FINAL REPORT

Crane Transfer Incident Data Review and Risk Estimation

Marine Transfer Forum

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Abstract:
This report reviews available data on incidents during transfer of personnel by crane to/from offshore installations, and produces up-to-date estimates of fatality risk.

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SUMMARY

This study reviews available data on incidents during transfer of personnel by crane to/from offshore installations, and produces up-to-date estimates of fatality risk, intended to improve a previously published estimate. It makes use of a database of incidents during crane transfer of personnel to/from offshore installations world-wide, which has been gathered by Reflex Marine (RM). The study has been conducted for the Marine Transfer Forum by Det Norske Veritas Ltd (DNV)[1].

This report documents DNV's review of RM's incident database. DNV compared the fatality data to an independent collection from public sources. The review concluded that there were no obvious omissions from the RM database apart from a well-known case of platform collision following basket transfer. It is therefore considered suitable as the basis of an improved estimate of fatality risks in crane transfer. Nevertheless, the difficulty DNV experienced in identifying accidents in public sources reinforces the desirability of publishing improved data.

DNV also evaluated the quality of the RM database, using the ratio of incidents to fatal accidents. This suggested that non-fatal incidents are not reported comprehensively, except by the USA in the period 1996 to 2010. World-wide coverage of non-fatal incidents is poor, and it is likely that many have been missed. Therefore the non-fatal incident data is not used in making the new risk estimates.

The report combines the fatal accident data with activity estimates provided by RM, and makes an updated estimate of the fatality risk in crane transfer. This is similar to the previously published estimate, but has a much narrower confidence range. The analysis shows no significant differences in fatality risk for different methods of crane transfer, but does show some significant differences in risks between transfers in different regions. DNV proposes to adopt the new risk estimate in risk assessments covering offshore transfer, as it is clearly more robust than the previously published estimate.

The causal breakdown clearly shows that the largest contribution to fatality risks is passengers falling, and this therefore appears the most fruitful area for future risk reduction.

The report concludes with recommendations for improved data collection, which would allow the current risk estimate to be progressively improved as more experience is gained.

[1] Following merger with the GL Group in 2013, DNV is now part of DNV GL.

1 INTRODUCTION

1.1 Background

Risk assessments of crane transfer (CT) of personnel to/from offshore installations commonly use an estimate of the fatality risk that was published by Det Norske Veritas Ltd (DNV) in 1994[2]. This was based on experience with rope swings in the offshore industry in Brunei and Malaysia prior to 1991. Since no fatalities had occurred in the data, the risk was estimated using an assumption about how close the operation might be to its first fatality. Although outdated and limited, no more recent data has been published, so the risk estimate remains in common use.

Reflex Marine (RM) has gathered a database of CT incidents world-wide, which includes 13 fatal accidents. In combination with estimates of the number of personnel transfers, this appears to be a suitable basis for an improved estimate of the fatality risk in CT. The database also includes causal information, which RM has used to estimate the benefits of different designs of personnel carrier.

The newly established Marine Transfer Forum (MTF) has identified that the industry as a whole would benefit from publication of up-to-date and reliable estimates of risk in different types of CT. MTF has therefore commissioned a study from DNV[3] to estimate the risks based on the data RM has collected. In due course, MTF will encourage the collation and sharing of incident data and risk estimates, which will enable development of more reliable estimates.

1.2 Objectives

The objectives of DNV's study are:

- To review the incident data from available sources, including the data set that has been produced by RM, with the aim of verifying its quality or identifying additional data collection necessary to make it comprehensive.
- To produce updated estimates of personnel accident and fatality risk in different types of carrier.
- To gain industry acceptance of the new values, as improvements on the previous risk estimate.
- To publish the updated risk estimates, making them available for future risk assessment studies.
- To indicate areas of design or operating procedure with the greatest scope for improvement in order to further reduce risks.
- To help establish a template for the on-going evaluation of risks and activities by MTF.

The present document addresses these objectives through a review of the available incident data and an updated estimate of the risk.

[2] Spouge, J. R., Smith, E.J. & Lewis, K. J. (1994), "Helicopters or Boats – Risk Management Options for Transport Offshore", SPE Paper No. 27277, Conference on Health, Safety and Environment in Oil and Gas Production, Society of Petroleum Engineers, Jakarta.

[3] Following merger with the GL Group in 2013, DNV is now part of DNV GL.

1.3 Report Structure

Section 2 of this report documents DNV's review of the RM incident database, and draws conclusions on its suitability for improved risk estimates.

Section 3 documents DNV's review of the RM activity data, and draws conclusions on its suitability for improved risk estimates.

Section 4 develops updated estimates of accident risk based on the above data sources. It also includes a review of the causal breakdown, which gives a preliminary indication of the areas with greatest scope of risk reduction.

Section 5 summarises the conclusions from the study and makes recommendations for on-going data collection by MTF that would enable improved risk estimates in the future.

2 REVIEW OF INCIDENT DATA

2.1 Scope

To be useful for risk analysis, an incident database should be comprehensive within a defined scope. The intended scope of the database is therefore defined as follows:

- **Transfer types** include any planned movement of personnel between marine vessels and offshore installations. This includes crew-change, in-field movement by vessel between installations and medical evacuation. Maintenance work that is accessed from baskets or cranes without any movement between installations is excluded.
- **Transfer methods** include all types of soft rope and rigid personnel carriers that are moved by crane. This includes various designs of baskets and capsules. Transfers by rope swing and direct access onto ladders, boat landings or other parts of the structure without the use of a crane are also considered, as they may be included in future work.
- **Locations** include oil & gas production platforms, drilling rigs, support vessels, offshore wind facilities or other structures. The study also tentatively includes transfers between vessels where a carrier is used, but does not include other transfers between ships. It does not include transfers in port or shipyards.
- **Transfer phases** include the boarding, lifting and descent of the carrier. Events during the preparation for boarding and immediate dispersal afterwards (e.g. approach to and movement away from the transfer location) are also included, although it is recognised that these are unlikely to be complete. Events on the marine vessel before or after the transfer may be included in future work.
- **Time period** at present is unlimited, but may be restricted in future work to avoid under-reporting or to match available activity data.

2.2 Data Sources

The study uses as its starting point the RM incident database (130425 Crane Transfer Incident Database Revision FA.xlsx) supplied to DNV on 16 May 2013.

In order to review the quality of the RM database, DNV made an independent collection of data and compared with the database. For efficiency, only fatal accidents have been compared in this way, as these have the greatest influence on the overall accident risks.

DNV used the following sources for its data collection:

- Internet searches by Google, Metacrawler and Bing, using various combinations of search terms based on "crane/basket/transfer/fatality" and synonyms. This was the most productive of the search methods, and found most of the accidents listed below.
- Search of the World Offshore Accident Databank (WOAD) using the search term "transfer", and the event sequence "falling load/dropped object". This identified 2 relevant fatal accidents but provided very few details about them.
- Search of the International Association of Oil & Gas Producers (OGP) safety performance indicators fatal incident reports 2003-10. The search term "transfer" was combined with a review of each individual offshore incident. This identified one relevant fatal accident during transfer and 3 others on crew boats.

- Search of the UK Health & Safety Executive (HSE) offshore RIDDOR data for 1980-2007 using the search terms "transfer" and "basket". This did not reveal any relevant fatal accidents.
- Search of the following US Bureau of Safety and Environmental Enforcement (BSEE) (previously the Minerals Management Service, MMS) sources for the US Outer Continental Shelf (OCS):
    - Lifting accident data for 1996-2012. Systematic search of this data is possible but did not reveal any relevant fatal accidents.
    - District Investigation Reports for 2003-13. Search of these reports using the term "fatality" revealed one relevant rope swing accident.
    - Panel Investigation Reports for 1984-2013. Systematic search of this data is difficult because the summaries are uninformative, but no relevant fatal accidents have been found.
    - Fatality summaries for 2006-2012. Systematic search of this data is possible and revealed 3 rope swing accidents.
- Review of International Marine Contractors Association (IMCA) Safety Flashes 1997-2013. This identified 2 relevant fatal accidents but does not reveal their precise date or location.

