HSE
Health & Safety
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Weather-sensitive offshore operations and Metocean data

Prepared by **PAFA Consulting Engineers**
for the Health and Safety Executive

OFFSHORE TECHNOLOGY REPORT

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EXECUTIVE SUMMARY

Monitoring of weather, meteorological, oceanographic (METOCEAN) and motion response parameters is important for the safe implementation of many offshore operations. Crane and mechanical handling operations; supply voyages, loading and back-loading; helicopter flights; over-side and diver maintenance operations; emergency rescue and recovery; FPSO shuttle loading operations; support from large semi-submersibles and jack-up drilling rigs, to name a few, are limited by equipment performance that deteriorates in poor weather conditions. In detail, each has a different requirement for monitoring instruments and forecast data to allow appropriate operational decisions to be taken. A wide variety of companies take part in such weather-sensitive operations.

The North Sea is a mature offshore oil province with a mixture of historic legacy equipment and new facilities. There have been staff and ownership changes, and many offshore facilities have seen substantial modification to their topside process and utility layouts that will have had effects on their weather monitoring sensors.

Metocean monitoring instruments and weather forecasting services have continued to develop and there are many more possibilities for providing accurate data than were available when the United Kingdom Continental Shelf (UKCS) was developed initially.

Companies in the offshore industry who participate in weather-sensitive offshore operations have been approached for their observations and asked to comment specifically on whether the safety of these operations might be improved if they had at their disposal, a better range of site-specific meteorological, oceanographic and weather forecast data. Mandatory occurrence reports (submitted to formally record incidents that have or may have led to a dangerous incident) have also been examined and interviews have been extended to a small number of key players in the Norwegian offshore industry.

The consultation progress has been broad-brush extending over as wide a range of operations as possible. The scope of the study was wide rather than deep so there has not been an opportunity to follow-up any issues in detail.

The objective of this study was to identify whether the industry might make better use of new services to improve the safety of weather-sensitive operations and to allow the Health and Safety Executive to consider whether it should take a more proactive roll in the adoption of these systems.

Since this has not been an in-depth investigation of any particular issue, it was not felt appropriate to formulate detailed recommendations. Instead the conclusions are summarised and presented in Chapter 9 as a range of observations. These observations offer the industry the widest scope to implement a more detailed examination to see if they indicate a need to learn particular lessons, improve operational procedures or identify an opportunity to improve safety.

One general observation is that for the North Sea viewed as a whole, metocean measurement and forecasting services are disjointed. There would appear to be multiple redundancy but variable, uncontrolled quality. It is suggested that the offshore industry would obtain much better value and higher quality for a lower overall cost if companies were to invest in a shared activity rather than operate independently. An effective, high-quality shared service would bring benefits to a wide range of people who earn their livelihoods on the UK continental shelf and even possibly extend to safety improvements for other industries.

1 INTRODUCTION

1.1 BACKGROUND

Health and Safety Executive (HSE) have asked P A F A Consulting Engineers to carry out a review within the offshore industry to establish whether or not safety of offshore operations could be improved by the provision of installation-specific weather data.

Installation-specific data might comprise:

1) Better use of existing instrumentation on each platform (with improvements, updates, maintenance and calibration if necessary).
2) Better integration of and access to weather monitoring instrumentation from surrounding platforms.
3) Upgrading data collection and recovery from a select few platforms to provide high quality information from a representative chain of platforms across the United Kingdom Continental Shelf (UKCS).
4) Site-specific weather forecasts whether in the present-day format or with more specific reference to particular weather parameters (atmosphere, wind, waves, swell, currents) or including predictions of response.

HSE wished this issue to be tackled by the collection of information on wind/weather-sensitive operations for installations on the UK continental shelf and the reflection of the experience of those who use current weather instrumentation and forecasts to plan offshore operations.

1.2 SCOPE OF WORK

Initially, a representative sample of operators was interviewed to assess, in a systematic manner, the number and variety of weather-sensitive operations that are conducted offshore. The objective of this phase of the work was to establish the precise nature of relevant operating restrictions, for example: Do simple combinations of wind speed and/or direction cause most restrictions? Which are governed by platform orientation? Does wind turbulence or flow around large obstructions, which are an integral part of the topside configuration, impose significant restrictions? Do other aspects of metocean conditions or platform operations play a significant part?

A number of service providers (helicopter companies, supply boat operators, shuttle tanker operators, weather forecasters and specialist contractors for offshore inspection and maintenance activities) were then interviewed to elucidate their requirements for supporting meteorological data when planning weather-sensitive operations.

An attempt was made to assess which aspects of site specific metocean data (wind speed, direction, turbulence and angle of approach relative to the platform or its major component substructures) might improve safety of weather-sensitive operations. Could information that is normally available today (from weather forecasts, for example) be significantly improved by a wider availability of live raw or processed data from a number of existing North Sea installations?

The findings of this part of the study are reported in Chapter 2.

1.3 COVERAGE OF SURVEY AND REPORT

Initially, two major oil companies (Shell and BP-Amoco) who operate facilities throughout the geographic area of interest were approached for extensive consultation. Contact was established, not only with engineering departments but also with operational staff to ensure that proper recognition was given to day-to-day operational difficulties.

Several smaller companies and the individuals responsible for planning the implementation of weather-sensitive operations and/or devising operational procedures that govern the conduct of such tasks were also approached. Operators of both fixed and floating production facilities were interviewed.

Discussions focused on determining specific details of wind, wave and visibility that limited operations and on assessing which major factors have been found most relevant to their safe and successful completion.

Helicopter operators, supply boat companies, supply boat logistic planners, diving support vessel owners, representatives of emergency response and rescue vessel operators and representatives of the shuttle tanker operators were contacted for their views as were several members of the regulatory authorities (CAA, HSE, NPD). Chapter 3 sets out the findings of this aspect of the work.

Two significant extensions were made to the study when it became evident that they were necessary.

1. It was difficult to identify and focus on specific areas of operational difficulty. Many opinions were received about critical aspects of offshore operations. However, as a result of early North Sea experience, many safety-critical aspects have been identified and have been the subject of close scrutiny in the design phases of more recent developments. It is difficult to be certain whether these critical areas remain sources of operational danger or whether other, more subtle aspects have replaced them. It was decided to examine recent mandatory occurrence reports (MORs) which incorporated a mention of meteorological conditions or weather forecasting to find if these gave any clues. The outcome of this review is presented in Chapter 4.

2. One or two interviewees pointed out that it would be wise to extend the study to cover events in the adjacent Norwegian sector of the North Sea. Since many of the systems used, particularly for shuttle tanker loading, originate from Norwegian bases, it may be important to understand the approach to safety which has been adopted in the Norwegian Sector. One helicopter pilot also pointed out that the Norwegian approach to helicopter operations is quite different from that in UK waters and that he was able to glean important safety information from the Norwegian installations that are close to the boundary line. With this in mind it was decided to approach the Norwegian Petroleum Directorate (NPD) to obtain an overview of relevant Norwegian experience. This aspect of the study is reported in Chapter 7.

In Chapter 5, special considerations that affect floating (compared with fixed) production facilities are discussed.

Throughout the study, it was borne in mind that needs might vary significantly across the different geographical areas of the UKCS: Southern North Sea/Irish Sea/Liverpool Bay; Central North Sea; Northern North Sea; and North Western Approaches. Factors contributing to these differences are collected Chapter 6.

Chapter 8 draws together the different aspects of the study and suggests a few alternatives that have been considered as a way forward for each of the major classes of operation. Finally, the main findings, observations and conclusions are summarised in Chapter 9.

2 ASSOCIATED LIMITS AND RESTRICTIONS

2.1 GENERAL

There is considerable variability in the detail of companies' approaches to the planning and implementation of weather-sensitive operations. In general, each company has a weather alert procedure for each installation and will provide some guidance concerning when weather-sensitive operations may or may not proceed - but there the similarity ends. The detail, the levels of prescription, the general approaches to responsibility and the level of specification of associated measuring instruments vary considerably.

Legally, the requirements for measuring and recording meteorological, oceanographic and information relating to the movement of the offshore installation are set out in The Offshore Installations and Pipeline Works (Management and Administration) Regulations 1995 (MAR) (1995/738), Regulation 14, "Operational information," which is quoted as follows:

> "*The duty holder shall make arrangements for the collection and keeping of –*
>
> *(a) such meteorological and oceanographic information; and*
>
> *(b) such information relating to the motions of the offshore installation,*
>
> *as is necessary for securing, so far as is reasonably practicable, the safe operation of the installation and the safety of persons on or near it.*
>
> 81 Environmental conditions may affect the safety of activities carried out on or around the offshore installation (eg loading or unloading and, in particular, helicopter operations). They may affect the ability to implement emergency plans. Monitoring of environmental conditions is therefore vital offshore. The regulation requires the duty holder to collect information on these conditions. Information needs should be determined in the light of reasonably foreseeable operating conditions (eg based on the operating limits set out in the safety case) and arrangements made to collect and, if necessary, to keep the relevant information. Information to be collected might need to include:
>
> (a) wind speed and direction;
>
> (b) the sea state;
>
> (c) air temperature;
>
> (d) barometric pressure;
>
> (e) visibility, cloud base and cover;
>
> and in respect of floating installations (including mobile units and floating production installations):
>
> (f) the roll, pitch, heave, yaw and heading of the installation.
>
> 82 Some information (eg visibility) can be collected visually. If equipment is used it could be based on the offshore installation itself or nearby (eg on a vessel, or covering a group of installations, particularly installations with no person on board), if the nature of the information needing to be collected allows. Some information such as roll, pitch etc can only be collected on the offshore installation. Much information will be

collected for immediate use only. It need be recorded and kept only if necessary for later use."

In line with the goal setting environment in which the legislation was framed, this regulation is non-prescriptive and allows the duty holder considerable leeway to measure and record these data to achieve safe operation of the installation, 'so far as is reasonably practical.' The duty holder is expected to set and achieve his own standards. From the comments received, it seems that the standards being applied across the installations on the United Kingdom Continental Shelf are highly variable.

In discussion with a number of service providers, one particular operator was seen as having the "most advanced", "best funded" and "most enlightened policy" in this area. It has adopted a highly detailed and prescriptive approach both to management and implementation of adverse weather procedures, backed up by clear recommendations and a large investment in access to measured data. Others put more emphasis on review of procedures and documentation prepared by external contractors, held together by some company-specific general guidance or strategy. Hence, one company's adverse weather advice is a document with sixty-three pages of text relating, in detail, to metocean conditions at particular facilities and procedures to be followed when thresholds for each weather-sensitive operation are exceeded. Another's has only seven pages of general advice (some of which quote 'standard design' information, not specifically relevant to any particular operation).

For operations of supply boats and other 'small' monohulls, one large operator provides closely argued discussion with trigger values for environmental conditions at which management reviews and/or actions are required and decision trees for captains, supervisors and managers who need to contribute to decisions. The corresponding procedure for another major operator makes reference to an industry-standard document prepared by the UK Offshore Operators Association that puts more onus on the master of the vessel to make an 'appropriate assessment of risk.'

One operator, with a large number of operating facilities in the North Sea, has made a considerable investment in meteorological measurement stations on each manned and unmanned platform. It has sought to tie all of these systems together in a way that makes the data available to anyone planning an operation on any one of their platforms. Several companies maintain high quality instrumentation on their platforms in support of the UK Met Office's data gathering service while a group of companies provides similar types of data to a system operated by Muir Matheson Ltd which is relayed to helicopter operators. Others, if anecdotal evidence is to be believed, rely on their (hopefully) near-by emergency rescue and recovery vessel (ERRV), to provide them with the readings of wind speed and direction which they are required to provide to an approaching helicopter!

Some companies subscribe to a 24-hour weather forecasting and advice service for their staff and subcontractors, while others rely on their service providers to make provision for their own needs.

2.2 HELICOPTERS

Many of the risks inherent in helicopter flight are managed by careful attention to design details and strict implementation of operating procedures. Provided these restrictions are observed, helicopter operations need be no more dangerous than many other employment activities. In this respect it is important to distinguish between safety requirements and those of efficiency. If a helicopter has to turn back to base or progress to a designated, alternative landing-site because it cannot land at its intended destination, this is an inefficiency for the client and his personnel. If the flight has been made in accordance with existing limits and regulations, however, it should not represent a threat to the safety of the pilot and passengers.

On the other hand, a multi-leg helicopter flight, which would require the pilot to make difficult landings on a succession of oil platforms or floaters, might be regarded as pushing normal operational requirements too far. This is particularly the case if the later landings would impose a severe burden on the pilot who might already be suffering from fatigue.

In short, helicopter safety requires not only regulations, procedures and limits, but also good professional judgement from all concerned. Whether a flight should take place or not will depend on input from several individuals, at a minimum, the helicopter landing officer (HLO) on the installation, the helicopter captain, the offshore installation manager (OIM) and the master of the attendant standby vessel. Unless all of these individuals participate effectively in the decision-making process, there will be increased risk to the success of the mission and perhaps, in case of extreme mishap, even to those on the helicopter or the oil installation.

Weather forecasting and readings from meteorological monitoring instruments impinge on helicopter operations at several levels. In preparing for a flight, the helicopter captain must take into account:

- Current weather at take-off
- Current/forecast weather for the flight
- Reported and forecast conditions for his landing approach
- Prescribed or anticipated restrictions for the specified landing site(s)
- Forecast conditions for his onward flight and landing at a designated alternate location.

In reaching his decisions regarding flight preparation, he will have at his disposal:

- Terminal Approach Forecasts (TAFs) and trends for any designated airfield close to his route
- Read-outs from arrays of metocean monitoring instrumentation on some platforms along this route
- Weather forecasts for conditions along the route
- Reported meteorological and motion parameters (for a floater) for his destination
- TAFs or similar information for the designated alternate landing sites.

As the helicopter approaches its destination, the pilot needs to take account of the detailed meteorological data radioed ahead by the helicopter landing officer (HLO) on the platform. Table 2.1 summarises the types of meteorological triggers that apply to offshore helicopter operations. Provided the platform-based instrumentation is functioning correctly, is correctly located and is within calibration, this should remove any dependence of the critical approach and landing phase on forecast values.

The platform should also be equipped with a brightly coloured windsock to alert the captain if there is a serious discrepancy between the data he has been advised and the conditions near to the helideck. However, it is important to safe operations that the evidence of the windsock should not be relied upon as the sole input to the pilot. There are many factors that affect the handling of a helicopter as it comes in to land and the associated risks can only be properly managed if the pilot is provided with accurate data. The minimum instrumentation that is required to provide a pilot with these data is described in CAP437 (Ref. 5). This may be summarised in brief as:

> "…means of ascertaining and reporting at any time:
> a) The wind speed and direction;
> b) The air temperature;
> c) The barometer pressure;
> d) The visibility, cloud base and cover; and
> e) The sea state "
>
> "An indication of wind speed and direction will be provided visually to the pilot by the provision of a wind sock coloured so as to give maximum contrast with the background."

> "Measuring instruments used to provide the data listed….should be periodically calibrated in accordance with the manufacturers' recommendations."
>
> "…the movement of the helideck in pitch, roll, heave and heading…to be recorded on the vessel prior to and during all helicopter movements."

Some instrumentation readings may be more important than others in particular circumstances (a day time approach in high wind, for example), see Chapter 3, but in other circumstances other readings might be more critical (flights at night in fog or freezing conditions, say). It may be possible to consider reductions in the CAP 437 requirements for particular circumstances (eg use of automatic weather readings), but it would seem unlikely that general reductions could be accepted unless they had been thoroughly investigated through an extensive consultation process.

Note the occurrence of sea state as a reporting requirement. This follows from the general requirement that there should be a reasonable chance of recovering someone from the water should the helicopter ditch. Hence a range of wave height triggers apply to all flying operations and there is a general discouragement/prohibition of flying for all but emergency purposes in sea states with wave height greater than 7m significant (even though the associated wind speed would cause no particular problems for many aircraft).

2.3 SMALL MONOHULLS

2.3.1 General

In general terms, masters of vessels and offshore installation managers (OIMs) have legal responsibilities for the safety of their respective crews and facilities, legal obligations to communicate with each other to ensure safety of any joint operations and the authority to decide whether operations affecting their vessels should proceed or terminate. They should also question any instructions that might create a hazard.

Not withstanding these general legal requirements, a variety of guidance concerning safety of weather-sensitive offshore operations is available from several sources.

Both sheets of Table 2.1 contain summary information relating to the general weather-related triggers that apply to the operations of such vessels. The limitations that apply in the field are considered at the beginning of this section. The decision whether or not to sail from port is discussed towards the end.

