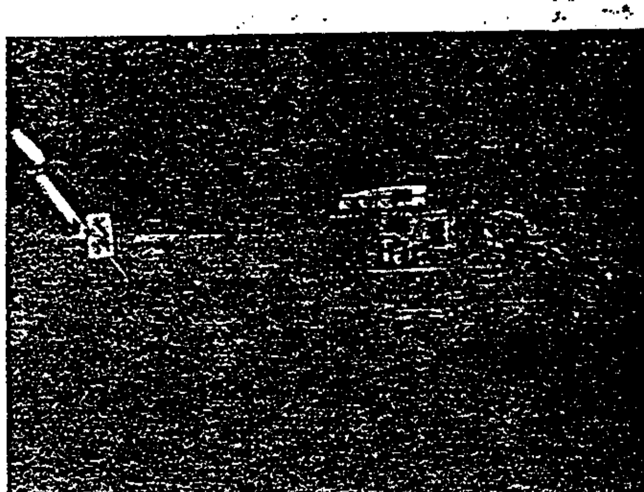
# GENERAL SPECIFICATIONS
## BOELKOW 105 TWIN TURBINE HELICOPTER



– Stretched airframe area





PHi Petroleum Helicopters

## GENERAL SPECIFICATIONS

### SIKORSKY S-76 (IFR) TWIN TURBINE HELICOPTER

**DIMENSIONS**

| | |
|---|---|
| Length | 52' 6" |
| Width | 8' 5.5" |
| Height | 11' 9" |
| Main Rotor Dia. | 44' 0" |

**POWER PLANT**

Two (2) Allison 250-C30
Turbine Engines rated at 650 SHP each.

**LANDING GEAR**

Tricycle retractable type landing gear with pilot activated emergency pop-out float system.

**HELIPORT SIZE**

48' x 48' Landing Deck
(normal operations)

**STANDARD EQUIPMENT**

Dual (2) VHF Radio
Dual (2) VOR Navigation Equipment
Dual (2) Automatic Flight Control System

Loran C Navigation System
Radar
Fully IFR Equipped
(2) Eight-man Life Rafts with Survival Gear

**CARGO/BAGGAGE**

Tail Boom Cargo Space 38 Cubic Feet 600 lbs.
Internal Cargo Space 204 Cubic Feet
(floor loading 75 lbs. per square foot)

**SPECIFICATIONS**

| | |
|---|---|
| Maximum gross weight | 10,500 lbs. |
| Average basic weight | 6,865 lbs. |
| Fuel capacity | 286 gal./1945 lbs. |
| Fuel consumption | 90 gph/612 pph |
| Average cruise speed | 130 kts/150 mph |
| Maximum range | 348 nm/400 miles with 30 min fuel reserve |
| Passenger seats | 12 passengers plus 2 pilots |

**LOADING INFORMATION**

| | |
|---|---|
| Basic weight | 6,865 lbs. |
| Full Fuel | 1,945 lbs. |
| Pilots (2) | 400 lbs. |
| Operating weight | 9,210 lbs. |
| Max. gross weight | 10,500 lbs. |
| Minus operating weight | 9,210 lbs. |
| Total Payload | 1,290 lbs. (Full Fuel) |

**PAYLOAD**

Distance vs Fuel Requirement = Payload & Flight Time

| DISTANCE (round trip) | FUEL REQUIRED* | PAYLOAD OUTBOUND | FLIGHT TIME |
|---|---|---|---|
| 348 nm/400 miles | 1945 lbs. | 1290 lbs. | 2:40 |
| 304 nm/350 miles | 1740 lbs. | 1495 lbs. | 2:20 |
| 260 nm/300 miles | 1530 lbs. | 1705 lbs. | 2:00 |
| 217 nm/250 miles | 1330 lbs. | 1905 lbs. | 1:40 |
| 174 nm/200 miles | 1125 lbs. | 2110 lbs. | 1:20 |
| 130 nm/150 miles | 920 lbs. | 2315 lbs. | 1:00 |
| 87 nm/100 miles | 715 lbs. | 2520 lbs. | :40 |
| 44 nm/ 50 miles | 510 lbs. | 2725 lbs. | :20 |

**Includes 30 min. reserve*

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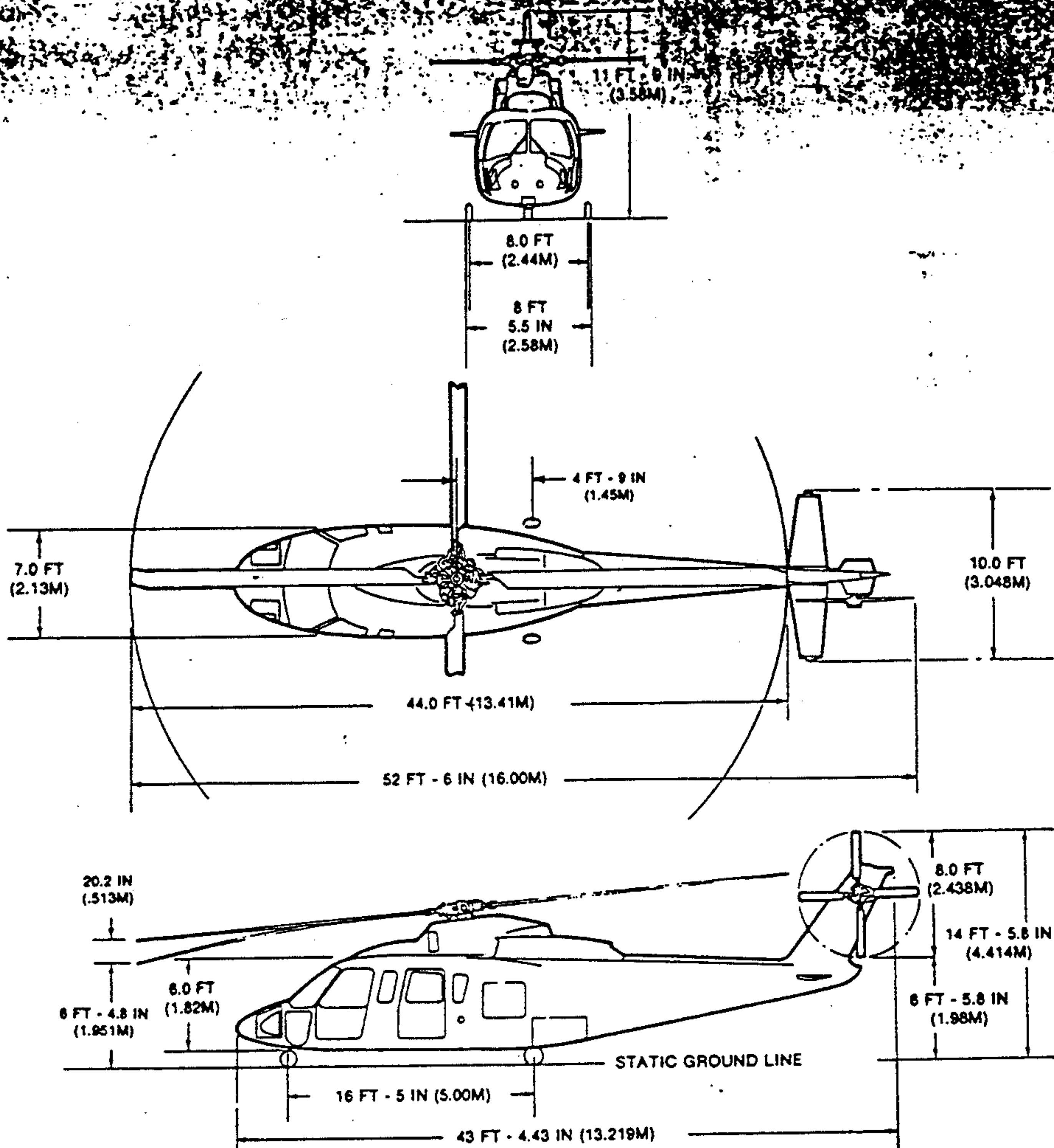
# Sikorsky S-76 (IFR) Twin Turbine Helicopter