2.3 Fatal Accidents from DNV's Search

This section reviews the relevant fatal accidents that were found in DNV's search, and checks whether they are included in the RM database. This is expected to show whether or not the RM database is a comprehensive collection of such accidents.

2.3.1 1976 Crane Collapse, USA

A crane collapsed onto a crew boat, killing the crane operator (see the WOAD record shown in Figure 2.1). This appears to be relevant because it is likely to have resulted from a personnel transfer operation, but no further details are available on this incident. This accident is not in the RM database.

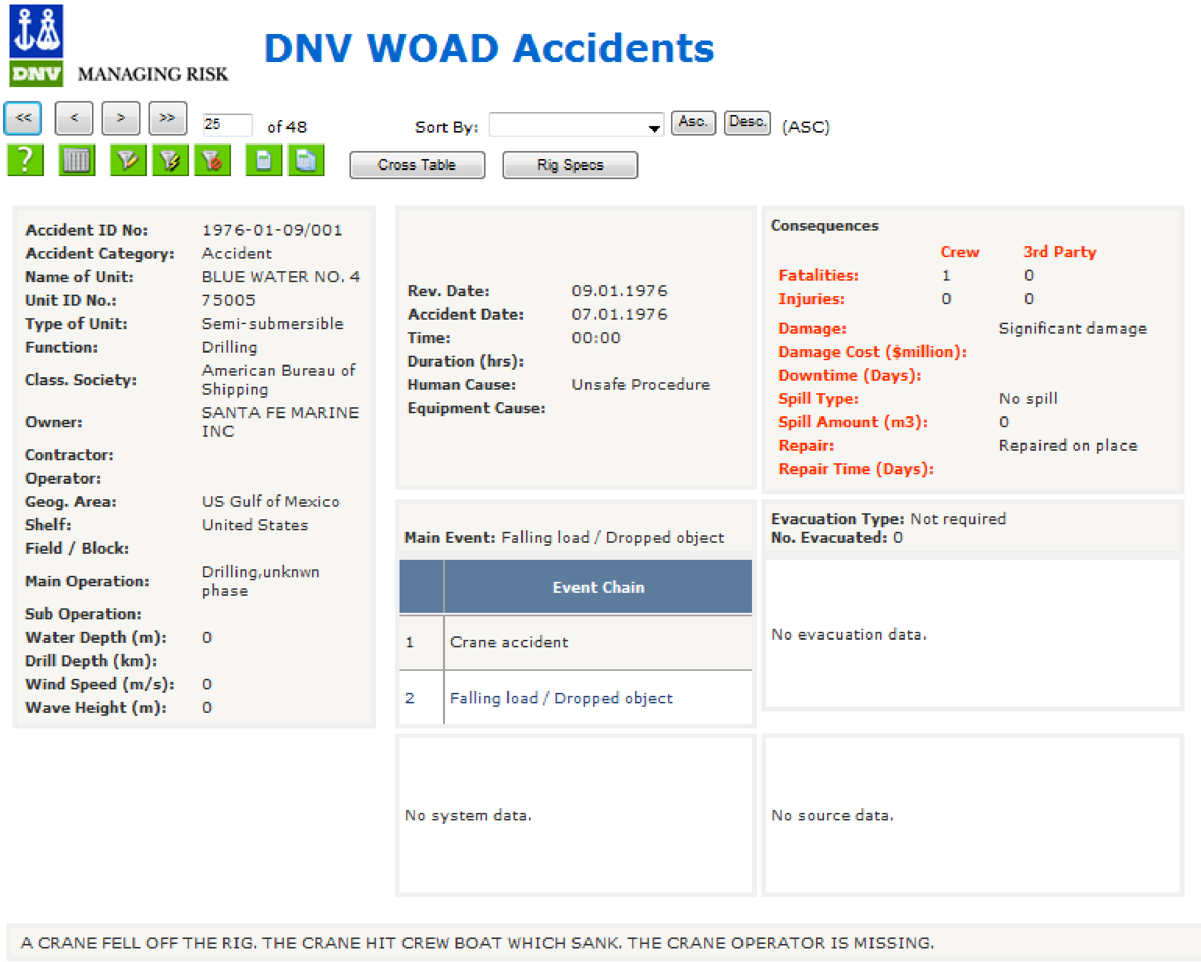
2.3.2 1978 Dropped Personnel Basket, USA

During a basket transfer from a supply vessel to an offshore platform, the basket was dropped onto the vessel's deck and a passenger died. This accident is included in the RM database.

2.3.3 2004 Personal Accident, Russia

A passenger fell down an opening and died while approaching a capsule for transfer. This accident is included in the RM database.

Figure 2.1 WOAD Record of Fatal Crane Collapse



DNV MANAGING RISK

DNV WOAD Accidents

25 of 48 Sort By: Asc. Desc. (ASC)

Cross Table Rig Specs

Accident ID No:	1976-01-09/001
Accident Category:	Accident
Name of Unit:	BLUE WATER NO. 4
Unit ID No.:	75005
Type of Unit:	Semi-submersible
Function:	Drilling
Class. Society:	American Bureau of Shipping
Owner:	SANTA FE MARINE INC
Contractor:	
Operator:	
Geog. Area:	US Gulf of Mexico
Shelf:	United States
Field / Block:	
Main Operation:	Drilling,unknwn phase
Sub Operation:	
Water Depth (m):	0
Drill Depth (km):	
Wind Speed (m/s):	0
Wave Height (m):	0

Rev. Date:	09.01.1976
Accident Date:	07.01.1976
Time:	00:00
Duration (hrs):	
Human Cause:	Unsafe Procedure
Equipment Cause:	

Consequences

	Crew	3rd Party
Fatalities:	1	0
Injuries:	0	0
Damage:	Significant damage	
Damage Cost ($million):		
Downtime (Days):		
Spill Type:	No spill	
Spill Amount (m3):	0	
Repair:	Repaired on place	
Repair Time (Days):		

Main Event: Falling load / Dropped object

	Event Chain
1	Crane accident
2	Falling load / Dropped object

Evacuation Type: Not required
No. Evacuated: 0

No evacuation data.

No system data.

No source data.

A CRANE FELL OFF THE RIG. THE CRANE HIT CREW BOAT WHICH SANK. THE CRANE OPERATOR IS MISSING.

2.3.4 2005 Collision During Basket Transfer, India

Following a basket transfer of a medical casualty between a multi-purpose support vessel (MSV) and the Mumbai High North platform, the MSV struck the platform riser causing a fire that led to 22 fatalities[4]. This accident resulted from a crane transfer, and hence can be considered to reflect some of the risks involved, although the transfer itself had been completed before the collision occurred, and there is no information to suggest the passenger was among the fatalities. This accident is not included in the RM database.

2.3.5 2006 Rope Swing Accident, USA

A worker died while trying to make a rope swing transfer from a vessel to the installation[5]. This accident is not included in the RM database list of rope transfer accidents, which is acknowledged to be incomplete.

2.3.6 2008 Direct Access Accident, USA

A worker fell into the sea and died while trying to cross from a motor boat to the installation without using the rope swing, which was not accessible[6]. This accident is also in WOAD, but

[4] Daley, J. (2013), "Mumbai High North Platform Disaster", Coastal and Ocean Engineering Undergraduate Student Forum, COASTAL-2013 Memorial University, St. John's, NL, Canada, March 2013.

