HAZARDS IDENTIFICATION AND SAFETY MANAGEMENT PRACTICES FOR MAJOR HAZARDS IN ROUTINE SHIP TOWAGE OPERATION IN INDIAN COASTAL WATERS

By

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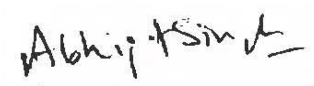
DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.



ABHIJIT SINGH

THESIS COMPLETION CERTIFICATE

This is to certify that the thesis on “Hazards identification and safety management practices for major hazards in routine ship towage operation in Indian coastal waters” by Abhijit Singh in partial completion of the requirements for the award of the Degree of Doctor of Philosophy (Management) is an original work carried out by him under out joint supervision and guidance.

It is certified that the work has not been submitted anywhere else for the award of any other diploma or degree of this or any other University.

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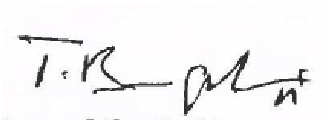

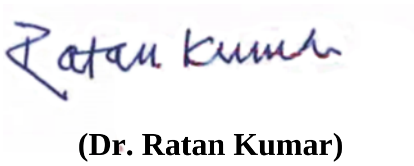

(Dr. T. Bangar Raju) | **(Dr. Ratan Kumar)**

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Executive Summary

Tugboats are considered as 'workhorses of ports', they assist bigger vessels to come alongside, mooring & un-mooring activities & providing tow service in manoeuvring within the ports & on all seas. In literature, the significance of these small ships is often neglected but in fact their value is of great importance especially in manoeuvring during bad weather conditions in restricted areas within port in particular. Now-a-days tugs are considered as part of port infrastructure in harbours worldwide & it is almost part of the business at some ports.

Accidents don't just happen on its own but they are cumulative results of series of unsafe events, in context to ports such as unsafe water conditions, human error, machinery & equipment failure - anyone or a combination of these can turn random events into accidents, sometimes with fatalities.

Ship Towage Operation involves one of the potentially hazardous operations i.e. mooring & unmooring of vessels at ports. These operations require an efficient team work as a prerequisite to secure safety. Crew members indulging in this operation must be efficiently trained & equipped. They must possess ample understanding of their role & responsibilities of their own as well as other team members.

From past four decades, researches have been conducted in order to have a better understanding of the effects on tug operations which are leading to many accidents in recent times.

It is a point of consideration that there are different ways to provide towage service in tug operation & these mainly differ from place to place. Basically there are two methods to assist a ship, one is to push or pull a ship with tug fastened alongside the ship. In this method interaction forces have very small contribution. The other method is towing a ship on a line the tug is fastened to bow or stern to make a connection with towline near the bow in particular, in this interaction forces contributes in a major proportion.

Traffic at Indian Ports

The port sector of India can be divided into two categories namely Major Ports & Non-Major Ports. Major ports are those ports which are run & governed by an act of Indian Parliament while on the other hand Non Major ports includes private ports, captive ports, or ports which are owned by state government. In total there are 12 major ports in India along with 187 Non major ports stretched over 7512 kilometers of the coastal line of India.

Ninety percentage of India's international trade by volume & seventy percentages by value are represented by Major & Non-major ports in India. Data shows that 975 million tons of total traffic was handled by Indian ports in 2013-14, whereas 40% of the total traffic was handled by Non Major ports. There are other coastal vessels which are also contributing to this high traffic. To handle this high volume of traffic efficiently, tugs play a vital role in providing safe mooring, unmooring operations & assistance to vessels coming alongside. Tug activities has increased tremendously in these ports & so is the risk to safety in these towage operations.

This study attempts to explore the safety risk factors which are threat to Routine Ship Towage operation in Indian Coastal Waters and explore various solutions practiced worldwide to mitigate such safety risks. This research was not subjected to extremely structured deductive approach & not able to control variables in order to generate data for analysis because it is an exploratory non-experimental research. Therefore a phenomenological approach is adopted to gather relative experiences of people & used active experiences as an open ended enquiry.

Study uses various research tools & techniques to collect samples such as 10 years database of accidents related to harbour towage, survey through questionnaire of industry experts & semi-structure interview of experienced professional from towage industry, conclusion was derived after triangulation. The Principal Component analysis was used to find grouped dimensions from identified hazard variables. Critical analysis of incident type frequency, cause & consequences was done to get a clear picture of critical safety risk factors.

Hence, Research Problem comes as "Hazards identification, which is a preliminary step of most of the safety model and risk related methodology, has not yet been done for tugboat operation in Indian coastal waters and that is leading to incomplete process of risk assessment. Consequently, Indian maritime Industry is not able to adopt or form required safety management practices."

Research Questions are "What are the hazards associated with tugboat operation in Indian Coastal Waters?" and "What are the known preventive measures practiced worldwide to mitigate these major identified hazards which can be used in Indian maritime industry?"

The main objectives of the study derived as:

- First objective is to identify hazards which are threat to Routine Ship Towage operation safety in Indian coastal waters
- After achieving first objective, the second objective is to explore existing towage safety management practices worldwide, which can be used in Indian maritime industry.

To achieve First Research Objective of finding leading safety risk factors, the three research methods were adopted:

1. Questionnaire survey of practitioners' professional experience;
2. Quantitative analysis of existing accident data base using Investigation Reports and Case Reports data;
3. Semi-Structured Interview for observational analysis of expert witness opinion;

The first stage consisted of a questionnaire survey of current practitioners. Questionnaire was designed basis literature review. Likert style questionnaire was used to allow comparison of independent variables. It was to get precise contemporary figures, to help ascertain patterns of safety incident type, cause, result, frequency & criticality.

Questionnaire was designed in such a way that most questions were closed, containing measurable factual information; also there was an option of providing additional descriptive information & facts. Factor analysis was done with the help of PCA subsequently significance test between risk factors & consequences.

The second stage consisted of an analysis of secondary 10 years data followed by statistical testing to establish any correlation between Routine Ship Towage & Non-Routine Ship Towage. The use of minimum 175 Investigation report/case studies aimed to reduce sampling error. A Chi Square test was performed to test Null Hypothesis to compare RST & NRST operations. This was to find out whether there is any noticeable difference between RST & NRST operations. During the process key safety risk factors were identified, critically evaluated & categorised. Their likelihood & severity was measured, & this information was used to test hypotheses.

The third stage involved interviews of experts in Indian subcontinent. Variables identified in first & second stage were used to frame questions. This was to explore other variables that were not identified in first & second stage, in addition to get the depth of perception & to validate findings. The interview was semi-structured with judgmental sampling (non-probabilistic sampling).

Since this research has used different methods, some adjustment was necessary to allow comparison of the three distinct samples & enable triangulation to achieve and validate conclusions.

The findings of this research were that in broader category seven factors were responsible to a great threat to Routine Ship Towage safety and those are poor work process, poor maintenance of equipment, rough weather, poor or no risk assessment, occupational incompetence, the suitability of the type of tractor & poor safety management system. Expert Interview also confirms same.

Expert Interview also mentioned additional safety risk factors such as Stability(which can be taken in watertight Integrity), Commercial Pressure(Time), Poor Seamanship, Wash/squash effect (Navigational Obstacle), Fatigue & Bad attitude, these were not explicitly identified in the Case Studies and Questionnaires.

In second objective, the research design followed was thematic case study approach in which interviews were conducted of exceptionally high experienced experts and many solutions and good practices were explored which is been practiced worldwide in towage industry.

The aim of this research is just only to find the problems but also to suggest solutions. The solution presented in this research is just for indicative purpose, the research does not answer the effectiveness of those control measures. Hence, it is advisable the practitioners to do proper risk analysis before adopting one.

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List of Abbreviations

ASD	Azimuth Stern Drive [tug]
ATSB	Australian Transport Safety Board
BTA	British Tugowners Association
CR	Case Reports
DSB	Dutch Safety Board
EI	Expert Interview
EMSA	European Maritime Safety Agency
RST	Routine Ship Towage [operation]
ILO	International Labour Organisation
IMO	International Maritime Organisation
ITA	International Tugmasters Association
KMSB	Korean Maritime Safety Board
MAIB	Marine Accident Investigation Branch
NRST	Non Routine Ship Towage [operation]
QU	Questionnaire
RO	Research Objective

RO1	Research Objective-1
RO2	Research Objective-2
TSBC	Transport Safety Board of Canada
UK	United Kingdom
US	United States of America (USA)
USCG	United States Coastguard
VS	Voith Schneider [tug]

Chapter 1

INTRODUCTION

1.1 Background

"Shipping is perhaps the most international of all the world's great industries and one of the most dangerous." (International Maritime Organization [IMO], 2002a)

Marine accidents have been occurring ever since men started to set sail. The custom of the trade has been systematized over time, and later, by the middle of the 19th century, the navigational standards emerged primarily as regulations for preventing collisions at sea. Since the beginning of the last century, marine accidents have resulted in maritime industry efforts to improve ship construction, ship systems reliability and onboard operations organization aiming at reduction of marine accidents.

Maritime safety is increasingly significant in a growing, global industry where major accidents have wide reaching impacts. Whilst large shipping accidents do still occur on the scale of the Prestige and the Erika, they are fortunately quite rare. The overall industry picture is one of continual improvement with Lloyds List Casualty Survey noting an 18% decrease in the number of accidents and the International Union of Marine Insurers recording a continuing downward trend both in tonnage and the percentage of the world fleet lost since 1980 (over the past 30 years). However it is important to keep the pressure focused on this trend for improvement and clearly understand the factors which are most significant in contributing to losses of lives at sea. Despite the noted improvements, shipping accidents still occur globally on a regular basis and can often be linked to a certain set of criteria such as certain geographical locations (Figure 1.1). Whilst general improvements are apparent, a minority of flag States and port States are still operating outside of the legislative requirements resulting in sub-standard shipping slipping through the net and compromising human life and the marine environment. East Indies region reported greater number of incidents.

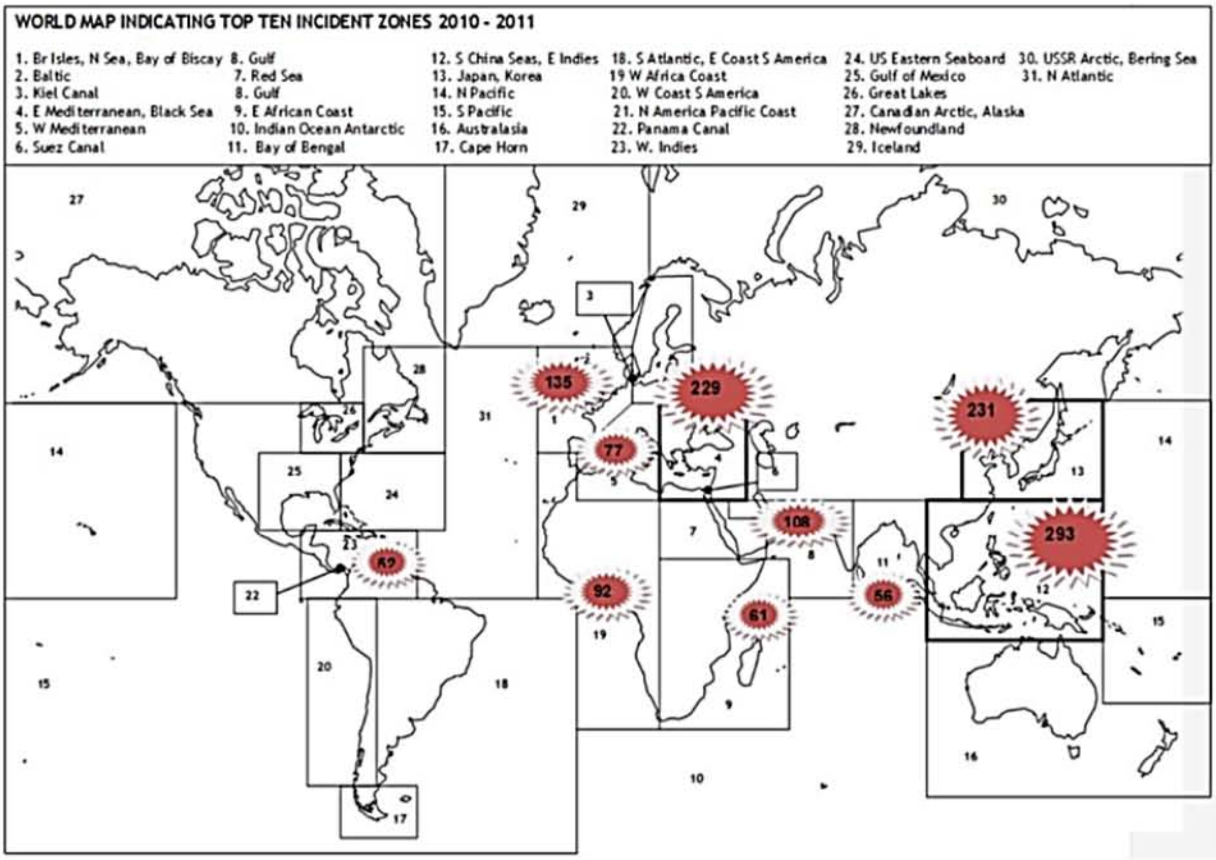


Figure 1.1- World Map Indicating Top Ten Incident Zones 2010 -2011

Source: MAIF Report 2012

When Figure 1.2 is compared with Figure 1.1, the world map indicating the top ten incident zones between 2010 and 2011, it is clear that many of the areas where shipping traffic is heaviest marries up. Many of the highlighted regions are also on the financial radar for higher insurance premiums. The maps provide a clear indicator of potential problem areas and should be a focus of international attention for increased safety measures and enforcement of regulations and high standards.

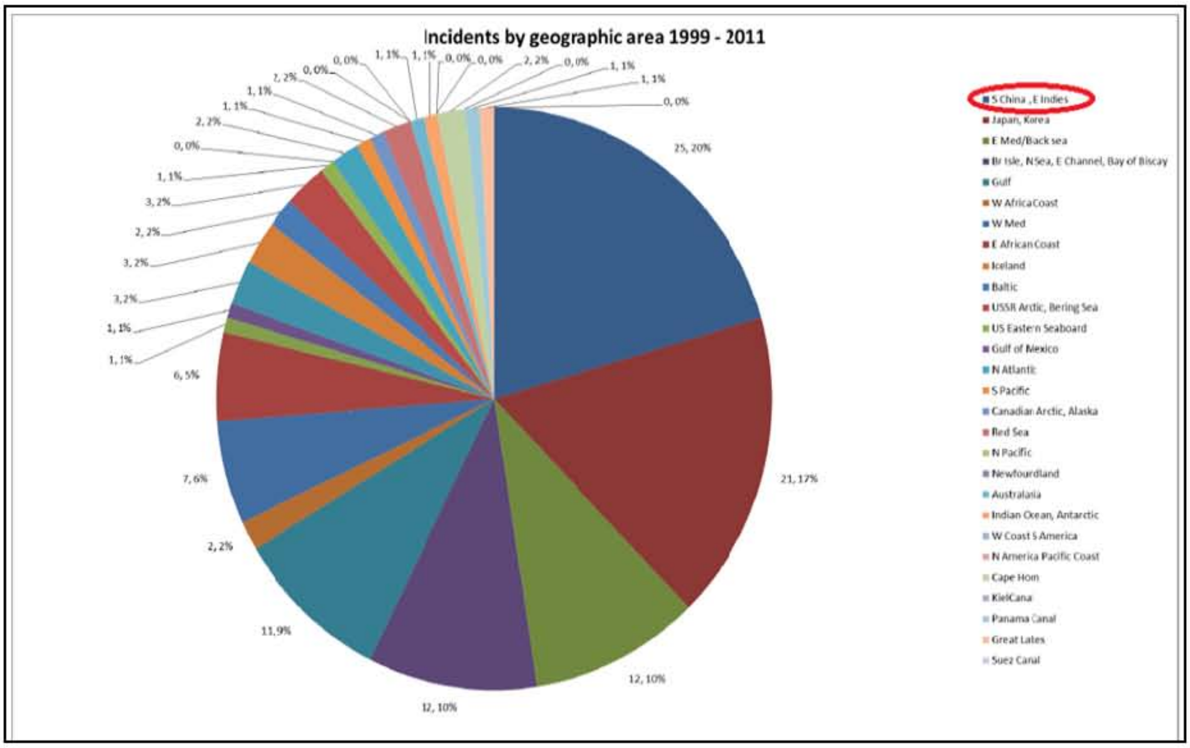


Figure 1.2 - Incident by Geographic Area 1999 - 2011

Source: Admiralty Report 2012

The steady growth in seaborne trade has meant an increase in global shipping movements and tonnage, Figure 1.2. Vessel size has increased the need to benefit from economies of scale, whilst manning levels on ships has tended to be reduced with the introduction of labour saving and assistive technologies on board. At the same time mariners are under pressure to meet deadlines imposed by shipping companies and to comply with a raft of legislation pertaining to safety, security and the protection of the marine environment. The associated administrative burden is expected to be delivered without any additional manning on board the vessels to account for the additional hours required to complete the tasks in order to comply with company and industry regulations. All these factors impose additional stresses and can impact on the safe passage of a vessel (Stockman, 2010).

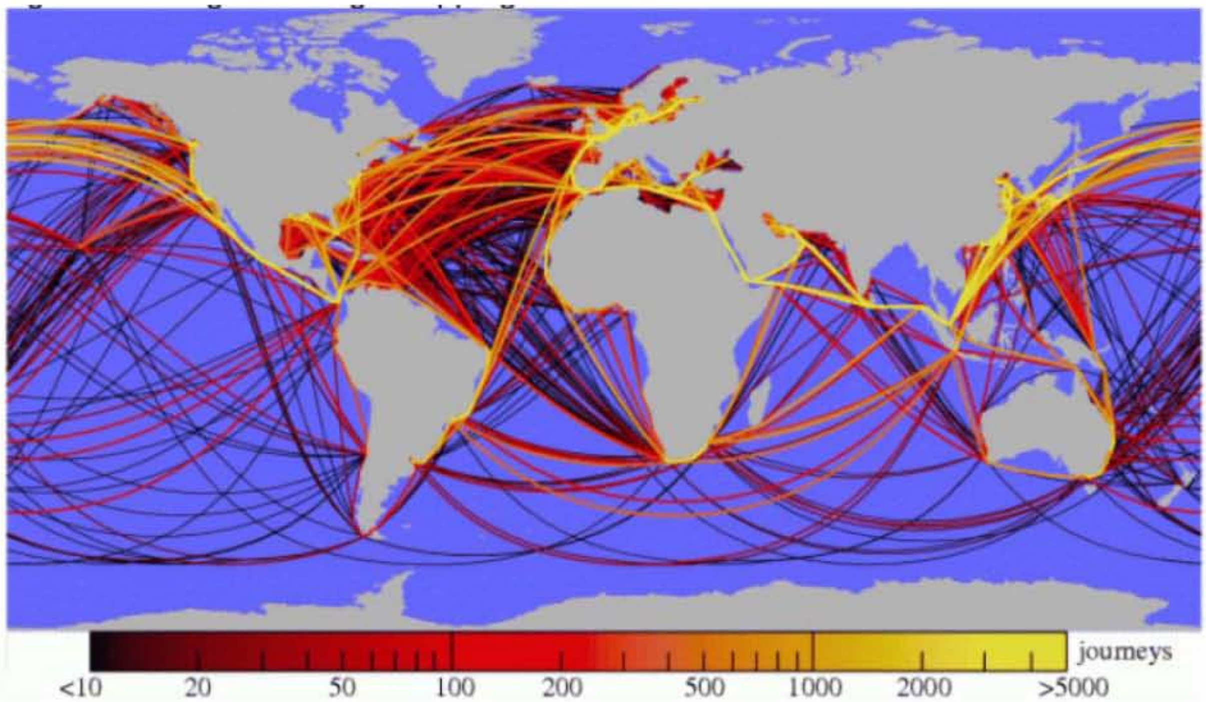
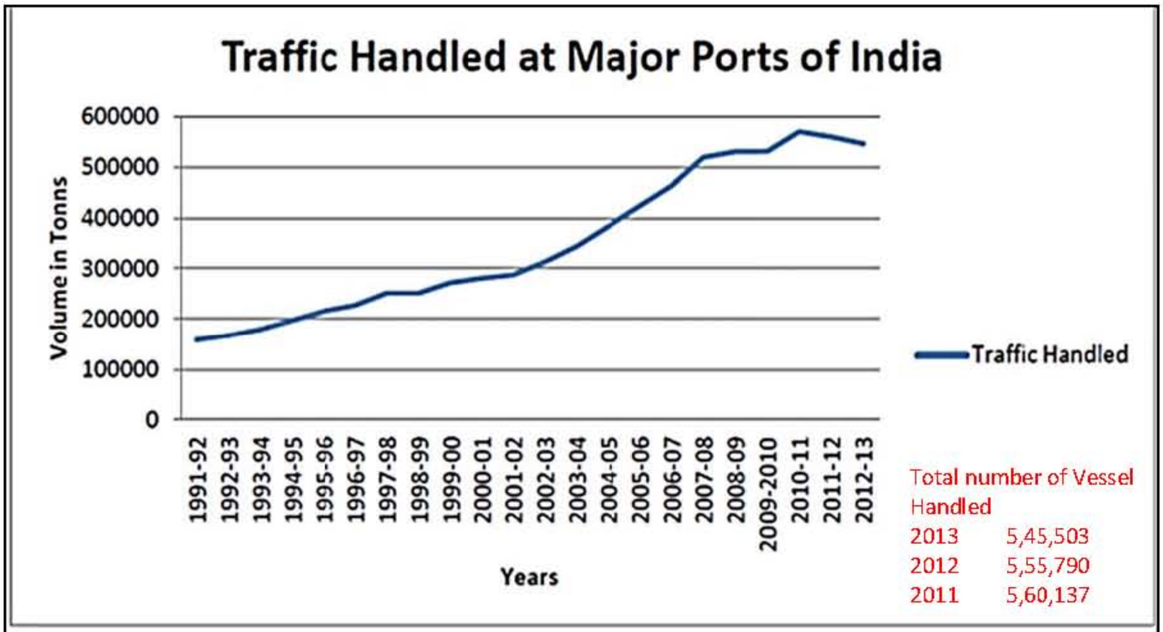


Figure 1.3 - Global Cargo Shipping Movement

Source: Admiralty Report 2012

Traffic Handled at Major Ports of India has been seen increasing, below Figure 1.4 indicates cargo traffic volume in tons. No. of vessel handled in year 2013



Source: Compiled from the publications of Indian Port Association, Annual Reports (1991-2013)

Figure 1.4 - Traffic Handled at Major ports of India (1991-2013)

Organisations such as the Marine Accident Investigation Branch (MAIB) UK and the European Maritime Safety Agency (EMSA) Europe and others, work to identify the causes of these accidents and to share information with the industry so that they can learn from the experiences and recommendations made as a result. Data quality and quantity associated with reporting shipping accidents and detentions is the responsibility of the many organisations and flag States involved, and the member State in whose territorial waters the accident/ detention occurred. This becomes more of an issue when several organisations or member States are involved who may not be collecting the same data or using the same criteria or methods for recording the information. India has no structured mechanism for Accident Reporting System.

Table 1.1 - Limitation of Research: List of Accident Reporting Forums Worldwide.

US/ Canada	UK/Europe
• The United States National Transportation Safety Board – NTSB • International Maritime Information Safety System -IMISS • Canada - The Transportation Safety Board of Canada – TSB	• The United Kingdom – Statutory Instruments • Marine Accident Investigation Branch – MAIB • Confidential Hazardous Incident Reporting Programme – CHIRP • The European Maritime Safety Agency – EMSA • Marine Accident Investigators' International Forum – MAIF • The Nautical Institute – MARS
Netherland/Sweden/AUS	Asia /India
• The Dutch Transport Safety Board – DTSB • Australian Transport Safety Bureau – ATSB • Transport Accident Investigation Commission – TAIC • The Swedish Accident Investigation Board – SHK	• Hong Kong - The Marine Department of the Hong Kong Special Administrative Region (SAR) *Regional Classification Societies (ABS, Lloyds Register, IRS, DNV etc) as part of their own R&D activities they works on Maritime Safety*

The International Maritime Organisation (IMO) provides support to member and States to encourage them to ratify their Conventions, although more needs to be done in this area. The IMO process is demonstrably effective, but notably slow, which has a bearing on safety response legislation following major accidents, as seen by the time line

Flag State performance continues to play an important role in the quality and safety of sea-going vessels around the world. Several organisations publish guidelines on flag State performance. These include bodies such as the International Chamber of Shipping (ICS), the Maritime International Secretariat Services (MARISEC) and the International Transport Workers' Federation (ITF). These guidelines provide indicators to enable performance measurements in a number of key areas for example the enforcement of the international maritime treaties, maritime security, seafarers' welfare and movement of ships between flags (MARISEC, 2006). Yearly performance tables are produced using these indicators to raise awareness of the best and worst performing flag States. The following two sections describe the role of flag States addressing the terminology and definitions surrounding open registries.

Shipping incidents such as the Hebei Spirit and MV Rena, and the 10th year anniversary of the sinking of the Prestige (2002) further highlight the need to identify and understand the factors contributing to shipping accidents. These incidences among others renew the spotlight on the main causes of shipping accidents, including the role played by flag States. Despite the continual increase in the world's shipping fleet a decrease in overall numbers of shipping accidents has been seen over the last few decades. Whilst the data shows that poorly performing flag States are still an associated factor, there are other criteria that also strongly contribute to accidents, including: vessel age, vessel type, area of operation and challenging sea states (linked to the most common incident type – foundering) and vessel size. Behind these criteria there are layers of administrative complexities within the shipping industry which are connected to port and flag State control, flag registration and ratification of IMO conventions. Economic factors also have an impact on shipping safety, such as turn-around times and use of the minimum number of crew required to handle a vessel which often has implications such as staff working whilst fatigued.

1.2 Shipping Accidents as drivers of Maritime Legislation

It has long been recognized that one of the key measures of improving safety at sea is to develop, implement and enforce international regulations. History has demonstrated that large-scale shipping accidents serve as key drivers of change, which is often manifested in new or amended safety regulation (Bryman, 2004).

	1980	
	1987	MV DERBYSHIRE – LOSS OF LIFE
	1989	HERALD OF FREE ENTERPRISE – LOSS OF LIFE EXXON VALDEZ – OIL SPILL
SOLAS CH VI INTERNATIONAL GRANE CODE MARPOL ANNEX 1	1990	
DOUBLE HULL AMENDMENTS	1992	
	1994	MS ESTONIA – LOSS OF LIFE
STCW MARPOL PROTOCOL ISM CODE 1 SOLAS CH VII	1997	
BULK CODE AMENDMENTS	1999	ERIKA – OIL SPILL
	2000	
	2001	
ISM CODE II	2002	PRESTIGE – OIL SPILL
PAL PROTOCOL FUND PROTOCOL ERTICA I (EU)	2003	
SOLAS CH VI	2004	
REVISED BULL CODE	2005	
ERTICA II (EU)	2006	STAR PRINCESS – LOSS OF LIFE
	2007	
	2008	
3RD MARITIME SAFETY PACKAGE (ERTICA III)		
	2009	
	2010	
STCW 95 MANILLA AMENDMENTS HNS PROTOCOL INTERNATIONAL MARITIME SOLID BULK CODE	2011	
	2012	CASTA CONCORDIA – LOSS OF LIFE

Figure 1.5 - Evolution of Maritime Safety

The timeline in Figure 1.5 highlights the drivers for change through the introduction of new or updated legislation attributed to major incidents or a series of incidents focusing on the past 35 years. For example, the Safety of Life at Sea (SOLAS) Convention traces its origins to the loss of the Titanic (1912) with significant updates in more recent years, such as the introduction of the ISM Code (Chapter IX of SOLAS) after the lessons learnt from the loss of the Herald of Free Enterprise in 1987. Similarly changes have taken place to regulations governing the operation of dry bulk carriers and tankers, including *inter alia* the amended

Bulk Code, amendments to MARPOL Annex I, and the introduction of the US legislation such as the Oil Pollution Act 1990 (OPA '90). These were triggered by the large number of dry bulk carrier losses in the 1980s, most notably the Derbyshire in 1980, and the grounding of the Exxon Valdez oil tanker in 1989.

This retrospective amendment of legislation continues; the loss of the MV. Erika in 1999 saw changes to the operation of tankers and new European Regulations. The serious fire on the cruise ship the Star Princess in 2006 brought changes to fire regulations. It remains to be seen what affect the cruise ship the Costa Concordia (2012) will have after such a serious loss of life. Other contributing factors to improved vessel safety and reduction in shipping accidents should also be considered such as the introduction of the International Safety Management (ISM) code (adopted 1994), the increasing role of port State control with regard to vessel inspections and detentions and the increasing role of corporate social responsibility (CSR) for shipping companies.

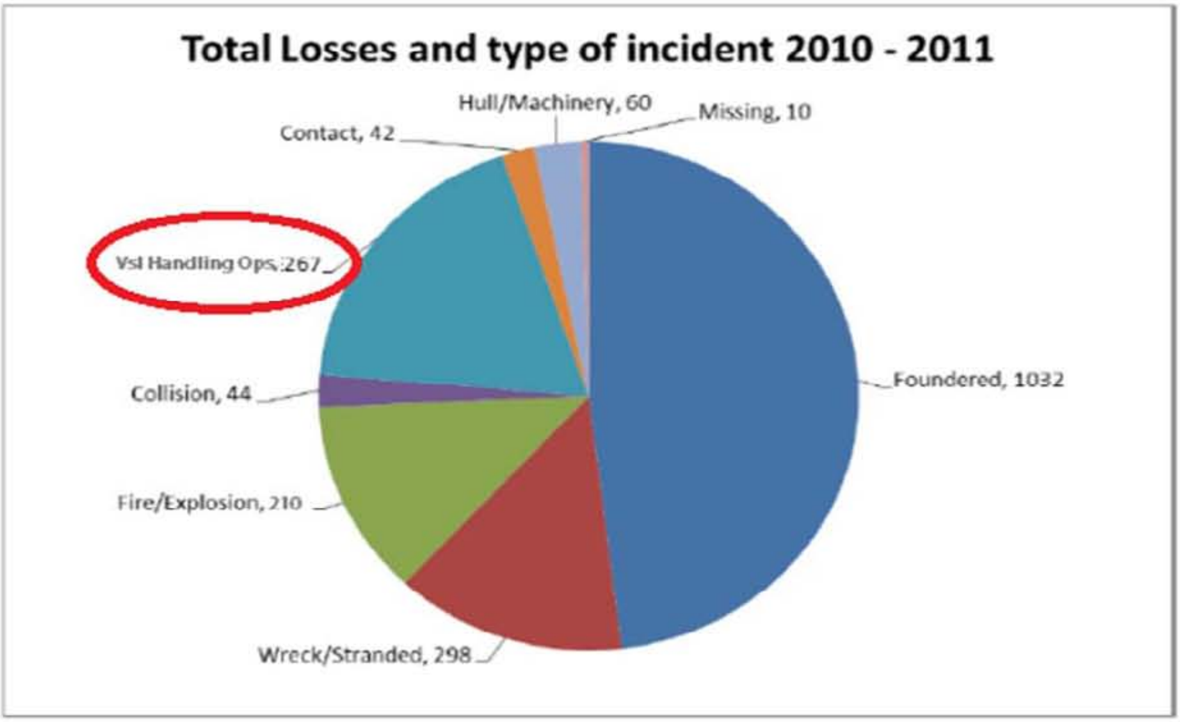


Figure 1.6 - Total Losses and type of Incident 2010 – 2011
Source: Admiralty Report 2013

1.3 Motivation of Research

- Personally faced "Death Defying Moments" thrice on-board ship
- This research was initiated out of concern for "shipping safety" specifically in Indian Coastal Waters and the number of tugboat accidents impacting human life, the environment, finances and the reputation of the industry. Figure 1.8
- To reduce the number of accidents it is necessary to improve the understanding of the underlying causes of Safety error, and to understand better the factors that affect risk performance in relation to the technical systems being operated and the environment in which work is taking place (Salvendy, 1997). With this view, this research study will contribute significantly in the field of Maritime HSE management by exploring the various management strategies adopted by other countries tugboat operators to mitigate associated hazards to prevent the future accidents in tugboat operation.

1.4 Safety Management V/s Commercial Benefit

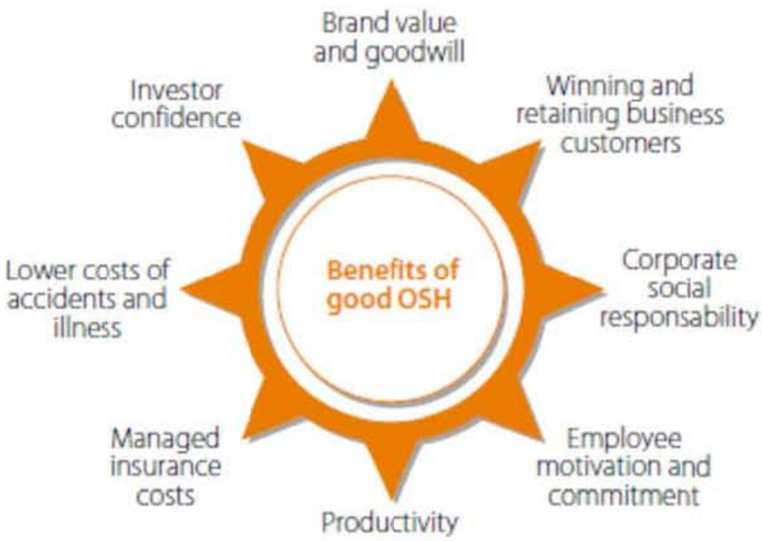


Figure 1.7 - The definitive guide to the new social standard, Financial Times
Source: D. Leipziger (2001), SA8000

"Managing the Risk Factor is an excellent analytical history of the early twentieth-century emergence and development of human resource management as a distinct management function and profession…." (James, 2008).

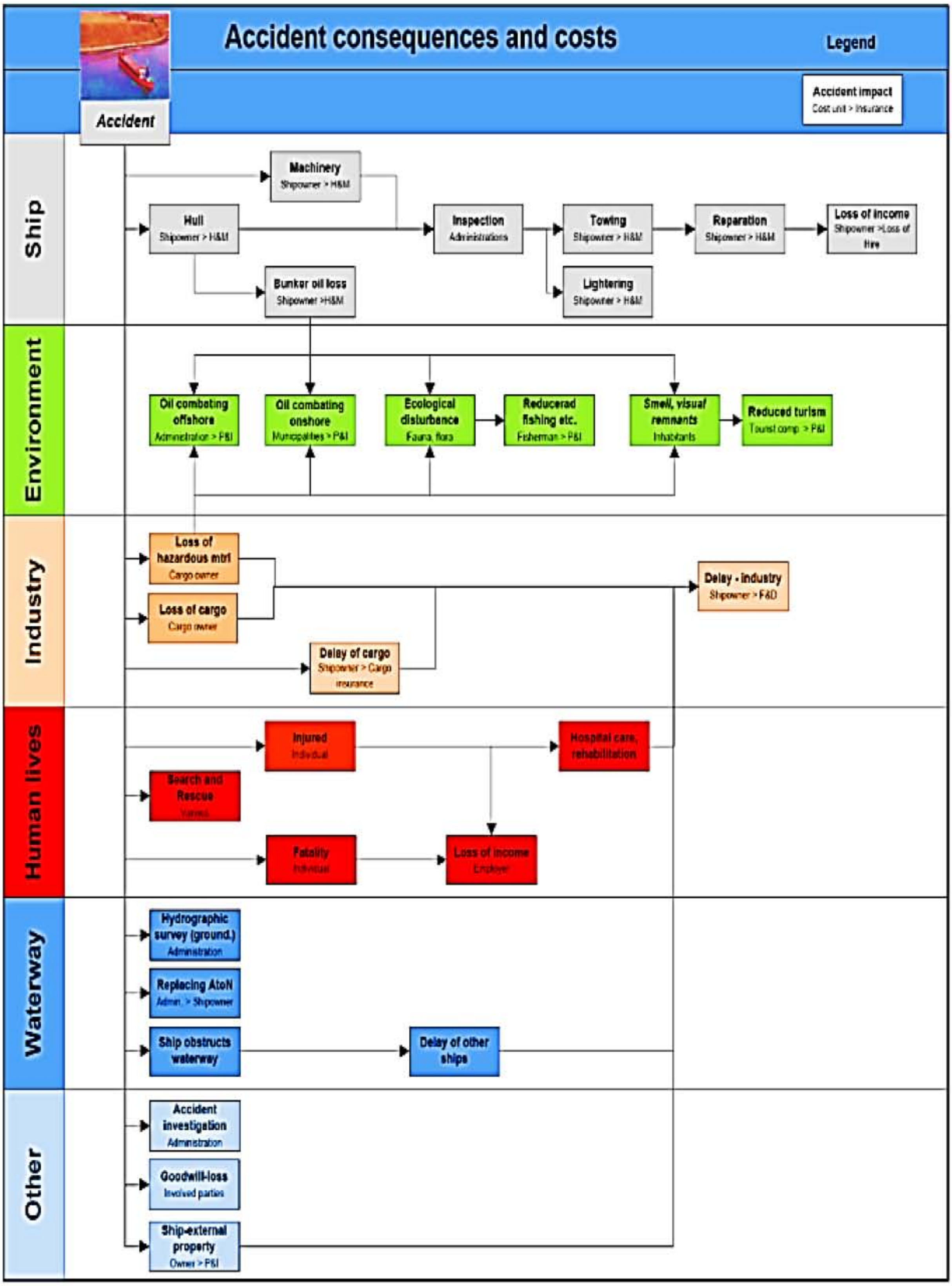
Managing Safety risk considered as one of the important component of managing risk, for which integrated strategies are required. Safety should be managed as part of strategic, human resource management perspective (Kontogiannis, 1999).

" By considering Safety Management the maritime industry can increase product quality and productivity, while reducing injuries, illnesses and worker's compensation costs to the point of being beneficial to the industry's position in the global marketplace" (Kirwan, 1997)

ETA (2012) identified concern over the issue of ship size, stating that Pilots and tug captains are 'increasingly facing operational problems handling ever growing ship sizes'.

Henson (2011) in Safe Tug Procedures underlines the importance in choice of tug type, to help ensure safety of operations. He points out, 'if tugs with propulsion units aft are very close to the ship's bow, to get clear by steering away, the tug's stern will come closer to the ship, increasing the suction forces and consequently the risk of hitting the bow'.

The Australian Transport Safety Board (2006) identify risks from lack of maintenance in their report considering the collision between a bulk carrier and a tug. They conclude that, 'a crack in the tug's starboard main engine clutch oil discharge pipe, led to the engine's shutdown; this caused the tug's stern to swing sharply to starboard, making heavy contact with the ship, and puncturing the ship's shell plating'.



Simplified model of accident consequences that can result from collision, contact, and grounding accidents (M. Lundkvist, 2010).

Figure 1.8 - Incident losses and Consequences

Cost Trillion in Losses, Over 150 marine accidents in last four years: Indian Govt

Source: TOI, 2012: In the past four years, 153 marine accidents have occurred off the Indian coast and 66 people have died in these mishaps. In a written reply in Lok Sabha , shipping minister G K Vasan said seven people died in such accidents in 2009 while the toll was 24 this year.

The reply said 78 ships involved in accidents had Indian flags. The nature of casualty included accidental death, collision, man overboard, fire, loss of ship and sinking.

The minister also submitted that the government had stipulated that cargo ships above 25 years, oil tankers above 20 years and gas carriers above 30 years entering Indian ports, anchorages and offshore facilities should be classed with India Register of Shipping or any one of the 12 societies of International Association Classification Society.

In the fatal accident where the tug *Flying Phantom* was damaged and which later sank; the cause was identified to be thick fog led to a disorientation of the tug crew. A joint paper produced by the European Tugowners and the European Pilots Associations' (2011) demonstrates how advances in vessel design may produce risks to Routine Ship Towage safety. They point to the, 'operational problems European pilots and tug operators have increasingly experienced over the last decade; relating to the type and strength of deck equipment on board of ships'. This highlights a contradiction posed by increased tug bollard pull, versus moderated bollard structural strength.

1.5 Business Problem:

Indian Maritime Businesses have been facing commercial losses in Harbour Towage accidents because of failure to recognise preventive measures for unidentified hazards. See Figure 1.8

1.6 Problem Statement:

Although studies are made with some variables on harbour towage covering operational, behavioral & constructional parameters yet many of them are still, conspicuously, missing.

1.7 Need of Research:

Need for research and business problem are derived on the basis of challenges faced by maritime towage industry during the course of its commercial and technical operation. Time & again various literatures on safety have stressed on fact that accident actually is a summation of series of events which finally lead to unfortunate consequence. Identification of hazards is the first step of risk assessment. The Routine Ship Towage Operation is potentially a hazardous operation. This study attempts to explore the safety risk factors which are threat to Routine Ship Towage operation in Indian Coastal Waters.

A holistic research is required to bring-out the reasons for such safety incidents. Later part of research moves towards providing solutions practiced worldwide to mitigate such safety risks.

1.8 Organisation of Report:

The entire study is encapsulated **Five chapters**. The first chapter titled **Introduction** includes the safety concerns in maritime trade and ports across the world. It discusses how safety in maritime industry evolved. It also debates over importance of operational safety in commercial management of tugboat. Briefly it states the interrelation between accidents consequences and cost. Need and motivation of research is also discussed in this chapter.

The second chapter is **review of literatures**, details about the existing studies on similar hazards associated with towage operation in other industry. The reviews of research works are broadly categorized on the basis of thematic studies to derive concrete inferences and gaps. The literature review is also classified on geographical basis to assess the level and types of existing studies. The review is also aimed to derive certain pertinent variables that can be considered for the current study. Various theories related to maritime safety are also discussed briefly in this chapter.

The third chapter **research design** focuses on the rationale of this current study followed by statement of research problem, objectives of study, research questions, scope of the study, data collection methods, data analysis strategy, operational definitions of variables identified.

The fourth chapter **Data Analysis & Findings** discusses about the sources of data followed by selection of data. Chi Square analysis of the selected variables and validation of selected data and subsequently data analysis using PCA technique are also detailed with their interpretations.

Finally, the fifth chapter provides **Conclusions & Suggestions**. Bibliography is given at the end as reference.

1.9 Concluding Remarks:

This chapter discussed the context and background of this research. Impact of economic reforms across the world on trade volumes has given opportunity to improvement in cargo movement through ships. This spurt in trade volumes has mandated the improvement of port facilities such as towage services. Ports being a key part of infrastructure sector play a key role in the progress of a country and thus, their efficient and safe operations become detrimental to the pace of economic growth of the country. Lots of accidents happening but many of them go unnoticed and undocumented. The business problem is derived from this background, and attempts to probe the reason and level of actual need of adoption of safety management practices.

The business problem has led to further exploration of literature. A thorough literature review on similar hazards associated with towage operation in other sector of maritime industry. Literature collected on safety is segregated on the basis of world ports, Indian coastal waters to understand the occupational hazards at both levels. Subsequently the problem statement is derived.

Chapter 2

LITERATURE REVIEW

2.1 Introduction:

Literature on safety has emphasized on the fact that accident actually a summation of series of events which finally lead to unfortunate consequence. The first step of risk assessment is to identify the hazards that are present. The Routine Ship Towage, also called harbour towage, is potentially a hazardous operation.

2.2 Objectives of Literature Review:

1. To study the significance of safety management in shipping industry;
2. To study modes of identifying hazards across the world;
3. To make a thematic segregation of the research works;
4. To study the safety risk factors involved across the world with a special reference to ship towage operation and safety management practices to mitigate those risk;
5. To study the maritime accident trends and current status in Indian coastal waters;
6. To study the different techniques used for identifications of hazards, factor analysis; and Data analysis.
7. To identify research gap in the existing body of knowledge.

2.3 Some Ship Towage accidents in Literature:

The dredge barge Arthur J. involving the Tug Madison by her tow had accident which resulted in capsizing of Tug at Lake Huron on July 2012, (USCG, 2012);

Similarly, while towing the crane barge Skyline the capsizing of tug Chieftain with the loss of one life, at the River Thames on August 2011, (MAIB, 2012 A);

Another accident where the tug Adonis was capsized with the loss of one life at the time of engaging the barge Chrysus, in Gladstone, on June 2011 (ATSB, 2013);

Henson (2012) points out that, 'tug operations near the bow of a ship having headway are very risky; the higher the ship's speed, the larger the risks'. Dand (1975) said that, 'interaction forces varied with the square of the speed; and near the fore body of a ship the tug may drive itself under the bow'.

There is high risk when ship is having high speed and tug is operating near bow of ship having headway (Henson, 2012). In addition Merkelbach and Van Wijnen (2013) in their extensive global survey report emphasized both on 'safe speed' and safe operating procedure when making connection of towline.

Dand (1975) model test report stated that there is most likely the tug may drive itself under the bow near the fore body of a ship as there are large interaction forces which influence the maneuverability of tugs, these forces is directly proportional to square of the speed.

The safety report published by Australian Transport Safety Board statistics shows those consequences of accidents involving tugs were collisions, contact damage and capsizing. (ATSB, 2011)

An accident reported by International Tugowners Association reveals hydrodynamics sphere of influence on tug sailing close to bow of ship was the main reason of fatal collision with vessel, and tug capsized. The tug failed to maintain safe distance due to interaction force around bulbous bow (ITA, 2012).
The significance of tow planning to prevent Routine Ship Towage accidents was well described by Transport Accident Investigation Commission of New Zealand. (TAIC, 2001)

The associated risk of Girting was mentioned in circular of British Tug Association where barge while berthing capsized and foundered due to wrong operational procedure by tug. The tug was acting as resistant that lead uncontrolled yawing of barge. (BTA, 2010)

In British Tugowners Association's Safety delegates Seminar emphasized the significance of training and expressed concern over poor seamanship and incompetency of tug crew that are leading to high number of safety incidents occurrence (BTA, 2012). The same was stressed by Livingstone (2012) for adoption of simulator based training that would boost tug masters confidence by increasing their competency in efficient operation of their tug.

Henson, Merkelbach and Van Wijnen (2013) recognized the significance of competency which is attribute to skills, great teamwork and experiential comprehensive training for tug captains, pilots, ship's master and crew involved in towage operations.

Importance of following standard operating procedure was emphasized by Stockman (2010) report, in which there was incident of near girting and ultimately could also have led to capsize of tug.

In Marine Safety Information Bulletin published by United States Coast Guard underlines the significance of Tug Handling techniques in reducing down streaming conditions (USCG, 2009).

In one of accident where tug was assisting vessel in a narrow channel collided, British Tugowner Association in its report emphasized on hazards associated with lack of maneuvering space which may also arise due to navigational obstacle in harbour towage operations (BTA, 2010).

The EMSA (2010) stressed over the tug approach maneuvers, stating that Pilots and tug masters need to be very careful in towage operations.

Choosing a Tug type for efficient and safe towage operation is critical as mentioned by Henson (2011) in Safe Tug Procedures. Tugs with propulsion units aft are more prone to safety risk as the tug's stern will come closer to the ship bow that will lead to increase of suction forces and consequently the high risk of heavy contact with the bow. He also pointed out that proper tow planning can give opportunity to choose right tug type, he proposed greater use of tugs with propulsion unit forward as they are less affected by interaction forces and are much safer to operate as bow tug.

The poor maintenance of tug propulsion engine that led to collision between bulk carrier and tug was reported as the main cause by Australian Transport Safety Board (ATSB, 2006). Details of report mentions about breakdown of main engine, due to seepage of clutch oil from discharge pipe, this led to loss control over tug propulsion and it made heavy contact with starboard ship hull and damaging shell plating.

TAIC, New Zealand (2000) reported issue of poor communication between crew of ship and tug led to safety incident involving man overboard and near capsize of tug. There was inadequate communication between bridge and crew at mooring station; and also between pilot and tug master.

European Tugowners Associations (2011) stressed on safety culture and human factor in tug operating companies, highlighting casual attitude of company staff and tug crew due to lack of enforcement legislation for safety management system as they fall below 500 GT for many international conventions. Another example Maritime Labour Convention 2006 (ILO, 2013) which has provision for suitable hours of rest for seafarers but this cannot be applied to mariners engaged on tug boats (ABS, 2002).

RST operation has complex legislation, leaning to deluge from International Conventions of IMO (2013). The fundamental treaties consist of the international convention for the Safety of Life at Sea (SOLAS) 1974, International convention on load Lines 1996; and the international convention on Standards of Training, Certification and Watchkeeping for seafarers (STCW) 1978.

The Canada shipping Act 2001, load line Regulations (SOR| 2007-99 and the safety Management Regulation (SOR| 98-348) are meant to endorse convention in Canadian state level. Some of the example of endorsing regulation are US title 33 (Navigation and Navigable waters) for shipping Title 46 which is for USA, the merchant Shipping notice 1812 and 1826, the merchant Shipping Act 1995, Merchant shipping notices 1812 and 1826 (SOLAS) interpret international codes and the Merchant Shipping (Load Line) Regulation 1998 from the UK.

The safety of RST operations can be benefitted through these legislative frameworks. Tugs can also fall less than the gross towage bar for many international conventions. For vessels with less than 500 GRT to operate safely management systems have no requirement of legal aspects, despite the fact that the company investigated by authors was willingly complied with SOLAS chapter IX (Management of the safe operation of ships)

The Load line Regulation which are applicable to vessels of 150 GT or more, and length of 24 m or more; certain vessels committed on sheltered waters voyages may find exceptions and rule out , particularly certain categories of tug.

Favorable growth was acknowledged in the sphere of non-legislation, with refined understanding in relation to technical aspects. Henson (2012) stated that to bring about better safety operations there is a requirement for proper tow planning; proposing that the use of 'Tractor tugs and tugs with propulsion units forward are much safe to operate as bow tugs as they can better compensate for the interaction forces'.

EDDY, a new designed tug, was developed to improve better handling it is designed with one thruster forward and one aft; Rotor used as a new towing system which is in operation, to work and minimize the friction in towline.

Henson, Meskelback and Van Wyen (2013) in auxiliary to safe procedure and speed also traced the importance of 'Comprehensive training underpinned by experiences for tug masters, pilots and ship's captain, ensuring optimum team working between all those involved in safe routine ship towage operations'.

2.4 Selection of Key Words:

The search for literature holds key in accurate navigation of the proposed research. Identification of key words has commenced with some of the general words like 'Tugboat Accidents', 'Accidents report Marine', 'Accident report shipping' and slowly drifted towards domain terms such as 'Maritime safety', 'shipping accidents in India', 'Marine accidents India', 'tug operational safety', 'tugboat operation', 'tug operation accidents', 'ship operation risk', 'risk factor tugboat India', 'risk factor shipping', 'occupational risk factor', 'occupational risk analysis', 'risk management shipping', 'safety management shipping', 'safety procedure tug', and 'tugboat safety'. Techniques used for checking hypothesis in checking RST & NRST similarity used by various researchers such as 'Chi square test', data analysis techniques such as 'factor analysis', 'thematic analysis' were also searched to gather research.

2.5 Literature Search Process:

To ensure thorough research, online database like Taylor & Francis, Elsevier, Palgrave, Scopus, Emerald, and Google Scholar were searched for available literature between 2002 and 2014. A total of 19 Journals of National and International repute and over 8 reports published by various national and international agencies are reviewed.

List of Journals Explored	
1. Journal of Maritime Research	12. Transport Research
2. Alliance Journal of Business Research	13. JSS: Safety Science
3. JRESS: Reliability Engineering & System Safety	14. JSR: Journal for Safety Research
4. Indiastat Reports	15. MAIB – Report
5. Transportation Planning and Technology	16. DMAIB – Report
6. Maritime Policy & Management	17. ATSM – Report
7. International Journal of Logistics Research and Applications	18. JAAP: Accident Analysis & Prevention
8. International Journal of Environmental Sciences	19. Transportation Research
9. Nautical Institute Publications	
10. Journal of Economics & Business	
11. Transport Reviews	
List of Database Explored	
SCOPUS, TAYLOR & FRANCIS, ELSEVIER, GOOGLE-SCHOLOR, PALGRAVE, EMERALD INSIGHT, INDIAN BUSINESS INSIGHT, EBSCO, JSTOR	

Table 2.1- Database and Journals Explored

2.6 Thematic Review of Literature:

To have a clear vision on the evolution and flow of research made till now, reports and literature collected through the search process are categorized into broad themes

THEME 1 "Hazards elements Identification" of Maritime Accident (Not related to towage)		
VARIABLES	**INFERENCE**	**GAP**
Procedures, Risk, Safety system, Job satisfaction, Rules, Competence, Participation, Safety system, Design, Management Competence, Safety behavior, PTW	Scales correlated (ex-Safety reps) with self-reported accident Competence rates across sites. Most factor scores discriminated self- reported accident from non-accident groups	Holistic picture not represented as only broader parameters are considered. Many variables of relevance ignored
THEME 2 **"Hazards elements Identification " Risk Analysis of Similar Operations (from other Industry)**		
Skepticism, Responsibility, Work environment, Safety system, Personal immunity, Risk, Time independence, Work environment, Participation, Safety system, Sensation seeking, Safety system, Work pressure, Peer support, Safety system	All factors related to, self-reported accidents. Company expert ratings of safety align with safety climate rankings. Differences in climate perceptions. Between accident versus non-accident groups	Limited size of sample leads to incomplete identification External factors not taken into account for Studies
THEME 3 **"Hazards elements Identification" of Similar Operations (Maritime Industry)**		
Safety awareness/Attitudes, Work values, Communication, Training Procedures, Management Safety need Risk,	Accident data by occupational hazard/department some comments but no analysis reported Competence	VRST operation not been studied in a holistic manner in safety climate w.r.t

Blame Control, Support, Management, Speaking up, Competence, Work practices, Attitudes, Personal motivation, Positive safe practice, Risk justification, Fatalism/optimism, Climate, Terrorism	Procedures. Non defined safety climate scores accident versus non-accident groups. Self-reported accidents classification predicted by optimism and safe practice.	Indian Context. Risk Identification & Assessment not been done for VRST operation. Berthing Navigational Procedure not taken into account for any study & structural analysis
THEME 4 **"Hazards elements Identification" Associated with tugboat Operations/ Risk Analysis/Safety/Accidents Worldwide**		
Competence, Management, Communication, Wind, Girting, Swell, Ship Size, Tug Equipment, Tow Planning, Maneuvering Space, Career, Work pressure, Human Error, Safety system, Peer judgment, Safety system, Safety reporting, Violations, Supervision, Rules/procedures, Management, Work pressure, Work clarity, Communication, Risk, Safety system	Main Emphasis on Girting & Speed of approaching Vessel Safety inspectors' rankings of safety/accident prevention practices correlation with climate. Cultural differences in factor structure in cold countries & associated different handling equipment Several attitude factors related to prior individual accident involvement but not work climate scales.	Very limited literature available (many Hazards associated with Indian Safety Culture & Safety climate not been taken into account). Limited literature (guidelines, practices, procedure) on best preventive measure to limit Hazards in tugboat operation.

Table 2.2 - Inference from Literature Review

2.7 Author-wise details of the research papers gathered:

Research work covering various similar towage associated hazards in maritime and non-maritime industry both across the World and India are listed in the following table. This comprehensive list covers details of author(s), context of study, their finding/conclusion, variables used by them, and model/technique used by them on the basis of year of such studies a total of 62 research papers on all the Themes were traced from the literature review and are listed below.

THEME **"Hazards elements Identification" Risk Analysis of Similar Operation (other Industry)**		
AUTHOR\ TITLE OF PAPER	TOOLS\METHOD\INDUSTRY	SUMMARY\ INFERENCE
An integrated frame work to the predictive error analysis in emergency situation (Kim&Jung,2002)	Task Analysis -Qualitative – Facts	The basic viewpoint on the occurrence of cognitive error taken in this paper is that the cognitive function failures occur from the mismatch between operator's cognitive capability and the requirements of a given task and situational condition. In accordance with this viewpoint, performance influencing factors that influence the occurrence of human errors are classified into three groups, i.e. Performance Assisting Factors (PAF), Task Characteristic Factors (TCF), and Situational Factors (SF). Further, it enables analysts to draw specific error reduction strategies. The framework suggested was applied to the analysis of cognitive error potential for the bleed and feed operation of emergency tasks in nuclear power plants.
Risk analysis of a typical chemical industry using ORA procedure (Khan&Abbasi,2001)	ORA - Quantitative &Qualitative - Facts	This paper presents a risk assessment study of a typical chemical process (sulfolane manufacturing) industry using optimum risk analysis (ORA) methodology Risk analysis; a systematic method for harzard identification and assessment. Techniques for risk analysis of chemical process industries. The paper also describes briefly the different steps of ORA methodology and the available techniques and tools to conduct each step of the ORA.
Safety in construction – a comprehensive description of the characteristics of high safety standards in construction work, from the combined perspective of supervisors and experienced workers (Törner & Pousette,2009)	Checklists, Safety audits - Qualitative – Empirical data	The study identified four main categories of work safety preconditions and components: (1) Project characteristics and nature of the work, which set the limits of safety management; (2) Organization and structures, with the subcategories planning, work roles, procedures, and resources; (3) Collective values, norms, and behaviors, with the subcategories climate and culture, and interaction and cooperation; and (4) Individual competence and attitudes, with the subcategories knowledge, ability and

		experience, and individual attitudes.
Risk- assessment tools incorporating human error probabilities in the Japanese small-sized establishment (Moriyama&Ohtani,2009)	HEP/HEA – Hybrid – Theoretical foundations &Empirical data	Human error probability (HEP) and human error analysis (HEA) have been used for large-scale, safety-critical industries these tools are not suitable for smaller, more general industries that comprise the majority of accident settings. Here, in this paper describe and verify a risk assessment tool that includes human-related elements for small companies. The tool expands on traditional risk assessment methods, such as matrix, risk graph and numerical scoring method, by adding human-related elements.
An optimizing hazard/risk analysis review planning (HARP) frame work for complex chemical plants (Reniers,2009)	HARP – Qualitative - Theoretical foundations	This paper discusses the elaboration of a framework which can easily be used within a complex chemical facility for optimizing risk analysis planning considering both process and non-process risks. Furthermore, legislative requirements as well as optimizing company guidelines for risk analysis reviews are integrated into the framework.
An occupational safety risk analysis method at construction sites using fuzzy sets (Gürcanli & Müngen, 2009)	Fuzzy event tree analysis (FETA)technique - Hybrid – Fuzzy sets	Method for assessment of the risks that workers expose to at construction sites using a fuzzy rule-based safety analysis to deal with uncertain and insufficient data
Identifying and analyzing hazards in manufacturing industry – are view of selected methods and development of a frame work for method applicability (Willquist & Törner,2003)	HAZOP,OSHA, checklists, HRA, Justification of Human Error Data Information (JHEDI) - Qualitative – Empirical data	This paper proposes a quantitative view to develop an algorithm for the scheduling of measures within a safety improvement program.
Use of risk assessment in the nuclear industry with specific reference to the Australian situation (Cameron &Willers,2001)	HIFARPSA(Probabilistic safety assessment) - Quantitative - Theoretical foundations	This paper reviews the use of risk assessment in the light of the need for acceptability criteria and shows how these tools are applied in the Australian nuclear industry, with specific reference to the probabilistic safety assessment (PSA) performed of HIFAR
A tool based approach to checking logical consistency in accident	Accident reports – Qualitative – Theoretical	In this paper, we present a technique to analyse consistency in accident reports. This is achieved using the prototype verification system. The

reports (Krishnan,2002)	foundations	relevant evidence and the rules for normal behavior are coded as axioms. These axioms are then used to identify the cause of the accident other formal methods used to analyse accident reports
An analytic model for situation assessment of nuclear power plant operators based on Bayesian inference (Kim&Seong,2006)	Human Reliability Analysis (HRA)methods - Quantitative – Empirical data	Study of an analytic and quantitative model of SA for NPP operators. The model postulates the situation assessment as followings; 1) Abnormal or accident situation occurs. 2) Operators recognize it by onset of alarms. 3) Operators read the relevant indicators. 4) Operators try to establish their situation models. At this point, operators usually also consider the possibility of sensor or indicator failures. 5) If operators receive other alarms, operators will read the relevant indicators. Even if operators do not receive other alarms, operators will probably decide to monitor other indicators to confirm their situation models.
The'PROCESO' index: a new methodology for the evaluation of operational safety in the chemical industry (Maroño,Peña,&Santamaria,2006)	Operational Safety Index: the'Proceso' Index (PROCedure forthe Evaluation of Operational Safety) - Quantitative – Dataset	This paper proposes a quantitative view to develop an algorithm for the scheduling of measures within a safety improvement program.
A fuzzy modeling application of CREAM methodology for human reliability analysis (Konstandinidou, Nivolianitou,Kiranoudis,&Markatos,2006)	CREAM methodology - Quantitative – Fuzzy sets	
Cause and effect analysis by fuzzy relational equations and a genetical algorithm(Rotshtein, Posner, &Rakytyanska,2006)	Cause and effect analysis - Quantitative – Fuzzy sets	In this paper, a problem of MIMO object identification expressed mathematically in terms of fuzzy relational equations is considered. The identification problem consists of extraction of an unknown relational matrix, and also parameters of membership functions included in fuzzy

		knowledge base, which can be translated as a set of fuzzy IF-THEN rules. The approach proposed is illustrated by computer experiment and examples of diagnosis and prediction.
Condition-based fault-tree analysis (CBFTA):A new method for improved fault-tree analysis (FTA), reliability and safety calculations (Shalev&Tiran,2007)	Condition-Based FTA(CBFTA) - Quantitative – Statistical data	FTA can be used to analyse hazards and calculate system reliability for simple as well as complex systems FTA looks at a consequence and traces this back to possible initiating events that could be risks. Relevant risks can be considered, whereby various causes that can result in one and the same interfering event are identified
An algorithm for the implementation of safety improvement programs (Cagno, Di Giulio, & Trucco, 2001)	Algorithmic approach - Quantitative - Empirical data - Industry	This paper proposes a quantitative view to develop an algorithm for the scheduling of measures within a safety improvement program.
Classification of errors contributing to rail incidents and accidents: A comparison of two human error identification techniques (Baysari, Caponecchia, McIntosh, & Wilson, 2009)	Socio-technical risk – Quantitative - Theoretical foundations & Empirical data - Mechanics (socio-technical systems)	This paper Identifies the errors that frequently result in the occurrence of rail incidents and accidents can lead to the development of appropriate prevention and/or mitigation strategies. Nineteen rail safety investigation reports were reviewed and two error identification tools, the Human factors analysis and classification system (HFACS) and the Technique for the retrospective and predictive analysis of cognitive errors, used as the means of identifying and classifying train driver errors associated with rail accidents/incidents in Australia.
Severity analysis of Indian coal mine accidents e A retrospective study for 100 years (Maiti, Khanzode, & Ray, 2009) The weighted risk analysis (Suddle, 2009)	HFACS TRACE - Quantitative & Qualitative - Accidents data – Industry	A retrospective study on severity analysis of Indian coal mines accidents for 100 years was done considering fatal and serious accidents and the resulting causalities. An event evaluation algorithm (EEA) was developed for this purpose. The study evaluated the status of safety level as well as the scope of improvement for Indian coal mines safety.
The weighted risk analysis (Suddle, 2009)	Qualitative - Theoretical foundations - Mechanics	In this paper, relations between safety and risk are described.