# Petroleum Helicopters

## GENERAL SPECIFICATIONS

### AEROSPATIALE AS 355F-1 TWIN TURBINE HELICOPTER

### DIMENSIONS

| | |
|---|---|
| Length | 42.64' |
| Width | 6.88' |
| Height | 10.98' |
| Main Rotor Dia. | 35.07' |

### POWER PLANT

Two (2) Allison 250C 20F- engines developing a maximum of 420 SHP each for take off and 370 SHP for cruise.

### LANDING GEAR

Fixed skid type landing gear with pilot activated emergency pop-out float system.

### HELIPORT SIZE

36' x 36' Landing Deck (normal operations)
24' x 24' Landing Deck (restricted operations)

### STANDARD EQUIPMENT

Loran C Navigation System
VHF Radio Communications
Life vests
Customer FM Radio (optional)
Cargo hook (optional)

### CARGO/BAGGAGE

Tail boom 20 cu. ft.

### SPECIFICATIONS

| | |
|---|---|
| Maximum Gross Weight | 5,291 lbs. |
| Average Basic Weight | 3,398 lbs. |
| External Sling Load | 2,200 lbs. |
| Fuel Capacity | 194 gal./1,319 lbs. |
| Fuel Consumption | 58 gal./394 pph |
| Average Cruise Speed | 117 kts/135 mph |
| Maximum Range | 335 nm/385 miles with 30 min. reserve |
| Passenger Seats | 5 passengers plus pilot |

### LOADING INFORMATION

| | |
|---|---|
| Basic Weight | 3,398 lbs. |
| Full Fuel | 1,319 lbs. |
| Pilot | 180 lbs. |
| Operating Weight | 4,897 lbs. |
| Max. Gross Weight | 5,291 lbs. |
| Minus Operating Weight | 4,897 lbs. |
| Total Payload | 394 lbs. (full fuel) |

### PAYLOAD

Distance vs. Fuel Requirement = Payload + Flight Time

| DISTANCE (Round Trip) | FUEL REQUIRED* | PAYLOAD OUTBOUND | FLIGHT TIME |
|---|---|---|---|
| 335 nm/385 miles | 1,319 lbs. | 394 lbs. | 2:50 |
| 260 nm/300 miles | 1,073 lbs. | 640 lbs. | 2:15 |
| 217 nm/250 miles | 926 lbs. | 787 lbs. | 1:50 |
| 174 nm/200 miles | 780 lbs. | 933 lbs. | 1:30 |
| 130 nm/150 miles | 635 lbs. | 1,078 lbs. | 1:10 |
| 87 nm/100 miles | 489 lbs. | 1,224 lbs. | :50 |
| 44 nm/50 miles | 343 lbs. | 1,370 lbs. | :25 |

* *Includes 30 min. reserve*

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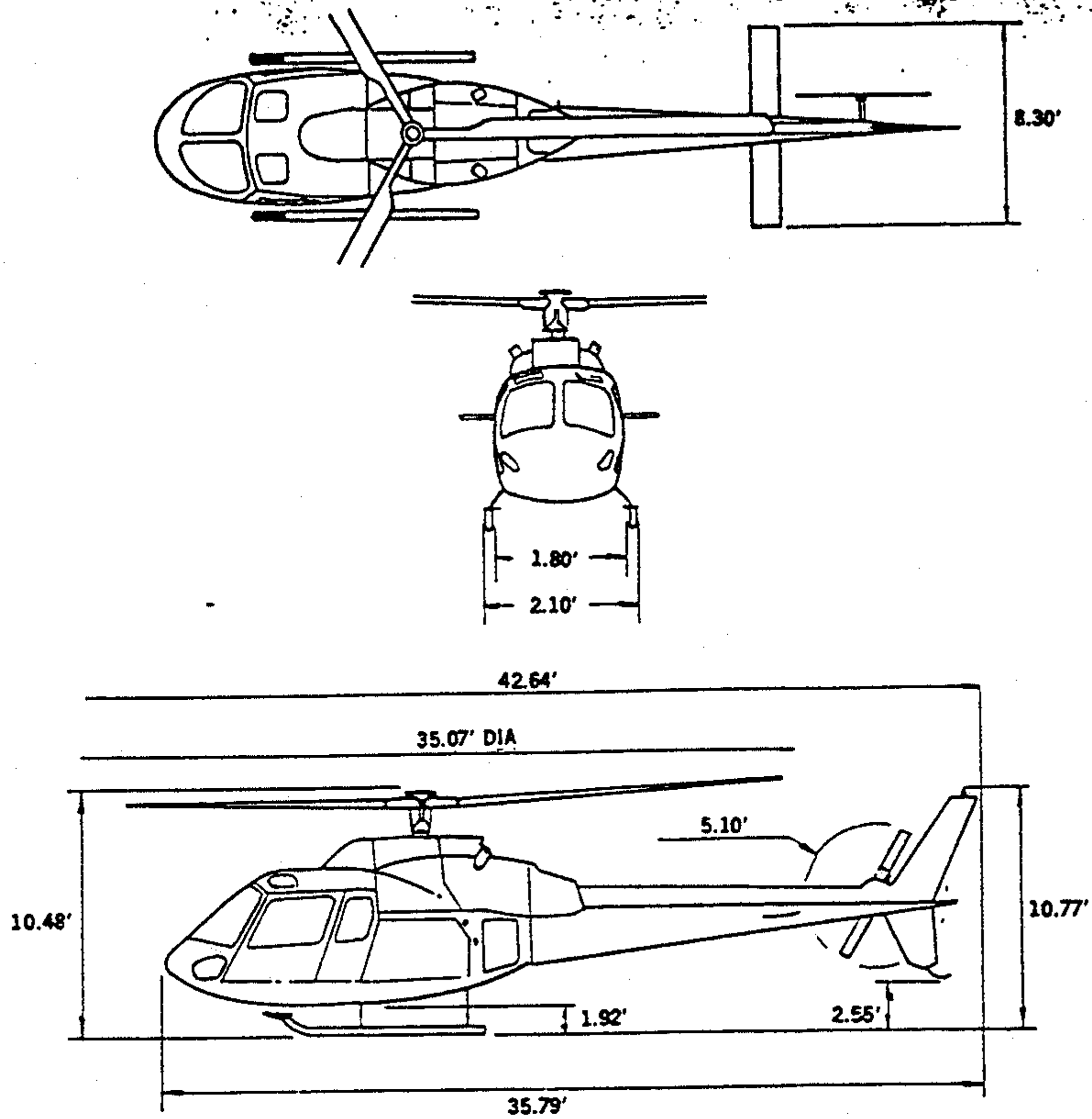
# AEROSPATIALE AS 355F TWIN TURBINE HELICOPTER