[5] http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Fatalities/

[6] http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/acc_repo/2008/080413-pdf/

with no additional information. This accident is not a crane transfer, but the transfer was intended to be by rope swing. However, it is not included in the RM database list of rope transfer accidents, which is acknowledged to be incomplete.

2.3.7 2008 Gangway Transfer Accident, UAE

A worker was crushed and died while trying to cross from a ship (presumed to be an offshore tanker) to a supply vessel type crew boat using direct access from the ship's gangway[7]. This accident is not a crane transfer or rope transfer, which explains why it is not included in the RM database.

2.3.8 2009 Basket Transfer Accident, USA

A surveyor fell into the sea and died during a basket transfer between two tankers engaged in a ship-to-ship transfer operation. The transfer used a ship's hose-handling crane. This accident is included in the RM database, although its location is recorded as GOM but should be USA as it was off the Pacific coast.

2.3.9 2011 Rope Swing Accident, USA

A contractor died while trying to make a rope swing transfer from a vessel to the installation[8]. This accident is not included in the RM database list of rope transfer accidents, which is acknowledged to be incomplete.

2.3.10 2012 Basket Transfer Accident, India

A passenger fell from a personnel basket and died during a transfer between a heavy-lift barge and a platform under construction. This accident is included in the RM database.

2.3.11 Summary

There were 10 fatal accidents identified in the DNV search. Of these, just 4 are included in the RM database. The reasons for the omission of the other 6 are understood to be:

- One has insufficient information to confirm it was a personnel transfer. It would be desirable to investigate this accident further.
- One was intended to be a rope transfer, although the rope was not used. DNV suggests it should be added to the list of rope transfer accidents.
- Two others were rope transfers.
- One was a gangway transfer and hence is outside the scope.
- One was a collision following a basket transfer, which is different from the other events. DNV suggests it should be included to complete the risk picture.

In summary, DNV has not identified any obvious omissions from the RM database of crane transfer fatalities apart from the collision during basket transfer. There are three rope transfer accidents that could be added, and one possible transfer accident to be investigated. The difficulty DNV experienced in identifying fatal accidents in public sources reinforces the desirability of publishing improved data.

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7 http://www.qatargas.com/English/SafetyAndEnvironment/SafetyAlerts/Pages/QG_OPCO_Item.aspx?ID=4

8 http://www.bsee.gov/Inspection-and-Enforcement/Accidents-and-Incidents/Fatalities/

2.4 Other Fatal Accidents in the RM Database

This section reviews the other fatal accidents that are in the RM database but were not found in DNV's search. This is expected to show whether or not the DNV search was sufficiently rigorous. It may also show whether the RM data is adequately documented.

2.4.1 1996 Basket Transfer Accident, Angola

Two passengers fell from a personnel basket and died during a transfer. No other details are available. This accident was reported by RM's industry contacts, and was not found by DNV in any public sources.

2.4.2 1998 Dropped Personnel Basket, USA

During a basket transfer from a workboat to an offshore platform, the basket was dropped onto the vessel's deck and a passenger died. This accident was reported by USCG, but the link in the RM database is broken and the accident report has not been found.

2.4.3 2000 Basket Transfer Accident, Indonesia

Four passengers fell from a personnel basket during a transfer and one died. No other details are available. This accident was reported by RM's industry contacts, and was not found by DNV in any public sources.

2.4.4 2005 Dropped Personnel Basket, Mexico

During a basket transfer, the basket was dropped onto the platform's deck and two passengers died. This accident was reported by RM's industry contacts, and was not found by DNV in any public sources.

2.4.5 2006 Basket Transfer Accident, Romania

Four passengers fell from a personnel basket during a transfer and one died. This accident was reported by RM's industry contacts, and was not found by DNV in any public sources.

2.4.6 2007 Basket Transfer Accident, Mexico

A passenger fell from a personnel basket during a transfer and died. This accident was an anecdotal report by RM's contacts, and was not found by DNV in any public sources.

2.4.7 2008 Work Basket Accident, USA

While positioning a boat tie-up rope over the side of a mobile platform, a crane boom collapse caused a Billy Pugh work basket to fall into the sea and two workers died. This accident was found in the DNV search but discarded as out of scope, and the boat ropes are presumed to be supply boat moorings not crew transfer ropes. However, it is included in the list of rope transfer accidents in the RM database.

2.4.8 2011 Basket Transfer Accident, Brazil

A passenger fell from a personnel basket during a transfer and died. The public report on this accident was found by DNV from the link in the RM database. It was not found in DNV's search because it is very brief and does not contain the key words basket, transfer or crane.

2.4.9 2011 Basket Transfer Accident, USA

The entry in the RM database only reports that a worker died in a Billy Pugh transfer incident. This accident was reported by RM's industry contacts, and was not found by DNV in any public sources, including the MMS fatality lists.

2.4.10 2013 Basket Transfer Accident, Mexico

A passenger fell from a personnel basket during a transfer and died. The public report on this accident was found by DNV from the link in the RM database. It was not found in DNV's search because it is in Spanish.

2.4.11 Summary

There were 13 fatal accidents in the RM database, of which 9 were not identified in the DNV search. The reasons are:

- One was publicly reported in Spanish, and not found in DNV's English key-word search.
- One had only a very brief public report that would be difficult to locate through a key-word search.
- One had a public report that appears to have been removed from the internet.
- One was a work basket accident that is outside the study scope.
- Five accidents were reported by RM's industry contacts, and not found by DNV in any public sources.

In summary, it is clear that RM's industry contacts contribute significantly to the data collection. A possible improvement to DNV's search would be to use key-words from languages that correspond to the places where basket transfer is used, such as Portuguese and Spanish.

2.5 Absence of Fatal Accidents

As well as searching for reports of fatal crane transfer accidents, it is desirable to search all fatal accidents to check that none were associated with personnel transfer. This positive confirmation is a better indicator of comprehensive reporting.

Complete searches of fatality lists have at present only been made for the following datasets:

- UK offshore HSE RIDDOR data for 1980-2007.
- US offshore BSEE/MMS fatality summaries for 2006-2012.
- OGP offshore fatality summaries for 2003-2010.

These are the only areas in which the fatality data can be considered to be comprehensive. Future searches might expand these areas.

However, even this may not be fully comprehensive, because transfer accidents may fall outside the jurisdiction of reporting authorities. For example, an accident may be missing from the MMS list if it is being investigated by the USCG or did not occur on the OCS. Similarly, OGP reports do not cover all offshore operators.

2.6 Fatal Accident Summary

Table 2.1 lists the fatal accidents that DNV considers relevant to the present study. In total there are 15 fatal accidents in basket transfer and 3 known fatal accidents in rope swing transfer. It is acknowledged that rope swing accidents, having been subject to a less detailed search, are more likely to be incomplete.