A proactive approach to human error detection and identification in aviation and air traffic control (Kontogiannis & Malakis, 2009)	Event evaluation algorithm (EEA) – Quantitative - Accidents data - Mechanics	This Paper discusses about occupational risk model, to derive improvement measures and support cost-effective risk reduction strategies.
A method to identify strategies for the improvement of human safety behavior by considering safety climate and personal experience (Zhou, Fang, & Wang, 2008)	WRA – Quantitative - Empirical data (Case study) – Engineering	This paper discuss about the method to find a strategy by controlling one individual factor (or simple strategy) to improve safety behavior was then investigated. The analysis suggested that a joint control of both safety climate factors and personal experience factors worked most effectively. Finally, the prediction of human safety behavior under a specific climate was tested with the BN.
Toward risk assessment for crane activities (Aneziris, Papazoglou, Baksteen, et al., 2008; Aneziris, Papazoglou, Mud, et al., 2008)	Event evaluation algorithm (EEA) – Quantitative - Accidents data - Mechanics (coal mine)	In this Paper a logical model for quantifying occupational risk in case of collapsing or overturning cranes, falling loads or falling objects struck by cranes developed under the Workgroup Occupational Risk Model (WORM) project is presented. Quantification results are presented for the risk of contact with collapsing, overturning cranes and falling loads from cranes.
Injuries in U.S. mining operations e A preliminary risk analysis (Komljenovic, Groves, & Kecojevic, 2008)	Bayesian network Analysis – Quantitative - Empirical data -Industry (constructions)	This paper proposes a quantitative view to develop an algorithm for the scheduling of measures within a safety improvement program
Explaining safe work practices in aviation line maintenance (Pettersen &Aase, 2008)	Workgroup Occupational Risk Model (WORM) - Quantitative -Accidents data - Mechanics	This Paper presents research results from a qualitative study of aviation line maintenance operations, with the objective of describing operational work practices. The study identifies features, such as practical skills, support from colleagues, creation of performance spaces, and flexibility in problem solving, that are important for safe work practices in line maintenance operations.
Quantifying occupational risk: The	Workgroup Occupational	This Paper discusses about occupational risk model, to derive

development of an occupational risk model (Ale et al., 2008)	Risk Model (WORM) - Quantitative -Accidents data - Mechanics	improvement measures and support cost-effective risk reduction strategies.
Quantified risk assessment for fall from height (Aneziris, Papazoglou, Baksteen, et al., 2008; Aneziris, Papazoglou, Mud, et al., 2008)	Qualitative - Empirical data - Mechanics (aviation)	This paper proposes a quantitative view to develop an algorithm for the scheduling of measures within a safety improvement program.
Exploring the organizational preconditions for occupational accidents in food industry: A qualitative approach (Stave &Törner, 2007)	Occupational Risk Model (ORM) - Quantitative - Accidents data - Engineering	This research is on the continuing high frequency of occupational accidents in the Swedish food industry calls for new approaches to better understand the underlying factors. In the present study, 54 accidents involving hand injuries were investigated from the operators' perspective, to explore the organizational preconditions. In-depth interviews were conducted with operators and their supervisors, and 24 of these interviews were analysed using the Semi- Structured Interview method. The core category 'safety as a process' was identified encompassing the perception of the process of the accident at operative level and organizational preconditions that increased the risk of occupational accidents. These preconditions were open factors: deficiencies in technical/physical environment and work organization; and concealed factors: insufficient communication and learning, a high level of responsibility in combination with low control, conflicting goals and a gap between procedures and practice.
Combining road safety information in a performance index (Hermans, Van den Bossche, & Wets, 2008)	Workgroup Occupational Risk Model (WORM) - Quantitative - Accidents data - Mechanics	In this paper an essential step in the construction process of a composite road safety performance indicator: the assignment of weights to the individual indicators. This research provide insights in the most important weighting methods: factor analysis, analytic hierarchy process, budget allocation, data envelopment analysis and equal weighting. This will facilitate the selection of a justifiable method.

Sensitivity analysis of an accident prediction model by the fractional factorial method (Akgüngör &Yıldız, 2007)	Semi- Structured Interview Approach - Qualitative - Accidents data - Industry (food)	In this study, the sensitivity of the accident prediction model proposed. Overall, the fractional factorial method was found to be an efficient tool to examine the relative importance of the selected accident prediction model parameters.
Application of a human error framework to conduct train accident/incident investigations (Reinach & Viale, 2006)		In this Paper the application of HFACS-RR and a theoretically driven approach to investigating accidents/incidents involving human error ensured that all levels of the system were considered during data collection and analysis phases of the investigation and that investigations were systematic and thorough. Future work is underway to develop a handheld software tool that incorporates these data collection and analysis tools.
Risk-based maintenance strategy and its applications in a petrochemical reforming reaction system (Hu, Cheng, Li, & Tang, 2009)	Weighting method - Quantitative - Empirical data - Industry (transportation)	Risk-based maintenance (RBM) - An improved RBM approach based on the proportional age reduction model is proposed in this paper. The parameters of the failure distribution and maintenance effect of equipment are estimated by maximum likelihood estimation. The results show most equipment in this system is imperfectly repaired. The imperfect nature of the periodic preventive maintenance means it needs to be carried out more frequently.
The costs of industrial accidents for the organization: Developing methods and tools for evaluation and cost benefit analysis of investment in safety (Gavious, Mizrahi, Shani, &Minchuk, 2009)	HFACS, HFACS-RR - Qualitative - Empirical data - Industry	This paper proposes methods for reliable evaluation of the costs involved in industrial accidents for an organization – especially in relation to loss of production. This paper use a management approach that is based on the "Theory of Constraints". Industrial accident costs contain two major cost-categories: direct costs and indirect ones. The research shows the importance of evaluating indirect costs and develops a model that calculates the real cost of an accident.
Operational risk assessment of chemical industries by exploiting accident databases (Meel et al., 2007)	Risk-based Maintenance - Hybrid - Facts - Industry	This paper uses Bayesian theory to forecast incident frequencies, their relevant causes, equipment involved, and their consequences, in specific chemical plants. Systematic analyses of the databases also help to avoid future accidents, thereby reducing the risk. More specifically, this paper

		presents dynamic analyses of incidents in the NRC database. Finally, the fast-Fourier transform is used to estimate the capital at risk within an industry utilizing the frequency and loss-severity distributions.
Integration of accident scenario generation and Multi objective optimization for safety-cost decision making in chemical processes (Kim, Chang, &Heo, 2006)	Theory of Constraints - Quantitative - Empirical data - Industry	Integration of accident scenario generation and Multi objective optimization for safety-cost decision making in chemical processes
Offshore oil and gas occupational accidents—What is important? (Kim, Chang, &Heo, 2006)	Operational risk Assessment - Quantitative - Facts - Industry	In this Paper a quantitative model capable of predicting occupational accident frequency in the offshore petroleum industry is being developed. The model offers a means to optimize safety spending, thereby maximising benefits to personnel and the organisation. A questionnaire was the chosen method to consolidate industry opinion. The results of the questionnaire are presented in this paper, together with a discussion, interpretation, and conclusions
Development of a risk-based maintenance (RBM) strategy for a power-generating plant (Krishnasamy, Khan, &Haddara, 2005)	Operational risk Assessment - Quantitative - Facts - Industry	In this Paper, Risk-based maintenance (RBM) is analysed. Adapting a risk-based maintenance strategy is essential in developing cost-effective maintenance policies. The RBM methodology is comprised of four modules: identification of the scope, risk assessment, risk evaluation, and maintenance planning. Using this methodology, one is able to estimate risk caused by the unexpected failure as a function of the probability and the consequence of failure. Critical equipment can be identified based on the level of risk and a pre-selected acceptable level of risk. Maintenance of equipment is prioritized based on the risk, which helps in reducing the overall risk of the plant. The case study of a power-generating unit in the Holyrood thermal power generation plant is used to illustrate the methodology. Results indicate that the methodology is successful in identifying the critical equipment and in reducing the risk of resulting

		from the failure of the equipment.
THEME "Hazards elements Identification (FSA's fundamental step" of Similar Operations (Maritime Industry)		
Comparison of techniques for accident scenario analysis in hazardous systems (Nivolianitou, Leopoulos, &Konstantinidou, 2004)	Accident scenario Generation-Quantitative-Empiricaldata- Industry (chemical installations	In this paper, three accident scenario analysis techniques are presented and compared regarding their efficiency vs. the demanded resources. The comparison is done through the application of Event Tree analysis, Fault Tree analysis and Petri Nets technique—two relatively simple and a more demanding methodology—on the same hazardous chemical facility in view of analyzing an accident scenario of a hazardous transfer procedure.
A predictive risk index for safety performance in process industries (Chen & Yang, 2004)	Quantitative- empirical data – industry (petroleum industry)	In this Paper a novel predictive risk index (PRI) is proposed as an indication of safety performance in the process plant. The predictor is developed based on a regular observation of unsafe acts and conditions.
Risk-based maintenance (RBM): a quantitative approach for maintenance/inspection scheduling and planning (Khan & Haddara, 2003)	Risk-based maintenance (RBM) Hybrid Facts Industry (electric) power production)	This paper presents a new methodology for risk-based maintenance. The proposed methodology is comprehensive and quantitative. It comprises three main modules: risk estimation module, risk evaluation module, and maintenance planning module. Details of the three modules are given. A case study, which exemplifies the use of methodology to a heating, ventilation and air-conditioning (HVAC) system, is also discussed.
Designing for safety in passenger ships utilizing advanced evacuation analysesd A risk-based approach (Vanem & Skjong, 2006)	What-if - Quantitative - Accidents data - Industry (navigation)	This paper describes a novel set of well-defined evacuation scenarios for use in advanced evacuation analyses of passenger ships according to present maritime safety regulations. The scenarios are based on a recently performed risk assessment of passenger ship evacuation and can be related to actual accident scenarios, covering the major hazards passenger ships are exposed to. Furthermore, a risk-based methodology for using the set of scenarios in evacuation performance evaluation is proposed and it is demonstrated how the scenarios can be used to relate actual design options to the overall level of risk associated with the ship. The paper includes a brief introduction and describes the background for developing the evacuation scenarios. The results from a recently performed risk assessment is reviewed and it is explained how this can be used as basis

		for deriving a complete set of realistic evacuation scenarios. Furthermore, it is outlined how to use the evacuation scenarios to estimate the overall risk associated with a specific passenger ship.
Qualification of Formal Safety Assessment: an exploratory study (Rosqvist & Tuominen, 2004)	Formal Safety Assessment - Qualitative - Facts - Industry (navigation)	This paper addresses the issue of confidence in a FSA, as encountered during three case studies conducted by the authors over the years 1998–2002.
What is most important for safety climate: The company belonging or the local working environment? –A study from the Norwegian offshore industry (Høivik,Tharaldsen,Baste,&Moen, 2009)	ANOVA – Hybrid - Facts	The aim of this study was to examine the relative influence of offshore installation (local working environment) and company belonging on employees' opinions concerning occupational health and safety.
On the ALARP approach to risk management(Melchers, 2001)	ALARP approach – Qualitative – Theoretical foundations	In this paper it is suggested that there are a number of areas of concern about the validity of ALARP approach. These include representativeness, morality, philosophy, political reality and practility. An important and in some respects fundamental, difficulty is that the risk acceptance criteria are not fully open to public scrutiny and can appear to be settled by negotiation.
Risk indicators as a tool for risk control (Øien,2001a,b)	Risk influencing factors - Quantitative – Theoretical foundations	An organizational factor framework is developed based on a review of existing organizational factor frameworks, research on safety performance indicators, and previous work on QRA-based indicators. The results comprise a qualitative organizational model, proposed organizational risk indicators, and a quantification methodology for assessing the impact of the organization on risk.
Risk assessment in maritime transportation (Guedes Soares&Teixeira,2001)	Quantified risk assessment - Quantitative – Theoretical foundations	In this paper the researcher reviewed different approaches to quantify the risk in maritime transportation. A brief account is given of recent development of using formal safety assessments to support decision

		making on legislation applicable internationally to maritime transportation.
Determinants of crew injuries in vessel accidents. (Lars Harms-Ringdahl, 2004)	Operational risk Assessment - Quantitative - Facts	This study investigates determinants of the number of non-fatal crew injuries, fatal crew injuries and missing crew in freight ship, tanker and tugboat vessel accidents based upon individual accidents investigated by the US Coast Guard for the 1991–2001 period. Poisson and negative binomial regression estimates suggest that: (1) freight ship and tanker non-fatal injuries are higher when the vessel is moored or docked and during high winds and cold temperatures; (2) tugboat non-fatal injuries are higher during poor visibility; (3) freight ship fatal injuries increase with vessel age and tanker and tugboat fatal injuries are higher for fire and capsize accidents, respectively; and (4) freight ship missing crew increase with vessel age and tugboat missing crew are higher for fire and lake accidents.
Safety in maritime oil sector: Content analysis of machinery space fire hazards (U.M. Ikeagwuani, G.A. John,)	Quantitative - Accidents data - Industry (navigation)	An in-depth study of the practice within the maritime oil industry was undertaken to ascertain safety issues in seafaring vessels. It was more concentrated on the type of accidents that occur in machine spaces of seafaring vessels in this industry. The main focus of the research was streamlined to fire in machinery spaces. The literature review later concentrated on two of such incidences, they are oil spill and fire events. An investigation was done to assess those factors which actually contribute or are in association to fire outbreak. A content analysis methodology was used to investigate the associative relationships to fire outbreak with the aid of NVivo 9.0 software. The investigation focused on 15 key in-depth reports on machinery space incidences which were uploaded into the software.
Safety-culture in a Norwegian shipping company (Hartzell, 2001)	Quantitative - Accidents data - Industry (navigation)	Method: Using both self developed items and items from published research on safety culture, safety climate, and quality and management style, a 40-item safety culture questionnaire was developed. The questionnaire was distributed in a self-administered form to sailors onboard 20 vessels. A total of 349 questionnaires were collected (total

		response rate, 60%). Results, discussion and impact on industry: Principal component analysis (PCA) revealed 11 factors when the Kaiser eigenvalue rule was used and four factors when the scree test criterion was used. The factor structure in the material confirmed structures found in other industries. The relative importance of the factors from the factor analysis on ''level of safety'' measures was tested by canonical correlation analysis and regression analysis. The results confirmed previous research and showed that the most important factors were influential across industries. To determine weather differences existed between nationalities, occupations, and vessels the factors from the PCA was subjected to Multiple Discriminant Analysis. Significant differences between occupations, nations, and vessels were found on one or more of the factors from the PCA.
Risk perception and safety on offshore petroleum platforms - Part II: Perceived risk, job stress and accidents (Lars Harms-Ringdahl, 2004)	Accident scenario Generation - Quantitative - Empirical data - Industry	In this paper relations between perceived risk, job stress, and frequency of accidents and near accidents are analyzed. The analysis was based upon a self-completion survey among petroleum personnel (n =915) on the Norwegian Continental Shelf. The survey, conducted in spring 1990, drew respondents from five companies and eight installations. The response rate was 92%. Physical working conditions, safety and contingency factors, and assessment of the respondents' risk were found to exert influence on the number of accidents and near accidents. Results are presented and implications discussed.
Risk assessment of marine traffic safety at coastal water area (Hu,Fang,Xia,&Xi,2007)	Accident scenario Generation - Quantitative - Empirical data - Industry	This is Investigation report, according to the investigation of safety situation at coastal water area of China, applied on Formal Safety Assessment (FSA) approach which was held by International Maritime Organization, the characteristics of hazards and accidents at coastal water area were analyzed and some results of risk distribution were held out in quantities. Furthermore, some proposed risk control options (RCO), synergy-based management mode by grid or cell, and long-term strategy in Coastal Water Area were carried out, which included hazard identification, risk evaluation, crisis early-warning, emergency handling

		and decision-making.
Relationships between accident investigations, risk analysis, and safety management (Lars Harms-Ringdahl, 2004)	Accident scenario Generation - Quantitative - Empirical data - Industry	Several different approaches to achieve safety are in common use, and examples are accident investigations (AI), risk analysis (RA), and safety management systems (SMS). The meaning of these concepts and their practical applications vary quite a lot, which might cause confusion. A summary of definitions is presented. A general comparison is made of application areas and methodology. A proposal is made how to indicate parameters of variation. At one end of the scale there are organisations, which are highly organised in respect to safety.
Qualification of Formal Safety Assessment: an exploratory study (Celik&Cebi, 2009)	Quantitative - Accidents data - Industry (navigation)	This paper addresses the issue of confidence in a FSA, as encountered during three case studies conducted by the authors over the years 1998–2002. A peer review process—FSA qualification—is introduced to support the consolidation of confidence in FSA results. Some qualification criteria are suggested.
Formal safety assessment based on relative risks model in ship navigation (Hu,Fang,Xia,&Xi,2007)	Formal Safety Assessment(FSA) - Quantitative – Fuzzysets	This paper discusses quantitative risk assessment and generic risk model in FSA, especially frequency and severity criteria in ship navigation. Then it puts forward a new model based on relative risk assessment. The model presents a risk-assessment approach based on fuzzy functions and takes five factors into account, including detailed information about accident characteristics. It has already been used for the assessment of pilotage safety in Shanghai harbor, China. Method to solve the problems in the risk assessment of ship navigation safety in practice.
THEME "Hazards elements Identification" Associated with tugboat Operations/ Risk Analysis/Safety/Accidents Worldwide		
A Critical Analysis of Routine Ship Towage operations risks to safety (Stephen Ford, 2013)	Accident Data -Quantitative & Qualitative	This research contains a statistical comparison of Routine Ship Towage and non-Routine Ship Towage risk factors. Critical analysis of harbor towage operations is taken into account for this research. Certain risk factors were only present in Routine Ship Towage operations, and risk factor volumes were greater. Statistical testing of the relationship between

		individual risk factor and consequence significance revealed a link.
Analytical HFACS for investigating human errors in shipping accidents (Celik&Cebi, 2009)	HFACS - Quantitative - Accidents data - Industry (navigation)	This paper generates an analytical Human Factors Analysis and Classification System (HFACS), based on a Fuzzy Analytical Hierarchy Process (FAHP), in order to identify the role of human errors in shipping accidents.
Risk analysis as a basis for safety management system (Demichela, Piccinini, & Romano, 2004)	SMS - Quantitative - Facts - Industry	The paper shows, with a practical application, how the hazard identification and evaluation phase of the Safety Management System (SMS) in a major risk installation (as defined by EC Directive CEE 96/82 (Seveso II) is the sizing criteria for the whole SMS, with its procedures. Probabilistic risk assessment techniques are applied to a foaming agent production plant. The links between quantitative risk analysis steps and results and SMS procedure are explicitly shown. In conclusion, it is shown how a correct and careful risk analysis is necessary to design and implement a SMS able to pursue the policy's objectives allowing an effective revision of the policy itself.
Proposal for Global Standard Maneuvering Orders for Tugboats (A.Ishikura & K.Sugita, Y.Hayashi & K.Murai, 2013)	Quantitative - Accidents data	This research shows that there are "Non-standard" special maneuvering orders other than those "standardized," which causes such problems as a gap in perception between pilots a nd tugboat's operators, etc. The purpose of this paper is to research the de lay time between orders for and actions by tugboats and consider the Appropriate and safe timing of providing instructions to them, And then to propose globally authorized "Standard Maneuvering Orders for tugboats", discussing a problem in volved in the use of the special orders used in Japan, and the way in whic h tug orders are used in other countries.
Harbor Towage: Perfect or Imperfect. Competition in the Global	Operational risk Assessment - Quantitative - Facts	This paper explores the balance between the forces for competition and those for concentration and, furthermore, the implications for the future of the industry.

Market? (Merv Rowlinson,2002)		
Causal Analysis of a Tugboat Capsizing Accident in Rough Weather Condition Based on a Dynamical Simulation (Apeland, S., Aven, T., & Nilsen, T., 2002).	Operational risk Assessment - Quantitative - Facts	In this paper, the dynamics of a tugboat and a towed barge in conjunction with the external force and moment were established, and the possible input parameters and operational scenarios which might influence the large roll motion of the tugboat were identified. As a result of analyzing the simulated time history of the excessive roll motion of the tugboat, it was found that roll motion can take place when the tugboat is situated on the crest of a wave and when it is pulled by a towed barge through a towing line.
Safe tug operation: Who takes the lead? (Capt Henk Hensen, 2012)	Operational risk Assessment - Quantitative - Facts	This a Accident Case study, Tug operations near the bow of a ship having headway are very risky. The higher the ship's speed, the larger the risks. This is nothing new. The accident to the tug Fairplay 1, which came under the bow and was run down by the passenger ship Italia in Cuxhaven Roadstead, Germany, is a tragic example of a tug trying to make fast at the bow of a ship having headway. This accident also illustrates the risk to human beings on board the tug.
THEME **"Hazards elements Identification" of Maritime Accident (Not related)**		
The relationship between culture and safety on offshore supply vessels (Antonsen, 2009)	Checklist/safety audits – quantitative and qualitative – empirical data – industry	The paper examines the relationship between culture and safety on offshore supply vessels in the Norwegian petroleum industry, relying on both qualitative and quantitative data. The analysis makes a general description of cultural traits of the vessels studied, epitomized through the notion of 'good seamanship', and discusses the way these traits influence on safety.

2.8 Safety Management:

There are several major theories concerning accident causation, each of which has some explanatory and predictive value.

1.The domino theory developed by H. W. Heinrich, a safety engineer and pioneer in the field of industrial accident safety. See Figure 2.1

2. Human Factors Theory

3. Accident/Incident Theory

4. Epidemiological Theory

5. Systems Theory

6. The energy release theory, developed by Dr. William Haddon, Jr.,of the Insurance Institute for Highway Safety.

7. Behavior Theory

Accident theories guide safety investigations. They describe the scope of an investigation.

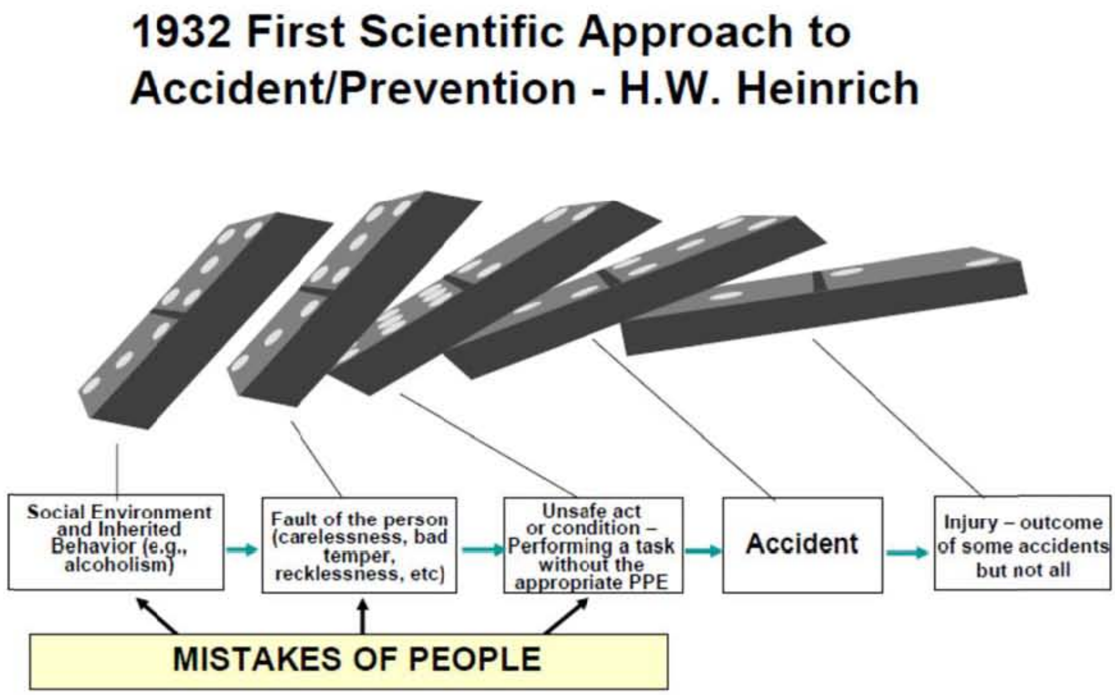


Figure 2.1 - First Scientific Approach to Accident/Prevention

A practitioner of this regulatory job is to plan and change produces, locations, missions to the body, conceptual, perceptional traits and constraints of those who can be employing them. Completed properly, the consequence must be less mistakes and damage; and humans must perform missions further successfully and proficiently (Kobayashi Hiroaki, 2006).

2.8.1 Clarifying Hazards & Risks

The UK Government, like many other countries, delegates the technical control of hazards to those who create them, concentrating their role instead towards policy making and assessment of safety related management systems (Hollnagel, 2000). Industry's answer is the use of *Risk Management* processes.

The British Standard BS4884-3:1996, identical to European standards IEC 300-3- 9:1995, provides guidelines to risk analysis and defines the following (BSI 1996):

- *Harm* – physical injury or damage to health, property or the environment.
- *Hazard* – a source of potential harm or a situation with a potential for harm.
- *Safety Risk Factors* – Similar to hazards, factors associated to risk of safety
- *Hazard identification* – the process of recognizing that a hazard exists and defining its characteristics.
- *Risk* – combination of the frequency, or probability, of occurrence and the consequence of a specified hazardous event.
- *Risk Assessment* – the overall process of risk analysis (identification and estimation) and risk evaluation (measurement and tolerance).
- *Risk Management* – the systematic application of management policies, procedures and practices to the tasks of analysing, evaluating and controlling risk.

BS4884-3:1996 explains that these concepts are unilateral to many disciplines, hazard groups and risk categories. Examples of these are given in Figure 2.2

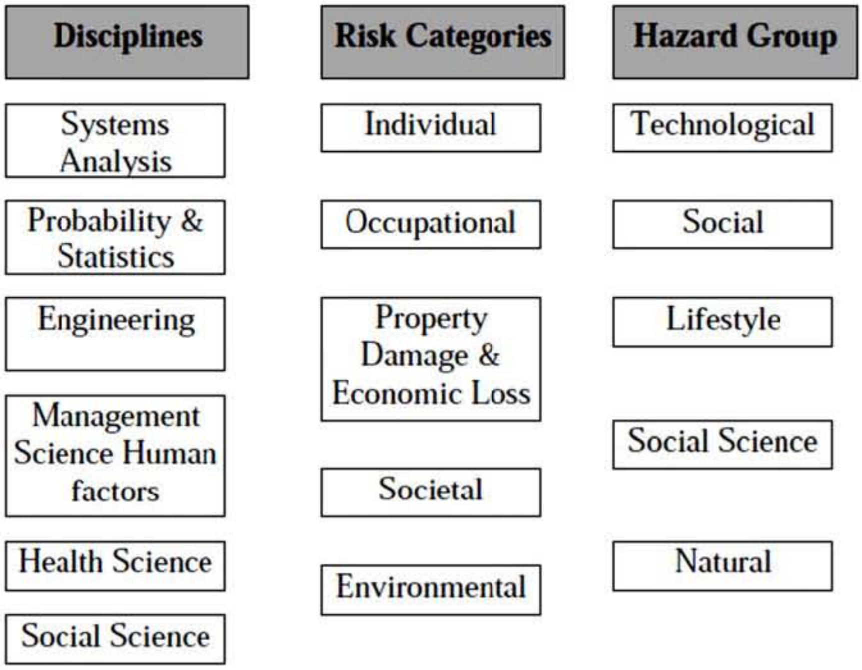


Figure 2.2 - Examples of Industrial Disciplines, Hazard Groups & Risk Categories
Source: BS4884-3:1996

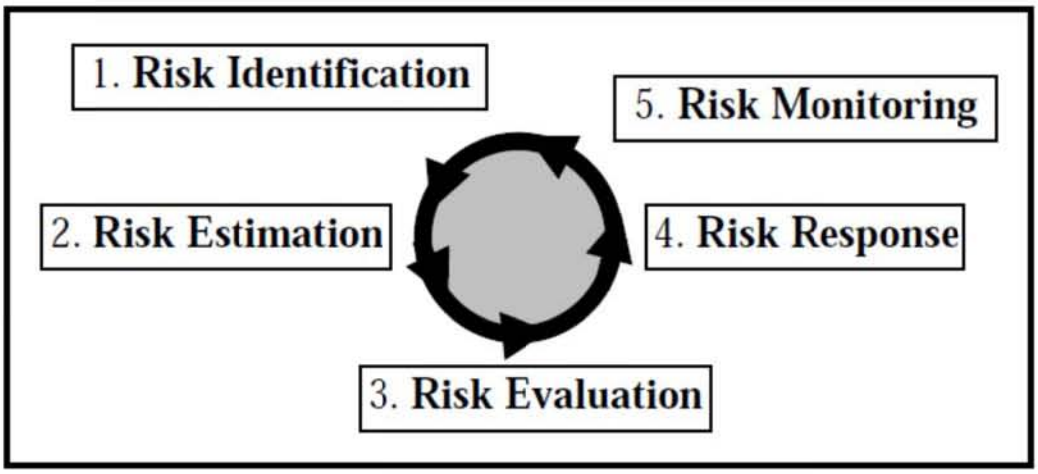


Figure 2.3 - Established Risk Management Cycle Adapted from Baker et al(1999)

The established *Risk Management Cycle* (RMC) is shown in Figure 2.3 (Baker *et al.* 1999). Although BS4884-3:1996 does not explicitly express each of these stages in this form, definitions from this document are paraphrased below:

Risk Identification is formalised after significant hazards have been identified. Hazard Analysis includes hazard identification, classification and assessment of associated mitigation techniques to establish whether hazards can be avoided or that they will not affect the dependability of a working system (Holdsworth & Smith, 2005). Where hazards

are eliminated and / or their consequences are deemed insignificant, analysis may be discontinued at this point and assumptions and deciding judgements documented.
The *Safety Management Flow Chart* in incorporates the hazard inputs and processes necessary to fulfil the five *RMC* processes (see Figure 2.4). This flowchart recognizes several important issues that are ignored in the established model, namely:

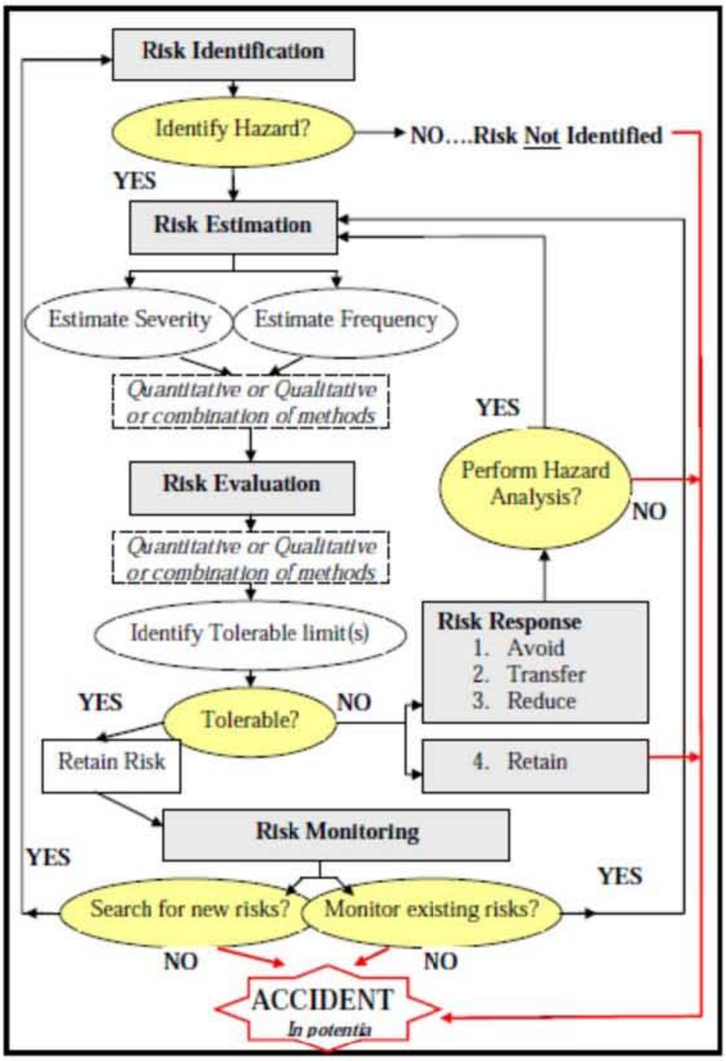
Complete dependence on hazard processes:

- *Hazard Identification*, acts as the main 'bottle neck' and barrier to risk identification.
- *Hazard Analysis* must be performed to allow estimation and evaluation of risks based on proposed responses.
- Internal cycle and iteration between risk evaluation and estimation stages based on hazard analysis process and results.

Continual improvement by searching for 'new risks' as well as evaluating previously identified risks, linking Risk Monitoring and Estimation stages.
Deviation from the model could result in accidents in 3 specific hazard related locations; *Risk Identification, Risk Evaluation* and *Risk Monitoring*.

These findings corroborate research linking confidence in risk management directly to the rigour and accuracy of hazard analysis (Smith and Harrison 2005).

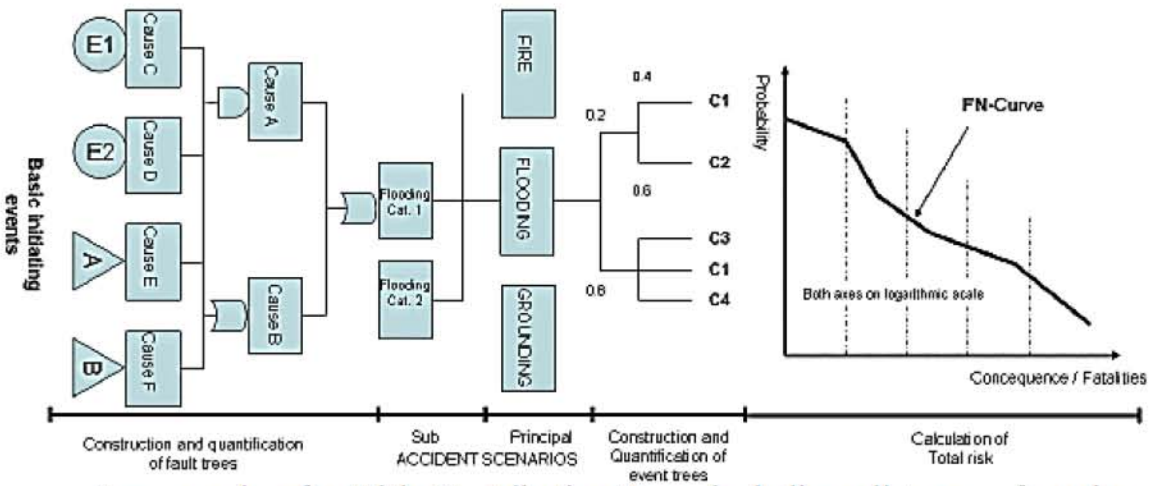
Figure 2.4 - Safety Management Flow Chart



Source: Smith and Harrison, 2005

2.8.2 Safety Theory – Accident Models & Risk Models

Accidents models are the base for the risk models. A capable risk model is termed to be more extensive than an actual accident model. There are different types of risk models particularly descriptive, explanatory, quantitative and qualitative. Better understanding of risk mechanism is provided by the descriptive risk models. However, the complex information is attained through quantitative and qualitative models. It is important that vital parameters and factors which contribute the risk models primarily to be included. By gathering all similar risk models together a tree of risk contribution is framed, see the below Figure 2.5.



An example of a Risk Contribution Tree, including all types of marine accidents with type specific fault tree and event tree, [Kristiansen, 2001].

Figure 2.5 - Risk Contribution Tree Example

The tree can be established either be a type of quantitative model or a type belonging to the qualitative model. The former type of model is feasible if the event and fault tree can be furnished with essential data which is quantitative and relevant to the risk contributions. The usage of the risk contribution tree can be done after this, for example the focus in the areas where risk control gives greater impact and at the same time done in an cost efficient way. The possibilities to improve the outcome i.e. decrease the probability and or the consequences depend on the stakeholder. A crew member, ship designer, owner of the ship and the administrator do not have similar alternatives available for risk reduction. However, by the use of proper risk models it will be easier to select the best alternative(s) in each case.

2.8.3 The Evolution of Safety:

Looking back we can see that the security, safety procedures specific to a messy asystematic has undergone a development from well-meaning, albeit collection process and quality. Piper Alpha served as the catalyst for this change. Once the SMS (Safety Management System) is the place to extend the range of other factors such as environmental and occupational health , leading to include the whole HSE is an integrated approach becomes possible.

The question now is, is there another stage or is the integrated approach the end of the story? The answer lies in the way in which safety management is carried out. Management systems are primarily rational inventions, defined on paper in offices and capable of objective evaluation in audits. The next stage is one in which the aims and intentions can be allowed to flourish, even if there are gaps. This is a situation in which formally undefinable characteristics such as enthusiasm, care and belief are to be found. The kind of organization that provides this support is a safety culture.

In a managed organization it is still necessary to check and control externally. In a safety culture it becomes possible to find that people carry out what they know has to be done not because they have to, but because they want to. It is at this point that worker involvement becomes both meaningful and necessary. Advanced safety cultures can only be built upon a combination of a top-down commitment to improve and the realization that the workforce is where that improvement has to take place. The workforce has to be trusted and has a duty to inform. What this means in practice is that in an advanced safety culture it becomes possible to reap extra benefits, beyond having fewer accidents, such as reductions in the audit frequency.

2.8.4 ISO Risk Management Process

A draft International standard 17776 (ISO 1999) related to identifying and assessing events in the offshore products installations which are hazardous gives an indication which is highly conventional of how the process of risk management can be made to fit according to the risk assessment.

Figure 2.6 - The Process of Risk Management (ISO 1999)

The first step of risk assessment is to identify the hazards. Then the risks arising from them are evaluated either qualitatively or, if appropriate, quantitatively. Risk reducing measures are introduced if the risks exceed "screening criteria". Once the necessary measures have been identified, the functional requirements of these measures should be defined.

2.8.5 IMO Formal Safety Assessment

As defined by IMO, FSA consists of a 5-step process, involving hazard identification, risk assessment, development of risk control options, cost-benefit assessment, and making recommendations for decision-making Figure 2.7. The determination of FSA is to provide and develop risk based regulation and it is not to be muddled with assessment of risk which is to support for a case of safety, which also used many such techniques. Application of FSA is done for ship types which are generic and this is also noticed as a substitute to safety case approach as it is generally considered that the shipping industry is not yet prepared to take up the safety case approach.

Flowchart for Formal Safety Assessment (IMO 1997)

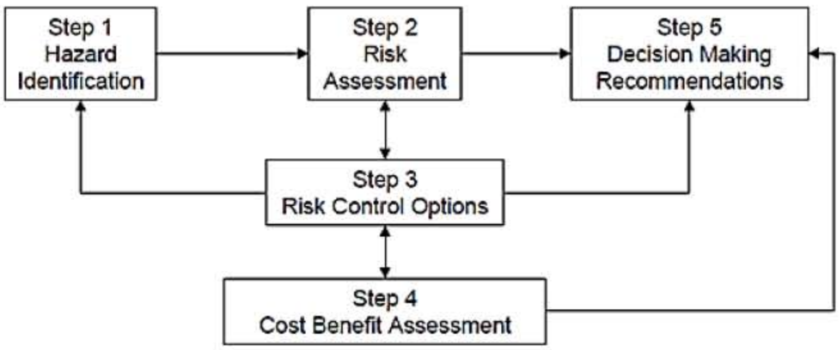


Figure 2.7 - Flowchart for Formal Safety Assessment (IMO 1997)

2.9 Gaps from Literature Review

1. There are no holistic studies on associated Hazards (safety risk factors) with respect to tugboat operation in Indian coastal waters

2. There is very limited literature available on tugboat-operation risk management practices (Best practices/ guidelines/procedures/system etc.) globally.

2.10 Research Problem

Hazard identification, which is a preliminary step of most of the safety model and risk related methodology, has not yet been done for tugboat operation in Indian coastal waters and that is leading to incomplete process of risk assessment. Consequently, Indian maritime Industry is not able to adopt or form required safety management practices.

2.11 Conclusions:

This chapter started with an objective to review existing research works on hazards associated with towage operation across the world. After getting clarity on issues like maritime safety, an attempt to gather research papers on maritime towage safety was made. Using a few words like 'towage operation', 'towage accidents', 'tugboat safety', 'tugboat operation safety', 'risk assessment towage', 'tugboat accidents' etc. the author gathered over 62 research papers. Research papers published in a total of 19 Journals were referred and 8 reports across the world, including India, were referred. The gathered research papers were then segregated on few broad themes. A review of these works led to identification of few research gaps and around 21 variables that are used by various researchers for assessment.

Chapter 3

RESEARCH DESIGN & METHODOLOGY

3.1 Introduction

This chapter details with design and methodology required for conduct of research study. A research design is a grand plan of approach to the topic being considered for research (Greener, 2008). In continuation of the literature review and theories of this study a conceptual framework for research question has been established and methodologies used in this study and were presented to show the approach towards the study followed by discussion of the validity and reliability of the study.

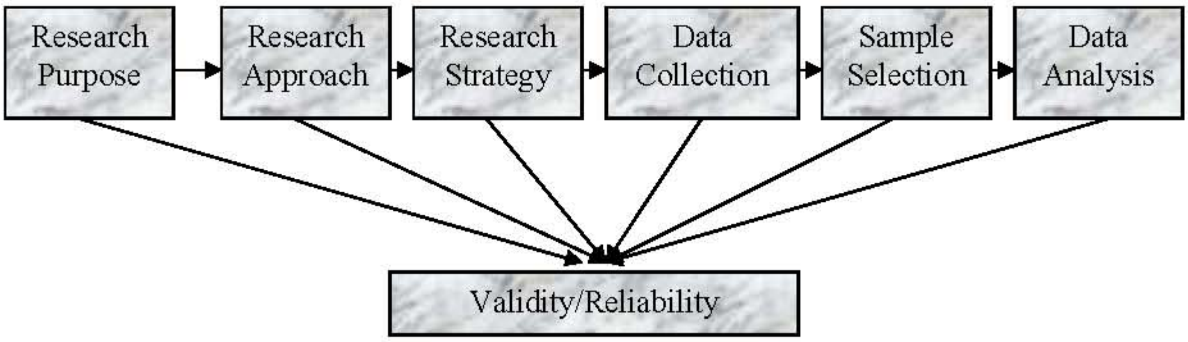


Figure 3.1 - Typological theory of project management
(Source: Shenhar, A.J. & Dvir, D. (2005) toward a typological theory of project management. Research Policy Vol. 25, No. 4, p. 607)

The objective of this research is to identify and quantify independent variables causing a threat to Routine Ship Towage safety, the dependent variable.

The difficulty of sampling a population not involved in safety incidents, in order to establish a control group, raised investigative problems. Experimental research would be an ideal methodology; however, it would not be practical or ethical to have accidents under controlled conditions, in order to determine Risk Factors.

Analytical survey, through exploration of associations between variables, was considered a more appropriate choice.

As an exploratory non experimental project, the research was not able to follow a highly structured deductive approach and control variables to generate data for analysis. The research relied upon a Phenomenological approach, gathering contextual descriptions of people's experiences, and as an open ended enquiry using active experience, it containing Heuristic elements.

The survey, sampling over a discrete 6 month period was cross-sectional; however it also relied upon data collection over a period of 10 years it incorporated longitudinal qualities.

3.2 Research Design

Ideally *Research Design* should be the general plan of how a researcher will go about answering the research question(s) (importance of clearly that defines research question cannot be over-emphasised). It should contain clear objectives, derived from the research question(s), specify the sources of probable data to be collected, and consider the possible constraints that a researcher will inevitably have (e.g. access to data, time, location and money) as well as discussing ethical issues (Saunders et. al., 2009). It explicitly addresses different scientific paradigms, scientific approaches, research approaches, research methods, research strategy, data collection method and data analysis strategy.

Research design is an overall approach and rationale for selecting a particular approach of study (Saunders et. al. 2009). A research design clarifies on the proposed study, the mode of inquiry (strategy) the researcher proposes to follow, and methods of data collection, analysis, and interpretation to be followed to arrive at some logical conclusions. The selection of a research design depends on the nature of research problem or issue being addressed, researchers' personal experiences, and target audiences for the study. From the above, a list of key contents of research design may be highlighted as follows:

a. Nature of the proposed study;
b. Purpose of the proposed study;

c. Location where the study is conducted;
d. Nature of data required;
e. Source of data collection;
f. Time period considered for the study;
g. Proposed type of sample design;
h. Techniques of data collection;
i. Methods of assessing data collected;
j. Manner of report generation.

3.3 Research Question

- What are the hazards associated with tugboat operation in Indian Coastal Waters?

- What are the known preventive measures practiced worldwide to mitigate these major identified hazards and which can be adopted by in Indian maritime industry?

3.4 Research Objective

The main objectives of the study are:

- First objective is to identify hazards which are threat to Routine Ship Towage operation safety in Indian coastal waters

- After achieving first objective, the second objective is to explore prevailing safety management practices worldwide, which can be used in Indian maritime industry.

3.5 Scope of the Study

The study attempts to explore the safety risk factors which are threat to Routine Ship Towage operation in Indian Coastal Waters. Study uses various research tools and techniques to collect samples such as 10 years database of accidents or incident related to harbor towage, survey through questionnaire of industry experts and semi-structure interview of experienced professional from same industry. The other objective is to explore safety management practices adopted by industry leaders for their organizations to mitigate identified safety risk factors. So the scope of study is to identify hazards and put forward the solutions to mitigate those hazards. This research doesn't answer which solutions or results are better or why it is been adopted by industry.

3.6 Nature of Research Questions

Both the research questions (RQ – 1 & RQ – 2) are explanatory in nature as they seek to explore the problem and solution respectively. Research question 1 is aimed to explore the safety risk factors which are threat to Routine Ship Towage operation in Indian Coastal Waters and Research Question 2 is to explore current safety management practices adopted by industry leaders for their organizations to mitigate identified safety risk factors. So the temporal focus of this study for RQ 1 would be towards backward looking and RQ2 would be current looking (in Grey & Blue Colour respectively) in the following Table 3.1.

Type of RQ	Backward looking	Current	Forward looking
Exploratory	Exploratory backward looking	Exploratory Current	Exploratory Forward Looking
Less factual, more oriented towards understanding a trend/pattern	What could have been done? What would have made more effective? Yin (2003) Exploratory what questions	What could be done in this situation? What is the background of this trend? Yin (2003) Exploratory what questions	What will happen? What will be the impact of this initiative? How will people respond? Yin (2003) Exploratory what questions?
Descriptive and predictive	Descriptive backward looking	Descriptive current	Descriptive forward looking
Factual representation or estimation of study object	What were the outcomes of this strategy? How many projects have met expectations? Yin (2003)	How many firms employ thee processes? Who are currently involved in this	What will be the outcome of adopting the processes? Yin (2003) Inventory what

	Inventory what questions, who what where questions	project? Yin (2003) Inventory what questions, Who what where questions	questions, who what where questions
Explanatory	Explanatory backward looking	Explanatory current	N.A
Factual, focused on understanding a limited number of events	What happened? Why did it happen? What is the current status? Yin (2003) How, why questions	What happened? Why did it happen? What is the current status? Yin (2003) How, why questions	N.A
(Source: Yin, 2003)			

Table 3.1 - Temporal Orientation of Research Questions (RQ)

3.7 Selected Strategies of Inquiry

The strategies of inquiry relate to the quantitative, qualitative, and mixed methods of study through which the research is actually implemented. The strategies of inquiry have evolved over a period of time and with the availability of numerous computer technologies have push forwarded the ability of data analysis. Ability to analyze complex models have helped researchers to articulate new procedures for conducting social science research.

A paradigm or world view is a "basic set of beliefs that guide action". These beliefs are called as philosophical assumptions, epistemologies, and ontologies (Crotty, 1998); broadly conceived research methodologies (Neuman, 2000); alternative knowledge claims (Creswell, 2003); philosophical worldviews (Guba, 1990); and philosophical paradigms (Lincon & Guba, 2000; Mertens, 1998) by many other researchers. The four philosophical paradigms that inform qualitative research include postpositivism, constructivism, advocacy/participatory, and pragmatism (Creswell, 2003) are further explained as under:

3.7.1 Postpositivist paradigm

This paradigm comes from 19th century writers such as Comte, Mill, Durkheim, Newton, and Locke (Smith, 1983). Assumptions of this paradigm represent the traditional form of research that hold good for quantitative research rather than qualitative research. This is also called scientific method or doing science research. It is also termed as positivist/postpositivist research, empirical science, and postpostivism. Researchers supporting postpositivist approach advance closer to truth while recognizing that discoveries as only partial segments or estimates of truth (Clark, 1998). Studies in this paradigm hold a deterministic philosophy that causes probably determine outcomes (Creswell, 2009). Therefore, problems studied reflect the need to identify and assess the causes that influence outcomes. It can also be reductionist with an intention to reduce ideas into small, discrete set of ideas.

Postpositivists studies are based on assumptions such as (Phillips & Burbules, 2000):

a. Knowledge is hypothetical and absolute truth can never be found. Thus, researchers instead of proving hypothesis, indicate a failure to reject a hypothesis.
b. Research is a process of making claims followed by refining or deserting some of the claims for others that are more warranted.
c. Data, evidence, and rational considerations carve knowledge. In practice, researchers gather information on instruments based on measures completed by the participants or by observations recorded.
d. Research seeks to devise relevant true statements from the outcome which can serve to explain a situation of concern or describe the casual relationships of interest. Under, quantitative studies, researchers advance these relationships among variables and pose them in terms of questions or hypothesis.

Four Paradigms (Worldviews)	
Postpositivism	**Constructivism**
• Determination • Reductionism • Empirical observation and measurement • Theory verification	• Understanding • Multiple participant meaning • Social and historical construction • Theory generation
Advocacy/Participatory	**Pragmatism**
• Political • Empowerment issue-oriented • Collaborative • Change-oriented	• Consequences of action • Problem-centered • Pluralistic • Real-world practice oriented
Source: Adapted from Creswell, Qualitative Inquiry and Research Design, Pg. 19-30, Sage	

Table 3.2 - Four Paradigms (WorldViews)

3.7.2 Constructive Paradigm:

This has evolved from the works of (Berger & Luckmann, (The social construction of reality) 1967, Lincoln & Guba, 1986). This is based on the assumption that individuals wish to understand the world in which they live and work (Lincon & Guba, 2000; Schwandt & Marquardt 2000; Neuman 2000; Crotty 1998). Individuals develop subjective meaning based on their experiences which are varied and multiple and lead the researcher to look for the complexity of views rather than narrowing meanings into a few categories or ideas. Meaning is derived with an interaction between the interpreter and the interpreted (Crotty, 1998). Researchers aim to depend on participant's view on the situation being studied to the maximum possible level. The questions are broad and general giving an opportunity to the participants to construct the meaning of a situation, typically involved in discussions or interactions with other persons. Usage of open-ended questions gives ample opportunity to researcher listen carefully to the opinion of participants. The researcher's aim to make sense of the meanings others have about the world rather than starting with a theory that inquirers generate or inductively develop a theory or pattern of meaning.

Assumptions of constructive Paradigm (Crotty, 1998)

a. Meanings are constructed by human beings as they get involved with world they interpret. Qualitative researchers tend to employ open-ended questions to facilitate participants share their views.

b. Human beings engage with the world they live and make sense of it based on their historical and social perspectives. Therefore, qualitative researchers wish to understand the context of participants through visiting this context and gathering information personally. They also interpret what they notice which is based on their own experience and background.

c. The basic generation of meaning is often social, budding in and out of interaction with human community. The process of qualitative research is generally inductive, with the inquirer generating meaning from data collected from the field.

3.7.3 Advocacy/Participatory Paradigm:

Researchers (Fay, 1987; Heron & Reason, 1997; Kemmis & Wilkinson, 1998) propounding this paradigm feel that research inquiry needs to be intertwined with politics and political agenda. Therefore, research includes agenda for reform that may change the lives of participants, institutions for which individuals work, and the researcher's life. Some of the writers like have drawn their propositions from the works of Marx, Adorno, Marcuse, Habermas, and Freire (Neuman, 2000). Specific issues addressing prevailing social concerns are addressed. This research assumes that the inquirer will proceed collaboratively so that no further marginalization of the participants happens with the results of the inquiry. This gives a chance for participation of the participants even in designing the questions, collection of data, analysis of information, or in any other requirement of the research. Thus, this becomes a proactive and participative methodological study.

Features of Participatory Paradigm (Kemmis & Wilkinson, 1998)

a. Participative action is recursive and focusses on bringing about change in practices and thus, researchers advance an action agenda for change.
b. This type of inquiry helps individuals to free themselves from constraints found in media, in language, in work procedures, and in the relationships of power in educational settings. These studies are initiated with an important issue concerning the society.
c. These studies are emancipatory and help unshackle people from the constraints of irrational and unjust structures that limit self-development and self-determination. These studies aim to create political debate or discussion for a possible change.
d. It is practical and collaborative as it is done with other rather than on or to others.

3.7.4 Pragmatic Paradigm:

This paradigm has stemmed from actions, situations, and consequences rather than antecedent conditions. Pragmatism is derived from the works of Peirce, James, Mead, and Dewey (Cherryholmes, 1992). Recent research works on pragmatic paradigm include (Rorty, 1990; Murphy, 1990; Patton, 1990; and Cherryholmes, 1992). Instead of focusing on methods, researchers stress on the research problem and use all approaches available to understand the problem (Rossman & Wilson, 1985). This paradigm is not committed to any single system of philosophy and reality. This is applicable to mixed methods research where inquirers draw liberally from both quantitative and qualitative assumptions of the engaged research (Tashakkori & Teddlie, 1998; Patton, 1990).

Assumptions of pragmatism studies (Cherryholmes, 1992; Murphy, 1990; Crewsell, 2003):

a. Individual researchers are free to choose the methods, techniques, and procedures of research that suits their needs and purposes.
b. Researchers look to many techniques for collecting and analyzing data rather than sticking to one single way.

c. Researchers use both quantitative and qualitative data as they work to provide best understanding of a research problem.
d. Researchers should establish a purpose for their mixing, rationale for the reasons why quantitative and qualitative data need to be mixed in the first place.

3.8 Paradigm Selected for Current Research:

The current research focuses on both quantitative and qualitative data pertaining to Indian coastal waters for a period of 10 years and participants from same region having experience not less than 20 years. Therefore, the research is based on Pragmatic Paradigm. The research is aimed to identify hazard and explore available control measures. Instead of focusing on methods, researcher stressed on the research problem and uses all approaches available to find and understand the problem researcher has used mixed methods research where inquirers draw liberally from both quantitative and qualitative assumptions of the engaged research region by collecting data pertaining to various incidents occurred or experienced.

3.9 Framework of Research Design:

Research design is a plan or proposal for conduction of research and involves the intersection of philosophy, strategies of inquiry, and specific methods. While planning a study, researchers think through the philosophical worldview assumptions that they bring to study, the strategy of inquiry that is related to this worldview, and the specific procedures or methods of research that transform the approach into practice. Quality of research design improves trustworthiness of the entire research (Yin, 1994). For being worthwhile a research must maintain “truth value”, “applicability”, “consistency”, and “neutrality”, however, nature of knowledge inside the rationalistic (quantitative) paradigm would be different from the knowledge in naturalistic (qualitative) paradigm is different from knowledge in naturalistic (qualitative) paradigm (Guba & Lincoln 1981).

The framework for research design may be explained in the following manner.

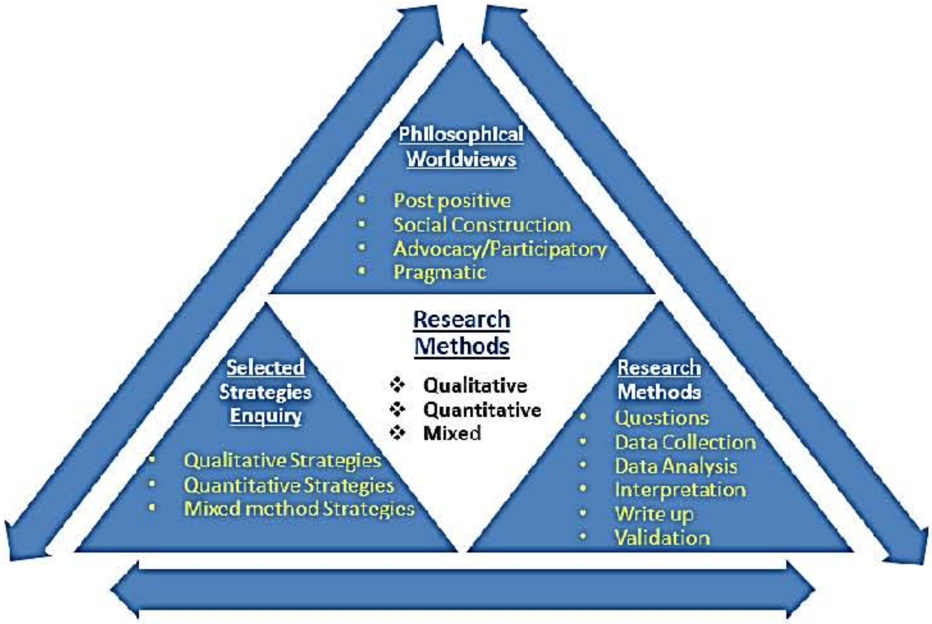


Table 3.3 - Framework for Research Design
The Interconnection of Worldviews, Strategies of Inquiry, and Research Methods
Source: Author Drawn

3.9.1 Types of Research Designs:

Research design can be broadly classified as Qualitative Research and Quantitative Research. There is a criticism that research design has been gendered (Oakley, 1997; 1998), with quantitative methods linked with words like positivism, scientific, objectivity, statistics and masculinity. On the other hand, qualitative methods have are generally associated with interpretivist, non-scientific, subjectivity and femininity (Fielding & Schreier, 2001).

Alternative strategies of inquiry	
Quantitative	**Qualitative**
• Experimental design • Non-experimental design like surveys	• Narrative research • Phenomenology • Ethnography • Grounded theory studies • Case study
Source: Research Design, Creswell, 2003, pg. 13.	

Table 3.4 - Alternative strategies of inquiry

3.9.1.1 Quantitative Strategies:

Quantitative Research is an approach with a focus on testing or measuring or examining considerable data. In this approach the investigator uses post-positivist claims for developing knowledge (including cause and effect thinking, reduction to specific variables and hypothesis and questions, use of measurement and observation, and the test of theories) employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data. The research involves establishing relationship between variables and deriving of inferences by comparing these variables (Creswell, 2013; Kleinbau & Kupper, 1982).

- **Experimental design** – it aims to determine if a particular treatment influences an outcome. The impact is assessed by giving a specific treatment to one group and withholding it from other group (Keppal, 1991). Results are derived by checking the difference, if any, in performance of both groups.

- **Survey design** – it provides a numeric or quantitative description of attitudes, trends, or opinions of population by studying a sample of such population. It involves cross-sectional and longitudinal studies using questionnaire or structured interviews for collection of data with an intent to generalize from a sample to a population (Pinsonneault & Kraemer, 1993).

3.9.1.2 Qualitative Strategies:

Qualitative research is employed on data which does not indicate any ordinal values (Fraenkel & Wallen, 1993). Qualitative research is a means to explore and understand the meaning individuals or groups attribute to a social or human problem (Creswell, 2013). It also attempts to get an in-depth opinion from participants. The research process includes emerging questions and procedures; data typically collected in the participant's setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data. The final written report has a flexible structure. (Creswell, 2007).

Methodologies of qualitative research include:

- Narrative research – a researcher works in close collaboration with a group to improve a situation in a particular setting by actually working with them by being a facilitator (Sandelowski, 1991). Therefore, researchers are good at group management and understand group dynamics (Kitzingar, 1995).

- Phenomenological research - a strategy of inquiry in which the researcher traces the essence of human experiences regarding a phenomenon described by participants (Groenewald, 2004). Assessing the live experiences makes phenomenology both as a philosophy and also as a method. The process requires the researcher to set aside his or her own experiences in order to understand those of the participants involved in the study (Thompson et. al. 1989).

- Ethnography – routed from anthropology (Stocking, 1984; Clifford & Marcus, 1986), a popular mode of inquiry where anthropologists travelled across the remote tribes across the world. Ethnography emphasise on describing and interpreting cultural behavior by mingling with the group being studied to understand their lives and culture (Gregory, 1983).

- Grounded theory – often applied in education and health research studies is based on data. It is a method of explication and emergence (Charmaz, 2008).This methodology is depended on generation of theory that is grounded on data. In this theory, methods like focus groups and interview tend to be the choice of data collection method, along with an exhaustive literature review that takes place throughout the data collection process (Eisenhardt & Graebner, 2007). The researcher collects data until a point of '*saturation*' is reached (Suddaby, 2006).

