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Reducing incidents in marine personnel transfer

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Abstract

Millions of crew transfers take place each year and whether they are by boat or helicopter, this remains one of the highest risk activities in offshore operations. Although the safety of crane transfers compares favorably with other methods of crew supply, incidents and associated litigations are not infrequent.

Why does such an 'apparently simple' operation go wrong? One reason is a lack of recognition of the true risks. Operators go to great lengths to improve the safety of helicopter operations, whilst marine transfers rarely get a second thought. The underlying objective, however, remains the same; to move personnel to and from their place of work in a safe, cost effective and reliable manner.

This paper looks at the real risks, the root causes of recorded incidents and outlines how transfers can be made safer. Risk can be managed in two ways:

- **Engineered protection** – A modern car provides a secure environment that can protect passengers from impacts. A transfer device can do the same and guard against the inevitable human factors that contribute to the majority of incidents.

- **Improved operational control** – Procedures, pre-lift planning, communications and training can all play a significant role in reducing risk.

The paper also describes how analysis of past incidents led to the development of improved equipment and operating practices. Considerable focus was given to 'human factors' to prevent minor misjudgments, for example by a crane operator or a vessel skipper, leading to serious incidents.

After ten years working with enhanced systems and after millions of safe transfers, the author explains why serious transfer incidents are not an inevitable feature of offshore life. Modest investments and changes in operational practices have provided many operators with a dual benefit of safer operations and reduced downtime.

Finally, the author takes a look at the future of offshore crew supply, providing details of a ground breaking new project that will utilize a state of the art high speed catamaran and newly developed transfer system. This will be the first time that a vessel and transfer system has been custom built to provide swift, comfortable and safe transfers to offshore installations. The system, dubbed 'Crew-Express', is due to be commissioned in the Gulf of Mexico in late 2007.

Introduction

Over the past few years operators have become increasingly aware that the movement of personnel is one of the highest risk activities associated with offshore operations[1, 2]. The emergence of new equipment and operational philosophies are leading many industry professionals to take a fresh look at their crew supply options and associated risks, efficiencies and costs.

A lack of good data relating to marine activity and incidents continues to be an impediment, although awareness of this issue is now increasing in the industry.

This paper outlines how a group of transfer specialists compiled their own data-base in order to evaluate the root causes of past incidents. Analysis suggested an over-reliance on human responses and that improved equipment and operational control would be required to reduce this reliance. It describes the approach taken to develop a safer transfer solution. It also looks at how one vessel operator plans to introduce a completely new approach to marine transfers and has custom designed a vessel specifically for the purpose of providing safer and more efficient personnel transfers.

Background

Crane transfers - Marine transfer in the offshore industry started from humble beginnings; in the 1950s it was common practice to carry out crane transfers in a cargo net. In 1955, Billy Pugh developed a transfer basket specifically designed for personnel riding. This was a significant enhancement to the cargo net and is still in common use in the industry today (Fig.1).

Fig.1 – Basket transfer in progress.

It should also be recognized that many evacuations of endangered installations have been performed by crane transfer, so it can be argued that traditional basket transfers have saved many lives over the past 50 years.

However, despite giving good service to the industry, transfer incidents have continued to occur and the industry is now looking for improvements in safety.

Crane transfers are not the only method in use for marine access to offshore installations. A method commonly used when crane access cannot be provided is the swing-rope transfer (Fig.2). This involves personnel making a timed swing on a knotted rope between a vessel and an installation. This is still commonly used in the Gulf of Mexico and elsewhere, but again relies heavily on human responses and serious incidents are not uncommon.

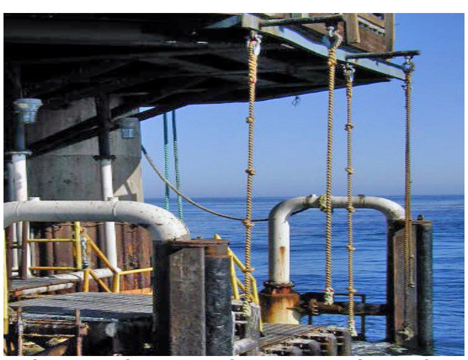

Fig. 2 - Swing ropes for personnel transfer

In areas with benign sea conditions, personnel board installations by stepping onto landing platforms, ladders and gangways.

Activity and risks

Overall risk perspective – Whilst there is a great deal of data available relating to helicopter operations and incidents, data on marine transfers is sparse. It is difficult to draw a clear picture of the overall level of marine transfer activity and the associated safety performance. To provide some idea of the scale of the operations, the author would offer a qualified estimate that in excess of 5 million passengers are moved each year by crane, resulting in 1-5 fatalities per year. Activity levels (in terms of passengers carried) appear to be of a similar order to those carried out by helicopter.