Table 2.1 Fatal Accidents in Crane Transfer and Rope Swing Transfer

Date	Location	Method	Description	Fatalities	Passenger fatalities
Jan-2013	Mexico	Basket	Transfer from vessel to platform in high wind; basket swung into vessel mast; passenger fell onto deck.	1	1
Mar-2012	India	Basket	Transfer between platform under construction and barge; passenger fell onto platform.	1	1
Dec-2011	GOM	Basket	No details.	1	1
Dec-2011	Brazil	Basket	Transfer from vessel to platform; basket swung, 3 passengers fell onto platform deck; one died.	1	1
Feb-2011	GOM	Rope swing	Transfer from vessel to platform; fell into sea	1	1
Aug-2009	California	Basket	Transfer between tankers in ship-to-ship transfer in rough weather; wire broke; passenger fell into sea.	1	1
Apr-2008	GOM	Rope swing	Direct transfer from vessel to platform while rope swing inaccessible; fell into sea.	1	1
Oct-2007	Mexico	Basket	Untrained crane operator in rough weather; passenger fell.	1	1
Jan-2006	GOM	Rope swing	Transfer from vessel to platform boat landing.	1	1
Jan-2006	Romania	Basket	Basket swung into vessel; 4 passengers fell; 1 died after recovery from sea.	1	1
Dec-2005	Mexico	Basket	Basket became unhooked and fell onto platform deck; 2 out of 4 passengers died.	2	2
Jul-2005	India	Basket	Collision following medevac from MSV to platform; riser fire; 22 of 384 crew died.	22	0
Aug-2004	Russia	Rigid capsule	Passenger fell down opening while preparing for transfer.	1	1
Jun-2000	Indonesia	Basket	4 passengers fell from basket; one died.	1	1
May-1998	GOM	Basket	Transfer from boat to platform; basket snagged and dropped onto vessel deck.	1	1
Jan-1996	Angola	Basket	Basket snagged on structure; 2 passengers fell and died.	2	2
Nov-1978	GOM	Basket	Transfer from supply vessel to platform; basket dislodged from crane hook; fell onto vessel deck; 1 of 2 passengers died.	1	1
Sep-1976	GOM	Basket	Crane fell onto crew boat; crane operator died.	1	0

2.7 Quality Indicators for Non-Fatal Incidents

To be considered high quality, a database should make a comprehensive record of all events within defined reporting criteria. In the present study, "quality" refers both to the standard of reporting of the relevant operators and authorities, as well as the standard of capture of such incidents in the RM database. It also refers to the database of incidents as a whole, not just to the fatal accidents discussed above.

Based on DNV's experience with accident/incident databases, the ratio of incidents (including all reported events, whether fatal or not) to fatal accidents is a good metric to indicate comprehensive reporting. The ratio of injuries to fatalities can also be used, but in the present case this is unsuitable because the number of injuries is unknown in many events. In the real world, the ratio of incidents to fatal accidents reflects the inherent risks in the activity, and shows rather small variations in time and between locations. When large variations are observed in this parameter it is therefore most likely to reflect poor quality of reporting, which tends to affect non-fatal incidents much more than fatal accidents.

A notable feature of the RM database is that 14 incidents out of 129 have no information on their circumstances except the year of occurrence and the fact that they were non-fatal. These are likely to distort the ratio of incidents to fatal accidents, so they are discarded and the following analysis addresses only the 115 incidents where something more is known about them. Rope swing accidents are also excluded in this section.

Figure 2.2 shows the trends in the fatal and non-fatal incidents in the database. Apart from an almost complete absence of data during the 1980s, there appears to be a peak in the incidents around 2006, while the fatal accidents remain roughly constant in the period since 1996. This pattern is interpreted as a quality issue as follows.

Figure 2.2 Trend of Fatal and Non-Fatal Incidents in the Database

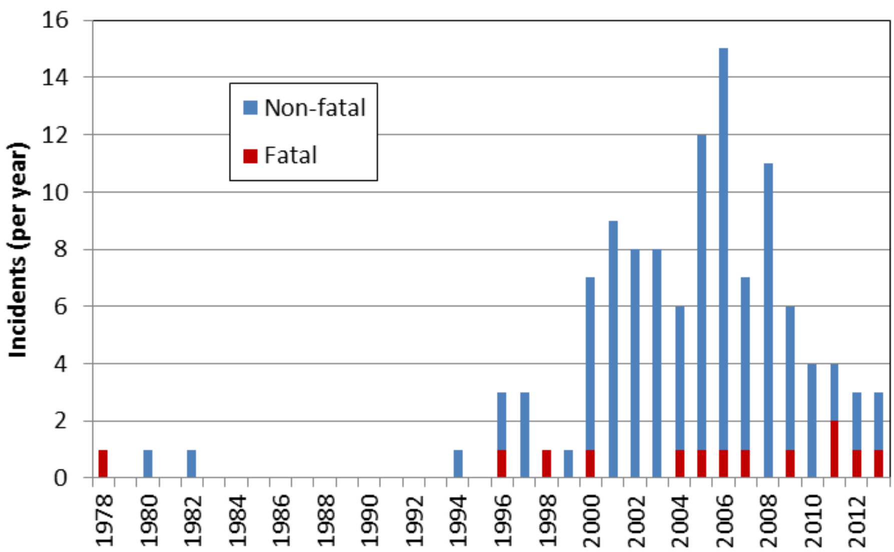
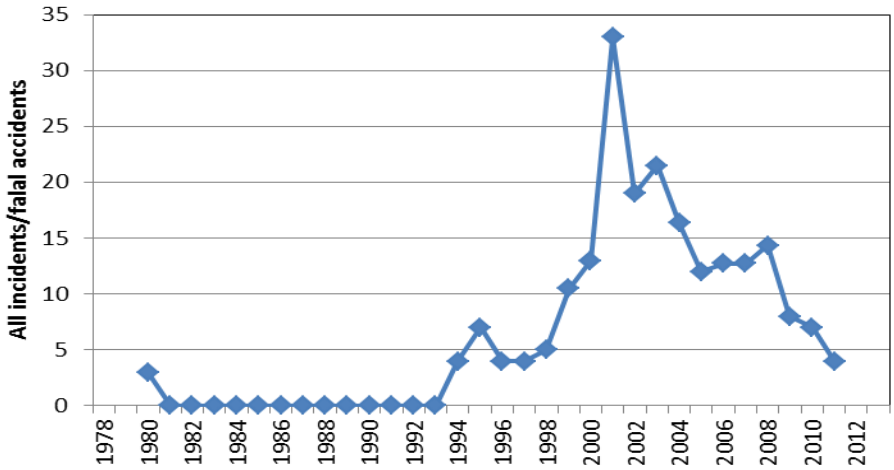


Figure 2.3 shows the trend in the chosen quality indicator, which is the number of incidents (including all reported events, whether fatal or not) divided by the number of fatal accidents, averaged over 5-year periods to minimise random fluctuations. The high value in 2001 is disregarded as a random effect, caused by a 5-year period with only one fatal accident. The

overall pattern is low quality prior to 2000, high quality during 2000-08, and declining quality since then.

Figure 2.3 Trend of Quality Indicator in the Database



There are several possible reasons for the changes identified above:

- Prior to 1996 there is very little data available. This accounts for the poor quality in this period.
- During 1996 to 2001 the database was mainly populated with US data from MMS. This accounts for the improved quality in this period.
- From 2002 RM's industry sources have been used extensively. This accounts for the high quality in this period.
- Since 2007 the database has an increasing proportion of incidents from non-US regions. The quality of data from these regions is lower (see Table 2.2 below). This may account for the decline in overall data quality since then. It would be of interest to see the quality indicator trend for the USA alone, but there have been too few fatalities to give reliable results.
- Since 2010 no MMS data has been included. This may account for the most recent decline in data quality.

Table 2.2 shows the breakdown of the quality indicator by geographical region. In this analysis, Latin America includes Trinidad; and Asia includes Australia and Russia. It is clear that the USA is the region with the highest data quality, i.e. the reporting of non-fatal incidents is most comprehensive. Europe and Africa are lower quality. Asia and Latin America are the lowest quality, with very few non-fatal incidents reported.

Table 2.2 Quality Indicator in Different Regions

Region	All incidents	Fatal accidents	All incidents/ fatal accidents
Africa	7	1	7.0
Asia	10	4	2.5
Europe	8	1	8.0
Latin America	7	4	1.8
USA	79	5	15.8
Unknown	4	0	
Total	115	15	7.7

If all regions had the same ratio of all incidents to fatal accidents as the USA, there would be approximately 16 x 15 = 240 incidents in the database, compared to the 115 at present. In other words, the total number of incidents could be more than twice as high as recorded at present.