All vessels are required to stay beyond 500m from an oil installation unless they have permission from the OIM and have made arrangements with the OIM or his nominee to approach closer.

2.3.2 Supply Boats and Diving Support Vessels

The guidelines for the safe management and operation of offshore support vessels, Reference 7, which is the document referred to by most operators, focuses heavily and in general terms on the responsibilities and experience of the master of the vessel. It gives few specific triggers for actions based on weather conditions. For example, the following is the guidance given for approaching an installation:

"When the vessel approaches the installation to commence work, the Master should make his approach in a safe and seamanlike manner taking into account wind, wave and tidal conditions."

It describes procedures that should be followed during the final approach to an offshore installation. These may 'only' be common sense and/or good seamanship but they allow the performance of a vessel positioning system to be checked against the prevailing weather conditions as the vessel is moved onto station in close proximity to an offshore installation (fixed or floating). Thus even if there has been a misreading or erroneous reporting of some weather parameter, this should be spotted or compensated for in an inherently safe manner when the approach procedures are implemented properly.

Later, Reference 7 goes to some length to layout thirteen factors that the Master of a vessel should consider in making his risk assessment before engaging in weather-side working. This focuses, correctly, on many issues other than weather. However, it makes few specific recommendations about weather limits or triggers which should apply other than a passing reference to “any specific weather policy which the Charterer or Installation may have.”

Reference 7 reinforces the Master’s responsibility, and guides him to all the aspects that he should consider when making his judgements but, in failing to provide specific guidance, it seems to increase the load on the master’s shoulders without giving him support. There is one notable exception. It states that a master must stop any weather-side working when the power consumption of his dynamic positioning system exceeds 45% of the total available. The North Sea Marine Affinity Group has prepared an adverse weather working guideline (Table 2.2). While giving precedence to the recommendations of Reference 7, this adverse weather guideline presents a set of trigger values for metocean parameters and the associated precautions that should be taken when these are exceeded.

By contrast Shell, reference 6, detail many triggers for the working of standby vessels, multi-role vessels, supply vessels and diving support vessels adjacent to a fixed or floating production facility. While acknowledging the master’s responsibility for the safety of his vessel, Shell also detail multiple wave height and wave period conditions, visibility limits, wind speed/direction limits and tidal currents which all require the master or OIM to reconsider the operation in which they are engaged. Several triggers also refer to other vessel systems, for example the exceedence of specific motion criteria and the power utilisation by the station keeping system. It may be difficult to specify uniquely limiting combinations of wind speed, wave height and current which apply to any given draught and trim values. However, the power consumption of the DP system is a good guide to the magnitude of the forces which are being resisted. If the power consumption begins to climb towards 50% of the total available (taking into consideration any power generation capacity that may not be available on the day), this is a strong indicator that the master should be disengaging from the operation at hand.

As might be expected, the triggers for weather-side working are more strict than those for lee-side working.

Crane operations will be discussed more fully in Section 2.6 below, but it is important to note that several individuals need to participate in decisions about whether such operations should proceed/continue. The master of the supply vessel, the OIM (or his representative) and the banksman all need to participate in safety-critical decisions which are influenced by the current weather conditions.

In addition to the instantaneous meteorological and tidal conditions, the master of a supply vessel must consider how circumstances might change throughout the duration of a given operation. Offloading of one or two specific items may only take an hour but, generally, unloading a whole range of supplies may take a day or more particularly if it involves transfer of large quantities of bulks in fluid form. Cherry picking particular items from a shipload is generally discouraged. The duration of an offloading operation may be extended if the relevant crane is needed for other duties or if crane movement is not allowed because of a helicopter operation. The master needs to be informed of any forecast changes in weather, in particular, a change in wind direction which might fundamentally change his position from lee-side working (inherently safe in most instances) to weather-side working (inherently risky). Depending on the geographical area, similar changes may be caused by tides or currents.

The time required to move off 'in an orderly fashion' depends on the nature of the task at hand. If a simple lift is being made, only a few minutes may be required. If a fluid transfer is taking place then to get crane assistance, disconnect the hoses and move off may take up to 30 minutes. If a DSV has a team deployed and working underwater, then if might take several hours to bring a team on board safely and move off. The DSV may also be more restricted in its available manoeuvring footprint while it has a team of divers or an ROV deployed.

A master also needs to be aware of any changing conditions that might be experienced as he moves location around an offshore facility. To this end he needs the best information available. Unfortunately, a supply boat working in the lee of a fixed structure is not always in the best location to measure or detect incipient changes.

In weather conditions identified as 'subject to small intense squalls' a master may be able to see approaching squall incidents on his radar and take action accordingly. Otherwise much of the data which a supply ship needs to ensure safe operation, such as wave heights, wind speeds, wind direction and current speed/direction, could most easily be obtained from instruments mounted on a fixed structure. In fact, to follow Shell's approach and impose restrictions which depend on 0.5 m increments of wave height and assessment of associated wave periods, platform based instrumentation would seem to be essential. However, care is required in maintaining instruments in a serviceable accurate condition and in interpreting the data that is most relevant to a vessel at sea level. These data are of limited use to other fixed platform operations. Further, it is by no means certain or even likely that there will be anyone on board many fixed platforms with the necessary marine experience to interpret data in a way which is acceptable to a supply boat captain.

There is also reluctance among supply boat captains to accept too much data from a platform. Already, masters feel peer pressure to operate in marginal conditions because another master did so previously. They are wary about putting too much data in the hands of those with little marine experience in case additional unwarranted pressure is also applied. Generally, only the master of a vessel knows enough about the load condition and performance of his vessel and his crew to make valid judgements in marginal weather conditions.

Forecasting should have a strong influence on the decision for a supply vessel to set sail. Commercial pressures on a production operation may lead an OIM to request that a supply vessel sets sail so that it is available in the field with an essential item "whenever there is a break in the weather." However, if a prolonged spell of bad weather occurs this simply leads to a tired boat crew attempting a supply operation in marginal weather conditions with all its associated dangers. Partly because of such pressures, there is now a tendency to give the final decision on sailing to a marine controller since he is the only person in the chain with a full appreciation of both offshore requirements and up-to-date weather forecasts.

The North Sea Marine Affinity Group provides an adverse weather sailing guideline in the format of a decision flow chart (See Table 2.2). Similarly, Shell provides guidelines for sailing decisions for both the Central North Sea and the Northern North Sea areas. These take into account the different lengths of voyage and, in some cases, the need to sail for the sheltered waters around Shetland so that it is possible for the supply boats to make use of short breaks in persistent poor weather, which can affect the Northern North Sea.

Likewise, BP Amoco is in the process of developing a working procedure that takes into consideration the conditions experienced West of Shetland.

Smaller companies may or may not have the marine experience to develop their own policies and they may rely on their suppliers to provide the necessary guidance. However, it is still possible for undue pressure to be brought to bear on supply boat owners to sail when this would not be the recommended safe option.

2.3.3 Emergency Rescue and Recovery Vessels (ERRVs)

The United Kingdom Offshore Operators Association has published a set of guidelines for the safe operation of vessels standing by offshore installations, Reference 8.

There are somewhat in excess of 100 ERRVs serving the oil installations on the UKCS. Many of these vessels carry daughter craft, fast rescue vessels (FRV), which are deployed to recover anyone from the sea. The ERRVs may be assigned uniquely to one facility or located in some central position from whence a FRV will provide coverage of operations on each platform. Typically, the FRV may work up to 10 miles from the ERRV although trials are taking place to see whether this distance could be extended to 15 miles. The FRVs may have top speeds in ideal conditions in the region of 30 kt but in marginal conditions and unfavourable weather, the speed over the ground can easily drop to 15 kt. For someone wearing the correct protective clothing and buoyancy aids, a commonly accepted upper limit for recovery from the sea to a place of safety where they can receive treatment is two hours – perhaps one hour in the sea and one in transit. This guideline upper limit may need to be revised downwards in the face of emerging experimental data. For people without the appropriate kit, recovery from the water would need to be significantly shorter.

Generally, successful operations of ERRVs and the FRVs are difficult in high, steep, short period seas but are not too seriously affected by long period swells. Hence any definition of an operational limit will be a complex specification of wave heights, periods and other parameters. ERRV operations may be carried on safely in high seas West of Shetland if the swell is the dominant component but may have to be curtailed in lower waves in the Southern North Seas if the wind direction changes to one which induces steeper short-period seas. In some areas, tidal current or increased current velocities over underwater sandbanks can cause operational difficulties.

2.4 SHUTTLE TANKERS

Table 2.1 indicates a typical range for the different types of operational restrictions and environmental triggers that are used in the safe management of shuttle loading operations. Almost all loading facilities are different in some respect (see Reference 2):

- There have been and continue to be developments in loading hardware (mooring arrangements, buoys, turrets, loading arms/hoses, floating storage units (FSUs), FPSOs);
- Dynamic positioning systems for shuttle tankers have developed in many respects and
- The layout of loading systems relative to other platforms in the field imposes restrictions on tanker manoeuvres as they approach or leave the loading facility.

This is reflected in operational restrictions and environmental triggers for application when a shuttle tanker should approach, when it should begin to make preparations to leave, when it should leave, and any associated contingency planning for “emergency departure”. These restrictions tend to be set uniquely for each different loading facility.

There is also recognition within the literature (operation guidance manuals, adverse weather policies and the like) that there are too many interacting influences on the behaviour of a tanker at a buoy or tied to another floating vessel for any restrictions to be totally prescriptive. Consequently over-riding guidance is often included along the lines of “the master of the off-take vessel and the OIM have the authority to suspend cargo loading if they consider the operation to be at risk from bad or deteriorating weather”.

Some of the restrictions on shuttle tanker operations (particularly for older facilities) arise from the performance of secondary support equipment and the need for manned access to make an attachment or recover items from the sea. In all cases there will be environmental restrictions arising from the design phase of the project. Thus, depending on vessel draught and trim, there may be wind speed, current speed or wave height restrictions arising from limiting loads in a hawser or expected maximum relative motions between two points of two floating vessels. These restrictions may need to be observed even when they are not self-evidently necessary from the vessel motions and responses on the day. (It is unreasonable to expect operating personnel to make an in-field assessment and anticipate extreme motions or loads from observed significant wave heights or wind speed/gust conditions. Occasionally, operators will install extra monitoring equipment such that extreme loads arising during field operations can be studied with a view to identifying more realistic operational boundaries.)

Restrictions in visibility, wind-direction and current speed and direction (tidal or otherwise) may arise from safety considerations of field layout. This will be particularly important if the separation between the loading facility and a fixed platform or other obstruction is small. The consequences of a collision between a tanker and a fixed structure are potentially so severe for danger to life and/or the environment that many precautionary measures are taken to minimise the possibility.

Operational restrictions may also arise from specific aspects of an FPSO configuration or operational requirement. Some FPSOs use laterally mounted fixed flare towers towards the stern of the vessel. These obstruct potential escape routes for a shuttle tanker should the need arise to make an unexpected or emergency break-away. With at least a quarter of his escape routes blocked, the shuttle tanker captain may prefer to give himself a margin by maintaining a specific heading relative to the prevailing weather. Whether he has the thruster capacity to do so will depend upon wind, current, sea-state and the draught/trim of his vessel. The relative location or orientation of the associated FPSO may also affect the wind, current and wave forces experienced by his vessel.

2.5 SUPPORT OPERATIONS

Long term support operations by a larger vessel such as a flotel, a utility service or tender assist vessel (semi-submersibles) or jack-up will generally be subject to specific study and preparation of a safety case. Part of this safety case will involve the specification of limits and procedures for adverse weather working. Just as with the smaller vessels, a range of different weather conditions may trigger some operational response with particular attention needed if the vessel is relying on some level of thruster assistance to hold station. Unlike with smaller vessels, however, the limiting wave heights will be higher and wave periods will be longer. Thus operating restrictions requiring a semi-submersible to take up a stand-by location or to move to survival draught will tend to be accompanied by a moderately severe storm and the build up of these weather conditions will normally have been spotted by available weather forecasts.

Both semi-submersible and jack-up operations will attract restrictions relating to relative motion between the unit and the production facility although the scale of motion and the capability to take corrective action is very different in the two cases. The semi-submersible will be subject to restrictions imposed by the gangway and any other connections (free-hanging risers or power supply cables, for example). Typically, the gangway will be instrumented to give warnings before it reaches the limits of its operating envelope and use of the gangway can be curtailed before it becomes strictly necessary to disconnect it. At about the same time (i.e. in similar weather conditions), depending on the weather forecast, preparation may be made to pull away to a standby location and, if really severe weather is expected, the draught of the vessel may be changed to the survival condition. All of these conditions and the associated preparatory operations will have been considered in advance and/or further developed from operational experience.

Particular care is necessary if the impending storm is in such a direction as to carry a floating vessel towards a fixed platform. Extensive studies will have been performed into the effects of the dragging of an anchor and/or the breaking of an anchor line but in the face of a really severe storm, extra precautions may be necessary before the worst of the weather is imminent.

Depending on the nature of the support being provided, much preparatory work may be necessary to close down and make safe dependent systems. To this extent, it is common to operate an adverse weather warning alert (with associated operational procedures) so that sensitive operations are not initiated in the face of a poor weather forecast even if the storm is not expected for a day or two.

Other interactions occur between adjacent large structures, each with its own operating system. Hence careful consideration needs to be given to the location of the helideck and any wind directions which could lead to turbulence. Likewise, vents and discharge systems should also have been considered to ensure that they do not interfere with each other or with a site where personnel are expected to work.

2.6 TOPSIDE AND MAINTENANCE OPERATIONS

Topside-based operations on a fixed platform are generally restricted by wind speed. Cranes will be subject to limits laid down by the manufacturer or due to the effect of wind on the load being lifted. Generally, platform topsides are in exposed locations and similar restrictions may apply to general maintenance and mechanical handling work unless it is taking place in a sheltered position on the platform. Typical wind speed limits, which will lead to working restrictions, are 30 to 35 knots but lower speeds may cause restrictions if the direction of the wind is such as to carry noxious fumes or discharges onto the work site. Even at lower wind-speeds, care will be required when moving around the platform in case a strong gust is experienced when moving into an unsheltered area. Depending on the detail of the adverse weather operating procedure, use of tag lines attached to the lifting loads may also have been specified for consideration. As wind speed increases beyond the values indicated by these tags, work will generally be restricted to that required to make the work place safe against higher winds. (By convention, wind-speed limits are quoted in terms of the 10-minute mean value at an elevation of 10 m above mean sea level - though this should be clearly stated in any official documentation.)

Visibility, heavy rain and lightening may also restrict general out-door topside operations and, if over-side working is required, it will also be subject to restrictions associated with the capability of the recovery vessel to retrieve someone from the water. Typically 5.5m significant wave height is quoted as a value above which serious injury may be expected by someone attempting to use these recovery devices. However, there seems to be some scepticism about whether this is a sensible upper limit particularly if the fast recovery craft may be required to work close to a fixed structure. Shell lay down more stringent conditions that also depend on the dominant wave periods present in the sea. If the dominant periods are less than seven seconds, then the FRV is expected to move more severely and lower wave heights apply.

The International Rope Access Trade Association (IRATA) has a code which covers all aspects of over-side working by rope. This lays down appropriate levels of personnel training and weather limits that should apply to teams engaged in over-side working. Typically there will be limits on wind speed (less than 30 knots) and wave/swell height dependent on the elevation above mean sea level. Another factor relates to any general discomfort due to weather that may arise in cold and stormy conditions.

Generally, a forecast will be obtained before initiating an operation and appropriate weather limits will be specified as part of the permit to work. A key requirement relates to the ERRV and its ability to launch a FRV to recover anyone who falls into the water.