- Case reports – a mode of inquiry where the researcher probes in depth a program, event, activity, process, of one or more individuals. These studies are bounded by time and activity, and researchers collect detailed information by applying a wide variety of data collection procedures over a sustained period of time (Baxter & Jack, 2008).

Features of Quantitative and Qualitative Methods	
Quantitative Methods	Qualitative Methods
• Pre-determined • Instrument based questions • Performance data, attitude data, observational data, and census data • Statistical analysis • Statistical interpretation	• Emerging methods • Open-ended questions • Interview data, observation data, document data, and audio-visual data • Text and image analysis • Themes, patterns, and interpretation
Source: Creswell, 2007	

Table 3.5 - Features of Quantitative and Qualitative Methods

3.10 Rational of the Research:

- From the **business perspective** this research study would help the top management of tugboat operator company and policy maker in India to understand the safety issues in marine industry with respect to the Tugboat operation and further this will help them to explore relevant strategies to mitigate such issues adopted by operators in other countries.

- From **academic perspective**, the researcher would be able to understand the marine safety issues during the tugboat operations. This research has extended studies in Maritime HSE management, specifically adding inputs to preliminary steps of safety theory (Accident & Risk Model) & Risk analysis methodology such as Risk Management Process ISO 1999 and for maritime FSA (Formal Safety Assessment- IMO 1997). Researchers can do further studies on risk assessment & evaluation.

3.11 Research Method:

To achieve first objective (RO 1), the three research methods were adopted:

1. Questionnaire survey of practitioners' professional experience.
2. Quantitative sampling analysis of existing accident Investigation Report/Case Study data;
3. Semi-Structured Interview (Marshall, 1996) qualitative Interview and observational analysis of expert witness opinion;

The first stage consisted of a questionnaire survey of current practitioners. Questionnaire was designed basis literature review. This used a Likert style questionnaire (Social Research Methods, 2006) to enable comparison of independent variables and to cross check results. Its purpose was to provide specific contemporary figures, to help identify patterns of safety incident type, cause, result, frequency and criticality. Factor analysis was done with the help of PCA subsequently significance test between risk factors and consequences.

The second stage consisted of an analysis of secondary data followed by statistical testing, to establish any correlation. The use of minimum 175 Investigation report/Case reports aimed to reduce sampling error. A Chi Square test was performed to test Null Hypothesis to compare Routine Ship Towage (RST) and Non Routine Ship Towage (NRST) operations. This was to find out whether there is any detectable difference between RST & NRST operations. During the process Factor Analysis was carried out, key safety Risk Factors was identified, critically evaluated and categorised. Their likelihood and severity was measured, and this information was used to test hypotheses.

The third stage involved interviews of experts in Indian subcontinent. Variables identified in first & second stage was used to frame questions. This was to explore other variables that were not identified in first and second stage, in addition, other is to get the depth of perception. The interview was semi-structured with judgmental sampling (non-probabilistic sampling).

Since each technique was different, some adjustment was necessary to enable comparison of the three separate samples and allow triangulation (Holtzhausen, 2001) to help validate conclusions.

However, to achieve second objective (RO 2) i.e to explore prevailing Tugboat Operation safety management practices/methods/set of guidelines adopted by various tugboat operation experts around the globe to mitigate similar safety risk factors, personal interviews were conducted through skype/telephone and email exchanges. Set of questions relevant to identified risk factors were asked to subject experts to explore management practices and validate findings from objective one. The interviews were semi-structured with judgmental sampling (non-probabilistic sampling).

3.11.1 Primary Data

3.11.1.1 Questionnaire Survey

A Semi Structured questionnaire approach was selected to gather primary data:
As it provide a systematic quantitative measure, describing, comparing and explaining contemporary factors effecting Routine Ship Towage operations safety (Sapsford, 1999); enabled gathering large volumes of information over a short time period, from across the globe.

The questionnaire process was planned to ensure systematic data collection; efforts were made to standardise the process and eliminate error, by following set procedures and keeping robust records.
The questionnaire was divided into five sections (See Table 3.6.). Most questions were close, dealing with factual, measureable information; although there are opportunities to provide additional alternatives or descriptive facts.

Section five uses a unipolar, Likert, forced choice, response scale, to grade degree of applicability. This is to choose to reduce selection of a middle 'neutral' option, and to motivate greater consideration of all explanations.

Section	Purpose
1	Instructions and further information concerning the research project.
2	Factual details concerning the particular Routine Ship Towage operation.
3	Environmental factors affecting the operation.
4	Details of the risk or safety issue encountered.
5	Risk Factors considered to be causing the risk or safety issue.

Table 3.6 - Questionnaire Sections (RO1-QU)

Process

A pre-test survey was conducted, by providing the draft questionnaire to two non-participants, to check for comprehension, construction and clarity. See Appendix II Questionnaire.

To maximise participation, a publicity plan was followed (*See Table 3.7*). This enabled identification of potential sources and methods to advertise the project. The Internet and electronic communications media was the key to ensure global participation, in the short time frame available.

Research Participants

Target group	Method of publicising
Harbour Towage Organisations	Conference, Seminar- Hardcopy of Questionnaire, Direct email, provision of electronic questionnaire, and follow-up correspondence to relevant organisations.
Professional Mariners	Conference, Seminar- Hardcopy of Questionnaire, Contacted various Stakeholder, Associations, with a press release and followed it up with correspondence.
Pilotage Groups	Email communication, electronic questionnaire, and follow-up correspondence.
Harbour Towage Enterprises	Post Mail/email, e-questionnaire, & follow up communication.
Professional Contacts	Post mail/e-questionnaire.

Table 3.7 - Research Participants (RO1-QU)

Sample size

Sample size has an effect on how the sample findings accurately represent the population (Cresswell, 2013). The larger the sample is, the more likely that the generalisations are an accurate reflection of the population (Saunders, Lewis & Thornhill, 2009).

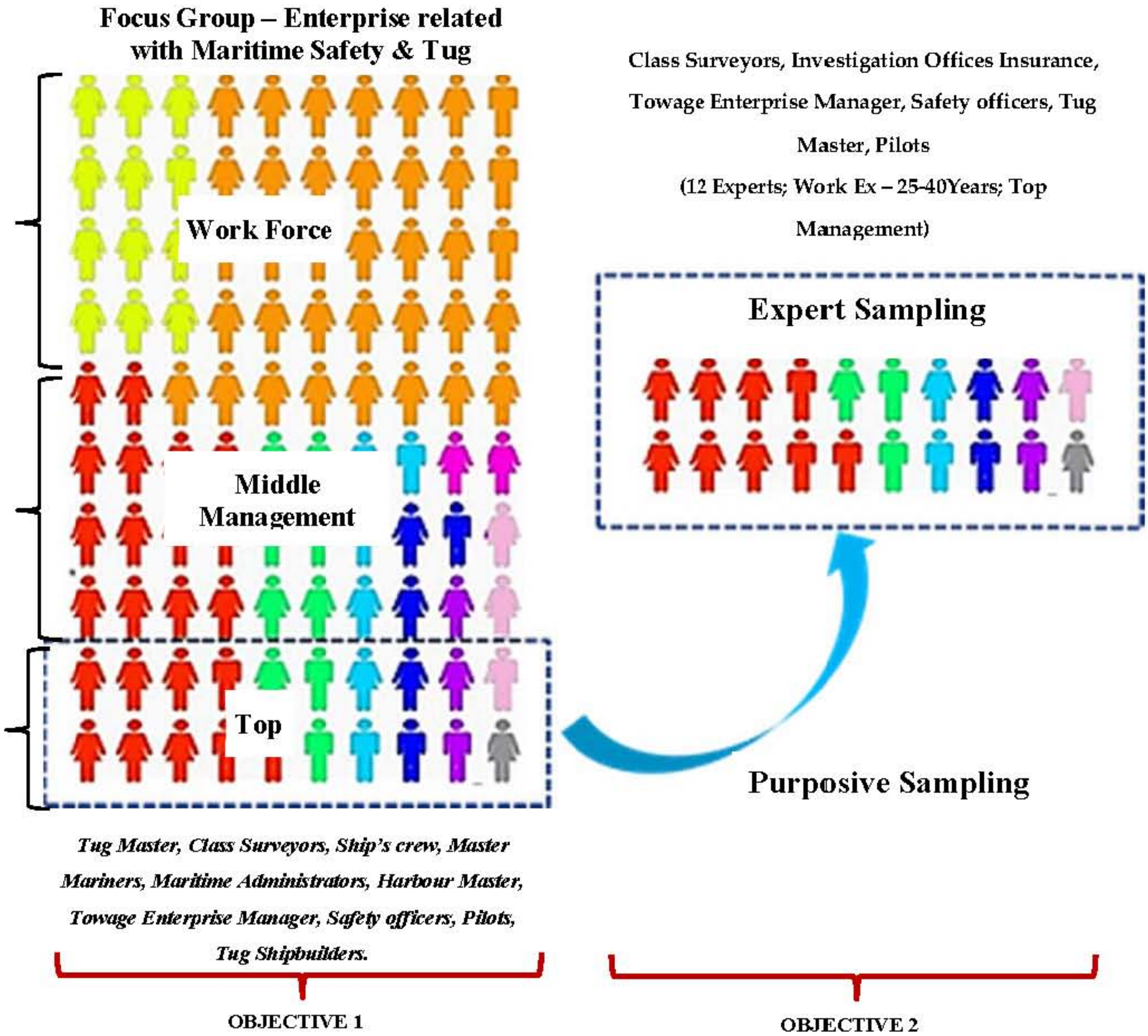
Sample sizes depend on factors such as the time and money available to collect the data (Hair 2006); they also depend on the statistical analysis used in the study (Saunders, Lewis & Thornhill, 2009). According to Hair (2006), small or very large samples have a negative impact on the statistical tests because either the sample is either not big enough to make generalizations or too big to reach any conclusions.

Tabachnick and Fidell (2007) established that a sample size of 300 is adequate for factor analys is. In general, there has been an understanding among authors of statistical books that the larger the sample the more appropriate it is for factor analysis (palla nt, 2007).

Hair (2006) suggested that a sample size larger than 100 is needed for factor analysis and as a general rule of thumb, the observations should be 5 times the number of variables. The number of variables in this study before factor analysis is 20 variables which suggests that the sample size should be larger than 100.

Non-probability Sampling

It refers to objects that are selected based on the judgment of the researcher and usually generalizations from this method are possible, although not by using statistical techniques. According to (Keppal, 1991) statistical inferences are not appropriate when non-probability sampling is the technique used.



3.11.1.2 Semi-Structured Interview

A Semi-Structured Interview qualitative research process was selected because in contrast with the other techniques it was explicitly emergent;

- it allows the study of social interactions & behaviour, measuring attitude & opinion, as integral factors;
- it allows an in-depth exploration of this relatively new area, where previous research is limited.

The first stage of the process, involved a literature review. The interview process and analysis was then planned, to establish systematic sampling and data collection.

Research Participants

A Judgement sample of expert interviewees was targeted: those with over 20 -40 years of professional experience (a period during which practitioners might reasonably be expected to have encountered a range of Routine Ship Towage operations safety issues). To maximize variation in experience and avoid subject bias, experts from contrasting operations, management and regulatory roles was selected, from:

- Tug Handlers;
- Harbour Pilots;
- Harbourmasters;
- Maritime Legislators.

All interviewees were volunteers and no pressure was applied to participate. Before interviews commence, the process was risk assessed and interviewees was informed of the purpose of the research.

To ensure confidentiality, only one transcript was produced for each interview, this was maintained as a controlled document, and no details of interviewees were released to third parties.

Process

Initial contact was made with potential expert interviewees; after they agree to participate, a date was decided for subsequent interview. On the agreed date the interview was conducted, following recommended guidelines (Tellis, 1997).

Interviews was semi-structured, with the participant was asked to describe and reflect upon experiences of Routine Ship Towage safety, using a series of short, clear prompt questions, concerning tug operations and potential threats to safety, where necessary. This was commenced with 'Open-ended Questions' (Charmaz, 2006) concerning the experts background and views on Routine Ship Towage safety. 'Intermediate Questions' was then probed deeper into safety issues, and 'Ending Questions' for any concluding remarks.

Interview process and analysis was simultaneous; the first interview was to provide an initial question framework, while subsequent interviews evolved iteratively, allowing enquiry to focus upon apparent patterns (Hoda, 2011). Emerging codes, concepts, and categories helped structure and systematically capture information from subsequent interviews (Strauss and Corbin 1994). Written transcripts provided additional observations, further insight and validation of themes. See Interview Transcripts in Appendix VIII.

During coding, the transcript data was gone through several times to get a general impression and to identify the major ideas, unusual events and deviant cases. It was then progressively ‘chunked’ into sentences or phrases, to allow ‘Open Coding’ (Hallberg, 2006).

Constant comparison was used ‘Selectively Code’ material into concepts, and to identify ‘Core Categories’ (central themes, reoccurring most frequently, and related to main categories). The text will be systematically marked with the codes or categories.

Once the interviews get coded and categorised the resulting Semi- Structured Interview were triangulated with the other research techniques.

3.11.2 Secondary data

The research employed two stages of secondary data collection. The first stage was a preliminary exploration of the issues, to ensure a full range of incidents and factors to investigate. The second involved collection of a portfolio of Investigation reports and Case reports from the databases of independent Investigation agencies and bureau for Indian coastal water incidents.

A mixture of textbooks, journals and articles were investigated relevant to Indian coast. This included Maritime Safety Agency, tug company, harbour authority and other organisation safety incident reports (MAIB, 2012; DSB, 2011). Manuals and professional books provided specialist technical advice on safety risk factors and best practice guidance (Slesinger, 2010; Livingstone, 2006). Trade and industry journals afford additional expert opinion and contextual information (International tug and OSV Magazine, 2013).

3.12 Research Approach:

There are two most important methodological approaches available which are extensively used within the social science; quantitative and qualitative research and what kind of information that is studied would decide which approach to choose (Groenewald, 2004).

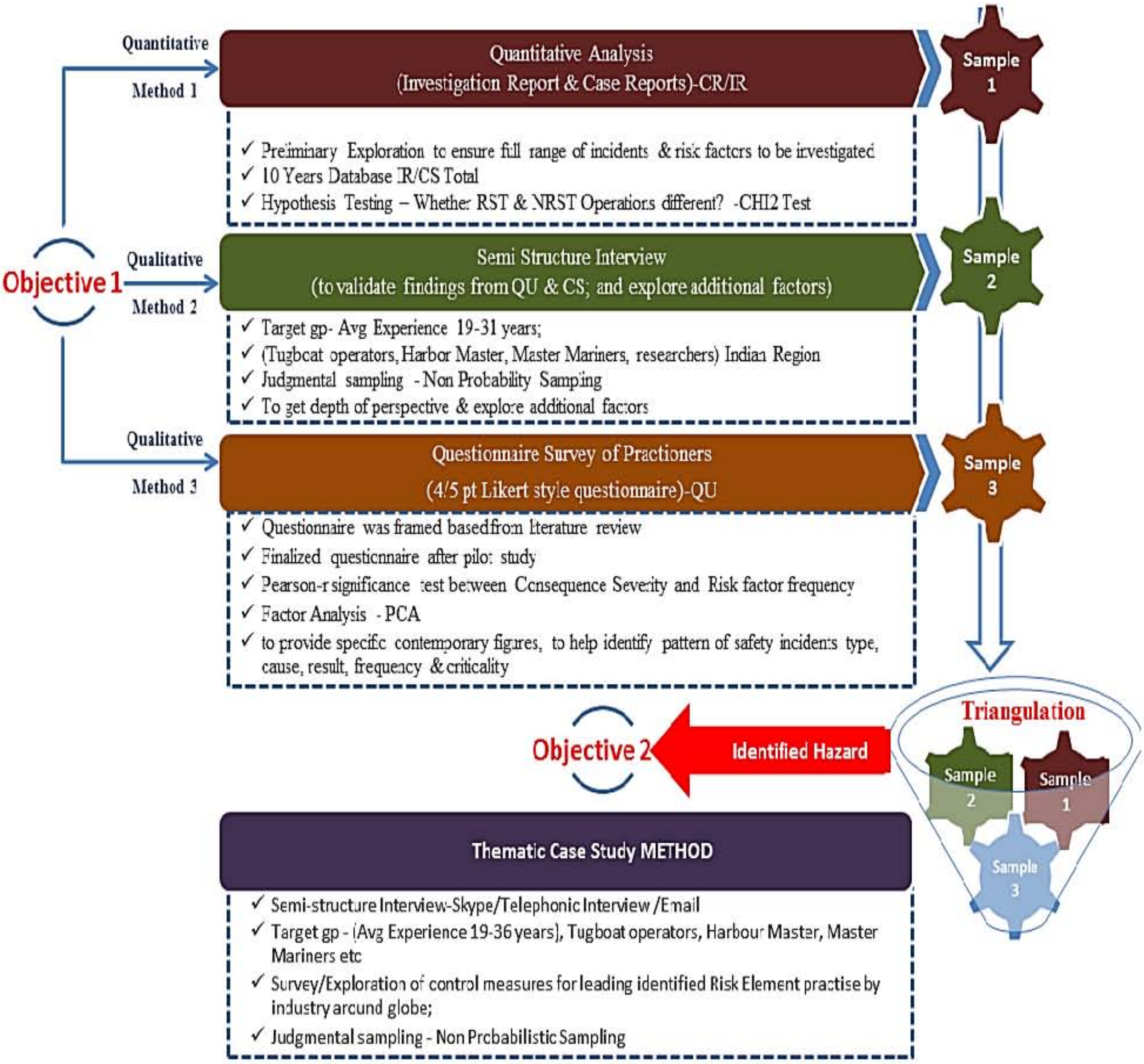


Figure 3.2 - Research Approach

Source: Author Drawn

3.12.1 Research Objectives 1 (RO1)

3.12.1.1 Case Report Account (CR)

This method comprised of an analysis of secondary data (top classification society database located in Indian subcontinent) and statistical testing in order to assess any correlation. Application of one hundred seventy five Case reports intended to reduce sampling error.
The process was divided into two stages. The stage comprised of comprised of preliminary investigation of issues, a complete series of incidents and factors involved were explored in order to be ensured. In second stage portfolio of Case reports from the databases of five states were collected.

A number of journal, articles , reports and books were consulted including Tug Company, Maritime Safety Agency, harbour authority and other organisation's safety incident reports (MAIB, 2012; DSB, 2011).Books and manuals providing special technical advice on safety risk factors and best practice guidance (Slesinger, 2010; Livingstone, 2006) were thoroughly examined. Journals on trade and industry were also consulted (International tug and OSV Magazine, 2013).

To avail current information, database and internet search engines were used (Intute, 2006). Internet was also proved to be useful in accessing university library, government and company databases (KMSB, 2012; EMSA, 2012).

Except consulting literature online, internet was proved to be a useful way to contact with persons and organizations (International Tug masters Association, 2012; UK Harbour Masters Association).

An excel worksheet was used based on an accident data sheet shared by the regional office of a classification society to collect the data on risks to safety in harbour towage operations. Recent accident Case reports were used to collect data on risks to safety. Information received from this data was analysed in order to ensure quality and validity of data.

Case reports provided by classification societies and government agencies were accepted only and date of incident and names were also rechecked in order to prevent duplication.
The following generic data was derived from Case reports and filled in to the Excel Spreadsheet Incident type and consequence: collision or grounding; damage or injury; Prevailing environmental conditions: weather& sea state; Towage operation particulars : tug type& tow point, Findings concerning analysis, causes and conclusions: contributing factors, risks& potential solutions.

Risk Factors were classified under generic headings derived from maritime safety reports. Missing of particular factor was recorded if that factor was reported to be a cause of accident: for instance if inadequacy in safety management systems was identified than this would be recorded as Risk Factor: 'Safety Management System'.

Irrelevant cases studies containing insufficient verifiable facts were identified and separated. Rest of the Case reports in which it is mentioned as deep sea towing or not engaged in towing were classified as Non Routine Ship Towage (NRST).

A total of 175 Case reports (CR) were selected from five Indian states. 15 CR were inadmissible through insufficient validation (See Table 3.8). Out of 160 were admissible CR, 175 were classified as Routine Ship Towage (RST) and the remaining 34 Non Routine Ship Towage (NRST).

State	Inadmissible Case reports	Routine Ship Towage	Non Routine Ship Towage	Total
Gujarat	2	31	5	38
Maharashtra	5	26	11	42
Karnataka	6	28	2	36
Tamil Nadu	2	20	6	28
Andhra Pradesh	0	21	10	31
Total	15	126	34	175

Table 3.8 - Distribution of RST and NRST Case reports (RO1-CR)

3.12.1.2 Questionnaire Survey Account (QU)

Questionnaire survey method was adopted to assess the practitioners' professional experience in this research. To compare independent variables and to cross check the results, Likert Style questionnaire was utilised (Social Research Methods, 2006). It was aimed at generating particular contemporary data in order to identify model of types of safety incidents, their frequency and criticality, cause and results.

The main challenge faced at the time of research was to establish a control group who are involved in safety incidents. As already discussed, the best method was to adopt an experimental approach but that would not be ethical and practical to have accidents in controlled circumstances to determine the risk factors involved in towage operation. Therefore, to explore the association between variables, analytical survey was chosen. The methodology would be required for statistically skewed distributions as sample population studied represented a particular segment.

This research was not subjected to extremely structured deductive approach and not able to control variables in order to generate data for analysis because it is an exploratory non-experimental research. Therefore a phenomenological approach is adopted to gather relative experiences of people and used active experiences as an open ended enquiry.

Questionnaire approach was adopted to collect primary data because of following advantages

- It supplements a systematic quantitative measure, suitable to describe, compare and explains contemporary factors influencing routine ship towage operations safety (Sapsford, 1999)
- Facilitated in collecting huge amount of information in a short span from across pan India.

The questionnaire method was adopted to ensure systematic data collection; attempts were made to regularize the process and to reduce errors, by keeping records and following set methods.

The questionnaire was categorised into five sections. Questionnaire was designed in such a way that most questions were closed, containing measurable factual information; also there was an option of providing additional descriptive information and facts. (Refer Appendix I)

To categorize the applicability extent, unipolar, likert, forced choice, and response scale were used in section five. It was applied to lessen the choice of a middle 'neutral' option and to induce a better reflection of all explanations. (Refer Table 3.9)

Section	Purpose
1	Instructions and further information concerning the research project.
2	Factual details concerning the particular Routine Ship Towage operation.
3	Environmental factors affecting the operation.
4	Details of the risk or safety issue encountered.
5	Risk Factors considered to be causing the risk or safety issue.

Table 3.9 - Questionnaire Sections (RO1-QU)

A Pilot survey was carried out by draft questionnaire to verify comprehension, structure and precision of the questionnaire prior to the actual survey, by having response of five non-participants.

A publicity scheme was planned in order to maximize involvement which resulted into identification of potential resources and ways to publicize the research. The prerequisite of advertisement through conventional medium is to create prompt promotional material and which requires a long time frame. On the other hand internet and e-communications are the most suitable method to have global participation in short span of time. Refer Table 3.10

Target group	Method of publicising
Harbour Towage Organisations	Conference, Seminar- Hardcopy of Questionnaire, Direct email, provision of electronic questionnaire, and follow-up correspondence to relevant organisations.
Professional Mariners	Conference, Seminar- Hardcopy of Questionnaire, Contacted various Stakeholder, Associations, with a press release and followed it up with correspondence.
Pilotage Groups	Email communication, electronic questionnaire, and follow-up correspondence.
Harbour Towage Enterprises	Post Mail/email, e-questionnaire, & follow up communication.
Professional Contacts	Post mail/e-questionnaire.

Table 3.10 - Publicity Program me (RO1-QU)

In order to achieve target participation, the questionnaire was circulated to a stratified set of involved organizations and individuals. (Refer Table 3.11*)*

Group	Total questionnaires distributed
Class surveyors	10
Harbour Masters	50
Maritime Administrators	10
Master Mariner	10
Maritime Regulators	10
Pilots	30
Ship's crew	40
Towage Enterprise Managers	20
Tug Master	40
Tug concern organisations	20
Tug shipbuilders	10
TOTAL	**250**

Table 3.11 - Questionnaire Distribution Groups (RO1-QU)

All of the individuals participated voluntarily, were intimated about the objective of research and no force was applied for their involvement. Certain measures were taken in order to achieve the privacy i.e. researcher was the only authority to contact the participants, in order to avoid release of information to the third party, submission of responses was entered in only one computer which was not accessible to anyone else other than the researcher and all of the submissions were deleted from computer on 15 January 2016.

Three mode of participation were also identified

- Employer to forward questionnaire to the respective participants.
- Questionnaire to be obtained from shipowner association head office.
- A questionnaire to be directly sent to individual via e mail.

Quality Control

Certain measures were taken to mitigate the vagueness of online surveying. There was less control on participants' response as there was no password protection which leads to reduced validity of data. Contact details of respondents were kept, in order to manage a global response for subsequent confirmation.
There may be a possibility for skewed distributions where volunteers were involved rather than the random sample, therefore use of a stratified population is applied in order to diversify the population, to reduce sampling errors and distribute errors randomly. In fact, ambiguity of online surveying contributes to more reliable responses and less biased social desirable responses.

Each and every Questionnaire was given a unique number for reference and the collected data was optimized and cleaned (checking for obvious errors and ineligibility). The data was then organized and coded for analysis on an Excel spread sheet.

These Likert elements was taken as ordinal data & considered for analysis separately; four significance levels have been used, so that respondents could distinguish the difference between next levels, as equidistant. Ordinal data gathered from Likert responses has been analyzed using non-parametric testing.

3.12.1.3 Expert Interview Account (EI)

The methodological approach employed for this study is qualitative, drawing on interviews as sources of data collection. The study adopts a case report design with an intention to explore unidentified risk factor in Indian context. The qualitative case report provides description as well as nuances that quantitative research may not always be able to do, as argued by Mack (2007) in her work on Norwegian seafarer's career experiences.

Sampling

Key participants in the towage subject expert were identified through non-probability purposive sampling. Purposive sampling allows the researcher to target participants based on their knowledge of the population, its elements and the purpose of the study (Babbie 2013) Table 3.12 provide a summary of the participants' characteristics.

Five key maritime stakeholders from towage industry were interviewed in 2015, with interviews ranging from 45 minutes to 130 minutes. Interviews were digitally recorded with consent of the participants and transcribed. Interviews were conducted by independent interviewers from the UK media consultancy.

Participants interviewed by the researcher were asked two open-ended questions:

(Question 1) In broad category, we have identified seven risk factors relevant to Indian towage industry; such as poor maintenance/substandard condition of equipment's, poor work process, Incompetency, rough weather, poor safety engagement and unsuitability of tug. What's your say on these identified risk factors?

(Probing Question): Did you ever feel that there were some risk factors that are real threat to safety but knowingly and unknowingly industry ignored them?...What are they?

(Question 2) "Please describe various safety issues in towage operation and your recommendations to deal with those"

Probing questions were also used to guide the interview when needed. The selection of participants was made if the interviewees were key stakeholders in the maritime industry and addressed the broad themes of issues & challenges causing threat to harbor towage operations.

Five Experts were interviewed from Indian region. Interviewees had between Nineteen to twenty eight years employment experience in maritime operations; roles performed included as Tug Master, Ship Master, Harbour Master, Pilot, Class Surveyor and Marine Consultant.

PARTICIPANTS	BUSINESS OF ORGANIZATION	WORK PROFILE/ EXPERTISE	LOCATION	POSITION	WORK EXP (years)	DURATION OF INTERVIEW (Minutes)
1	Towage Service	HSEQ	Dubai/Gujrat	Sr Safety Officer	28	90
2	Tug Training Programs	Training - Simulator	Singapore/ Paradip	Sr Trainer	21	50
3	Tug Operator	Tug Master	Dubai/Gujrat	Tug master	22	110
4	Port Operation	Port Operation	Mumbai	Harbour Master	31	90
5	Ship Owner	Ship operation	Singapore/ Mumbai	Master Mariner	19	70

Table 3.12 - Participants Demography (RO1-EI) : Indian Region

3.12.2 Research Objective 2 (RO2) - Expert Interview

The methodological approach employed for this study is qualitative, thematic analytical tool, drawing on interviews as sources of data collection. The study adopts a case study design with an intention to explore solutions & practices adopted by various organizations in towage industry to deal risk factor causing threat to safety and to draw some indication to validate identified risk factors. The qualitative case study provides description as well as nuances that quantitative research may not always be able to do, as argued by Mack (2007) in her work on Norwegian seafarer's career experiences.

Sampling

Key participants in the towage subject expert were identified through non-probability purposive sampling. Purposive sampling allows the researcher to target participants based on their knowledge of the population, its elements and the purpose of the study (Babbie 2013, 128). Table 3.13 provides a summary of the participants' characteristics.

Twelve key maritime stakeholders from towage industry were interviewed in 2015, with interviews ranging from 45 minutes to 130 minutes. Interviews were digitally recorded with consent of the participants and transcribed. Interviews were conducted by independent interviewers from the UK media consultancy. Missed data was also collected through email exchanges.

Participants interviewed by the researcher were asked two open-ended questions:

(Question 1) In broad category, we have identified seven risk factors relevant to Indian towage industry; such as poor maintenance/substandard condition of equipment's, poor work process, Incompetency, rough weather, poor safety engagement and unsuitability of tug. What's your say on these identified risk factors?
(Question 2) Please describe various safety issues in towage operation and your recommendations to deal with those.

Probing questions were also used to guide the interview when needed. The selection of participants was made if the interviewees were key stakeholders in the maritime industry and addressed the broad themes of issues & challenges causing threat to harbor towage operations.

Twelve Experts were interviewed from various part of world. Interviewees had between Nineteen to thirty six years employment experience in maritime operations; roles performed included as Tug Master, Ship Master, Harbour Master, Pilot, Trainer, Class Surveyor and Marine Consultant.

PARTICIPANTS	BUSINESS OF ORGANIZATION	WORK PROFILE/ EXPERTISE	LOCATION	POSITION	WORK EXP (yrs)	DURATION (Minutes)
1	Towage Service	Towage Operation	Long Beach, USA	Top Management	36	130
2	Towage Service	HSEQ	Dubai/Gujrat	Sr Safety Officer	28	90
3	Tug Training	Training - Simulator	Singapore/ Paradip	Sr Trainer	21	50
4	Pilotage	Vessel Navigation	Southampton UK	Pilot	26	90
5	Towage Service	Safety Officer	Southampton UK	Sr Manager - HSE	21	110
6	Tug Operator	Tug Master	Southampton UK	Tug master	28	110
7	Tug Operator	Tug Master	Dubai/Gujrat	Tug master	22	110
8	Regulatory	Surveyor/ Inspector	Long Beach, USA	Sr Surveyor	23	45
9	Port Operation	Port Operation	Mumbai	Harbour Master	31	90
10	Ship Owner	Ship operation	Singapore/ Mumbai	Master Mariner	19	70
11	Tug Building	Naval Architecture/ Tug Operation	Southampton UK	Sr Naval Architecture	22	130
12	Consultancy/Training	Trainer/ Safety Analyst	Southampton UK	Sr Trainer	23	60

Table 3.13 - Participants Demography (RO2-EI)

3.13 Data Collection: Documentation and Interviews:

There are six sources of evidence when executing a case study: documentation, archival records, interviews, direct observation, participant-observation, and physical artifact.

Source of Evidence	Strengths	Weakness
Documentation	○ Stable-can be reviewed repeatedly ○ Unobtrusive-not created as a result of the case study ○ Exact-contains exact names, references and details of an event ○ Board coverage-long span of time, many event and many settings	○ Irretrievability can be low ○ Biased selectivity, if collection is incomplete ○ Reporting bias reflects bias of author ○ Access may be deliberately blocked
Interviews	○ Targeted focuses directly on the case study topics ○ Insightful provides perceived casual inferences	○ Bias due to poorly constructed questions ○ Response bias ○ Inaccuracies due to poor recall ○ Reflexivity interviewee gives what interviewer wants to hear

Table 3.14 - Critical factors and performance measures of total quality management
(Source: Motwani, J. 2002 ''Critical factors and performance measures of total quality management.'' The TQM Magazine, pp 292–300.)

The sources of documentation were letters, agendas, administrative documents, formal studies or evaluations, and newspapers. A case report is performed through collection of evidence various multiple sources. Correct documents are useful while preparing for an interview session to avoid error in data or fact collection. All these documentations are considered secondary data because it is likely written to address another audience and for some other specific purpose other than the purpose for this particular case study (Sieber &

Samuel, 1973). Interviews are vital sources for case study information. They are guided conversations between the interviewer and the chosen resources. Therefore even if the researchers are pursuing a steady line of inquiry, the case study interview becomes fluid rather than rigid.

Case study interviews are of open-ended nature which means that the interviewer can ask key respondents about facts on a specific matter as well as their own opinions about certain actions. Alternatively a second type of interview adopted wherein the respondent is interviewed for a short period of time and this is called a *personal interview taken on telephone*. This interview could also be an open-ended one and could also have conversational character, but the interviewer is more likely to follow a specific series of questions which could originate from the case study protocol (Sieber & Samuel, 1973). Since there were specific questions here to ask, this aided in the collection of the necessary data to answer the research questions. Two focused interviews were conducted for this study. Few characteristics of an open-ended interview have also been kept, in order to maintain the flexibility of the interviews.

The interviews were conducted in English, and an interview guide was used as a guideline conductor. The interview guide was sent in advance to the respondents in order to guide them in preparation for the interview. This enabled the researcher to collect the data needed to answer the research questions properly (Shavelson, Richard, and Lisa, 2002).

3.14 Validity & Reliability of the Data Collected:

The most important thing in a research is to judge the quality of the research. This is done by testing if the research instruments will be neutral and valid which refers to how well a research method will be measured or what it is supposed to measure (Keeves, 1988). One should also test if other researchers can draw the same conclusions, ensuring reliability. Construct validity means establishing the correct operational measures for the concepts being studied. Internal validity means establishing a casual relationship, where certain conditions are proven to lead to other conditions, as distinguished from spurious relationships whereas External validity is again which establishes the domain to where a study's findings can be generalized (Hammersley, Martyn, and Roger, 2000). According to Keeves, 1988 "Reliability: demonstrating that the operations of a study – such as the data collection procedures – can be repeated, with the same results". There are different strategies to apply when dealing with the different types of tests and they should be applied throughout the case study (Hofstede and Geert, 2008).

Tests	Case Study Tactic	Phase of research in which tactics occurs
Construct validity	• Use multiple sources of evidence • Establish chain of evidence • Have key informants review draft case study report	Data Collection Data Collection Composition
Internal validity	• Do pattern-matching • Do explanation-building • Address rival explanations • Use logic models	Data Analysis Data Analysis Data Analysis Data Analysis
External validity	• Use theory in single- case studies • Use replication logic in multiple-case studies	Research Design Research Design
Reliability	• Use case study protocol • Develop case study database	Data Collection Data Collection

Table 3.15 – Case study Tactics

(Source: Hofstede, G. (2008) The Poverty of Management Control Philosophy. Academy of management Review,pp 450-461)

During the interviews, sound recording system was used so that nothing of what the respondents answers bed was overlooked on the phone. To increase the internal validity of the study pattern matching was used comparing the empirical data to the conceptual framework. The patterns matching were compared in an empirical based pattern with a prediction (Yin, 2003). While conducting the interviews, careful measures were adopted not ask leading questions and the collected data from the interviews were presented to ensure that appropriate interpretation is done to match the answers correctly (Hofstede and Geert, 2008).

Chapter 4

DATA ANALYSIS & RESULTS

4.1 RESEARCH OBJECTIVE 1 (RO1)

4.1.1 Questionnaire Survey Account (QU)

One hundred and forty three questionnaires were received by various data collection sources mentioned above; forty of these were given by Tug Masters, thirty by vessel Pilots and forty by Master Mariners.

Responses were received from nine states and most of them taken as valid. See Table 4.1

State	Number of questionnaires
Gujarat	38
Maharashtra	33
Karnataka	14
Kerala	7
Tamil Nadu	15
Andhra Pradesh	13
Orissa	7
Delhi	11
Goa	5
TOTAL	**143**

Table 4.1 - Questionnaire Response from Various States RO1-QU

The collected data was not statistically Normally Distributed was found by analysing Mean, Median, Mode and Standard Deviation; in fact the plotting the histogram of risk factor frequency shows a positive skew.

Fifty Two Percentages of the Questionnaires indicates Near Misses, twenty three percentages were Incidents, fifteen critical Challenging operations, twenty three Accidents (See Chart 4.1 - Safety Occurrence Description RO1-QU).

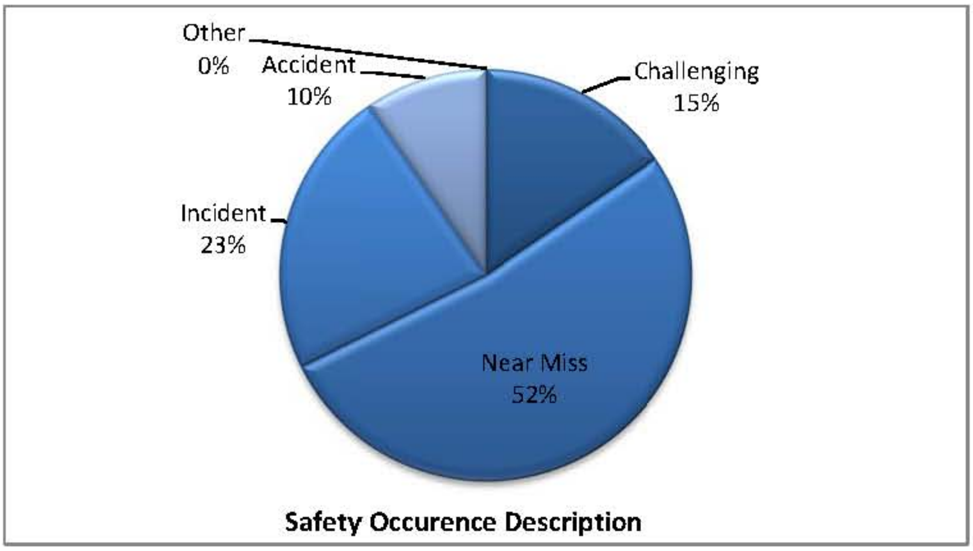


Chart 4.1 - Safety Occurrence Description RO1-QU

Questionnaire distribution of accident type** for Collision was eighty two percentage, Grounding fifty two percentage and Capsize or Foundering forty eight percentage. See Chart 4.2

***Figures (below) total over 100%, as a single safety incidence can lead to tree events that can lead to multiple Incidents.*

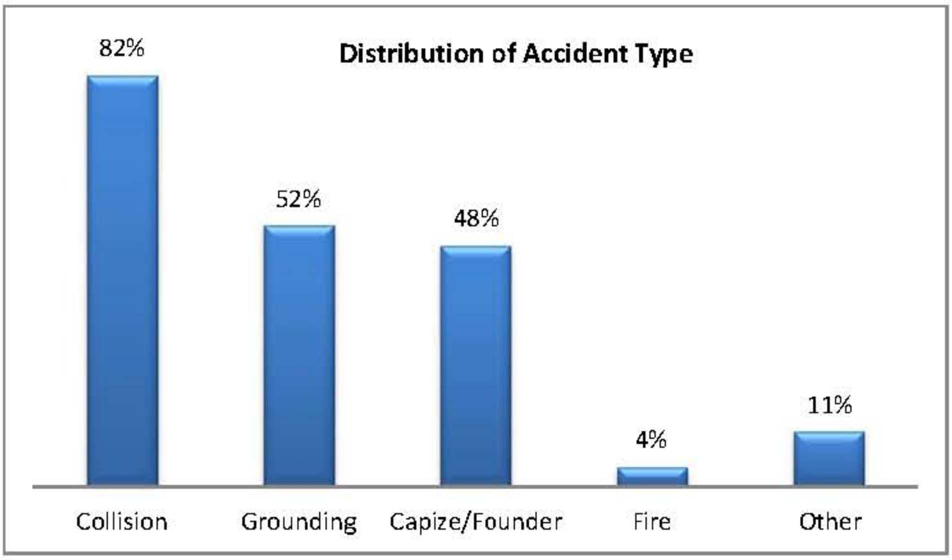


Chart 4.2 - Safety Occurrence Potential Result (Percentage) RO1-QU

An analysis of consequences from safety Incidents includes ninety one percentage possibilities for Damage and seventy six percentages depicts likelihood for Injury. There was also sixty percentages potential for Loss of Life, with fifty nine percentage possibility for Pollution (See Chart 4.3).

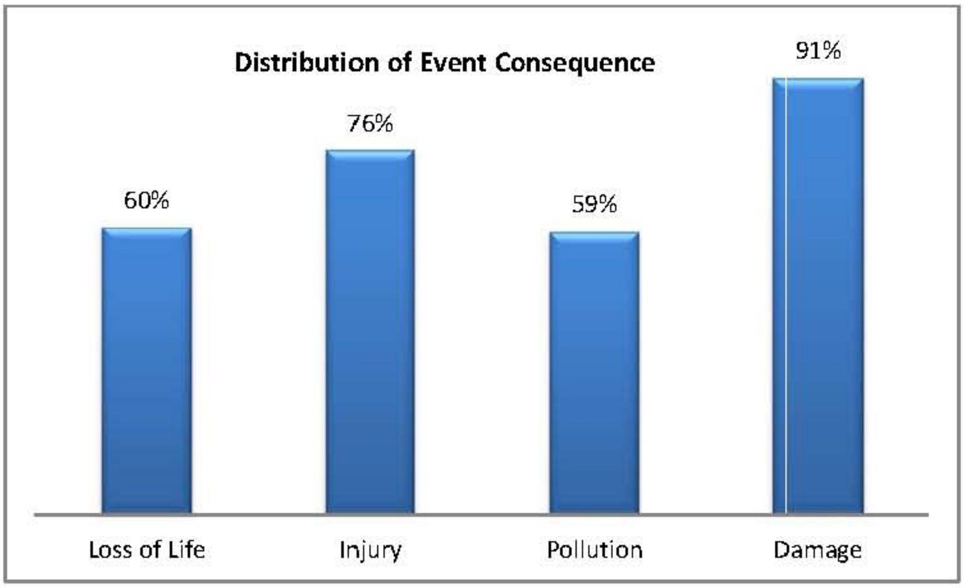


Chart 4.3 - Safety Incidents Possible Consequence (Average of Likelihood) RO1-QU

Twenty two percentage of the Tugs mentioned in questionnaire were of ASD (Azimuth Stern Drive), fifty nine percentage were Conventional, thirteen percentage had VS (Voith Schneider) propulsion systems and Six percentage were Unspecified (See Chart 4.4)

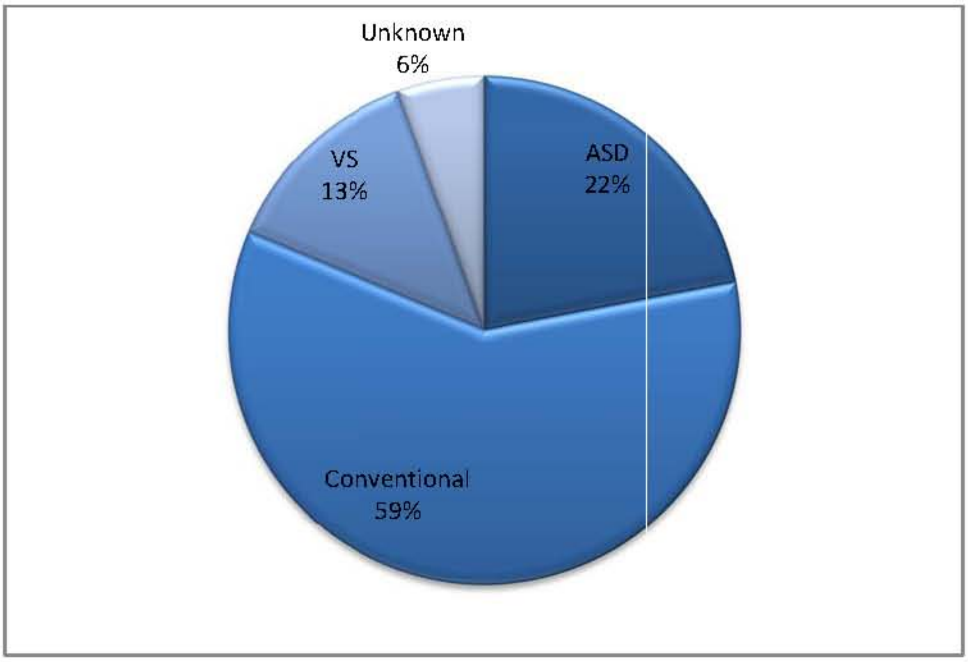


Chart 4.4 - Tug Types

Thirty eight percentages of tugs were Moderate (See Chart 4.5.) Forty nine percentages were Medium and five percentages were High powered (See Table 4.2). All of the Conventional tugs used were Moderate powered.

Tug Boat Power	Bollard Pull in tonnes
Moderate	< 30
Medium	30 – 70
High	>70

Table 4.2 - Tug Power distribution RO1-QU

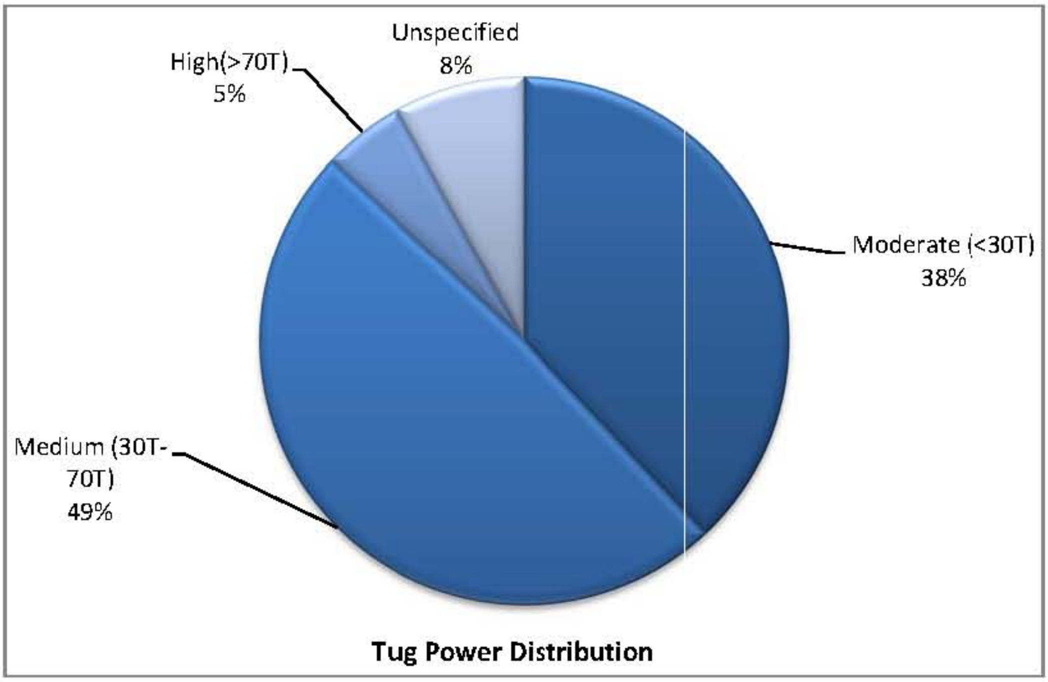


Chart 4.5 - Distribution of Tug Bollard Pull RO1-QU

Forty eight percentage of safety incidents involved use of a line (Push/Pull); while forty percentages of cases were using the Tug's tow on Line (See Chart 4.6).

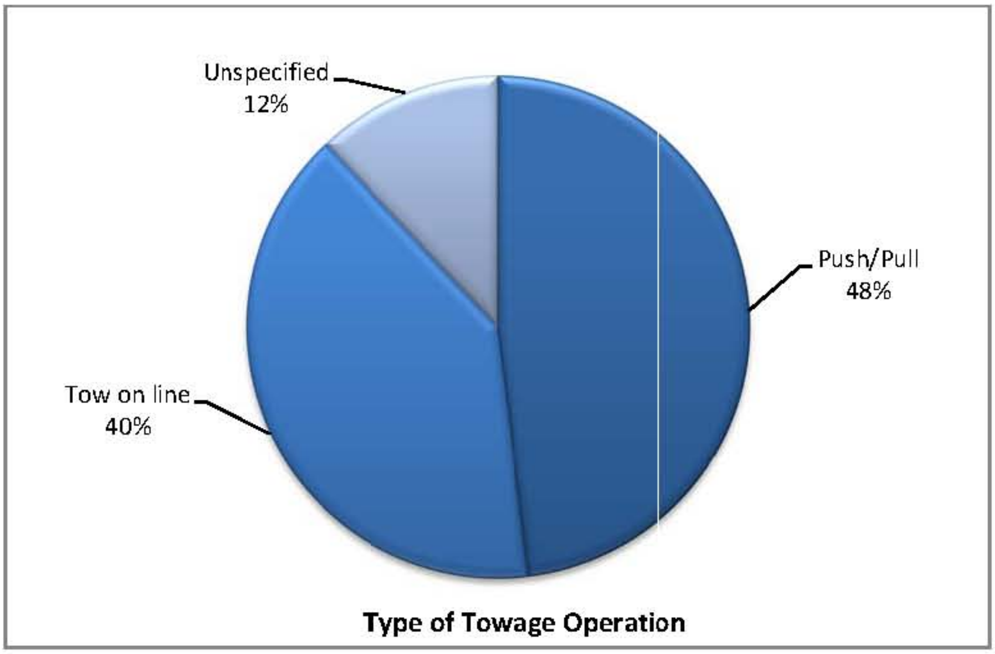


Chart 4.6 - Towage operation type RO1-QU

Thirty one percentages of vessels were categorised into Container Ships, Roll-On Roll-Off or General Cargo, twenty eight percentages were Tanker Ships, Gas or Bulk Carriers, ten percentages were Barges and the remaining one were considered into Unspecified (See Chart 4.7).

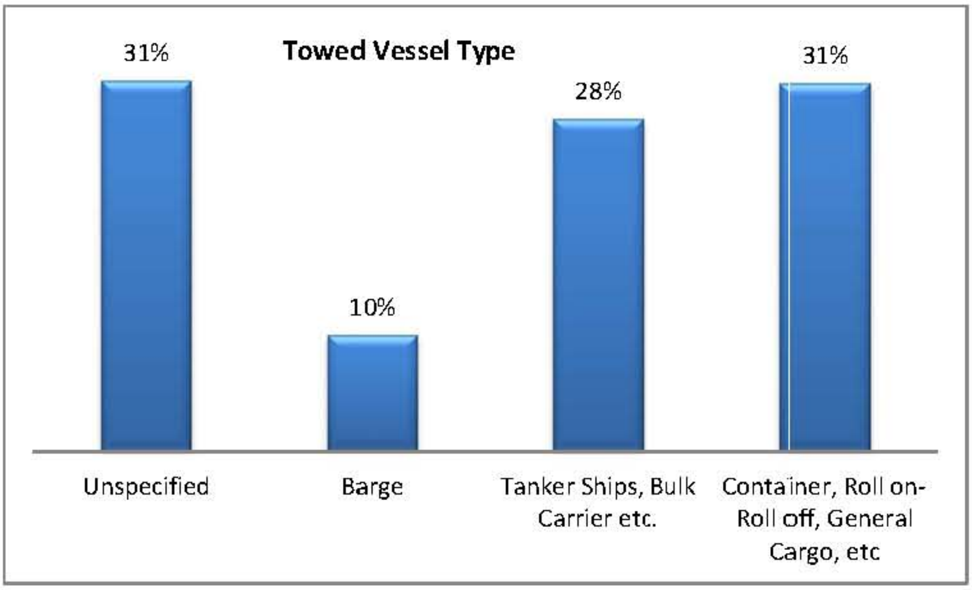


Chart 4.7 - Towed Vessel Type RO1-QU

From the data obtained it was observed that Thirty one percentages of vessels had fine formed bows, twenty six percentages moderate and thirty five percentages were broad bowed (See Chart 4.8).

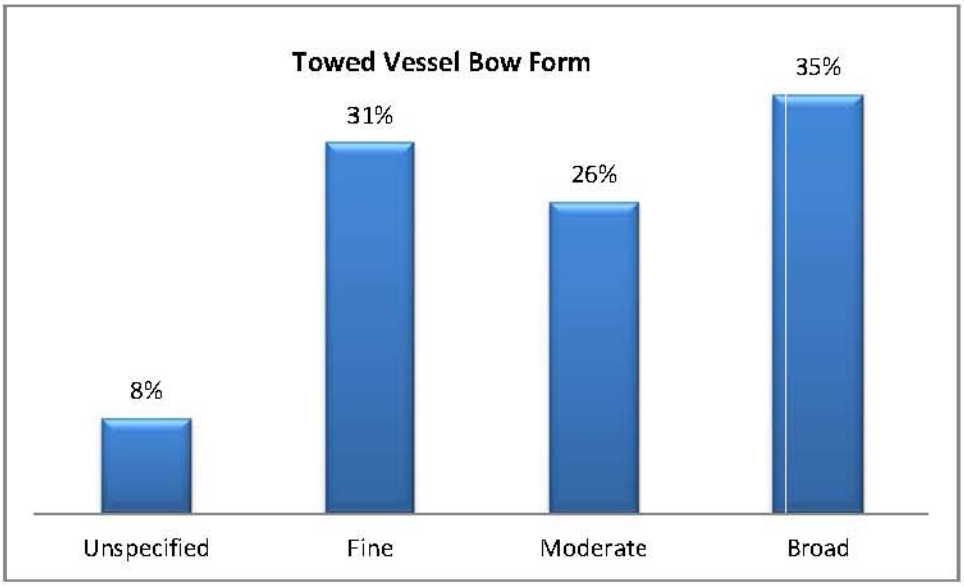


Chart 4.8 - Towed Vessel Bow shape RO1-QU

Towed Vessels were in the Small (<10,000mt DWT) category were Twelve percentages and seven percentages in Very Large (See Table 4.3). Twenty seven percentages were of Large, thirty five percentage of Handy, and twenty one percentages were of unknown size (See Chart 4.9)

Towed Vessel Size Category Table-	4.1 DWT
Small	< 10,000
Handy	10,000 – 50,000
Large	50,000 – 160,000
Very Large	> 160,000

Table 4.3 Towed Vessel Size RO1-QU

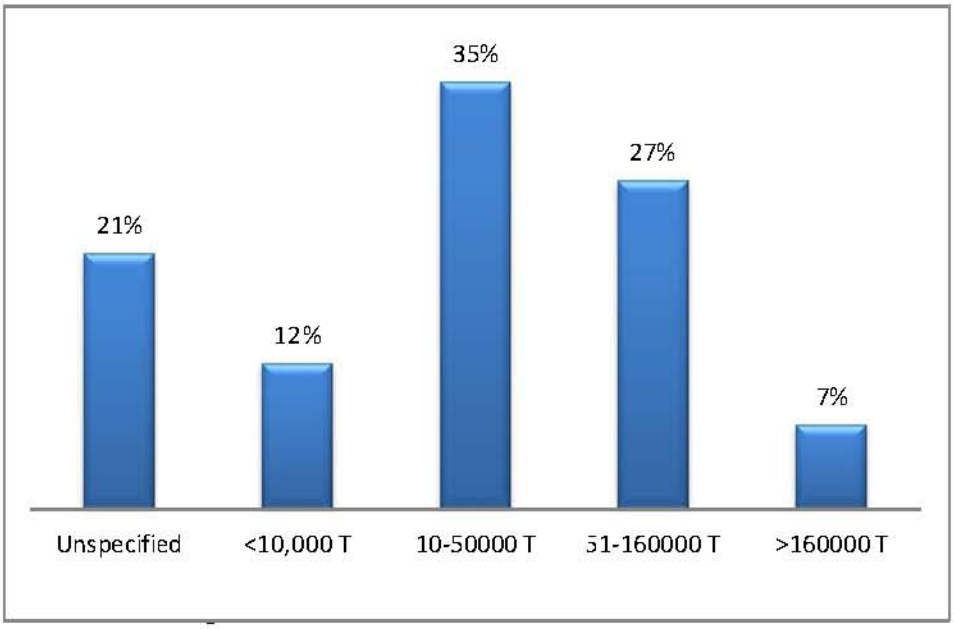


Chart 4.9 - Distribution of Towed Vessel RO1-QU

Weather conditions varied; Data collected states wind was Moderate between Beaufort Scale Wind Force 4-6. Swell conditions identified were Calm (< 0.2 meter height); although they were considered as Rough (1 - 1.5 meter) on 6% of cases and Heavy (>1.5 meter) on 9% of cases. Modal current conditions were Low (< 1 knot) with Moderate current on 19% and Strong current on 9% of cases. Fog was present on 9% of cases (See Chart 4.10).

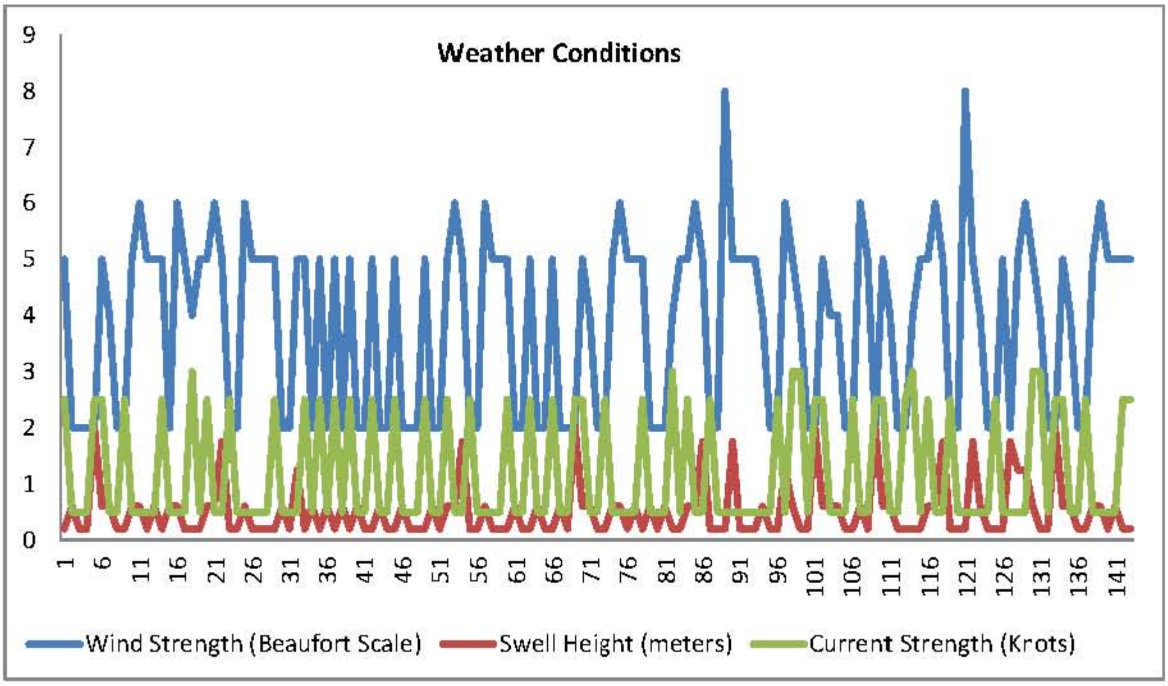


Chart 4.10 - Weather Conditions RO1-QU

4.1.1.1 Risk Factors

Questionnaires Survey depicts that the most frequently occurring risk factors (>50%) which attributes to risks were:

- Poor Training;
- Human Factors;
- No Tow Planning;
- Poor Tug Handling;
- Communication Procedure;
- Substandard Tug Equipment;
- Tug Approach Manoeuvres;
- Interaction;
- Safety Culture;

(Refer Chart 4.11)

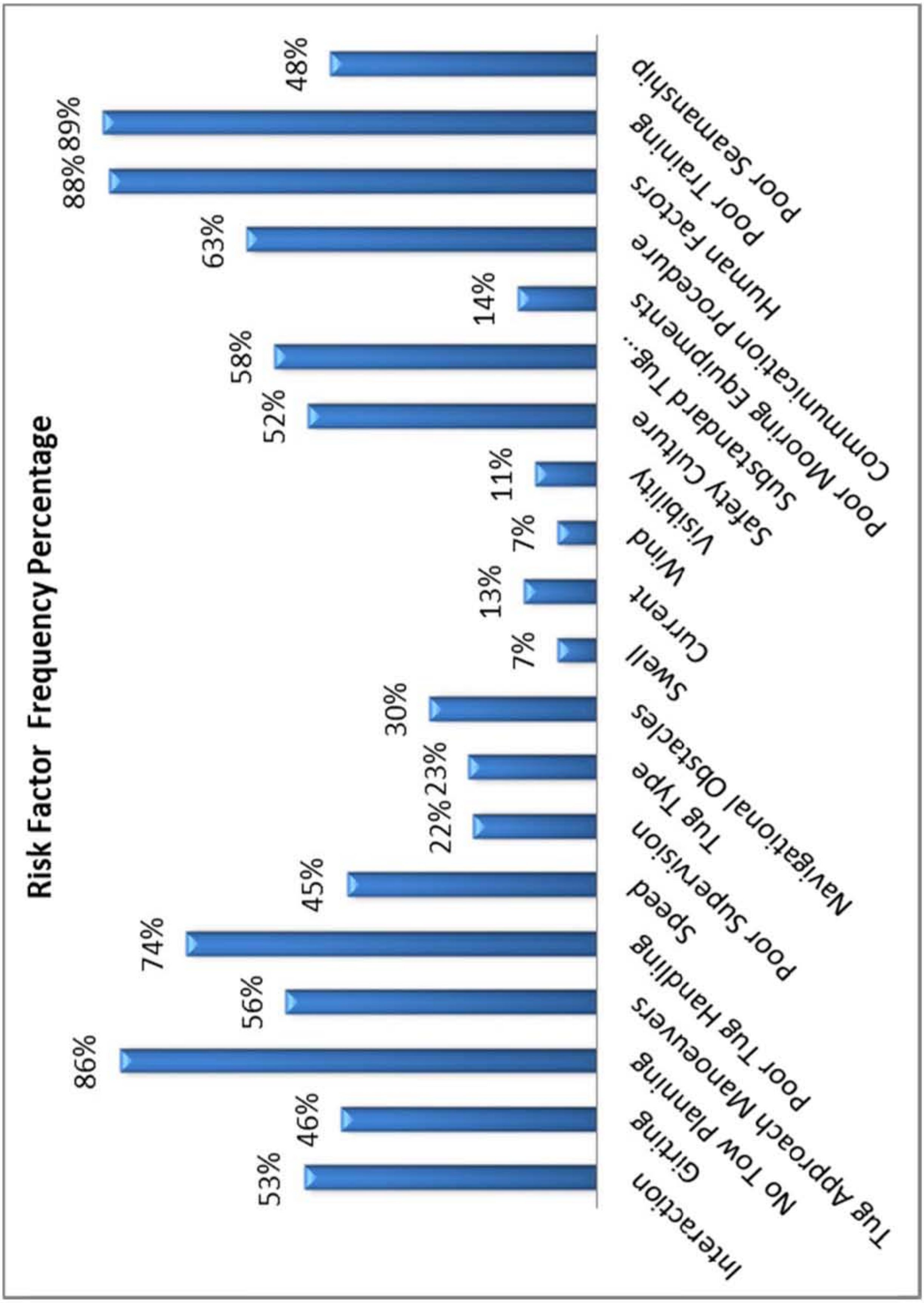


Chart 4.11 - Pearson's r Significant Number Test for analyzing rellationship between Consequence Severity and Risk Factor RO1-QU

A statistical tool Pearson's r significant number test was used to assess relationship between Risk Factors & Consequence severity significance. The test acknowledged a Strong relationship (r > 0.39) for four factors:

- Human Factor;
- Poor Training;
- Poor Safety Culture;
- Substandard Tug Equipment

The following guiding principle were used for inferring positive or negative correlations (Pearson's r).