Comprehensive data on helicopter operations is made publicly available by the OGP. This allows operators to assess incident rates by operational category, aircraft type and region and to make quality 'risk based' decisions. Table 1 gives a small sample of the type of data available:

Table 1 - Helicopter data 5 year average 2000-04	
Passengers carried p.a.	9.3 million / year
Fatalities p.a.	21 / year
Fatality rate	2.2 / million passengers
Injuries p.a.	12 / year
Average duration of flight	21 minutes
Source International Oil & Gas Producers Association[1]	

Given this asymmetry of data between aviation and marine activities, there appears to be a good case for the industry to give higher priority to the collation of marine related incident data. The underlying objective for all crew supply operations remains the same; namely, to move personnel in a safe, reliable and cost effective manner. Better data would allow industry professionals to make better decisions.

Some companies have made efforts to share their experiences with the wider industry[3]. This data appears to indicate that marine transfers suffer a much lower level of fatalities (per passenger carried), but injury rates appear to be considerably higher. However, until quality data becomes more widely available, managers will struggle to make objective and rational choices about their transport arrangements.

Marine transfer incidents – Faced with a lack of quality data, Reflex Marine's development team decided to compile its own marine transfer data base. Incident data from a range of sources was used, including public authorities in various countries, information provided by operators and data from reliable media sources. Table

2 indicates the size of the overall data set used for the analysis.

Table 2 - Summary of data set	
Total number of Incidents	62
Total number of Fatalities	7
Total number of Injuries	48
Data taken from MMS website[(4)], UK HSE web sources[(5)], and information provided by operators.	

80% of the incidents occurred since 2000. Although it is acknowledged that this represents just a small proportion of overall incidents, in the authors view, it provides a good indication both of the risks and the type of incidents that occur. Table 3 identifies the locations where incidents occurred.

Table 3 - Incidents by Location		
Location	**No. incidents**	**%**
Support vessel	45	**83%**
Mid-transfer	5	**9%**
Host installation	4	**7%**
Unknown	8	**n/a**
Total	**62**	**100%**

As expected the vast majority (c. 80%) of incidents happen on the boat. Perhaps less predictable was the high level of incidents that occurred during pick-up off the deck of the vessel, which exceeded those due to heavy landing (Fig.3). More detailed analysis indicated that many of these incidents were caused by the pendulum 'swing factor' as a result of misalignment between the crane line and the transfer device (this is discussed in more detail below).

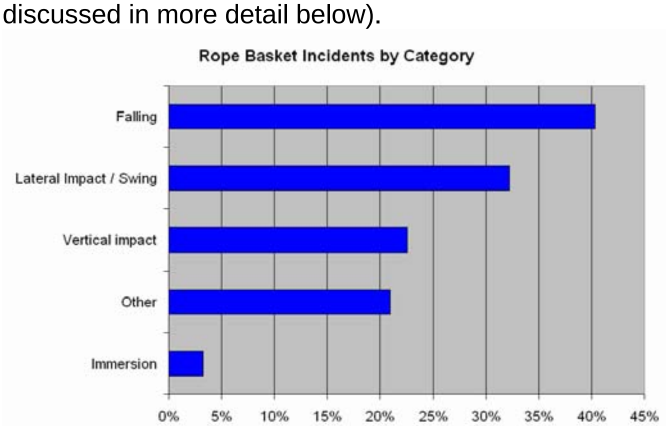

Fig.3 - Categories of transfer incidents

Also it was noticed that incidents due to heavy landings were more likely to result in minor injuries, such as fractures and back injuries. Collisions during pick up however, often resulted in falls from height which are much more likely to result in serious injuries or fatalities.

Immersion incidents were found to be relatively rare, although it should be acknowledged that when they do occur the potential for a fatality is high, particularly in harsh environments.

Swing factor – The dynamic motion of a vessel makes it difficult to ensure that a crane is centred directly over a load prior to making a lift. 'Off-centred' lifts tend to result in a sudden swinging motion (or pendulum effect) which can lead to violent collisions. Such collisions are part of the everyday concerns of offshore crane operators and deck crews, who are trained to try to anticipate, manage and sometimes control such motions. However, given the number of variables involved (vessel motion, crane motion, timing of lifts etc.); it is unrealistic to expect to completely avoid such collisions.