Table 2.1
Overview/Summary of Triggers for Offshore Operations

Operation	Triggers	Note/comment
Flying	Low wind speed	Take-off weight limit
	High wind speed/direction	Turbulence near obstructions (on platform or on near-by support craft)
		ERRV operation
	Wave height	
	Visibility	
	Cloud base	e.g. freezing altitude
	Specific aircraft limits	
Helideck	High Mean Wind speed (various):	Rotor start/stop Personnel access/safety
	Wind gust speed	
	Wind speed/direction	Turbulence
	Wind direction	Gas turbine exhaust
	Visibility	Visual cues to pilot
	Snow/Ice accumulation	
	Sea spray	
	Heave, pitch/roll motion (including motion periods)	Landing Helicopter movement on deck
General offshore activities	Mean wind speeds (various)	
	Snow	
	Snow/Ice accumulation	
	Poor visibility	
	Wind chill	
	Temperature < -1° C (freezing)	
	Lightening	
General over-side offshore activities	As previous plus	
	Various wave heights	ERRV vessel limits
		Inundation/green water
	Water temperature	Hypothermia risk
ERRV/multi-role vessels	Wave heights (various) together with: wave periods wind speed visibility	Vessel equipment limits

Table 2.1 (Continued)
Overview/Summary of Triggers for Offshore Operations

Operation	Triggers	Note/comment
Supply vessels	Wind speeds (various) Unfavourable wind direction Sea state (Wave height and period, various) Strong tidal currents Visibility Vessel specific limitations Vessel motion limits Power utilisation General sailing weather and WOW conditions in field	Adverse weather sailing guidelines
Flotels, Utility Service Vessels and Tender Assist Drilling Support	Combined wind speeds and directions (various):	Effects of turbulence Gangway usability
	Wind direction	Noxious fumes or discharges
	Sea state	Air gap
	Vessel mooring equipment limitations Gangway motion (triggers)	
Tanker loading operations	Wind direction Mean wind speed (various): Together with effects of DP reliability Tide, current magnitude and direction	Limits vary with vessel draught and trim
	Weather forecast Sea state (various)	Personnel transfer (in some cases) and/or DP performance
	Visibility Vessel specific limits Vessel specific alarms Relative motion excursions	
Normally Unmanned Installation Access	Wind Tide Sea state Visibility Daylight	Marine access
Crane	Wind (various) Sea state (various) Rain Snow/ice Visibility	Banksman – Crane operator

Table 2.2
Adverse weather guidelines from North Sea Marine Affinity Group

Trigger	Precaution
Wind	
20-25 knots Mean Wind Speed at 10m level	Risk assessment should be conducted, prior to commencing any operation alongside an installation, involving the OIM of the installation, crane driver and Master. Consideration should be given to vessel motion and potential cargo damage when reviewing prevailing weather conditions and immediate forecast.
Unfavourable Wind Direction	No planned installation overboard venting/discharges whilst working supply vessels, unless previously agreed with vessel Master.
Sea State	
3m – 4m Significant Wave Height	Prior to arrival within 500m zone, risk assessment to be conducted by installation OIM, crane driver and Master of vessel on positioning and cargo handling. Due account must be taken of vessel motion, any awkward lifts, potential of cargo damage due to heave and potential effects of sea on hose work. **Continued operations at Master's discretion. If power utilisation approaches 50%, just to maintain station, then consideration should be given to ceasing hose work**.
Tidal Streams	
Strong currents/Tides	Delay discharging until slack tides if vessel cannot hold satisfactorily against tide. Vessel must not get into 'drift on' situation where power consumption approaches 50% to hold station.
Visibility	
Poor visibility	Cease cargo operations if vessel deck crew unable to see crane operator clearly. Risk of injury to personnel.
Visibility <250m	Remain outside 500m zone of installation to avoid collision with installation or other vessels. Maintain RADAR watch.
Vessel and Equipment	
Vessel rolling heavily	Master may elect to cease operations at lower wave heights than those shown above if rolling starts to affect station keeping and/or crew safety.
Vessel moving violently	If vessel motion adversely affects any station-keeping equipment in use by the vessel, then the Master will cease operations and clear the installation.
Weather Side Working	
20 – 25 knots Mean Wind Speed at 10m level and/or 3m-4m Significant Wave Height	Very large PSVs may have to cease weather side working if positioned beam on to weather.
Power utilisation	If vessel power use increases to around 45% + to maintain station, then the Master will cease operations. This is particularly pertinent when a vessel is lying beam on to an installation.

NB: REFERENCE SHOULD BE MADE TO 'GUIDELINES FOR THE SAFE MANAGEMENT AND OPERATION OF OFFSHORE SUPPORT VESSELS', SECTIONS 8.5, 8.6 AND 8.7. THESE SECTIONS SHOULD TAKE PRECEDENCE THROUGHOUT.

3 VIEWS AND OPINIONS

3.1 OPERATORS

Most operators of fixed platforms or older floating production facilities do not appear to have a need for a meteorologist on each facility. They and their support contractors learned how to cope without this extra overhead cost during the early days of North Sea development. Nevertheless, some opinions were expressed that as older staff are replaced or larger companies are replaced with smaller newer ones, essential experience of dealing with offshore weather conditions is being lost. Several experienced people from support contractors pointed to cases where platform based operating staff made unreasonable requests with apparent disregard or lack of appreciation of the prevailing weather conditions.

Operators of new floating facilities, particularly in an exposed location, might employ meteorologists (working a shift pattern) to assist with the effective interpretation of weather forecasts until safe and effective patterns of work and supply have been established. One operator pointed out that the performance of some facilities is so dependent on effective management in a marine-dominated environment that they needed to employ experienced mariners as senior operations staff to have any chance of success! If vessel heading is to be adjusted to suit multiple production and performance requirements possibly in a wide variety of loading conditions, then the operating staff need to have a clear appreciation of many interacting effects. Co-ordination of activities with others who might be affected is essential.

With one or more floating facilities working in a remote, exposed location, many tasks need to be managed taking into consideration the inherent limitations that adverse weather imposes. In this situation, the task of co-ordinating and ensuring effective communication between all the parties who may be affected by different aspects of weather limitations is not insignificant. This appears to have been the findings of BP-Amoco in the operation of their Schiehallion and Foinaven facilities, and it was evident that their supply-boat logistics planners appreciated the efforts made to co-ordinate their services with those of others.

3.2 HELICOPTER PILOTS/OPERATORS

Several pilots/ex-pilots were consulted. Two currently active pilots expressed unease about the accuracy of data they received from offshore installations via the (HLO) or the radio officer. They had several concerns:

- They were aware of the age of some offshore equipment and were concerned about its continued reliability and accuracy.
- They were aware of the number of platform topsides that have been reconfigured and were concerned that the siting of the wind speed and direction indicators might have been adversely affected by these changes for particular wind directions.
- As NS production has continued, there has been a tendency to reduce manning levels and for experienced staff to move elsewhere. New appointees, working for 'new' operating companies, appear to have less appreciation of marine or aviation matters than those they replace.
- It is possible, on some occasions, that the person responsible for forwarding meteorological data is working from instrument readings in the bowels of a platform with little awareness of the conditions outside.

While most of the meteorological parameters provided by an offshore rig could be important in some circumstances (some will be more important than others depending on the visibility, time of day, etc), the pilots felt that accurate information about wind speed and direction immediately above the helideck was particularly important. When combined with information contained on the Installation/Vessel Limitation List (IVLL), the wind speed and direction give pilots important information about routes into and away from platforms that will avoid areas of excessive turbulence. A pilot's workload is high as he approaches or leaves a landing site and unexpected turbulence is particularly unwanted and potentially dangerous at this time.

An accurate reading of atmospheric pressure is also fairly important since it allows the pilot to set his altimeter to assist with his landing on a helideck. Other equipment on the helicopter can be used for the same purpose but this has a fairly long response time and will tend not to provide the desired accuracy during the approach.

In cold weather, it is important for a pilot to be aware of surface temperature and the approximate elevation of freezing level. North Sea helicopters are not generally fitted with fully functional de-icing equipment so it important for a pilot to know that he can use particular elevations to reduce any build-up of ice.

As a matter of regulation, Norwegian offshore installations are designated as airfields while UK installations are not. Being designated an airfield carries with it fairly onerous requirements for meteorological monitoring equipment (see Tables 3.1 and 7.1) and the issuance of regular weather forecasts (TAFs and trends). Aviators can routinely access these data. As a result, a pilot may consult the data issued by the Norwegian platform which is near to his route to determine what sort of weather he may expect to encounter. This may also warn him in advance if there is a marked discrepancy with data being reported from a nearby UK rig.

CAP 437 (Ref. 5), Chapter 6 "Helicopter Landing Areas – Miscellaneous Operational Standards," covers - 6.2, "Wind Direction (Vessels)"; 6.3, "Helideck Movement" and 6.4, "Aircraft Operational Data - Reporting and Recording" describing the corresponding requirements for meteorological and movement monitoring for helicopter operations to a helideck on the UKCS. The salient points of these are outlined in Table 3.2.

There is an on-going discussion in the helicopter operating community about the effect of lightning. Some claim that helicopters attract lightning and are uneasy about the threat which it poses while others maintain that lightening poses no threat to a properly maintained helicopter. In any event, it appears that a helicopter that is struck by lightning must be subject to an expensive maintenance check afterwards. The meteorological office claims that new forecasting models can predict lightning, detect it remotely and so could issue warnings. This may not be adequate if the presence of the helicopter increases the chance of lightening. Some helicopters carry equipment that can detect whether there is a risk of lightening strike, but the efficacy of this equipment is in dispute. If lightning strike is a serious hazard, there would seem to be a strong case for implementing combined evaluations of forecasts and detection equipment.

In general, high wind speed in itself, is not a bar to helicopter flight. However high waves accompany high winds and high waves would cause danger to a rescue craft trying to recover someone from the sea. High winds would also pose a serious risk to someone trying to negotiate an exposed helideck to get on or off a helicopter. It is for these reasons that there are strict limits to all normal offshore commercial flying activities.

3.3 MASTERS OF SMALL MONOHULL SUPPORT CRAFT AND LOGISTICS PLANNING COMPANIES

3.3.1 Supply-boat Masters and Supply Logistics Companies

Several people expressed unease about the commercial pressure which supply boat captains can be put under to approach and deliver to offshore facilities in weather conditions which are too severe to guarantee safety. BP-Amoco actively discourages this practice and encourages supply boat captains to report any instances when they experience it. Where an operator has a marine operations department, there appears to be a general appreciation of the inherent dangers and support for Captains to stick by their best judgement. However, several vessel masters and operations co-ordinators believed that the problem still exists. They pointed out that it is very difficult to prove that such pressure is being applied since it may not become evident until the next supply contract is offered to another company.

Several people pointed to the lack of "marine awareness" of many current personnel on fixed North Sea structures. Reference 7 describes how a supply vessel should take some time (typically 10 to 20 minute) to ensure its positioning system is functioning properly and coping with the environmental forces as it comes on station alongside a fixed structure. One supply boat co-ordinator noted how it had received a complaint from one platform that it was losing 15 minutes every time a supply boat approached because it was following the recommended procedure. BP-Amoco expressed unease that good data on wave heights, for example, might be used by inexperienced personnel to apply even greater pressure to marine crews – "the last boat loaded in 4 m wave heights so why aren't you!" – for example.

In the case of floating production facilities the problem of inexperienced staff is not so prominent. Generally, a floating facility will have several members of staff with marine experience and so they appreciate the point of view of the master of an approaching vessel. This is doubly true where the floating facility has a lively response and requires an experienced marine crew to coax an effective production operation from it. In all such cases, however, it is important to realise that the overall performance of a floating facility may depend on the management and control of its heading. A captain of a supply vessel needs to be aware of the current operating regime for such an FPSO since it will need to be taken into consideration when he plans his approach for an offloading operation. The heading may be less than ideal for a particular approach route (due to the effects of thruster out-wash, for example), or it may be detrimental to the operation of a particular crane. Good communication and a willingness to address unexpected operational problems would seem an essential prerequisite for the development of appropriate adverse weather policies at such facilities. It may take some considerable time before an efficient operating procedure can be devised which takes into consideration all of the competing requirements and inherent variability in metocean conditions.

Discussions with marine personnel indicated an unwillingness to devolve any responsibility away from the master of the vessel. At the same time they were aware of the heavy burden of responsibility which had to be borne by masters, whether they were "new and untested" or "old sea dogs". It is evident to everyone that the supply boat is not always in the best position to make a judgement about a weather condition, particularly when the supply boat is in a sheltered position and when the weather may be changing rapidly. However, few seemed willing to identify any platform-based instrumentation that might assist the master in making better judgements. A fixed platform would be an ideal place to establish many measuring instruments but only if these were monitored, maintained and interpreted by staff with appropriate experience.

In the case of a floater such as an FPSO, the situation is less clear. The performance of wind, wave and current sensors on an FPSO may be strongly affected by the operation in hand, and by the response and heading of the vessel. Hence there may be an inherent difficulty in determining when trigger values of metocean parameters are in danger of being exceeded. This could be accepted by the industry as inevitable and be the reason that experienced marine crew are required on both FPSOs and their attendant supply vessels. However, experience of shuttle-tanker operations indicates that trigger values of key variables need to be identified so that crews know when the danger from continued operation is increasing and can make preparations to withdraw in the face of further deterioration.

The comments of one senior captain are precised as follows:

- Wind speed and direction data gathered in support of helicopter operations is a good indicator (even though it is strictly applicable to a higher elevation).
- A barograph is useful in trained hands since it indicates trends.

- Wave heights and directions associated with sea and swells are difficult to estimate and predict. Ideally each field should have a wave rider buoy so that information is available locally and can be sent to the Met Office.
- Tide and current data should also be available locally. Current meters should be installed at each location in the Southern North Sea, if necessary on the standby vessel.
- The final decision about whether or not to proceed with an operation must still rest with the Master. Providing him with better more accurate data and forecasts can only be beneficial.

West of Shetland, BP-Amoco have a resident meteorologist permanently on duty. They use the experience of these personnel to detect and confirm reasonable prospects (forecasts) of spells of less severe weather and plan shuttle-tanker and supply boat movements to take advantage of them. The meteorologists are aware of the limitations of on-board weather sensors and the weather forecasts that apply to the area and use their own observations and experience to make appropriate corrections and allowances. The difficulties of operating in this area throughout the winter months are making BP-Amoco consider major modifications to the mountings of their wind instruments and the possible installation of a wave buoy.

In less severe environmental conditions and/or in less remote areas, a resident meteorologist may seem an over-expensive solution to what may only be an occasional problem. However, it would seem inappropriate to rely solely on "marine experience" where there are clearly many difficult decisions to be made in the face of considerable commercial pressures.

The presence of more than one floating vessel in the proximity of a production facility can complicate operations considerably. In these circumstances, it is essential that all involved communicate and make each other aware of their intended movements well in advance since these may impinge on intended "emergency escape corridors" or interfere with other essential tasks. This would be especially true in the face of a rising or changing weather condition when extra time may be needed to effect a safe retreat. It would appear logical for some one to co-ordinate such operations and vessel movements, but since it is unlikely that there would be anyone on the fixed platform with sufficient marine experience, this may not be feasible.

3.3.2 Emergency Rescue and Recovery Vessels

As for many other marine operations, there is a reaction against anything which might lead to restriction on the freedom of a master to exercise his best judgement. A typical, representative quote was as follows:

> "We should never take away the role of the Master in deciding from his long experience at sea and his knowledge of the motion characteristics of his vessel when it is safe or not to offer a good prospect of recovery. There are too many variables. If from a study such as this, some 'person' decides to put finite limitations on operations they will not apply equally to all vessels and crews. Similarly the Master is given some leeway in his decision if estimations are used. Often rig personnel would argue a point if they have wave-riders…. It is a retrograde step to have automation."

It is important to acknowledge this type of feeling in implementing any recommendation from this study.

An experienced master will make a complex judgement based not only on the weather but perhaps based on his knowledge of local conditions or some aspect of the state of maintenance of his vessel or the experience (or lack of experience) of the coxswain of his FRV. In reaching his final judgement he is most likely to be affected by his judgement and anticipation of whether the weather is liable to deteriorate over the forthcoming period. If better instrumentation or weather forecasting is to assist him in this task, it must be accurate over the relevant period and also take account of any specific local peculiarities (e.g. tidal current or wave generation over a shallow water area). According to the information set out in Chapter 2, this period is liable to be approximately between 1.5 and 2.5 hours. To be of help, it should offer reliable advice based on the current (perhaps marginal) conditions and how the weather pattern is liable to change over that period.

To some extent masters are content with their present lot. If there is a real emergency, they may effect a rescue in conditions that might exceed any normal recommendation of a safe limit. However, if better reliable weather forecasting were available to both the OIM and the Master of the ERRV, it might prevent extreme rescue situations arising.

3.4 SHUTTLE TANKER MASTERS/OPERATORS

The Oil Companies International Marine Forum, OCIMF, has issued a document (Reference 1) that provides an overview and excellent guidance to offshore loading in harsh weather zones. Tanker loading is recognised as a difficult and potentially dangerous operation and a broad yet detailed approach is recognised as being essential to managing the associated risk. Although weather limitations are important, there are many other factors that need to be addressed for safe operation and these are broadly recognised in the main chapter headings of the cited publication, namely: health, safety and the environment; risk management; legislation and shipping standards; joint operations manual; preliminary assessment of off-take vessel; communications; pre-arrival safety procedures; equipment; operations and emergency and contingency planning. The need for a holistic approach is also emphasised in Reference 2 where various hardware and people concerns are expounded.