If r = +.70 or higher Very strong positive relationship
+.40 to +.69 Strong positive relationship
+.30 to +.39 Moderate positive relationship
+.20 to +.29 weak positive relationship
-.19 to +.19 No or negligible relationship
-.20 to -.29 weak negative relationship
-.30 to -.39 Moderate negative relationship
-.40 to -.69 Strong negative relationship

The test showed a Moderate +ive relationship (r value between 0.30 - 0.39) for Three Risk Factors:

- Tug Type
- Poor Tug Handling
- Poor Training

Weak Positive relationship in tow planning, whereas negligible relationship was found in twelve remaining factors (See Table 4.4). Severity of consequences was calculated following risk assessment guidelines. *(Refer Appendix III)*

	Pearson Correlation [Sig.(2-tailed)]	Consequence	Relationship
Interaction	0.000	0.168**	Negligible
Girting	0.000	0.099**	Negligible
Tow planning	0.031	0.201*	Weak Positive
Tug Approach Maneuvers	0.044	0.07*	Negligible
Poor Tug Handling	0.000	0.393**	Moderate Positive
Speed	0.000	0.165**	Negligible
Poor Supervision	0.040	0.145*	Negligible
Tug type	0.036	0.322*	Moderate Positive
Navigational Obstacle	0.004	0.034*	Negligible
Swell	0.031	0.01*	Negligible
Current	0.000	0.015**	Negligible
Wind	0.001	0.01**	Negligible
Visibility	0.004	-0.040	Weak Negative
Safety Culture	0.040	0.472*	Strong Positive
Substandard Tug Equipment	0.003	0.447**	Strong Positive
Poor Mooring Equipment	0.024	0.083*	Negligible
Communication Procedure	0.000	-0.387	Moderate Negative
Human factor	0.041	0.464*	Strong Positive
Poor Training	0.001	0.496**	Strong Positive
Poor Seamanship	0.041	-0.060	Negligible

** .Correlation is significant at the 0.01 level (2-tailed).

*.Correlation is significant at the 0.05 level (2-tailed).

Table 4.4 Pearson's r Significant Number Test for analysing relationship between Consequence Severity and Risk Factor (SPSS Software output) RO1-QU

Alteration in ranking when Risk Factor frequency equated to consequence significance

The largest positive change in rank observed (negative movement by eight positions) as a result of Pearson's r test was for Tug Approach Manoeuvres, while the largest Positive change was for Safety Culture.

Overall the most noteworthy change in rank was for Safety Culture (increase of Seven positions), Tug Type (increase of Seven positions), Tug Approach Manoeuvres (decrease of Eight positions) and Navigational Obstacles (decrease of four positions) (See Chart 4.12).

Poor Training, Human Factors, Poor Tow Planning, Poor Tug Handling remain at significant position attributing risk; while Communication Procedure, Substandard Tug

Equipment, Safety Culture, Tug Type, Interaction regarded as important factors which may also effect safety risk.

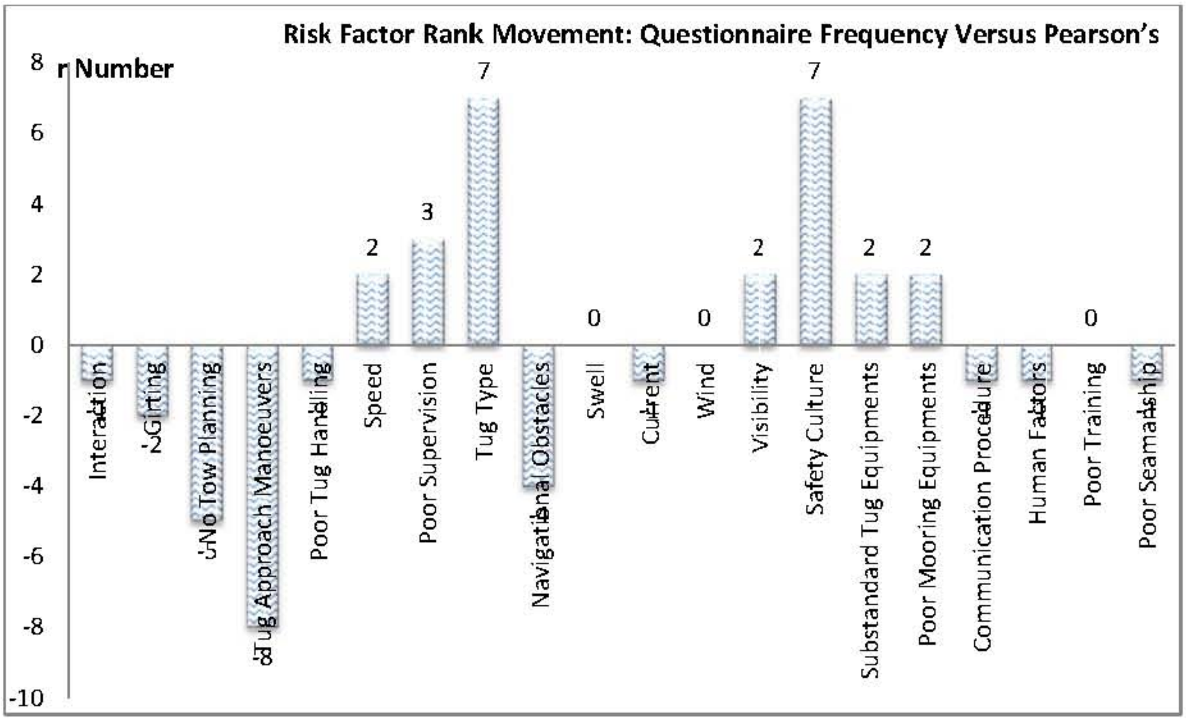


Chart 4.12 - Change in Risk Factor Rank: Questionnaire Frequency V/S Pearson's r Number RO1-QU

The Pearson's r test also supported the significance of Safety Culture and Tug type, and magnified the importance of Poor Supervision; it however pull down the ranking of Tug approach Manoeuvers, Poor Tow Planning & Navigational Obstacle. This may be due to reason that these factors may be more frequent and therefore are less significant, to a specific accident.

A Figure of Risk Factor frequency with significance of incident, indicated a substantial relationship; the higher the risk factor frequency, the greater the accident significance. A Pearson's r significance test value of individual factor supported this (signifying a notable relationship between the two variables).

4.1.1.2 Factor Analysis Results - PCA RO1-QU

Statistical analyses Data were analysed using SPSS 16.0. Factor analysis using PCA (Principal Components Analysis) Extraction Method and varimax rotation is applied to analyse the association between various risk factors. A factor analysis is useful to identify common underlying dimensions (factors) that consist of items (in this case concerns) that are strongly interrelated (Hair et al., 2006). The selection of factors was based on Eigen values (>1 as threshold), while factor loadings were used to interpret the meaning of the resulting factors. Cronbach's alpha was used to decide and interpret upon internal reliability consistency. Threshold value for acceptable construct is 0.6, which denotes that the dissimilar items measure one single construct and therefore may be grouped. Aggregation was done through averaging the scores across issues assigned to a specific factor.

PCA is a method used for altering the variables in a multivariate data set, A_1, A_2, A_3....Ap into new variables, B_1, B_2, B_3...Bp which are uncorrelated with each other and account for decreasing proportions of the total variance of the original variables defined as:

$$B1=x_{11}A_1+x_{12}A_2+x_{13}A_3+\ldots+x_{1p}A_p$$

$$B2=x_{21}A_1+x_{22}A_2+x_{23}A_3+\ldots+x_{2p}A_p$$

$$B3=x_{21}X_1+x_{22}X_2+x_{23}X_3+\ldots+x_{2p}X_p$$

With the coefficients being preferred; so that B_1, B_2, B_3...Bp are accounted for decreasing magnitudes of the total variance of the original variables A_1, A_2, A_3....Ap. (Everitt and Dunn, 2009).

Data Screening

The data was screened for univariate outliers. From overall data, five out-of-range values, due to clerical or data collection errors, were identified and logged as missing data. The minimum sample size for factor analysis was identified, with absolute sample size of 143 (using list wise omission), with over 8 cases per variable.

Factor Analysis

Before proceeding to Principal Component Analysis following assumptions need to be checked. The factorability of the 20 items was examined. We have multiple variables with ordinal values derived from 4 point Likert scale. There was also need to have a linear relationship between all constructs. This is because PCA is based on Pearson correlation coefficients, and there needs to be a linear relationship between the construct. Linearity was tested using a matrix scatterplot, which was selected randomly for just a few possible relationships between variables and tested.

Some well-known criteria for the factorability of a correlation were used. Firstly, 15 out of the 20 items correlated at least 0.30 with at least one other item, signifying rational factorability. Secondly, the Kaiser-Meyer-Olkin measure of sampling appropriateness was 0.699, above the suggested value of 0.6, and Bartlett's Test of Sphericity was significant (χ^2 (335) = 5.091E3, $p < .05$). The diagonals of the anti-image correlation matrix were mostly over 0.5, supporting sampling adequacy i.e. the inclusion of most of the item in the factor analysis.

a. Determinant = 3.33E-02

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.699
Bartlett's Test of Sphericity	Approx. Chi-Square	5.091E3
	df	335
	Sig.	.000

Table 4.5 KMO and Bartlett's Test RO1-QU

The determinant value of sample data is 3.33E-02 (which is 0.0333) which is more than the required value of 0.00001. Hence, multicollinearity is not a found in these data. To sum up, none of the questions in the Questionnaire have correlation coefficients particularly high and all of them correlate fairly well; therefore, there is no need to consider excluding any questions at this stage.

There are no significant outliers for ordinal values of Likert scale of 4 point used. Outliers are important because these can have a disproportionate influence on the results. Viewing at the mean values, we can conclude that crew incompetency is the most important risk factor that accounts maximum impact on safety; and it has two variables Human Factor & Poor Training. It has the highest mean of 2.67 & 2.63 respectively. Internal consistency for variables from questionnaire was assessed using Cronbach's alpha. The alpha is acceptable 0.733.

Table 4.6 Reliability Statistics RO1-QU

	Mean	Std. Deviation
Interaction	1.5804	.75445
Girting	1.3776	.67973
Tow planning	2.57343	.496318
Tug Approach Maneouvers	1.6783	.62350
Poor Tug Handling	2.2028	.40350
Speed	1.3497	.58453
Poor Supervision	.6713	.50037
Tug Type	.6853	.48090
Navigational Obstacle	.8951	.36987
Swell	.2098	.40859
Current	.3986	.49133
Wind	.2098	.40859
Visibility	.3357	.47388
Safety Culture	.6713	.50037
Substandard Tug Equipment	.8322	.63895
Poor Mooring Equiments	.4126	.49403
Communication Procedure	1.8811	.36559
Human Factor	2.6364	.48274
Poor Training	2.6713	.47138
Poor Seaman ship	1.4545	.49968

Finally, the communalities were all above 0.3 (see Table 4.7); further confirming that each item shared some common variance with the other items. Given these overall indicators, factor analysis was conducted with all 20 items. Communalities Table show how much of the variance in the variables has been accounted for by the extracted factors. For instance over 96% of the variance in Human Factor is accounted for while 64.1% of the variance in Girting is accounted for.

Communalities		
	Initial	Extraction
Interaction	1.000	0.888
Girting	1.000	0.641
Tow planning	1.000	0.835
Tug Approach Maneuvers	1.000	0.524
Poor Tug Handling	1.000	0.627
Speed	1.000	0.501
Poor Supervision	1.000	0.943
Tug Type	1.000	0.856
Navigational Obstacle	1.000	0.452
Swell	1.000	0.894
Current	1.000	0.783
Wind	1.000	0.894
Visibility	1.000	0.823
Safety Culture	1.000	0.943
Substandard Tug Equipment	1.000	0.755
Poor Mooring Equipment	1.000	0.572
Communication Procedure	1.000	0.422
Human factor	1.000	0.961
Poor Training	1.000	0.9
Poor Seamanship	1.000	0.77

Extraction Method: Principal Component Analysis

Table 4.7 Communalities (SPSS Software output) RO1-QU

Principle components analysis was used because the primary purpose was to identify and compute composite coping scores for the factors underlying the Hazards in Routine Ship Towage. The initial Eigen values showed that the first factor explained 22.66% of the variance, the second factor 15.14% of the variance, the third factor 12.48% of the variance, the fourth factor 10.49% of the variance, the fifth factor 8.93% of the variance and a sixth factor 5.18% of the variance. All the six factors had Eigen values of just over one, each factor explaining 12.4%.

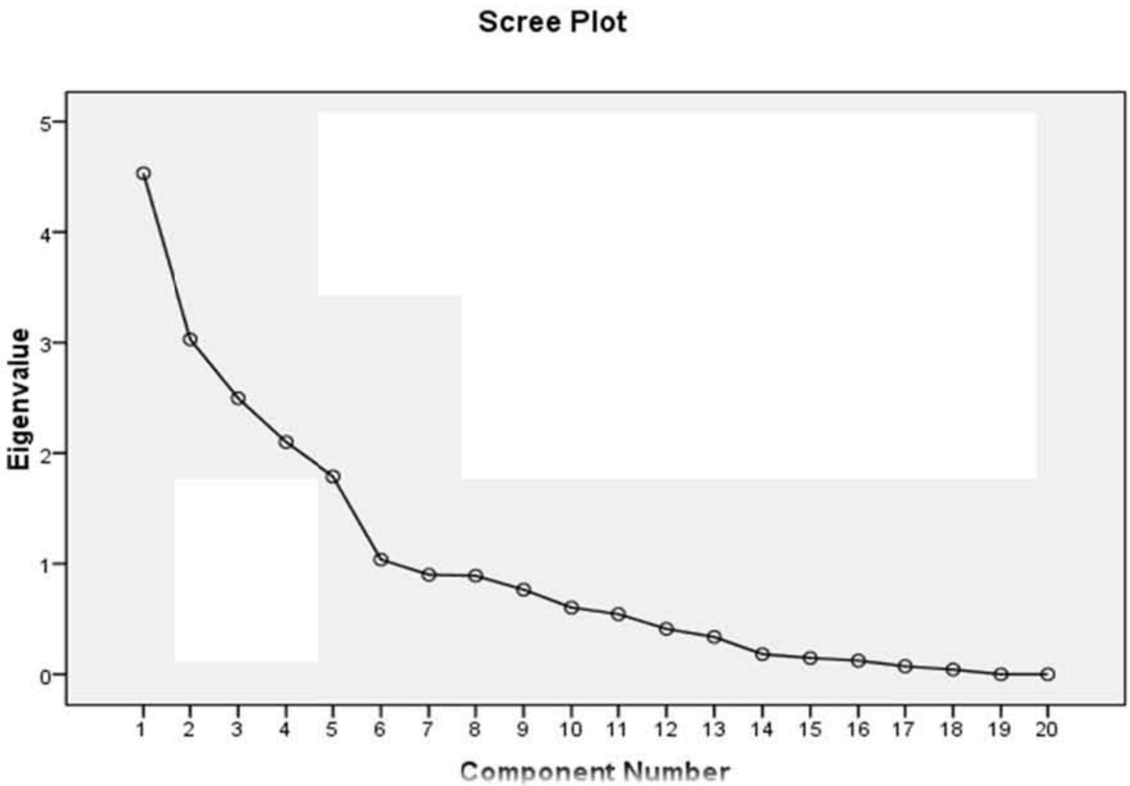


Chart 4.13 - Scree Plot RO1-QU

All Six factor solutions were assessed in factor loading matrix using both Varimax and oblimin rotations. The identified six factors explained 74.92% of the variance and its 'levelling off' of Eigen values on the screen plot, and subsequently the inadequate number of primary loadings and difficulty of interpreting the Seventh factor and succeeding factors. There was minor dissimilarity between the Varimax and oblimin solutions, thus both solutions were assessed in the subsequent analyses before determining Varimax rotation for the final solution.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.532	22.662	22.662	4.532	22.662	22.662	3.438	17.190	17.190
2	3.030	15.149	37.811	3.030	15.149	37.811	3.095	15.477	32.667
3	2.496	12.482	50.293	2.496	12.482	50.293	2.931	14.655	47.322
4	2.100	10.499	60.792	2.100	10.499	60.792	2.327	11.633	58.954
5	1.788	8.939	69.731	1.788	8.939	69.731	2.143	10.715	69.670
6	1.038	5.189	74.920	1.038	5.189	74.920	1.050	5.251	74.920
7	.900	4.501	79.421						
8	.891	4.455	83.877						
9	.765	3.824	87.701						
10	.602	3.011	90.712						
11	.544	2.718	93.429						
12	.410	2.050	95.480						
13	.337	1.685	97.164						
14	.181	.907	98.071						
15	.147	.733	98.804						
16	.123	.616	99.420						
17	.073	.363	99.783						
18	.043	.217	100.000						
19	-5.35E-17	-2.677E-16	100.000						
20	-1.99E-16	-9.948E-16	100.000						

Extraction Method: Principal Component Analysis.

Table 4.8 Total Variance (SPSS Software output) RO1-QU

During analysis, one of the items was disregarded because it did not contribute to a simple factor structure and failed to pass a requisite minimum criteria of having a primary factor loading of 0.4 or above, and no cross-loading of 0.3 or above. The item "Speed" did not load above 0.3 on any factor. It had a primary factor loading of 0.48 on the third component (which was well defined by 4 other items) and a cross-loading of 0.32 on Sixth component for the Varimax solution. In addition, this item had a floor effect, with 55% of the participants not reporting this Risk factor as hazard.

The table below shows the loadings of the twenty variables on the six factors extracted. The higher the absolute value of the loading, the more the factor contributes to the variable.

	Component					
	1	**2**	**3**	**4**	**5**	**6**
Human factor	0.742	-0.545	-0.139	0.221	0.205	0.059
Poor Training	0.719	-0.515	-0.089	0.254	0.212	0.034
Tow planning	0.668	-0.513	-0.254	0.186	0.158	-0.044
Interaction	0.653	0.168	0.452	-0.468	0.099	0.007
Girting	0.578	0.064	0.369	-0.351	0.024	-0.207
Poor Tug Handling	0.538	0.056	0.235	-0.522	-0.171	-0.044
Visibility	0.484	0.696	-0.206	0.077	0.189	0.143
Swell	0.369	0.656	-0.459	0.305	-0.021	-0.154
Wind	0.369	0.656	-0.459	0.305	-0.021	-0.154
Current	0.521	0.646	-0.095	0.105	0.17	0.214
Poor Seamanship	-0.556	0.557	0.199	-0.322	-0.083	-0.023
Substandard Tug Equipment	0.298	0.143	0.66	0.402	-0.22	-0.03
Tug Type	0.105	0.048	0.608	0.566	-0.391	0.01
Speed	0.352	0.126	0.456	-0.009	0.176	0.35
Poor Mooring Equipment	0.249	0.139	0.452	0.402	-0.349	-0.051
Poor Supervision	-0.471	0.096	0.315	0.302	0.722	0.014
Safety Culture	-0.471	0.096	0.315	0.302	0.722	0.014
Communication Procedure	-0.316	-0.135	-0.221	0.341	-0.373	0.009
Tug Approach Maneuvers	0.204	0.053	0.052	-0.173	0.207	-0.635
Navigational Obstacle	0.108	0.033	-0.171	-0.246	-0.088	0.585

Table 4.9 Component Matrix (SPSS Software output) RO1-QU

The principle-components factor analysis of the remaining 20 items, using Varimax and oblimin rotations was conducted, with the six factors explaining 74.9% of the variance. An Varimax rotation provided the best defined factor structure. All items had primary loadings over 0.5 and only one item had a cross-loading above 0.3 (Speed). The factor loading matrix for this final solution is presented in Table 4.11

.

*Factor loadings and communalities based on a principle components analysis with Varimax rotation for 20 items depicting Risk factors qualified for Hazards (*N *= 143)*

	Component					
	1	**2**	**3**	**4**	**5**	**6**
Human factor	0.963	0.026	0.167	0.027	-0.066	-0.028
Poor Training	0.93	0.029	0.165	0.075	-0.027	0
Tow planning	0.893	0.053	0.086	-0.061	-0.138	0.064
Poor Seamanship	-0.868	0.019	0.057	-0.058	0.1	0
Swell	0.024	0.918	-0.109	0.019	-0.135	0.142
Wind	0.024	0.918	-0.109	0.019	-0.135	0.142
Visibility	0.004	0.852	0.275	-0.002	0.044	-0.138
Current	0.042	0.789	0.32	0.098	0.064	-0.205
Interaction	0.084	0.086	0.916	0.142	-0.116	-0.017
Girting	0.13	0.035	0.728	0.157	-0.174	0.195
Poor Tug Handling	0.064	0.009	0.721	0.001	-0.321	0.01
Communication Procedure	-0.045	0.087	0.603	0.125	-0.179	-0.031
Speed	0.102	0.069	0.484	0.311	0.227	-0.322
Tug Type	0.004	-0.056	-0.081	0.92	0.023	-0.005
Substandard Tug Equipment	0.043	0.046	0.208	0.837	0.072	0.042
Poor Mooring Equipment	0.026	0.093	0.047	0.742	-0.087	0.044
Poor Supervision	-0.153	-0.078	-0.097	0.002	0.947	0.086
Safety Culture	-0.153	-0.078	-0.097	0.002	0.947	0.086
Tug Approach Manoeuvres	0.052	0.076	0.303	-0.106	0.002	0.642
Navigational Obstacle	0.005	0.06	0.11	-0.192	-0.171	-0.609
Extraction Method: Principal Component Analysis Rotation Method: Varimax with Kaiser Normalization						

Table 4.10 Rotate Component Matrix (SPSS Software output) RO1-QU

4.1.1.3 Discussion and Conclusion

Overall, these analyses indicated that Six distinct factors were underlying maximum threat to Routine Ship Towage safety namely Crew incompetency, Poor Work Process, Rough Weather, Suitability of tug type, Navigational Obstacle and Poor Safety Management System. *(Refer Table 4.12)*

Extracted Risk Factor	Risk Factors	Frequency Percentage	Relationship Between Risk Factor & Consequences
Crew Incompetency	Poor Training	89%	STRONG
	Human Factor	88%	STRONG
	Poor Tow Planning	86%	NONE
	Seamanship	48%	NONE
Rough Weather	Wind	13%	NONE
	Visibility	7%	NONE
	Current	11%	NONE
	Swell	7%	NONE
Poor Work Process	Poor Tug Handling	74%	MODERATE
	Communication Procedure	63%	MODERATE
	Girting	46%	NONE
	Interaction	53%	NONE
Unsuitability of Tug Type	Tug Type	23%	MODERATE
	Tug Equipment	58%	STRONG
	Mooring Equipment	14%	NONE
Poor Safety Management System	Safety Culture	52%	STRONG
	Poor Supervision	22%	NONE
Poor Navigational Risk Assessment	Navigational Obstacle	30%	NONE
	Tug Approach Manoeuvring	56%	NONE

Table 4.11 Result RO1-QU

The most potential safety event in RST operations is Collision (eighty two percentage) followed by Grounding (fifty two percentage) and Capsize / Foundering (forty eight percentage).

The most potential consequence is Damage (ninety one percentage) followed by Injury (seventy six percentage) and Pollution (fifty nine percentage). There is also indication of a noticeable risk of Loss of Life (sixty percentages).

As it was evident from analysis that there is a correlation between frequency of Risk Factor & consequence significance, the interpretations need to be optimized due to complexity of association between factors (a lesser number of Safety Risk Factors can underlie the most disastrous accidents).

The data was not normally distributed hence the test was not carried out to assess whether Safety Risk Factor magnitude had any effect, a simple plot of Safety Factor frequency against accident severity showed some increase, however there were:

- fluctuations;
- significant maximum Safety Risk Factor frequencies in average ranked incidents;
- A smaller amount of Safety Risk Factor frequency for the most catastrophic incidents.

Poor training and Poor Tow Planning which is attributed to crew incompetency showed substantial amount of risk frequency, in fact Human factor which represents the issue related to human element also exhibited high frequency. Moreover, issues related to poor training and human element shows strong relationship between risk factor and consequences.

The Tug type involved in Routine ship towage operation though shows small risk factor frequency but it shows moderate relationship with consequences whereas substandard tug equipment shows high risk factor frequency and strong relationship with consequences. Hence, Suitability of tug type as identified risk factor significantly contributes to threat to RST.

Poor work process components like communication procedure and poor tug handling and interaction are with high risk factor frequency and moderate relationship with consequences. Poor Safety Management System which is an attribute of poor implementation of safety culture accounting high risk factor frequency and strong relationship with consequences are main cause to threat to RST operation. However, Poor navigational risk assessment and rough weather though carrying low risk factor frequency and no relationship with consequences were also identified as threat to RST operation.

Safety Risk Factor identified in Indian coastal waters by this Questionnaire survey can be further validated by researchers with the help of other data collection tool such as studying secondary data i.e accident and investigation reports relevant to Indian coastal waters or extensive interviews of experts & professionals from RST industry.

4.1.2 Case Reports Account (CR)

Ninety seven percent of the CRs were categorized as Accidents, rest of CR were categorized as Incident. Eighty nine percent of the CR comprised of Collision, fifty two percent in Capsize and seventy percent Grounding (See chart 4.14.).

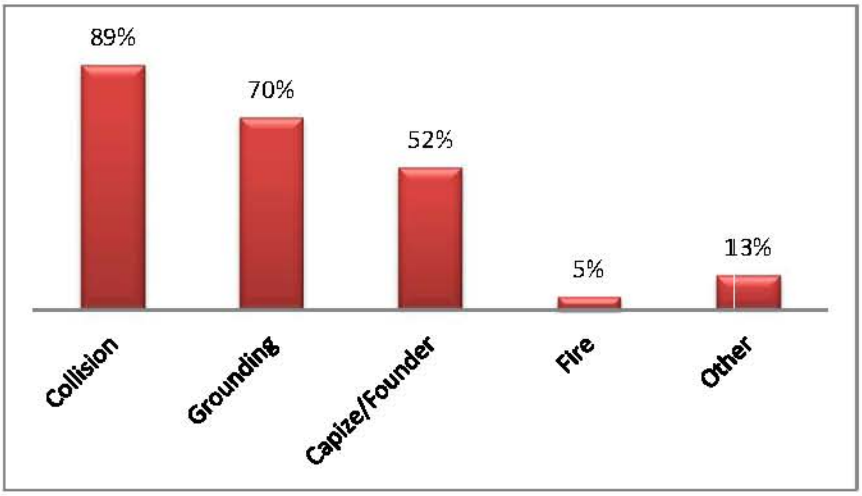


Chart 4.14 - Apportionment of Accident Type (Percentage) RO1-CR
**Figures may exceed total Case reports, since one event may lead to several consequences.*

Analysis of incident consequence shows that twenty nine resulted in Loss of Life, fourty seven in Injury and eighty four in Damage.

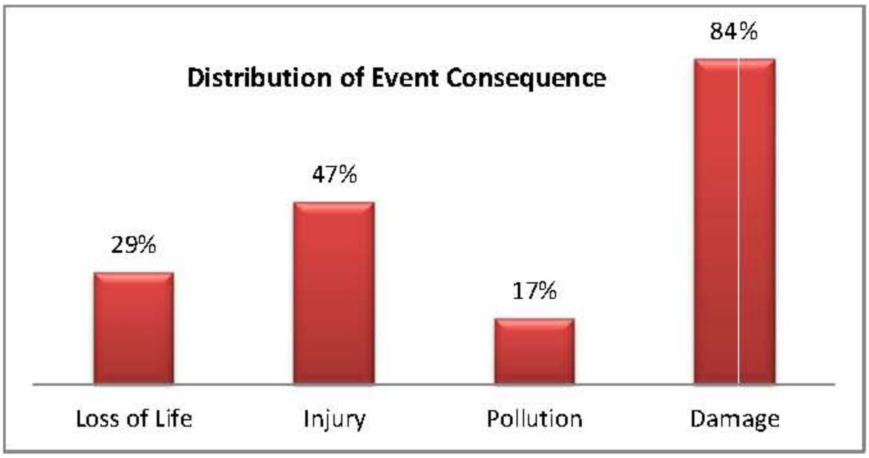


Chart 4.15 - Apportionment of Event Consequence (Percentage) RO1-CR

Seventy percent concerned Conventional tugs while twenty five percent undetermined tug type (See Chart 4.16) were involved in towage operation

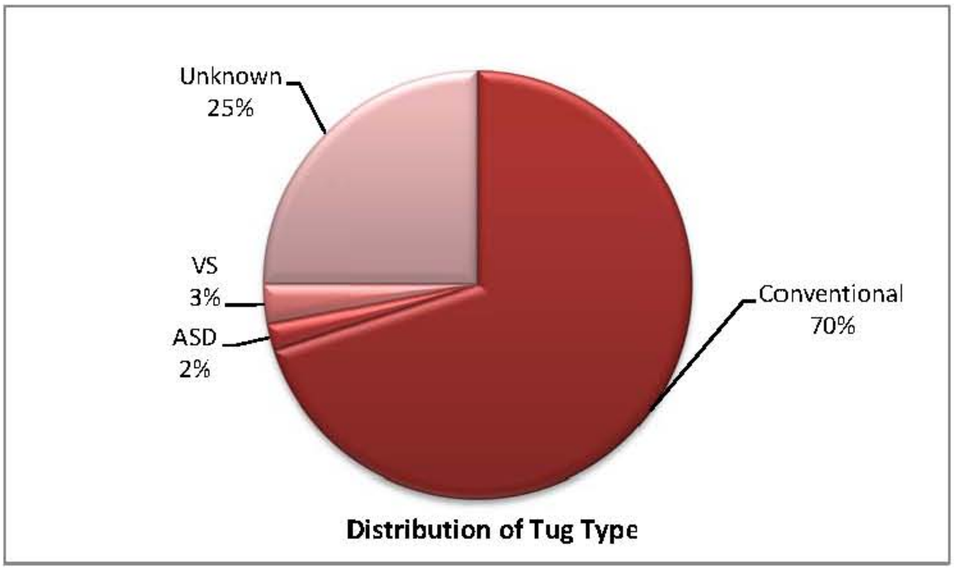


Chart 4.16 - Distribution of Tug Type (Percentage) RO1-CR

Sixty two percent of tugs were moderately powered while twenty percent were Medium powered and seventeen percent Unspecified (See Chart 4.17).

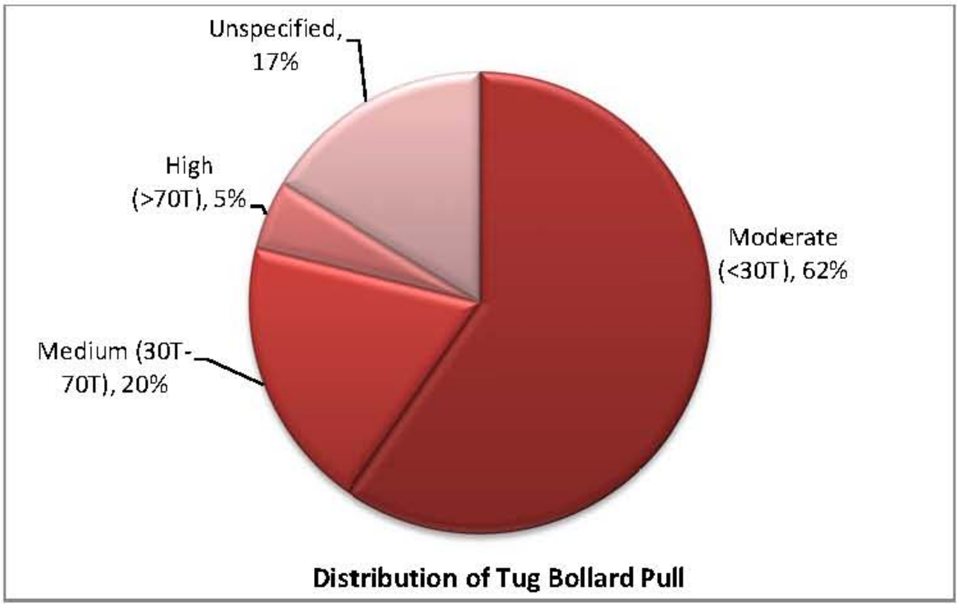


Chart 4.17 - Distribution of Tug Bollard Pull (Percentage) RO1-CR

Thirty eight percent of events involved Towing from Forward, fifteen percent Pushing, while thirty percent were unspecified (See Chart 4.18).

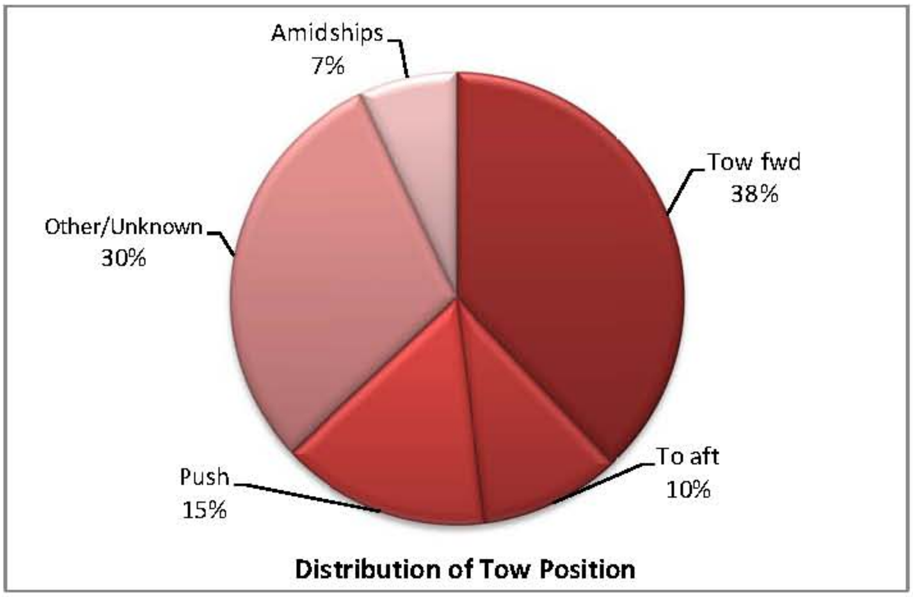


Chart 4.18 - Distribution of Tow Position (Percentage) RO1-CR

The majority of events (fifty eight) concerned barges (See Chart 4.19).

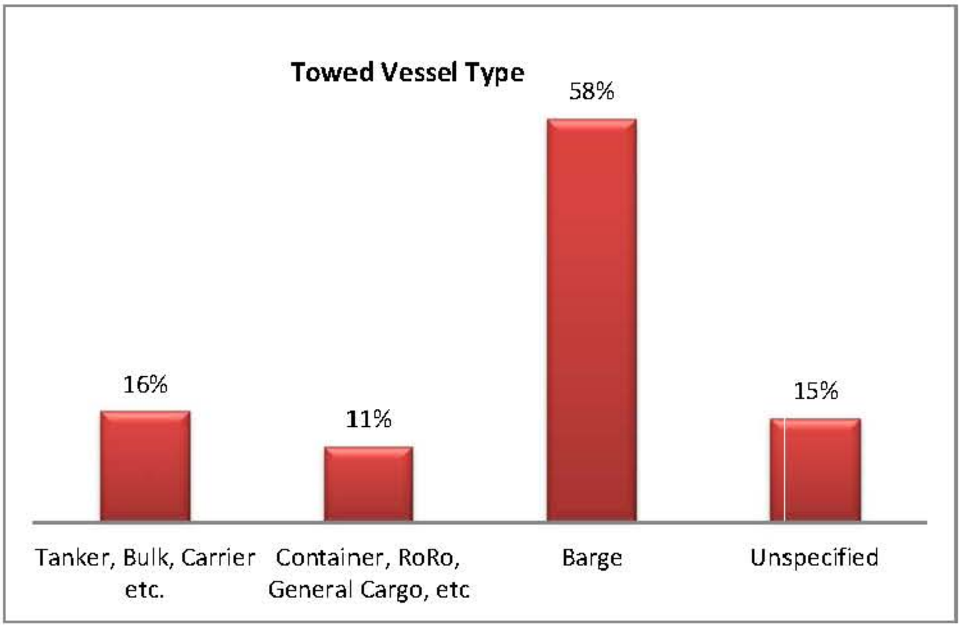


Chart 4.19 - Towed Vessel Type (Percentage) RO1-CR

The majority of towed vessels (fifty three percent) had broad bow forms (See Chart 4.20)

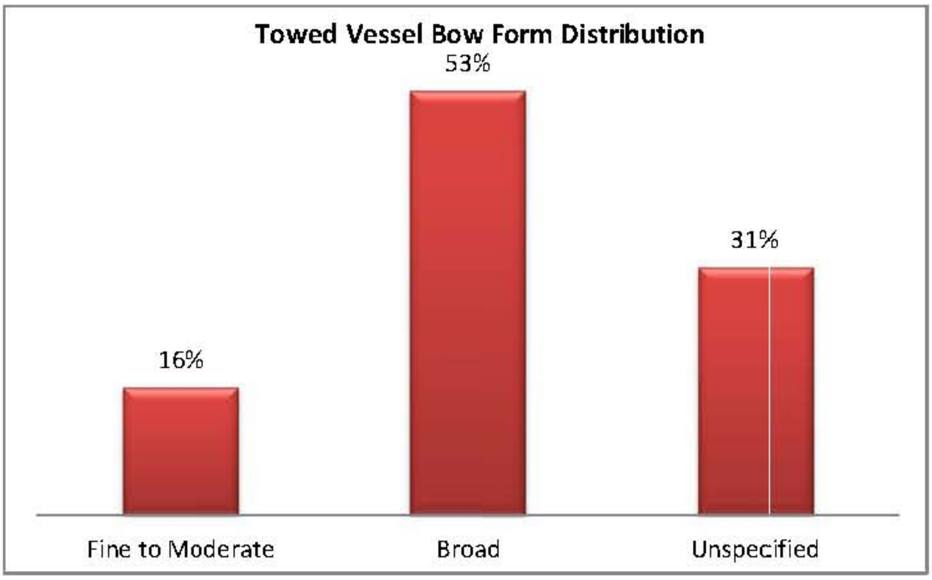


Chart 4.20 - Bow Form Distribution RO1-CR

The majority of towed vessels (forty six percent) were classed Small (under 10,000 tonnes deadweight) while sixteen percent were Handy or were Large (MAN, 2007). There were no Very Large vessels (over 160,000 tonnes deadweight) while twenty percent were of unspecified size (See Chart 4.21).

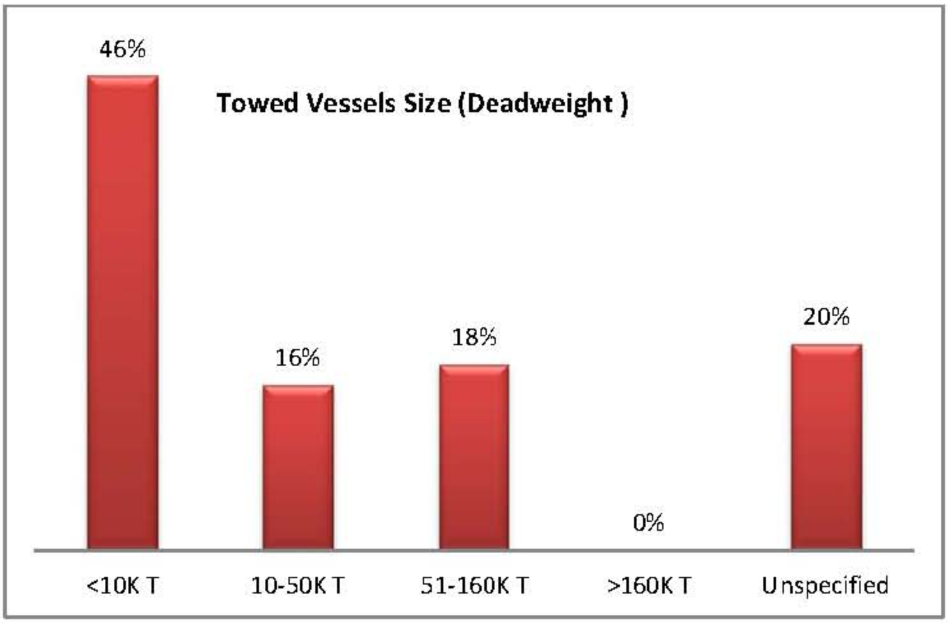


Chart 4.21 - Distribution of Towed Vessels Size (Deadweight Cate) RO1-CR

4.1.2.1 Comparison of RST & NRST Data

Routine Ship Towage (RST) operations had eighteen percent more Collisions, while Non Routine Ship Towage (NRST) operations had thirty percent more Groundings (See Chart 4.22).

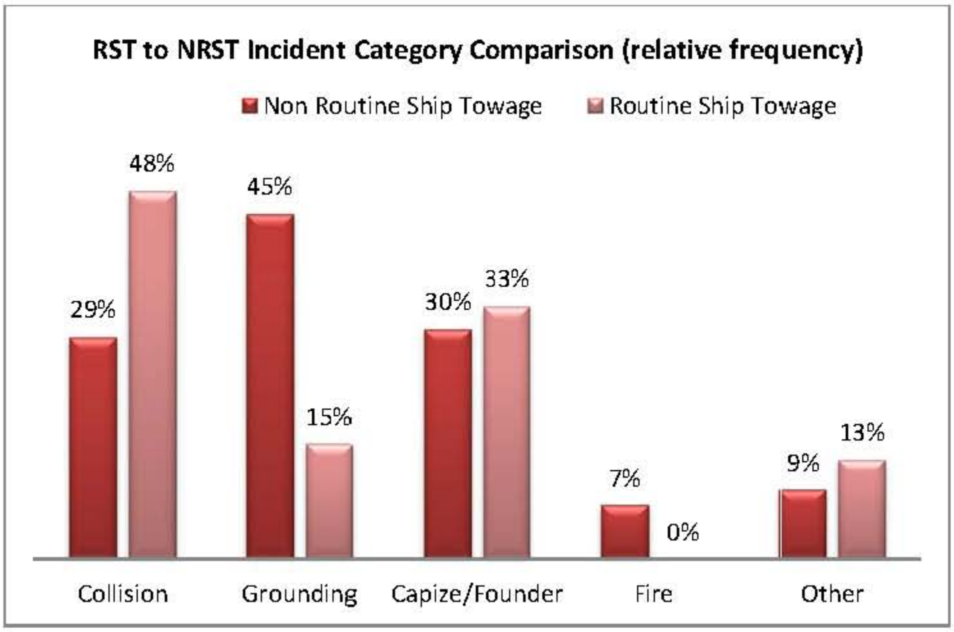


Chart 4.22 - RST to NRST Incident Category Comparison (relative frequency) RO1-CR

RST had almost doubled the frequency in all Consequence categories (See Chart 4.23).

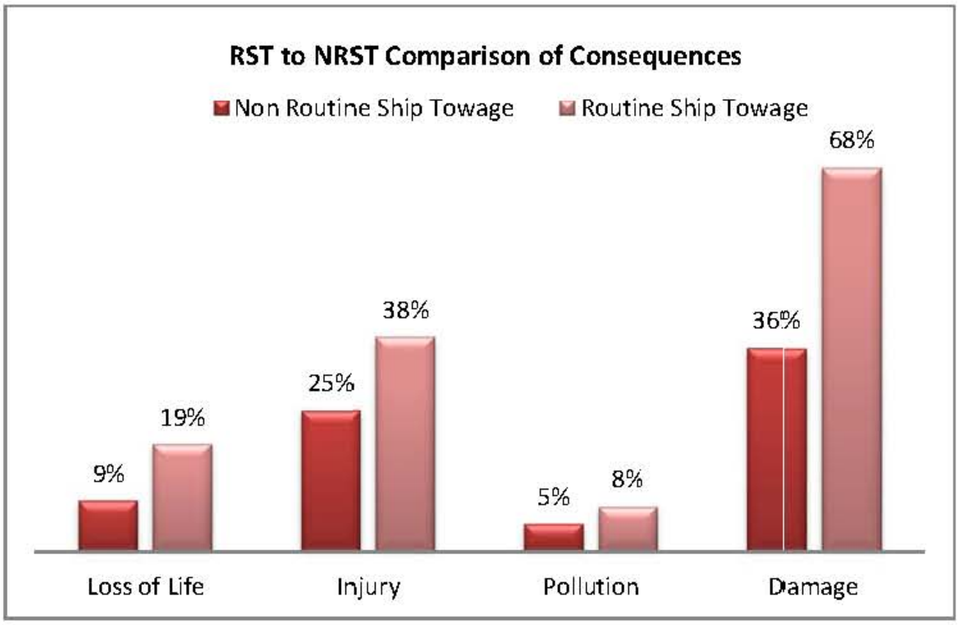


Chart 4.23 - RST to NRST Comparison of Consequences RO1-CR

Forty two percent of NRST operations involved towing from Forward, while thirty seven percent of RST (See Chart 4.24).

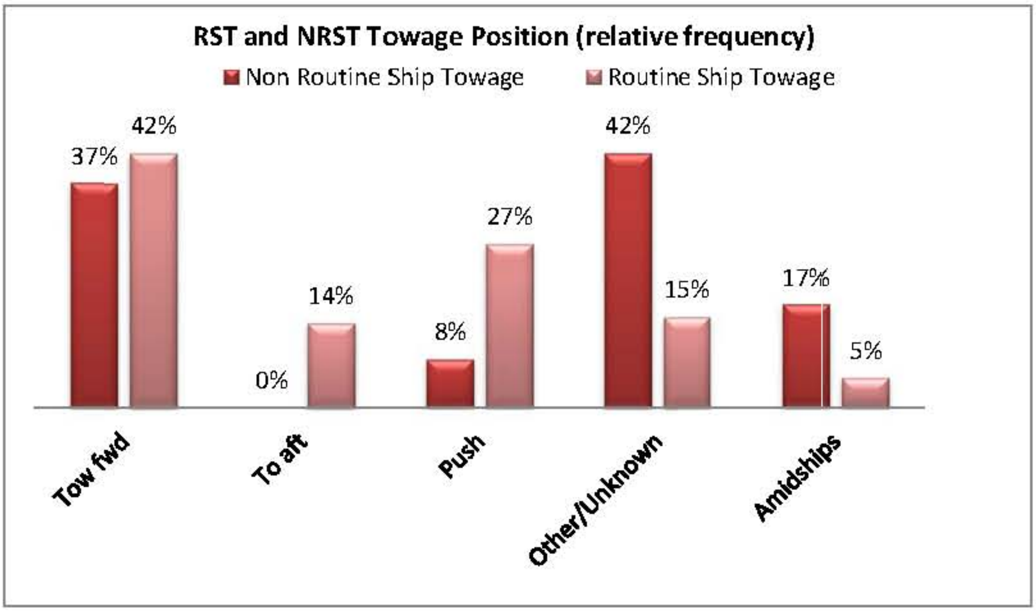


Chart 4.24 - Comparison of RST and NRST Towage Position (relative frequency) RO1-CR

Comparative analysis between RST and NRST incidents, represent similar proportions of barges (fifty eight to fifty Six percent); however there was significant variation in all other classes (See Chart 4.25).

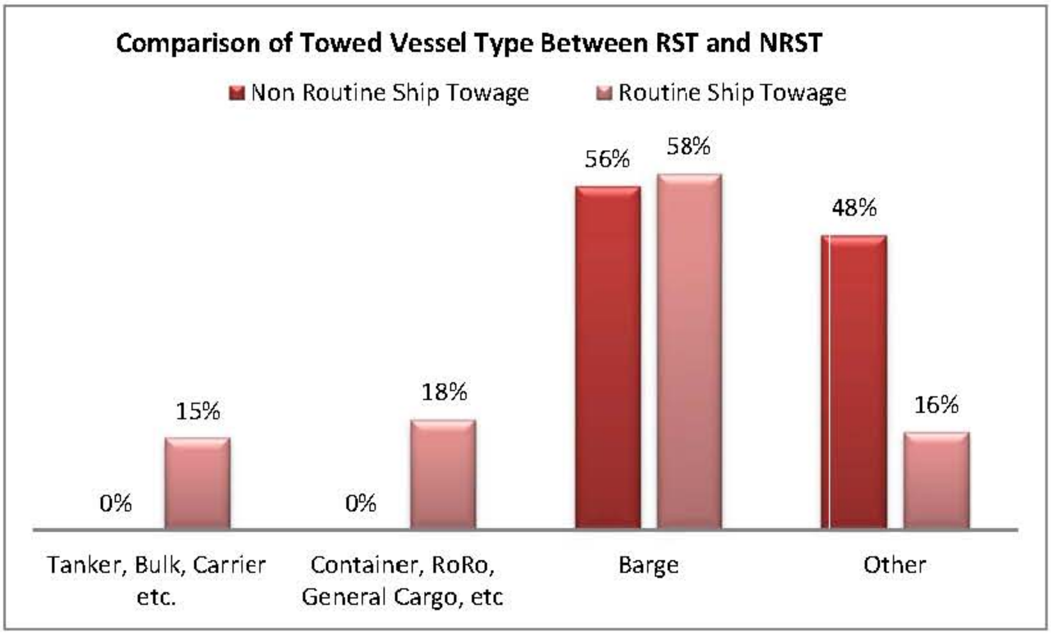


Chart 4.25 - Comparison of Towed Vessel Type between RST and NRST Case reports RO1-CR

Comparative analysis between RST and NRST incidents, represented by similar proportions of Small Towed Vessels (under ten thousand tonnes Deadweight):: fifty eight and sixty percent respectively; however there was significant variation amongst all other classes (See Chart 4.26).

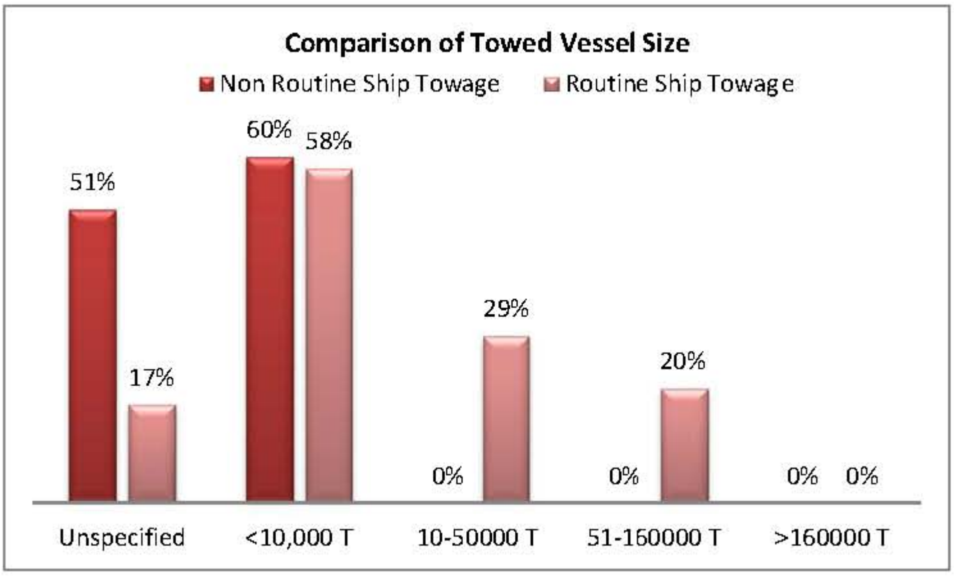


Chart 4.26 - Comparison of Towed Vessel Size RO1-CR

Fifty six percent of NRST Towed Vessels were Broad Bowed, compared to fifty four percent of RST.

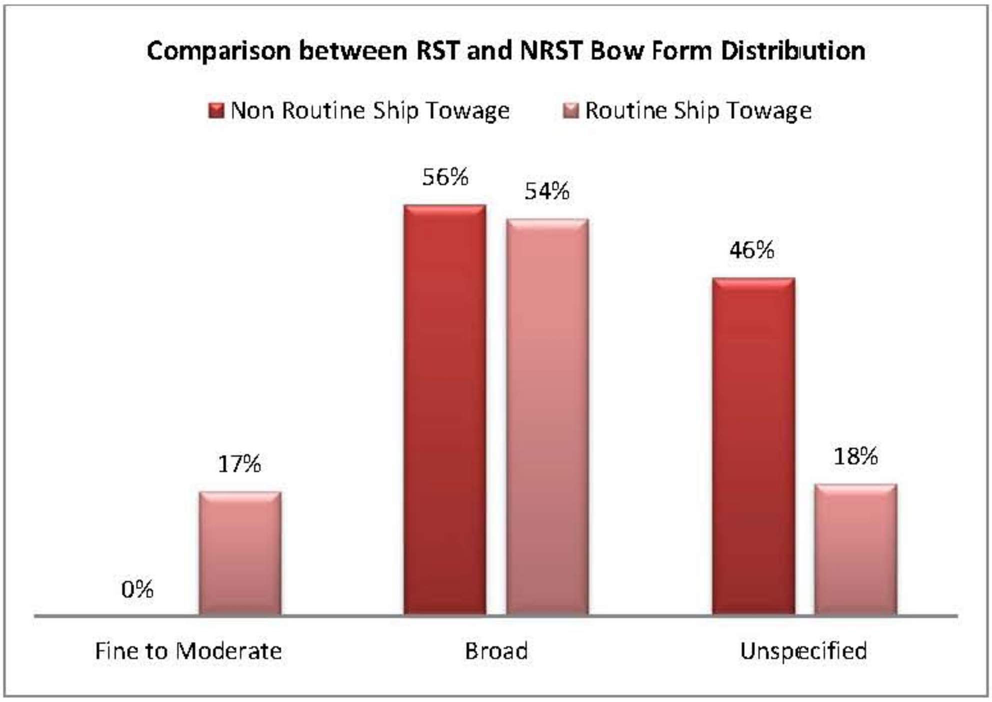


Chart 4.27 - Comparison between RST and NRST Bow Form Distribution RO1-CR

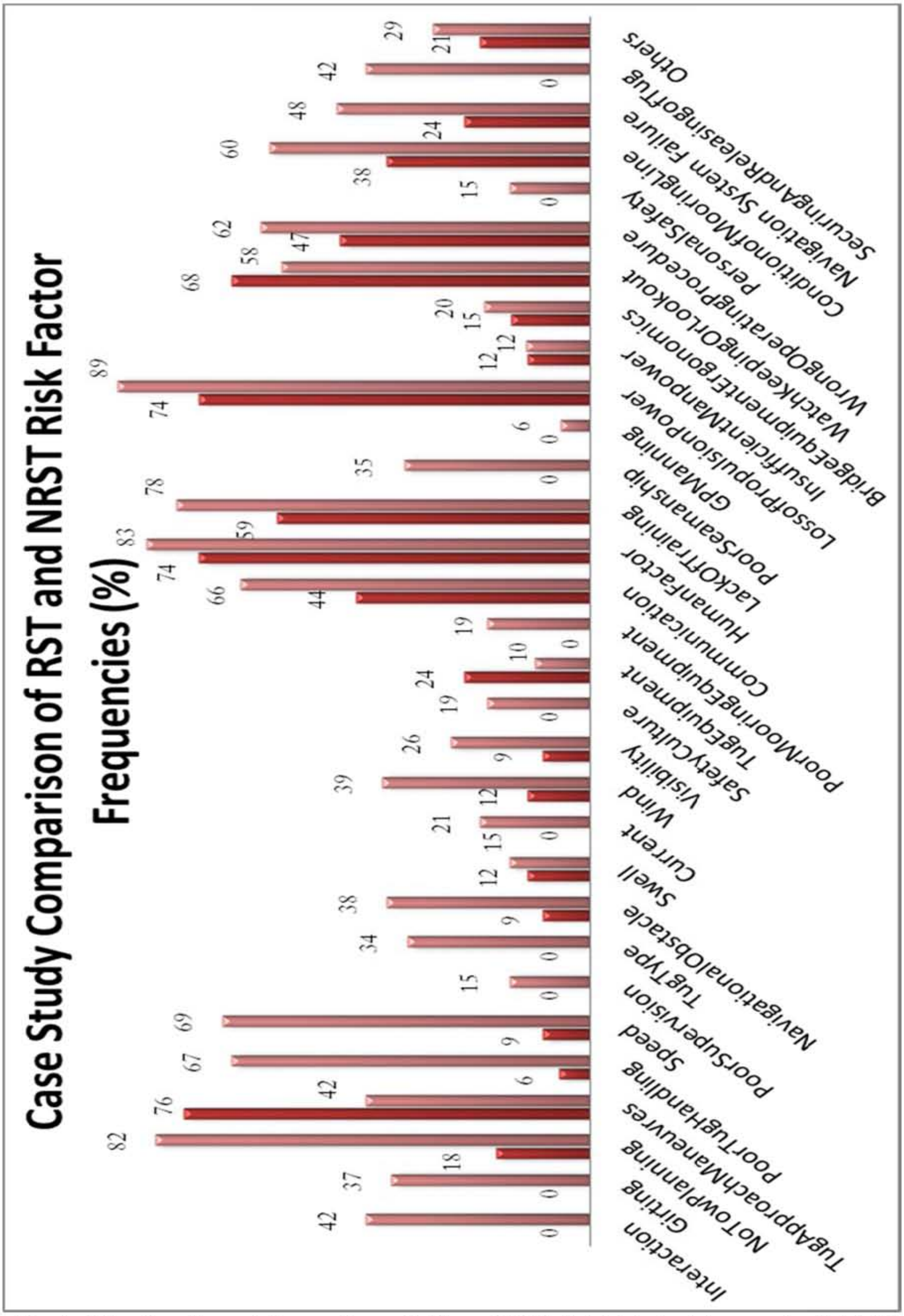


Chart 4.28 - Case Report Comparison of RST and NRST Risk Factor Frequencies RO1-CS

Risk Factor comparison between Routine Ship and Non Routine Ship Towage produced several findings (See Chart 4.28). Eleven Risk Factors were present only in harbour towage operations (in rank frequency):

Interaction (42%), Girting (37%), Poor Supervision (15%), Tug Type (34%), Safety Culture (19%), Poor Mooring Equipment (19%), Poor Seamanship (35%), GP Manning (6%), Personal Safety (15%), Securing And Releasing of Tug (42%)

Four Risk Factors were noticeably more frequent in RST Operations:

- No Tow Planning;
- Loss of propulsion power;
- Human Factor.
- Lack of Training

Seven Risk Factors had prominent frequencies in RST(and NRST) operations (in rank average frequency):

- Tug Approach Manoeuvres;
- Human Factors;
- Lookout;
- Communication;
- Lack of Training;
- Wrong Operating Procedures;
- Loss of propulsion power;

4.1.2.2 Hypothesis Testing

Weather there is a measureable difference between Harbour Towage and Non Routine Ship Towage Operations (Chi Square test)

A Chi Square test comparing Routine Ship Towage (RST) and Non Routine Ship Towage (NRST) Risk Factors rejected the Null Hypothesis in all cases. (The test could not be performed on other Risk Factors who's Estimated Values were below ten).

Risk Factors	RST Frequency	NRST Frequency	CHI^2 Stats	P-value	Result
Interaction	42%	0%	Test NA	-	Invalid
Girting	37%	0%	Test NA	-	Invalid
No Tow Planning	82%	16%	16.9030	0.0000390	Significant
Tug Approach Manoeuvres	42%	76%	12.6810	0.0003690	Significant
Poor Tug Handling	67%	4%	40.9240	0.0000000	Significant
Speed	69%	9%	39.4610	0.0000000	Significant
Poor Supervision	15%	0%	Test NA	-	Invalid
Tug Type	34%	0%	Test NA	-	Invalid
Navigational Obstacle	38%	9%	10.5650	0.0011520	Significant
Swell	15%	10%	5.1420	0.0253100	Significant
Current	21%	0%	Test NA	-	Invalid
Wind	39%	10%	8.8925	0.0028630	Significant
Visibility	26%	7%	4.6312	0.0313960	Significant
Safety Culture	19%	0%	Test NA	-	Invalid
Tug Equipment	10%	23%	4.0989	0.0429110	Significant
Poor Mooring Equipment	19%	0%	Test NA	-	Invalid
Communication	66%	42%	5.3393	0.6208500	Significant
Human Factor	83%	70%	10.6450	0.0012320	Significant
Lack Of Training	78%	60%	4.9688	0.0258090	Significant
Poor Seamanship	35%	0%	Test NA	-	Invalid
GP Manning	6%	0%	Test NA	-	Invalid
Loss of propulsion power	89%	72%	5.1318	0.0236160	Significant
Insufficient Manpower	12%	10%	0.0005	0.0315560	Significant
Bridge Equipment Ergonomics	20%	14%	0.1921	0.6611550	Significant
Watch Keeping Or Lookout	58%	66%	1.0520	0.0012670	Significant
Wrong Operating Procedure	62%	48%	2.4351	0.1186480	Significant
Personal Safety	15%	0%	Test NA	-	Invalid
Condition of Mooring Line	60%	38%	5.2894	0.0214560	Significant
Navigation System Failure	48%	22%	6.3582	0.0116840	Significant
Securing And Releasing of Tug	42%	0%	Test NA	-	Invalid

Table 4.12 Chi Square Test values RO1-CR

Detectable difference between Routine Ship towage and Non Routine Ship Towage operations (See Table 4.12) indicated by Chi Square test of Risk Factors.