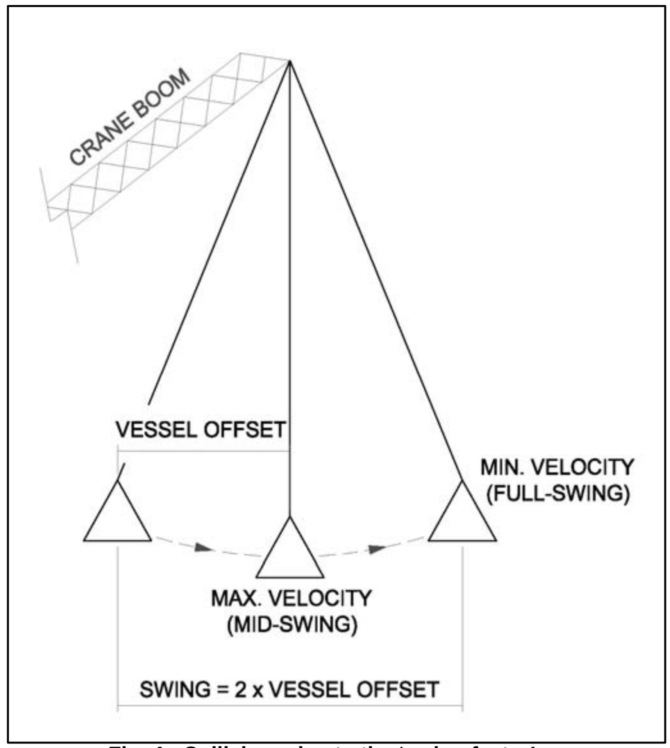

Fig. 4 - Collisions due to the 'swing factor'

Collisions involving traditional personnel carriers with no peripheral protection are of particular concern. A lifted load will swing twice the distance of the offset of the vessel from the crane boom tip (Fig.4) i.e. for an offset of 10ft the load will swing 20ft. The highest velocity is reached at the lowest point (half way through the swing); therefore a collision at this point would result in the maximum impact. There is also little time to react. For example, with a 10ft vessel offset and a 100ft crane line, an impact with an obstacle 10ft away will occur in just 2.8 seconds (and at a speed of 5ft/s).

The 'swing factor' was evident in c. 30% of all crane transfer incidents reviewed. To avoid the risk of collision, the landing area on a vessel should have a radius of twice the maximum anticipated vessel offset. It may be impractical to provide this amount of space. Also, even on a flat deck, the descent of the transfer device during the swing can result in re-collision with a heaving deck. Serious incidents have resulted from this scenario. Whilst efforts should be made to avoid collisions, a more practical approach is probably to provide greater protection for the occasions when they do (inevitably) occur.

Root causes - Further analysis provided an indication of the 'root causes' of incidents, as outlined in Fig. 5. This indicated that lack of planning and preparation were causal factors in the vast majority of incidents and that inadequate equipment design was a factor in 60% of all incidents.

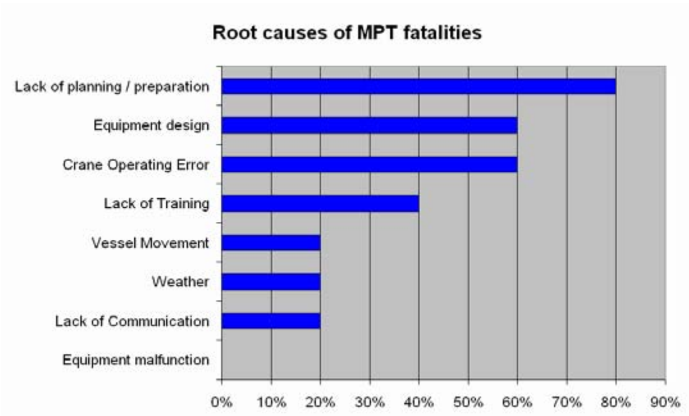

Fig. 5 - Root causes of MPT fatalities

It should also be noted that very few incidents appeared to relate directly to the condition of the transfer device or of the crane. Equipment design was clearly a far more prominent factor than its condition and maintenance.

The root cause analysis suggested that 80% of all incidents could be avoidable with better equipment and operational control.

Managing risks

Analysis of past incidents clearly established that traditional transfer equipment offers minimum protection when things do go wrong. The provision of more robust and protective carriers was therefore viewed as a priority.

It was also apparent that the traditional crane transfers rely heavily on human response and communications. Initial impressions suggests that these are quite simple operations; but closer assessment reveals that all is not so straight-forward. Key variables include:

i. Human factors - The responsiveness, skill and experience of crane operator, vessel masters, passengers and deck crews.

ii. Communications – Safe transfers rely on clear 2-way communication between the Crane Operator on the installation controlling the lift and the Vessel Master controlling the vessel maneuvers. This is difficult, as decisions on crane and vessel maneuvers are often taken in split seconds.

iii. Environmental factors – Sea-state and wind affect both vessel motions and crane operations. Visibility can also be impaired in poor weather or during night time operations.

iv. Site specific factors – The size and shape of landing areas, adjacent obstacles (collision risks), lift heights, line of sight for both crane operator and vessel master.