Several comments were received after a presentation to an assembled group of shuttle tanker captains:

- Successful offshore loading operations depend on good assessment and forecasting of metocean conditions.
- There is some scepticism about reliability of weather forecasts particularly when different but equally valid sources appear to provide significantly different predictions.
- Wind and wave measurements from FSUs and FPSOs are not renown for their accuracy. Wind-speed readings can be distorted by obstructions on the topside and weather-vaning of the hull leads to problems in assessing absolute wind and current directions. Accurate measurements of significant wave height are difficult from a floating platform with variable mass and inertial properties.
- When no reliable measurements are available, the master of the vessel has to rely on his experience of wave observation, but he would prefer that he had not to rely on this in marginal conditions.
- Captains are particularly anxious that they are not caught out by sudden, unexpected changes in wind direction. Wind changes are usually caused by movement of weather fronts and should normally be anticipated by weather forecasts, at least in the North Sea area.

  If the weather forecast were inaccurate, there would be an extra risk to the loading operation particularly if the switch took place in hours of darkness when the surrounding sea surface could not be observed by the captain from the bridge.
- If wind speed and direction readings were available in some suitable format from nearby platforms, this might alert a Master to changes that were occurring quicker than forecast.
- Some areas of the world are affected by small intense weather systems that can be missed by large scale forecasts. Occasionally, but seldomly, northerly areas of the North Sea may be subject to “polar lows” propagating south from Arctic regions. These are usually weak by the time they reach UK latitudes but the Norwegian Petroleum Directorate is assembling more data about these features in support of their more northerly operations
- Changes in current direction can also be troublesome. In Norwegian waters, large scale vortices can cause rapid changes in current direction, but these features are believed to be less important on the UKCS.
- Due to the proximity of some loading facilities to other platforms or vessels, it is necessary for the shuttle tanker captain to be vigilant and make the broadest use of his marine training in assessing whether or not to proceed.

3.5 ENGINEERING CONSULTANTS AND CONTRACTORS

Platform based maintenance and repair operations will generally require a risk assessment and the granting of a permit to work. Both these activities require an assessment of any wind/weather conditions that might prevent the operation being completed satisfactorily. It was noted that this assessment is highly dependent on wind direction since many operations can be completed if part of the topside structure provides a windshield.

One of the major engineering contractors who would traditionally deal with large scale topside modifications commented:

> "Our logistics people say that we do not experience problems with the quality of forecasts and, considering local variability within the North Sea, the data are sufficiently accurate for our purposes."

One operator drew attention to one of the effects of the CRINE initiative; namely that some production facilities are equipped with only one crane. Consequently it may only be possible to access a platform from one side and this will frequently be the weather-side. This is viewed as a retrograde step in operational safety.

According to comments received from those involved in over-side working:

> "Quality/quantity of safety/weather limitations vary from installation to installation (within International Rope Access Trade Association requirements) very much depending upon the competence/personality of the key personnel. Some are very strict and work to predetermined limits, others less safety conscious. The best talk to all parties and take all opinions on-board. Accidents/near misses that have occurred are very rarely due to poor weather – mostly are due to lax control by personnel, i.e. human factors."

Once an over-side activity has begun the ERRV will make periodic reports including notable weather readings. These will probably be made on the support vessel rather than the platform. If the weather is getting bad or near the specified limits then the technician in charge of the operation will radio the control room and arrange to bring-in the inspection team.

3.6 METOCEAN INFORMATION SOURCES AND CONTRACTORS

One government agency and several commercial contractors measure, collect, interpret, analyse, issue and forecast weather data for the offshore industry. Three were contacted:

- The Met Office
- Oceanroutes
- Muir Matheson.

Talking to these three organisations has provided a good overview of the types of metocean services on offer.

In the case of the Met Office it is important to distinguish two roles:

- Data gathering in support of the UK meteorological forecasting model.
- All other meteorological services.

There is one Met Office employee in Aberdeen who fulfils the first role (his salary comes from the UK taxman). He <u>solicits</u> support from the offshore industry on a <u>purely voluntary basis</u>. He provides, maintains/calibrates and generally controls the quality of instruments for companies which volunteer to provide regular meteorological readings as input to the meteorological model. If he suspects an instrument is not functioning correctly or is out of calibration, he intervenes to prevent these data being fed into the model while he makes contact with the associated operator or vessel owner to negotiate access for essential maintenance. Table 3.3 provides an overview of the input to the UK forecasting model from offshore installations and

Figure 3.1 shows where all these units are located. Generally, there is a policy of free availability of raw data, so anyone who needs access to this information can, in principle, get it.

It can be seen that a reasonable coverage of the oil producing areas of the UKCS is available from these sources. The accuracy of the UK weather forecasting model will depend on a wide variety of geographically diverse sources, with very many more inputs other than those from the offshore locations. However, if any subsequent detailed forecast or interpretation of the output depends upon correlation against actual current readings, there would appear to be a reasonable base of readings on which to make an accurate interpretation.

The other part of the Met Office in Aberdeen and Oceanroutes appear very similar in the range of services they offer the industry although there are differences in detail, style, presentation and quality of service as you might expect to see in any commercially competitive area. Typically, these organisations offer detailed interpretation of the output from a range of weather forecasting computer models in a form that supports their client's needs.

The extent and presentation of the metocean data are areas in which significant advances are currently being made. The Met Office says that there have been significant improvements in forecast models in recent years, with many more output parameters available on a routine basis. The follow-up software development to deliver these forecast parameters to the offshore industry are only just beginning to emerge, but the Met Office expects to see greater availability of, for example, lightning risk forecasts, visibility forecasts and sea state prediction. Some of these services were first made available commercially late in 2000 and an wider customer base is currently developing. The means of delivering these data may also be expected to take a quantum leap with the development of web-based technology. It is difficult to predict the impact these items might have on offshore safety. It would seem important to keep abreast of the developments and perhaps hold a seminar or two to inform the industry about basic availability of new services and to monitor the experience of those who have tried to use them to improve operational efficiency.

Some operators prefer the form of presentation of one commercial company to that of another, and one company rather than another may be better established to provide specific data for one particular type of operation (e.g. helicopter operations, supply boat logistical planning or shuttle tanker loading). It seems this is a normal feature of a commercially active market.

Both the Met Office and Oceanroutes provide experienced qualified meteorological staff in teams to support the planning of high-value weather-limited operations or individually for offshore secondment. There continues to be a strong interest in these services for offshore installation activities, but routine availability of platform-based weathermen is much reduced by comparison with the early days of North Sea development.

Some interesting comments were received from one of the meteorologists who had been seconded to an offshore floating production facility. He pointed out that:

- Wind measurement on a weather-vaning vessel can be extremely problematic. The superstructure of an FPSO affects the airflow towards the instrument in different ways depending on whether the vessel is allowed to weather vane freely or whether its heading is controlled for some other purpose.
- It is very difficult to measure waves from a floating vessel which has a variable load condition.
- Rain can influence automatic recording of cloud cover to such an extent that human judgement is the only way of ensuring an accurate assessment.
- Where there is no meteorologist on board specifically assigned to providing regular readings, this task is undertaken by someone else without a steady workload, for example, the medic (whether or not he has the necessary background and experience).
- He finds his advice is sought primarily to co-ordinate supply boat and shuttle tanker operations.

- He thought that routinely available swell forecasts seemed poor and he felt that he improved these predictions significantly by careful attention to interpretation of details in available source information.
- Although he is in an ideal situation to provide actual and forecast data to the helicopter-landing officer on his current vessel, he is never asked! This is a strange situation particularly if his comments about the difficulty of interpreting wind data are correct. The implication is that the HLO may be providing data, as required by statute, without taking advantage of the best available data sources. Is this an instance of demarcation or poor co-ordination? If there have been no complaints from the helicopter operators, then this is strongly suggestive that site specific forecasting would be a waste of time for support of helicopter operations.

Muir Matheson, with their collaborators Meteo Consult, might also provide general meteorological services but it would appear that they have one particularly strong niche. They provide instrumentation for automatic measurement and reporting of meteorological data and have strong links to the helicopter operators who make use of the data in planning their day to day operations. They have established a “Helimet” system for provision of appropriately coded and quality controlled weather reports to helicopter operators. The locations of these instruments (which may double as input to the Met Office) are shown in Figure 3.2.

Their view is that the reporting of meteorological parameters from offshore platforms is very mixed: some good, others terrible! They have encountered situations where the report of wind conditions on a helideck (insisted on by CAA) is achieved by asking a stand-by vessel several kilometres distant and much closer to the sea surface. For some wind conditions and directions, this could be so poor as to be dangerous.

Use of instrumentation helps standardise the estimation of metocean parameters, thereby reducing the effects of subjective interpretation by an observer.

Muir Matheson pointed out that many of the instrumentation readings specified for offshore operations are required only as a matter of guidance and there is little required by way of regulation. As a result, offshore instruments may be poorly maintained and out of calibration. This also leads to a situation in which no single individual is in effective control of a platform’s ability to report the measurements. With a few notable exceptions, Muir Matheson experience great difficulty in identifying the individual within an oil company who has responsibility for the upkeep of offshore measurement instruments.

Muir Matheson report that there is some difficulty in getting automatic meteorological data accepted as input to weather forecasting models and generally a trained observer is required to vouch for such data before it is accepted. They feel that for a limited set of parameters, which could be very helpful for planning miscellaneous offshore operations, automatic data is sufficiently accurate. Such automatic data could be acceptable without vetting by a human observer or, at worst, the training required to vouch for this limited set of data would be much less than is required to make a full set of meteorological readings.

Table 3.1

Desirable and Attainable Accuracy of Measurement or Observation

Element to be observed	Operationally desirable accuracy of measurement or observation	Attainable* accuracy of measurement of observation (1994)
Mean surface wind speed	Direction: ± 10° Speed: ± 2 km/h (1 kt) up to 19 km/h (10 kt) ± 10% above 19 km/h (10 kt)	Direction: ± 5° Speed: ± 2 km/h (1 kt) up to 37 km/h (20 kt) ± 5% above 37 km/h (20 kt)
Variations from mean surface wind speed	± 4 km/h (2 kt.), in terms of longitudinal and lateral components	As above
Visibility	± 50 m up to 600m ± 10% between 600 m and 1500m ± 20% above 1500m	± 50 m up to 500m ± 10% between 500 m and 2000m ± 20% above 2000m up to 10 km
Runway visual range	± 10 m up to 400m ± 25 m between 400 m and 800m ± 10% above 800m	± 25 m up to 150m ± 50 m between 150 m and 500m ± 10% above 500m up to 2000 m
Cloud amount	± 1 okta	In daylight an observer can attain an accuracy of ± 1 okta at the point of observation. In darkness, and when atmospheric phenomena limit the viewing of low cloud, there will be difficulty in attaining that accuracy.
Cloud height	±10 m (33 ft) up to 100 m (330 ft) ±10% above 100 m (330 ft)	±10 m (33 ft) up to 1000 m (3300 ft) ±30 m (100 ft) above 1000 m (3300 ft) up to 3000 m (10,000 ft)
Air temperature and due point temperature	±1°C	±0.2°C
Pressure value (QNH, QFE)	±0.5 hPa	±0.3 hPa

* *The accuracy stated refers to assessment by instruments (except for cloud amount): it is not normally attainable in observations made without the aid of instruments.*

Notes: The above table is extracted from "International Standards and Recommended Practices Meteorological Service For International Air Navigation" Annex 3 to the convention on international civil aviation, twelfth edition – July 1995, Attachment B. It describes the operationally desirable and currently attainable accuracy of measurement or observation.

Chapter 4, section 4.1.12 of said document states: "Owing to the variability of meteorological elements in space and time, to limitations of observational techniques and to limitations caused by the definitions of some of the elements, the specific value of any of the elements given in a report shall be understood by the recipient to be the best approximation to the actual conditions at the time of observation."

Table 3.2
Précis of CAP 437 Guidelines re Movement and Operational Data

Section	Concern	Detail
6.2	Wind direction (vessels)	Some vessels have a capability to manoeuvre and take up a heading suitable for helicopter operations. Others do not. This paragraph, in theory, allows the British Helicopter Advisory Board (BHAB) to set appropriate operating restrictions or requirements in these cases. In many situations, it may be expected that other operational constraints will place a higher priority on heading selection!
6.3	Helideck movement	Specifies in some detail the status of vessel motion monitoring and reporting to an approaching helicopter. Details of these requirements for motion amplitudes and rates are the subject of on-going research. (To be more precise, current research is focusing on the effects of vessel movement on a helicopter once it has landed – will it remain immobile on the helideck or could it move as a result of the vessel motion? The effects of motion on a pilot's ability to land do not appear to be a major concern at the moment.)
6.4	Aircraft operational data – reporting and recording	…means of ascertaining and reporting at any time+: • wind speed and direction • air temperature • barometric pressure • visibility, cloud base and cover • sea state

+*Notes*

Wind speed and direction

- The importance of these readings is described in the main body of the text of chapter 3. Zero or low wind speed may cause aircraft handling difficulties.
- Turbulent wake from solid bodies or clad structures can cause difficulties but can be predicted, given accurate information about undisturbed wind speed and direction.
- If there is a false reading from a platform instrument then the HLO needs to spot it and take some readings of his own (standing with a hand-held instrument in the centre of the helideck) to warn the approaching helicopter pilot. A well located wind sock should give the pilot a visual warning that things may not be as claimed for whatever reason.
- The HLO needs to beware in case the combination of wind and weather could make it difficult for the helicopter passengers to negotiate their way around the helicopter, across the helideck and into shelter after landing.

Air temperature

- Air temperature over the helideck may provide an indication whether there are any efflux gases from a vent above the helideck. Efflux, especially when not visible to the pilot, can cause difficulties and it is important that sources are identified in model tests and documented in procedures.

Barometric pressure

- Again an important parameter since it provides calibration data for the helicopter altimeter and also affects the handling during descent.

Visibility, cloud base and cover

- If visibility is poor or has been incorrectly stated by the HLO, then this will generally be evident to the pilot during his approach and he can fly on to his alternative landing site. If this condition is correctly recorded by platform instrumentation or can be inferred from other readings, it might ease commercial pressure placed on the pilot by the operator (commercial pressure can take unseen forms and be difficult to avoid entirely).

Sea state

- Concerns the prospect of recovery by ERRV should it be necessary to ditch in the sea.