More frequent Collisions in harbour towage (RST) operations, in comparison to more frequent Groundings in Non-Routine Ship Towage (NRST) operations, indicate the presence of different underlying Risk Factors; for example, Collisions might pointed towards Manoeuvring Space, while Groundings might indicate Watch keeping Risk Factors.

While harbour and Non Routine Ship Towage had similar frequencies of towed Barges, harbour towage also included a range of vessel categories. This difference may have been because tugs involved in Non-Routine Ship Towage, had accidents where no other vessel was involved. This Non Routine Ship Towage characteristic was repeated, in high proportions of Unspecified Bow Forms and Unknown Deadweight's; and it compares with a broader cross section of categories for harbour towage accidents. In this respect, harbour towage operations accidents are more likely to involve another vessel.

With respect to Risk Factor variation, eleven factors were present in RST, but absent from NRST operations; these Risk Factors may therefore be considered specific to RST operations.

Some of the risk factors were reported in over fifty percent of RST operations; their presence and high frequency might be specific to these operations. In comparison to other Risk Factors which are present in high frequencies in both groups, and therefore might be common to all types of operations while some of the risk factors were more prominent in NRST, and may therefore not be features of RST operations.

4.1.2.3 Discussion and Conclusion

These analyzes that seven factors were responsible to a great threat to Routine Ship Towage safety for bad working procedure , poor maintenance of equipment, severe weather, poor or no risk assessment, occupational incompetence, the suitability of the type of tug and poor safety management system . (See Table 4.13)

Extracted Risk Factor	Risk Factors	Frequency Percentage
Poor Maintenance/Substandard condition of Equipment's	Bridge Equipment Ergonomics	20%
	Navigation System Failure	48%
	Condition of Mooring Line	60%
	Loss of propulsion power	89%
Poor Work Process	Wrong Operating Procedure	62%
	Interaction	42%
	Insufficient Manpower	12%
	Communication	66%
	Girting	37%
	Poor Tug Handling	67%
	Securing And Releasing of Tug	42%
Crew Incompetency	Poor Seamanship	35%
	Lack Of Training	78%
	Poor/No Tow Planning	82%
	Watch Keeping Or Lookout	58%
	Human Factor	83%
Rough Weather	Current	21%
	Swell	15%
	Visibility	26%
	Wind	39%
Poor Safety Management System	Personal Safety	15%
	Safety Culture	19%
	Poor Supervision	15%
Unsuitability of Tug Type	Tug Equipment	10%
	Tug Type	34%
	Poor Mooring Equipment	19%
No/Poor Navigational Risk Assessment	Navigational Obstacle	38%
	Tug Approach Manoeuvres	42%
	Speed	69%

Table 4.13 Case Report Account result RO1-CR

Collision (forty-eight percent) are the potential security event in RST operations followed by grounding (fifteen percent) and Capsize / foundering (thirty three percent) .
The most potential consequence is Damage (sixty eight percentage) followed by Injury (thirty eight percentage) and Pollution (eight percentage). There is also indication of a noticeable risk of Loss of Life (nineteen percentages).

The data was not found to be distributed normally therefore the test was not conducted in order to analyse effect of safety risk factor potential, a simple plot of Safety Factor frequency against accident severity reported some increase, however there were: fluctuations; noteworthy maximum Safety Risk Factor frequencies in average ranked incidents and a lesser amount of Safety Risk Factor frequency for the most disastrous incidents.

Crew incompetency due to poor training and Human factor indicated substantial amount of risk frequency, in fact Human factor also showed high frequency which represents the issue related to human element.

Although small risk factor frequency is observed because of tug type involved in Routine ship towage operation but it indicates a fair relationship with consequences, on the other hand high risk factor frequency and significant relationship with consequences is exhibited by navigational obstacle or restricted manoeuvring space.

High risk factor frequency was lies with Poor work process components like speed; wrong operating procedure and poor tug handling and interaction. Poor implementation of safety culture contributed by poor Safety Management System was responsible for Poor Safety Management System and therefore is the main source to threat to RST operation.

High frequency of insufficient Safety Management Systems and Human Factors (legislated for in International Maritime Conventions) are included in substantial Risk Factor evidence comparatively.

Changes to tug design and increased complexity were identified as factors. Modern engine management systems can provide dead slow speeds of ten knots; equally tug power has increased to an extent where bollard strength can be insufficient.
The significance of an adequate number of appropriately qualified and experienced crew were also identified. New entrants from other maritime sectors replaced by migration might not be aware equally risk factors associated with RST operations.

Many risk factors are related to training. In harbour towage operations, tow planning emphasized the significance of prerequisite of adequate information and experienced persons involved in operations; Following Operation Procedures marked the significance of effective tug crew training programmes; and Tug Handling stressed upon sufficient training of tug masters.

Training issues might also comprehended to personal attributes and attitudes; emphasizing on the importance of teamwork and effective communication in order to secure safety in harbour towage operations. A specific code, analysis of situation (whether an action was safe) was marked; whether it was related to handle tugs of new generations (with reported exceptional tug size to power ratios) or the capability to judge speed of a vessel to decide whether it was safe to close on her bow to make a tow.

4.1.3 Expert Interview Account (EI)

4.1.3.1 Data analysis

All 5 interviews were transcribed. The transcribed interviews were then coded and analyzed using the approach suggested by Braun and Clarke (2006). This approach consists of six steps, as outlined in Figure 4.1.

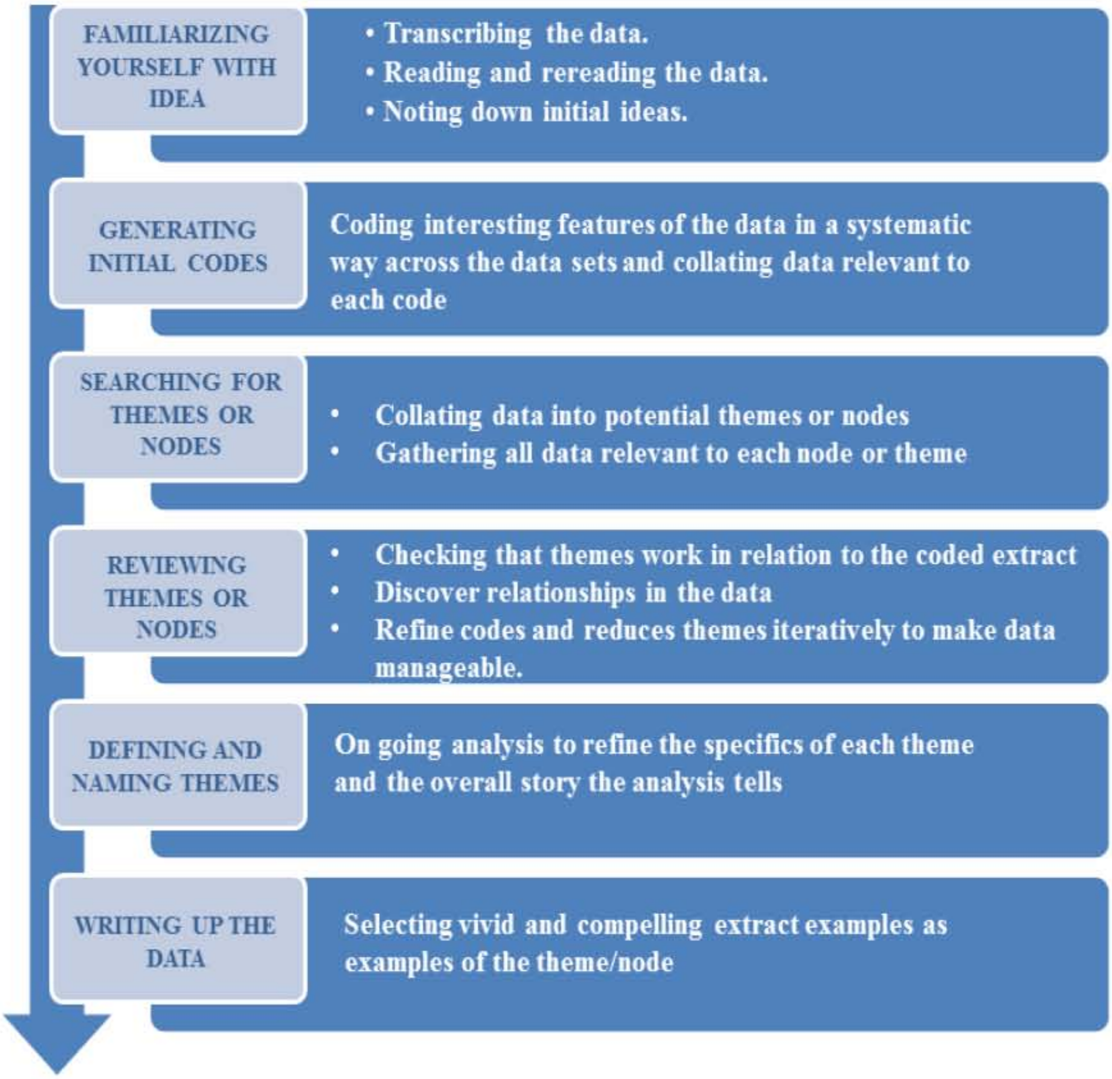


Figure 4.1 - Approach to analyze transcribed interviews (RO1-EI)
Source: Author Drawn

The transcripts were coded into broad nodes. Codes were not predefined but rather discovered through a thorough reading and rereading of the transcripts. Initially, 11 broad nodes or themes were discovered in the data. Finer coding subsequently took place to reduce the number of categories. Finer coding was aided by careful analysis that revealed relationships between nodes as well as summaries of nodes. These analyses revealed the number of sources in which nodes were discovered, the number of coding references, the number of words coded and number of paragraphs coded. Credibility of data was ensured through the development of a code book, where codes and nodes are defined, thus enabling independent verification. Triangulation of the interview data with the case report account and questionnaire survey further ensured credibility as participants' claims were able to be verified.

4.1.3.2 Ethics

All participants gave informed consent to participate in the study and were advised that they could withdraw at any point. Whilst all requested for their names and organization not to be revealed anywhere, the thesis does not refer to their names in reporting the data.

4.1.4 Final Nodes by Source with Exemplar Nodes (Experts - India)

Parent Node	No. of Participants quoted	Child Node	No. of times node is coded for in data	No. of sources the node appears in	Recommendations in Exemplar quotes
Poor Maintenance/ Substandard condition of Equipment's	P2, P7, P9, P10	Poor Mooring Equipment	5	4	*"Ancillary towage equipment, such as wire towage protectors and thimbles should be regularly inspected and should be form a part of the PMS."*
	P3, P7, P10,	Bridge Equipment Ergonomics	3	3	*"...wheelhouse should be properly designed to minimize incidents with respect to human factor..".*
	P7, P9	Navigation System Failure	2	2	*"Unexpected events, such as navigational equipment failure or unusual traffic movements. Led many accidents in past.."*
	P2, P7, P9, P10	Condition of Mooring Line	5	4	*"..Mooring lines equipment should be closely examined to ensure all linkages are working correctly, brake band material thickness is adequate and the condition of the brake lining is satisfactory...It is important that the shackles and wires used are appropriate for the operator, certified and in good condition."*

	P7, P9	Loss of propulsion power	2	2	*"The tugs should in all aspects be safe tugs. This applies to operational reliability of engines, propellers/thrusters, steering equipment, deck equipment, - Seaworthiness (if applicable);when rendering assistance; in case of engine/steering failures; there are grave dangers associated with M/E or electrical failure.."*
Poor Work Process	P2, P9, P10	Wrong Operating Procedure	7	3	*"..Clear operating instructions in the appropriate language should be available near all the manual and emergency controls. The working of the winch emergency release system (ERS), if fitted, should always be understood by those operating the winch..."*
	P9	Interaction	3	1	*"Several ship captains experienced interaction effects and a large percentage of pilots and tug masters had critical experiences with these effects."*
	P2, P7, P9, P10	Speed	11	4	*"With matching ship's speed, it is clear what safety margin you have with respect to tug power"*
	P9	Girting	1	1	*"There are many dangers associated with girting (girding) situations...It is the most prevalent reason for tugs to capsize and can cause fatalities..."*

	P2, P10	Poor Tug Handling	2	2	*"..ships' crews, pilots and tug-masters must repeatedly be made aware of such possible forces and the inherent dangers"*
	P2, P9, P10	Securing And Releasing of Tug	6	3	*"If the tugs crew are required to access the towed unit plans must be made so that it can be carried out safely in the prevailing circumstances..."*
Incompetency	P9, P10	Poor Seamanship	4	2	*"..Overall, the mooring operation should have a fixed rhythm and coordination, with crew both fore and aft depending on each other. Timing is often a vital factor when making fast the various lines and if it is not done right the first time, it can put safety at risk."*
	P3, P7, P9, P10,	Lack Of Training	11	4	*"..The agility of the modern ship handling tug is such that it has the ability to ensure that the vessel's BP can be applied precisely, where and when it is required... "*
	P3, P9, P10	Communication	8	2	*"...decisions taken in the isolation of the wheelhouse (from where the tugs are often not visible) can have serious outcomes if not communicated adequately and the consequences of certain manoeuvres understood..."*
		Watch Keeping Or Lookout	0	0	

	P3, P10	Human Factor	4	2	*."...it has been researched time and again that 70% of accidents happen due to human mistake.....effectively managing the human factor can lessen the exposure to accidents...."*
	P3, P10	Poor tow Planning	2	2	*"..a good practice is that a Towmaster should be nominated for each tow. The Towmaster will present a tow plan to the Harbourmaster in good time for a review and for permission to be given or other requirements to be accommodated."*
Rough Weather	P9, P10	Current	3	2	*"Mariners will be aware of the effects that currents have on a craft being manoeuvred in water. The effects of current in open waters are less important than the effects in confined waters which can be significant particularly when manoeuvring in busy waters."*
	P7, P9, P10	Swell	5	3	*"..Working in coastal areas or tidal areas is particularly hazardous due to strong swells, currents and unexpected change of current direction..."*
	P7, P9, P10	Visibility	5	3	*"..During operations in restricted visibility the Pilot / Master of the assisted vessel shall provide well in advance all engine movements, thrusters movements and alterations of course.."*
	P7, P9, P10	Wind	5	3	*"..Preventing accidents is about reducing the risks of those factors. The only parameter that is hard to overcome in this respect is the weather..."*

Poor Safety Management System	P2	Personal Safety	1	1	*"Personnel working on tugs have a responsibility for their own and their colleagues' safety..."*
	P2, P10	Safety Culture	3	2	*"Why a Safety Culture? ... the most sophisticated safety system is useless without a supportive culture..."*
	P2, P9, P10	Poor Supervision/ Command	4	3	*"..Tugmasters need to show leadership in all areas of operation, it is fundamental to their position and role. The key to developing a successful culture of safety onboard is leadership. .."*
unsuitability of Tug	P2	Tug Equipment	1	1	*"...Again, before every towing operation the towing gear should be visually inspected and tested..."*
	P2, P9, P10	Tug Type	9	3	*"..Safe speeds depend on tug type. For instance, safe speeds for tractor tugs can be higher than for conventional tugs. Weather conditions and tug master experience play a role as well..."*

	P2	Navigational Obstacle	2	2	*"..Very often, the tug and barge transit through waters where the sea room is restricted. The master then must consider shortening the tow wire to ensure better control of the barge. The length of the tow wire is at the master's discretion depending on the prevalent situation..."*
No/Poor Risk Assessment	P2, P3, P7, P9, P10	No Tow Planning	9	5	*"....In all incidents pre-planning may not have been carried out for a variety of reasons; sometimes it is because the task is considered routine or there is no time available...."*
	P7, P9, P10	Tug Approach Manoeuvres	8	3	*"..Most captains say that tugs should only approach the ship for securing when the crew is ready. More than half of the pilots prefer to instruct the attending bow tugs to approach the bow only when the ship's crew is ready to send a heaving line. Some rely on tug masters' experience..."*
	P9, P10	Insufficient Manpower	2	2	*".. The manning of the towing vessel may be determined by an appropriate regulatory authority; however it is the responsibility of the owner/operator to ensure that the tug is manned with adequately certified and experienced personnel for the voyage...."*
Fatigue / Commercial Pressure	P10		1	1	*"...Fatigue should not be underestimated and it is now acknowledged that many incidents occur where fatigue is a factor ...."*

Negative attitudes	P9		1	1	*"one problem is complacency; old skippers saying, I've always done it this way..."* *"there is no reason for this to occur other than negligence ..."*
Watertight Integrity	*P9*		*1*	*1*	*"tugs have got such bloody good stability that you can yank them right over and they will bounce back. But they won't bounce back if you've got a door open ..."* *"it's always someone leaving the door open ..."*

Wash/Squat effect	P9		1	1	*" this is when the wash's contact with the towed object/barge reduces the pulling effectiveness of the unit. Factors that can contribute to this are- Small under keel clearance of the assisted unit.; Hull form of the assisted unit; Length of tow line; Area of operation – confined areas will increase the wash effect. Under keel clearance- If the under keel clearance is small the propeller wash effect is increased reducing the tug's pulling effectiveness. Obviously pulling a barge or a vessel that is effectively aground or stuck in mud will increase the tension in the tow line. The suction effect can cause unexpected dangers as the barge can come clear of the suction effect of the mud and become free suddenly. Tugs' crews should be aware of this possibility and stand in a place of safety."* *"Squat effect- is often applied to ships, but any moving craft through the water can be affected by squat. The effects of squat are greatly increased by speed and if operating in waters of a confined width and may result in the change to the vessel's headings and the possibility of the towline shearing..."*

Table 4.14 Final Nodes by Source with Exemplar Nodes (Experts from Indian region)

4.1.5 Comparison of Secondary with Primary RST Quantitative Data

The most frequent Event in both Case reports (89%) and Questionnaires (82%) was Collision.

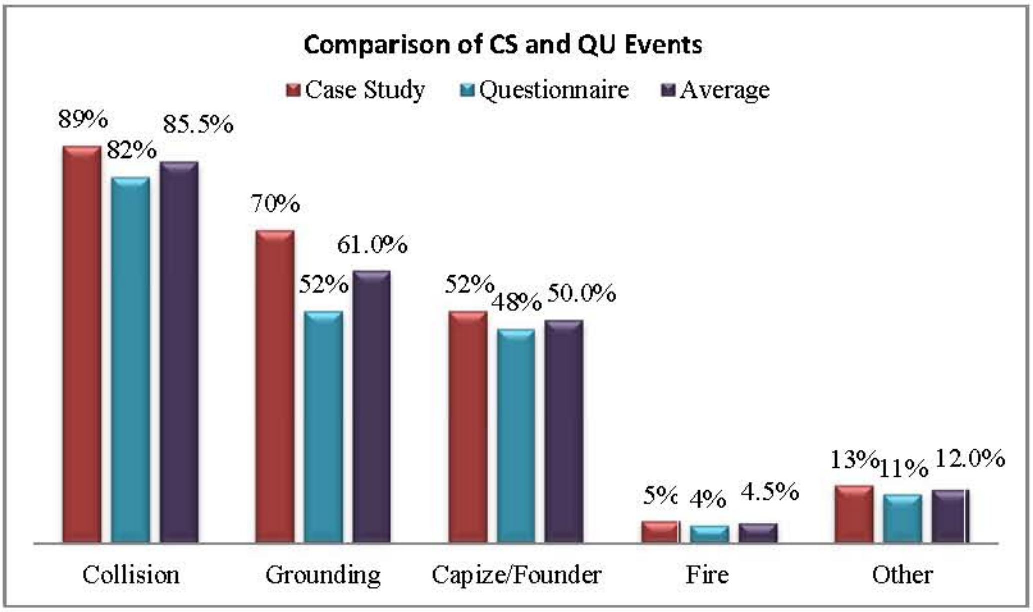


Chart 4.29 - Comparison of CR and QU Events

The most frequent Consequence in both CR (72%) and QU (91%) was Damage. Both surveys also had a noticeable Loss of Life frequency (40%).

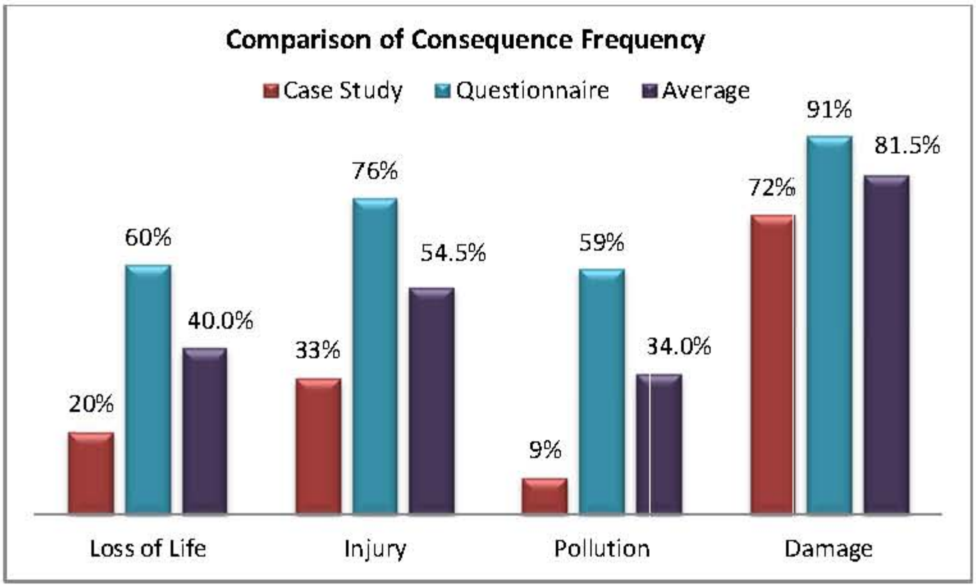


Chart 4.30 - Comparison of Consequence Frequency CR and QU

Conventional Tugs were most frequent in CR (70%) whereas ASD Tugs were most frequent in QU (22%).

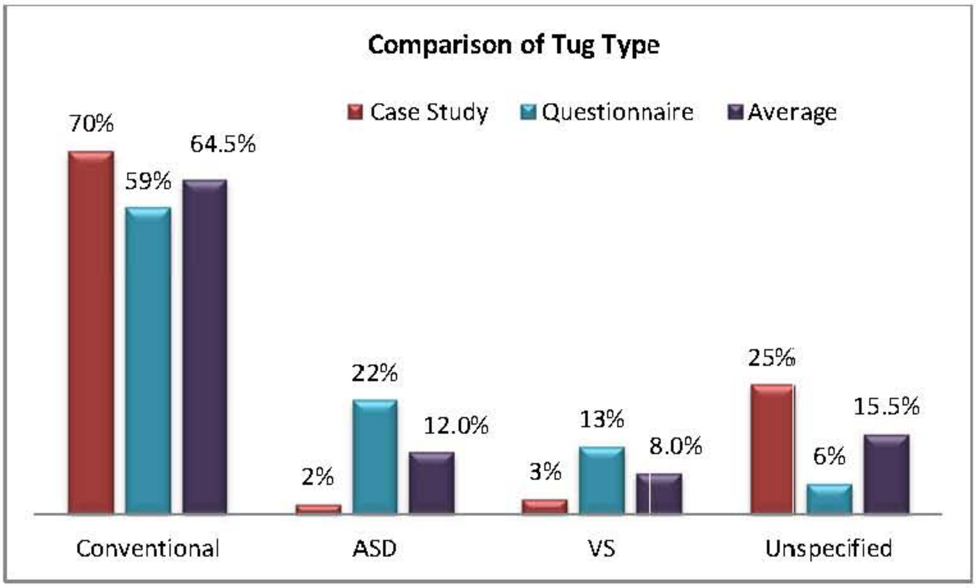


Chart 4.31 - Comparison of Tug Type CR and QU

Moderately powered Tugs were most frequent in CR (62%) whereas Medium powered tugs were most frequent in QU (49%).

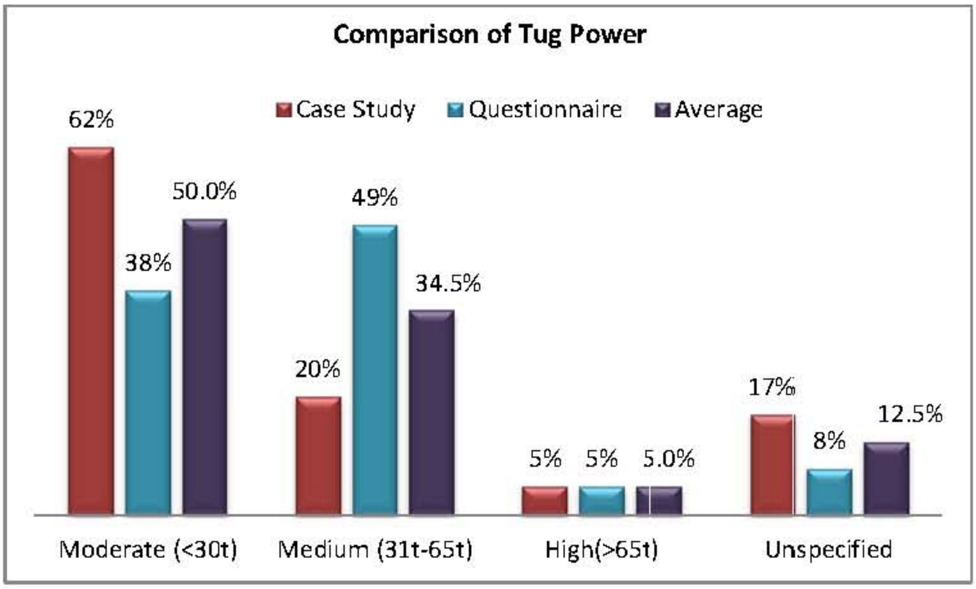


Chart 4.32 - Comparison of Tug Power CR and QU

A Forward tow position was most frequent in CR, whereas an Aft tow position was most common in QU (52%).

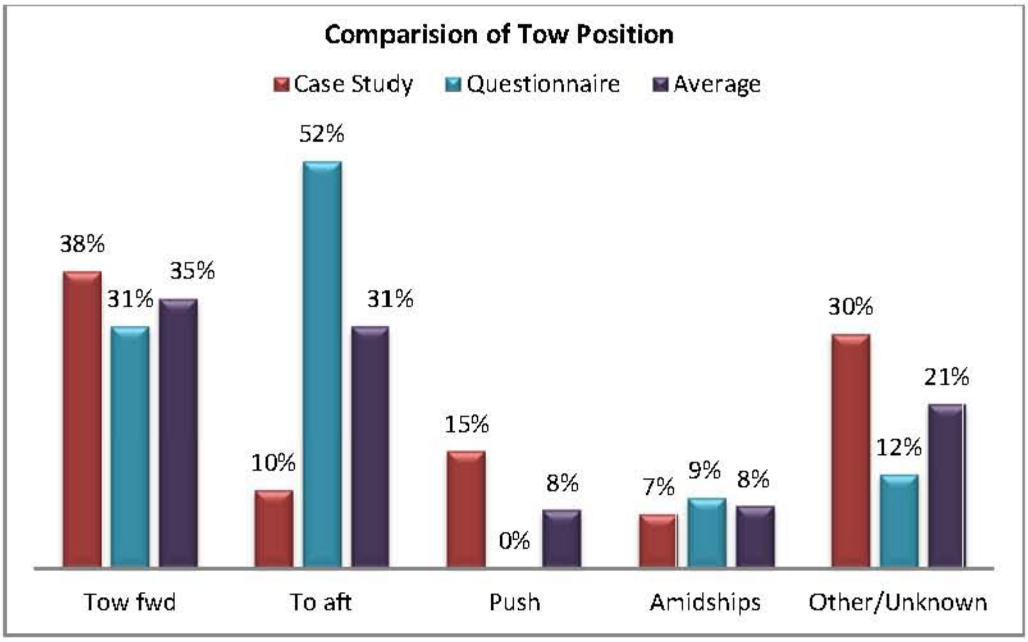


Chart 4.33 - Comparison of Tow Position CR and QU

Barges were the majority of towed vessels in the CR (58%) whereas they were the least frequent Category in the QU (10%).

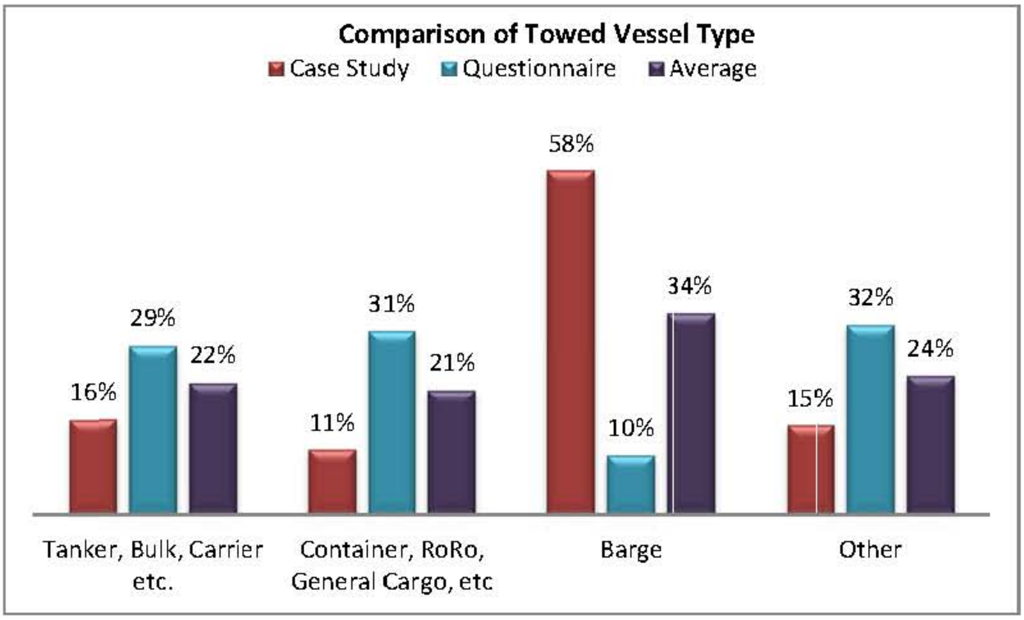


Chart 4.34 - Comparison of Towed Vessel Type CR and QU

The most frequent Bow form in CR was Moderate (53%) whereas a Fine bow form was most common in QU (31%).

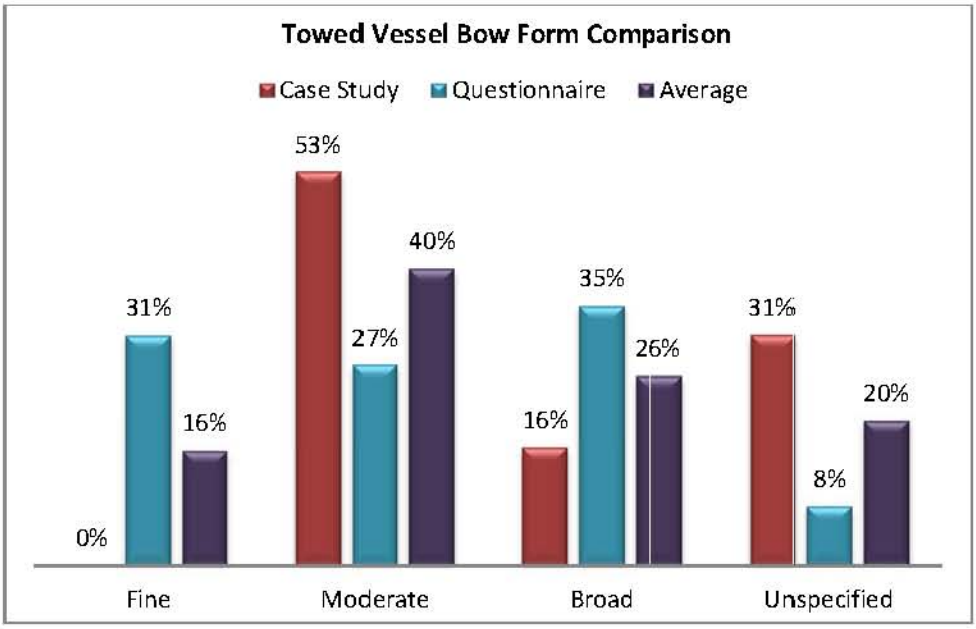


Chart 4.35 - Towed Vessel Bow Form Comparison CR and QU

The most frequent Towed Vessel category in the CR was small (46%) whereas the most frequent category in QU was Medium (35%).

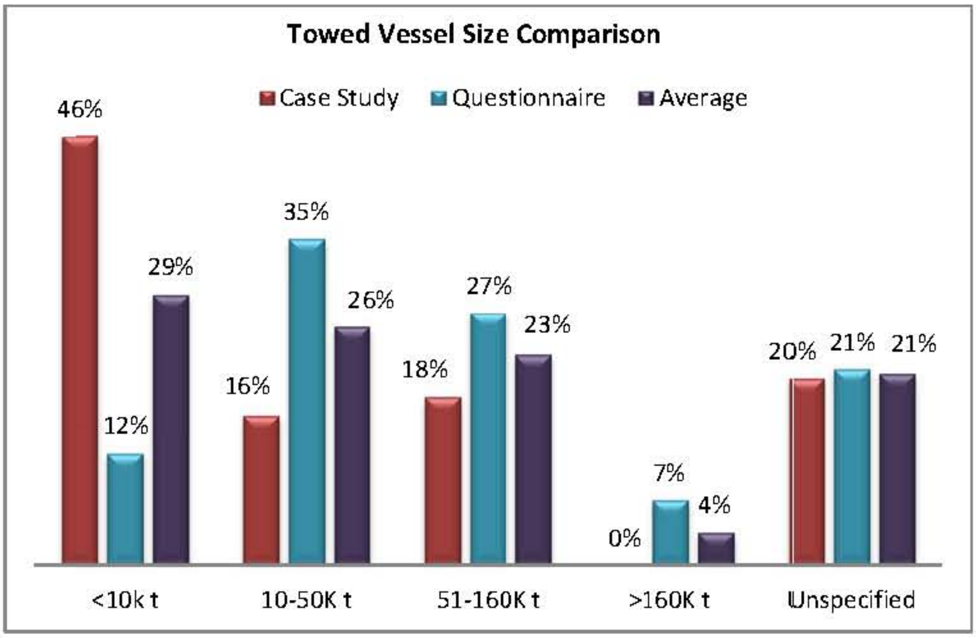


Chart 4.36 - Towed Vessel Size Comparison CR and QU

4.1.6 Discussion & Conclusion

The most frequent Risk Factors in both the Case Report and Questionnaire were (average):

- Human Factors (86%);
- Tow Planning (84%);
- Communication Procedure (64%);
- Poor Training (83%);
- Poor Tug Handling (69%).
- Speed (57%)

Other notable Risk Factors in both surveys were (average):

- Tug Approach (49%);
- Interaction (47%);
- Tug Type (29%);
- Girting (41%);
- Navigational Obstacle (34%)
- Safety Culture (36%)
- Substandard Equipment (34%)
- Poor Seamanship (41%)

Substandard Tug Equipment and to a lesser extent safety culture had notable frequencies; however there was clear variation between the CR and QU data:

- Substandard Tug Equipment (average 34%, with 48% variation);
- Safety Culture (average 36%, with 33% variation).

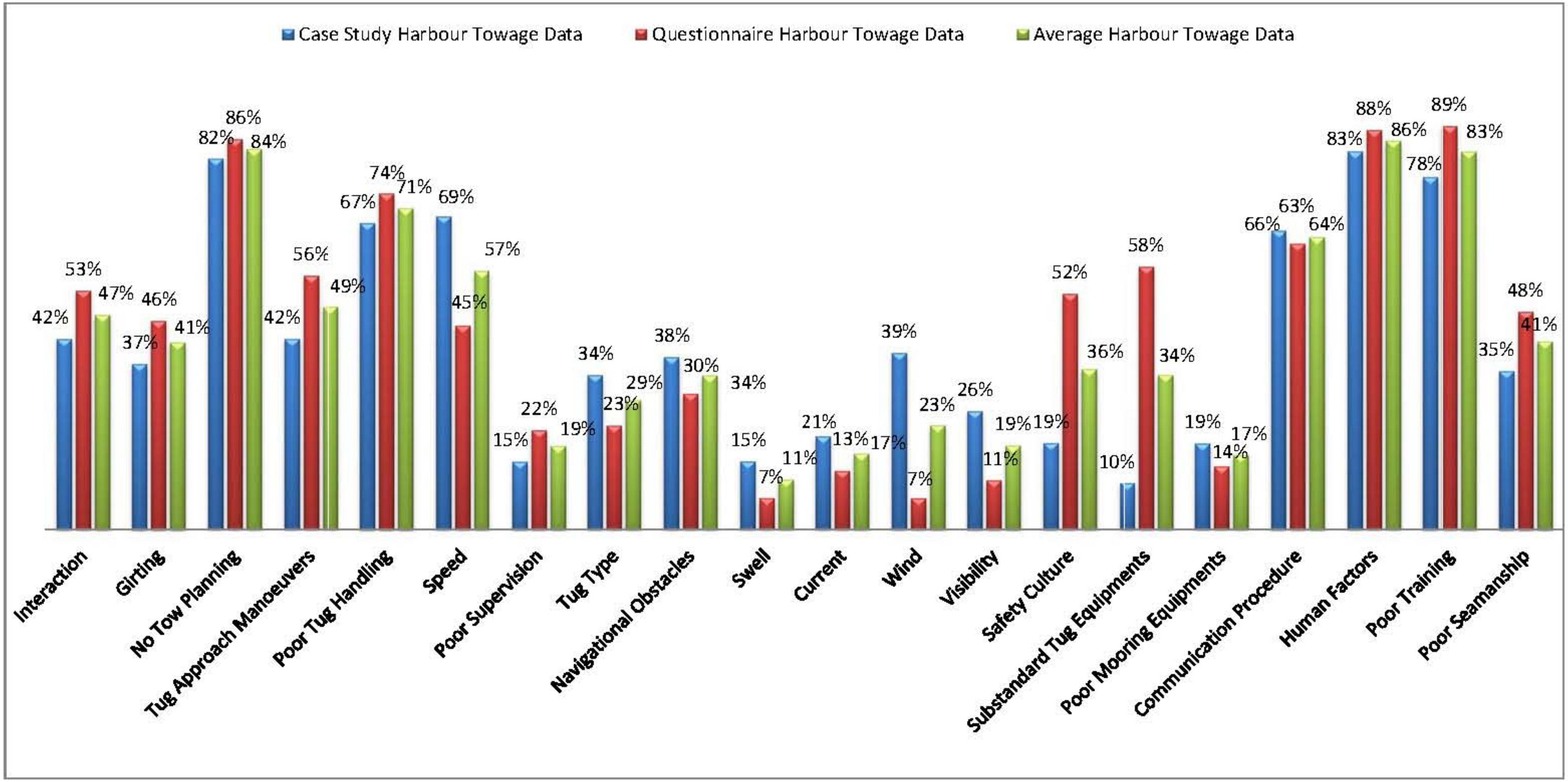


Chart 4.37 - Comparison of Questionnaire & Case Report Harbor Towage Risk Factors CR and QU

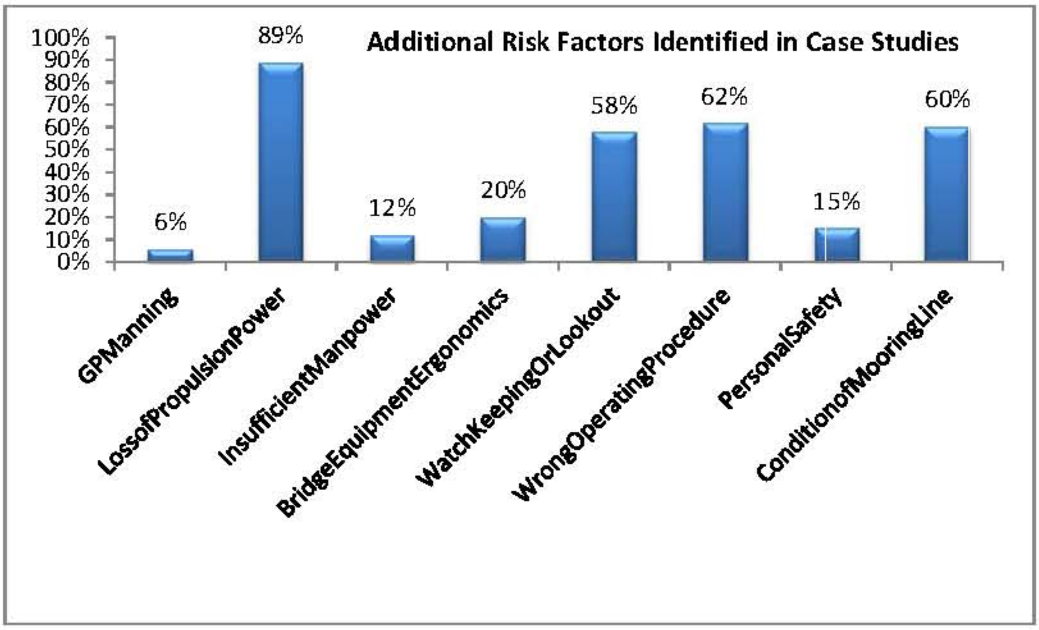


Chart 4.38 - Additional Risk Factors identified in Case reports

Stability, Time, and Crew Qualities & Attitudes were identified in the Expert Interviews, but were not explicitly identified in the Case reports or Questionnaires.

Expert Interview confirms that seven factors are responsible to a threat to Routine Ship Towage safety in Indian Coastal waters, these are Poor work process, poor maintenance of equipment/substandard condition of Equipment, severe weather conditions, poor or no risk assessment, occupational incompetence, the suitability of the type of tug and poor safety management system.

Expert Interview also mentioned additional safety risk factors such as Stability(which can be taken in watertight Integrity), Commercial Pressure(Time), Poor Seamanship, Wash/squash effect (Navigational Obstacle), Fatigue & Attitudes, these were not explicitly identified in the Case Studies or Questionnaires.

4.2 RESEARCH OBJECTIVE 2 (RO2): Expert Interview

In this objective we intend to explore solutions & practices adopted by various organizations in towage industry to deal risk factor causing threat to safety and to draw some indication to validate identified risk factors.

4.2.1 Data analysis

All 12 interviews were transcribed. The transcribed interviews were then coded and analyzed using the approach suggested by Braun and Clarke (2006). This approach consists of six steps, as outlined in Figure 4.2.

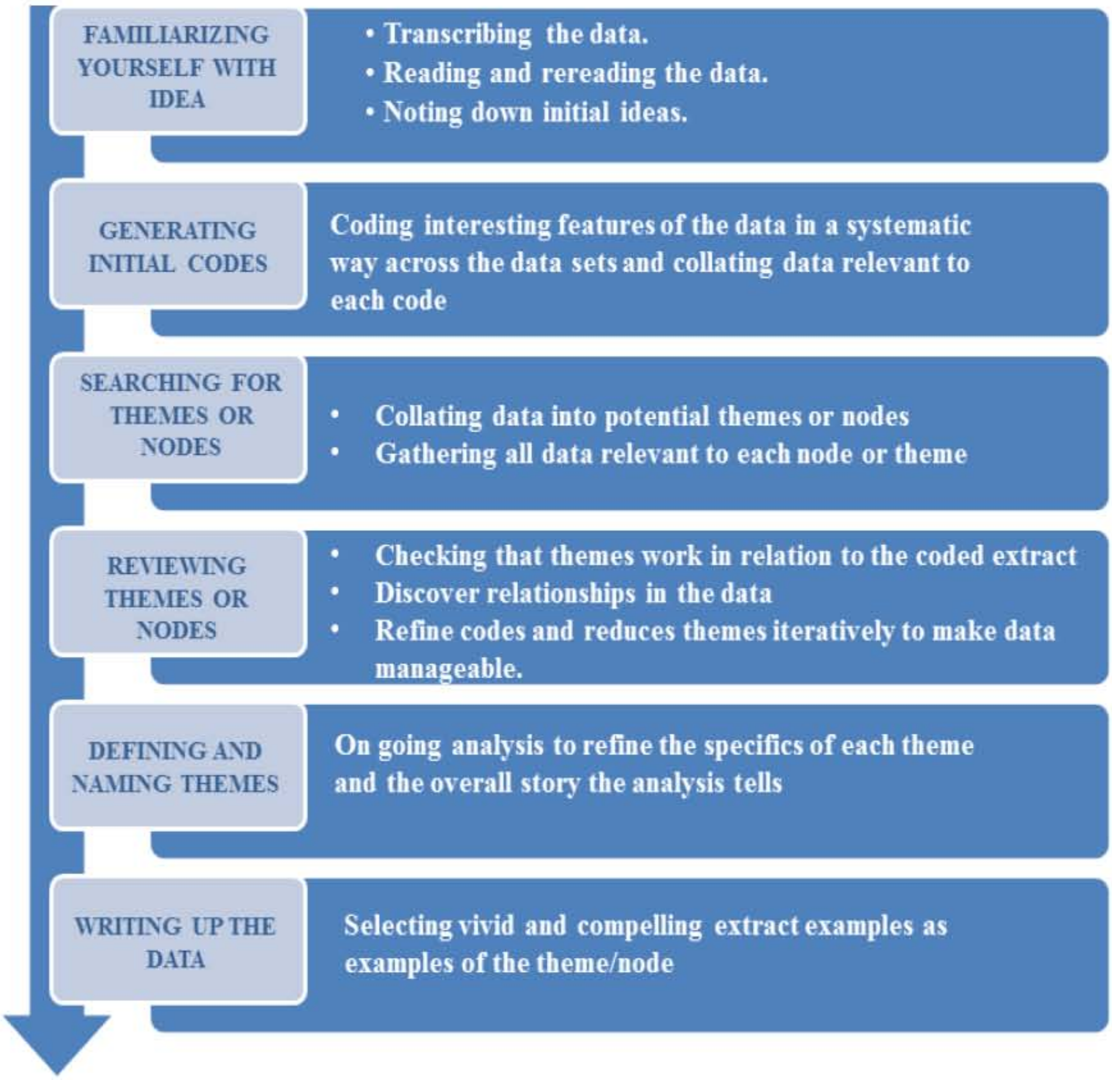


Figure 4.2 - Approach to analyze transcribed interviews (RO2-EI)
Source: Author Drawn

The transcripts were coded into broad nodes. Codes were not predefined but rather discovered through a thorough reading and rereading of the transcripts. Initially, 11 broad nodes or themes were discovered in the data. Finer coding subsequently took place to reduce the number of categories. Finer coding was aided by careful analysis that revealed relationships between nodes as well as summaries of nodes. These analyses revealed the number of sources in which nodes were discovered, the number of coding references, the number of words coded and number of paragraphs coded. Credibility of data was ensured through the development of a code book, where codes and nodes are defined, thus enabling independent verification.

4.2.2 Ethics

All participants gave informed consent to participate in the study and were advised that they could withdraw at any point. Whilst all requested for their names and organization not to be revealed anywhere, the thesis does not refer to their names in reporting the data.

4.2.3 Final Nodes by Source with Exemplar Nodes (Experts - Global)

Parent Node	No. of Participants quoted	Child Node	No. of times node is coded for in data	No. of sources the node appears in	Recommendations in Exemplar quotes
Poor Maintenance/ Substandard condition of Equipment's	P2, P4, P5, P6, P7, P9, P10, P11	Poor Mooring Equipment	11	8	*"Industry has seen losses due to poor maintenance of mooring equipment……all fixed and running gear including ropes shall be carefully maintained, tested, certified and regularly inspected against wear, damage and corrosion….. Particular attention is drawn to the need to ensure that fairleads, lead bollards, mooring bitts etc. are used appropriately and within their design capabilities and effectively secured to a part of the ship's structure which is suitably strengthened."* *"Ancillary towage equipment, such as wire towage protectors and thimbles should be regularly inspected and should be form a part of the PMS."*
	P3, P5, P7, P10, P11	Bridge Equipment Ergonomics	5	5	*"…wheelhouse ergonomics related to … radar, communication systems, engine and/or rudder controls, winch control, quick release system, switching between manoeuvring panels, optimal visibility from the wheel house, clear windows, lighting, back-up systems, etc…should be properly designed to minimize incidents with respect to human factor..".*
	P5, P7, P9, P11	Navigation System Failure	4	4	*"Unexpected events, such as navigational equipment failure or unusual traffic movements..led many accidents in past.."* *"The tugs should in all aspects be safe tugs. This applies to operational reliability of engines, propellers/thrusters, steering equipment, deck equipment, etc. Navigation lights should be independently powered and the fuel or power source should be adequate for the maximum duration of the towage with reserve. It is also advisable for a searchlight to illuminate the tow to be available."*

	P1, P2, P4, P5, P6, P7, P9, P10, P11	Condition of Mooring Line	13	9	*"..The towline must be checked periodically for a fairlead and chafing. Points of chafe must be protected.... Appropriate lubrication and wearing surfaces should be placed so as to eliminate towline-to-hull contact....there is exist..danger from damaged tow lines or equipment."* *"Routine maintenance should include regular visual inspections of all equipment, greasing of grease nipples on moving machinery and of rollers on fairleads and pedestal fairleads. Open gearing and clutches should also be suitably greased with an appropriate dressing. Brakes should be closely examined to ensure all linkages are working correctly, brake band material thickness is adequate and the condition of the brake lining is satisfactory...It is important that the shackles and wires used are appropriate for the operator, certified and in good condition."* *"The care of wire and synthetic ropes, including stretchers, is an important part of the PMS. Formal guidance on how to inspect, stow and maintain ropes and wires should be provided...."* *"A major issue is trying to maximise the service life of rope and still maintain safety. All tug's deck crew should be trained in rope inspection and gauging when a rope is damaged and is no longer fit for purpose and safe for use".*
	P5, P6, P7, P9, P11	Loss of propulsion power	5	5	*"The tugs should in all aspects be safe tugs. This applies to operational reliability of engines, propellers/thrusters, steering equipment, deck equipment, - Seaworthiness (if applicable);when rendering assistance;in case of engine/steering failures; there are grave dangers associated with M/E or electrical failure.."* *"...it is important that maintenance of critical equipment is monitored and recorded and this includes the towing gear. If no records are kept and there is no reliable knowledge on what has been inspected or overhauled, in good or poor order..."*

Poor Work Process	P1, P2, P4, P5, P9, P10, P11	Wrong Operating Procedure	16	7	*"..Shipping companies and ship captains should implement rules for safe procedures regarding the securing and releasing of tugs, including safe speeds, use of suitable heaving lines and proper handling of heaving lines and tow lines in a safe and efficient way, SWL of bollards and fairleads, proper bollard use with respect to towlines, and keeping an eye on the tugs when fastening and releasing. Ship's crew should be trained in all these issues..."* *"..I believe in writing down the best procedure for a particular operation in a safety management system (SMS) helps standardize operations and minimize human error..."* *"..Need of regular meetings between port authority, pilots and tug masters about proper procedures. The owner and/or master must develop a procedure to ensure that the vessel can be moored safely."* *"..Clear operating instructions in the appropriate language should be available near all the manual and emergency controls. The working of the winch emergency release system (ERS), if fitted, should always be understood by those operating the winch..."* *The master must have procedures in place and must consider the following before towing another ship; ships at sea are only obligated to attempt to save life. Property rescue should only be considered when, in the master's opinion, there is no perceived risk to the crew and ship; the vessel should be capable of towing or being towed by a vessel of similar size ...; the tow should be made fast to the towing ship forward of the rudders and propellers so the ship will retain steerage. If this is not practical, a bridle using a running block can be arranged to move the effective towing point forward and retain steerage, even though the tow is attached to the stern of the ship ...;the towing load should be distributed evenly across cleats and bollards, or if a strong point is provided for that purpose the tow should be attached to it ...; messenger lines or a dinghy can be used to carry the towline to the tow if it is difficult or dangerous to come in close to the tow ...; a means of communicating between the two ships must be established (radio, voice, flags, hand signals).. ;the master will make provision for the rapid slipping or cutting of the tow in an emergency situation..;ensure the appropriate day shapes and lights are displayed"*

	P1, P5, P6, P9, P11	Interaction	7	5	*"...The phenomenon of interaction is well known to mariners and it is particularly dangerous in situations where there is a larger vessel or barge moving at speed in close proximity to another smaller vessel, such as a tug. The effect is increased further in confined and shallow waters. Areas of high and low pressure exist in and around the ship's hull and these areas can cause adverse movements of smaller vessels in close proximity. The speed of water flowing between the tug and the vessel increases at the last moment as the tug comes alongside. As this happens the tug therefore has to increase speed to maintain the same speed as the vessel. The Tugmaster has to compensate for the tug either being drawn in or pushed off the vessel..."* *"Several ship captains experienced interaction effects and a large percentage of pilots and tug masters had critical experiences with these effects."*
	P1, P2, P5, P6, P7, P9, P10	Speed	16	7	*"With matching ship's speed, it is clear what safety margin you have with respect to tug power"* *"..Safe speed to be based on what speed a tug master can drive his/her tug in a controlled manner (particularly going astern for bow-to-bow) on one engine. Once this speed is established for the specific tug, prevailing conditions and competency of the tug master, I recommend taking one knot off the figure and we are getting close to determining the safe connection speed. ;...Half of the tug masters say there are speed limits in their ports, either through regulation, by guidelines, or established practice.;...A maximum speed of 6 knots is most common, with 7 or 8 knots in a very few ports;...Pilots report that some ports have a pre-agreed speed of 6 knots through the water, or 5 knots for bow-to-bow operations. Some pilots say that they usually reduce speed to 6 knots, while others trust the tug masters' insight."* *"..Some tug masters reported that their towing companies have maximum speed restrictions or guidelines. A maximum speed of 6 knots is mentioned most often, and 11 knots for escorting. ...Safe speeds depend on tug type. For instance, safe speeds for tractor tugs can be higher than for conventional tugs."*

	P5, P9	Girting	3	2	*"There are many dangers associated with girting (girding) situations…It is the most prevalent reason for tugs to capsize and can cause fatalities. This occurs at either end of the tow and can happen very quickly. Rarely does it happen slowly enough to allow all of the crew to leave the tug before it capsizes. Tug masters must be aware of the phenomenon and understanding the quick release to the tow wire is essential if disaster is to be averted….."* *"GGT is particularly relevant to conventional single screw tugs. Tractor and ASD (Azimuthing stern drive) tugs are less likely to girt because their tow is self-aligning and the tug master is able to produce significant thrust in all directions. It is clearly understood that towing from a point near amidships on a conventional tug is inherently unstable and can result in situations where the load on the tow rope can heel the tug over to a large and dangerous angle."*
	P1, P2, P10	Poor Tug Handling	5	3	*ships' crews, pilots and tug-masters must repeatedly be made aware of such possible forces and the inherent dangers"*
	P2, P5, P6, P9, P10	Securing And Releasing of Tug	9	5	*"…There are no strict rules to making fast the tow. Each tow will be different; the barge size, shape, draught, weather, current strength, light or location will vary. Prior planning will make the operation safer. A briefing between the tug master and his crew on how the job is to be approached is vital. Before arrival at the connecting location effective communications should be established between the tug and towed unit if manned. Ideally, a risk assessment would be in place. Tug speed should be adjusted for a safe rendezvous and connection."* *"If the tugs crew are required to access the towed unit plans must be made so that it can be carried out safely in the prevailing circumstances…"*

Incompetency	P1, P4, P5, P9, P10	Poor Seamanship	7	5	"..Overall, the mooring operation should have a fixed rhythm and coordination, with crew both fore and aft depending on each other. Timing is often a vital factor when making fast the various lines and if it is not done right the first time, it can put safety at risk."
	P1, P3, P5, P6, P7, P9, P10, P12	Lack Of Training	20	8	*"..It is recommended that pilots (including PEC -Pilot Exemption Certificate- holders are trained on the same subjects as mentioned above, such as with regards to the capabilities and limitations of tug types in use, safe tug and communication procedures, safe speeds, knowledge about interaction effects and their effect on tugs, and all other important aspects of safe towing…"* *"..The agility of the modern ship handling tug is such that it has the ability to ensure that the vessel's BP can be applied precisely, where and when it is required… In this way ship handling becomes quicker, safer and more efficient. This ability is, however, coupled to a real need for understanding by the tug master of exactly how a tug will react… With the agility and power available, mistakes can occur rapidly in the hands of the unwary. In order to benefit fully from the advantages offered by modern ship handling tugs, a new standard of crew training is essential…."* *"…To be successful, a candidate must be pre-screened and become familiar with the type of tug and its design dynamics. Docking procedures and techniques must be fully explained and understood, in theory and practice…"* *"..I well recall taking command of my first tugboat, a small single screw wooden vessel engaged in port services. The attitude of management then was, 'you've got the ticket, do the job'. So, left to my own devices, I learned more from the kindly old deckhand than from any of my peers. Thankfully attitudes have changed, but not everywhere. Any Master taking command of a tug should not be expected to do so without first being trained to operate the vessel safely…"*

	P1, P3, P4, P5, P6, P9, P10, P11	Communication	20	8	*"...decisions taken in the isolation of the wheelhouse (from where the tugs are often not visible) can have serious outcomes if not communicated adequately and the consequences of certain manoeuvres understood..."* *"..All pilots and most of the tug masters prefer to communicate in the local language. Possible mistakes and errors are mentioned by the pilots as reasons. On the other hand, all captains say that communication with the tugs should be done in English...* *Information communicated to tug masters includes SWL of bollards, where to secure tugs, mooring plan, etc.."*
	P1, P5	Watch Keeping Or Lookout	2	2	*"...most of ship captains say they prefer to instructed their officers to keep an eye on the tugs in general and when they are not visible from the bridge..."*
	P3, P4, P10 P12	Human Factor	6	4	*."...it has been researched time and again that 70% of accidents happen due to human mistake.....effectively managing the human factor can lessen the exposure to accidents. A safety management system allows a company to put into place the building blocks for reducing incidents of human error...others are.. Quality in the safety context is about being able to reflect on your own operations and procedures, and being open to assessment by others. Nautical safety is not a project with an ending, it is a continuous process which involves many human factors. Learning and being aware are key elements in reducing risk..."*

	P1, P5	Poor tow Planning	2	2	*"..a good practice is that a Towmaster should be nominated for each tow. The Towmaster will present a tow plan to the Harbourmaster in good time for a review and for permission to be given or other requirements to be accommodated.* *The tow plan should include taking all the action a prudent Master or Pilot would in having conduct of the operation. This tow plan should include but not be limited to Risk Assessment (Method Statement, Number and position of tugs, Type of tug , use of particular tugs, Position of tugs, Use of release mechanism, Manning, Passage plan berth to berth.."* *"Regular dumb tow operations e.g. barges, pontoons and leisure operations may be covered with a generic tow plan and details of Skipper/Master/Coxswain qualifications"*
Rough Weather	P1, P4, P5, P9, P10	Current	10	5	*"Mariners will be aware of the effects that currents have on a craft being manoeuvred in water. The effects of current in open waters are less important than the effects in confined waters which can be significant particularly when manoeuvring in busy waters."* *"..the speed and direction of currents are also unpredictable, reasons include; changes in tidal direction, sudden water flows at river mouths due to rains or ice melt, constraints such as narrows, reefs, breakwaters and harbour walls. The effect of squat in shallow water can be considerable, particularly for large barges with a flat hull form"* *"Check the weather. If you have a short run and need to be alongside, determine which side will be the lee side. It will be more comfortable for the crew and will lessen surging between tug and barge on the lee side..."*
	P1, P4, P5, P7, P9, P10	Swell	11	6	*"..Working in coastal areas or tidal areas is particularly hazardous due to strong swells, currents and unexpected change of current direction..."*

	P1, P4, P5, P6, P7, P9, P10	Visibility	15	7	*"..During operations in restricted visibility the Pilot / Master of the assisted vessel shall provide well in advance all engine movements, thrusters movements and alterations of course.."*
	P1, P4, P5, P7, P9, P10	Wind	12	6	*"..Not appreciating the effects of the wind when towing can result in collisions, groundings, towlines parting, injury and girting. The wind causes headings to change, speeds to increase and a towed craft to drift…Manoeuvring can become difficult if the wind increases or changes direction suddenly. Tug masters should always be aware of the potential effects of the wind before a tow commences or before commencing the next part of a towing operation. Knowing the forecast or local weather conditions is essential.* *Preventing accidents is about reducing the risks of those factors. The only parameter that is hard to overcome in this respect is the weather…"*
Poor Safety Management System	P2, P4, P5, P6, P12	Personal Safety	10	5	*"..Risk of personal injury is high. Recent studies indicate that the one of the largest risks to personnel is falling over the side into the water. Owners and tug masters should have a Clear Deck policy that does not allow personnel onto the towing area when the unit is being towed.."* *"Personnel working on tugs have a responsibility for their own and their colleagues' safety…"* *"..Tug crews involved in towage operations on deck will always wear approved and in-date self inflating lifejackets and other appropriate PPE throughout the operation… They should ensure that the working area is safe and free from trip or slip hazards and remain alert to what the vessel crew is doing…"*

	P1, P2, P4, P5, P6, P10, P12	Safety Culture	11	7	*"..Culture and values will certainly influence our attitude toward safety. Attitudes are a primary factor in the success or failure of safety programs. Attitudes that say 'we've always done it that way,' 'it costs too much,' or 'it's too slow' predicate failure. ....Whereas attitudes that adapt to change and learn from experience are necessary for success..."* *"Why a Safety Culture? ... the most sophisticated safety system is useless without a supportive culture ..."*
	P1, P2, P4, P5, P6, P9, P10 P12	Poor Supervision/Command	17	8	*"...Unless the tow is manned it should be boarded on a regular basis by the crew of the tug particularly after a period of bad weather. This should be done only when the prevailing weather allows such an operation and when on board the crew must verify that all the towing arrangements, condition of the cargo sea fastenings and watertight integrity of the tow are satisfactory. Suitable access must be provided which may include at least one permanent steel ladder on each side from main deck to below waterline ..."* *"..Tugmasters need to show leadership in all areas of operation, it is fundamental to their position and role. The key to developing a successful culture of safety onboard is leadership. Leadership must be displayed by Masters and supported by shore management. Before leadership can be displayed it is necessary for the leader to believe in, and be committed to, safe work practices and operations. This means that 'cowboys' need not apply!"*

unsuitability of Tug	P1, P2, P4, P11	Tug Equipment	10	4	*"...Again, before every towing operation the towing gear should be visually inspected and tested. Towing arrangements and equipment should conform to the following - All the towing equipment and gear, towing hook and fittings should be strong enough to withstand all loads imposed during the tow and fully certified with up to date tests in place; Ideally the towing hook or towline should have a means of release which can operate in all conditions. The release mechanism should include both remote and local controls. The operation of this equipment is to be fully understood by the crew..."* *"..To reiterate, for the equipment to be in good order there has to be a regime of inspection and maintenance on board the tug as part of a company planned maintenance system (PMS). It is not possible to operate a tug safely without an effectively operating PMS. The PMS should include other critical systems on board, such as the main engine and electrical power systems..."*
	P2, P4, P5, P9, P10, P11	Tug Type	14	6	*"..Safe speeds depend on tug type. For instance, safe speeds for tractor tugs can be higher than for conventional tugs. Weather conditions and tug master experience play a role as well.."* *"Ship handling towage from conventional single-screw tugs is giving way to increasing choices of technologies matching tug types to individual port profiles.... ASD drive, tractors, reverse tractors and Rotor Tugs are modern examples but it is important that ship's crews understand their different operating modes, the guidelines explaining not only what you see but what is below the waterline..."*
	P1, P5	Navigational Obstacle	2	2	*"..Very often, the tug and barge transit through waters where the sea room is restricted. The master then must consider shortening the tow wire to ensure better control of the barge. The length of the tow wire is at the master's discretion depending on the prevalent situation..."*

No/Poor Risk Assessment	P1, P2, P3, P5, P6, P7, P9, P10, P11	No Tow Planning	21	9	*"..Before beginning towing operations, a comprehensive plan, as part of the ship's port passage plan and the Pilot's own plan, should be agreed by the Master and Pilot, where a Pilot is embarked. This should take account of all relevant factors, including tide, wind, visibility, ship size, type and characteristics, and specific berth requirements. A good knowledge of the type and capabilities of the tugs allocated to the job is important, in order that the Master / Pilot can ensure tugs are both suitable for the task ahead and positioned on the vessel so as to be most effective to facilitate a safe operation. Incidents may occur because no pre-planning was carried out. Incidents can occur if the operations are not thought through prior to commencing the towage operations..."* *"..In all incidents pre-planning may not have been carried out for a variety of reasons; sometimes it is because the task is considered routine or there is no time available. Often, the argument is made that hands-on operational type work cannot be planned. However, in the form of a risk assessment it may effectively reduce the risk to personnel, damage to the environment and property..."*

	P1, P6, P7, P9, P10, P11	Tug Approach Manoeuvres	14	6	*"..Most captains say that tugs should only approach the ship for securing when the crew is ready. More than half of the pilots prefer to instruct the attending bow tugs to approach the bow only when the ship's crew is ready to send a heaving line. Some rely on tug masters' experience…"* *"..In general most tug masters keep pace with the ship; some will approach the securing position at the ship from behind.* *If securing at the bow of a container ship, almost half the tug masters will keep pace with the ship and will steer slowly towards the bow, regardless of tug type. Tug masters may wait right in front of the ship till it comes closer, while some will wait in front of the bow and somewhat to port or starboard, which is much safer in case the tug suffers engine failure …ASD-tugs that operate in the conventional mode will overtake the ship and will then carefully manoeuvre towards the bow…"* *"..If securing at the bow of a loaded bulk carrier or tanker, the same approach manoeuvres as with container ships are used by approximately the same percentage of tug masters.* *There are a large variety of answers regarding the preferred location to pick up the heaving line, due to the different tug types and operating modes…"*

	P9, P10	Insufficient Manpower	2	2	*"..The International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW Code) is often not applicable to towage operations carried out in some jurisdictions, particularly for non-international voyages, such as river passages..."* *".. The manning of the towing vessel may be determined by an appropriate regulatory authority; however it is the responsibility of the owner/operator to ensure that the tug is manned with adequately certified and experienced personnel for the voyage. Following an accident it has sometimes been found that the cause was due to unqualified personnel, in which case P&I insurance cover could be compromised..."*
Fatigue / Commercial Pressure	P4, P10, P12		3	3	*"..Although a routine job, mooring often involves huge stress for the teams. There is often little time to prepare, so it is important that all are involved and fully aware of the limitations of the mooring process and that all use their best efforts so that the crew involved in mooring can act as a team. There are very few rules that apply to all mooring operations, but the following dangers should be absolutely avoided in any situation..."* *"...Fatigue should not be underestimated and it is now acknowledged that many incidents occur where fatigue is a factor. Local and international regulations may apply to the working hours of the crew. The international rules for working hours are regulated by the IMO Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), amended in 2012. These require a minimum of ten hours of rest in any 24 hour period; hours of rest may be divided into no more than two periods, one of which shall be at least six hours in length. These regulations may not apply to non-international trading tugs, but in the absence of other guidelines could be used...."*

Negative attitudes	P4				*"one problem is complacency; old skippers saying, I've always done it this way…"* *"there is no reason for this to occur other than negligence …"*
Watertight Integrity					*"tugs have got such bloody good stability that you can yank them right over and they will bounce back. But they won't bounce back if you've got a door open …"* *"it's always someone leaving the door open …"*
Wash/Squat effect	P5		1	1	*" this is when the wash's contact with the towed object/barge reduces the pulling effectiveness of the unit. Factors that can contribute to this are- Small under keel clearance of the assisted unit.; Hull form of the assisted unit; Length of tow line; Area of operation – confined areas will increase the wash effect. Under keel clearance- If the under keel clearance is small the propeller wash effect is increased reducing the tug's pulling effectiveness. Obviously pulling a barge or a vessel that is effectively aground or stuck in mud will increase the tension in the tow line. The suction effect can cause unexpected dangers as the barge can come clear of the suction effect of the mud and become free suddenly. Tugs' crews should be aware of this possibility and stand in a place of safety."* *"Squat effect- is often applied to ships, but any moving craft through the water can be affected by squat. The effects of squat are greatly increased by speed and if operating in waters of a confined width and may result in the change to the vessel's headings and the possibility of the towline shearing…"*

Table 4.15 Final Nodes by Source with Exemplar Nodes (Experts from all around world) (RO2-EI)

4.2.4 Safety Management Practices

A) Poor Maintenance/Substandard conditions of Tow Equipment's

Poor Mooring Equipment's

Mooring winches, capstans, windlasses, mooring lines and mooring fixtures and fittings must be properly maintained and periodic maintenance undertaken as prescribed in the planned maintenance system.