# PHi Petroleum Helicopters

## GENERAL SPECIFICATIONS

### BELL 412 (IFR) TWIN TURBINE HELICOPTER

**DIMENSIONS**

| | |
|---|---|
| Length | 56' 2" |
| Width | 9' 4" |
| Height | 15' 1" |
| Main Rotor Dia. | 46' 0" |

**POWER PLANT**

Two (2) Pratt & Whitney PT6T-3B engines developing 1,800 SHP derated to a total of 1,350 SHP.

**LANDING GEAR**

Fixed skid type landing gear with automatic and pilot activated emergency pop-out float system.

**HELIPORT SIZE**

48' x 48' Landing Deck
(normal operations)

**STANDARD EQUIPMENT**

Automatic Flight Control System
Dual VHF Radio
Loran C Navigational System
VOR/ILS
ADF Navigation Equipment
Internal/External PA System
Life Vests
(2) life rafts with survival gear

**CARGO/BAGGAGE**

Tail boom cargo space 28 cu. ft. (400 lbs.)
Internal cargo space-220 cubic feet with 49" x 92" sliding doors

**SPECIFICATIONS**

| | |
|---|---|
| Maximum gross weight | 11,900 lbs. |
| Average basic weight | 7,650 lbs |
| External sling load | 4,000 lbs. |
| Fuel capacity | 293 gal. one aux. tank |
| Fuel consumption | 110 gph/750 pph |
| Average cruise speed | 117 kts/135 mph |
| Maximum range | 252 nm/290 sm with 30 min. fuel reserve |
| Passenger seats | 11 to 13 passengers depending on configuration |
| Crew | 2 Pilots |

**LOADING INFORMATION**

| | |
|---|---|
| Basic weight | 7,650 lbs. |
| Full fuel (1 aux. tank) | 1,992 lbs. |
| Pilot (2) | 400 lbs. |
| Operating weight | 10,042 lbs. |
| Max. gross weight | 11,900 lbs. |
| Minus operating weight | 10,042 lbs. |
| Total payload | 1,858 lbs. (Full Fuel) |

**PAYLOAD**

Distance vs Fuel Requirement = Payload & Flight Time

| DISTANCE (round trip) | FUEL REQUIRED* | PAYLOAD OUTBOUND | FLIGHT TIME |
|---|---|---|---|
| 234 nm/290 sm | 1992 lbs. | 1858 lbs. | 2:10 |
| 217 nm/250 sm | 1765 lbs. | 2085 lbs. | 1:50 |
| 174 nm/200 sm | 1490 lbs. | 2360 lbs. | 1:26 |
| 130 nm/150 sm | 1208 lbs. | 2642 lbs. | 1:04 |
| 87 nm/100 sm | 933 lbs. | 2917 lbs. | :43 |

**Includes 30 min. reserve.*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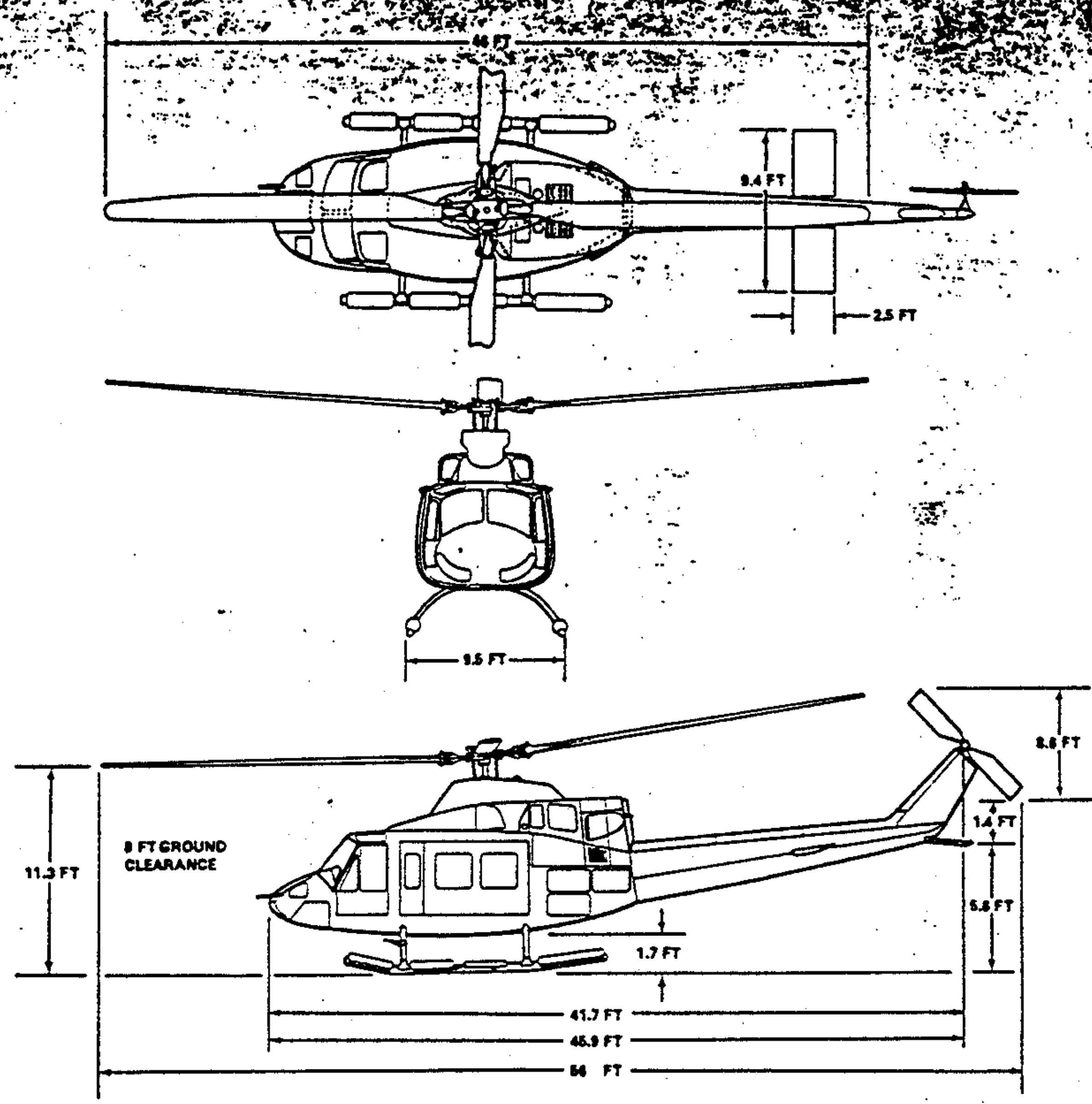
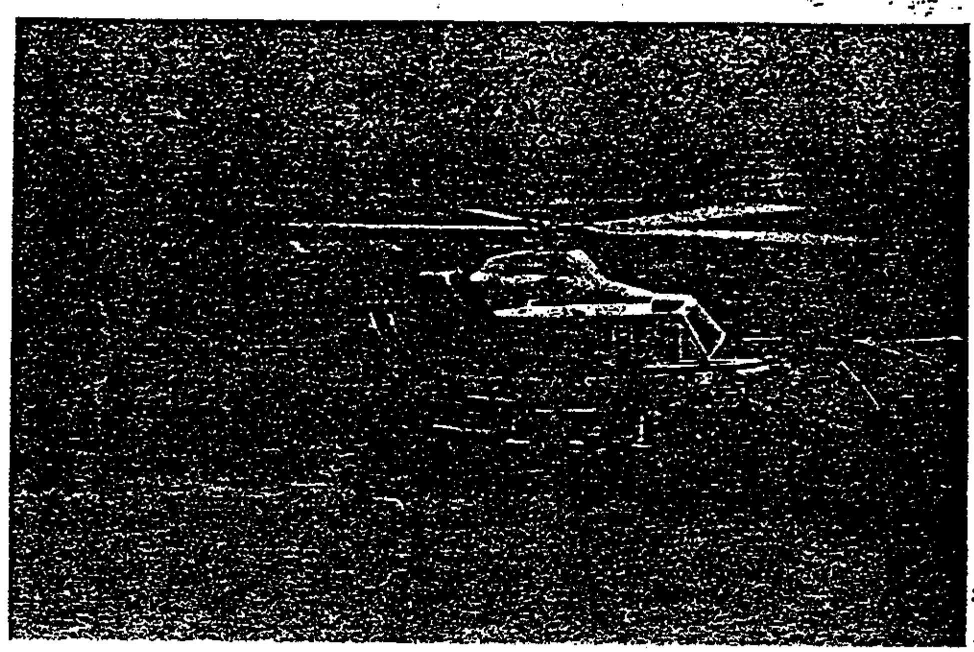
# GENERAL CONFIGURATION
# BELL 412 (IFR) TWIN TURBINE HELICOPTER