Table 3.3
Weather Elements available from Offshore Platforms/Installations

Offshore platform/ installation / Weather element:	AH001	Anasuria	Auk "A" AWS	Beatrice "A"	Berge Hugin FPSO	Beryl "A"(manual)	Beryl "B"	Brae "A" AWS	Brent "A" AWS	Brent "B" AWS	Buchan "A"	Captain WPP "A"	Clipper AWS	Cormorant "A" AWS	Douglas platform	Dunlin "A" AWS	Fulmar "A" AWS	Gannet AWS	Gryphon "A"	Hewett Arpet "A"	Janice "A"	Kittiwake AWS	Leman (Shell) AWS	Maureen "A"	Morecambe AP1	Morecambe AP1 AWS	North Alwyn "A"	North Cormorant AWS	Norther Producer	Ravenspurn North	Sean P AWS	Tartan "A"	Tern "A" AWS	Tiffany Platform	Viking "B"
MSL pressure	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
Pressure tendency	Y	Y	Y		Y			Y	Y		Y	Y		Y		Y	Y	Y	Y		Y	Y			Y	Y		Y	Y			Y	Y	Y	Y
Air Temperature	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
Dew-point					Y	Y						Y		Y			Y	Y	Y		Y	Y			Y	Y		Y	Y	Y		Y		Y	Y
Wet-bulb temperature					Y							Y		Y			Y	Y	Y	Y	Y	Y			Y				Y			Y		Y	Y
Sea temperature		Y	Y																						Y				Y						
Wind speed direction	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y
Present weather	Y			Y	Y	Y	Y				Y	Y			Y				Y	Y	Y			Y	Y		Y		Y	Y		Y		Y	Y
Past weather	Y				Y	Y	Y				Y	Y							Y	Y	Y			Y	Y		Y		Y	Y		Y		Y	Y
Measured visibility						Y								Y		Y	Y					Y													
Estimated visibility	Y			Y	Y		Y				Y	Y			Y				Y	Y	Y			Y	Y		Y		Y	Y		Y		Y	Y
Total cloud amount	Y			Y	Y	Y	Y				Y	Y			Y				Y	Y	Y			Y	Y				Y	Y		Y		Y	Y
Measured cloud height						Y								Y		Y	Y					Y		Y										Y	
Estimated cloud height	Y			Y	Y		Y				Y	Y			Y				Y	Y	Y				Y		Y		Y	Y		Y			Y
Cloud types					Y	Y						Y							Y		Y				Y				Y	Y		Y		Y	Y
Measured waves	Y	Y	Y		Y	Y		Y	Y		Y							Y				Y					Y	Y							
Estimated waves				Y			Y					Y			Y				Y	Y	Y			Y	Y				Y	Y		Y		Y	Y

Note : AWS is automatic weather station

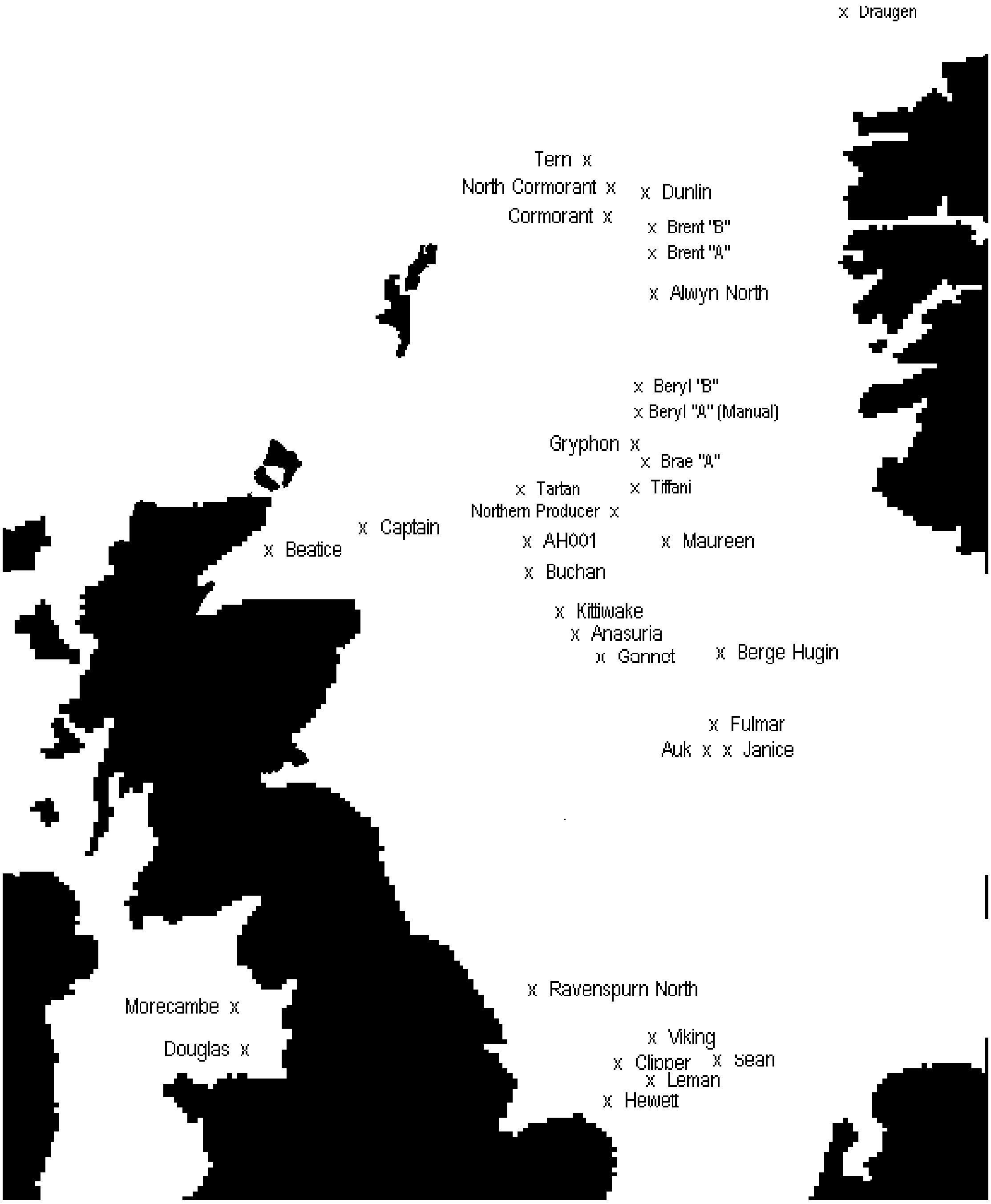

Figure 3.1
Met Office Offshore Weather Measurement Input Locations

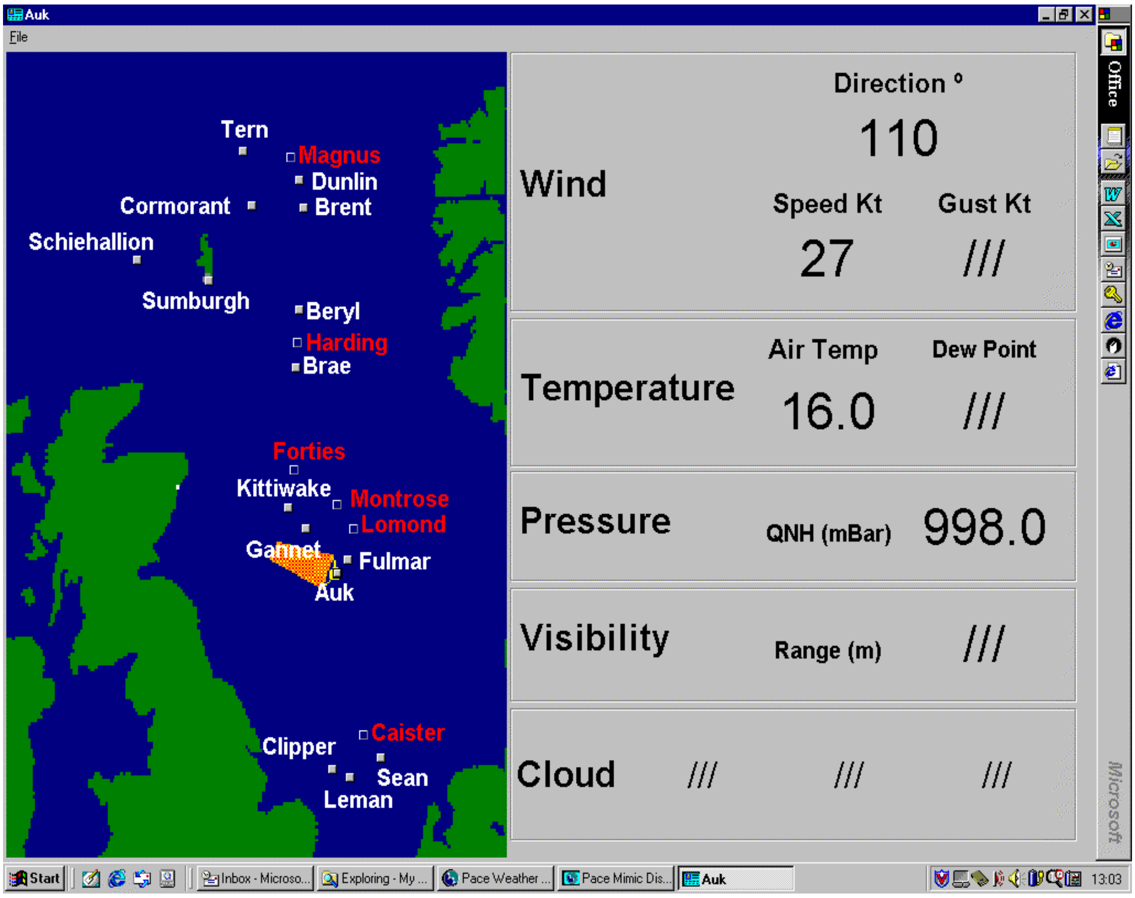

Figure 3.2
Helimet screen with weather input locations

4 REVIEW OF MANDATORY OCCURRENCE REPORTS

4.1 GENERAL

In most procedures and operations, a number of phases are identified that are critical to success and/or safety. For helicopters, for example, the minutes just after take-off and just prior to landing are usually identified as critical. However, the very fact that these have been identified may mean that they are well catered for in design and do not present a threat to properly conducted operations.

For this very reason it was decided to extend the scope of this study to examine MORs. In many fields a system of mandatory occurrence reporting is established to record events that led to accidents or seemed dangerous at the time and which might be used to avoid future similar incidents.

MORs should give a fairer representation of those circumstances that could become dangerous in the operational scenario rather than relying on preconceptions, which have already been taken into account.

Three sets of MORs were consulted. The Civil Aviation Authority holds a database for MORs associated with helicopter operations. A query was set up which interrogated this database for any incidents in which weather data were mentioned as a contributory factor. A similar procedure was implemented for the Health and Safety Executives database of MORs reported from offshore. The help of the Oil Company's Marine Forum was requested in identifying incidents associated with shuttle tanker loading.

4.2 CAA REPORTS REGARDING HELICOPTER OPERATIONS

The CAA provided a printout from their database of those occurrences which contained a reference to meteorological factors or inaccurate metocean data as part of the report.

The numbers of MORs and the relevant years for the data obtained by this search in the database are as follows:

Year	Number of reports registered
1976	2
1977	2
1978	1
1983	1
1985	1
1993	1
1996	1
1997	18
1998	12
1999	13
2000 (part)	1
Total number of reports	53

Most of the earlier reports, pre 1985, refer to errors in meteorological data reported by oil platforms to approaching helicopters. The majority of the more recent reports, 1997 and later, refer to "alleged errors" in terminal approach forecasts (TAFs) associated with helicopter movements. Some reports claim that the TAFs provided were "out-of-date." A substantial number of the more recent reports also refer to "inaccurate forecasts for a North Sea sector." Unlike the early reports, most of these problems are ascribed to inaccuracies in information supplied by shore-based airfield-based meteorological stations. Only two refer to inaccuracies in data coming from North Sea platforms. A further two refer to inaccurate data in relation to motion of a floater on which a helicopter had landed.

The problems created by these measurement and forecasting errors are attributed predominantly to the cruise phases of missions but a few are also reported as causing problems during approach phases of a flight. Sometimes the problem does not arise in respect of an intended landing sight but with the nominated alternative landing site. In these cases the problem may be more hypothetical than real for the flight registering the report but since the inherent safety of helicopter operations is based around the availability of alternative landing sites, it is important that notice is taken of these potential problems.

Most of the reports refer either to the "TAF" or the "weather" and are no more specific about which aspect of these affected the helicopter operation that logged the report. However, it is evident from those which did give details, that wind speed, wind direction, visibility and cloud-base are each likely to be in error on some occasions.

4.3 HSE REPORTS REGARDING OPERATIONS ON THE UKCS

The database of mandatory occurrence reports was interrogated for incidents between 1996 and 2000 which reported weather conditions as a contributory factor. A total of 88 category 1,2,3 and 4 incidents were found.

Of these the majority related to incidents caused by wind. Thirty-two MORs related to items being dislodged by wind and falling to the deck or into the sea. Doors being caught in wind, trapping fingers, causing a shoulder dislocation or knocking someone over caused eight. Seven arose from wind gusts either moving a load or causing someone to over-balance.

Sixteen related to wave damage, whether green water damage (on an FPSO and a TLP), damage to boat bumpers or under-deck damage caused by a large wave and a further five were caused by vessel movement in waves.

Six incidents of mooring line breakage and/or anchor dragging were found but these all related to mobile drilling units and are therefore not of prime interest to the present study.

There were seven incidents relating to crane or mechanical handling operations which went wrong. Those relevant to this study are detailed below:

- A crane could not be replaced in its rest because wind speed was too high and subsequently caused damage.
- There were four incidents in which supply boat operations were influenced by high wind and/or re-contact between load and deck of supply boat.

None of these reports is supported with any evidence about the wind or wave conditions at the time. It is difficult to know whether recommended operating limits were being exceeded or not.

Of the remaining seven miscellaneous incidents, those relevant to this study can be identified as:

- A gangway disconnect occurred even though the weather had not been sufficiently severe as to activate the disconnect alarms
- An incident occurred in which blocks of ice fell from the structure of a drilling derrick onto those working below
- A drum was released from its lashings during motion of an FPSO

- A shuttle tanker responding to wave excitation parted the hawser at the Kittiwake loading buoy. The shuttle tanker was preparing to depart at the time.

4.4 SHUTTLE TANKER OPERATIONS

There have been several instances of shuttle tanker incidents at loading buoys (Reference 4). There are many causes for these incidents (Reference 3) but some are due to operations taking place in marginal weather conditions. Initially, having talked to a tanker Captain at OCIMF, the impression was gained that there had been sufficiently large improvements in dynamic positioning technology that these incidents should be reducing. However, the NPD commented that despite the technological improvements, they seemed to receive just as many incident reports as previously. During a visit to Navion, reports were reviewed on three incidents and reference was given to a further three in UK waters. Of the three examined in detail, one was clearly due to attempts to work in marginal weather conditions that were not fully recognised because of poor wave measurement readings from the FPSO.

5 FLOATING AND FIXED INSTALLATIONS

5.1 GENERAL

Insofar as the differences that have emerged between provisions for weather-sensitive operations for fixed and floating production systems, the comments are collected and discussed in this chapter.

5.2 HELICOPTER OPERATIONS

There are several factors which distinguish between helicopter operations to floating and fixed structures:

1) motion of the helideck
2) location of the helideck
3) vessel heading
4) measurement of meteorological data.

Motion of the helideck causes problems for landing and also for static stability of the helicopter after it has set down. According to information received, once in receipt of advanced information that helideck motion is within specified norms, pilots do not appear to find it too difficult to make a landing on a moving helideck (at least in hours of daylight). A pilot can usually approach to a suitable point alongside and monitor the movement of the helideck before choosing his time to move in to land when he is satisfied that he can do so safely.

There appears to be a problem in assessing whether a helicopter will continue to sit at rest on a moving helideck and the CAA are having this aspect assessed in an on-going research project. Pilots themselves also question whether present-day motion measurement parameters are sufficient for making a land/no-land decision. Hence heave motion of plus or minus 2 m may allow a landing when the associated wave period is long (greater than 20 seconds, say). There would appear to be scope for providing an HLO with better instrumentation and a better model against which he can evaluate landing clearance and on-deck-stability for an approaching helicopter. The model might be complex in some circumstances since it should take into account the combined effects of ship heading and wind direction together with real-time values of helideck motions. The HSE have implemented a pilot study to determine whether it is possible to provide forecasts of vessel responses which might be useful in this context.

Location of the helideck is liable to affect not only the airflow over the helideck, but also the pilot's view of the ship and helideck during his approach. In extreme conditions, the pilot may be deprived of good visual cues during his landing manoeuvres. However, the British Helicopter Advisory Board (BHAB) are aware of these problems and might be expected to provide excellent guidance on the design and outfitting of the helideck area to avoid them (provided they are consulted/made aware of the specific design in good time).

In theory, a vessel heading could be changed to allow more beneficial conditions for helicopter operations to be established and thereby reduce the pilot’s work load during landing and take-off. Unfortunately, there are many other priorities for selecting vessel heading such as separator performance, reduction of roll motion, dispersal of noxious effluxes, supply boat operation, etc., and it is unlikely that the pilot will be able to count on this type of intervention on his behalf except in very special or emergency circumstances.

It has been pointed out that the measurement of wind direction from a weather-vaning floater and wave height from any monohull is difficult. More effort should be assigned during the design stages to ensure that wind measuring equipment is sited and properly supported in areas where it can provide accurate data, no matter what the wind direction or how the heading of the vessel is controlled. If wave height, rather than vessel motion, is an important parameter for setting operational limits, then more research is required to establish how these data can best be obtained.

5.3 SMALL MONOHULL SUPPORT VESSELS

5.3.1 Supply Ships and Diver Support Vessels

There is little in published guidelines to distinguish between supply boat operations at fixed and floating facilities. An FPSO makes an excellent wind shield so it is possible in many instances, for the supply boat to work in a relatively sheltered location. This assumes that the FPSO has a functional crane with adequate reach and lift capacity on both sides. If not, the supply boat may be forced to operate on the weather side and this will only be undertaken under more restrictive weather conditions.

A floater will also be subject to slow motion oscillations as it moves on its moorings and this will demand more vigilance by the master of a dynamically-positioned supply boat as he tries to maintain himself in a good position relative to the crane or hoses.

Clearly, if the heading of an FPSO were being maintained by thruster action, then the visiting supply boat skipper would need to be aware of the potential disturbances that might be caused by propeller out-wash. Further, if the FPSO were subject to excessive motions, then this might affect the safety of an intended loading or back loading.