Routine maintenance should include regular visual inspections of all equipment, greasing of grease nipples on moving machinery and of rollers on fairleads and pedestal fairleads. Open gearing and clutches should also be suitably greased with an appropriate dressing. Brakes should be closely examined to ensure all linkages are working correctly, brake band material thickness is adequate and the condition of the brake lining is satisfactory.

Clutches should operate smoothly and pins for securing the clutches should be attached to the clutch control levers ready for use. Winch control levers must be marked with the direction of operation for both paying out and heaving in. Drum ends should be kept free from damage, rust and paint, and machinery bed plates should be periodically inspected for deterioration or damage.

It must be ensured that mooring fairleads are all turning freely and that their surfaces are free of rust or damage that could abrade the mooring lines. The integrity of all mooring equipment such as bitts, pad eyes and leads should be closely examined.

Prior to mooring operations commencing, all equipment should be visually examined for any visible defects and machinery tested. Any defective equipment must be taken out of service

Towing arrangements and equipment should conform to the following:

- All the towing equipment and gear, towing hook and fittings should be strong enough to withstand all loads imposed during the tow and fully certified with up to date tests in place.
- Ideally the towing hook or towline should have a means of release which can operate in all conditions. The release mechanism should include both remote and local controls. The operation of this equipment is to be fully understood by the crew.

- Navigation lights are rigged and are capable of remaining alight during the hours of darkness for the duration of the voyage. Navigational shapes are to be made available for daylight navigation as appropriate.

To reiterate, for the equipment to be in good order there has to be a regime of inspection and maintenance on board the tug as part of a company planned maintenance system (PMS). It is not possible to operate a tug safely without an effectively operating PMS. The PMS should include other critical systems on board, such as the main engine and electrical power systems.

Planned maintenance system (PMS)

Planned maintenance systems can be sophisticated computer based, giving real-time data back to the technical office and sometimes these systems are approved by a classification society. Or, they can be simpler paper based systems, but no less effective. Whichever PMS is in place, it is important that maintenance of critical equipment is monitored and recorded and this includes the towing gear. If no records are kept and there is no reliable knowledge on what has been inspected or overhauled, in good or poor order.
The PMS should include:

- Towing hooks and arrangements.
- Towing hook quick release systems.
- Hydraulic systems, pins, sharks jaws or equivalent.
- Towing winches.
- Bollards, fairleads and sheaves.
- Ropes and wires.
- Ancillary equipment, i.e. shackles, thimbles, eyes, rings, plates.

All PMSs require a structure to ensure equipment inspections on a regular basis, weekly, monthly or annually – whatever is considered suitable by the company or by legislation. The time between inspections of equipment will depend on their criticality and their amount of usage. The PMS should also include the maintenance, testing and keeping of test certificates for the different equipment.

New lifting and towing equipment and wires should always be received on board with approved test certificates. It is important to maintain an ordered system for all test certificates including wires, pennants, stretchers, ropes, towing plates, shackles, rings, bridles and other towing or lifting equipment.

It should be noted that whenever accidents have occurred as a result of equipment failure it has been found that the equipment was not maintained correctly and/or was repaired incorrectly by an unauthorised or inexperienced person. The use and failure of welded fittings where the welding was carried out by unqualified staff or the welds were not inspected or tested by an appropriate person has often been the cause of personal injuries.

Many port and river authorities will require that inspections and testing of towing equipment should be regularly carried out and appropriate records maintained.

Testing and certificates

It is important that the company and tug master are aware of the regulations required for the testing and inspection of the towing gear and equipment. Regulations may differ depending on location and the following is usually an accepted guideline if no other guidance is available.

All towing gear, hooks, shackles, winches and wire ropes should always be provided with test certificates when new and kept as a record. All gear should be tested and re-certificated by an approved contractor every five years or after any significant repairs have been carried out. Mooring ropes also should be issued with certificates when they are new.

Keeping track of wires and shackles (with their certificates) is important and the PMS should allow for this. Apart from the visual inspection of all gear before a towing operation commences, all gear should be formally inspected annually by a competent person. This could include the tug master or experienced crew person.

In the event of an accident the ability to prove that the gear was in a good condition with all the certification and tests in order are a strong indication that the tug was operating to the correct standards.

All damaged equipment should be isolated and removed from operation. If it cannot be repaired properly by a competent person it should be condemned and discarded. Damaged equipment should never be used.

Towing winch

Towing winches come in different designs and sizes and the workings of winches should be understood by those using them. The manufacturer's manual should always be available on board to refer to. If the tug is provided with additional secondary winches these should also be included in the PMS.

Clear operating instructions in the appropriate language should be available near all the manual and emergency controls. The working of the winch emergency release system (ERS), if fitted, should always be understood by those operating the winch.

Checks on the towing winch should include:

- Effective operation of the braking system.
- Winch power and hydraulic systems.
- Signs of corrosion or fractures on the holding bolts, welds and supporting deck.
- Effectiveness of the emergency release from the wheelhouse and/or the local activation point.
- Effectiveness of the spooling mechanisms.
- Connection end of the towline should always be fixed but with a force of less than 15% of the breaking load of the towline.

The towing winch brakes should provide a static holding capacity of at least 1.1 times the breaking load of the tow line.

There are no accepted international standards for tug tow line ERS. Following many accidents, particularly those that have been caused by girting, it has been found that the ERS for the towing winch or the towing hook failed or did not operate quickly enough to prevent the tug from capsizing.

It is important for the crew to be aware of the operating limitations of the ERSs on board their vessel. There have been cases where some older types of manual ERSs have not released when there was an excessive load on the tow wire/hook. These should be tested at the earliest opportunity to ascertain the operating parameters and if necessary then prominent notices must be put up at the winch/towing hook and on the bridge that some weight must be taken off the tow line before the emergency release can be activated.

Towing hook

The maintenance of the towing hook should be included in the PMS and thus inspected regularly and visually before each tow. The towing hook release mechanisms should be tested and recorded to ensure that the hook releases properly. Damage to the towing hook (or other essential equipment) must be reported and not used until the damage is rectified. Generally it is not regarded as good practice to utilise towing hooks for ocean passages.

Bollards, fairleads and sheaves

Checks should include:

- Regular inspection for wear, excessive corrosion and wastage.
- Inspection for fractures to welds and supporting structures.
- Ensuring that all rotating sheaves are properly greased and free.

Towlines, wire and synthetic ropes

The care of wire and synthetic ropes, including stretchers, is an important part of the PMS. Formal guidance on how to inspect, stow and maintain ropes and wires should be provided.
A major issue is trying to maximise the service life of rope and still maintain safety. All tug's deck crew should be trained in rope inspection and gauging when a rope is damaged and is no longer fit for purpose and safe for use.
Maintenance guidance and checks on ropes should include:

- Pennants inspected prior to every use, annually and tested after a suitable period or five years.
- Main tow wire 'end for end' every year, and replaced when appropriate.
- Main tow wire physically inspected every month and/or before each tow.
- Main tow wire physically inspected after every deployment for damage and abrasions such as: Ultra violet (sunlight), heat or chemical degradation.
- Wear, broken, cut or fused strands.
- Overstretched rope (can reduce the effective diameter of the rope).
- Distortion and kinking of the rope, particularly wire rope indicating that the wire has been severely stressed.

- Rope not properly stowed can degrade, for example synthetic rope can deteriorate, become mouldy if stowed wet with no proper air flow.

All towing pennants should have the same lay as the tow wire with a Minimum Breaking Load (MBL) of not less than the tow wire.

The tow wire minimum breaking load should never exceed the breaking loads of the connecting points or equipment. A suggested general rule is that the tow wire and springs and towing hooks should have a Safe Working Load (SWL) of at least 2.5 times (some suggest 3 times) the bollard pull of the tug.

Ancillary equipment

Ancillary towage equipment, such as wire towage protectors and thimbles should be regularly inspected and form a part of the PMS.

Sufficient tow wire protectors should be on board to prevent the tow wire from excessive chafe. These can be in the form of custom-made polyurethane sleeves which are exceptionally durable/resilient and are usually employed as a protection on tow wires. The simpler method for short towing voyages is just by wrapping the chaffing part of the tow rope with a piece of hawser or gantline and coating it with a bit of grease. Care must be taken to not to overdo the grease in case it causes an oil sheen in water during adverse weather including rain.

A powered workboat which the administration may accept as being a part of the lifesaving equipment should be available for use as an inspection boat when towing a barge. The tug should be fitted with adequate launching devices to lower the boat in open sea conditions. All personnel should be wearing appropriate PPE at all times and be trained in the launching of the boat. An operational searchlight should be available to illuminate the tow at night.

Navigation lights and shapes

The tow shall carry the lights and shapes required by the International Regulation for Preventing Collisions at Sea, 1972 amended 1996 and any local regulations.

Navigation lights should be independently powered and the fuel or power source should be adequate for the maximum duration of the towage with reserve. It is also advisable for a searchlight to illuminate the tow to be available.
Towed objects where necessary should be fitted with a radar reflector mounted as high as practical.

Safety factors

There are no statutory international guidelines.
A tug master should always be aware of the condition of his tug and its equipment. As a guideline, steel and fibre tow wires/ropes should have a Safe Working Load (SWL) of at least two to three times the BP of the tug. This safety factor can also be used when considering the towing hooks and fittings.

B) Poor Work Process

Planning and Coordination

Before beginning towing operations, a comprehensive plan, as part of the ship's port passage plan and the Pilot's own plan, should be agreed by the Master and Pilot, where a Pilot is embarked. This should take account of all relevant factors, including tide, wind, visibility, ship size, type and characteristics, and specific berth requirements. A good knowledge of the type and capabilities of the tugs allocated to the job is important, in order that the Master / Pilot can ensure tugs are both suitable for the task ahead and positioned on the vessel so as to be most effective to facilitate a safe operation.
Any conflict or mismatch between the required manoeuvre and the tugs allocated must be resolved before the towage operation begins. Responsibility for co-ordinating a towage operation lies with whoever has the conduct of the vessel being towed, be that the Master or the Pilot. Communication with the tugs will be through the pilot. When berthing and unberthing, it is the duty of the Master / Pilot to ensure that the vessel is handled in a safe and controlled manner, having due regard to the safety of all those involved, including the assisting tugs, line-handlers or mooring gangs and other port users as appropriate.

The number of personnel employed in any towage operation should be determined having due regard for the size of the vessel and the prevailing operational and environmental circumstances. In all cases, sufficient manpower should be provided to ensure that individuals are not exposed to undue risk, and that the operation can be conducted safely and efficiently. Due regard should also be given to the size, weight and scope of the towing gear and lines to be handled.

All those with a responsibility for personnel or equipment involved in assisting the towage / mooring of vessels have a duty to ensure that safe working practices are followed, and that associated equipment is fit for purpose. They should also ensure that those involved are properly trained, adequately briefed in their duties and issued with, and use, suitable and effective personal protective equipment (PPE).

Incidents may occur because no pre-planning was carried out. Incidents can occur if the operations are not thought through prior to commencing the towage operations. In some cases the local port authority was not informed of the proposed towage operation and therefore important impending traffic information was not received by the parties concerned.

In all incidents pre-planning may not have been carried out for a variety of reasons; sometimes it is because the task is considered routine or there is no time available. Often, the argument is made that hands-on operational type work cannot be planned. However, in the form of a risk assessment it may effectively reduce the risk to personnel, damage to the environment and property.

Tow plan

Planning and preparation before a tow commences might include:

- Assessing the size and type of vessels or barges to be towed and any limitations of the tow. Confirmation that the tug is of suitable; size, manning, sea-keeping, horse power (HP) and bollard pull (BP). Tow wire and towing equipment is suitable for the planned tow.
- Route to be taken and passage planned, including safe transit times (day/night transits), and times when passing through narrows, under bridges or areas of high traffic density, tight bends in rivers and adjacent river berths.

- Noting any areas of reduced depth, tidal limitations and currents expected during the voyage. A list of bridges with maximum and minimum height; tide height for each arch to be passed under showing the bridge's maximum air-drafts.
- Weather forecasts to include outlook for at least 48 hours. Confirmation of sufficient fuel, water, spares on board.

Preparations on board the tug

It is essential that checks should be completed on board the tug and vessel or barge to be towed, which should include:

- All water/weathertight openings are securely closed with signs indicating that they should remain closed for the duration of the voyage. It is a reality that tugs have capsized as a result of doors and ports being left open when in difficulty, e.g. girting. down flooding is a real danger to small tugs.
- Life-saving and fire-fighting appliances must always be operational.
- Navigational equipment, wheelhouse whistles, horns, shapes for day signals and communication gear are fully operational.
- All critical machinery prior to commencing a towing operation should be confirmed as operational – this would include; main engine, steering gear and towing equipment (winches, wires) etc.
- All personnel are fully familiar with the intended towage plan and their responsibilities.
- Any change of fuel and ballast to the tug and/or tow have been fully calculated and the crew are aware of any factors of concern.

Checks on board the towed vessel or barge

The tow should not proceed until a satisfactory inspection of the tow has been carried out by a competent party.

Checks should include:

- Condition of the towing arrangements.
- Condition of the anchoring equipment if fitted. If not fitted some authorities require a temporary anchor to be supplied of an adequate weight.

- Condition of tow including an inspection of the peaks and buoyancy spaces to check for water ingress.
- Watertight integrity of the unit to be towed; obvious signs of damage, especially in the hull and deck plating. Hatchways, ventilators, doors, scuttles, manholes and other openings are closed and sea valves shut.
- Fore and aft drafts, appropriate freeboard for the voyage and no evidence of a list. Generally a slight trim by the stern ensures that the tow is laterally stable when towed
- Air draft of the tow, appropriate for the voyage and bridge transits.
- Power is available for navigation lights.
- Safe method of boarding available (portable or fixed rungs).
- Emergency towline rigged.
- Life-saving and fire-fighting appliances are in good condition and in the regulatory number required.
- Cargo, whether it is bulk cargo (within the holds), containers or break bulk cargo can shift causing the barge to capsize and sink and therefore stowage and securing arrangements must be verified as adequate for the intended voyage prior to departure.

Some bulk cargoes pose a serious hazard, including spoil and certain ore cargoes which are liable to liquefaction e.g. spoil cargoes can contain a high amount of moisture which can assume a liquid state in a seaway and can cause the barge to lose stability, list and even capsize. Reference should be made to the IMO International Maritime Solid Bulk Cargoes (IMSBC Code). When it is suspected that cargoes with high moisture content have been loaded onto a barge advice should be sought.

If cargo is liable to move e.g. vehicles and timber, the lashing arrangements and sea fastenings should be inspected.

Passage planning and bridge equipment

Reference material is available on passage planning, including IMO Res.893 - Guidelines for Voyage Planning, which states that the need for voyage and passage planning applies to all vessels. A large part of a towage risk assessment can be included in the appropriate passage plan. Even for experienced tug masters, plying familiar waters, the formal process of planning the voyage, however short, is a useful one.

A passage plan as a minimum should include and consider, but not necessarily be limited to the following:

- Plotting the intended route on appropriate, large scale and up to date chart.
- Reference to appropriate routing and passage information, publications, sailing directions and local information published by competent authorities.
- Towing draughts in relation to water depths and under keel clearances.
- Proximity of other shipping traffic and anticipated high traffic density areas.
- Manoeuvrability of tow in relation to the navigational channel constraints, including river and river bank operations e.g. construction or diving.
- Current and tidal information.
- Weather information and forecasts, in particular forecasted restricted visibility.
- Reporting positions and vessel traffic services information.
- Safe anchorages/places of shelter.
- Tow speed and adjustments to pass danger points.
- Consideration whether night-time transits should be restricted.
- Air-draft restrictions for passing under bridges.
- Navigational warnings, changes to navigational marks or lights.
- Available wheelhouse personnel, potential working hours and fatigue during the passage.

Current and tidal information may not be accurate even in well charted areas and therefore local knowledge may have to be relied on. Tugs work in all waters and at times extraordinary currents are a problem. In some rivers and inland waters where very high tides, heavy rains, currents of 16 knots are not unusual.

In addition it should be ensured that all critical bridge equipment must be in good working order prior to commencing any operation.

Emergency planning

A prudent towing plan includes 'what if' situations, unexpected events that could happen during the tow. This preparation could be a formal plan for specific contingencies and/or training.

Consideration should always be given on how to transfer personnel and equipment to the towed vessel or unit during an emergency. Personnel should always wear life-jackets and utilise communication equipment and portable lights during darkness. The safety of personnel is paramount and a transfer should not go ahead if considered too dangerous.

Contingency plans could include the following:

- Girting or girding situation
- Failure or parting of the tow wire.
- Failure of gob wire arrangements.
- Grounding of the tug or tow.
- Loss of hull integrity in either tug or towed vessel.
- Collision or contact with a fixed object or installation.
- Loss of main propulsion power or electrical power.
- Failure of steering and/or other critical control systems.
- Man overboard.
- Bridge, accommodation or engine room fire.
- Actions to take in the event of unexpected poor weather.

Pilot/Vessel Master Exchange

In addition to the standard information passed to the Pilot, it is recommended that the Master provides the Pilot with a plan showing the layout and safe working load (SWL) of the mooring fittings and inform him:

- which fairleads, chocks, bollards and strong points can be used for towing;
- the SWL of this equipment;
- areas of hull strengthened or suitable for pushing by tugs and relevant identification marks employed;
- Any special features (e.g. controllable pitch propellers, thrusters etc.);
- power available at fairleads

The Pilot should advise the Master of the following:

- the tug rendezvous time and position;
- the number of tugs and the mode of towage;
- the planned (optimum) ship speed when connecting the tugs' lines;
- whether the ship's or the tug's lines are recommended for use;
- the type of tugs to be used and their bollard pull;
- if escorting, the maximum towline force that the tug may generate at escort speeds;
- maximum planned speed for the passage;
- the method by which the ship's crew should heave and release the tug's towline;
- a dedicated crew member to monitor tug and tug's line during heave and release;
- the prohibition on the use of weighted heaving lines;
- that on release, the tug's gear should be lowered back under control;
- areas of the transit posing particular risks with respect to the possible use of the tug;
- intentions with regard to use and positioning of each tug for berthing manoeuvres;
- intentions with regard to use of tugs in an emergency (escort operations); and
- primary and secondary VHF channels for use in the operation.

Pilot/ Master/Tugmaster Exchange

The Pilot / Master and Tugmaster should, as a minimum, discuss the following issues:

- the SWL of the vessel's chocks, bollards and strong points to be used for towing;
- the tug hook up point, taking into account the prevailing weather and sea conditions, for escorting operation (if appropriate) and berthing;
- the planned (optimum) ship speed when connecting to the tug's lines;
- if active escorting, the start point of the escorted passage;
- the maximum speed of the tug;
- passage details in their entirety while accompanied by the tugs, particularly details of any swing, manoeuvre, release position and sequence of release;
- berthing details in their entirety, including tug positioning around the vessel's hull and the vessel's required position on the berth;
- intended and emergency use of ship's anchors;

- any unusual items regarding the particular vessel as gleaned from the Master / Pilot exchange;
- if appropriate, any shallow water or bank effect areas where significant surges may be experienced that might add to the tug loads;
- the Tugmaster should advise the Pilot / Master (as far in advance as possible of the scheduled manoeuvre) if the tug is experiencing a failure or reduction in its ability to manoeuvre or deliver full bollard pull;
- when confirming that the tug is fast and ready to assist, the Tugmaster should also confirm both the tug's name and her position on the vessel.

Communications

VHF Channels signals

Whistle signals to be used between tug and tow. A power driven vessel and any vessel being towed by it when signalling to each other by means of a whistle shall use the following signals and no others:-

a) Signals to or from a towing vessel ahead:

- Tow ahead – one prolonged blast followed by three short blasts.
- Tow to port bow – one prolonged blast followed by two short blasts
- Tow to starboard bow – one prolonged blast followed by one short blast.
- Cease tow – one prolonged blast followed by six short blasts in succession.

b) Signals to or from towing vessel astern:

- Tow astern – three short blasts.
- Tow to port quarter – two short blasts.
- Tow to starboard quarter – one short blast.
- Cease tow – six short blasts in succession.

c) Signals to all towing vessels:

- Hold in position – one prolonged blast followed by one short blast followed by one prolonged blast followed by one short blast.
- Let go – one prolonged blast followed by two short blasts followed by one prolonged blast.

Tow Master Requirements on Dumb Tows Routine and non-piloted

A Tow Master should be nominated for each tow. The Tow Master will present a tow plan to the Harbourmaster in good time for a review and for permission to be given or other requirements to be accommodated.

The tow plan should include taking all the action a prudent Master or Pilot would in having conduct of the operation. This tow plan should include but not be limited to:

Risk Assessment

- Method Statement
- Number and position of tugs
- Type of tug (e.g. push/pull, on hip etc.)
- Use of particular tugs
- Position of tugs
- Use of release mechanism
- Manning
- Passage plan berth to berth
- Regular dumb tow operations e.g. barges, pontoons and leisure operations may be covered with a generic tow plan and details of Skipper/Master/Coxswain qualifications

Non Routine Dead Tows

The same principle applies to dead tows involving piloted or non-piloted craft.

The nominated Towmaster should present the tow plan as before to the Harbourmaster for approval. To that end, sufficient time must be given for the tow plan to be reviewed.

In the case of complex dumb tows, a Harbourmasters Working Group may be convened consisting of appropriately skilled personnel to ensure that all risks have been considered.

Follow correct procedure:

a) Connecting and disconnecting towing gear

Before arrival at the tug connecting position, the Pilot / Master shall establish effective communications with each tug and agree working channels. Likewise, effective communications must be established between the bridge and the vessel's crew at 'stations' and they should confirm that they are ready to receive the tug. The vessel's speed must be reduced to that which allows a safe rendezvous and connection with the tug. The required speed should be agreed in advance between the Master / Pilot and with all Tugmasters involved. At all times during the connecting process, the Pilot / Master should be aware of the position and intention of all relevant shipping movements in the area.

The Pilot / Master should ensure that his planning takes full account of the time taken to connect each tow, especially if adverse conditions are likely to extend this process. Account should also be taken of potential language difficulties, which may lead to confusion. Vessel mooring parties should be fully briefed and the Pilot / Master should check when in doubt and be confident that his instructions are being followed.

Ships heaving lines should be readily available and of a suitable make up. Extra weights must NEVER be inserted in the 'Monkey's Fist' or attached to the heaving line.

A small canvas sandbag is the towage industry's preferred option. Ship's personnel should wherever possible, agree with the tug crew the area where the heaving line is to be thrown, to allow the recipients to move clear. When connecting to the vessel, the tug crew should ensure that the towing gear is clear of any obstructions, able to run freely and is released from the tug in a controlled manner. The ship shall not test the bow or stern thrust controls prior to berthing at the time when the tug is under the bow or stern passing a line.

Changes in speed and or course should also be avoided while the towing gear is being connected as it may not be possible for tugs to react sufficiently quickly to sudden increase or decrease in a ship' speed/direction. Where a change in speed /course is necessary, the Pilot / Master should ensure that all tugs involved in the operation are advised in good time.

Some tugs may use a compressed air line throwing apparatus to efficiently send a line from the tug to the ship's crew. Before any such exercise is undertaken, the Tugmaster will advise the Ship's Master and Pilot so that appropriate instruction can be passed to crew at stations.

The Pilot / Master shall maintain contact with the Tugmaster / vessel crew throughout the process. He should be ready to revise the intended tug position if the Tugmaster reports any restrictions at the chosen position, e.g. large flare, overhanging anchor or unsuitable push up point. The Pilot / Master must keep all those involved up to date on the plan and apprised of any changes to the agreed plan.

During disconnection, both the vessel's and tug's crew on deck should be aware of the risk of injury if the towing gear is released from the tow in an uncontrolled manner and avoid standing directly below. They should also be aware that any towing gear which has been released and is still outboard may 'foul' on the tug's propeller(s), steelworks or fendering, causing it to come tight unexpectedly. The towline should always be lowered onto the tug deck, never just 'cast off' and left to run, unless specifically directed by the Tugmaster.

The positioning of tugs on a vessel is a matter for discussion between the Pilot / Master and the Tugmaster, having full regard for the areas of the hull which should be avoided, e.g. watertight doors, between frames etc. The forward tug is especially vulnerable when passing up the tow line. This tug has to position itself very close under the bow, sometimes under 1 metre from the ship's water plane. The Tugmaster will be concerned about any bulbous bow or other underwater protrusion, the proximity of the flare of the bow etc. At the same time the Tugmaster is countering the hydraulic pressure wave that exists around the bow to avoid severe interaction.

Flares or cut-aways at the bow or stern are of particular concern and can increase the dangers of interaction. Extra caution should be taken by Pilots / Masters when the tug is making fast under a flare / cutaway, especially when the vessel is moving / swinging towards the tug. The danger is compounded at night with the risk of shadows from deck lighting.

b) Safe speed

Speed is a critical factor for the tug when making fast and letting go. When considering speed it is the **speed through the water** that is of concern. It is generally accepted that 5 to 8 knots is appropriate when making fast and letting go; however, due consideration should be given to tugs manoeuvring astern.

For other, possibly smaller, tugs a safe speed may be lower and this should be discussed between the Master, Ship Master and Pilot. For Escort duties entering the West Channel, the optimum speed for the tug to be effective is 8 knots.
Caution must be exercised when using the engines whilst the tugs are working. The stern tug will be affected by the wash and every tug will be affected by the change of speed either up or down, and a rapid change in speed is all the worse. If the situation dictates the use of the engines, the minimum that the situation allows should be used and the tugs should be informed of what the ship is about to do as it will affect their own actions. In strong tidal conditions a high percentage of the tug's power may be utilised in maintaining position on the vessel before applying thrust to the vessel. If the tugs are made fast alongside they are at their most effective with a minimal ship speed through the water.

- Safe speeds depend on tug type. For instance, safe speeds for tractor tugs can be higher than for conventional tugs. Weather conditions and tug master experience play a role as well.
- Discussion between pilots and tug masters is very useful.
- Not all ports operate with bow tugs towing on a line.
- Safe speed to be based on what speed a tug master can drive his/her tug in a controlled manner (particularly going astern for bow-to-bow) on one engine. Once this speed is established for the specific tug, prevailing conditions and competency of the tug master, it is recommended to take one knot off the figure and that will be close to the safe connection speed.

The following manoeuvres are mentioned to reduce speed if it is too high:

- Stop engine frequently for as long as safety permits. If there is sufficient room, use fish-tailing with rudder. Abort approach and prepare anchors if necessary.
- Apart from the above suggestions a very good solution is to make a stern tug fast to assist in reducing speed.

Complaints:

- Many container ships have a Dead Slow Ahead speed of 10 knots or more.

c) Interaction

Interaction and its effects on the tug and its handling are well known, and appreciated in port/harbour towage. Pilots, Masters and Tugmasters are reminded that these effects are multiplied as the vessel's speed increases. Areas of high and low pressure exist in and around the ship's hull and these areas can cause adverse movements of smaller vessels in close proximity. The speed of water flowing between the tug and the vessel increases at the last moment as the tug comes alongside. As this happens the tug therefore has to increase speed to maintain the same speed as the vessel. The Tugmaster has to compensate for the tug either being drawn in or pushed off the vessel.
In areas where interaction exists, and when manoeuvring alongside a vessel, the Tugmaster should be aware of the possibility of underwater obstructions such as bulbous bows, stabiliser fins etc.; and areas of the ship's side, such as pilot doors, which are to be avoided.

PRECAUTIONS DURING TOWAGE OPERATIONS

Once the towing gear is connected, the crew should indicate this to the Tugmaster and then clear the area. Any crew that are required to remain on deck should stand away from the towing gear in a safe position. If the crew are required to attend the towing gear during a towing operation, the length of time exposed should be kept to a minimum.

During towage operations the towing gear equipment and personnel should be continuously monitored and any change in circumstances immediately relayed to the Tugmaster. This is particularly important on tugs where the Tugmaster has a restricted view of the towing area/personnel. Tug and vessel crews should be aware that the towline may have to be release in an emergency situation, and that this may occur without warning.
Ships crew confirm with tug crew that tow is secure. The Tug master, having verified with the tug and vessel' crews that the towline is fast to the vessel, must confirm this with the vessel's bridge. The Pilot / Master should then re-confirm this to the Tug master, thus completing the communication loop. Sometimes it is not possible for the Tug master to see the crew on deck due to structural design or at night when they may be obscured by deck lighting on the ship.

Tug masters, Pilots and Masters should be aware, at all times, of the position and intentions of mooring boats, especially in strong tidal conditions, at night or during restricted visibility or adverse weather conditions. This is particularly important in circumstances where visibility is limited from the tug's wheelhouse and ship's bridge. Remember that bow and stern thrusters, and the wash from tugs and the vessel being assisted, can all cause significant problems for mooring boats, especially when they are in close to the vessel and/or tug(s), picking up and running with lines. Controllable pitch propellers are a separate but equally dangerous hazard.

The Pilot or Master should never use the vessel's engines without confirming with the Boatmen and / or Line handlers as to the position of the mooring boats. Sound signals can be used as a warning on occasions when vessel noise compromises VHF monitoring.

C) Rough Weather

Wind

Not appreciating the effects of the wind when towing can result in collisions, groundings, towlines parting, injury and girting. The wind causes headings to change, speeds to increase and a towed craft to drift.

Manoeuvring can become difficult if the wind increases or changes direction suddenly. Tug masters should always be aware of the potential effects of the wind before a tow commences or before commencing the next part of a towing operation. Knowing the forecast or local weather conditions is essential.

Current

Mariners will be aware of the effects that currents have on a craft being manoeuvred in water. The effects of current in open waters are less important than the effects in confined waters which can be significant particularly when manoeuvring in busy waters or rivers. The speed and direction of currents are also unpredictable, reasons include; changes in tidal direction, sudden water flows at river mouths due to rains or ice melt, constraints such as narrows, reefs, breakwaters and harbour walls. The effect of squat in shallow water can be considerable, particularly for large barges with a flat hull form.

Current direction can be influenced by:

- Bends in rivers or configuration of channel or river entrances.
- Shallow water.
- Man-made constructions; piers, berths, breakwaters.
- Bridges with pillars.
- Industrial cooling water outlets.
- Geographical obstructions such as islands.

Currents can also help manoeuvring, for example:

- To control speed when approaching a berth.
- To assist a tug and tow to move sideways.
- To assist in a turn.

River tugs work where currents can be strong and changeable over short distances. Over the width of a river the current strength may vary. The outer parts of the river may be faster flowing than in the centre. The more forceful current at the starboard bank impacts on the port quarter and as the vessel turns the bow is in a less strong current and so there is a turning moment to port. This effect can be sudden and the effect should not be underestimated. The industry has unfortunately suffered many incidents where this has been the case and contact has been made with installations on the river bank. Navigating in water where there is a constant current could be safer.

The act of assisting a tow to berth or un-berth needs to take account of the current. It is usual for a river berth to lie in the same direction as the prevailing current so that the current can be used to assist with berthing.

A berth can be approached bow into the current to give a relatively high speed through the water with a reduced speed over the ground which will provide good steerage because of the good water flow over the rudders. The towed unit is also easier to stop and the current can be used to assist the tow alongside the berth. Currents in some locations can be complex and changeable so again local knowledge is essential.

Berthing in a following current is difficult and potentially dangerous since the tug and tow must develop sternway through the water in order to be stopped over the ground. In these circumstances, control of a conventional tug will not be easy and an approach into the current is possibly the best method of nearing the berth.

Planning for rough water

Rough water in the context of a small tug or workboat is not restricted to being caused by strong winds. The Club has suffered many claims where the tug and tow unit have contacted a third party vessel, berth or other fixed floating object due to misjudging the prevailing weather conditions when manoeuvring. Adverse weather conditions can be caused by any of the following:

- The action of wind against tide.
- Tidal bores, rip tides or strong currents.
- Interaction of strong river currents and prevailing currents/winds e.g. at mouths of large rivers.
- Sudden changes in the current due to increased rains.
- Turbulence, undertows and/or wash reflected off river or channel banks.
- Wash from passing craft.
- Geographical/seasonal issues such as the freshet where operations on the Fraser River are affected by the seasonal ice flows.

The effects of rough water on a tug and tow can be appreciable and in extreme cases water over the bow of the tow can impact on barge stability. Extra strain on towing and mooring lines and potential damage to barges being towed alongside or in tandem can occur.

In order to reduce the potential of an incident due to rough weather the following should be considered:

- Delay departure and wait for an improvement in weather or tide.
- Anchor or tie up and wait for an improvement in weather or tide.
- Reduce speed of tow.
- Increase the length of the tow to compensate for power surge and wire tension due to tows movement in the seaway/swell.
- Consider towing astern if tow is arranged for towing alongside.
- Alter course.

Other concerns effecting manoeuvrability

Wash effect: this is when the wash's contact with the towed object/barge reduces the pulling effectiveness of the unit. Factors that can contribute to this are:

- Small under keel clearance of the assisted unit.
- Hull form of the assisted unit.
- Length of tow line.
- Area of operation – confined areas will increase the wash effect.

Under keel clearance: If the under keel clearance is small the propeller wash effect is increased reducing the tug's pulling effectiveness. Obviously pulling a barge or a vessel that is effectively aground or stuck in mud will increase the tension in the tow line. The suction effect can cause unexpected dangers as the barge can come clear of the suction effect of the mud and become free suddenly. Tugs' crews should be aware of this possibility and stand in a place of safety.

Squat effect: is often applied to ships, but any moving craft through the water can be affected by squat. The effects of squat are greatly increased by speed and if operating in waters of a confined width and may result in the change to the vessel's headings and the possibility of the towline shearing.

Length of towing line

The less water under the keel the more power the tug will need to apply. This will increase the wash effect and a longer towline can reduce or avoid the wash effect.
A short tow line in a confined area can produce a significant wash effect. Tractor tugs pulling over the stern and ASD tugs pulling over the bow can reduce the wash effect since the propellers are further away from the towed unit's hull.

Shortening the length of the tow

Very often, the tug and barge transit through waters where the sea room is restricted. The master then must consider shortening the tow wire to ensure better control of the barge. The length of the tow wire is at the master's discretion depending on the prevalent situation. The shortening of the tow should be carried out preferably in deep water, weather permitting, and most certainly well before entering congested waters. The shortening in deep water reduces a lot of wear and tear in the wire which it would have endured with dragging on the seabed. However, if the weather is severe, then there will be no choice but to defer it to as late as possible.

It is recommended that the length of the tow should not be too short as if anything were to go wrong, the tug will not be able to manoeuvre out of the barge's path and can result in her coming into contact with by her own tow. If the tug has a wild tow on a short wire, the master should call for assistance without further delay to bring the barge under control. When on a short wire, utmost caution must be taken to avoid sharp alterations or else the chances are that the barge may violently swing out of control. If this happens then the master should immediately consider paying out some length of tow wire to dampen the violent movement.

Establishing the tow connection

There are no strict rules to making fast the tow. Each tow will be different; the barge size, shape, draught, weather, current strength, light or location will vary. Prior planning will make the operation safer. A briefing between the tug master and his crew on how the job is to be approached is vital. Before arrival at the connecting location effective communications should be established between the tug and towed unit if manned. Ideally, a risk assessment would be in place. Tug speed should be adjusted for a safe rendezvous and connection.

If the tugs crew are required to access the towed unit plans must be made so that it can be carried out safely in the prevailing circumstances.

Position of barges

If the tow consists of a number of barges with different loads, sizes and shapes, the barges should preferably be arranged by similar size and design, with similar sized barges as the lead. If possible, loaded barges should be placed first with empty barges astern.

Tow ropes should be similar sized and of the same material, secured to the barges in equal lengths, with the same number of turns so that the tow ropes can be equally rendered if necessary and the stretch is similar. Where more than one barge is towed the remaining barges can be bundled into ranks using rope breast or stern lines.

Towing alongside

When a barge is to be towed alongside the tug, the connection should be made with a suitable heavy spring and a stern rope. The tug should be positioned close to the stern of the barge so that the tug's stern overhangs the stern of the barge. The further forward the tug is positioned the more difficult it is for the tug to steer the combined unit. Barges should be made fast to each other with the use of non-jamming turns so that they can be released if necessary. Picking the best leads is also important, particularly when the barges are of a different size or height.

Pushing ahead

Tugs will regularly have to push barges ahead even though they may not be specifically designed to do so. It is recommended that the barge is secured to the tug using winch wires attached to corner bollards of the barge/s so that the whole unit can be operated as a single unit. There should also be two substantial ropes made fast to the tug's centre bollard and the barge's port and starboard quarter bollards.

During the tow

In addition to the normal navigational and collision avoidance duties, the watch keeper has to ensure that the tow wire and tow are positioned correctly. The tug master should ensure that those carrying out wheel- house duties are aware of the requirements of the towing operation. This should be written down in the tug master's order book or as part of the standing orders. The tug master should always be satisfied that his watch keepers are aware of how to use the towing winch and its quick release system correctly.
These instructions may also include:

- In what circumstances the tug master wants to be alerted.
- In what circumstances the watch keeper should shorten or lengthen the tow line.
- Appropriate engine revolutions.
- In what circumstances and how often the watch keeper should freshen the tow line particularly in heavy weather.
- What length of tow wire and catenary should be maintained.
- Precautions to take in different water depth and weather conditions.
- Attention paid to chafing or friction in the towline; position of protectors or regularly adjustment tow wire length.
- Towing speed and headings to be maintained.
- Vessel Traffic Service and security communication if appropriate.

During the voyage the duty officer on the tug must also keep watch on the barge. One easy way to determine that the barge integrity has not been compromised and is not taking in water would be to paint the barge with a strip of high visibility paint at the waterline on the bow before commencement of the voyage. This would be a good benchmark for the duty officer to observe during the sea passage and so long as he can observe this line above the water, it can be safely concluded that the barge's draughts have remained the same.

Towage in Restricted Visibility

Should visibility become restricted during a towage operation, the Pilot / Master and the Tug master will discuss the situation immediately and agree upon a course of action to ensure the safety of all persons and vessels involved given the location, environmental and vessel traffic conditions, seeking the advice of Port Control as appropriate.

The Pilot or Master will advise Port Control of the circumstances and any decisions made immediately, keeping Port Control informed of any operational developments, or any improvement or deterioration of the visibility.

The Tug master should immediately inform the Pilot / Master and Port Control of any concerns that he may have as to the safety of his tug and crew. The Pilot / Master and Tug master should take immediate action to ensure the safety of both the tug and the assisted vessel. If necessary the operation should be aborted as soon as it is safe to do so.

- Towage operations should not normally take place in visibility of less than those described in Port Guidelines for visibility;
- The pick up speed in reduced visibility to be a maximum of 3-5 knots through the water;
- Tug masters may request the Pilot / Master to take all way off the vessel and the tugs manoeuver the vessel.
- Tugmaster to confirm watertight integrity of tug, Pilot / Master to inform tug if they observe any exterior openings on the tug that are not closed, and which affect tugs' watertight integrity.
- Pilot / Master and Tugmaster to agree the plan, which should be recorded;
- During operations in restricted visibility the Pilot / Master of the assisted vessel shall provide well in advance all engine movements, thrusters movements and alterations of course;
- Both Pilot / Master and Tugmaster shall inform the other of any changes in their circumstances that will impact on the agreed plan.

D) Incompetency

Manning and Training

The International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW Code) is often not applicable to towage operations carried out in some jurisdictions, particularly for non-international voyages, such as river passages. The manning of the towing vessel may be determined by an appropriate regulatory authority; however it is the responsibility of the owner/operator to ensure that the tug is manned with adequately certified and experienced personnel for the voyage. Following an accident it has sometimes been found that the cause was due to unqualified personnel, in which case P&I insurance cover could be compromised.

The towing master should be aware that inexperienced personnel must not be exposed without training and supervision to carry out high risk tasks, such as hooking up or releasing the tow. It is also the custom and practice in many areas that personnel supplied by barge operators are often part-time, contracted in and therefore possibly inexperienced and poorly trained. Their actions can therefore impact on the safety of a towing operation.

Training should be frequent and recorded in ship's log books. This should cover safety aspects such as lifesaving and fire-fighting, and:

- Dangers of and the safe practices for hooking up and releasing a tow.
- Capabilities and limitations of the towing equipment.
- Controls of the winches and use of the emergency quick release mechanism.
- Emergency contingency plans for if the wire/rope parts during a tow. Dangers associated with reconnecting the tow.
- Dangers associated with girting (girding) situations.
- Dangers associated with main engine or electrical failures.
- Risks associated with working in heavy weather and strong currents.
- Shortening the tow line.

An effective safety management system (SMS) allows these training requirements to be formalised and become second nature.

Training Programs

Professional towage companies have come to the conclusion that the cost of training is an investment.

There is no doubt that training is vastly more cost effective than repairing people, vessels, third party assets and the company's reputation. Furthermore, in the event of a serious incident, companies are now being called upon in court to prove their operating standards are appropriate and their tugmasters are competent.

As an example of a professional training programme, the Seaways Tugmaster Training Program has six differing modules that clients can elect to take. All have unique skill-sets to suit differing towage operations, ie training for a harbour towage operation involves four streams of training taking place simultaneously:

- ASD Tug Handling;
- Undertaking Harbour Towage Operations;
- Learning the company's Safety Management
- System (SMS) and procedures;
- Learning the management of the tug, including PMS, booking system, ordering system, crew management etc.

The process is about setting high competency standards and then having tugmasters operate on a day-to-day basis well within their skill-sets. This ensures that when operations start to become more challenging, the tugmasters remain within their skill-sets, resulting in appropriate and safer outcomes.
Humans are genetically programmed for 'flight' or 'fight' when overly challenged. In the tugmaster's case this often results in the tugmaster, when scared, failing to respond at the controls (in some cases I've actually seen them taking their hands off the controls) or giving the controls fistfulls, and thus dramatically overdriving the tug. Both scenarios are equally dangerous.

Proper training helps to manage this. Importantly, having a highly developed and diverse skill-set helps prevent tugmasters going into sensory overload. Furthermore, if this should happen their reactive subconscious instinctive actions are the ones that have been preset via the training.

Tugmaster Training

A good training system should:

- Lay out clearly in writing the whole structure of dos, don'ts, whys and wherefores;
- Design the structure to protect the rights of all parties concerned, ie:
  - the trainee;
  - the training master;
  - the competency check master;
  - the clients (pilot and ship-owner);
  - owners of third party assets (port authorities etc);
  - the towage company.
- Ensure competency-based training starts with the basic steps and works its way through listed and identified steps one by one, thus climbing a ladder of competency and confidence to an agreed predetermined standard;

- Use skilled, respected and qualified trainers who can 'walk the talk', who have empathy with the trainees and are adapt at getting the message across to colleagues;
- Include repetitive training that fixes the basic moves in the subconscious minds of the trainees;
- Ensure trainees are trained to competently drive the tug before undertaking towage operations;
- Give equal emphasis to operational and procedural knowledge;
- Develop a tugmaster's professionalism in all facets of the job;
- Be designed to cope equally with timid, apprehensive trainees as well as over confident egomaniacs;
- Be based on an effective 'style' of tug driving using a combination of authority, control and finesse.
- Some of the inferior training programmes I have seen on my travels have included:
- Attempting to train a tugmaster to undertake harbour towage without training him first on how to effectively and instinctively handle an omnidirectional tug to its fully capacity;
- Training programmes that are time- or job-number governed;
- Training given in-house by tugmasters who are passing on their own bad habits, albeit in good faith and intent, and who have no experience or qualifications as trainers;
- Insufficient time given on controls to ensure base competency is firmly entrenched in the subconscious mind of the trainee;
- Training masters pushing the trainees way beyond their comfort zones and, in so doing, taking away their confidence and raising stress levels to an unacceptable level;
- Lack of formal structure and record keeping;
- *Ad hoc*, non-standardised training that has differing levels of skill, knowledge and competency outcomes between graduating trainees;
- Too much subjectivity in assessing whether a trainee is competent or not;
- Overestimating the benefits of simulator training, particularly in the case of trainers with questionable towage skills, experience, respect and qualifications;

- Not understanding or recognising the limitations of a simulator and the handling behaviour of tug models and that, as good as they may be, they do differ from real on-board operations.

Competency Checking

At the completion of training, and every 12 months there should be a formal competency assessment.
There are two parts to this assessment, operational competency and procedural competency.

A good competency checking system should include:

Operational competency

Driving the tug through a non-subjective competency circuit that comprises all the basic manoeuvres that an Omni-directional tug can perform and in a style of driving that is based on a combination of:

- ✓ Authority: to ensure timely responses to the pilot's orders and minimization of effects around a ship;
- ✓ Control: to ensure safe and effective operations at all times;
- ✓ Finesse: to ensure no damage or injury when touching down alongside or to push up;
- ✓ Driving on the secondary steering system;
- ✓ Driving on one engine;
- ✓ Emergency response exercises;
- ✓ Onboard equipment and systems operation;
- ✓ If 'Undertaking Harbour Towage' is a component, observing a towage operation;
- ✓ If 'Undertaking Escort Towage' is a component, observing an escort towage operation;
- ✓ Driving standards and skills set at an appropriate level that all tugmasters can realistically achieve;
- ✓ Tug driving competency checks that are carried out in real time on board a tug, not in a simulator;

Issues which are identified dealt with and remedied immediately by the competency check master.

Procedural competency

Recording the company's SMS, which has been read and understood by the tugmaster, within the previous six months;
Nine questions from the SMS to ensure there is a thorough working knowledge;
Three questions from the Security Manual to ensure there is a thorough working knowledge;
The questions should be relative to issues that have occurred in the company during the previous 12 months or likely to occur in the coming 12 months;
The nine questions should be chosen to bring focus, education and better understanding and, as such, time taken by the competency check master to fully explains incomplete or incorrect answers; Word-perfect answers are not a requirement, but a meaningful working knowledge is; There is no failure involved; the process is about development of the tugmaster's knowledge and understanding.

A sub-standard competency check system

- Overly subjective in assessment;
- Peer group self-assessment-based;
- Has no outside influence to establish industry best standards;
- Has no outside influence to stimulate broadening of experience and knowledge base;
- Has driving standards and skills set at a level that only the better tug-masters can achieve;
- Uses simulators for the operational tug driving assessment;
- Requires word-perfect answers, rather than a sensible, pragmatic working knowledge;
- Is used as a policing tool;
- Is driven or influenced by internal politics;
- Has competency checks that are not totally without 'fear or favour';
- Has too long between competency checks, allowing bad habits to become entrenched.

Benefit of Annual Competency Checking

Annual competency checks ensure standards and skills are maintained, especially those that are rarely used, i.e. driving on one engine. Furthermore, in the event of an incident, both the company and the tugmaster can clearly demonstrate they have been trained and assessed to operate competently and professionally to recognised industry best practice standards and these competencies have been regularly maintained via a structured, pragmatic and independent assessment.

In my experience, it is rare that a tugmaster can undertake an annual competency check without requiring some additional training to reset skill-sets or correct bad habits. Any issues can be dealt with immediately via training as part of the competency check. As such, there is never failure attached to competency checks, because training is given to correct the issues and then the competency check redone. The whole process is about development, education and growth, not about policing or penalising, and takes some eight to 10 hours per tugmaster. A number of marine authorities, organisations, and client companies are now starting to require towage companies to have proof of professional operating standards and competency of operational personnel. The very nature of a professionally developed and administrated tugmaster training and competency-checking programme ensures this can be readily established.

Critical to the success of any training programme is that it educates and develops individuals for the common good. Specifically, competency checking must never be used in a negative or penalising manner or it will become counterproductive owing to a loss of support, credibility and effectiveness.

If a towing company decides to carry out annual competency checking internally, it is imperative it invests in training and qualifying its competency check master to ensure he is a skilled, respected and qualified trainer. The alternative is to engage an outside specialist consultant.

Professional Development

- In many cases, tugmasters have a background either in the small boat industry, as a seaman or deckhand, or in the fishing industry. Personnel coming from this background have many enduring traits:
- Can-do attitude;
- Small boat handling experience;
- Professional work ethic;
- Small boat husbandry skills.
- But some do not necessarily have a high degree of:
- Safety culture;
- Towage industry knowledge;
- Personal presentation;
- Administrative and computer skills;
- Crew management skills, particularly in a unionised environment.
- An effective and well thought-out training programme should endeavour to address these points so as to
- ensure a fully rounded, competent and professional tugmaster who has the mindset and skills to be the
- company's on-board line manager of the facility.
- A component of SeaWays Tugmaster Training Programme is specially designed to address this.

E) Poor Safety Management System/Lack of Safety Culture

All towing vessels must be operated in compliance with an Owner/Managing Operator (O/MO) implemented Towage Safety Management System (TSMS).

(a) TSMS establishes policies and procedures and require documentation to ensure the O/MO meets its established goals while ensuring continuous compliance with all regulatory requirements. The TSMS must contain a method to ensure all levels of the organization are working within the framework.

(b) A TSMS establishes and maintains:

(1) Management policies and procedures that serve as an operational protocol for all levels within management
(2) Procedures to produce objective evidence that demonstrates compliance with the requirements of this subchapter
(3) Procedures for an O/MO to self-evaluate that ensure it following its own policies and procedures and complies with the requirements of this subchapter
(4) Arrangements for a periodic evaluation by an independent third party to determine how well an O/MO and their towing vessels are complying with their stated policies and procedures and to verify that those policies and procedures comply with the requirements of this subchapter
(5) Procedures for correcting problems identified by management personnel and third parties and facilitating continuous improvement

Training for safety

One of the cornerstones of a successful safety program is that all participants are well trained. It cannot be expected that the uninitiated person will have an understanding of the hazards and risks involved in an occupation. Without that understanding mistakes are inevitable. Therefore it is important that training programs are implemented at all levels and disciplines. It is important to ensure that in the hurly burly of high pressure operations, as well as in the doldrums of routine; when we are too stressed or tried to think on our feet, that the safe option becomes the default.

Communicate.

Another cornerstone of safety is effective communication. Safety has no secrets. The old attitude of knowledge is power sought to contain knowledge. A better attitude is knowledge empowers, where the sharing of knowledge gives us all a better understanding of what is going on and what is required to work safely and efficiently. In an occupational health and safety aspect we need to ensure that the deckhand is aware of the right way to carry out a task. In an operational safety aspect it is important to communicate with crew, pilots, authorities and other vessels to ensure that the full picture is apparent to all.

Managing safety.

The fundamental elements of safety management are hazard identification and risk management. Hazard identification involves examination of a task in its elements to assess where it could go wrong. Effective hazard identification involves training, experience and communication. Safety Management Systems use tools such as Job Safety Analyses (JSA) and checklists to aid in hazard identification. Risk management involves assessment of the severity of the risk and implementation of risk control measures. The severity of risk is most often determined by evaluating the likelihood of a situation occurring and the expected outcome of such an event. A risk assessment matrix is a common tool used. Risk control means developing and implementing ways to ensure the hazard is not allowed to become an event. This is done by adopting the highest level controls from a hierarchy of control measures that range from elimination of the hazard by doing the task differently (or not at all), down to the use of personal protective equipment. Most often effective control will involve a selection of measures from various levels.

The application of managing what we can control and planning for what we can't is usually achieved through the use of the safety management system, i.e. standard and emergency procedures. Masters and crew alike should be well versed in these procedures which have been developed to facilitate safe operations and work practices. The safety management system should include a process to be adopted for use when the unusual task presents, i.e. the JSA.

Leadership

Tugmasters need to show leadership in all areas of operation, it is fundamental to their position and role. The key to developing a successful culture of safety onboard is leadership. Leadership must be displayed by Masters and supported by shore management. Before leadership can be displayed it is necessary for the leader to believe in, and be committed to, safe work practices and operations. There is an old attitude which says that a concern for safety is less than manly and that real men just get on with the job. Among today's tough tugboat men such attitudes can still be found. It is my belief that toughness should be tempered with humanity and a concern for those we work with.

Safety makes sense (and cents)

A good safety record is now regarded as a commercial asset. It can help to win tenders and maintain contracts. Getting the job done safely means a gain for efficiency. Accidents have a commercial cost; but more than that, accidents disrupt, and sometimes steal, the lives of fellow mariners. They also have ongoing ramifications that will affect the lives of managers and supervisors, workmates, and family members. The sensible approach is to take action to avoid accidents at the outset.

Personnel Injury Risk

Risk of personal injury is high. Recent studies indicate that the one of the largest risks to personnel is falling over the side into the water.

Owners and tug masters should have a Clear Deck policy that does not allow personnel onto the towing area when the unit is being towed. Personnel working on tugs have a responsibility for their own and their colleagues' safety. They should:

- Wear approved personal protective equipment (PPE) (hard hat, safety footwear, high visibility clothing etc). Personnel not wearing the correct PPE are exposed to increased risk. Tug masters should demand that their crews wear the appropriate PPE.
- Wear approved and appropriate in-date self-inflating lifejackets whenever on deck. Not using a lifejacket when working on deck, boarding, tying up or connecting up a barge can be hazardous.
- Ensure that working areas are safe and free from trip or slip hazards, particularly around bollards.
- Remain alert to the ongoing operations.
- Listen to orders from the tug master.
- Hold a line by the side of the eye or the standing part.
- Be aware of lines (towing or mooring) suddenly coming under tension.
- Stay clear of snap back zones.

Other factors that can impact on the safety of crew during a towing operation include:

- Fatigue should not be underestimated and it is now acknowledged that many incidents occur where fatigue is a factor. Local and international regulations may apply to the working hours of the crew. The international rules for working hours are regulated by the IMO Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), amended in 2012. These require a minimum of ten hours of rest in any 24 hour period; hours of rest may be divided into no more than two periods, one of which shall be at least six hours in length. These regulations may not apply to non-international trading tugs, but in the absence of other guidelines could be used.
- Poor weather increases the risk to a towing operation and has to be properly assessed by the tug master. It is better to abort an operation than risk life.
- Night working requires additional vigilance and good lighting.
- Danger from damaged tow lines or equipment.
- Working in rivers or tidal areas is particularly hazardous due to strong currents and unexpected change of current direction.
- Working alone.
- Failures to communicate effectively.
- Tug working decks should be non-slip in the working areas, well lit with obstructions, trip hazards and snap back zones highlighted. Steps and ladders should be in a good condition with non-slip steps painted in a light colour to be easily visible at night.
- The tug shall have means of recovering a man overboard (MOB) either by a rescue boat or a MOB device such as a Jason's Cradle when the tug can actually pick up the casualty alongside.

Communication Equipment

Communication equipment on board both the tug and the towed unit must comply with the requirements of the administration.