Petroleum Helicopters

# GENERAL SPECIFICATIONS

## BELL 206L-1 (LONG RANGER) II TURBINE HELICOPTER

### DIMENSIONS

| | |
|---|---|
| Length | 42' 8.5" |
| Width | 7' 2" |
| Height | 11' 8.3" |
| Main Rotor Dia. | 37' |

### POWER PLANT

Allison 250-C28B, developing a maximum of 500 SHP, derated to 435 SHP for takeoff, 348 SHP for cruise.

### LANDING GEAR

High skid type landing gear with pilot activated emergency pop-out float system.

### HELIPORT SIZE

37' x 37' Landing Deck (normal operations)
24' x 24' Landing Deck (restricted operations)

### STANDARD EQUIPMENT

VHF Radio Communications
Loran C Navigation Equipment
Life vests
Customer FM Radio (optional)
Cargo hook (optional)

### CARGO/BAGGAGE

Baggage Compartment 16 cu. ft.
35" x 35" 250 lbs. Maximum
Passenger compartment 90 cubic feet
Area: Length 60"; Width 46"; Height 34"

### SPECIFICATIONS

| | |
|---|---|
| Maximum gross weight | 4,150 lbs. |
| Average basic weight | 2,630 lbs. |
| External sling load | 1,110 lbs. |
| Fuel capacity | 98 gal./666 lbs. |
| Fuel consumption | 34 gph/230 pph |
| Average cruise speed | 113 kts/130 mph |
| Maximum range | 270 nm/310 miles with 30 min. fuel reserve |
| Passenger seats | 6 passengers plus pilot |

### LOADING INFORMATION

| | |
|---|---|
| Basic weight | 2,630 lbs. |
| Full fuel | 666 lbs. |
| Pilot | 180 lbs. |
| Operating weight | 3,476 lbs. |
| Max. gross weight | 4,150 lbs. |
| Minus operating weight | 3,476 lbs. |
| Total payload | 674 lbs. (full fuel) |

### PAYLOAD

Distance vs. Fuel Requirement = Payload & Flight Time

| DISTANCE (Round Trip) | FUEL REQUIRED* | PAYLOAD OUTBOUND | FLIGHT TIME |
|---|---|---|---|
| 270 nm/310 miles | 666 lbs. | 674 lbs. | 2:35 |
| 260 nm/300 miles | 607 lbs. | 733 lbs. | 2:20 |
| 217 nm/250 miles | 520 lbs. | 820 lbs. | 2:00 |
| 174 nm/200 miles | 433 lbs. | 907 lbs. | 1:35 |
| 130 nm/150 miles | 368 lbs. | 972 lbs. | 1:10 |
| 87 nm/100 miles | 281 lbs. | 1059 lbs. | :50 |
| 44 nm/ 50 miles | 194 lbs. | 1146 lbs. | :25 |