To achieve safe operations all these factors must be addressed either through improved equipment design or greater operational control. The degree to which the transfer equipment provides protection against falls, vertical impacts and lateral impacts (caused by 'the swing factor' discussed above) is paramount. The protection offered in the event of accidental immersion is also important.

Equipment design

A development team was set up to design a new transfer device; their objective was to provide 'engineered protection' against the inevitable human factors contributing to most incidents. The philosophy was similar to that used by the motor industry; modern cars being designed to provide a secure environment to protect passengers when things do go wrong.

They also aimed to develop a device that could operate close to (or beyond) the limits at which crane operations would normally be shut down. This would provide operators with the assurance that in an emergency (e.g. an evacuation or medivac), transfers could be performed with confidence. This provided the additional benefit for routine operations by reduced weather down-time.

Below is an account of how the design brief was fulfilled:

Overall design – As well as providing fall and impact protection (Table 4*)*, the capability of rapid access and egress for passengers was viewed as a key requirement. A partially open structure fulfilled these access needs, whilst still providing comprehensive collision protection (Fig.6). Passengers benefit from a 120^{o} field of vision allowing them to easily communicate with deck crews and to assess adjacent hazards before disembarking. Testing showed passengers were generally able to exit the capsule in less than 3 seconds.

Table 4 – Protective design features	
Feature	**Design basis**
Vertical Impact Protection	13.1 ft/sec
Side Impact Protection	6.6 ft/sec
Full Scale impact testing	Yes
Bio-mechanical impact assessment	MIRA [6]

Significant advantages were also provided by a transfer device that would remain stable during crew access. Traditional baskets oblige the crane operator to maintain tension to prevent the net from collapsing whilst passengers are still boarding. This creates other hazards as baskets are prone to being dislodged due to vessel heave or loss of station. Also, passengers are often required to jump clear of the basket at the moment of landing, and remain alert to unexpected movements during pick-up. This issue remains with more recently upgraded rigid basket type carriers, as the crane operator is still required to maintain line in tension to avoid destabilizing the unit.

Fig 6. - New generation transfer device in the Gulf of Mexico

The solution was to provide an inherently stable rigid device; the crane operator simply paying out sufficient line to allow for vessel motions. This gives passengers and deck crew more time to board the device when operating on a heaving vessel. The capsule has a very low centre of gravity and testing demonstrated that it remained stable up to an angle of 35^{o}.

Fall protection – With over fifty percent of the transfer incidents involving falling, it was clear that passenger fall-restraints were a design essential. Additionally, the high number of side impacts suggested a protective environment for collisions was required. Passengers are restrained by four-point seat harness, the quick release buckle still allowing rapid egress.

Lateral impact protection – A protective shell to absorb side impacts was also considered essential. The tetrahedral stainless steel frame has the impact strength requirement and the required buoyancy configuration, discussed below. The frame was subjected to horizontal impact testing and survived impacts against a container at 6.6ft/sec. Finite element analysis was used to verify the inherent strength of the tetrahedral structure.

Additionally, in order to assess risks to passengers during high speed collisions, a detailed biomechanical assessment[6] was carried out by the independent research authority MIRA (Motor Industry Research Association). This confirmed that the capsule provided good protection against neck and back injuries due to heavy landings and whiplash (from lateral impacts).

Vertical impacts – A spring loaded seat base and shock-absorbing landing feet provide protection against heavy landings (in harsh weather). Drop tests to the maximum anticipated landing speed, 13.1 ft/sec confirmed the engineering design. Deceleration loads were analyzed by MIRA, who confirmed that the capsule provided excellent protection against back injury even in the heaviest of landings[6]

Immersion risk – Although immersion is a lesser risk the consequences of accidental immersion can be serious. The capsule is the only transfer device designed to float and self-right. Extensive testing in a wave simulation pool to an equivalent Beaufort 6 conditions was conducted to verify the performance.

Operational envelope - In general there are limits beyond which any piece of equipment can operate safely. The development team found little evidence of measures taken to establish the safe operational envelopes of equipment in common use. As conditions deteriorate transfers become more hazardous. Decisions about operational limits and the safety of individual transfer devices were generally found to be highly subjective and usually left to personnel in the field. Clearly the experience and qualifications of offshore personnel to make such decisions varies from operation to operation. The design team recognized this and felt that a rigorous process should be applied to establish limits beyond which safe operations could not be assured.