Summarising these results, it is apparent that the non-fatal incidents are only reported comprehensively by the USA in the period 1996 to 2010. RM's industry sources have improved the data quality in the period since 2002, but the world-wide coverage of non-fatal incidents remains poor, and it is likely that many have been missed.

This analysis is not able to show whether the fatal accidents themselves are comprehensively reported. It provides good evidence that they are comprehensively reported in the USA during 1996-2010, but it is possible that fatal accidents have been missed in other regions.

2.8 Conclusions on Incident Data

DNV has reviewed the crane transfer fatalities in the RM database by comparing with an independent search of public sources. DNV did not identify any obvious omissions from the RM database apart from a well-known case of platform collision during basket transfer. There are three rope transfer accidents that could be added, and one possible transfer accident to be investigated. The difficulty DNV experienced in identifying fatal accidents in public sources reinforces the desirability of publishing improved data.

DNV has also evaluated the quality of the RM database using the ratio of incidents (including all reported events, whether fatal or not) to fatal accidents. This showed that non-fatal incidents are only reported comprehensively by the USA in the period 1996 to 2010. RM's industry sources have improved the data quality in the period since 2002, but the world-wide coverage of non-fatal incidents remains poor, and it is likely that many have been missed.

In DNV's opinion, the quality problems that have been identified above are no greater than experienced by any comparable accident database that is based on voluntary reporting. DNV considers the RM database is of a suitable quality to support improved risk estimates, provided that the identified limitations are taken into account during the analysis.

3 REVIEW OF ACTIVITY DATA

3.1 Data Source

Risk estimates need to know the activity data (i.e. the number of transfers carried out) in the same period and scope as the accident data. This study uses the activity data (130718 activity data.xlsx) supplied by RM on 24 July 2013.

DNV also attempted to make an independent estimate of activity data from data on offshore working hours[9]. However, the available source does not give a complete breakdown of offshore hours by country, and the assumptions necessary to estimate the numbers of crane transfers from these are so uncertain that the results are not considered suitable for risk estimates. In future work, improved activity data collection would be desirable.

3.2 Activity Summary

Table 3.1 summarises the activity estimates. RM has estimated the crew-change transfers, and applied a 20% increase to represent other transfer categories (see Section 4.4 below). This gives a total of 5.15 million person transfers by crane per year.

Table 3.1 Crane Transfer Summary, 2012

Region	Country/ Sub-region	Crew change transfers (per year)	Total transfers (per year)
Africa	Angola	57,524	69,029
	Ivory Coast	14,600	17,520
	Nigeria	11,880	14,256
	Other	154,744	185,693
Asia	Australia	63,000	75,600
	Caspian	54,588	65,506
	China	136,000	163,200
	Indonesia	330,063	396,075
	Middle East	200,000	240,000
	Russia	19,000	22,800
	Other	2,560	3,072
Europe	UK	10,000	12,000
	Other North Sea	7,228	8,674
Latin America	Brazil	25,000	30,000
	Caribbean	50	60
	Mexico	469,300	563,160
USA/Canada	Canada	3,162	3,794
	East Coast/Alaska	100,000	120,000
	GoM	2,628,000	3,153,600
	Nova Scotia	3,000	3,600
	Other	3,557	4,269
Total		4,293,256	5,151,907

Table 3.2 gives the breakdown by transfer method (see definitions in Section 4.3 below).

[9] OGP, "Safety Performance Indicators – 2011 data", May 2012.

Table 3.2 Transfer Method Summary, 2012

Transfer group	Transfer method	Crew change transfers (per year)	Total transfers (per year)
Crane transfer	Basket	3,206,968	3,848,362
	Rigid capsule	1,086,288	1,303,546
	Total	4,293,256	5,151,907
Rope swing transfer		1,000,000	1,200,000
All transfers		5,293,256	6,351,907

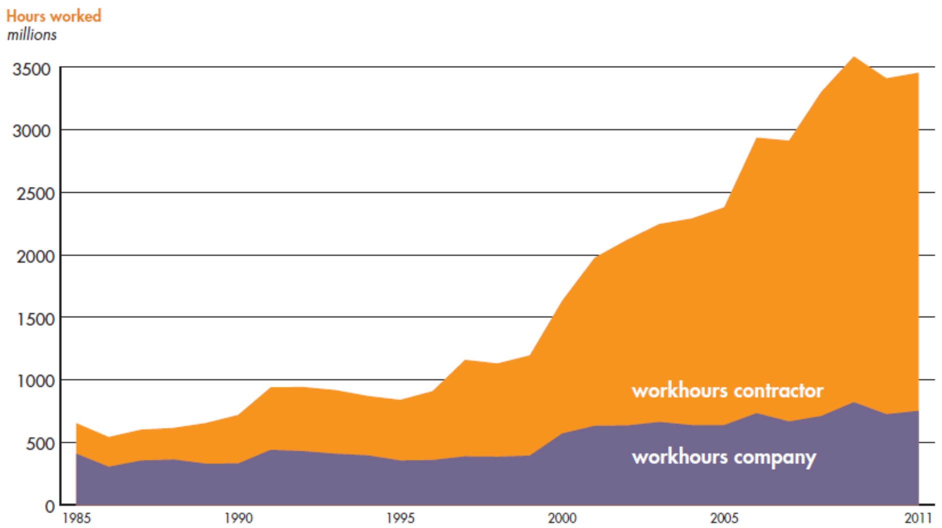
RM also indicated that there are approximately 1 million transfers by rope swing per year[10]. They are common in only a few regions with benign climates, including West Africa and SE Asia. They are still used in near-shore operations in the US Gulf of Mexico, but probably no more than 10,000 transfers per year. For consistency, a 20% increase is applied to represent in-field and ad-hoc transfers. This activity estimate is acknowledged to be very uncertain, and it would be desirable for MTF to collect improved data.

3.3 Activity Trends

The RM activity data was mainly derived for 2012, but some values are referenced to other years between 2009 and 2013, and many are not specific to any one year.

In the absence of any data on trends in activities, Figure 3.1 shows the hours worked in the oil & gas exploration and production industry world-wide, 78% of which is offshore, as reported by OGP[11]. If crane transfers grew in proportion to this, it would suggest 3-fold growth during the period 2000-2008, and much slower changes before and after that. Some of this may be due to improved coverage of the industry in the OGP data. However, it is consistent with the growth of incidents reported in Figure 2.2.

Figure 3.1 Oil & Gas Exploration and Production Industry Work Hours Trend



[10] Strong, P., personal communication, 22 January 2014.

[11] OGP, "Safety Performance Indicators – 2011 data", May 2012.

3.4 Cross-Check with Incident Data

Comparing the activity data with the incident data to check that activity data has been estimated for all activities in which incidents are recorded, the following comments are made:

- A fatal accident occurred in Romania, but this location is not covered by any other categories in the activity data. The use of generic categories such as "Asia – others" in the activity data prevents further cross-checks of this type.
- A fatal accident occurred in ship-to-ship transfer, but this is not explicitly covered by the activity data. However, it is likely to form a small component of the in-field and ad-hoc transfers.

3.5 Cross-Check with Previous Publications

RM previously expressed the view that "more than 5 million crane transfers take place each year"[12]. The current total of 5.15 million per year is consistent with this.

DNV's previous estimate of activity in Brunei and Malaysia prior to 1991 amounted to 2.6 million passenger transfers in approximately 20 years[13], i.e. approximately 0.13 million per year. These were all by rope swing, and do not appear in the activity data. Hence it cannot be cross-checked.

3.6 Conclusions on Activity Data

DNV has reviewed the activity data estimates by RM and has not identified any evident discrepancies or major omissions. It appears suitable for the planned risk estimates.