* *Includes 30 min. reserve.*

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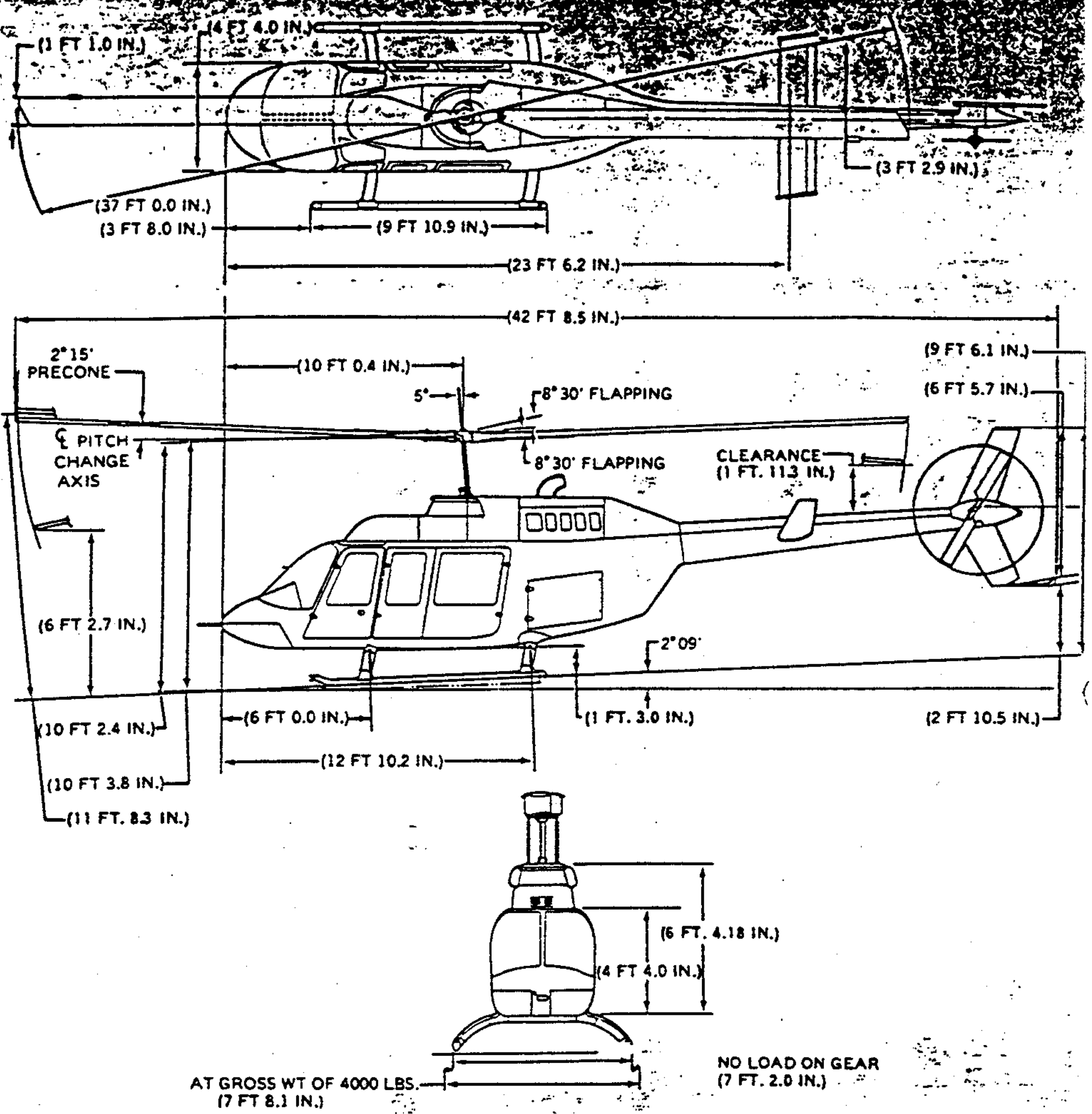
## GENERAL CONFIGURATION
## BELL 206L-1 (LONG RANGER) II TURBINE HELICOPTER




Petroleum Helicopters

# GENERAL SPECIFICATIONS

## BELL 206B-III TURBINE HELICOPTER

### DIMENSIONS

| | |
|---|---|
| Length | 39' 1" |
| Width | 6' 3½" |
| Height | 9' 7½" |
| Main Rotor Dia. | 33' 4" |

### POWER PLANT

Allison 250-C20B developing a maximum of 420 SHP derated to 317 SHP for take off and 254 SHP for cruise.

### LANDING GEAR

Fixed skid type landing gear with pilot activated emergency pop-out float system.

### HELIPORT SIZE

36' x 36' Landing Deck (normal operations)
24' x 24' Landing Deck (restricted operations)

### STANDARD EQUIPMENT

VHF Radio Communications
Loran C Navigation Equipment
Life vests
Customer FM radio (optional)
Cargo hook (optional)

### CARGO/BAGGAGE

Baggage Compartment 16 cu. ft., 35" x 35" 250 lbs. maximum
Passenger compartment, 40 cu. ft.
Area: Length 39"; Width 46"; Height 34"

### SPECIFICATIONS

| | |
|---|---|
| Maximum gross weight | 3,200 lbs. |
| Average basic weight | 2,000 lbs. |
| External sling load | 1,000 lbs. |
| Fuel capacity | 91 gal./618 lbs. |
| Fuel consumption | 30 gph/204 pph |
| Average cruise speed | 104 kts/120 mph |
| Maximum range | 260 nm/300 miles with 30 min. fuel reserve |
| Passenger seats | 4 passengers plus pilot |

### LOADING INFORMATION

| | |
|---|---|
| Basic weight | 2,000 lbs. |
| Full fuel | 618 lbs. |
| Pilot | 180 lbs. |
| Operating weight | 2,798 lbs. |
| Max. gross weight | 3,200 lbs. |
| Minus operating weight | 2,798 lbs. |
| Total payload | 402 lbs. (full fuel) |

### PAYLOAD

Distance vs. Fuel Requirement = Payload & Flight Time

| DISTANCE (Round Trip) | FUEL REQUIRED* | PAYLOAD OUTBOUND | FLIGHT TIME |
|---|---|---|---|
| 260 nm/300 miles | 618 lbs. | 402 lbs. | 2:30 |
| 217 nm/250 miles | 526 lbs. | 494 lbs. | 2:05 |
| 174 nm/200 miles | 442 lbs. | 578 lbs. | 1:40 |
| 130 nm/150 miles | 357 lbs. | 663 lbs. | 1:15 |
| 87 nm/100 miles | 272 lbs. | 748 lbs. | :50 |
| 44 nm/ 50 miles | 187 lbs. | 833 lbs. | :25 |