The new device provides the greatest proven operating envelope (Table 5) of any transfer device on the market.

Table 5 – Operating limits of new transfer device	
Maximum Recommended Wave Height*	* 16.5 ft sig.
Maximum Wind Speed	40 knots
Angle of stability on deck (fully loaded)	35^{o}

* Platform to Vessel Transfers

Verification - The engineering design was reviewed by Bureau Veritas, Sparrows Offshore Services and Det Norske Veritas (DNV). All impact testing was witnessed by DNV and the unit was the first transfer device to be given CE certification (complying with the EC Machinery code).

Special applications – The capsule is custom designed for the transfer of sick or injured persons accompanied by a paramedic. It will protect them from impacts and heavy landings, clearly a concern when transferring the critically ill, particularly those with spinal injuries. Since its introduction, the capsule has been used in numerous emergency situations and medivacs (sometimes in extreme conditions).

A special low temperature version of the capsule was designed to operate down to -40^{o}F. It has been used in many projects in the far northern hemisphere including Alaska, Russia, Canada, Norway and China.

Operational control

As indicated equipment design alone cannot ensure the safety of operations. The development team focused strongly on operational support in order to help operators to ensure safe operation. The key aspects of the support arrangements have been as follows:

Quality technical documentation – High quality procedures and technical documentation (in down-loadable form) were provided to assist operators with operational control and maintenance routines.

Training / operating briefing aids – A high quality Operational Briefing video was made, targeting crane supervisors, crane operators, passengers, vessel crews and deck crews.

Training – On and offsite training is provided to increase risk awareness and build operational knowledge. A number of training organizations have made use of **computer based crane simulators** to simulate personnel transfers with the new device. These provide a highly realistic learning environment similar to that used to train airline pilots.

Operational reviews and audits – Field reviews and audits have been used, in particular where operators have faced challenging operational environments.

In general the approach has been to maintain close contact with client's field operations. This has allowed ongoing development of equipment, procedures and support services. There is no substitute for field experience!

Crew-Express

In 2006, Seacor Marine LLC, commissioned a project aimed at improving the safety, comfort and efficiency of crew supply operations.

The important issues of speed and comfort were addressed by the specification of the new Crew-Zer Class vessel, a catamaran capable of 42 knots. It recognized though, that the weak link in marine crew supply was the safety of the crane transfer operation. After investigating a range of options (including concepts still under development), it selected a solution based on a new generation of transfer capsules that had gained an excellent track record over the past few years.

A decision was made early on to integrate the activities of the vessel and transfer system design teams, in order to develop the safest and most efficient system. It also decided to increase the transfer rate and established a partnership to develop a new high-capacity (9-person) transfer capsule. The project sets an industry precedent, as the first direct collaboration between a vessel operator and transfer specialist.

The catamaran hull provides excellent stability, minimizes vessel roll and a wide deck reduces collision hazards. The landing area is positioned at mid-ships for increased stability, better visibility from the bridge and improved access for passengers. A special passenger flow system is under development and a number of special guidance and protective features are being developed to improve safety and increase the operational envelope.

Conclusions

i. A lack of data makes reliable comparisons between the safety performance of marine and helicopter transfers difficult.

ii. Industry efforts to collate better data on marine transfer activities and incidents would aid the development of safer solutions and facilitate better decisions on crew supply arrangements.

iii. Despite the lack of available data there is evidence that marine transfers result in high injury levels, although low fatality rates, in comparison to helicopter transfers.

iv. Although simple on the face of it, safe marine transfers rely on a complex interaction of human, site specific and environmental parameters. As a result incident rates have been relatively high.

v. A new generation of marine transfer equipment protects passengers from a wide range of risks, reducing the current over-reliance on human responses.

vi. Analysis suggests that a small investment in improved transfer equipment and operational controls could lead to an early reduction in transfer incidents (of the order of 70-80%).

vii. A new generation crew transfer service based on a high speed catamaran, promises to herald a new era for crew transfers. It has the potential to provide levels of safety and efficiency previously thought unobtainable. The new service is due to be launched in late 2007.

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Philip Strong (BSc C.Eng) is Managing Director and co-founder of Reflex Marine Ltd. In his early career at BP he was involved in well construction and production operations. Later at Enterprise Oil he was Team Leader for the company's first deepwater wells in the Adriatic Sea. He holds several patents and is accredited as inventor of the 'Reamer Shoe', winner of the Scottish Offshore Innovation Awards (Technical Prize for 1996).