[12] Strong, P., "Examining Marine Safety Operations", JPT, January 2008.

[13] Spouge, J. R., Smith, E.J. & Lewis, K. J. (1994), "Helicopters or Boats – Risk Management Options for Transport Offshore", SPE Paper No. 27277, Conference on Health, Safety and Environment in Oil and Gas Production, Society of Petroleum Engineers, Jakarta.

4 RISK ESTIMATES

4.1 Individual Risk for Passengers

This section makes updated estimates of passenger fatality risk in crane transfer, using the fatal accidents from Table 2.1 and the activity data from Table 3.1. Because the available information on fatal accidents and transfer activity is more reliable for recent years, the best approach is to estimate the risk as follows:

$$\text{Individual risk per transfer} = \frac{\text{Average passenger fatalities in transfer per year}}{\text{Average people transferred per year}}$$

This approach avoids any need to specify the data period, and reduces the influence of uncertainties about historical accident records and activity trends. The use of "passenger fatalities" eliminates the multiple-fatality accident at Mumbai High North. The risk of such events is considered in Section 4.10 below.

The average annual number of people transferred by crane is given directly in Table 3.1. The average annual number of fatal accidents is shown in Figure 2.2 to be very close to 1 per year. Table 2.1 shows 5 fatal accidents in crane transfer during the most recent 5-year period 2009-13. All of these were single-fatality accidents, but the complete dataset includes two accidents that killed 2 passengers, and the average number was 15/13 = 1.15 passenger fatalities per fatal accident. The average annual number of fatalities is therefore taken as 1.15 per year. The average individual risk in crane transfer is then estimated as:

$$\begin{aligned}\text{Individual risk per transfer} &= \frac{\text{1.15 fatalities per year}}{\text{5.15 million people transferred per year}} \\ &= 2.2 \times 10^{-7} \text{ fatalities per transfer}\end{aligned}$$

This is approximately a 1 in 5 million chance of fatality for each person transferred.

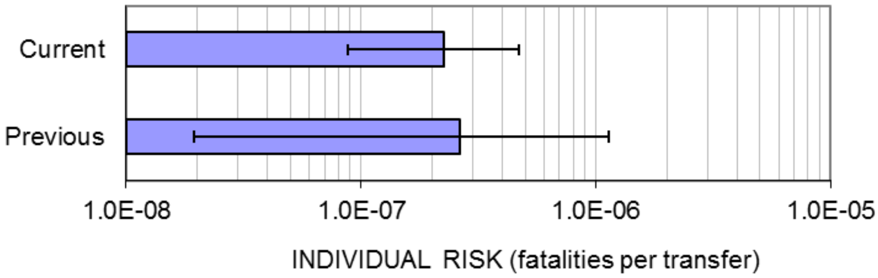
The uncertainty in this result arises mainly from the small number of events, which fluctuates randomly from year to year. With only 5 fatal accidents, the 90% confidence range on the individual risk is from 8.8×10^{-8} to 4.7×10^{-7} fatalities per transfer. The confidence range would be narrower if based on the full dataset of 15 fatalities, but there is also uncertainty in the activity estimate, so the range based on 5 fatalities is considered to be the most appropriate.

4.2 Comparison with Previous Estimate

The previously published estimate, based on no recorded fatalities in 2.6 million passenger transfers prior to 1991, was an individual risk of 2.7×10^{-7} per transfer, with a confidence range from 1.9×10^{-8} to 1.1×10^{-6} per transfer.

The current estimate is slightly lower than the previous estimate, but is within its confidence range. Figure 4.1 shows the current and previous results, with I-shaped bars representing their 90% confidence ranges, taking account of the small numbers of accidents, which may not be representative of the long-term averages. In simple terms, the new risk estimate (a 1 in 5 million chance of fatality) is very similar to the previous one (which was approximately a 1 in 4 million chance of fatality). The main difference is the much greater degree of confidence in the result (that is, the narrower confidence range), because it is based on a larger group of transfers with actual fatality experience.

Figure 4.1 Individual Risk Comparison with Previous Estimate



4.3 Breakdown by Transfer Method

Transfer devices can be categorised as follows[14]:

- Crane transfer methods:
    - Collapsible transfer net, with unsecured external standing passengers.
    - Rigid transfer basket, with unsecured internal standing passengers.
    - Rigid transfer capsule, with secured internal seated passengers.
- Other transfer methods
    - Rope swing
    - Pilot ladder
    - Surfer device, mating the bow of the vessel to a receptacle structure
    - Hydraulic gangway

To maximise the dataset in the following breakdown, the complete fatality dataset from Table 2.1 is used. This assumes that the breakdown of transfer method for the 15 passenger fatalities from 1978-2013 is not significantly different from the sub-set of 5 from 2009-13. It produces smaller confidence ranges on the total risk, which are valid when assessing the significance of risks in different transfer methods, but may under-estimate the overall uncertainty in the results.

Currently available fatality and activity data allows risk estimates for the following methods:

- Basket transfer (including collapsible nets and rigid baskets, but excluding rigid capsules) – 14 passenger fatalities out of 15 crane transfer fatalities (Table 2.1), compared to a base fatality rate of 1.15 per year and activity of 3.8 million transfers per year (Table 3.2).
- Rigid capsules – 1 passenger fatality out of 15 crane transfer fatalities (Table 2.1), compared to a base fatality rate of 1.15 per year and activity of 1.3 million transfers per year (Table 3.2).
- All crane transfer (i.e. capsules and baskets) – a fatality rate of 1.15 per year and activity of 5.2 million transfers per year.

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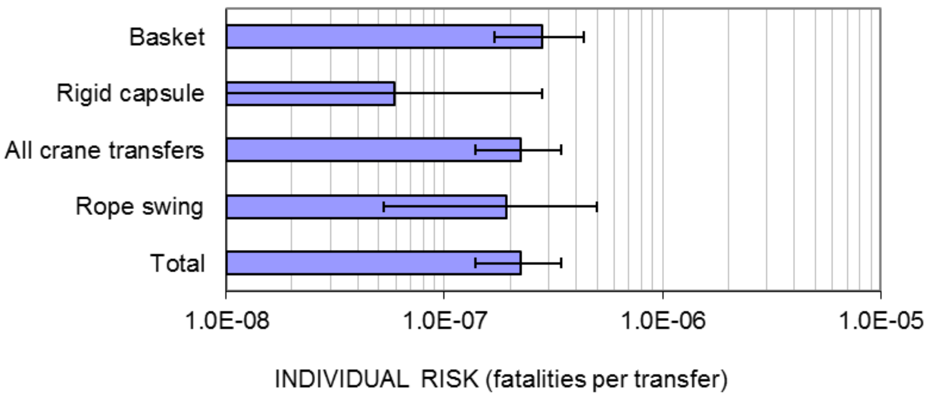
14 IMCA (2010), "Guidance on the Transfer of Personnel To and From Offshore Vessels", M202, International Marine Contractors Association, March 2010.

- Rope swing – 3 passenger fatalities compared to 15 in crane transfer which has a base fatality rate of 1.15 per year, and activity of 1.2 million rope swing transfers per year (Table 3.2).

The resulting individual risks are shown in Figure 4.2.

Figure 4.2 Individual Risk Breakdown by Transfer Method



The risk for capsules appears lower than for baskets, but this is not statistically significant because too few events have been recorded. In fact, the only fatality recorded for capsules was during preparation for boarding, and arguably not part of the crane transfer itself. If this were excluded, the uncertainty range would be wider.

The risk for rope swings appears similar to average for crane transfer, but this result may be unreliable because the data collection was less thorough than for crane transfers. The uncertainty may be greater than shown, because the calculated confidence ranges only reflect the uncertainty due to the small numbers of accidents.