* *Includes 30 min. reserve.*

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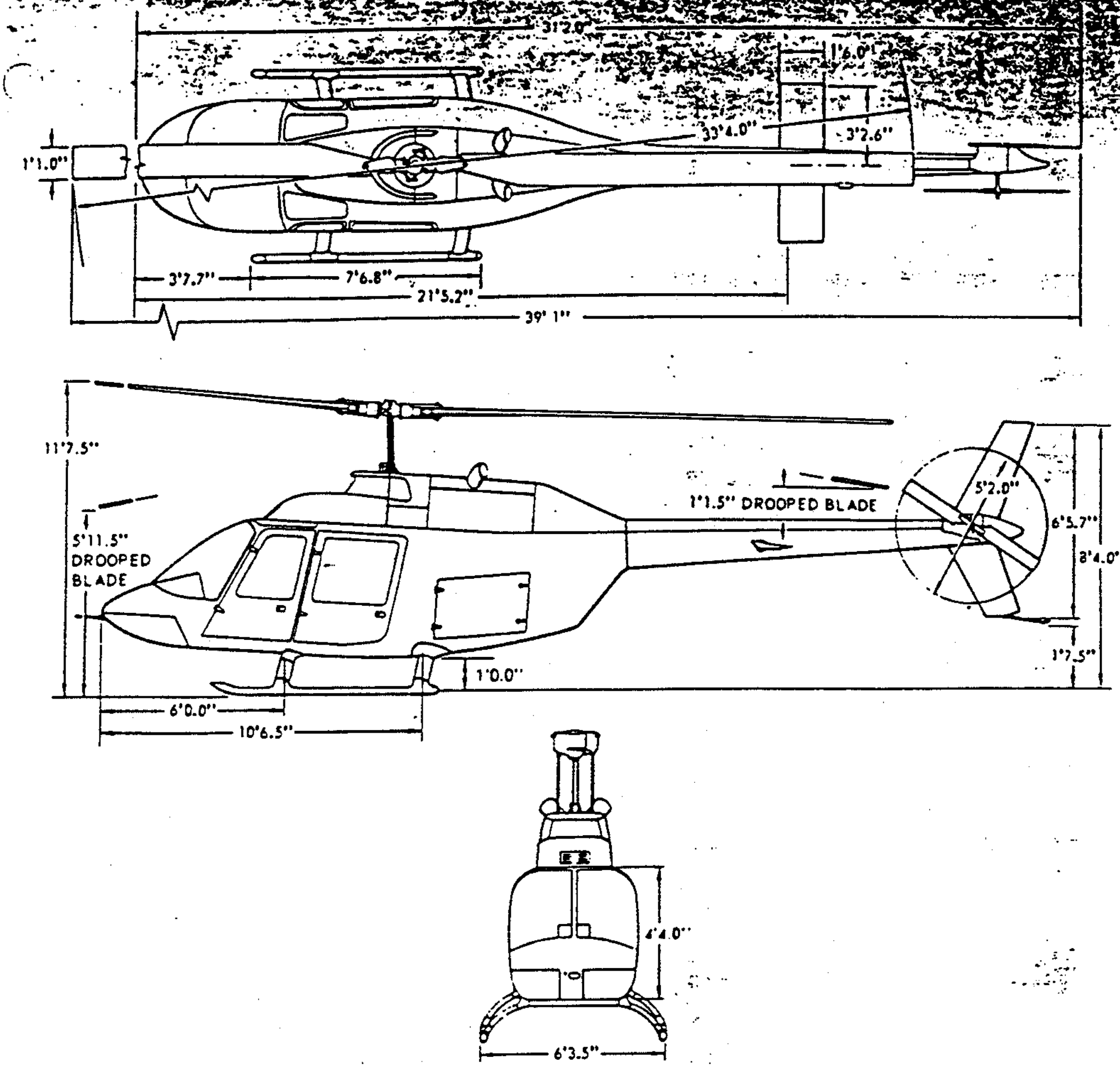
## BELL 206B-III TURBINE HELICOPTER




# Petroleum Helicopters

## GENERAL SPECIFICATIONS

### BELL 212 TWIN-TURBINE HELICOPTER

### DIMENSIONS

| | |
|---|---|
| Length | 47' 1" |
| Width | 9' 4" |
| Height | 12' 10" |
| Main Rotor Dia. | 48' 0" |

### POWER PLANT

Two (2) Pratt & Whitney PT6-3 engines developing 1,800 SHP derated to a total of 1,290 SHP.

### LANDING GEAR

Fixed skid type landing gear with automatic and pilot activated emergency pop-out float system.

### HELIPORT SIZE

48' x 48' Landing Deck (normal operations)

### STANDARD EQUIPMENT

Dual VHF Radios
Loran C Navigation System
ADF Navigation Equipment
VOR/ILS
(2) life rafts with survival gear
Internal/External PA system

### CARGO/BAGGAGE

Tail boom cargo space 28 cu. ft. (400 lbs.)

Internal cargo space—220 cubic feet with 49" x 92" sliding doors

### SPECIFICATIONS

| | |
|---|---|
| Maximum gross weight | 11,200 lbs. |
| Average Basic Weight | 7,227 lbs. |
| External Sling Load | 4,000 lbs. |
| Fuel Capacity | 307 gal./w/auxiliary tank |
| Fuel Consumption | 103 gph/700 pph |
| Average Cruise Speed | 100 kts/115 mph |
| Maximum Range | 245 nm/280 sm with 30 min. fuel reserve |
| Passenger Seats | 11 passengers (one aux. fuel tank) |
| Crew | 2 pilots |

### LOADING INFORMATION

| | |
|---|---|
| Basic Weight | 7,227 lbs. |
| Full Fuel | 2,108 lbs. |
| Pilot | 400 lbs. |
| Operating Weight | 9,735 lbs. |
| Max. Gross Weight | 11,200 lbs. |
| Minus Operating Weight | 9,735 lbs. – |
| Total Payload | 1,465 lbs. (full fuel) |

### PAYLOAD

Distance vs. Fuel Requirement = Payload & Flight Time

| DISTANCE (Round Trip) | FUEL REQUIRED* | PAYLOAD OUTBOUND | FLIGHT TIME |
|---|---|---|---|
| 245 nm/280 sm | 2,065 lbs. | 1,465 lbs. | 2:30 |
| 217 nm/250 sm | 1,875 lbs. | 1,700 lbs. | 2:10 |
| 174 nm/200 sm | 1,570 lbs. | 2,000 lbs. | 1:45 |
| 130 nm/150 sm | 1,265 lbs. | 2,305 lbs. | 1:18 |
| 87 nm/100 sm | 880 lbs. | 2,690 lbs. | :52 |

* *Includes 30 min. reserve*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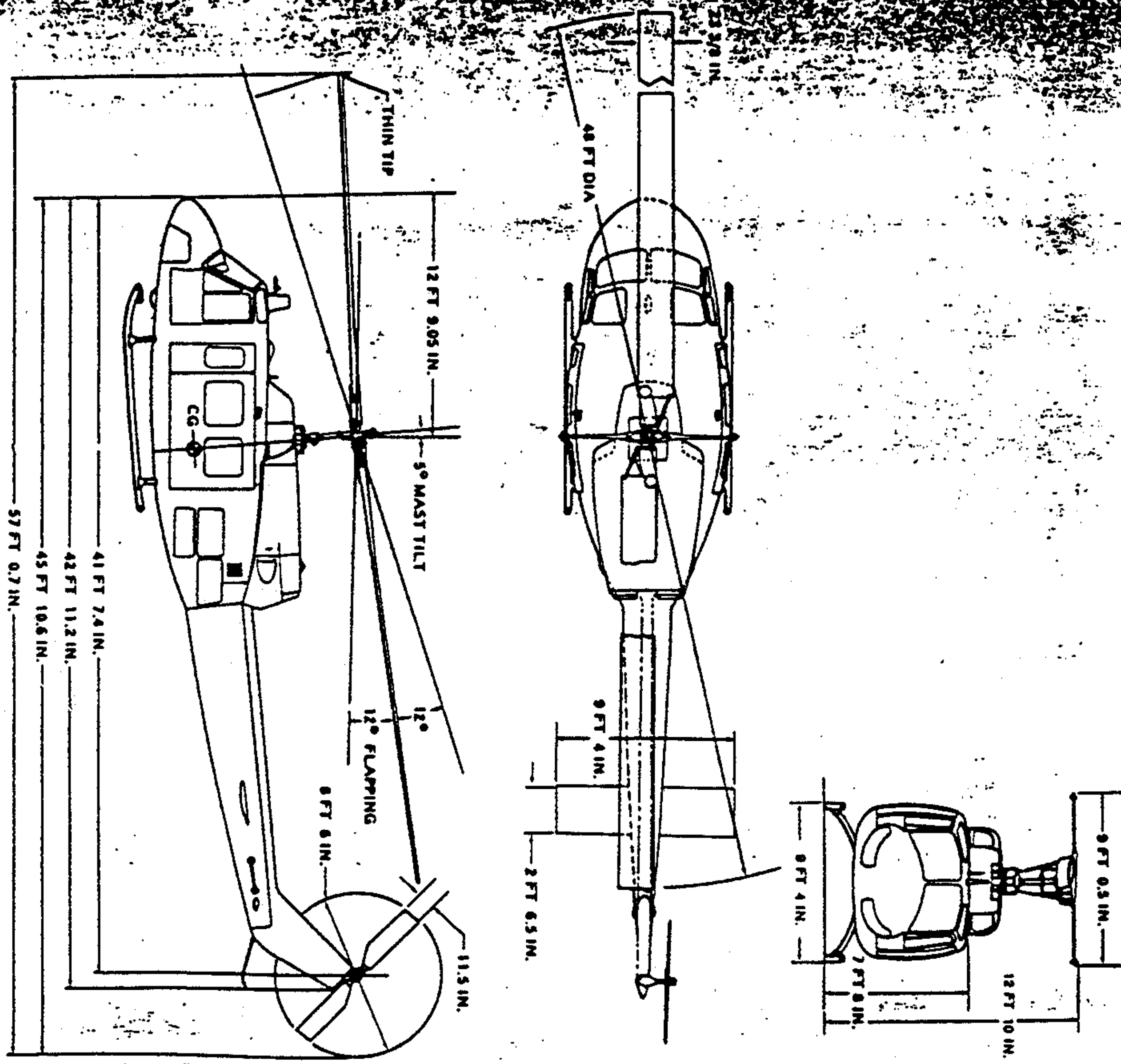
# GENERAL CONFIGURATION
## BELL 212 TWIN-TURBINE HELICOPTER