Attention should be given to the communication equipment on board a manned towed unit. This should include at least two portable VHF radio telephones and a daylight signalling lamp. If the towed unit is boarded at least two VHF radios should be available.

Lack of effective communication is often a factor in the cause of accidents. Effective communication must include:

- Good communication between the wheelhouse, working deck and engine room. The use of pre-towing briefings (tool box talks) is essential.
- Good communication from the tug to the port/river authorities to keep the tug updated on hazards and traffic movements.
- Good communication with the tow master and the towed unit.
- All personnel must understand any agreed hand signals.

Personal Protective Equipment

All personnel engaged in mooring and towing operations should wear the correct personal protective equipment. This should be detailed in the Safety Management System and will include high visibility coveralls, a hardhat with chin strap, safety shoes or safety boots, gloves and in colder weather suitable high visibility warm clothing. Personnel on the forecastle should have safety goggles to hand in case the anchor has to be let go in an emergency. The use of gloves for mooring operations is an often debated topic, the best advice being that gloves should ideally not be too loose fitting so that they do not get trapped within ropes on drum ends. Gloves should always be used when handling wire ropes due to the possibility of hand injury arising from broken wires.

Bollard pull (BP)

When a tug is hired the chartering party requires knowledge of the BP of the tug i.e. the pulling capability of the tug. The charterer will know what the required BP is for the contract, either through experience or it will have been calculated. When newly built the pulling capability of the tug is measured using a load cell under certain conditions, including the main engines being at the manufacturers maximum recommended torque for a continuous period of 30 minutes. The classification societies have their guidelines on how the BP should be measured.

Problems can arise where the tug is chartered to carry out a task that requires a certain BP rating. The specification given to the charterer will usually be as per the BP certificate. The tug will have on board documentation, including a certificate issued by a competent authority proving the BP. It is not unexpected that as the tug gets older, the efficiency of the main engines and equipment will decrease the BP. It is generally accepted that if the BP certificate is less than 10 years old the BP rating is as stated on the certificate. Surprisingly some older tugs have actually produced a higher bollard pull than that recorded when the tug was built and this is often thought to be due to unsuitable conditions at the testing site which may have included one or more of the following conditions: insufficient depth of water, insufficient length of towing gear, high wind speeds, poor tidal conditions or a damaged load cell.

Other factors may also affect the tugs efficiency, e.g. age, appreciable hull growth, propeller condition and high sea water temperatures. Another factor identified in fatal accidents is when a tug is using a shaft alternator during a tow. Therefore the main engine output will be reduced and consequently the BP is reduced. This fact should always be taken into consideration when in an operational mode.

For tugs less than 10 years old with no valid BP certificate the BP can be estimated as (1 tonne /100) x Brake Horse Power (BHP) of the main engines. For tugs over 10 years old without a valid BP certificate the BP value can be estimated as 1 tonne/100 x BHP reduced by 1% per year of age greater than 10 years.

A tug master should always be aware of the commercial demands made of his tug and that the tug is able to comply with those demands.

Pivot point

It is important to understand the effect of the pivot point on any vessel but particularly with tugs when towing. Knowledge of the pivot point assists the tug master to understand how the unit being towed will steer in different situations. A floating unit rotates about a point situated along its length called the pivot point and when a force is applied, it will turn about this point. These forces could be rudder movements, the tug pulling in one direction, wind or current. The position of the pivot point will change due to speed, draught, under keel clearance, rudder size/type, tug construction and hull form.

It is also important to understand how the pivot point of the towed unit changes. A ship or barge stopped in the water, with no external forces applied, will have a pivot point coinciding with the centre of flotation which is approximately amidships. When a vessel is making headway the pivot point will move forward. Generally it will move about 25% of the towed unit's length towards the bow when moving ahead and vice versa if moving astern.

For example if a barge is moving forward towards a berth being assisted by a tug 'breasting' the barge alongside and the tug is positioned at the barge's pivot point there will be no turning of the barge. If the tug is positioned away from the pivot point there would be a turning motion on the barge; the further away from the pivot point the greater the turning momentum.

A moving barge or ship will travel laterally or drift across the water when turning because the pivot point is not located at the craft's centre when moving forward. It is useful to be aware where the pivot point lies on the assisted vessel and how lateral movement can cause sideways drift. This awareness is crucial when manoeuvring close to hazards.

Position of tug and interaction

The position of the tug is always important especially when assisting a barge or vessel. The safe position of the tug relative to the assisted unit depends on many factors which include the size and pivot point of the unit, the number of tugs assisting, the speed of the unit being assisted, the depth of water, and amount of manoeuvrable room, currents and winds. Often when assisting a barge or vessel the tug will have to make fast with a towline. If the tug is to make fast to the barge with its own crew the risks are obviously increased, more so in poor weather.

The phenomenon of interaction is well known to mariners and it is particularly dangerous in situations where there is a larger vessel or barge moving at speed in close proximity to another smaller vessel, such as a tug. The effect is increased further in confined and shallow waters. Tugs and smaller vessels have capsized as a result of this, particularly when being overtaken by a larger, faster vessel in a confined waterway, such as a river or channel.

When a tug approaches a vessel or barge that is going at a moderately fast speed through the water there are various suction and pressure forces around the vessels hull – the greater the speed, the greater the effect.

Approaching the forward end of a ship or barge

If a tug approaches a vessel going ahead at speed forward of the pivot point it will be pushed away and if approaching from aft of the pivot point there will be little or no suction effect. This suction effect will increase as the tug approaches the vessel's stern or quarters, as the water flow increases due to the hull shape or increased water flow from the ship's propellers. The amount of force felt is related to the distance from the hull of the vessel. The force can also be increased by reduced water depths or confined water areas such as narrow channels.

Approaching the aft end of a ship or barge

When a tug approaches the aft end of a ship or barge there is considerable suction effect. This effect is dependent on how close the tug is to the barge or ship, speed and the shape of hull form around the stern. The suction effect can be huge and the tug is unable to manoeuvre away. This can result in damage to the tug as it is dragged beneath the ship's counter (when the ship is in ballast) or towards the ship's propellers.

Another effect of interaction is water flow around larger moving vessels acting on the under hull of the tug. This can cause a decrease in effective stability and increases the possibility of the tug capsizing if the two vessels come into contact.

Accidents occur if the tug and unit being assisted are not similar in size and the speeds are relatively high, in one case a tug with a 2 metres draught was making fast to the starboard bow of a ship with a draught of 3 metres. The tug was proceeding at about 4 knots parallel to the ship, gradually pulling ahead until about 6 metres abeam of the ship's forecastle. As the tow line was being passed the tug took a sudden shear to port and the two vessels touched before the tug master reacted. The impact was minimal in this case however, in seconds, the tug took a starboard list and capsized resulting in a fatality. Research confirms that the following consequences happen with hydrodynamic interaction:

- Interaction effects are increased in shallow water.
- Rudder effectiveness can be reduced in shallow water.
- Squat effects are increased in shallow water and the risk of grounding is enhanced.
- Transverse thrust of the propeller changes in shallow water.
- Changes in manoeuvring characteristics are experienced in shallow water.

- A large vessel or barge with small under keel clearance which is stopped in an enclosed basin can experience strong turning forces.

Girting, girding or tripping (GGT)

The terms mean the same thing and refer to the situation when a vessel, usually a tug, is towed broadside by a towline and is unable to manoeuvre out of this position.

This phenomenon is known to all tug masters. It is the most prevalent reason for tugs to capsize and can cause fatalities. This occurs at either end of the tow and can happen very quickly. Rarely does it happen slowly enough to allow all of the crew to leave the tug before it capsizes. Tug masters must be aware of the phenomenon and understanding the quick release to the tow wire is essential if disaster is to be averted.

GGT is particularly relevant to conventional single screw tugs. Tractor and ASD (Azimuthing stern drive) tugs are less likely to girt because their tow is self-aligning and the tug master is able to produce significant thrust in all directions. It is clearly understood that towing from a point near amidships on a conventional tug is inherently unstable and can result in situations where the load on the tow rope can heel the tug over to a large and dangerous angle.

Various organisations have issued advice, recommendations and investigation reports into girting incidents.

A recurring feature of these accidents has been that, once girded, the towboat capsized so rapidly that crew members were unable to operate the tow, abort control or make use of lifesaving equipment.

The use of well-established towing arrangements to prevent girding may not always be effective in certain confined areas involving smaller towboats. In such cases potential dangers can best be avoided through careful planning and by each crew member being vigilant. A back-up strategy should always be considered in advance if, because of unusual or unforeseen conditions, a particular manoeuvre or action is not having the desired effect.

A review of girding incidents has shown that a towboat carrying out routine tasks in close proximity to the forward end of a barge under way is particularly at risk. At such times it is essential to ensure that the manoeuvrability of the towboat is not compromised by the weight and motion of the tow.

Tug masters should consider practical measures which might be adopted to avoid being placed in a girding situation

Girting can occur for a number of reasons including:

The ship or barge being assisted turns or shears abruptly away from the tug. The speed of the vessel or barge being towed is too high, either intentionally or due to external forces such as increased currents or windage on a towed unit.
The tug is too far astern of its intended position compared to the speed of the vessel if the tow is moving ahead, or too far astern if the tow is moving astern.

The design of the tug, hull form and propulsion arrangements can affect performance in a girting situation. It should be noted that in some ports the ship's speed is restricted to as low as 5 knots whilst making the tow connection.
If an approach is made to a fast moving unit there is the danger from the hull interaction which can cause the tug to be sucked to the towed hull. As a rule the interaction force increases by the square root of the towed unit's speed.
The conventional tug is particularly vulnerable to girting when acting as the stern tug or as a brake at speeds above approximately 3 knots in a towed situation. To minimise the risk of girting a gob wire or similar arrangement can be used. When the tug is fast aft and used as a brake the tug master should concentrate on the following:
Risk of girting increased due to changes in the speed and/or course of the towed unit.
The tug is often out of sight of the lead tug or bridge of the assisted vessel and therefore good communication is essential. On a conventional tug a gob wire is recommended, pulled down as far aft as possible.

Other Suggestions

Company should have their Towing **Standard Operating Procedures (SOPs)** for critical operations, like

ALONGSIDE

- Before making up to the barge, find out where it will end up. This will help determine which side you should make up to for a more controlled landing at your destination.
- Check the weather. If you have a short run and need to be alongside, determine which side will be the lee side. It will be more comfortable for the crew and will lessen surging between tug and barge on the lee side.
- The tug secures to one side of the tow with her own stern abaft of the stern of the tow. This will increase the effect of the tug's screw and rudder. The side chosen depends on how much the tug must manoeuvre with the tow.
- If all turns are to be made with the tug's screw going ahead, she will be more favourably placed on the outboard side of the tow-the side away from the direction toward which the most turns are to be made.
- If a sharp and difficult turn is to be made under headway, the tug should be on the side toward which the turn is to be made. Here she is properly placed for backing to assist the turn, because as she slows, the tow's bow will turn toward the side the tug is on.
- If a turn is to be made under no headway, the tug is more efficient on the starboard side of the tow. When the tug backs to turn, the port send (side force) of her screw will combine with the drag of the tow to produce a turning effect greater than that which could be obtained with the tug on the port side.
- The best position for a long back in a straight line is to have the tug on the port side. Then the drag of the tow tends to offset the port send of the backing screw.
- As you come alongside, the deckhand should be preparing to put out a spring line.
- Once the spring line is secured, angle the bow in and make up the head (bow) line. The bowline or backing line is paid out over the outboard side of the

bow stem or king post and lead to a bitt on the forward end of the tow. Once the bowline is secured on the tow, all the slack is taken in and the bowline secured. This will bring the tug into proper position, slightly bow-in to the tow. When backing down, the bowline becomes the towline.

- Once the bow line is secured bring the stern in and make up the stern line. The stern line or turning line is lead from the tug's stern to the outboard side of the tow's stern. The purpose of this line is to keep the tug's stern from drifting out. The three lines, when properly secured and made taut, will make the tug and tow work as one unit.
- It will be necessary to work up as hard as practical (up to 1450 rpm's) to get the stern line tight. Make sure that you are against a pier that can handle the tug working up hard on the barge. Also, watch your wheel wash. If the lines are great between the barge and pier, or if other factors won't allow you to work up hard then make it up as tight as you can then once out in open water off the pier, work her hard over (stern to barge) and tighten the line.
- If taking the barge alongside in open water (not against a wall or pier) make sure that you have sufficient room to turn a full circle as you put out and tighten lines. This includes room around all piers, docks, marinas, shorelines, etc and other vessels.
- It is usually a good practice to double up on your spring line and bow line. You can also double up the stern line. It will provide a better ride and piece of mind.
- You may find yourself with two barges. If you have to pick them up at a pier and they are side by side, nose between them after you have taken off the stern line (line at your bow) between the barges. Leave the bows tied together. Make up as you would with a single barge. Get all lines between the tug and barges as tight as possible. Double up the line between the barges' bows.
- Use chafing gear. If any of the lines lead over rough or sharp edges, put out chafing gear. This could be fire hose or rug wrapped around the line or wood placed under the lines at the wear points.
- Don't forget the barge lights both putting them out and taking them in.

- Occasionally, it will be necessary to shift from one side of the tow to the other. You can let the barge go completely if you have enough sea room, or you can keep lines out.

Warning

1. When securing these towlines, remember; NEVER secure the line so that it cannot be thrown off quickly and easily.
2. Areas of the harbor subject to wave action should be avoided whenever possible. The tug and tow seldom pitch in the same tempo. When both start pitching out of harmony, the lines take a heavy strain and may part. When equipped with a rudder the tow assists in steering. Size and loading of the tow may obstruct the view of the tug's conning officer. In that case, a lookout is stationed aboard the top who keeps the conning officer fully informed of activity and hazards in

PUSHING

- Before making up to the barge, find out where it will end up. This will help in determining which end to push from. The contractor may want the crane end forward and the crane may be on the stern of the barge. If your destination is a narrow space, you may not have room to spin the barge and put the crane end where they want it. Ask first!
- Check the weather. Do not push in seas over 2 feet.
- As you come up to the barge, the deckhand must get your head line(s) out first.
- On barges without a center bitt/cleat, run a line to each side from the tug's stem.
- Put out the safety lines next from the tug's forward quarter bitts to the barge's corners.
- Put out the push wires last. Make sure the tug is centered and straight for maximum steering.
- If you know that you are going to handle the same barge later, when breaking down, slack one wire and then when you make up again, put that wire out first (after the head and safety lines).
- Don't forget the barge lights both putting them out and taking them in.

ASTERN

- You will generally tow astern because the weather will not permit you to tow alongside or push.
- Check the weather! The forecast will help you determine how much hawser to put out.
- Unless towing on gate lines, you want the barge away from the tug's stern. The tug's wheel wash will have an effect on the tow. It will try to push the barge backwards. Get the tow out of your wheel wash.
- Gate lines are for towing short with the maximum steerage. You will take two lines and run them out to the barge. One on each corner and then bring them back to the tug's stern quarter bitts. You can lead them around the bitts and make up on the H-Bitt if it is easier for you. The lines must be of equal length when made up. Ideally, you will almost be able to step off of the tug's stern onto the barge when made up.
- Use chafing gear. If the barge has sharp edges, use chafing gear on the bridles or shackle the bridles into chain or cable donuts that are looped over the bitts and lead over the sharp/rough edge.
- Old fire hose cut into 4- to 6-foot lengths and then split lengthwise makes excellent chafing gear. It is wrapped around the hawser or towing cable to protect it from wear due to constant rubbing.
- Hawser length will be determined by the sea! Barge and tug must be in step. Too much line out could cause the towline to foul on the bottom. Too little line out will cause the line to jump out of the water. This puts too much strain on the line.
- The scope of a hawser should be long enough to provide a good catenary, but not to the extent of having the towlines drag on the bottom if in shallow water. A catenary absorbs shocks. You should not put stress on a towline to the extent of lifting it out of the water, but you can increase the catenary by reducing the tug's speed.
- Towlines should never be made fast on the capstan.
- To rig a stern towline, the towing hawser should be faked out in the fantail of the tug. This will ensure that the hawser will pay out without becoming fouled.
- The eye of the hawser is led back over the top of the "H" bitt, over the shoulder of the horn, and back through the legs of the bitt. Then the hawser is played out. When you get close to the point where you are going to secure the tow, take a full round turn and cross the line back onto itself. Then take two or three additional rounds

turns before you figure eights the line on the bitts, and finish it off with two or three turns on the arm of the bitt.

Note: A hawser watch must be posted on the after deck to keep tow and gear under constant observation. Instruct the crew member, on watch, to immediately report the following-

  - Too much tension is on the towline.
  - The tow is not weathering properly.
  - The bridles or other gear fail.

- In addition to chafing gear, continued monitoring of the towline's condition is necessary and important. Stern rollers and other fairleads must be properly lubricated and all possible points of line wear offered a fairlead. Canvas, hose, line, wood, or other materials should be used for chafing gear as required. Chafe must be eliminated or reduced on board the tow and the tug as much as possible. Continued paying out and retrieving of the towline can cause excessive chafing. Freshening the nip and lengthening or shortening the tow wire should be done every few hours in moderate weather and more often during heavy seas.
- The towline must be checked periodically for a fairlead and chafing. Points of chafe must be protected. Appropriate lubrication and wearing surfaces should be placed so as to eliminate towline-to-hull contact.

Tandem Tow Make-up

- When towing more than one barge astern, it is referred to as tandem towing. In a pure sense, tandem means one behind the other.
- In this method, the tug is connected to the first tow. The first tow connects to the second, and so on if additional units are towed. The intermediate hawser, connecting the first tow to the second, must be streamed and allowed a proper catenary depth. The surging action must be eliminated between tug and first tow and between first tow and second tow.

Honolulu Tow Make-up

  - In this method, the first tow is connected to the main tow wire. The second tow is connected, with an auxiliary tow wire, to the bitts on deck. The Honolulu rig allows independent connection of the two tows. Disconnecting and control are readily workable.

WARNINGS:

1. Always face your work.
2. Never step over a line that is laying on the deck. Either lift it up and walk under it, or step on top of it and cross over. Never straddle or step in the bight of a line.
3. When towlines are coming under or are under a strain, work fast. Get the turns or figure eights on a quickly as possible. When surging or slacking off on a line that is under strain, Keep your hands clear of the bitts.
4. The greatest danger in using towlines is that if the line should part when under strain, it will snap back its full length like a bull whip. The force of the snapback is tremendous depending on the strain that the line was under at the time it parted. There is no set pattern on how the line will whip back. It may snap back directly on itself or it may whip from side to side. There is no way to tell what it will do. If you see a synthetic fiber line under strain parting or beginning to part--DO NOT RUN--just fall flat down on the deck.

Safe tug communications

- Towing companies and tug masters, if possible together with pilots, should develop safe procedures for how to approach a ship for picking up a heaving line and for passing a tow line. It is recommended that these procedures include an instruction that tugs only approach the bow when the crew is ready.
- In case of a too high ship speed it is recommended to secure the stern tug first, in case a stern tug would be used, and when ship speed has dropped to an acceptable level the for-ward tug(s) can be secured.
- There must be safe and effective communication procedures between pilots and tug masters. Communication should include issues such as safe speeds, when and where to make fast to the ship, SWL of bollards and fairleads, intended manoeuvres, mooring details and all other relevant information.
- It should be made standard that a pilot translates communications with the tugs into English, unless the ship captain speaks the same language as the pilot.

Training of tug masters

- Training of all tug masters is vital and should include refresher courses. Training should include the capabilities and limitations of tug types in use, safe procedures, safe speeds, knowledge about interaction effects and their effect on tugs, teaching the right attitude (particularly for young tug masters), and all other important aspects of safe towing.

- Training, regular refresher courses and competency checks should be carried out by certified institutes and trainers.
- Interaction effects between tug and ship, including pressure waves, should be replicated in a realistic way in simulators used for training. Simulated interaction effects should be accurate for various hull forms, speeds, draughts, under keel clearances, tug locations with respect to the attended ship and distances between tug and ship.
- Pilots should always alert tug masters to problems e.g. regarding ships with high Dead Slow speeds, deep draft vessels, SWL of bollards, poor seamanship on board ships handled, and any other relevant information.

Training of pilots

- It is recommended that pilots (including PEC -Pilot Exemption Certificate- holders are trained on the same subjects as mentioned above, such as with regards to the capabilities and limitations of tug types in use, safe tug and communication procedures, safe speeds, knowledge about interaction effects and their effect on tugs, and all other important aspects of safe towing.

Safe procedures shipping companies and ship captains

- Shipping companies and ship captains should implement rules for safe procedures regarding the securing and releasing of tugs, including safe speeds, use of suitable heaving lines and proper handling of heaving lines and tow lines in a safe and efficient way, SWL of bollards and fairleads, proper bollard use with respect to towlines, and keeping an eye on the tugs when fastening and releasing. Ship's crew should be trained in all these issues.

Line throwing systems

- It should be investigated whether line throwing systems can safely and effectively be used for passing a heaving line to a tug.

Bow camera

- It is recommended to investigate whether a camera on the ship's bow can help in monitoring the tugs.

Final remarks

- Proper communication and information exchange needed (and emergency communication sets).
- Proper heaving lines should be used.
- Training is a must for everyone involved. Refresher courses. Experience.
- Know your tug capabilities and limitations (this applies to planners as well), local conditions and interaction effects.
- Tugs should be on time and ship's crew ready.
- Know the speed and ask to slow down if speed is too high.
- Sometimes tug masters make fast if speed is too high, even if they are told by the pilot not to do so.
- Young tug masters are sometimes too shy to ask the pilot to slow down.
- Keep sufficient reserve power.
- Towage companies, port authorities and pilot organisations to set maximum ship speeds for tug operations in general and for bow-to-bow operations in particular.
- Line throwing systems needed.
- Released towlines to be lowered carefully and slowly to the tugs.
- Lighter towlines with higher SWL needed.
- Set up an International Incident/Accident database. Set up a means of Formal Safety Assessment. Instigate Failure Mode & Effect Analyses for tugs to avoid single point failures, especially at the design stage. All these will help to avoid possible catastrophic failures for the forward tug.
- Why bow-to-bow? Use tractor tugs, or push pull method.
- Never connect a side tug before front tug is connected.
- Knowledge of towing in the conventional way is disappearing, and the knowledge is not being passed on, which can be dangerous.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Accidents are not because of fate or chances always. Researches on safety has stressed upon the point that accidents are resultant of a chain of incidents, which ultimately shaped into an adverse outcomes. The first task of risk assessment is to recognize the inherent hazards. Harbor towage which is also known as routine ship towage is potentially a hazardous operation. In order to operate in an efficient manner safely, this requires a high level of understanding about role and accountabilities of persons involved in operation of their own and their teammates, proper training and equipment should in addition be provided as a prerequisite.

Recent accidents in RST operations in Indian coastal waters have stressed on potential safety concern. Preliminary researches showed a requirement of empirical scientific research with respect to the specific accidents faced during harbor towage operations.

5.2 Findings

Seven factors were found responsible to a great threat to Routine Ship Towage safety and those are Poor work process, Poor maintenance of equipment/substandard condition of Equipment, Severe weather conditions, poor or no risk assessment, occupational incompetence, the suitability of the type of tug and poor safety management system.

Expert Interview identified extra safety risk factors; fatigue, negative attitude & commercial pressure, watertight integrity, and wash/squash effect. Risk factors elements such as Fatigue, negative attitude & commercial pressure are taken in Human factor, whereas watertight integrity is basically stability element. Moreover, wash/squash effect is attributing to Navigational obstacle.

Collisions were the potential safety event in RST operations followed by grounding and Capsize / foundering. The most potential consequence was Damage followed by Injury and Pollution. There is also indication of a noticeable risk of Loss of Life.

Crew incompetency due to poor training and Human factor indicated substantial amount of risk frequency.

Although small risk factor frequency is observed because of tug type involved in Routine ship towage operation but it indicates a fair relationship with consequences, on the other hand high risk factor frequency and significant relationship with consequences is exhibited by navigational obstacle or restricted maneuvering space.

High risk factor frequency was lies with Poor work process components like speed; wrong operating procedure and poor tug handling and interaction. Poor implementation of safety culture contributed by bad work attitude and Poor risk assessment was responsible for Poor Safety Management System and therefore was the main source to threat to RST operation.

An area of equitable system of regulatory oversight for the benefit of all tugs is identified which could benefit after further analysis. A disproportionately high number of smaller uninspected tugs, involved in accidents, provided limited anecdotal evidence to support this. High frequency of insufficient Safety Management Systems and Human Factors (legislated for in International Maritime Conventions) are included in substantial Risk Factor evidence comparatively.

Changes to tug design and increased complexity were identified as factors. Expert Interviews reported that modern engine management systems can provide dead slow speeds of ten knots; equally tug power has increased to an extent where bollard strength can be insufficient.

The significance of an adequate number of appropriately qualified and experienced crew was also identified. New entrants from other maritime sectors replaced by migration might not be aware equally risk factors associated with harbour towage operations.

Many risk factors are related to training. In harbour towage operations, tow planning emphasized the significance of prerequisite of adequate information and experienced persons involved in operations; Following Operation Procedures marked the significance of effective tug crew training programs; and Tug Handling stressed upon sufficient training of tug masters.

Interviews of experts implied that training issues might also comprehended to personal attributes and attitudes; emphasizing on the importance of teamwork and effective communication in order to secure safety in harbour towage operations. A specific code, analysis of situation (whether an action was safe) was marked; whether it was related to handle tugs of new generations (with reported exceptional tug size to power ratios) or the capability to judge speed of a vessel to decide whether it was safe to close on her bow to make a tow.

5.3 Conclusions

The research presented in this thesis has contributed to the fields of maritime hazard & risk management:

- The research aims to improve worker safety by providing measures to reduce fatalities and injuries to workers in the field of towage operation.
- This research proposes hazard controls used for a past problem can be applied and / or modified for similar associated in Indian subcontinent region.
- To this end, aiding hazard identification in the RST operation has been performed.
- This presents an avenue for further study towards investigating perception and worker competence levels based on work experience.
- The study shows potential to provide continual learning in hazard identification / management along with benchmarking company /individual risk perception levels and assessing the effectiveness of targeted training initiatives.

- Lastly, proposal for Further Work in Multidiscipline / Collaborative Research Opportunities such as other avenues for future research could involve collaboration between psychology / education and engineering fields.

5.4 Lessons Learned

I have gained a vast amount of knowledge throughout the course of this study, both in regard to the research topic and myself. I have found this experience has given me additional confidence by developing communication and presentation skills. These have been further reinforced by presenting my work at seminars and conferences, interacting with people of varying disciplines, and attending appropriate training. The research was a far greater challenge than I had originally anticipated, especially the collection of questionnaire samples and conducting interview. Although not pleasant at the time, these experiences acted as a reality check as to what was achievable within the timescale.

The most important lessons I have learned from undertaking this research are:

- Time management skills are paramount and realistic time scales / planning are required.

- A good understanding of research methodology and various tools for analysis.

- Consider the resources available to you, whether it is materials, software, or people. The overseas interview from different parts of world would not have come to fruition without the media consultancy support team.

- Face-to-face contact and strategic networking is invaluable. This is demonstrated by the lack of response when in search of participants for interview very few people elected to take part.

5.5 Limitations of Study

5.5.1 Practical Limitations

The practical limitations concern the scope of this research which is just limited to Hazard identification which is first and primary stage of any risk assessment tool. The second objective which is to explore various control measures practiced worldwide in towage industry is just a representation of recommendations which is actually a final stage of risk assessment tool. This research doesn't assess the cost-benefit analysis or doesn't answer good or bad practice. Hence, the control measures and practices listed out in second objective are for reference purpose. Organization need to do risk assessment before adopting or implementing any control measure on case basis. Perhaps, this limitation of research also open gap for future research study.

5.5.2 Methodological limitations

The major methodological limitations concern the validity of the questionnaire and sample characteristics. The questionnaire did not show the ability to cover all aspects of the safety risk factors, which is a limitation affecting the overall validity of the study. Due to low reliability, several items and constructs were excluded from the further statistical analysis. One explanation is poor representative reliability across subpopulations or groups of people (Hair, 1998; Neuman, 2000). It may be fair to assume that some groups (e.g., top management or senior officers) are better informed about their company's strategic and tactical management and operations and, therefore, are better placed to answer some of the questions related to the company. A second issue concerns the constructs itself. Yin (2003) focused on the fact that the items constituting a construct or dimension should share a common cause or consequence. Some of the questionnaire constructs did not meet this latter requirement. Biases could also be produced by cultural differences, languages, and response style. India is a country of many languages and cultures. In a cross-national study, Stake (1998) found that English language survey versions tended to be more homogenized, potentially obscuring cross-national differences. The sample taken from participants many not necessary are of different nationals but there are diverse relation between their mode of communication and thought process. Taking this into consideration, cross-cultural comparisons of results are not performed in the current study. In addition, indicated differences at the organizational level (e.g., between type of tug and employment terms) should not be overestimated. As participation was voluntary on behalf of the company, it is assumed that those participating do, in general, emphasize safety in their operations; thus, the results are biased in a positive direction. Moreover, the survey data are only representative of members of the Indian National Shipowners' Association. The possibility exists that the results are subject to the common method bias (Hammersley, Martyn, and Roger, 2000) due to the data deriving from a common source (e.g., a common scale for different questions). Potential statistical remedies have been suggested. Platt (1992) is skeptical of the merits of such approaches. He argued that—given that it is not possible to know the existence or extent of any possible bias—treating it could in fact introduce more bias than what existed in the first place. He recommended using a multi-method strategy so that results do not rely exclusively on the results of one questionnaire. In the current research, Case reports, interviews, and participatory studies were used to validate the data. As with the survey data, a question of validity arises to the qualitative data. Accordingly, all results in this thesis were also presented to several people working within the industry; they expressed that they believe the results to be giving an accurate representation of the situation.

5.5.3 Theoretical limitations

The principal objective of this thesis has been to identify risk factors which are causing threat to RST operational safety and various control measures. Limitations also follow from the theoretical stand and research perspective. By focusing on cultural influences on safety management, other areas of equal importance give way. Research with other perspectives (e.g., professional culture, state culture, or a sociotechnical approach) would bring about different results. For example, technological changes have unquestionably left their mark on both operational safety and the organizational structure of the industry. The shipping industry has, since the early 1960s, steadily adopted the automation and integration of new technology (Hill, 1992a). Yet despite the introduction of new technology partly intended to increase safety by, for example, reducing human error, new technology may also be the cause of new and emerging risk (Gallaspe, 2008). This could be a mismatch between ergonomic aspects and the human information processing system, overreliance in technology that may fail, loss of operational skills and experience necessary for handle critical and unexpected situations, or changes in the social and organizational system.

5.6 Future Scope of Study

This thesis has explored the hazards and safety management practices within shipping associated with Routine Ship towage Industry. The major limitations of the research along with implications for safety practitioners and researchers—previously addressed in this thesis—can be summarized as follows.

Survey: Parts of the applied questionnaire showed several deficiencies, and results may be biased due to common method, psychometric properties, language, and characteristic with the sample, which may affect the validity of the conclusions. Future research should strive to develop an instrument in order to reduce such biases.

Research model: The strengths and limitations of both qualitative and quantitative research should be acknowledged, and future research should be open to a multi-method approach.

Safety researcher: As the theories of safety management are developing overtime, safety researchers should strive to develop a better understanding of the limitations of current safety management systems and be open to research within the prevailing adaptive age. Researcher can also do assessment of each control measures with respect to hazards and develop relevant concepts or tools to provide effective control over associated safety risk

.

Safety practitioners: In practical applications of safety management, one should rely less on safety through standardized measures and experience data. This includes understanding the difference between events where such measures are applicable and unexpected events where it is adequate to support competence-promoting activities so that the operators have the ability to adapt their behavior to new situations. The human inferential capacity in handling unexpected situations should not be underestimated in relation to technology.

5.7 Final Remark

This research has identified hazards associated with RST operations and listed out various hazard control measures practiced worldwide in towage industry. However, the research is by no means all-embracing, and many other areas can be further investigated. 7 areas are identified: Poor work process, poor maintenance of equipment/substandard condition of Equipment, severe weather conditions, poor or no risk assessment, occupational incompetence, the suitability of the type of tug and poor safety management system.

Examples of further research include but not limited to:

- Assessing the scalability of results with regard to larger Sample & Case Base.
- 'Value-for-money' comparison with safety campaigns and hazard management tools
- Complete cycle of risk assessment- Monitoring system feedback regarding control measures and general suggestions for improvements.
- Investigate links between risk perception, competence and work experience.
- Academic and industrial collaborations must be actively sought and new projects managed well to enable extended field investigation. One suggestion is to approach DG Shipping in this regard. Contact with such high profile bodies could allow a larger sample collection and wider view of industrial practice and give opportunity to be involved with high profile projects, such as the detail RST activities involved pan Indian coastal waters. Sources of funding in other industry collaborations, such as Knowledge Transfer Partnerships (KTPs) could also be investigated and their strategies assessed.

5.8 Research Contribution:

This research has made an attempt to make useful contribution in the area of primary stage of risk assessment i.e Hazards Identification. ***Hazards Identification*** **acts as the main 'bottle neck' and barrier to risk identification.**

Primary aim of this research is just only to find the problems but also to suggest solutions. The problem was to identify hazards and solution is to present measures practiced worldwide to mitigate or control such hazards. The solution presented in just for indicative purpose, the research does not answer the effectiveness of those control measures. Hence, it is advisable the practitioners to do proper risk analysis before adopting one.

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Appendices

APPENDIX - I (Glossary)

Abeam	direction at right angles to the fore and aft line of a vessel
Aft	rear of the vessel
Athwartships	transversely across a vessel
Beam	width of a vessel
Beaufort scale	system of estimating wind speed
Bollard	firmly secured post of circular section used to secure ropes
Bollard pull	measure of the static pull a vessel can exert
Bowse	to exert a downward pull on a rope
Bulkhead	nautical term for wall
By the head	said of a ship when its draught forward is greater than its draught aft
Chart datum	zero height referred to on a marine chart
Case Study	Individual maritime safety agency accident report, analyzed to extract harbor towage operations risk and safety data.
Dolphin	structure used for mooring ships
Draught	depth in water at which a vessel floats
Expert Interview	Qualitative interview (supported by written submission and observational analysis) of expert witness experience of harbour towage operations safety.
Routine Ship Towage/Harbor Towage Operation	Movement, berthing or unberthing of a vessel with the assistance of a tug(s) within a harbour, port or equivalent area.
Girting	(*Also similar: Girding and Tripping*). Where a vessel is caused to potentially capsize, most commonly as a result of external towline and interaction forces. Ccondition of a tug when it is heeled by the direction of pull on a towline and is in danger of capsizing
Gob line	a line used to bowse a towline to move the towing point aft
Gross tonnage	a measure of the internal capacity of a ship; enclosed spaces are measured in cubic metres and the tonnage derived by formula
H frame	post on a tug for securing the towline
Heel	angle of tilt caused by external forces

Interaction	Hydrodynamic forces commonly found immediately adjacent to a vessel moving through the water.
Knot	one nautical mile per hour
Kort nozzle	solid shroud around the propeller of a vessel
Non-Routine Ship Towage/Non-Harbor Towage Operation	
	Any **o**peration or activity other than harbour towage, involving a tug(s) carried out in any sea area.
Port	left-hand side when facing forward
Questionnaire	Survey of current practitioners experience of harbour towage operations safety, using a Likert style questionnaire (*See Appendix A*).
Risk Factor	An element whose presence or absence has potential to lead to lead to an unsafe event.
Spring tide	period of highest and lowest tides in a lunar cycle
Stability	property of a ship by which it maintains a position of equilibrium, or returns to that position when a force that has displaced it ceases to act
Starboard	right-hand side when facing forward
Trim	difference between the forward and aft draughts of a floating vessel
Tow Planning	Planning and management of a harbour towage operation, commonly undertaken by a licensed pilot.
Yaw	to swing to either side of an intended course

APPENDIX – II (Questionnaire Form)

PhD Research - Towage Safety Questionnaire

This questionnaire has been produced by Abhijit Singh, as part of a Phd research into Tug Safety, with University of Petroleum and Energy Studies, Dehradun. The purpose of this questionnaire is to identify the specific risks involved in Tugboat towage operations.
It is addressed to all Harbour Masters, Port Authorities and Master Mariner & asks them to describe one berthing or unberthing operation which raised an issue of tug and vessel safety. This might have been a near miss or an incident, but it includes challenging jobs; for example where different choices were made on subsequent occasions.
All information provided will remain strictly confidential to myself, the researcher. Anything that attributes information to a particular person, vessel or company will be removed: any information provided is purely for statistical analysis. All responses will be destroyed upon completion of the research project in December 2015.
To fill in the form, respondents are asked to put a cross (X) in the most applicable box. If a question is not applicable, you are unsure about the answer, or you do not wish to answer a question, please leave it blank.

Please email your completed questionnaire to:
apshree4@gmail.com

Alternatively, this can be hand it over to the personal in recipient present.
I can be contacted at the above email address.
Thank you for your help with this research.

APPENDIX – II (Questionnaire Form)

1. Vessel type (Tanker, Bulk, Container, barge, etc.)

Bulk

2. Approximate size (dwt, tonnes etc)	**3. Bow form**	
○ Coastal/Barge (<10,000mt) ○ Handy (10,000-50,000mt) ◉ Large (51,000-160,000) ✓ ○ Very Large (>160,000) ○ Not known / other	○ Fine ○ Moderate ◉ Broad ✓ ○ Unsure / other (Please state..................	
4. Type of tug	**5. Tug Bollard Pull (Approx)**	**6. Tug Help**
◉ Conventional (propeller/ rudder) ✓ ○ ASD ○ Tractor ○ Not known / other	◉ Moderate <30t ✓ ○ Medium 31t - 65t ○ High > 66t ○ Not known / other	◉ Push &or pull ✓ ○ Tow on a line ○ Not known / other (Please state...........
7. Tug Position	**8. Whose line**	**13. How would you best describe the event:**
◉ Tug Forward ✓ ○ Amidships ○ Tug Aft ○ Not known / other (Please state................	○ Tug's ◉ Ship's ✓ ○ Unsure / Not Appropriate	○ Challenging / Instructive ◉ Near miss ✓ ○ Incident ○ Accident ○ Other
9. Wind (Beaufort Scale)	**10. Swell height (m)**	**11. Current (knots)**
◉ Low (<F3) ✓ ○ Moderate (F4-F6) ○ Gale (F7-F83) ○ Storm (>F9) ○ Unsure	○ Calm (<0.2) ◉ Moderate (0.3 – 0.9) ✓ ○ Rough (1.0-1.5) ○ Storm(>1.5) ○ Unsure	○ Low(<1) ◉ Moderate(2-3) ✓ ○ Strong(>3) ○ Unsure

12. Other external condition (please state)

14. Indicate the extent to which the following factors influenced the safety issue.

	No effect /Not Applicable	Some effect	Important effect	Fundamental effect
Training insufficient (e.g. more training in working with tugs would be beneficial)			✓	
Human factors (e.g. tug or ship's crew poor concentration, fatigue, etc.)			✓	
Language difficulties (e.g. lack of spoken English)	✓			
Inadequate tugs communication equipment (e.g. poor VHF)		✓		
Tug equipment inadequate (e.g. failure of emergency quick release)			✓	
Ship securing arrangements (e.g. suitable fairleads in wrong position)			✓	
Practical difficulties (e.g. tug needs to remain in 'critical area' to pass tow line)			✓	
Excessive wind strength (e.g. too great for tug power)			✓	
Excessive current (e.g. tug finds it difficult to control vessel)			✓	
Excessive swell (i.e. snatching or parting tow line)		✓		
Interaction between vessel & tug (e.g. tug enters ship's bow pressure wave)			✓	
Girting, Girding or Tripping (i.e potential for or actually observed)		✓		
Insufficient detailed planning of tow (e.g. pilot orders insufficient tug bollard pull)			✓	
Speed through water too fast (e.g. tug unable to maintain required position)			✓	
Ship size too large for tug/s (e.g. wind too great for tug bollard pull)			✓	
Ship too powerful for tug/s (e.g. main engines overpowering tug pull)		✓		
Wrong tug type used for job (e.g. conventional tug used in vulnerable position)			✓	
Lack of manoeuvring space (e.g. restrictions of shallow water, buoys or piers)			✓	
Other (please state: and continue in 'Brief Description' above) …………………………			✓	

15. How likely were the following outcomes in this case [The risk (to vessel or tug)]

	Not likely / Not applicable	Possible	Likely	Highly likely	Inevitable
Collision	○	○	○	◉ ✓	○
Grounding	○	○	○	◉ ✓	○
Foundering	○	○	◉ ✓	○	○
Major damage	○	○	◉	○	○
Minor damage	○	○	○	○	○
Loss of life	○	○	○	○	○
Major Injury	○	○	○	○	○
Minor injury	○	○	◉ ✓	○	○
Pollution	○	○	◉ ✓	○	○

16. Please use this space to briefly describe any other factors not already covered elsewhere.

....

APPENDIX – III (RISK ASSESSMENT GUIDANCE)

Risk Assessment Guidance

The assessor can assign values for the hazard severity (a) and likelihood of occurrence (b) (taking into account the frequency and duration of exposure) on a scale of 1 to 5, then multiply them together to give the rating band:

Hazard Severity (a)	Likelihood of Occurrence (b)
1 – Trivial (eg discomfort, slight bruising, self-help recovery) **2 – Minor** (eg small cut, abrasion, basic first aid need) **3 – Moderate** (eg strain, sprain, incapacitation > 3 days) **4 – Serious** (eg fracture, hospitalisation >24 hrs, incapacitation >4 weeks) **5 – Fatal** (single or multiple)	**1 – Remote** (almost never) **2 – Unlikely** (occurs rarely) **3 – Possible** (could occur, but uncommon) **4 – Likely** (recurrent but not frequent) **5 – Very likely** (occurs frequently)

	Trivial	Minor	Moderate	Serious	Fatal
Remote	1	2	3	4	5
Unlikely	2	4	6	8	10
Possible	3	6	9	12	15
Likely	4	8	12	16	20
Very likely	5	10	15	20	25

The risk rating (high, medium or low) indicates the level of response required to be taken when designing the action plan.

Rating Bands (a x b)		
LOW RISK (1 – 8)	**MEDIUM RISK (9 - 12)**	**HIGH RISK (15 - 25)**
Continue, but review periodically to ensure controls remain effective	Continue, but implement additional reasonably practicable controls where possible and monitor regularly	**-STOP THE ACTIVITY-** Identify new controls. Activity must not proceed until risks are reduced to a low or medium level

HSE, 2012 A. Risk Assessment. [online] Available: http://www.hse.gov.uk/risk/faq.htm [accessed: 22/06/15]

Risk Assessments

There are a number of explanations needed in order to understand the process and the form used in this example:

HAZARD: Anything that has the potential to cause harm. (Lifting/moving heavy items, vehicles, fire etc)

For example

- Physical causes (falling, injury from equipment)
- Environmental (water, rivers, hillsides etc)
- People (launch drivers, players, coaches)

PERSONS WHO MIGHT BE HARMED: e.g. the general public, employees, spectators etc

RISK: expresses the ***likelihood*** that harm from a potential hazard will be realised and taking into account the likely severity of harm.

The questions that need to be asked are:

How frequently does this sort of hazard occur in the activity taking place? (i.e. seldom, sometimes to often)
How severe are the consequences of an accident occurring from that hazard? (i.e. bruised arm or death – or something in between)
How many people are likely to be exposed to the hazard? (i.e. one, a small group or many)
Are specific groups more vulnerable than others? (i.e. inexperienced, children, people with disabilities, pregnant women)

RISK CONTROLS IN PLACE: What is already in place that has reduced the chance of somebody being harmed by the hazard?

Severity (of hazard) x **Likelihood** (of occurrence) = **Overall risk**

So, the **severity** of a plane accident could be high (death), the **likelihood** of a plane accident (given a company of international repute) is low (because of the huge amount of money and effort that goes into reducing likelihood) so the **overall risk** is low.

Severity (of the hazard) could be measured on a 4-point scale:
1 = No injury
2 = Minor injury – may need some first aid assistance, not life threatening
3 = Major injury – admission to hospital etc (not visit to A & E)
4 = Fatal

Likelihood (of occurrence) could be measured on a 5-point scale:
Improbable – so unlikely that probability is close to zero
1 = Remote – unlikely, although conceivable
2 = Possible – could occur sometime
3 = Probable – not surprised, will occur several times
4 = Likely – occur repeatedly/event only to be expected

Multiplying the **Severity x Likelihood** gives a number between 1 and 25. The person completing the Risk Assessment then has a relative scale of the overall risk on which to manage the problem and introduce any preventative or protective measures.

1 to 8 could be classed as a **LOW** risk
9 to 15 could be classed as a **MEDIUM** risk
15 + could be classed as a **HIGH** risk

The overall aim is to reduce or remove the risk to an acceptable (as close to **1** as possible) level!

HSE, 2012 A. Risk Assessment. [online] Available: http://www.hse.gov.uk/risk/faq.htm [accessed: 22/06/15]

APPENDIX – IV (Sample VOYAGE PLAN)

Transit under 4 hours **Transit over 4 hours**

Tug: Shenandoah Date: ___________________

Barge:_____________________ Cargo: _______________ Amount: _______________

Length/Width/Capacity: ____________________________ Drafts: ________________

Voyage Description: ____

____

LNM Updates (if applicable): ____

____

Weather Forecast: ____

Anticipated Tide and Current: ____

____

Fore and Aft Drafts & Minimum Clearances: ____________________________________

Anticipated Speed and ETA: ____

VTS, Bridges, Enhanced Security Calls and Destination: __________________________

____

Other Key Safety Factors: ____

Master: ____________________________ Mate: _________________________________

Deckhand: __________________________ Deckhand: ____________________________

Engineer: __________________________

APPENDIX – V (Best Practice: Pre-Towing CHECKLISTS)

1) Safe Towage Operations Checklist

	Task / Duty	Officer's Initials	Date
	When preparing to undertake a towage operation:		
1	Identify the principle risks and method of assessment		
2	Identify and understand the reasons for the towage method to be used		
3	Visual inspection of the towing wire		
4	Identify suitable towage points and the chafing areas		
5	Identify the characteristics of the tow		
6	Ensure rigging and correct deployment of the towing gear		
7	Knowledge of safe handling of the towing gear		
8	Identify safe areas on deck		
9	Ensure adequate lighting of working areas		
10	Identify the stability of the tug and tow		
11	Prepare a passage plan		
12	Identify local byelaws that may affect the operation		
13	Identify where different phases of the tow may require different towing requirements		
14	Identify berthing arrangements on arrival		
	On Passage		
15	Follow correct procedures to connect, let go and change of the towing gear		
16	Monitor the tow to take timely and effective corrective action when required		
17	Aware of the importance of avoiding large dynamic forces on the tow line		

2) Fitness for Purpose Checklist

	Task / Duty	Master's Initials	Date
	For an intended passage:		
1	Check correct documentation for the tug		
2	Check correct documentation required for the tow		
3	Verify tug requirements for the tow		
4	Assess fitness and suitability of navigation equipment for proposed passage		
5	Assess number, experience and qualifications of crew		
6	Assess the suitability of the towing equipment		

3) Internal & External Communications Checklist

	Task / Duty	Master's Initials	Date
	Verify Internal Communications		
	Conduct:		
1	A pre-tow briefing with crew		
2	The use of hand signals and state the importance of non-verbal signals		
3	The use of hand held radios and state the importance of correct radio procedures		
4	The use of on-board CCTV		
5	The use of on board alarms, signage and announcements		
	Verify External Communications		
	Ensure:		
1	Tow set up briefing with external stakeholders		
2	Agreement of terminology with pilot		
3	Check communications with other tugs and vessels		
4	Check traffic reports and communication with VTS / Port Control/vessel		

4) **Emergency Procedure Checklist**

	Task / Duty	Master's Initials	Date
	Verify Actions to be taken in the event of:		
1	Failure of towing lines and equipment		
2	Failure of gog arrangements		
3	Failure of engines, steering, electrical systems		
4	Failure of steering gear		
5	Failure of electrical systems		
6	Loss of external communication to pilot /port control etc		
7	Mechanical problem on the towed vessel		
8	Rope in propulsion system		
9	Compromise of watertight integrity of tug when towing		
10	Collision		
11	Grounding of tug and/or tow		
12	Man overboard		
13	Fire		
14	Pollution		
	Verify:		
15	Use of the emergency controls		
16	Deployment of the emergency tow line		
17	Emergency release of the tow procedure		
18	Crew preparedness at emergency stations		
	Awareness of:		
19	The statutory requirement to render assistance		
20	The difference between responding to a Mayday and rendering salvage assistance		

APPENDIX - VI (DISCUSSION ON A RESEARCH APPROACH)

Choosing my research methodology was perhaps the most difficult part of my research and caused me the most concern. Not because I could not decide how to conduct my research but more to find a category that my, what initially appeared to be unique approach, would fit in.

I wanted the research methodology to develop as the research progressed and that the data I would collect would be not only in the form of words but also to be in numbers, that, according to Fox *et al* (2007 pp.116), indicated a flexible design rather than fixed. *'Quantative researchers collect facts and study the relationship of one set of facts to another…. Researchers adopting a qualitative perspective are more concerned to understand individuals' perceptions of the world.'* Bell J. (2005 pp.7).

I have opted for a qualitative perspective as described by Bell and, in my research I will primarily use qualitative data, however I will use quantitative data to support and add impact to my findings. Rational for this comes in part from Fox *et al* who state, *"The key goal is to use the strength of one method to enhance the impact of the other. So information gained from one part of the study (either quantitative or qualitative) is used to strengthen the other aspects of the research. This is important to practitioner researchers who are often working on complex, multifaceted issues."* Bell J. (2005 pp.7).

Having determined that I required a flexible design collecting qualitative data I considered the methods I would use to collect my data.

These included:

• Questionnaires

• Selective case study of accidents and incident reports

• Participant Observation

• Non-structured interview, and

• Literature review.

To encompass all the above research methods I would need a *'multi method'* Robson (2002 pp.92) strategy. My research does not lend itself easily to action research, as I do not see any change being implemented by enforcement such as by legislation. Change will come from identifying the problem and providing a cost effective and ethical approach to its solution. This is one of my reasons for partnering with the Admiralty Group as they are in a global position to highlight the problem without political or commercial interference.

Reflecting on the problem I am addressing and the solution I have proposed I believe that a 'soft' approach is far more likely to produce the required results than a 'hard' approach such as with Action Research; I want people to engage with my research and to enter into the conversation. With this in mind I looked closely at Soft Systems Methodology which as Denscombe describes '*The basic shape of the approach is to formulate some models which it is hoped will be relevant to the real-world situation, and use them by setting them against perceptions of the real world in a process of comparison. That comparison could then initiate debate leading to a decision to take purposeful action to improve the part of real life, which is under scrutiny.' (*Denscombe, 2003).

On reflection, this approach is too complex for what I am trying to achieve by producing just one model, but the basic principle is correct.

Use of a questionnaire as my primary research tool naturally led me to consider survey as a research approach however Judith Bell (2005 pp. 13-14) reminds us *inter alia* that:

'Great care has to be taken to ensure that the sample population is truly representative,

All respondents will be asked the same questions in, as far as possible, the same circumstances, and *Surveys can provide answers to the questions What? Where? When? and How?, but it is not so easy to find out Why?'*

It is my aim to conduct much of my research through the Admiralty Group.

I do intend to ask the same questions of my respondents however in a widely differing circumstances as possible as I wish to gain a 'snap shot' evaluation of the perceived global problem. This research would, in my opinion, be useless if I did not provide practical and ethical solutions to the problem I am researching. Therefore the 'How?' question will be extremely important in my research. In rejecting survey as a research approach I note that Robson (2002 pp.87-89) does not list it as one of three approaches particularly relevant to real world solutions, instead listing '*case studies, ethnographic studies and grounded theory studies.'*

In real world research such as this, and with the facilities available to me for research, it seems very appropriate to combine approaches, thus providing a more holistic approach to the problem. With the above in mind I have concluded that a *Case Study, Questionnaire & Interview with triangulation* approach would be the most appropriate to my research project. As Bell describes it *"All organizations and individuals have their common and unique features. Case study researchers aim to identify such features, to identify or attempt to identify the various interactive processes at work, to show how they affect the implementation of systems and influence the way an organization functions"*. (Bell J. 2005 pp.10). In the context of my research we know that the incidence of marine accidents and incidents is increasing.

APPENDIX - VII (Interview Transcripts)

Participants interviewed by the researcher were asked two questions:

(Question 1) "In broad category, we have identified seven risk factors relevant to Indian towage industry; such as poor maintenance/substandard condition of equipment's, poor work process, Incompetency, rough weather, poor safety engagement and unsuitability of tug. What's your say on these identified risk factors?

(Question 2) "Please describe various safety issues in towage operation and your recommendation to deal with those"

Probing questions were also used to guide the interview when needed.

PARTICIPANTS	BUSINESS OF ORGANIZATION	WORK PROFILE/ EXPERTISE	LOCATION	POSITION	WORK EXP (years)	DURATION (Minutes)
1	Towage Service	Towage Operation	Long Beach, USA	Top Management	36	130
2	Towage Service	HSEQ	Dubai/Gujrat	Sr Safety Officer	28	90
3	Tug Training	Training - Simulator	Singapore/ Paradip	Sr Trainer	21	50
4	Pilotage	Vessel Navigation	Southampton UK	Pilot	26	90
5	Towage Service	Safety Officer	Southampton UK	Sr Manager - HSE	21	110
6	Tug Operator	Tug Master	Southampton UK	Tug master	28	110
7	Tug Operator	Tug Master	Dubai/Gujrat	Tug master	22	110
8	Regulatory	Surveyor/ Inspector	Long Beach, USA	Sr Surveyor	23	45
9	Port Operation	Port Operation	Mumbai	Harbour Master	31	90
10	Ship Owner	Ship operation	Singapore/ Mumbai	Master Mariner	19	70
11	Tug Building	Naval Architecture/ Tug Operation	Southampton UK	Sr Naval Architecture	22	130
12	Consultancy/Training	Trainer/ Safety Analyst	Southampton UK	Sr Trainer	23	60

PARTICIPANT 1			
BUSINESS OF ORGANISATION	*TOWAGE SERVICE*	**POSITION**	*TOP MANAGEMENT*
WORK PROFILE/EXPERTISE	*TOWAGE OPERATION*	**WORK EXP**	*36 YEARS*
LOCATION	*USA*	**DURATION OF INTERVIEW**	*130 MIN*

For ADMIRALTY GROUP
Verified By
Date - 12/11/15

REPLY TO QUESTION 1

The towing industry is still a dangerous business…. People get hurt real easily... We try to manage the risks and the dangers….

..New vessel safety management system (VSMS) helps us to manage those risks by identifying any potential problems on our boats and by helping crew gain a heightened sense of how to operate safely…

We're always trying to go for zero incidents… I think it's helped us to achieve that, the company's new management safety system….

…We moves barges around the port primarily serving a power plant by delivering coal for fuel and limestone for the scrubbers that remove pollutants from its stacks. Typically it is paired with a 360-foot barge that can carry 8,000 tons of coal... Occasionally the tug makes the 300-mile round trip and back…. of late vessel safety management systems have taken center stage in the towing industry because of the U.S. Coast Guard's proposed Subchapter M requirements……….

Under the new rules, most towing vessels would have to meet mandatory inspection requirements…. Towing companies would have to pass an annual inspection by the Coast Guard. Alternatively, an operator could create a towing safety management system, have it audited by an outside third party such as a classification society and then submit it to the Coast Guard for acceptance….

This the biggest change the industry has ever seen. If that doesn't shake them to the core, nothing will…

Despite the uncertainty about when the new regulations will take effect, our management decided it wanted to be ahead of the game by developing a VSMS that would be in place when the new rules are adopted…. Aside from regulatory compliance, the company sees the safety management program as valuable in and of itself. First, it reinforces the company's longstanding commitment to safety.... and being able to demonstrate that commitment may give company a competitive advantage when approaching customers concerned about the safe movement of their cargo...

We have long been a participant in the American Waterways Operators' (AWO) Responsible Carrier Program (RCP). Using the RCP as a starting point, We decided to develop a safety system that would meet the standards of the International Safety Management (ISM) Code, which the Coast Guard proposes to accept as equivalent to the TSMS requirements.

Please elaborate TSMS?

A TSMS is a Towing Safety Management System…. The TSMS is a document that is customized to your company and details the safe and correct way to perform the duties both on the vessel and ashore…..

The goal is safety and environmental protection… Keep the crew safe, the equipment safe and functioning as designed and protect the waterways, land and air around the vessel...

It boils down to risk assessment – something that each of us do daily and something that our mariner's do as such a regular part of their jobs that it is second nature. … Risk assessments are conducted to estimate how much damage or injury can be expected from exposures to a given risk agent and to assist in judging whether these consequences are great enough to require increased management and/or regulation….

So the TSMS starts out as a compilation of the assessed risks and how we deal with them…. It encompasses the what-if's – what if we went aground, what would we do to minimize injury or death, damage to the equipment and damage to the environment. .. It covers the procedures for safe use of equipment – deck machinery, tools, ladders, etc. …and it is built on a foundation of commitment. The company commits to operating in a safe and environmentally aware way. Roles and responsibilities are defined…. Authority of the Master is acknowledged. A maintenance program is committed to so that equipment is not just run to failure, but rather maintained in a responsible, safe manner….and then, the whole system is checked both internally and externally and the results of the audits are used to improve the company.

I show you the document….Here's part of what Sub M says a TSMS is:

Safety Management

All towing vessels must be operated in compliance with an Owner/Managing Operator (O/MO) implemented TSMS or be subject to an annual USCG inspection regime.

Purpose of TSMS

(c) TSMS establishes policies and procedures and require documentation to ensure the O/MO meets its established goals while ensuring continuous compliance with all regulatory requirements. The TSMS must contain a method to ensure all levels of the organization are working within the framework.

(d) A TSMS establishes and maintains:

(1) Management policies and procedures that serve as an operational protocol for all levels within management

(2) Procedures to produce objective evidence that demonstrates compliance with the requirements of this subchapter

(3) Procedures for an O/MO to self-evaluate that ensure it following its own policies and procedures and complies with the requirements of this subchapter

(4) Arrangements for a periodic evaluation by an independent third party to determine how well an O/MO and their towing vessels are complying with their stated policies and procedures and to verify that those policies and procedures comply with the requirements of this subchapter, AND

(5) Procedures for correcting problems identified by management personnel and third parties and facilitating continuous improvement

Objectives of TSMS

The TSMS through policies, procedures and documentation MUST:

(a) Demonstrate Management Responsibility. The management must demonstrate that they implemented the policies and procedures as contained in the TSMS and the entire organization is adhering to their safety management program.

(b) Document Management Procedures. A TSMS must describe and document the O/MO's:

- organizational structure
- responsibilities
- procedures
- resources which ensure quality monitoring

(c) Ensure Document & Data Control. There must be a clear identification of what types of documents and data are to be controlled, and who is responsible for controlling activities, including:

- Approval
- Issue
- Distribution
- Modification
- Removal of obsolete materials
- Other related administrative functions

(d) Provide a process and criteria for the selection of third parties. Procedures for the selection of third parties must exist that include:

- How third parties are evaluated

- Selection criteria

(e) Establish a System of Record-keeping. Records must be maintained to demonstrate effective operation of the TSMS. This should include:

- Audit records
- Non-conformity reports
- Corrective Actions
- Auditor qualifications
- Auditor training
- Other records as considered necessary

(f) Identify and Meet Training Needs. Documentation procedures for identifying training needs and providing training must be established and maintained.

(g) Ensure Adequate Resources. Identify adequate resources and procedures necessary to comply with the TSMS

Functional Requirements of TSMS

The functional requirements of a TSMS include:

(a) Policies and procedures to provide direction for the safe operation of the towing vessels and protection of the environment in compliance with applicable US law, including the CFR's, and international laws where applicable,

(b) Defined levels of authority and lines of communication between shore side and vessel personnel.

(c) Procedures for reporting accidents and non-conformities

(d) Procedures to prepare for and respond to emergency situations by shoreside and vessel personnel

(e) Procedures for verification of vessel compliance with this subchapter

(f) Procedures to manage contracted (vendor) safety services

(g) Procedures for internal auditing of the TSMS, including shoreside and vessel

(h) Procedures for external audits

(i) Procedures for management review

(j) Process to evaluate recommendations made by management personnel

TSMS Elements

The TSMS must include the following (non-applicable elements must be accompanied by documented justification that is subject to acceptance by the third party):

(a) Safety Management System Administration and Management Organization. A policy must be in place that outlines the TSMS culture and how management intends to ensure compliance with this subpart.

(b) Personnel. Policies must be in place that cover the O/MO's approach to managing its personnel, including, but not limited to:

- Employment
- Training
- Health
- Safety

Supporting these polices, the following procedures and documentation must be included:

(1) Employment Procedures.

(2) Training of Personnel. The TSMS must contain a policy related the the training of personnel, including:

(i) New Hire Orientation
(ii) Duties associated with the execution of the TSMS
(iii) Execution of operational duties
(iv) Execution of emergency procedures
(v) Occupational health
(vi) Crew Safety AND
(vii) Training required by this subchapter

(c) Verification of Vessel Compliance. Policies must be in place that cover the O/MO's approach for ensuring vessel compliance, including but not limited to:

- Maintenance and Survey
- Safety
- The environment
- Security
- Emergency preparedness

Supporting these policies, the following procedures and documentation must be included:

(1) Maintenance and Survey. Procedures outlining the O/MO's survey regime must specify all maintenance, examination and survey requirements.