Overall, the data is insufficient to show significant differences between transfer methods, so it is appropriate to use the overall average for crane transfers (Section 4.1) for all transfer methods. In future work, more comprehensive data collection may be expected to show different risks for different transfer methods.

4.4 Breakdown by Transfer Category

For risk analysis purposes, it would be desirable to categorise accidents according to the type of transfer, such as:

- Crew change – routine crew transfers between shore and offshore.
- Shift change – routine transfers between offshore accommodation and work locations.
- Operational – ad-hoc transfers during a working shift, such as to supervise operations, or carry out inspection and maintenance.
- Emergency – unplanned transfers including evacuations, medical transfers or emergency interventions.

At present, information on the transfer category in the fatal accidents is incomplete, although it is known that the accident in India in 2005 followed a medical evacuation. Activity in the shift change, operational and emergency categories has been estimated by RM as approximately 15%, 5% and 0.1% respectively, compared to crew change activity. However, this is very speculative. Overall, there is insufficient information to break down the risks by transfer category. In future work, more comprehensive data collection would be expected to show different risks for different transfer categories.

4.5 Breakdown by Transfer Phase

It may also be desirable to categorise accidents according to the phase of transfer, such as:

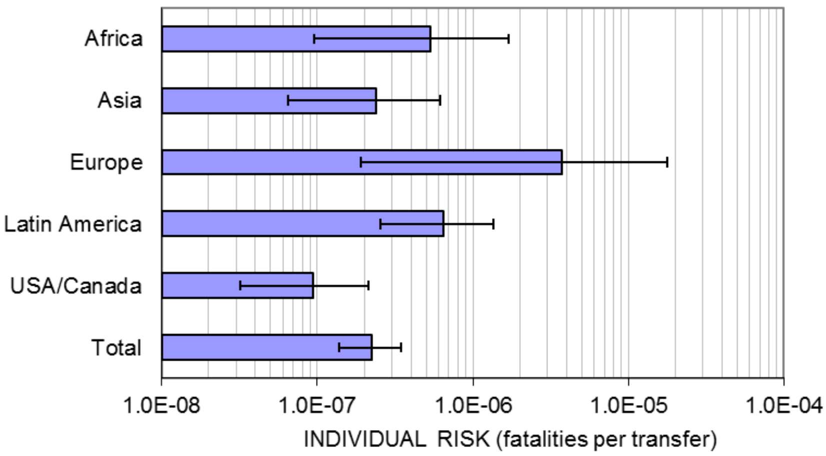
- Embarkation, including mustering for the transfer, moving to the transfer location and boarding the transfer device. The accident in Russia in 2004 occurred during this stage.
- Transfer operation, i.e. raising, slewing and landing the device (in the case of crane transfer).
- Disembarkation, including existing the transfer device and dispersing from the transfer location.
- Marine approach and departure, including manoeuvring of the crew vessel close to the offshore installation. The accident in India in 2005 occurred during this stage.
- Marine transit, including the journey to/from the destination/origin. This stage is not covered in the present accident data collection, but would be relevant if marine transfer was compared with helicopter transport.

At present, most fatal accidents occurred during the transfer itself, but this may result from greater difficulty in identifying accidents in the other phases. Activity data (in terms of the number of personnel transfers) would be the same for each phase, although activity data for the marine transit could be measured in units of hours on-board or miles travelled. Overall, current data is insufficient to break down the risks by transfer phase, but in future work more comprehensive data collection could enable this.

4.6 Breakdown by Region

This section combines the fatality data in crane transfers from Table 2.1 with the activity data from Table 3.1 to estimate the risks for crane transfers in different regions. The results are shown in Figure 4.3.

Figure 4.3 Individual Risk Breakdown by Region for Crane Transfer



Compared to the world average results above, the risks in each region are as follows:

- In the USA/Canada, risks are lower than world-average, and this is just significant (i.e. there is about a 5% probability that the risks are in fact the same and the result appears from a random fluctuation in the numbers of events).
- In Latin America, risks are higher than world-average, and this is just significant.
- In Europe, risks appear to be much higher than world average, but this is entirely due to one event in Romania, and there has been insufficient activity to draw other conclusions. It may therefore be appropriate to use the overall average value to predict risks for crane transfer operations in Europe, unless there are specific reasons to expect higher risks.
- In Africa and Asia, risks are not significantly different from world average.

An explanation of this pattern might be that it results from the different balance of hazards and safety management practices in the different regions.

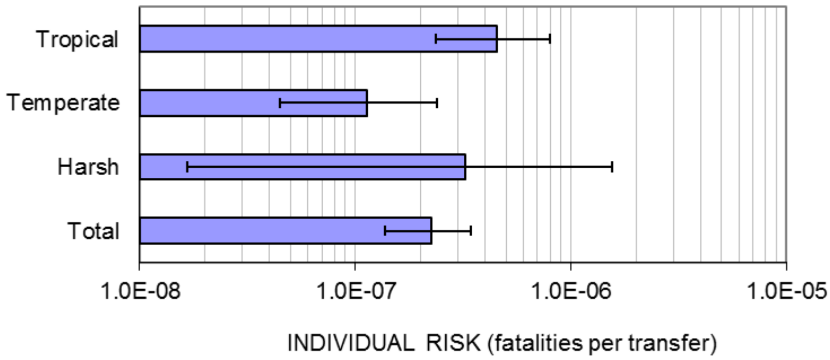
4.7 Breakdown by Climate

This section recombines the data above into the following climatic regions:

- Tropical, including all countries within the tropics.
- Harsh, including Europe, Russia, the Caspian, Canada and Alaska.
- Temperate, including all other regions.

The results are shown in Figure 4.4. This shows the risk is significantly higher in tropical than temperate climates. There has been insufficient experience in harsh climate to draw any conclusions for it. The reasons why risks might be higher in tropical climates are likely to relate to safety management, such as care in lifting and preparedness for vessel motions or immersion in the sea. These are in effect the same differences in the balance of hazards and safety management practices in the different regions noted above. It is therefore not considered appropriate to use the results to make predictions of risks in specific climates.

Figure 4.4 Individual Risk Breakdown by Climate for Crane Transfer



4.8 Incident Frequency

The risk estimates above refer to fatality risks. The quality of the non-fatality incidents is too variable to allow a reliable estimate of non-fatal incident frequency. However, Table 2.2 shows that, in the region with the best data quality, there were 20 incidents for each fatal accident.

Hence the non-fatal incident frequency is estimated to be approximately 20 times the values above. The average risk is therefore 4.4 x 10^{-6} incidents per transfer.

The database includes 115 incidents in total, consisting of 13 fatal accidents, 79 other incidents causing non-fatal injuries, and 23 incidents causing neither injuries nor fatalities. In total, 15 fatalities and 105 non-fatal injuries were recorded. This suggests the injury frequency is similar to the non-fatal incident frequency. Since, the recording of injuries is not usually very comprehensive or consistent, it is appropriate to assume that the incident frequency above is also approximately the injury frequency.

4.9 Causal Breakdown

The causes of incidents, where known, have been categorised by RM as shown in Table 4.1. Strictly, some of these are accident types rather than causes. Nevertheless, this is the best available information. Separate breakdowns are given for fatal accidents and for the dataset as a whole. In some incidents, no causes are known. In others, more than one cause is relevant, so the percentages sum to more than 100%.

Table 4.1 Causal Breakdowns

Cause	Fatal accidents	% of fatal accidents	Incidents	% of incidents
Passenger Falling	11	73%	63	55%
Lateral Impact / Swing	4	27%	46	40%
Vertical impact (Heavy Landing)	1	7%	19	17%
Trip / entanglement	0	0%	10	9%
Deck Crew	0	0%	6	5%
Immersion	2	13%	7	6%
Carrier Falling	3	20%	8	7%
Unknown	0		7	
All incidents	15	100%	115	100%

The breakdown clearly shows that the largest contribution to fatality risks is passengers falling, and this therefore appears the most fruitful area for future risk reduction.