# APPENDIX 3
# NAVY HELICOPTER ACCIDENT DATA BASE

HELO WEATHER INVOLVEMENT MATRIX
MATRIX TABULATED FROM EVENTS OCCURRING JAN 77 THRU FEB 93

| CODE | ALFA | BRAVO | CHARLIE | HAZARD | OTHER | TOTAL | DECODE |
|---|---|---|---|---|---|---|---|
| 00 | 1 | 1 | 0 | 8 | 0 | 10 | TURBULENCE |
| 01 | 0 | 0 | 0 | 3 | 0 | 3 | TURB - IN TSTMS |
| 02 | 0 | 0 | 3 | 3 | 0 | 6 | TURB - OROGRAPHICA |
| 03 | 0 | 0 | 1 | 0 | 0 | 1 | TURB - CLEAR AIR |
| 07 | 0 | 0 | 0 | 1 | 0 | 1 | UNDEFINED CODE |
| 10 | 0 | 0 | 2 | 3 | 0 | 5 | ICING - GENERAL |
| 12 | 0 | 0 | 0 | 1 | 0 | 1 | ICE - CLOUD/STRUC |
| 14 | 0 | 0 | 1 | 0 | 0 | 1 | ICE - GND/ENGINE |
| 15 | 0 | 0 | 2 | 0 | 0 | 2 | ICE - CLOUD/ENG |
| 16 | 0 | 0 | 0 | 1 | 0 | 1 | ICE - CLR AIR/ENG |
| 20 | 2 | 0 | 3 | 1 | 0 | 6 | STORMS - GENERAL |
| 21 | 1 | 4 | 12 | 6 | 0 | 23 | THUNDERSTORMS |
| 22 | 0 | 3 | 6 | 0 | 0 | 9 | HURRICANE |
| 23 | 0 | 1 | 6 | 2 | 0 | 9 | LIGHTNING |
| 24 | 0 | 0 | 0 | 1 | 0 | 1 | RAIN EFCT - GENERA |
| 25 | 0 | 0 | 0 | 4 | 0 | 4 | RAIN EFCT - HEAVY |
| 26 | 2 | 0 | 1 | 1 | 0 | 4 | RAIN EFCT - LIGHT |
| 30 | 4 | 6 | 18 | 44 | 0 | 72 | UNFAVORABLE WIND |
| 31 | 3 | 3 | 38 | 30 | 0 | 74 | UNF WIND - SURFACE |
| 40 | 0 | 0 | 1 | 0 | 0 | 1 | DA - GENERAL |
| 41 | 0 | 0 | 1 | 0 | 0 | 1 | DA - RWY LVL |
| 50 | 1 | 0 | 1 | 1 | 0 | 3 | PRECIP |
| 51 | 16 | 5 | 24 | 67 | 0 | 112 | RAIN |
| [illegible] | 2 | 0 | 3 | 5 | 0 | 10 | DRIZZLE |
| 53 | 17 | 3 | 13 | 13 | 0 | 46 | FOG |
| 54 | 29 | 11 | 35 | 197 | 0 | 272 | HAZE |
| 55 | 0 | 0 | 0 | 1 | 0 | 1 | FREEZING RAIN |
| 56 | 0 | 0 | 1 | 1 | 0 | 2 | SLEET |
| 57 | 3 | 1 | 4 | 1 | 0 | 9 | SNOW |
| 58 | 0 | 0 | 1 | 0 | 0 | 1 | FROST |
| 59 | 0 | 0 | 0 | 1 | 0 | 1 | HAIL |
| 60 | 1 | 1 | 0 | 0 | 0 | 2 | WHITEOUT |
| 62 | 17 | 23 | 77 | 294 | 0 | 411 | CLOUDS (BKN/OCST) |
| 63 | 2 | 1 | 3 | 11 | 0 | 17 | SKY OBS/CEIL INDEF |
| 64 | 1 | 0 | 0 | 5 | 0 | 6 | CEILING ZERO |
| 65 | 1 | 0 | 1 | 11 | 0 | 13 | CEILING LT 100 FT |
| 66 | 2 | 0 | 6 | 5 | 0 | 13 | CEIL 100-200 FT |
| 67 | 1 | 0 | 5 | 15 | 0 | 21 | CEIL 201-500 FT |
| 68 | 1 | 2 | 2 | 21 | 0 | 26 | CEIL 501-1000 FT |
| 69 | 3 | 0 | 5 | 34 | 0 | 42 | CEIL 1001-2000 FT |
| 70 | 77 | 38 | 190 | 1246 | 0 | 1551 | CEIL OVER 2000 FT |
| 99 | 0 | 0 | 1 | 3 | 0 | 4 | UNDEFINED CODE |
| OTHER | 157 | 133 | 1343 | 2555 | 0 | 4188 | NO WX INVOLVED |
| TOTAL | 316 | 213 | 1746 | 4381 | 0 | 6656 | |

COUNT OF MISHAPS/HAZARDS = 6656
COUNT OF AIRCRAFT = 6656

## EXPLANATION OF DATA FIELD HEADERS ON ENCL (2)

ALFA.....CLASS A MISHAP...DESTROYED AIRCRAFT/FATALITY/<br>
PERMANENT TOTAL DISABILITY/DAMAGE>$1M

BRAVO....CLASS B MISHAP...PERMANENT PARTIAL DISABILITY/<br>
$200K < DAMAGE <$1M

CHARLIE..CLASS C MISHAP...LOST WK DAY INJURY<br>
$10K < DAMAGE < $200K

HAZARD...INCIDENT.........FIRST AID OR LESS INJURY<br>
DAMAGE < $10K

NOTE: ROWS AND COLUMNS DO NOT NECESSARILY SUM DUE TO PRESENCE OF MULTIPLE CONDITIONS RECORDED WITH EACH EVENT.