If vessel movement is a common feature of the FPSO (whether an inherent characteristic or due to weather), it would seem essential to provide some rational estimate of the motion and the relative motion between it and a supply boat for the purposes of planning and ensuring safe supply operations. These calculations would need to take into consideration the vulnerabilities of FPSO and supply boat in the event that something went wrong and a ‘representative’ impact occurred. It seems unreasonable to expect anyone to make a balanced judgement about the risk of extreme relative motion and consequential impact damage in a situation in which commercial pressures may be intense. Operational limits need to be set against some rationally considered design scenario and observed by the field operatives.

5.3.2 Emergency Rescue and Recovery and Fast Rescue Vessels

The operators of ERRVs and their daughter FRVs did not acknowledge any appreciable differences in their operations around fixed and floating structures other than might be due to the different weather conditions associated with the areas in which they were located. Floating vessels tend to operate in moderately deep water remote from shore where short steep waves (which cause problems for smaller boats) may be less common.

5.4 CRANAGE

There are few essential differences between weather limits for crane operations from floaters and those from fixed platforms. In some cases, the floater supporting the crane may be moving too much in response to the weather but, in these conditions, the ship or barge from which an object is being lifted would also be moving and this would tend to restrict the crane operations more severely. The process and operation decks on FPSOs are lower than those on fixed structures, semi-submersibles and tension leg platforms and so tend to be less exposed to high winds.

5.5 SHUTTLE TANKER OPERATIONS

Generally, offshore shuttle tanker operations take place at floating facilities (buoys, or turret moored floating vessels). Fixed platforms, semi-submersibles and tension leg platforms are seldom approached by shuttle tankers because of the risks inherent in such manoeuvres. It is a general requirement for a tanker to avoid encroaching on a platform exclusion zone that might cause access difficulties or weather directional restrictions at a nearby loading buoy.

By contrast, shuttle tanker offloading from an FPSO or FSU is commonplace. However tandem loading is recognised as a difficult and potentially hazardous operation. This leads to the need for the elaborate system of training and risk management referred to previously.

5.6 ON BOARD OPERATIONS AND MAINTENANCE ACTIVITIES

Operations on-board or over the side of tension leg platforms suffer similar restrictions to those on a fixed structure. A semi-submersible working at operational draught will be similar with the exception that it will be necessary to maintain awareness of other conditions that could require the vessel to relocate on its moorings and/or go to survival draught in the face of a severe storm.

Since the process and operational decks of an FPSO are so much closer to the water surface, it may be necessary to suspend some operations and for the crew to vacate lower decks or seek shelter under certain wave conditions. These difficulties are not specifically identified in any of the documentation obtained during the conduct of this study and this raises the question as to whether the green-water events have been properly recognised in existing adverse weather policy documents.

A floating vessel may take up non-zero trim and heel angles from time to time, and these may make some maintenance operations more difficult. However, the planning of on-board operations and the permit-to-work system should take these factors into account.

6 REGIONAL VARIATIONS (SNS, CNS, NNS, IS & NWA)

6.1 GENERAL

This section considers where significant differences exist in the application of metocean measurements and meteorological forecasting according to region of the UKCS.

6.2 HELICOPTERS

There are significant differences in how meteorological observation and forecasting interact with helicopter operations across the various areas of the UK continental shelf. The following list attempts to set out in a succinct manner what the contributory differences are:

1) West of Shetland / North West Approaches

- Most/all production facilities and support vessels are floaters.
- There is a greater chance (50% greater by one estimate) that helicopter operations may be curtailed by deck motion limitations than in the Central or Northern North Sea.
- There is also a greater likelihood that helicopter operations may be curtailed by severe wave conditions, which would make recovery of personnel from the water more difficult.
- The sites in this area are exposed to potentially severe weather from different directions.
- Strong currents may prevent weather-vaning vessels from responding to prevailing conditions in the anticipated manner.
- There may be limited capacity to control ship's heading by using thrusters.
- Helicopter flights are similar in length to those to the Northern North Sea, but significantly longer than those to other areas.
- Alternate offshore landing sites will, most likely, be affected by the same weather as the intended destination and therefore there must be greater reliance on continuing the flight for some considerable distance to a shore-based airfield.

2) Northern North Sea

- Helicopter flights to these fields are long.
- The helicopter pilot may be reliant on weather information from shore-based facilities which are significant distances from his direct route.
- The area is exposed to severe weather from the North West.
- There are significant chances of severe weather in which Emergency Response and Rescue Craft would find it difficult to operate.

3) Central North Sea

- Single flights are shorter but there may be requests to combine multiple hops into one operation.

- Although weather may not be as severe as in the NNS or W of S it may still be sufficiently bad as to curtail helicopter operations for many of the reasons already cited.

4) Southern North Sea and Irish Sea

- Offshore wave heights are seldom so high as to prevent the ERRV from operating. However, wind directions may change and cause steeper, shorter period waves from particular directions. These may make operations of ERRV and their daughter craft more difficult. Hence information about storm directions are more important.

- Tidal currents may limit ERRV operations. Underwater sandbanks may cause particularly strong local currents. These can restrict the operation of ERRVs and their daughter craft.

- Flights over the sea are much shorter than in other areas and therefore less dependent on forecast conditions.

- There are many more "Normally Unattended Installations" (NUI) for which additional guidelines apply (reference UK Offshore Operators Association report on "Guidelines for Helicopter Operations to Normally Unattended Installations" Issue 2, March 1997).

- For most NUI satellite platforms, no weather measuring equipment is required but, as a result, some organisation or nearby facility should be nominated to monitor the weather in order that the personnel may be recovered before the onset of a deterioration which would subsequently prevent this."

- Guidelines for NUIs distinguish 'remote' installations, which are more than 40 nautical miles from the nearest installation or airport/heliport.

Taking into account comments received and the findings of the MOR reviews, the following would seem to be the most relevant observations pertinent to the present study.

1) West of Shetland

- The on-going study of Motion Reference Index being supervised by the CAA would still appear highly relevant.

- Consideration should be given to reviewing the performance of all meteorological parameter sensors on FPSOs to ensure that the HLO has the best information available to advise an approaching pilot. This is particularly important for the wind sensors, which may be adversely affected by turbulence depending on the vessel heading.

2) W of S, NNS and CNS

- It is surprising to see how often helicopter pilots are reporting allegedly inaccurate TAFs from share-based airports and how often they appear to encounter significantly worse weather than forecast. This would point to a need for a significant tightening of current procedures and the possible introduction of some extra airfields at key locations either onshore or offshore.

- To ensure that pilots are provided with accurate data about wind speed and direction, two actions should be considered:

    Review of the performance and calibration of platform-based wind monitoring equipment, particularly after a major topside re-configuration,

    Designation of a small number of offshore facilities as airfields to ensure the collection of accurate, wind data at more specific locations throughout the Central and Northern

North Sea. This would not necessarily help with cloud base and visibility data for all facilities because this information may be very localised, but it should be possible to give pilots a better view of the current wind conditions throughout this area of the North Sea which is based on 'reliable' data.

It is unclear, at present, whether emerging forecast technology will give the ability to present more reliable data regarding waves and currents. It would seem appropriate to initiate a pilot trial of this technology over a representative number of offshore installations.

3) SNS and IS

- Southern North Sea practices should be monitored to ensure that appropriate notice is taken of weather conditions for new platforms that are further from shore.

6.3 SMALL MONOHULLS

6.3.1 Supply Ships

Significant regional variations exist in supply boat operations on account of the relative severity of tidal effects, currents, wind and wave characteristics (ranges of heights, periods and steepnesses) and length of voyage.

In the Southern North Sea and Irish Sea, the weather is not so severe but the tidal currents can be so extreme as to prevent a supply boat taking up a heading which is required for some platform approach. Tidal currents are relatively predictable, however, and the skipper of a vessel can plan his operations with this in mind.

In some areas, wave details (length and steepness) may also change significantly depending on the water depth throughout the fetch and this may affect the response of a smaller ship.

Some operators (for example, Shell) lay down very stringent restrictions on conditions for marine access to normally unmanned platforms. These restrictions apply to visibility; daylight hours and duration of visit; wave height; tide; weather effects (wave, swell, wind, current - generally less than Beaufort 4 or 5); temperature (wind chill) and forecast conditions.

In the Central North Sea, weather conditions may be such as to prevent meaningful operations. If the weather en route is such that it might cause damage or severe discomfort to the crew and there is a likelihood that the vessel will spend a significant period waiting-on-weather (WOW) once it gets there, then the vessel should not leave port.

Similar restrictions apply to the Northern North Sea and West of the Shetlands, although in some cases a voyage to the sheltered waters around Orkney or Shetlands might be justified so that the operation can be completed relatively quickly when the weather abates.

In deeper waters, which justify the use of a floater, other considerations may apply as described in Chapter 5.

6.3.2 Emergency Rescue and Recovery and Fast Rescue Vessels

The variations in operational restrictions with location associated with these craft are similar to those for any other small monohull support ships as described above. Around underwater sandbanks, induced currents can be so strong as to make it more practical to take a course which avoids the area rather than attempt a direct traverse.

6.4 SEMI-SUBMERSIBLE AND JACK-UP SUPPORT

These two groups of operations tend to take place in different water depths, semi-submersible support in deeper water (greater than 80m, say) and jack-up support in shallower water (less than 90m). Hence jack-up operations on the UK continental shelf are limited to the Southern North Sea, the Irish Sea/Liverpool Bay and some shallow water pockets in the Central North Sea. Semi-submersible support operations tend to be in the other deeper water areas.

Jack-up movement and positioning may be limited by sea state, but once on location it must stay throughout the weather associated with that area at the requisite time of year. Nevertheless, there will be a relative motion between a jack-up and the fixed platform it is supporting and a number of operations may have to be suspended in storm conditions. Weather forecasting may be critical if it takes a protracted period to make an operation safe.

Semi-submersible support such as flotel operation, tender assistance or utilities support will not be sensitive to moderate sea states. They will require good forecasting of severe weather so that operations can be suspended in good order and made safe against the approaching storm. In both cases the main concern is that severe weather is correctly identified and forecast. Provided these forecasts can be made reliably throughout the UKCS, then there will be little difference in the operational requirements.

7 NORWEGIAN EXPERIENCE

7.1 GENERAL

When OCIMF were contacted for information about shuttle tanker operations, they pointed out that the majority of such vessels were Norwegian-based. They considered that this study should extend to shuttle tanker experience in Norwegian Waters. It was therefore decided to extend the study to a review of practices in Norwegian waters. To this end meetings were set up with the Norwegian Petroleum Directorate (NPD) to obtain an overview and with Navion ASA, to examine the shuttle tanker issues in more detail. Subsequently, telephone contact and e-mail contacts were made with NPD, the Norwegian Civil Aviation Authority (NCAA) and the Norwegian Meteorological Institute. This chapter describes the results of these contacts.

The regulatory requirements for the collection of environmental data from Norwegian oil facilities is set out in NPD Regulations (Acts, Regulations and Provisions for the Petroleum Activity, Volume 2, Updated 1/1/94).

The purpose of the regulations is to obtain:

- background data for use in planning and design
- environmental data in real time (for operations)
- forecast data

and to provide for suitable supervision. NPD supervises compliance with the regulations and may require the operator to collect, store, process and report environmental data such as:

- meteorology
- oceanography
- seismology
- biology

for a number of different 'end-users'.

All Norwegian platforms which support helicopter operations are designated 'airfields' within the terms of civil aviation authority definitions and consequently they are required to measure and record data in accordance with the International Standards and Recommended Practices for the Meteorological Service for International Air Navigation. Since satisfactory instrumentation for the measurement/identification of cloud cover has yet to be developed/tested/proved, this regulation has the effect that each platform must have meteorologically trained observers to make the necessary regular reports. The regulations also require that 'any malfunction or damage that might occur shall be rectified without delay.'

In addition to the instrumentation needed for helicopter operations, NPD have identified nine specific platforms for more extensive measurement of meteorological and oceanographic parameters. These are listed below and the locations of those close to UK waters may be determined from Figure 7.1.

Det Norske Meteorologisk Institutt (DNMI) and NPD are interested to understand the opportunities for automatic collection of meteorological data and to this end a trial set of automatic environmental sensors and recorders has been mounted on the Troll B platform in addition to the standard manual instruments.

Where an operator seeks a licence to explore and develop new areas, such as in the Barents Sea, then the NPD can require more extensive environmental measurements so that an appreciation of the key features of these areas can be built up before any development for oil production is initiated.

7.2 HELICOPTER OPERATIONS

The Norwegian Civil Aviation Authority (NCAA) controls helicopter operations to Norway's offshore oil fields. Since each production facility is designated an airfield, it is assigned a four letter identifier. Meteorological data, terminal approach forecasts and trends are provided regularly and can be accessed by any pilot who is planning a flight.

Meteorology, as referred to in the regulations, is taken to mean, inter alia:

- wind
- waves
- weather at the time of observation
- weather since the last observation
- clouds; altitude, types and amounts
- range of vision (visibility)
- air temperature
- atmospheric humidity
- precipitation
- atmospheric pressure, value and tendency
- sea temperature in surface layers
- ice accretion
- sea ice, type and concentration, thickness and the ice border

The range and accuracy of instrumentation associated with these measurements are contained in Table 7.1. However, trained observers are needed to make some of these measurements since suitable accredited instruments have yet to be devised.

Separate regulations apply to helicopter decks on offshore platforms, and these stipulate additional instrumentation to enable altimeter settings to be adjusted and to monitor vessel motions (when the helideck is on a floater).

DNMI recognise a range of difficulties in making correct meteorological readings, particularly from a floating monohull. These will be discussed more extensively in Section 7.4 where they are possibly more important.

UK helicopter pilots view the status of the organisation of the meteorological reading and forecast on Norwegian platforms with envy and frequently access data from the nearest available Norwegian site to back-up data they are provided from platforms in UK waters.

However, a spokesman for the NCAA admitted to being less than happy with the current state of offshore helicopter operations as a whole. They have asked SINTEF to undertake two studies to review all aspects of flight and helideck operations. This work is in hand. The first study which deals with legislation and organisational issues is scheduled to produce a first report in June 2001 while the second will examine more detailed technical concerns and is expected to report in the Spring of 2002. A brief description of the remit for the studies has been provided by Fure Dagheid from the Norwegian Civil Aviation Authority and is reproduced in the following two paragraphs.

"Norway's Civil Aviation Authority has the Secretariat for a Committee for the Review of Helicopter Safety on the Norwegian Continental Shelf. The Committee is appointed by the Ministry of Transport and Communications in Norway and is looking into helicopter operations/activities in connection with the petroleum business on the Norwegian Continental Shelf. The Committee consists of 11 members representing the public authorities, the industry and unions. The Chairman is Vice President, Research, Tor Ulleberg at SINTEF Industrial Management.

The Committee's review consists of two parts where the first part (which we are currently working on) will consider in particular how the public authorities' involvement on the continental shelf is organised. As part of the review the Committee's tasks is to obtain an overview of what public authorities/agencies are responsible regarding helicopter safety on the continental shelf, what their roles/tasks are, what laws and regulations govern this area and what is not clear when it comes to responsibilities, regulations etc. It's also part of the review to obtain an overview of British/Danish/Dutch laws, regulations etc. regulating the helicopter operations on the continental shelf, how these operations are regulated and organised, in addition to how the supervision with the operations is carried out. Finally, the Committee should propose how to improve the organising and regulating of this area. The review's deadline is 01.06.01. The second part of the review will propose realistic goals for helicopter safety and consider specific safety measures. Deadline is 01.04.02."

7.3 SUPPLY BOAT OPERATIONS

NPD have seen many collisions between supply boats and platforms, some of which were due to weather. They felt that some of these incidents arose from the rapid change in direction of environmental forces. They pointed out that the six hour period between 'standard weather forecasts' is too long to spot the types of rapid changes which could affect a supply operation. When a supply boat is operating close to a platform, the master of the vessel is not in the best position to spot some rapidly changing situations. Either the platform or a standby vessel may be better placed to make these observations and it is important that the captain of the supply boat is informed in time for him to take appropriate action.

7.4 TANKER/FLOATER OPERATIONS

NPD pointed to an incident which had occurred with the Balder FPSO. This vessel relies to some extent on DP technology to enable it to turn head into severe weather. Unfortunately, on one occasion, the DP system had been unable to react quickly enough to a rapid change in the direction of a storm and, as a result, it came broadside to the weather. It was unable to recover from this situation and had to remain broadside to the weather until the storm abated. Clearly this could have been a very serious incident had the storm developed further.

NPD commented that they seemed to be receiving a number of reports relating to damage caused by the operation of DP shuttle tankers. This is in spite of the great improvements in dynamic positioning technology.

Navion (one of the major operators of high specification shuttle tankers) made some incident reports available for review, relating to incidents in the Norwegian sector. They also referred to other incidents that had happened on the UKCS, but referred to the operators if more extensive information is needed. Specifically, incidents involving shuttle tankers at the FPSOs on BP's Scheihallion field, Texaco's Captain field and Kerr McGee's Gryphon field were mentioned.