4.10 Marine Transfer Risk

The results above refer only to risk of death among the passengers being transferred by crane. The complete marine transfer operation between an installation and the shore includes several other elements:

- Risks in port while boarding/unloading the vessel, such as falling from the gangway to shore.
- In-transit risks during the journey between the installation and the shore, such as fire or grounding.
- Risks to vessel crew and third-parties, such as people on other vessels that may be struck by the crew boat.
- Risks of major accidents that arise from the interaction between the vessel and the installation, such as collision or ignition of hydrocarbon leaks.

Major accident risks are difficult to quantify, but are illustrated by the Mumbai High North accident (Section 2.3.4). This accident resulted from a crane transfer, and hence can be considered to reflect some of the risks involved, although the transfer itself had been completed before the collision occurred. It was also an emergency operation, in which the risks are likely to be higher than in routine crew transfer. Since it appears the passenger was not a fatality in this incident, it is not included in the risk estimate above.

The occasional occurrence of such major accidents should be considered separately in any analysis of transfer risks. As a rough indication, we note that there were 22 fatalities in this accident, and just 15 passenger fatalities in all other crane transfer accidents in the data. This suggests that on average the major accident risk is at least as large as that from accidents affecting the passengers alone, but site-specific risk analysis would be needed to quantify it more accurately.

At present there is no reliable source of information on the risks in the other phases of marine transfer. The previous paper estimated a similar risk for both in-transit and transfer phases, but this was based on an absence of fatalities in either phase. This now appears pessimistic, as very few in-transit fatalities are known. However, further data collection would be needed to quantify the risk.

4.11 Comparison with Helicopter Transfer

The current estimate for crane transfer may be compared with the risks for helicopter transfer, as follows. Table 4.2 gives the injuries, fatalities and passenger numbers in offshore helicopter operations world-wide reported by OGP for the latest published 5-year period[15].

Table 4.2 Offshore Helicopter Data

Year	Injuries	Fatalities	Passengers
2003	24	49	8,486,838
2004	9	25	8,187,376
2005	23	8	8,490,290
2006	10	11	9,023,207
2007	6	11	9,326,136
Average	14.4	20.8	8.702,769

DNV has used unpublished data for the period 2008-11 to check that it would not significantly alter the following risk estimate.

The average individual risk in helicopter transfer is estimated as:

$$\text{Individual risk per transfer} = \frac{\text{20.8 fatalities per year}}{\text{8.70 million people transferred per year}}$$

$$= 2.4 \times 10^{-6} \text{ fatalities per transfer}$$

This is approximately a 1 in 400,000 chance of fatality for each person transferred. This is approximately 11 times higher than the risk for crane transfer estimated in Section 4.1.

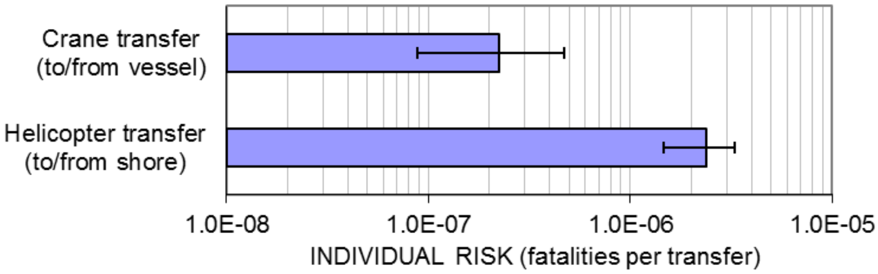
The uncertainty in this result depends mainly on the variability in the number of fatalities in each year. Based on this variability during 1997-2011, the 90% confidence range on the

15 OGP (2009), "Safety Performance of Helicopter Operations in the Offshore Oil & Gas Industry – 2007 Data", Report 424, International Association of Oil & Gas Producers, August 2009 (and earlier reports).

average is between 12.8 and 28.8 fatalities per year. The confidence range on the individual risk is then from 1.5 x 10^{-6} to 3.3 x 10^{-6} fatalities per transfer.

Figure 4.5 compares the individual risk for helicopter transfer with the current estimate for crane transfer. This shows the difference is significant, even taking account of the uncertainties.

Figure 4.5 Individual Risk Comparison for Crane and Helicopter Transfer



However, this comparison may be misleading for several reasons. For example, crane transfer excludes risks in transit, whereas helicopter risk covers the complete journey to/from shore. The crane transfer risk excludes major accidents such as collisions, which are analogous to the risks of fire due to helicopter crash onto the installation. It also excludes risks to vessel crew, whereas the helicopter risk includes fatalities to flight crew.

Furthermore, these results refer to world-average risks, and reflect the fact that marine transfer is often used in relatively benign climates, while helicopter transfer is often used for installations that are far offshore. If transfers to the same installation were compared, the differences might be much more or less than shown here. For example, the previous study showed no significant difference between marine and helicopter risks in the specific case of an installation close to shore.

The OGP injury data in Table 4.2 indicates 0.7 injuries for every fatality. This is a much lower ratio than the 20 injuries for every fatality estimated for crane transfer in Section 4.8. The injury risk in helicopters is estimated as 2.4 x 10^{-6} x 0.7 = 1.7 x 10^{-6} non-fatal injuries per transfer, compared to 2.2 x 10^{-7} x 20 = 4.4 x 10^{-6} non-fatal injuries per transfer for crane transfer. This suggests that the injury risk is 2.6 times higher in crane transfer than helicopters. However, the comparison may be sensitive to the adjustment of the crane data for under-reporting of injuries, since the helicopter injury data may also be under-reported.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

DNV's review of RM's incident database concludes that there are no obvious omissions of fatal accidents apart from a well-known case of platform collision following basket transfer. It is therefore considered suitable as the basis of an improved estimate of fatality risks in crane transfer. Nevertheless, the difficulty DNV experienced in identifying accidents in public sources reinforces the desirability of publishing improved data.

DNV's evaluation of the quality of the RM database, using the ratio of incidents to fatal accidents, suggests that non-fatal incidents are not reported comprehensively, except by the USA in the period 1996 to 2010. World-wide coverage of non-fatal incidents is poor, and it is likely that many have been missed. Therefore the non-fatal incident data is not used in making the new risk estimates.

The report combines the fatal accident data with activity estimates provided by RM, and makes an updated estimate of the fatality risk in crane transfer. This is similar to the previously published estimate, but has a much narrower confidence range. The analysis shows no significant differences in fatality risk for different types of crane transfer, but does show some significant differences in risks between transfers in different regions.

The causal breakdown clearly shows that the largest contribution to fatality risks is passengers falling, and this therefore appears the most fruitful area for future risk reduction.

5.2 Recommendations

DNV makes the following recommendations to MTF on the basis of the work reported here:

- Adopt the new estimate in risk assessments covering offshore transfer, as it is clearly more reliable than the previously published estimate.
- Support the publication of the new estimate in the open literature so that it is more readily available than the previous estimate.
- Enhance the present data collection by requesting operators to supply recent fatal accident experience and activity levels covering crane transfer.
- Promote an on-going collection of fatal and non-fatal accident experience and activity levels, with a consistent breakdown by:
    - Transfer method (see Section 4.3)
    - Transfer category (see Section 4.4)
    - Transfer phase (see Section 4.5)
- Consider extending the scope of the data collection to cover the marine transit phase and other transfer methods such as gangways, pilot ladders and surfer devices.
- Update the present risk estimates once improved data becomes available.

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