# APPENDIX 4
# EVACUATION DATA BASE

| SAMPLE AND TOTAL | THE WORLD | | | | | | | | | | NORTH SEA AND UK | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TOTAL 45 | | BLOWOUT 13 | | TOW/CALM 7 | | STORM 14 | | OTHER 11 | | TOTAL 14 | | BLOWOUT 1 | | TOW/CALM 0 | | STORM 8 | | OTHER 5 | |
| | NO | % | NO | % | NO | % | NO | % | NO | % | NO | % | NO | % | NO | % | NO | % | NO | % |
| Evac from rig only | 33 | 73 | 7 | 54 | 4 | 57 | 13 | 93 | 9 | 82 | 13 | 93 | 1 | 100 | | | 8 | 100 | 4 | 80 |
| Evac from sea only | 5 | 11 | 4 | 31 | 1 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | 0 | 0 | 0 | 0 |
| Evac from both | 7 | 16 | 2 | 15 | 2 | 29 | 1 | 7 | 2 | 18 | 1 | 7 | 0 | | | | 0 | 0 | 1 | 20 |
| Helicopter | | | 3 | 23 | 3 | 43 | 9 | 64 | 5 | 45 | 11 | 79 | 1 | 100 | | | 7 | 88 | 3 | 60 |
| Lifeboat/ Capsule | 9 | 20 | 2 | 15 | 1 | 14 | 5 | 36 | 1 | 9 | 2 | 14 | 0 | | | | 1 | 13 | 1 | 20 |
| Tug/other vessel | 18 | 40 | 5 | 38 | 4 | 57 | 3 | 21 | 6 | 55 | 2 | 14 | 0 | | | | 1 | 13 | 1 | 20 |
| Other method | 2 | 4 | 0 | 0 | 1 | 14 | 1 | 7 | 0 | 0 | 1 | 7 | 0 | | | | 1 | 13 | 0 | 0 |
| Helicopter | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 18 | 1 | 7 | 0 | | | | 0 | 0 | 1 | 20 |
| Lifeboat/ Capsule | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 0 | | | | 0 | 0 | 1 | 20 |
| Tug - other uses | 12 | 27 | 6 | 46 | 3 | 63 | 1 | 7 | 2 | 18 | 1 | 7 | 0 | | | | 0 | 0 | 1 | 20 |
| Other method | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 0 | | | | 0 | 0 | 1 | 20 |
| Involved death | 14 | 31 | 6 | 46 | 2 | 29 | 4 | 29 | 2 | 18 | 2 | 14 | 0 | | | | 1 | 13 | 1 | 20 |
| Involved injury (known) | 14 | 31 | 7 | 54 | 1 | 14 | 3 | 21 | 3 | 27 | 4 | 29 | 1 | 100 | | | 2 | 25 | 1 | 20 |

BREAKDOWN OF UK SECTOR ACCIDENT DATA ACCORDING TO ACCIDENT TYPE AND EVACUATION ACTIONS TAKEN (SEE TABLE 1 FOR KEY)

| ACC CLASS | ACCIDENT | TOTAL | EVACUATION ACTION TAKEN* | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | ?** |
| 1 | Blowout or well leak | 4 | 2 | | | | | 1 | | | | 1 | | | | |
| 2 | Topsides Leak, Fire, Explosion | 60 | 11 | 22 | 2 | | 2 | | | | | | 7 | 8 | 2 | 16 |
| 3 | Fire at Sea Level | 3 | | | | | | | | | | | | | | |
| 4 | Structural failure | 0 | | | | | | | | | | | | | | |
| 5 | Storm damage | 6 | | | | | | 3 | | | | | 2 | | | 1 |
| 6 | Ship collision | 13 | 6 | 1 | | | | | | | | 1 | 2 | 1 | | 3 |
| 7 | Helicopter crash | 2 | 1 | | | | | | | | | | | | | 1 |
| | | 88 | | | | | | | | | | | | | | |

* NOTE : Total adds up to more than 88 in table because in some cases more than one action was taken. See Table 1 for key to evacuation actions.

** NOTE : Unknown what action was taken.

### Fatalities by Phase and Location on the Norwegian Continental Shelf (1966 through 1985)

| Phase / location | Exploration | Field development | Production | Storage & transp. | Closing & removal | Unallocated | Total |
|---|---|---|---|---|---|---|---|
| Fixed platform | | 14 | 8 | | | | 22 |
| Mobile platform | 15 | 5 | | | | 8 | 28 |
| Flotel | | | 124 | | | | 124 |
| Supply ships | 1 | 1 | 1 | | 1 | | 1 |
| Crane barges/ vessels | | 5 | | | | 1 | 6 |
| Pipelaying vessels | | 3 | | | | | 3 |
| Helicopters | 4** | 24 | 6 | | | | 34 |
| Other | 1 | | | 1*** | | 2 | 4 |
| Total | 21 | 52 | 139 | 1 | 1 | 11 | 225 |

* Helicopter accident 24.11.77: 6 out of 12 were engaged in production, the other 6 in field development.

** Helicopter accident 9.7.73.

## Fatalities by Location and Activity on the Norwegian Continental Shelf (1966 through 1985)

| Location / Activity | Fixed plat-form | Mobile plat-form | Fot-hel | Supply ships | Crane vessels/ barges | Pipe-laying vessels | Heli-copt-ers | Oth-ers | Total |
|---|---|---|---|---|---|---|---|---|---|
| Maintenanc/ testing | 1 | 4 | 1 | | | | | | 6 |
| Construction | 11 | | | | 1 | | | | 12 |
| Drilling | 1 | 8 | | | | | | | 9 |
| Production process | | | 123 | | | | | | 123 |
| Diving | 1 | 10 | | | 1 | 1 | | 1 | 14 |
| Crane operations | 4 | | | | | | | | 4 |
| Anchor handling | | | | 2 | | | | | 2 |
| Trans. to/fr /betw. locat | | | | 1 | 1 | 1 | 34 | | 37 |
| Emergency evacuation | 3 | 6 | | | | | | | 9 |
| Others | 1 | | | 1 | 3 | 1 | | 3 | 9 |
| Total | 22 | 28 | 124 | 4 | 6 | 3 | 34 | 4 | 225 |