Of the three reports of incidents in the Norwegian sector, one appeared to be due to problems with the defaults built in to the operation of the DP system and was not weather related. A second arose from a problem with the position referencing system (again not due to weather). The third was a clear case of a DP operation that was being conducted in marginal weather conditions. A clear inference from that report was that even experienced masters cannot envisage all the extreme dynamic positioning and load conditions that might arise during a loading operation. Hence it is incumbent on the designer/operator to specify limiting sea states and for the operators and master to observe these. It is also evident that there are considerable difficulties in obtaining accurate data about significant wave heights from instruments that are situated on an FPSO vessel. Nevertheless such data is important for the proper management of loading operations.

DNMI have provided comments on the difficulties of measuring environmental conditions at an FPSO. First, since these monohulls normally weathervane, it is possible for wind sensors to move in and out of turbulence zones behind forward-mounted structures or antennae. DNMI have studied wind readings from the NORNE FPSO and are aware of the difficulties of interpreting the readings from the two wind sensors.

Second, DNMI prefer wind sensors to be located high up on a rig to avoid the effects of turbulence from other structures. However, the simple factors used to correct readings from, say, 140m to the standard 10m above sea level, are not reliable for making accurate measurements. The factors depend on the structure of the boundary layer above the sea and this is affected by the stability of the atmosphere. Temperature measurements at several different heights might resolve this problem, but currently temperature readings tend to be made only at one specific elevation.

Third, wave measurements are difficult from a floater. Readings need to be corrected for the response of the floater which varies according to the distribution of its load and ballast. If accurate wave heights are required, then a wave buoy or some other method might be necessary, and the wave buoy would have to be sufficiently remote as not to be affected by the wave reflected/refracted from the hull.

Navion provided an illustrative sketch showing the locations of all the loading systems that they visit with their shuttle tankers in the North Sea.. This is shown in Figure 7.2. It is evident from this illustration that there are scarcely two identical systems. This reflects the fast rate of development of these systems over recent years.

7.5 SEMI- SUBMERSIBLE AND JACK-UP SUPPORT OPERATIONS

NPD identified an incident involving a dynamically-positioned flotel working in the Troll field. A gangway linking a flotel to the Troll “A” platform had become detached. The cause was traced to a rapid change in current such that the Flotel’s DP system, which updates its current readings each 20 minutes, had been unable to maintain station. Fortunately the change in flotel position had been away from the platform and no one had been on the gangway at the time, or the accident might have had more serious consequences. It is important to realise that such rapid changes in current are possible in some areas of the North Sea.

In 1995, an incident occurred at the Oseberg ‘D’ platform when the gangway between a semi-submersible crane vessel (the Regalia) lifted automatically in response to wave motion. The motion which followed brought the gangway into contact with cable trays and a pipe, thereby causing damage.

The review of Norwegian Mandatory Occurrence Reports found an incident in the Ekofisk field in which a jack-up leg sank several metres in a storm due to scour round one of its legs. A serious accident was averted by the actions of the crew. However there were relatively few incidents involving jack-up rigs. This may only be a reflection of the depth of water in the Norwegian sector, which is generally too deep in most areas for jack-up rigs to operate.

7.6 TOPSIDE OPERATIONS AND MAINTENANCE

NPD reported a series of problems with cranes being used in poor weather. The cranes are adversely affected by high winds and this can lead to dangerous incidents. NPD thought that there is a need for:

- More accurate measurement of wind speed on topsides (see also Section 7.4 above).
- Platform crane operators to be more vigilant and observe the proper wind speed limitations identified by the crane manufacturer.
- Checks should be made that crane manufacturers have correctly calculated the wind speed limit which should be applied to their cranes.

The UK MORs seem to identify problems with the opening of doors in exposed locations leading to injury. NPD checked their records but found that relatively few such incidents had been reported in their system.

High winds had caused damage due to unexpected movement of an entire drilling rig on the Sleipner platform. It was found that the rig had not been sufficiently well tied down.

7.7 MANDATORY OCCURRENCE REPORTS

The MORs provided by Norway that are most relevant (to this study) have been described above. However there were a large number of reports which indicated some error in a design calculation such as an underestimate of a wind force or a required air-gap. Further, the query of the database was commented as only being partially successful and the comment was made that "there were more than likely, more relevant occurrences" which might have been retrieved given a longer time to make the search. If these are perceived as important issues, then further inspection of the recorded data be recommended.

Table 7.1
Instrument specification for meteorological and oceanographical data: NPD regulations

Parameter	Range	Instrument accuracy	Re-solution	Sampling frequency	Remarks
Wind velocity	1-60 m/s	Below 5 m/s:- +0.5 m/s Above 5 m/s:- +10%	0.5 m/s	2 Hz	Distance constant (response to wind changes) 2-5 metres
Wind Direction	0-360°	5°	2°	2 Hz	Should operate at wind velocity 1-60 m/s. Damping ratio: 0.3-0.7
Atmospheric pressure	940-1060 mb (at sea level)	± 0.3 mb	0.1 mb	Once every recording period	Mercury barometers. (When aneroid barometer is used, it should be checked against a mercury barometer at least once a week due to elasticity errors).
Air temperature	Depending on actual temperature in the area	± 0.1°C	0.1°C	Once every recording period	Ordinary thermometers and remote indicating instruments
Sea temperature	Depending on actual temperature in the area	± 0.1°C	0.1°C	Once every recording period	Ordinary thermometers and remote indicating instruments
Atmospheric humidity	10-100%	± 3%	1%	Once every recording period	Relative humidity
Wave height	0-30 m	±4%	0.2 m	2 Hz	Recordings for 17-20 min. each 3rd hour
Current velocity	0.2-2.5 m/s	± 0.05 m/s	0.02 m/s	Continuously or min. 0.1 Hz	Could be self-contained instruments with their own recording system
Current direction	0-360°C	± 5°	0.2°	Once every recording period	Could be self-contained instruments with their own recording system
Water level		0.02 m	0.01 m	Once every recording period	Could be self-contained instruments with their own recording system
Salt content	0-5%	+/- 0.01 %	0.01 %	Once a week	At standard depths as recommended by ICES

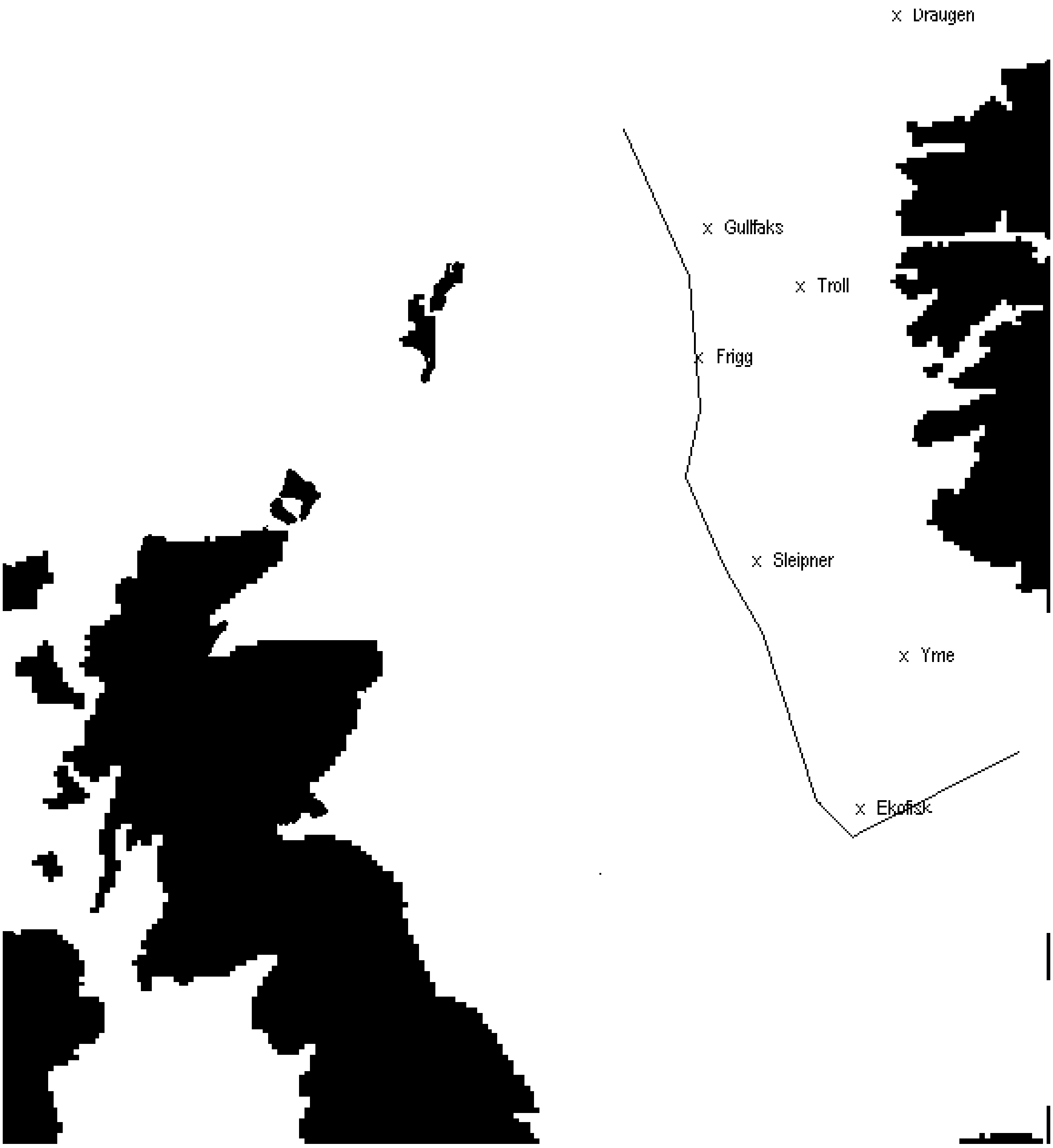

Figure 7.1
NPD Specified Metocean Data Collection Locations

Key: □ Field with single point mooring
○ Field with submerged turret loading
△ , ▲ Field with tandem loading from FSU/FPSO
▽ Field with single anchor loading

Figure 7.2
Location of shuttle tanker loading systems

8 DISCUSSION

8.1 GENERAL

Improvements are taking place in the types, level, detail and delivery of weather forecasting information that could be available in the foreseeable future. In addition to conventional forecasts, wind and swell models are being developed and pilot trials are being held of response-based forecasting. Before many of these schemes are introduced to the offshore community at large, it would be helpful if some general degree of verification and validation had been achieved by comparison with measured data. It would be a retrograde step to introduce for these schemes without assessing the reliability of the information for those whom it is meant to help. Wide spread validation and assessment throughout the North Sea (or UKCS) would be helped if there was in existence, a network of reliable data measurement stations among the existing platforms with the readings available from several onshore and offshore locations.

8.2 HELICOPTER OPERATIONS

It seems appropriate to begin the discussion with those items identified from MORs. The majority of MORs refer to meteorological data supplied for the planning of flights rather than to platform-based measurements used for the landing on offshore helidecks. This would seem to indicate inadequacy or slackness-in-application of normal airfield operating procedures or meteorological forecasting since the majority of these reports refer to data received from land-based airfields and not from any particular set of data provided by any offshore platform or group of platforms. On the other hand, given the relatively short journey times and the availability of "heli-met" data from all the sites shown in Figure 3.2, there must be a suspicion that pilots are not making best use of the data available to them. Figure 3.2 indicates the availability of valid 'heli-met' data for most sectors of the North Sea, so a brief review of these data would likely reveal any gross inadequacy in the assessment of weather for the following hour or so. It would seem that a review is needed to find out how the presentation of meteorological data to helicopter pilots is working and how it can be improved.

Helicopter operations to moving helidecks would seem to cause some problems. The current, about-to-be-completed CAA research, into the stability of a helicopter on a moving helideck should be closely examined to find if it indicates where any more general improvements can be made. No one indicated that pilots had any particular difficulties in effecting a safe landing on a moving helideck, but pilots seem to think that the present motion indicators are too simplistic since they do not distinguish rapid wave induced motions from slower, less troublesome swell movements. Note should also be taken of the comments received about the difficulty of making satisfactory measurements of wind speed/direction and wave height from an FPSO. The heading changes caused by weather-vaning or deliberate heading control, ensure that most wind sensors will find themselves in the turbulent wake of a structural element on some occasions and this could lead to inaccuracy in determining wind speed and direction. For an isolated FPSO, careful study and wind tunnel tests may be required to identify the best location for one or more sensors. When the FPSO is close to other fixed platforms, then provision should be made for additional data to be made available to the HLO and approaching pilot, such as readings of wind speed and direction from near-by facilities. Similarly, wave information, if not available from a suitably calibrated wave buoy should also be obtained from surrounding platforms.

The following points did not arise from the MORs but from specific comments received during the study:

- Platform-based instruments need careful monitoring to ensure that they remain serviceable and within calibration. This was felt important given the age of some North Sea structures.

BHAB should ensure that these aspects are adequately reviewed during their inspection visits.

- Access to corresponding information from surrounding platforms may alert an operator to a failure of his own equipment. The HLO or other responsible individual(s) should be charged with regular checking of wind sensor readings against those from surrounding platforms. This task could be made more productive if a network of platforms was maintained with known accurate calibrated sensors and each such platform was given the responsibility for issuing wind data to near-by platforms which was adjusted for any known differences in instrument height or location.
- All metocean equipment must be reassessed for adequacy and location after any substantial topside modifications, particularly when changes are made in the location and/or function of gas vents and exhaust ducts. Operators must be encouraged to register all such changes.
- Consideration should be given to requiring operators to identify an individual who is responsible for all aspects of heli-met equipment. It seems difficult to track down all the individuals who have a contribution to make (HLO, radio operator, instrument/electrical technician, OIM, helicopter pilots, BHAB, equipment suppliers) so an individual should be made a point of contact for all internal and external communications.
- Where Norwegian operational requirements would imply that a trained meteorological observer should always be on duty, this seems too onerous for the requirements of providing the data that is necessary to support helicopter operations. Consideration should be given to a minimum level of training necessary to provide these data and vouch for the adequacy of readings from automatic measuring instruments. The voluntary service of data collection which is provided to the Met Office may be satisfactory for general weather forecasting but does not seem appropriate to safety-critical operations.

Finally, the subject of lightning and helicopter flights came up in discussion with several contacts. One opinion arising from within the CAA was that lightning strike is not a safety issue for a properly serviced helicopter. Others were less certain but advised that there is a significant cost implication for helicopter maintenance when a helicopter sustains a lightning strike. (Does it become a safety issue if a lightning strike goes undetected or unreported?) Further research is required to establish the true nature of this situation. If lightning is a safety issue, then there are certainly things that can be done. Already, meteorologists can assess and forecast likelihood of lightning, weather radar can spot it and various instruments are available which would allow pilots to detect when they are approaching areas of high static charge. However, lightning is a complex phenomenon and a significant program of research would be necessary to establish whether the combination of these forecasts, monitoring and measuring instruments could provide a meaningful contribution to helicopter safety.

8.3 SUPPLY BOAT OPERATIONS

Before commenting on specific aspects or references to measuring instruments, it is important to acknowledge that the responsibility for making decisions about the performance of a ship and its crew must remain with the master. The overall circumstances that contribute to the response and performance of such vessels are too complex to be judged on the basis of a small number of instrument readings and the master is the only person in the loop with the necessary knowledge and experience to make that judgement. This is liable to remain the case for the foreseeable future.

However, it should be borne in mind that similar statements might have been made about landing an aircraft several years ago. Now, however, it is possible for an aircraft to make an instrument-only blind landing which would be foolhardy for a human pilot to attempt. It would be foolish to ignore the potential for advance in vessel control.

Several MORs relate to dangerous incidents that occurred during crane lifts from supply vessels. It is significant that none of these incident reports is backed up by weather data. Hence it is not possible to make a judgement about whether or not the conditions were too severe for the operation that was being attempted. The same mistakes could be made repeatedly until someone is seriously injured and more drastic measures are forced on the master, the operating company and all concerned.

As several contributors to this study have pointed out, it would be very useful for a captain if he knew, more precisely, the circumstances that he was facing. Hence reliable measurements of wind speed and direction (at a height relevant above mean sea level and for an appropriate averaging period), wave heights and periods and currents speed/directions can be of assistance to the master in reaching a good judgement about the performance of his vessel.

More importantly perhaps, the condition of the vessel's dynamic positioning system and the associated power consumption should also be available since it gives an 'average' indication of the station-keeping capacity in-hand at any particular time.

Perhaps some aspects of crane operation also need to be instrumented and recorded.

If the captain of a supply boat logs the weather conditions that prevail as he comes on station, there is a prospect of spotting changes that might put the vessel in a more hazardous situation.

Some thought needs given to the best location of instruments to provide the best input to the master. It would seem that a location high up on a fixed platform would give the best opportunity to measure wind speed and direction. However, the wind speed that is most relevant to a supply boat is much closer to the water surface and there is not a unique relationship governing ratio of wind speeds at different elevations. Hence, further supporting measurements would be necessary (an atmospheric temperature profile, for example) to get a reliable estimate of wind speed at, say, ten metres above sea level. Many supply vessels will carry their own anemometer and these readings should also be recorded although in many instances these will be affected by the presence of the platform near-by. Emergency rescue and recovery vessels will also carry anemometers and since these boats will tend to stand-off from the platform, their readings may be a more reliable indication of the free-stream conditions at the appropriate elevation. Wind-driven wave measurements would be most easily achieved from a fixed platform. The problems of wave measurement from an FPSO have already been mentioned and some other method may need to be adopted in these cases. If long-period swell is important, then it might be necessary to deploy other instruments to obtain these measurements. Detailed consideration should be given to the cost and feasibility of establishing and maintaining a suitable chain of calibrated measurements throughout the North Sea (rather than specific measurements at each platform). Current speed might best be measured either from the fixed platform or from the ERRV.

Effective supply boat operation, particularly in frontier and/or remote locations, calls for a great deal of communication among many interested parties. BP Amoco have established workshops to allow all those contributing to the supply operation West of Shetland to air their views and appreciate the problems others may be experiencing. This approach is to be welcomed. The meteorological measurement or forecast provider has an important part to play in these discussions. To some extent the marine logistics companies have an opportunity to ensure adequate communication in the more mature areas of the North Sea and they should be encouraged to take on that role, particularly when there are several vessels working in close proximity to a specific platform. This might lead to more logical decisions being taken about when and if to send out a supply boat, but only if the meteorological information about conditions en route and in the field can be trusted and can be interpreted correctly. To this extent, the type of information made available to helicopter pilots might be adapted and made more specific for marine supply operations. To a large extent this is already happening with the companies who have a track record in the North Sea. Every encouragement should be given to the newer, small operating companies to take part in these developments. It would be unacceptable for new companies to obtain their own new marine experience at the cost of more risky operations and repetition of old accident scenarios.

The type of weather forecasting information required in support of small monohulls operating near to fixed structures varies according to the type of operation being performed. Given crane availability (here is a point where good communication is needed between the OIM, the HLO, the crane driver, the banksman and the supply boat), all supply operations can be stopped in 'good order' within thirty minutes or less. Hence a good weather forecast for a critical or marginal condition would need to distinguish between a situation that is going to deteriorate within thirty minutes and one which is not. In the case of ERRVs, the corresponding period might be somewhat longer, if the vessel was covering several platforms from a central location. A DSV might also need a more extensive forecast, particularly if it had a dive team deployed at an awkward water depth. It seems unreasonable to expect shore-based forecasting teams to produce this level of detail: they can only provide the gross picture and rely on the mariners in the field to interpret what is happening to them in terms of this gross picture. To this extent a mariner might be in a better position to interpret his local information if he was given advanced warning from real-time data from adjacent fields. Given the network of heli-met data logging stations in the North Sea it would seem appropriate to extend it a little so that it gives a skeleton coverage of all areas of interest and to make the information contained therein available to any monohull which wished to access it. To be of best use it might be necessary to supplement the system with information about wave heights, wave periods and currents from several fixed platforms. This would have the effect of making information available throughout the North Sea which would allow any mariner to make sense of coarse weather forecasting information in terms of the particular circumstances imminent to his own location.

8.4 TANKER/FLOATER OPERATIONS

Safety of shuttle tanker loading operations, whether at a buoy or an FPSO, depend on many factors (Reference 2) not least the metocean parameters and their forecast changes, particularly in hours of darkness. As with smaller monohulls, a large number of variables affect these operations and it is often essential to defer to the experience of the ship's captain in assessing the likely performance and motion response of his vessel. However, most loading facilities are different and so a master's experience of being attached to any particular facility may be limited. Operational limits will have been determined during design, and it is necessary for all concerned to observe these limits or the risks to life and the environment may be unnecessarily high.

Most tanker captains would welcome better data about metocean parameters in making their assessments provided this data is not used to apply unnecessary commercial pressure. Further, if captains are to grow to trust metocean measurements and forecasts, it is necessary that these are accurate, reliable and of relevance to their vessels. The majority of shuttle tanker operations are in support of floating production facilities and the difficulties of obtaining accurate wind, wave and current readings for these vessels has already been mentioned.

This is yet another case where it would be helpful to provide a strategically chosen network of platforms throughout the UKCS to provide accurate and calibrated metocean measurements for the benefit of all. Figure 3.2 shows an existing network of helimet stations. This might be expanded to cover some of the obvious gaps, and an exchange of data agreement with the corresponding Norwegian platforms (Figure 7.1) would be beneficial to all concerned.

In respect of the forecasting of metocean conditions, those which are clearly of most concern to tanker captains are those which lead to a rapid change in incident angle of a predominant environmental load. It is evident from the tanker captains' experience that these conditions can change so rapidly that it is difficult to take appropriate corrective action and it can become necessary to make an emergency disconnection. It would seem to be appropriate to examine this subject in more detail since it ought to be possible to provide captains with good information concerning:

progress of frontal systems through the North Sea area

or

characteristic development patterns for wind-driven storms in terms of wind and wave directions

or

characteristic patterns of measurements from surrounding instruments that carry warnings of incipient changes.

The last is particularly relevant where current direction is a strong contributor to the net load on the vessel.

8.5 OTHER OPERATIONS

There are two major groups of incidents recorded in the mandatory occurrence reports that should be considered further with regard to general topsides operations.

First, by far the most commonly reported occurrence concerns the wind dislodging cladding, signs or items of equipment, which either fall onto a deck below or fall into the sea. In so far as permanently mounted items are concerned, this needs taken up with designers who are clearly not making adequate assessment of extreme wind loads. There would also appear to be a need for general education so that operations and maintenance staff are made aware of the levels of load that can be generated by high winds.

Second, there are many incidents caused by doors being 'caught in gusts of high wind.' It is self evident that there will be 'gusts of high wind speed' at exposed locations high above sea level on the topsides of offshore structures. Two actions could be taken. Guidance or warnings could be issued about choosing the location of doors on offshore platforms so that they do not open on to areas that are susceptible to extreme wind gusts. Improvements in the detailing of door opening and closing restraints could be considered so that doors in exposed locations can not move or slam shut unexpectedly.

Under a range of complex metocean conditions, operations and equipment on the decks of FPSOs are at risk from green water being shipped over the bow, side or stern of the vessel. There appears to be relatively little information available about the range of environment and response parameters that contribute to such events and whether operations managers can identify them before serious occurrences (particularly in hours of darkness). More research is needed in this area, but until it is, some precautionary advice should be included in all adverse weather warning procedures. This advice might extend to recommendations about conditions under which staff should wear safety lines and avoid designated zones.

9 SUMMARY AND CONCLUSIONS

This report has been produced on the basis of a brief, wide-ranging review of diverse weather-sensitive offshore operations, supporting metocean data measuring/collection activities and weather forecasting services. It was not within the remit of this study to investigate any of these areas in depth. Accordingly, the majority of the following conclusions are formulated as observations rather than as detailed recommendations. Many of the issues identified will require follow-up actions but, by framing the findings as observations rather than recommendations, it is intended to give the industry maximum freedom to implement more detailed investigations and identify the most appropriate and effective solutions. The observations and recommendations arising throughout this report are summarised in Tables 9.1 through 9.3 in respect of helicopters, small monohulls, and shuttle tanker and FPSO operations respectively.

Many independent meteorological and oceanographic (metocean) data measurement activities take place on the UK continental shelf. A few agencies process and interpret these data to make them available for particular activities and there are two or three major sources of general and detailed weather forecast information. However, with a few notable exceptions, data collection is disjointed. The quality of data from any particular facility is uncertain and it is not directly available to those who might wish to access it. It appears that the industry as a whole is funding a major data collection exercise but is not in a position to take full benefit from it for the safety, planning and control of many weather-sensitive operations.

Many operations could benefit from more direct access to an established network of high-quality measurements of weather, wind, wave and current data. The data should be available, in suitable format, to all who depend on the UKCS for their livelihood and it appears that emerging web technologies could make this practically realisable. Vessel operators could benefit from such data both for the planning of voyages and from the greater ability it would give masters to interpret the weather developments that are liable to overtake and affect the performance (safety) of the operations in which they are engaged. The providers of meteorological forecast information could also use such a facility to improve, verify and validate some of the data that are now available from wide-area weather forecasting models. Ultimately this might lead to more reliable forecasts that are better tuned to the needs of the seafaring community around the UK. One expensive component of this scheme is already nearly available, namely, the instruments, although it would be expected that many readings are redundant while specific additional instruments might be needed in some locations. More effort is required to share and integrate the information in such a way as would make it more available to all, whether on a neighbouring platform, in an operation control room or in a weather forecasting office.

Other important observations can be identified as follows:

- Improvements are required in the draughting or the implementation of design practices for the assessment of extreme wind loads on cladding, signs and ancillary equipment on offshore topside structures. Operations and maintenance staff need to be more aware of the levels of loads which can be generated by high winds
- Guidance may be required concerning the location of doors on offshore platforms so that they do not open directly onto areas that can be subject to high-speed gusts of wind.

Alternatively

- Improvements may be needed in door opening and closing restraints to prevent doors being swung rapidly open or closed by high winds.

It is observed that further work may be required in the following areas:

- Review of findings of CAA study into a motion evaluation index for helicopters operating on floating vessels. These findings may be more widely applicable.
- Review of instrument locations and Installation/Vessel Limitation Lists (IVLLs) for helicopter operations. How frequently are instruments calibrated, and do these systems keep pace with the effects caused by topside refurbishment and developments?
- More explicit guidance concerning the siting of metocean sensors, particularly for FPSO and shuttle loading operations.
- Evaluation of risks to FPSO topsides operations posed by green water events and the possibilities of forecasting potentially dangerous sea conditions.

Table 9.1
Summary of findings relating to *helicopters*

Item	Category of installation-specific data	Observation from study
1	Better use of existing instruments on each platform	• There does not appear to be any system for identifying an individual as a contact point for co-ordination of all aspects of metocean measurement systems. • The results of the on-going study into a platform motion index should be closely examined to find out whether they can be of wider application to flight planning. • Some concern was expressed about instrument functionality and calibration on older platforms • It is not clear whether IVLLs issued by the BHAB reflect all the effects of modifications to topside process activities. Perhaps some guidance is required about when and how often inspection visits are made.
2	Better integration of data and access to instrument readings on surrounding platforms	• Data available from mandatory occurrence reports suggest that pilots do not always have access to the latest TAFs and associated data. It is not clear why this difficulty exists. Perhaps there is need for a review of the presentation of meteorological data to pilots to find out if improvements are possible. • Access to instrument readings from surrounding platforms would aid the identification of instrument errors and malfunction.
3	Upgrade data collection and recovery from a few selected platforms	• There would seem to be benefits to be obtained if a network of high-quality, calibrated metocean readings could be established. Significant improvements might be obtained by providing extra data in a few, key, strategic locations.
4a	Site specific weather forecasts in present-day format	• Even where it is available, today, it does not appear to be used to assist helicopter operations.
4b	Site specific weather forecasts in some other format (specify)	• Differences of opinion exist concerning the consequences of lightning strikes to helicopter operations. • If lightning is judged to be a risk then the role of remote lightning detection, lightning warning instrumentation and forecasting should be evaluated for risk mitigation
5	Alternative source or presentation of relevant data	• No comment on this aspect within report

Table 9.2
Summary of findings relating to small *monohulls*

Item	Category of installation-specific data	Observation from study
1	Better use of existing instruments on each platform	• Problems have been encountered when weather conditions have changed while supply boats are alongside platforms. From the mandatory occurrence reports, there seems to be a lack of recorded data that can be used to analyse the ensuing events. Perhaps benefits could be derived if all metocean parameters relevant to each operation are logged when a monohull comes alongside a platform and at regular intervals during the following operation. Readings from platform, monohull and stand-by vessel might be combined. Other key parameters such as DP power consumption and crane performance indicators should also be logged.
2	Better integration of data and access to instrument readings on surrounding platforms	• If relevant, good-quality data is not available from one platform (of wave height, for example), operators might be encouraged to obtain measurements and log equivalent data from a neighbouring platform. • Problems have been noted with the siting of instrument sensors relevant to supply boat operations on all platforms but particularly on FPSOs
3	Upgrade data collection and recovery from a few selected platforms	• In areas of the UKCS where no suitable instruments are available, consideration should be given to establishing one as part of a network of high quality, calibrated facilities
4a	Site specific weather forecasts in present-day format	• In general, except perhaps at remote floating facilities that depend intimately of identification of weather windows for successful operation, site specific weather forecasts would be unlikely to be beneficial unless they were extremely detailed. • Problems have been encountered offshore with supply boats having to wait on weather for extensive periods before a weather window for offloading becomes available. All companies should be encouraged to adopt guidelines for deciding whether a supply boat should or should not set out on a voyage. This decision should be a co-operative decision between the platform offshore installation managers (OIM), the supply boat captain and some organisation that has sufficient information about metocean conditions and weather forecasts for the route, to judge whether it will be possible to unload the supplies on arrival. Some operators find that this decision is best taken within a marine operations base and not totally by discussion between OIM and ship's captain.
4b	Other site specific weather forecasts in some other format (specify)	• More detailed forms of weather forecast might be considered as an alternate solution to the problem identified in the table entry below.
5	Alternative source or presentation of relevant data	• Boats working in close proximity to an offshore facility (fixed or floating) are vulnerable to rapid veer in the environmental forces. Changes occurring over short periods, 30 minutes say, would not be detailed by current forecasting services although special forecasts might be capable of doing so. A mariner, given a warning in the form of a general weather forecast and with access to wind, wave and current data from surrounding platforms, should be able to spot the incipient changes before they affect an operation too seriously. Careful consideration should be given to whether it would be possible to make appropriate data available in an effective manner.

Table 9.3
Summary of findings relating to *shuttle tanker and FPSO operations*

Item	Category of installation-specific data	Deduction from study
1	Better use of existing instruments on each platform	• Review availability of reliable measurement of metocean parameters for all weather-sensitive operations at FPSOs, and in particular for shuttle tanker loading activities. • Green water events pose risks to operations on FPSOs. These should be clearly identified in adverse weather warning documents together with possible mitigation measures (e. g. when access to particular deck areas should be restricted or, operating at lighter draughts in certain conditions). By understanding critical metocean parameters, ship response and control strategy, it may be possible to devise operational procedures to minimise these risks.
2	Better integration of data and access to instrument readings on surrounding platforms	• Better availability of accurate data (for example, from nearby fixed facilities or wave-buoys) may improve safety of operations on FPSOs. In some circumstances, it can be difficult to obtain accurate readings of wave heights and wind speeds from instruments on FPSOs particularly during shuttle loading operations.
3	Upgrade data collection and recovery from a few selected platforms	• Where no nearby measurements are available, it may be beneficial to establish one as part of a network of high quality, calibrated facilities throughout the UKCS
4a	Site specific weather forecasts in present-day format	• In general, except perhaps at remote, floating facilities that depend intimately of identification of weather windows for successful operation, site specific weather forecasts would be unlikely to be beneficial unless they were extremely detailed.
4b	Other site specific weather forecasts in some other format (specify)	• More detailed alternative forms of weather forecast might be considered as a solution to the problem identified below
5	Alternative source or presentation of relevant data	• Shuttle tanker loading operations are vulnerable to rapid veer in the environmental forces. The relative importance of wind, wave and current forces will be dependent on the draughts of both vessels. An experienced captain, given a warning in the form of a general weather forecast and with access to wind, wave and current data from surrounding platforms, would have a better chance of spotting incipient changes before they affect an operation too seriously. Consideration might be given to whether it would be possible to make appropriate data and modelling tools available in an effective manner to allow a captain to make a better judgement. • FPSOs which use thrusters as part of their heading control, may be vulnerable to rapid changes in the direction of environmental forces since the thrust capacity may be inadequate to turn their head against a rising storm. Such facilities should be carefully assessed since this is a potentially dangerous situation. A better understanding would also allow operators to interpret real time data and manage this situation more effectively.

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