(2) Safety, Environment and Security. Procedures must be in place to ensure the safety of property, the environment and personnel. This must include procedures to ensure

- the selection of the appropriate vessel,
- including adequate maneuverability and horsepower,

- appropriate rigging and towing gear,
- proper management of the navigational watch,
- compliance with applicable security measures

(3) All procedures required by this subchapter must be contained in the TSMS

(d) Compliance with Subchapter M. Procedures and documentation must be in place to ensure that each towing vessel complies with the operational, equipment and personnel requirements of this subchapter

(e) Contracted (Vendor safety) Services. Procedures must be in place to ensure the safety, effective management and compliance with applicable regulations for contracted vessel towing services, including:

(1) Procedures to evaluate personnel qualifications

(2) Procedures to evaluate adequacy of vessel capability, condition and compliance with applicable regulations

(3) Compatibility of Safety Management Systems, AND

(4) Procedures to maintain objective evidence as required by both organization's SMS's.

However, we have observed few mistakes common to all quality systems

- Inadequate Management Support
- Inappropriate Scope
- Inadequate Resources
- Giving Up Early On

REPLY TO QUESTION 2

First and foremost area I believe is to define **responsibilities and accountability**

Organisational command lines should be established and responsibilities and duties clearly defined before a new towage commences…..

The tug master is at all times responsible for the vessel and crew and if acting as towing master also responsible for the towed unit. The tug master should always be satisfied before departing that his vessel is:

Compliant with appropriate regulations and all machinery and equipment is in good order and fit for the intended tow.

In addition:

- Crew are correctly certified, trained and using correct and appropriate personal protection equipment (PPE).
- Communications are established with the tow and tow master.

- Towing gear is in good condition and prepared.
- Watertight doors, hatches and ports are closed prior to the tow commencing.
- The barge certification is in order and the stability of the barge has been verified where applicable.
- It must be clear between the parties (other tugs etc.) who the towing master is and his responsibilities. Investigators often cite the failure of not having someone in overall control of the towing operation as a factor in incidents. All personnel should be aware of their own responsibilities and tasks.

The whole report boils down to a few crucial indispensables:

- TRAINING
- EXPERIENCE
- COMMUNICATIONS
- SAFE PROCEDURES

Most essential:

KNOW YOUR TUG. KNOW THE CAPABILITIES AND LIMITATIONS. KNOW THE CIRCUMSTANCES

It is strongly recommended that all parties involved in harbour towage operations pay the greatest attention to these essential aspects for safe towage operations.

In more detail…

Safe speeds

- Recommended safe speeds are Maximum 6 knots for securing at the bow, and maximum 6-8 knots for securing alongside and at the stern….
- The capabilities and limitations of the tugs should be known and taken into account, as well as weather conditions and tug master experience.
- Speed regulations are a very important aspect of tug safety... It is strongly recommended that ports, towing companies and pilot organisations create standards for safe speeds for tugs making fast to a ship having headway and when fastened.
- When speed regulations and/or guidelines are in effect in a port, it is vital to confirm regularly that they are complied with...
- It is strongly recommended to verify if the following method can be used to determine the safe connection speed for a specific tug that has to secure at the bow of a ship- Safe speed to be based on what speed a tug master can drive his/her tug in a controlled manner (particularly going astern for bow-to-bow operations) on one engine. Once this speed is established for the specific tug, prevailing conditions and competency of the tug master, it is

recommended to take one knot off the figure and that should be close to the safe connection speed.....

Company should have their Towing **Standard Operating Procedures (SOPs)** for critical operations, like

ALONGSIDE

- Before making up to the barge, find out where it will end up. This will help determine which side you should make up to for a more controlled landing at your destination.
- Check the weather. If you have a short run and need to be alongside, determine which side will be the lee side. It will be more comfortable for the crew and will lessen surging between tug and barge on the lee side.
- The tug secures to one side of the tow with her own stern abaft of the stern of the tow. This will increase the effect of the tug's screw and rudder. The side chosen depends on how much the tug must maneuver with the tow.
- If all turns are to be made with the tug's screw going ahead, she will be more favorably placed on the outboard side of the tow--the side away from the direction toward which the most turns are to be made.
- If a sharp and difficult turn is to be made under headway, the tug should be on the side toward which the turn is to be made. Here she is properly placed for backing to assist the turn, because as she slows, the tow's bow will turn toward the side the tug is on.
- If a turn is to be made under no headway, the tug is more efficient on the starboard side of the tow. When the tug backs to turn, the port send (side force) of her screw will combine with the drag of the tow to produce a turning effect greater than that which could be obtained with the tug on the port side.
- The best position for a long back in a straight line is to have the tug on the port side. Then the drag of the tow tends to offset the port send of the backing screw.
- As you come alongside, the deckhand should be preparing to put out a spring line.
- Once the spring line is secured, angle the bow in and make up the head (bow) line. The bowline or backing line is paid out over the outboard side of the bow stem or king post and lead to a bitt on the forward end of the tow. Once the bowline is secured on the tow, all the slack is taken in and the bowline secured. This will bring the tug into proper position, slightly bow-in to the tow. When backing down, the bowline becomes the towline.

- Once the bow line is secured bring the stern in and make up the stern line. The stern line or turning line is lead from the tug's stern to the outboard side of the tow's stern. The purpose of this line is to keep the tug's stern from drifting out. The three lines, when properly secured and made taut, will make the tug and tow work as one unit.
- It will be necessary to work up as hard as practical (up to 1450 rpm's) to get the stern line tight. Make sure that you are against a pier that can handle the tug working up hard on the barge. Also, watch your wheel wash. If the lines are great between the barge and pier, or if other factors won't allow you to work up hard then make it up as tight as you can then once out in open water off the pier, work her hard over (stern to barge) and tighten the line.
- If taking the barge alongside in open water (not against a wall or pier) make sure that you have sufficient room to turn a full circle as you put out and tighten lines. This includes room around all piers, docks, marinas, shorelines, etc and other vessels.
- It is usually a good practice to double up on your spring line and bow line. You can also double up the stern line. It will provide a better ride and piece of mind.
- You may find yourself with two barges. If you have to pick them up at a pier and they are side by side, nose between them after you have taken off the stern line (line at your bow) between the barges. Leave the bows tied together. Make up as you would with a single barge. Get all lines between the tug and barges as tight as possible. Double up the line between the barges' bows.
- Use chafing gear. If any of the lines lead over rough or sharp edges, put out chafing gear. This could be fire hose or rug wrapped around the line or wood placed under the lines at the wear points.
- Don't forget the barge lights both putting them out and taking them in.
- Occasionally, it will be necessary to shift from one side of the tow to the other. You can let the barge go completely if you have enough sea room, or you can keep lines out.

Warning

3. When securing these towlines, remember; NEVER secure the line so that it cannot be thrown off quickly and easily.
4. Areas of the harbor subject to wave action should be avoided whenever possible. The tug and tow seldom pitch in the same tempo. When both start pitching out of harmony, the lines take a heavy strain and may part. When equipped with a rudder the tow assists in steering. Size and loading of the tow

may obstruct the view of the tug's conning officer. In that case, a lookout is stationed aboard the top who keeps the conning officer fully informed of activity and hazards in

PUSHING

- Before making up to the barge, find out where it will end up. This will help in determining which end to push from. The contractor may want the crane end forward and the crane may be on the stern of the barge. If your destination is a narrow space, you may not have room to spin the barge and put the crane end where they want it. Ask first!
- Check the weather. Do not push in seas over 2 feet.
- As you come up to the barge, the deckhand must get your head line(s) out first.
- On barges without a center bitt/cleat, run a line to each side from the tug's stem.
- Put out the safety lines next from the tug's forward quarter bitts to the barge's corners.
- Put out the push wires last. Make sure the tug is centered and straight for maximum steering.
- If you know that you are going to handle the same barge later, when breaking down, slack one wire and then when you make up again, put that wire out first (after the head and safety lines).
- Don't forget the barge lights both putting them out and taking them in.

ASTERN

- You will generally tow astern because the weather will not permit you to tow alongside or push.
- Check the weather! The forecast will help you determine how much hawser to put out.
- Unless towing on gate lines, you want the barge away from the tug's stern. The tug's wheel wash will have an effect on the tow. It will try to push the barge backwards. Get the tow out of your wheel wash.
- Gate lines are for towing short with the maximum steerage. You will take two lines and run them out to the barge. One on each corner and then bring them back to the tug's stern quarter bitts. You can lead them around the bitts and make up on the H-Bitt if it is easier for you. The lines must be of equal length when made up. Ideally, you will almost be able to step off of the tug's stern onto the barge when made up.
- Use chafing gear. The Shenandoah has a hawser board to minimize chafing of the hawser on the tug's stern. Also, if the barge has sharp edges, use chafing gear on the bridles or shackle the bridles into chain or cable donuts that are looped over the bitts and lead over the sharp/rough edge.

- Old fire hose cut into 4- to 6-foot lengths and then split lengthwise makes excellent chafing gear. It is wrapped around the hawser or towing cable to protect it from wear due to constant rubbing.
- Hawser length will be determined by the sea! Barge and tug must be in step. Too much line out could cause the towline to foul on the bottom. Too little line out will cause the line to jump out of the water. This puts too much strain on the line.
- The scope of a hawser should be long enough to provide a good catenary, but not to the extent of having the towline drag on the bottom if in shallow water. A catenary absorbs shocks. You should not put stress on a towline to the extent of lifting it out of the water, but you can increase the catenary by reducing the tug's speed.
- Towlines should never be made fast on the capstan.
- To rig a stern towline, the towing hawser should be faked out in the fantail of the tug. This will ensure that the hawser will pay out without becoming fouled.
- The eye of the hawser is led back over the top of the "H" bitt, over the shoulder of the horn, and back through the legs of the bitt. Then the hawser is payed out. When you get close to the point where you are going to secure the tow, take a full round turn and cross the line back onto itself. Then take two or three additional round turns before you figure eight the line on the bitts, and finish it off with two or three turns on the arm of the bitt.

  Note: A hawser watch must be posted on the after deck to keep tow and gear under constant observation. Instruct the crew member, on watch, to immediately report the following-
    - Too much tension is on the towline.
    - The tow is not weathering properly.
    - The bridles or other gear fail.
- In addition to chafing gear, continued monitoring of the towline's condition is necessary and important. Stern rollers and other fairleads must be properly lubricated and all possible points of line wear offered a fairlead. Canvas, hose, line, wood, or other materials should be used for chafing gear as required. Chafe must be eliminated or reduced on board the tow and the tug as much as possible. Continued paying out and retrieving of the towline can cause excessive chafing. Freshening the nip and lengthening or shortening the tow wire should be done every few hours in moderate weather and more often during heavy seas.
- The towline must be checked periodically for a fairlead and chafing. Points of chafe must be protected. Appropriate lubrication and wearing surfaces should be placed so as to eliminate towline-to-hull contact.

Tandem Tow Make-up

- When towing more than one barge astern, it is referred to as tandem towing. In a pure sense, tandem means one behind the other.

- In this method, the tug is connected to the first tow. The first tow connects to the second, and so on if additional units are towed. The intermediate hawser, connecting the first tow to the second, must be streamed and allowed a proper catenary depth. The surging action must be eliminated between tug and first tow and between first tow and second tow.

Honolulu Tow Make-up

  - In this method, the first tow is connected to the main tow wire. The second tow is connected, with an auxiliary tow wire, to the bitts on deck. The Honolulu rig allows independent connection of the two tows. Disconnecting and control are readily workable.

WARNINGS:

5. Always face your work.
6. Never step over a line that is laying on the deck. Either lift it up and walk under it, or step on top of it and cross over. Never straddle or step in the bight of a line.
7. When towlines are coming under or are under a strain, work fast. Get the turns or figure eights on a quickly as possible. When surging or slacking off on a line that is under strain, Keep your hands clear of the bitts.
8. The greatest danger in using towlines is that if the line should part when under strain, it will snap back its full length like a bull whip. The force of the snapback is tremendous depending on the strain that the line was under at the time it parted. There is no set pattern on how the line will whip back. It may snap back directly on itself or it may whip from side to side. There is no way to tell what it will do. If you see a synthetic fiber line under strain parting or beginning to part--DO NOT RUN--just fall flat down on the deck.

Safe tug communications

- Towing companies and tug masters, if possible together with pilots, should develop safe procedures for how to approach a ship for picking up a heaving line and for passing a tow line. It is recommended that these procedures include an instruction that tugs only approach the bow when the crew is ready.
- In case of a too high ship speed it is recommended to secure the stern tug first, in case a stern tug would be used, and when ship speed has dropped to an acceptable level the forward tug(s) can be secured.
- There must be safe and effective communication procedures between pilots and tug masters. Communication should include issues such as safe speeds, when and where to make fast to the ship, SWL of bollards and fairleads, intended manoeuvres, mooring details and all other relevant information.
- It should be made standard that a pilot translates communications with the tugs into English, unless the ship captain speaks the same language as the pilot.

Training of tug masters

- Training of all tug masters is vital and should include refresher courses. Training should include the capabilities and limitations of tug types in use, safe procedures, safe speeds, knowledge about interaction effects and their effect on tugs, teaching the right attitude (particularly for young tug masters), and all other important aspects of safe towing.
- Training, regular refresher courses and competency checks should be carried out by certified institutes and trainers.
- Interaction effects between tug and ship, including pressure waves (see bow wave figure 3 Appendix), should be replicated in a realistic way in simulators used for training. Simulated interaction effects should be accurate for various hull forms, speeds, draughts, under keel clearances, tug locations with respect to the attended ship and distances between tug and ship.
- Pilots should always alert tug masters to problems e.g. regarding ships with high Dead Slow speeds, deep draft vessels, SWL of bollards, poor seamanship on board ships handled, and any other relevant information.

Training of pilots

- It is recommended that pilots (including PEC -Pilot Exemption Certificate- holders are trained on the same subjects as mentioned above, such as with regards to the capabilities and limitations of tug types in use, safe tug and communication procedures, safe speeds, knowledge about interaction effects and their effect on tugs, and all other important aspects of safe towing.

Safe procedures shipping companies and ship captains

- Shipping companies and ship captains should implement rules for safe procedures regarding the securing and releasing of tugs, including safe speeds, use of suitable heaving lines and proper handling of heaving lines and tow lines in a safe and efficient way, SWL of bollards and fairleads, proper bollard use with respect to towlines, and keeping an eye on the tugs when fastening and releasing. Ship's crew should be trained in all these issues.

Line throwing systems

- It should be investigated whether line throwing systems can safely and effectively be used for passing a heaving line to a tug.

Bow camera

- It is recommended to investigate whether a camera on the ship's bow can help in monitoring the tugs.

PARTICIPANT 2			
BUSINESS OF ORGANISATION	*TOWAGE SERVICE PROVIDER*	**POSITION**	*SR SAFETY OFFICER*
WORK PROFILE/EXPERTISE	*HSEQ*	**WORK EXP**	*28 YEARS*
LOCATION	*DUBAI/GUJRAT*	**DURATION OF INTERVIEW**	*90 MIN*

For ADMIRALTY GROUP
Verified By
Date : 12/11/15

REPLY TO QUESTION 1

We have system & procedures for inspecting our vessels, a much more rigorous system for documenting everything that is done... In the past some things would just be taken care of informally, perhaps with just a phone call. Now there is a paper trail for all the issues identified and the work done to resolve them….

In one sense, not much has changed as a result of the creation of the VSMS and the manual that defines it. The company's inspections of its vessels are not more frequent or rigorous and the operation procedures are much as they were….

In another sense, the changes are profound. From a regulatory perspective, we can now prove to outside parties the rigor of its maintenance and repair programs, and its operating procedures…and internally it has a document that it can use as a teaching tool to drive home to its crews the central importance of safe operations…

The ultimate goal is to get (the crew) to read this manual, to make it a part of their lives.

Essentially, the VSMS manual has become the textbook for each employee's continuing safety training.

There are at least four safety drills per month. An additional safety drill or safety meeting on a topic selected by the head office is performed weekly. The captain leads the onboard safety meetings, often in the mess area during lunch. The captain has wide discretion on how to conduct the meetings. In each case — whether drill or safety meeting — the topic corresponds to a section of the VSMS manual.

For example, in April the first safety meeting was to cover Vessel Safety Orientation. Chapter 5 of the manual has a section that discusses that topic. One drill for the month was Man Overboard. Those procedures are described in Chapter 6. With each drill and safety meeting, the crews are reminded of what the manual has to say on the subject.

New VSMS reinforces the company's longstanding commitment to operating safely, while demonstrating to customers that the company's vessels meet stringent safety operating standards.

Each week, the captain has an explicit duty to remind his crew of its contents. They are forced to open the book and involve the crew.

Each vessel gets an inspection visit from either Safety Officers once every three months. We expect this book to be dirty when we get aboard. They should have fingerprints on them. If they don't, That's an alarm.

While the company expects crews to abide by the manual, it also wants them to understand that this is a living document that will be constantly revised to reflect new information.

If an item is brought up by a customer, we change it, not just on that one (vessel); we change it companywide.

Information from inside the company can lead to changes as well. Suggestions from crews, lessons learned from an injury or near collision — any and all sources are considered. This isn't a set-in-stone book.

REPLY TO QUESTION *2*

High Bollard Pull of tugboats vs. strengths of ships' Bollards and Fairleads

The Problem: With the enormous growth of ships' sizes over the last years, the towage industry was forced to deploy different tugboats with strongly increased bollard pulls. Industry practioners has experienced that often designs of bollards and fairleads on all kinds of vessels are not in step with safety requirements. There have been cases were bollards and fairleads have been torn away, especially when tugboats have to work in the 'indirect towing mode'. There are wind forces and currents as well as on drag forces. If bollards, fairleads and winches of ships can withstand these calculated forces then these are considered suitable for 'normal' towing, i.e. harbour towage. The rules differentiate though between "normal towing" and "escort towing". The difference between these two "towing modes" is enormous. When a tug operates at the stern of a ship in 'indirect mode', towing forces can be up to 5 times higher than the static bollard pull of the tug. This has to be taken into account when designing ships' equipment.

Suggestions:

- ships' crews, pilots and tug-masters must repeatedly be made aware of such possible forces and the inherent dangers

- ships' operators, naval architects, shipyards, classification societies, marine surveyors as well as equipment providers must be made aware of these forces and include these considerations in their planning
- we need to be more specific on such towing aspects and here in particular in respect to container ships
- Ships' crews and pilots should be facilitated to have the "Towing and Mooring Arrangement Plan" at hand, summarizing on-board equipment and SWL's also for daily harbour towage operations

Position of ships' bollards, fairleads and winches

The Problem: Bollards, fairleads and winches on board vessels are often not optimally placed for connecting tugboats and for different tugboat manoeuvres. The positions of winches sometimes make it difficult for the ships' crews to safely handle heavy towing gear. Bollards and fairleads are often too far apart with the consequence that the towing gear might be damaged.

Towing and Mooring Arrangement Plans are issued by Classification Societies helping Masters and Pilots to be aware of the acceptable loads of these relevant parts for towing and mooring on board the ship. Since about 10 years the rules require marking of bollards, fairleads and winches with the SWL (Safe Working Load) limits. Amongst IACS members different opinions prevail whether the safety margins should be 1.25 or 1.5 times the actual towing forces. A very practical problem is that SWL's mentioned in ships' plans are expressed technically correct in Kilo Newton (kN) whereas ships' equipment is commonly marked in Metric Tons (MT), which, however, is only 10 % of the kN figure (e.g. 230 kN = 23 mt). These differences can easily lead to serious misunderstandings as to equipments' capacity.

As far as we understood, classification societies do not check the "Towing and Mooring Arrangement Plans" upon practicability, for example whether ships have Centreline
Fairleads, distances between fairleads and bollards, whether sufficient winch capacity is available to heave up the heaving towing gear etc.

Suggestions:

- "Towing and Mooring Arrangement Plans" are to be designed for good and safe seamanship
- Ships' crews and pilots should be facilitated to have the "Towing and Mooring Arrangement Plans" at hand, summarizing on-board equipment and SWL's also for daily harbour towage operations. Limitations need to be communicated to the tug-masters.

- Specific needs for harbour-towage (not only emergency-towing) to be recognized and considered for ships' designs

Push Points

The Problem: Push points on ships' hulls are located on transverse bulkheads or web frames to avoid damages to the shell plating. None of these Push Points is marked with any max SWLs. Are the acceptable pressures of these Push Points known? Will they stand the force of a 70 TBP tug pushing with full power on less than 1 m^2 plate/hull area? As far as we understood, such calculations are only available for the impact on shore fenders.

Often no information is available whether it is acceptable to let tugs push on the transom stern of the ship.

Suggestions:

- Push Points to be clearly marked with SWL's
- On-board information to be readily available whether tugs pushing at the transom stern is acceptable
- Already in the design phase, these criteria should be considered

High minimum speeds

The Problem: The latest generation of large container vessels have an enormous main engine output. Engine manufacturers and ship operators as well as many other actors in the maritime chain have focussed on economic fuel consumption, taking advantage of the ever increasing economies of scale and on the ever increasing sizes of ships. However, the downside is that

'Dead Slow' of these large vessels is usually in excess of 6-11 knots **through the water.**

Making fast a tug for a harbour towage at this speed - especially on the ship's bow - is simply dangerous. The maximum speed of a tug is approximately 11 to 12 knots. Once safely connected, high passage speeds are reducing tugs' abilities. Beyond 8 kn, tug's capabilities are very limited and on top it is getting very dangerous for tug and crew.

Our suggestion:

- Engines to be designed for 3-6 knots at 'Dead Slow' for safe harbour work of tugs and tugs' crews.

PARTICIPANT 3			
BUSINESS OF ORGANISATION	*TUG TRAINING PROGRAMS*	**POSITION**	*SR TRAINER*
WORK PROFILE/EXPERTISE	*TRAINING – SIMULATOR*	**WORK EXP**	*21 YEARS*
LOCATION	*SINGAPORE/PARADIP*	**DURATION OF INTERVIEW**	*50 MIN*

For ADMIRALTY GROUP
Verified By
Date : 12/11/15

REPLY TO QUESTION 1

We meet the standards of the AWO's Responsible Carrier Program.... The AWO is working with the Coast Guard so that its program will become a Coast Guard-accepted towing safety management system by the time the Subchapter M requirements take effect. That would give the AWO program the same status as an ISM system....

The foundation of our safety management system continues to be RCP.

The leadership of the company is thinking not just in terms of meeting the minimum regulatory requirements, but in achieving the highest safety operating standards possible...We operate a fleet of 35 towboats and more than 800 barges. Much of its business involves the transport of petroleum products. Its approach to safety management has been greatly influenced by practices developed in the petroleum industry. Notable among them is a program called Tanker Management Self-Assessment (TMSA)...

The oil industry devised the system to help vessel operators transporting their products meet higher safety standards. TMSA employs a process of continual improvement to prevent injury to people (both employees and the public), the environment and equipment. We are using TMSA since 2008 as a way to improve its management system effectiveness and operations.

Under TMSA, we assess specific aspects of its operations, including safety of mariners, navigation safety, environmental stewardship, preventive maintenance and risk assessment....The idea is to keep getting better rather than simply meet a set of standards or regulations. In the course of this effort, the company is constantly reshaping existing procedures and creating new ones to manage and reduce risk. This will help us go way beyond compliance....The involvement of the crews has been a key element in the success of this approach. This engagement is very crucial to the success of any safety management system. We do have good support from our mariners. Refining and improving procedures and then implementing them with the assistance of employees aboard vessels and ashore is not easy. Without a doubt, this has been hard work, over time it is very rewarding.

We are making significant progress, with the environment, with people and with the equipment.

Over the last eight years equipment has become more reliable and the number of spills has been reduced. Vessel crews have been involved in fewer collisions and groundings….and the severity of those incidents has also declined.

Continuous improvement is the mission……………

The tugboat industry has come a long way – we have built the super tugs, we have installed the render recover winches, we've added all the computer navigation systems available – but we still haven't implemented a training system that brings all of these elements together for successful tugboat operations…………… These new tugs are the most powerful and dynamic tugs that have ever been built, and we have no standards for training to match the sophistication of these vessels….. What we need is a comprehensive training regime that would encompass every aspect of training to enable new captains and crew of these powerful vessels to utilise them to their fullest extent…. In recent surveys of operational vessels, it appears that the tugs we have now are being utilised less than 80 per cent of their potential; the customer is expecting 100 per cent. There is a desperate need for new training methods…..

Quarter-scale tugboats, approximately 7.9m long (26ft), would make a superb choice for the training of new tug skippers…. These scale tugs would be fully equipped with all the same equipment as real tugs, including realistic scale thrust and dynamics, providing a base for skippers to build their skills while generating cost recovery.

REPLY TO QUESTION 2

Operational training

Today's tugs are becoming increasingly powerful and sophisticated but, above all, extremely manoeuvrable.

The agility of the modern ship handling tug is such that it has the ability to ensure that the vessel's BP can be applied precisely, where and when it is required… In this way ship handling becomes quicker, safer and more efficient. This ability is, however, coupled to a real need for understanding by the tug master of exactly how a tug will react… With the agility and power available, mistakes can occur rapidly in the hands of the unwary. In order to benefit fully from the advantages offered by modern ship handling tugs, a new standard of crew training is essential….

Operational requirements during escort and docking operations will also see a new set of commands between pilots and tugs to utilise the full potential of the new technology…. Considerable simulator training already takes place for both pilots and tug crews, particularly where the handling of large tankers and LNG shipping is involved, but training new tug masters does require a more hands-on approach. Traditionally new tug masters have come up through the ranks, starting as deckhands, progressing to mate and then captain. On modern high-tech tugs, designed for use with very small crews, many of those training opportunities have been lost…. Equally, putting a partially-trained novice into the driving seat of the company's latest new US$10m addition to the fleet is also fraught with problems. An opportunity to take the latest pieces of equipment away into a secluded corner to 'play and learn' for a few hours, which is possible in many other industries, rarely occurs in the towing business.

A possible alternative could be a quarter-scale training tug, just 7.3m (26ft) long with all the dynamics of the full-size tug…. Any such vessel would, of course, have to earn its keep and could be equipped to carry out other duties that require a small, agile, vessel with adequate (scale) power. Line handling and small ship assist duties might well contribute to a cost-effective training facility.

Scale model testing, employing smaller models, is being used very effectively for special tug master and pilot training, and works very well. Models are also used almost routinely to develop new techniques and hull designs……..In the early days of model testing, the use of powered models was shunned because suitable propulsion and control systems that could produce a scale performance were not available. That is no longer the case. Realistic, radio -controlled, scale models are now providing valuable data in the hands of design teams.

Recruit, train and retain

In the next 10 years, the industry will lose the largest number of senior staff in its history and will need to train a large number of tug masters to a new level of competency. This will require an investment in time and a carefully configured company training programme…. This will be more difficult than ever before because, as previously mentioned, there is less scope in a very small crew to undertake 'on the job' training… A world shortage of marine manpower has shown that an accelerated rate of intake and training is required. In this world downturn this must be done efficiently.

Introduction to new technology

Unprecedented development and the introduction of modern technology have resulted in the introduction of a wide variety of new vessels. These range from small 'compact' ship handling tugs of only 22-24m in length with BPs of up to 70 tonnes, to 36m terminal tugs.... The latter continue to develop and BP figures of 90-110 tonnes are not uncommon. Inherent in the modern terminal tug are a very real escort capability and the ability to produce dynamic forces in the towline exceeding 150 tonnes at a speed of 10 knots in the tethered escort mode...

The foregoing new vessels require new and greater skills to deliver safe operation – the dynamic performance of escort tugs alone demands real understanding to achieve the best and safest results. The next generation of crews will have new skills in order to utilise these technologies in the best possible manner... Winch development in the last five years has advanced to match the new tug performance, enabling and requiring the tug master to manage line tension in an entirely different way. History has shown that hands on the controls and time on the job will build confidence; modern training tugs and methods, with support from seasoned tug masters, will give us a new generation of tug captains for the future.

Tools for success

To be successful, a candidate must be pre-screened and become familiar with the type of tug and its design dynamics. Docking procedures and techniques must be fully explained and understood, in theory and practice...

Candidates must train on the new types of winch currently in use and be capable of working with pilots on voyage planning and communications. The safety requirements for LNG and crude shipments leave no room for mistakes.

Training

• Pilots and Skippers train together
• Pilots Tripping on Tugs
• Skippers tripping with Pilots
• Pilot familiarity with new plant
• Simulator training for new techniques
• Cross pollination of training
• Regular pilot / tug crew meetings
• At job end, if possible - debrief.
• Tug companies to exchange ideas.

PARTICIPANT 4			
BUSINESS OF ORGANISATION	*PILOTAGE SERVICE*	**POSITION**	*PILOT*
WORK PROFILE/EXPERTISE	*VSL NAVIGATION*	**WORK EXP**	*26 YEARS*
LOCATION	*SOUTHAMPTON UK*	**DURATION OF INTERVIEW**	*90 MIN*

For ADMIRALTY GROUP
Verified By

REPLY TO QUESTION 1

I believe in writing down the best procedure for a particular operation in a safety management system (SMS) helps standardize operations and minimize human error.

The content of each SMS will vary greatly, even within the same industry. That's because it's up to the company using or developing it to determine which operations should be included. Some regulatory requirements or industry programs dictate what topics require policies and procedures, but most provide general headings. For example, the International Safety Management (ISM) Code provides a general outline, such as Section 7 – Shipboard Operations. The company is expected to fill in the blanks…

Subchapter M is no different. The proposed requirements for the Towing Safety Management System (TSMS) states: "Procedures must be in place to ensure safety of property, the environment and personnel." But what procedures must be in place? This is where risk assessment comes into play….

What are the most dangerous evolutions that occur? How have people been hurt in the past? What caused a spill?

If a tugboat company handles lines all day every day, and parting lines pose a real and significant danger to crews, the company's SMS should contain procedures based upon the line manufacturers' specifications, inspect the lines regularly and know when they have become unserviceable….

Even if an auditor or government inspector doesn't catch these omissions, the courts may. In a recent court decision involving a deckhand that was crushed to death in a capstan during a swing manoeuvre, the vessel was found to be "unseaworthy." This ruling made the tug owner strictly liable under general maritime law. It was determined that the owner failed to adequately implement procedures and guidelines that would have provided the crew with the training, skill and knowledge to perform the maneuver safely.

Hence, my suggestion is to don't buy a TSMS off the shelf. Get someone to facilitate the development of one specific for your company and make sure your best captains are involved in it. One problem is complacency; old skippers saying, I've always done it this way…there is no reason for this to occur other than negligence

REPLY TO QUESTION 2

Personnel Injury Risk

Risk of personal injury is high. Recent studies indicate that the one of the largest risks to personnel is falling over the side into the water.

Owners and tug masters should have a Clear Deck policy that does not allow personnel onto the towing area when the unit is being towed.

Personnel working on tugs have a responsibility for their own and their colleagues' safety. They should:

- Wear approved personal protective equipment (PPE) (hard hat, safety footwear, high visibility clothing etc). Personnel not wearing the correct PPE are exposed to increased risk. Tug masters should demand that their crews wear the appropriate PPE.
- Wear approved and appropriate in-date self-inflating lifejackets whenever on deck. Not using a lifejacket when working on deck, boarding, tying up or connecting up a barge can be hazardous.
- Ensure that working areas are safe and free from trip or slip hazards, particularly around bollards.
- Remain alert to the ongoing operations.
- Listen to orders from the tug master.
- Hold a line by the side of the eye or the standing part.
- Be aware of lines (towing or mooring) suddenly coming under tension.
- Stay clear of snap back zones.

Other factors that can impact on the safety of crew during a towing operation include:

- Fatigue should not be underestimated and it is now acknowledged that many incidents occur where fatigue is a factor. Local and international regulations may apply to the working hours of the crew. The international rules for working hours are regulated by the IMO Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), amended in 2012. These require a minimum of ten hours of rest in any 24 hour period; hours of rest may be divided into no more than two periods, one of which shall be at least six hours in length. These regulations may not apply to non-international trading tugs, but in the absence of other guidelines could be used.

- Poor weather increases the risk to a towing operation and has to be properly assessed by the tug master. It is better to abort an operation than risk life.
- Night working requires additional vigilance and good lighting.
- Danger from damaged tow lines or equipment.
- Working in rivers or tidal areas is particularly hazardous due to strong currents and unexpected change of current direction.
- Working alone.
- Failures to communicate effectively.
- Tug working decks should be non-slip in the working areas, well lit with obstructions, trip hazards and snap back zones highlighted. Steps and ladders should be in a good condition with non-slip steps painted in a light colour to be easily visible at night.
- The tug shall have means of recovering a man overboard (MOB) either by a rescue boat or a MOB device such as a Jason's Cradle when the tug can actually pick up the casualty alongside.

Communication

Communication equipment on board both the tug and the towed unit must comply with the requirements of the administration.

Attention should be given to the communication equipment on board a manned towed unit. This should include at least two portable VHF radio telephones and a daylight signalling lamp. If the towed unit is boarded at least two VHF radios should be available.

Lack of effective communication is often a factor in the cause of accidents. Effective communication must include:

Good communication between the wheelhouse, working deck and engine room. The use of pre-towing briefings (tool box talks) is essential

Good communication from the tug to the port/river authorities to keep the tug updated on hazards and traffic movements

Good communication with the tow master and the towed unit

All personnel must understand any agreed hand signals.

Equipment Maintenance

Mooring winches, capstans, windlasses, mooring lines and mooring fixtures and fittings must be properly maintained and periodic maintenance undertaken as prescribed in the planned maintenance system.

Routine maintenance should include regular visual inspections of all equipment, greasing of grease nipples on moving machinery and of rollers on fairleads and pedestal fairleads. Open gearing and clutches should also be suitably greased with an appropriate dressing. Brakes should be closely examined to ensure all linkages are working correctly, brake band material thickness is adequate and the condition of the brake lining is satisfactory.

Clutches should operate smoothly and pins for securing the clutches should be attached to the clutch control levers ready for use. Winch control levers must be marked with the direction of operation for both paying out and heaving in. Drum ends should be kept free from damage, rust and paint, and machinery bed plates should be periodically inspected for deterioration or damage.

It must be ensured that mooring fairleads are all turning freely and that their surfaces are free of rust or damage that could abrade the mooring lines. The integrity of all mooring equipment such as bitts, pad eyes and leads should be closely examined.

Information on mooring line care and maintenance can be found in Risk Alert 07.

Prior to mooring operations commencing, all equipment should be visually examined for any visible defects and machinery tested. Any defective equipment must be taken out of service

Personal Protective Equipment

All personnel engaged in mooring and towing operations should wear the correct personal protective equipment. This should be detailed in the vessel's Safety Management System and will include high visibility coveralls, a hardhat with chin strap, safety shoes or safety boots, gloves and in colder weather suitable high visibility warm clothing. Personnel on the forecastle should have safety goggles to hand in case the anchor has to be let go in an emergency. The use of gloves for mooring operations is an often debated topic, the best advice being that gloves should ideally not be too loose fitting so that they do not get trapped within ropes on drum ends. Gloves should always be used when handling wire ropes due to the possibility of hand injury arising from broken wires.

Tug Operations

Personnel standing by forward and aft will be advised by the bridge when tugs are to be utilised, they will be informed when and where tugs are to be made fast and whether a tug's line or ship's line is to be used. In most instances a tug's line will be used, but if a vessel's mooring line is to be utilised it has to be confirmed that this has a minimum breaking load (MBL) that is at least twice the bollard pull of the tug, to allow for any possible dynamic snatch loadings that may be imparted during the towage operation. Vessels' lines used for towage must be in good condition with sound splices and without short splices within their length.

When heaving lines are used to pick up the tug's messenger line or to run lines to the berth these should be made up with a Monkey's Fist that does not contain any additional material or weight.

This is to reduce the risk of injury in the event of it striking personnel on the tug or ashore. Personnel on the tug must be directed to stand clear whilst the heaving line is being thrown to the tug's deck.

Once the towing line is made fast the tug must be informed that the line is fast and that weight can be applied. All crew must be standing clear in a position of safety as tension may come on the towing line suddenly with little warning.

Tugs' lines used for towing the vessel must be placed with the eye over the post of a mooring bitt, and vessels' lines used for towing should be laid up on bitts. The bitts used must have a safe working load in excess of the expected dynamic loads in the towline. The safe working load of the bitts should be prominently marked.

Whilst engaged in towing operations, crew should keep well clear of the tow line as it may come under tension suddenly and crewmembers must ensure they remain in a position of safety clear of the area where the line would snap back in the event of it parting whilst under tension. Lines will generally snap back in an area based along the line in which it was leading. If led around a bollard or pedestal the line may snap back and whip around the bollard or fairlead in a much wider arc.

Tugs' lines should only be let go when the order to do so is received from the bridge. Once the tow line eye has been removed from the bitts the tug should be signalled that recovery of the line can commence. The tug's line should be lowered under control with the messenger tended carefully whilst the tug heaves in his line.

The person tending the messenger must ensure they are standing clear of the loose messenger line flaked on the deck. Once the tug has recovered his towing line on deck, the messenger should be tended so far as possible whilst the tug crew are recovering it on deck.

Towing lines and messengers should not be let go and dropped into the water as this can lead to problems as one of the following case histories shows.

Case History

A crew member standing by aft on a bulkcarrier had his foot severed by the 20mm messenger line attached to the tug line whilst releasing the tow. The tug had been instructed by the pilot that the line had been released and then heaved in the towline, a crewman on the tug then went to pull the messenger line in manually but it became tight. The injured crewman on the bulk carrier had been slacking the messenger line that was turned around a mooring bitt post on deck. It would appear that he was standing in the bight of the messenger line. As the towline and messenger line were being recovered on the tug her engines were idling, however the bulk carrier went from slow to half ahead placing strain on the messenger line which trapped and severed the crew member's foot. In addition no hand signals were received by the tug from the vessel's poop deck when recovering the towline. The only instruction that the towline could be recovered came from the pilot.

Case History

A tug was involved in unmooring a vessel and was made fast to her starboard bow using a line from the tug's stern. After pulling the vessel clear of the berth and then astern into the river and turning her, the tug's line was let go. The ship's crew were supposed to lower the tug's line under control, but this was not done and the line was released while the three crew on the tug's after deck were retrieving the line by hand. As the ship went ahead the Master on the tug's bridge went astern to keep up with the ship, thinking the line was still being lowered and unaware the line was actually all in the water. With about 5 metres of the towline, along with a messenger and heaving line still outboard and in the water, the towline became caught in the tug's starboard propeller. As this happened, one of the deckhands laid up the towline on a cleat on deck to stop it all being taken around the propeller. The line subsequently went tight and struck one of the crew, it briefly went slack and then tight again and struck the same crewman once more. He sustained serious knee and chest injuries

Mooring

The bridge will advise which side the vessel is to berth alongside, the number of headlines/stern lines, breast lines and springs that are to be deployed, and which line will be the first line to be sent ashore, both forward and aft, and how this is to be sent ashore, be it by line boat or heaving line.

Anchor lashings need to be cleared away along with hawse and spurling pipe covers, and the anchors made ready for letting go. When it is not possible to let go the anchor 'from the pipe' the anchor must be walked back clear of the hawse pipe and put on the brake and the windlass taken out of gear so that is ready for use in an emergency.

Sufficient lengths of mooring line for the intended operation should be taken from the winch drums or loose coiled ropes and be flaked on deck prior to arrival ready for running to the berth. When running lines it is bad practice to attempt to stand on a line to stop it running away.

When heaving lines are to be thrown to the berth the linesman ashore should be alerted to the fact.

When heaving lines are being returned those on the deck must be alerted that a heaving line is being thrown back to the deck.

When line boats are used to run lines, care must be taken when lowering ropes that these are lowered under control at all times and are not let go to fall uncontrollably into the line boat.

When drum ends are used to tension lines, two personnel should be engaged in the operation, one tending the line on the drum end and one coiling the rope on deck as it is heaved in.

Three turns around the drum end should suffice for heaving; however, on whelped drums more turns may be necessary. The rope should not be surged on the drum end to prevent the rope melting and fusing on the drum end. Once adequate tension has been achieved, the rope should be stoppered and laid up on the mooring bitts.

With fibre ropes the stopper used should ideally be of the same material as the rope being stoppered, with synthetic stoppers for synthetic lines and natural fibre stoppers for natural fibre lines. The MBL of the stopper should be around 50% of the MBL of the line being stoppered.

Polymide (nylon) stoppers should not however be used on polymide lines due to the low coefficient of friction of the material. Wire ropes should be stoppered with a chain stopper with a widely spaced cow hitch being used and the tail of the chain wrapped around the wire against the lay. A clove hitch must not be used as this may damage the wire. When laying up the line onto the mooring bitts, the first one or two turns should be taken directly around the first post of the bitts or around the outside of both posts before the rope is laid up in figures of eight around the bitts. Once a rope is laid up on the bitts the stopper should be released from the rope. Ropes should never be left on drum ends when not being tensioned; they must always be laid up on the bitts.

Split drum winches are designed so that the line under tension is on the first wrap on the drum providing maximum holding power. When transferring the mooring line from the storage side of the drum to the tensioning side, care has to be taken when manoeuvring the line through the gap in the drum divider. Personnel should stand so that they are pulling the line from the storage side towards the tension side rather than pushing, which has the risk of the line springing back towards the crewmember pushing it and possibly causing injury.

Once the vessel is all fast alongside, the anchors need to be secured by placing the guillotine bars in place across the anchor cables.

Some vessels are fitted with winches that have a self tensioning or automatic mode. It is recommended that these are not used in the self tensioning mode when connected to a shore manifold or when space ahead and astern is limited, as there have been instances of vessels creeping along berths due to the prevailing environmental conditions.

As can be seen in the following case studies, the poor condition of mooring ropes coupled with personnel standing in snap back zones can sometimes prove fatal when ropes part.

Case History

While a 15,000 GT container vessel was engaged in mooring activities one of her mooring lines parted and the snap back of the line was so powerful that it struck two shore linesmen, one of whom was killed and the other seriously injured.

Case History

During unmooring operations on a 6,000 GT inter island RORO ferry a member of the ship's crew was seriously injured when a mooring line parted and the snap of the line struck him so as to cause serious head, arm and leg injuries

Unmooring

When letting go, lines should be released and heaved onboard in accordance with instructions received from the bridge.

Once the order is given to let go the remaining lines these should be promptly slacked and then heaved in once let go by the linesmen. Once they have been let go from the shore bollards the bridge should be advised of the fact. The bridge must also be advised once the lines are clear of the water and it is safe to use the propelling machinery and thrusters.

Anchors are to be secured once the order to do so is given by the bridge, and the bridge informed once the anchors have been made fast with all lashings for the sea passage applied and hawse and spurling pipes covered.

Record Keeping

As a minimum the tug should keep a towing log as well as other logs and records required by the flag state. It is important that good records are maintained. In the event of an incident these are referred to in detail and are important in supporting the tug master's description of events and defending a Member's position in the event of a related claim.

PARTICIPANT 5			
BUSINESS OF ORGANISATION	*TOWAGE SERVICE*	**POSITION**	*SR MANAGER*
WORK PROFILE/EXPERTISE	*SAFETY OFFICER – TOWAGE*	**WORK EXP**	*21 YEARS*
LOCATION	*SOUTHAMPTON UK*	**DURATION OF INTERVIEW**	*110 MIN*

REPLY TO QUESTION 1

Effective OHS&E requires building an environment where people are highly motivated because it is dependent on community interest to achieve the promise of the theory….

The elements of a successful safety program extend beyond the systems, policies and procedures to include the perceptions, values and actions of its participants…

The promise of a systematic safety program is to achieve the wellbeing and safety of all employees; however the promise will not be achieved without a commonly held goal and without motivated and diligent application….

Why a Safety Culture? … the most sophisticated safety system is useless without a supportive culture…

Today, most organisations will have a safety infrastructure comprising policy, procedure and safety hardware. All this is designed to protect employees and third parties from harm. Safety Management Systems are carefully drawn up and regularly reviewed to ensure that they are effective and that they comply with legislative requirements. Often these systems are elegantly presented and may even be accessible through intranet technology. The fact is they are useless in achieving ‘the promise of the theory’ if left on the bookshelf or in the computer files.

So, if the safety system is the machine or tool, the safety culture may be described as being what energizes the machine or, what makes it do the job for which it was designed.

For a set of values to become a culture they must be held by more than the individual, indeed, for a culture to exist it takes a common commitment by the overwhelming majority of the members of the organisation. So we can say that for a safety culture to exist in any Company there must be, across all levels, the same perceptions, values, goals and commitments, as well as practices, to ensure that the safety system achieves its potential.

………What defines a Safety Culture?

The overriding feature of a successful culture is that people believe in it. There must be a commonly held belief that it is a worthy culture, i.e. it has value, and that it is an effective culture, i.e. it works.

People have to think and act the OHS policy, not merely comply with it……..
Rather than mere compliance out of duty or fear, a vibrant safety culture will consist of informed participants. ….There are four main features of an informed and participative culture of safety. Those features are; a reporting culture, a just culture, a learning culture and a flexible culture.
The crucial feature of an informed culture is that it is a reporting culture, one in which people are prepared to report their errors and near misses. The issue is not whether the organisation has a reporting system, it is whether, as a matter of practice, errors and near misses are reported…..
The success of a reporting system will depend on whether the culture is deemed to be just. A just culture is one where punitive measures are reserved for proven instances of purposeful malpractice or neglect. A learning culture seeks to take the details of a report as instructive, using the lessons presented to improve procedures and practice. Finally, a flexible culture is one that can readily adapt to changing circumstances and needs.
……….Looking beyond the workplace.
Everyday work practice is also affected by influences from outside the workplace. The way we behave away from work is likely to sway the way we behave at work. We come to work as whole people carrying all our baggage. In order to be consistent, we need to assess our attitudes to the importance of safety in our private lives. This will mean looking at our homes, our road use and our recreation.
………..Introducing a focus on non-work related factors builds the health and safety culture by emphasising the importance of human wellbeing not just worker wellbeing…….
…..What we need to ask.
Is my safety, and that of those around me, important 24 hours a day?
Am I an informed participant or do I merely cover my a#%e?
Does the OHS Policy of my Company state values, goals and commitments that are worthy?
Do the actions of my Company, at all levels, demonstrate commitment to worthy goals and values?
The answers to these questions will help to reveal whether we have a culture of safety or just a safety system.

Safety Management

Although many towing companies are not required to comply with the ISM code, it is however recognised that implementing an SMS is consistent with good practice. A structured and recorded system of an appropriate size to the operation not only improves safety, and protects the employees but also protects the owner/operator. It is difficult to comply with accepted good practice if no SMS system is in place.
Experience shows that accidents often occur during routine operations and an SMS assists to identify the risks, allowing important lessons to be learnt so they will not be repeated.

REPLY TO QUESTION 2

Risks are increased with:

- Poor planning.
- Poor communication.
- Poor supervision.
- Failure to appreciate the dangers of a task or operation.
- Lack of experience or knowledge.
- Misuse of equipment.
- Taking of short cuts, possibly due to commercial pressure.
- Unpredictable environmental factors such as weather, tide or current.
- Changes or unappreciated factors of the tow, such as cargo shift.
- Unexpected events, such as equipment failure or unusual traffic movements.

Effectively managing the human factor can lessen the exposure to accidents. A safety management system allows a company to put into place the building blocks for reducing incidents of human error…others are..

Girting, girding or tripping (GGT)

The terms mean the same thing and refer to the situation when a vessel, usually a tug, is towed broadside by a towline and is unable to manoeuvre out of this position.

This phenomenon is known to all tug masters. It is the most prevalent reason for tugs to capsize and can cause fatalities. This occurs at either end of the tow and can happen very quickly. Rarely does it happen slowly enough to allow all of the crew to leave the tug before it capsizes. Tug masters must be aware of the phenomenon and understanding the quick release to the tow wire is essential if disaster is to be averted…..

GGT is particularly relevant to conventional single screw tugs. Tractor and ASD (Azimuthing stern drive) tugs are less likely to girt because their tow is self-aligning and the tug master is able to produce significant thrust in all directions. It is clearly understood that towing from a point near amidships on a conventional tug is inherently unstable and can result in situations where the load on the tow rope can heel the tug over to a large and dangerous angle.

Various organisations have issued advice, recommendations and investigation reports into girting incidents.

A recurring feature of these accidents has been that, once girded, the towboat capsized so rapidly that crew members were unable to operate the tow, abort control or make use of lifesaving equipment.

The use of well-established towing arrangements to prevent girding may not always be effective in certain confined areas involving smaller towboats. In such cases potential dangers can best be avoided through careful planning and by each crew member being vigilant. A back-up strategy should always be considered in advance if, because of unusual or unforeseen conditions, a particular manoeuvre or action is not having the desired effect.

A review of girding incidents has shown that a towboat carrying out routine tasks in close proximity to the forward end of a barge under way is particularly at risk. At such times it is essential to ensure that the manoeuvrability of the towboat is not compromised by the weight and motion of the tow.

Tug masters should consider practical measures which might be adopted to avoid being placed in a girding situation

Girting can occur for a number of reasons including:

The ship or barge being assisted turns or shears abruptly away from the tug….

The speed of the vessel or barge being towed is too high, either intentionally or due to external forces such as increased currents or windage on a towed unit.

The tug is too far astern of its intended position compared to the speed of the vessel if the tow is moving ahead, or too far astern if the tow is moving astern.

The design of the tug, hull form and propulsion arrangements can affect performance in a girting situation. It should be noted that in some ports the ship's speed is restricted to as low as 5 knots whilst making the tow connection.

If an approach is made to a fast moving unit there is the danger from the hull interaction which can cause the tug to be sucked to the towed hull. As a rule the interaction force increases by the square root of the towed unit's speed.

The conventional tug is particularly vulnerable to girting when acting as the stern tug or as a brake at speeds above approximately 3 knots in a towed situation. To minimise the risk of girting a gob wire or similar arrangement can be used. When the tug is fast aft and used as a brake the tug master should concentrate on the following:

Risk of girting increased due to changes in the speed and/or course of the towed unit.

The tug is often out of sight of the lead tug or bridge of the assisted vessel and therefore good communication is essential. On a conventional tug a gob wire is recommended, pulled down as far aft as possible.

Gob/Gog wire or rope

By shifting the tow point aft or by using a gob rope or wire tow stability can be improved on conventional tugs. A gob wire or rope, sometimes referred to as a guest rope or bridle is a short wire or rope made fast to the towline at the after end of a tug. In this way the use of the gob wire effectively moves the towing point aft, closer to the tug's stern. This gives the tug master greater control and allows more manoeuvrability to prevent girting when the tug is acting as a stern tug. Some port authorities make it a requirement that a gob rope is used by all conventional stern-drive tugs.

A gob wire can be rigged in a number of ways including the two ways which use a length of wire secured to the tug that passes through a fairlead or appropriate bollard on the centre line of the work deck. The end of the wire holds a large shackle which is attached around the towline. The large shackle is free to slide along the towline. When the towline moves towards the tug's beam, the bridle wire comes tight and keeps the towing point aft and close to amidships. Another method of rigging a gob wire is to have a separate gob wire winch with the gob wire leading through a swivel positioned at the centreline at the aft end of the tug. A shackle is used to slide along the towline and the winch is used to vary the length of the gob wire. Obviously this cannot be varied when the gob rope is under tension.

If a single wire or chain gob wire system is used the connection point should be on the centreline of the tug and the length of the gob wire should not exceed half the distance to the protection rails or side bulwark.

If a fixed towing pod is used it should also be on the centreline, in line with the towing winch drum and have a bend radius at least ten times the diameter of the tow wire.

It is important that the shackles and wires used are appropriate for the operator, certified and in good condition. Some small tugs or work boats may be fitted with centreline rings fitted into the aft part of the main deck from which the gob wire can be attached. These should be certified for use to take the weights applied and regularly checked to be in a good condition.

Other methods can be used to prevent a towing wire moving onto the tug's beam. For example, the fitting of stop or tow pins positioned on each quarter.

The use of the gob wire still requires the emergency quick release system to work correctly. The method of quick release must be known to those who are likely to be on the bridge. Small work boats towing without the facility of a quick release system should always have a cutting axe nearby should the tow line need to be parted quickly.

Bridles or gobs should only be adjusted or released under the direction of the tug master during towing operations.

Emergency quick release systems for towline

Most tugs are designed with emergency quick release systems which either trip the hook or release the brake on the towing winches so as to take the load off the towline and allow the tug some more time to regain control from a potential girting situation. These release systems are usually capable of being remotely activated from the bridge. There are also manual override arrangements available at the winch/hook in case of failure of the remote control. Crew members should familiarise themselves with these ship-specific arrangements, including limitations if any, as soon as they join the vessel. It must be borne in mind that these emergency quick release arrangements may not always release instantaneously due to various contributing factors such as the direction of pull, the heeling angle etc. and hence allowance must be made when contemplating its activation.

The effect of wind

Not appreciating the effects of the wind when towing can result in collisions, groundings, towlines parting, injury and girting. The wind causes headings to change, speeds to increase and a towed craft to drift.

Manoeuvring can become difficult if the wind increases or changes direction suddenly. Tug masters should always be aware of the potential effects of the wind before a tow commences or before commencing the next part of a towing operation. Knowing the forecast or local weather conditions is essential.

The effect of current

Mariners will be aware of the effects that currents have on a craft being manoeuvred in water. The effects of current in open waters are less important than the effects in confined waters which can be significant particularly when manoeuvring in busy waters or rivers. The speed and direction of currents are also unpredictable, reasons include; changes in tidal direction, sudden water flows at river mouths due to rains or ice melt, constraints such as narrows, reefs, breakwaters and harbour walls. The effect of squat in shallow water can be considerable, particularly for large barges with a flat hull form.

Current direction can be influenced by:

- Bends in rivers or configuration of channel or river entrances.
- Shallow water.
- Man-made constructions; piers, berths, breakwaters.

- Bridges with pillars.
- Industrial cooling water outlets.
- Geographical obstructions such as islands.

Currents can also help manoeuvring, for example:

- To control speed when approaching a berth.
- To assist a tug and tow to move sideways.
- To assist in a turn.

River tugs work where currents can be strong and changeable over short distances. Over the width of a river the current strength may vary. The outer parts of the river may be faster flowing than in the centre. The more forceful current at the starboard bank impacts on the port quarter and as the vessel turns the bow is in a less strong current and so there is a turning moment to port. This effect can be sudden and the effect should not be underestimated. The Club has unfortunately suffered many incidents where this has been the case and contact has been made with installations on the river bank. Navigating in water where there is a constant current could be safer.

The act of assisting a tow to berth or un-berth needs to take account of the current. It is usual for a river berth to lie in the same direction as the prevailing current so that the current can be used to assist with berthing.

A berth can be approached bow into the current to give a relatively high speed through the water with a reduced speed over the ground which will provide good steerage because of the good water flow over the rudders. The towed unit is also easier to stop and the current can be used to assist the tow alongside the berth. Currents in some locations can be complex and changeable so again local knowledge is essential.

Berthing in a following current is difficult and potentially dangerous since the tug and tow must develop sternway through the water in order to be stopped over the ground. In these circumstances, control of a conventional tug will not be easy and an approach into the current is possibly the best method of nearing the berth.

Other concerns effecting manoeuvrability

Wash effect: this is when the wash's contact with the towed object/barge reduces the pulling effectiveness of the unit. Factors that can contribute to this are:

- Small under keel clearance of the assisted unit.
- Hull form of the assisted unit.
- Length of tow line.

- Area of operation – confined areas will increase the wash effect.

Under keel clearance: If the under keel clearance is small the propeller wash effect is increased reducing the tug's pulling effectiveness. Obviously pulling a barge or a vessel that is effectively aground or stuck in mud will increase the tension in the tow line. The suction effect can cause unexpected dangers as the barge can come clear of the suction effect of the mud and become free suddenly. Tugs' crews should be aware of this possibility and stand in a place of safety.
Squat effect: is often applied to ships, but any moving craft through the water can be affected by squat. The effects of squat are greatly increased by speed and if operating in waters of a confined width and may result in the change to the vessel's headings and the possibility of the towline shearing.

Length of towing line

The less water under the keel the more power the tug will need to apply. This will increase the wash effect and a longer towline can reduce or avoid the wash effect.
A short tow line in a confined area can produce a significant wash effect. Tractor tugs pulling over the stern and ASD tugs pulling over the bow can reduce the wash effect since the propellers are further away from the towed unit's hull.

Shortening the length of the tow
Very often, the tug and barge transit through waters where the sea room is restricted. The master then must consider shortening the tow wire to ensure better control of the barge. The length of the tow wire is at the master's discretion depending on the prevalent situation. The shortening of the tow should be carried out preferably in deep water, weather permitting, and most certainly well before entering congested waters. The shortening in deep water reduces a lot of wear and tear in the wire which it would have endured with dragging on the seabed. However, if the weather is severe, then there will be no choice but to defer it to as late as possible.
It is recommended that the length of the tow should not be too short as if anything were to go wrong, the tug will not be able to manoeuvre out of the barge's path and can result in her coming into contact with by her own tow. If the tug has a wild tow on a short wire, the master should call for assistance without further delay to bring the barge under control. When on a short wire, utmost caution must be taken to avoid sharp alterations or else the chances are that the barge may violently swing out of control. If this happens then the master should immediately consider paying out some length of tow wire to dampen the violent movement.

Establishing the tow connection

There are no strict rules to making fast the tow. Each tow will be different; the barge size, shape, draught, weather, current strength, light or location will vary. Prior planning will make the operation safer. A briefing between the tug master and his crew on how the job is to be approached is vital. Before arrival at the connecting location effective communications should be established between the tug and towed unit if manned. Ideally, a risk assessment would be in place. Tug speed should be adjusted for a safe rendezvous and connection.

If the tugs crew are required to access the towed unit plans must be made so that it can be carried out safely in the prevailing circumstances.

Position of barges

If the tow consists of a number of barges with different loads, sizes and shapes, the barges should preferably be arranged by similar size and design, with similar sized barges as the lead. If possible, loaded barges should be placed first with empty barges astern.

Tow ropes should be similar sized and of the same material, secured to the barges in equal lengths, with the same number of turns so that the tow ropes can be equally rendered if necessary and the stretch is similar. Where more than one barge is towed the remaining barges can be bundled into ranks using rope breast or stern lines.

Towing alongside

When a barge is to be towed alongside the tug, the connection should be made with a suitable heavy spring and a stern rope. The tug should be positioned close to the stern of the barge so that the tug's stern overhangs the stern of the barge. The further forward the tug is positioned the more difficult it is for the tug to steer the combined unit. Barges should be made fast to each other with the use of non-jamming turns so that they can be released if necessary. Picking the best leads is also important, particularly when the barges are of a different size or height.

Pushing ahead

Tugs will regularly have to push barges ahead even though they may not be specifically designed to do so. It is recommended that the barge is secured to the tug using winch wires attached to corner bollards of the barge/s so that the whole unit can be operated as a single unit. There should also be two substantial ropes made fast to the tug's centre bollard and the barge's port and starboard quarter bollards.

Double tows and tandem tows

In this booklet a double tow refers to the an operation that is undertaken with two wires from two towing drums, or in the case of a tug with a single drum winch using a Canadian link and an under rider to the rear barge. The term tandem tow is often taken to be referring to in-line or series tows where the rear barge is connected to a bridle on the aft end of the forward barge. This set-up is not suitable for ocean tows. The control of the barge's relative motions can be lost in a seaway and snatch loads can part tow wires, not to mention other problems with the tracking or over-running of the barges. This method of towing is regarded as suitable only for rivers and sheltered inland waterways. The term tandem towing has also been used for tows with two or more tugs attached to a single towed object. This terminology is commonly encountered when multiple tows are proposed.
Having established a set of criteria for setting up double tows, i.e. either two wire set ups or under riders, the methodology of the tow becomes somewhat clearer. Obviously the making up and breaking up the tow at each end of the voyage is more complex than single tows. It involves factoring in the planning of the roles of the assist tugs, weather and sea conditions, setting up the gob arrangement, water depths and crew skills as well as equipment selection for the tug and the barges including the barge's main and emergency gear. Procedures during the passage such as catenary management, freshening the nip, control of the gob arrangement and tracking of the barges are all skills which require experience and intuition rather than ones that can be set out in formal text.

Single wire under rider tows

The single wire/under rider tows (often referred to as Honolulu or Christmas tree rigs in some areas) have several benefits when compared with tows from two separate towing drums. The make up and break up of single wire tows can often be less complicated than a two wire tow. The gob arrangements, chafe protection and freshening of the nip are simplified and some masters maintain barges track better with an under rider to the second barge compared to a two wire tow.
This type of tow does require some specific features on the tug, being the Canadian Link permanently fitted in the tow wire and the winch spooling gear designed to allow the link to pass through the rollers and wind onto the winch drum. The main drawback to this system lies in the vulnerability of the tow if the tow wire parts, leaving two barges adrift and still connected to each other.

Two wire tows

With a two wire tow the exposure from a wire parting is reduced to one barge adrift while the second barge remains under tow. However, the makeup and discharge of the tow can be more complex and wire management on deck requires more planning with two gobs, two chafing sleeves and routine freshing of the nip. The daily work load on deck increases with the efficient monitoring and managing of the tracking of the tows and the position of the wires. This requires skill and experience from the tug master, crew and officers.

During the tow

In addition to the normal navigational and collision avoidance duties, the watch keeper has to ensure that the tow wire and tow are positioned correctly. The tug master should ensure that those carrying out wheel- house duties are aware of the requirements of the towing operation. This should be written down in the tug master's order book or as part of the standing orders. The tug master should always be satisfied that his watch keepers are aware of how to use the towing winch and its quick release system correctly.

These instructions may also include:

- In what circumstances the tug master wants to be alerted.
- In what circumstances the watch keeper should shorten or lengthen the tow line.
- Appropriate engine revolutions.
- In what circumstances and how often the watch keeper should freshen the tow line particularly in heavy weather.
- What length of tow wire and catenary should be maintained.
- Precautions to take in different water depth and weather conditions.
- Attention paid to chafing or friction in the towline; position of protectors or regularly adjustment tow wire length.
- Towing speed and headings to be maintained.
- Vessel Traffic Service and security communication if appropriate.

During the voyage the duty officer on the tug must also keep watch on the barge. One easy way to determine that the barge integrity has not been compromised and is not taking in water would be to paint the barge with a strip of high visibility paint at the waterline on the bow before commencement of the voyage. This would be a good benchmark for the duty officer to observe during the sea passage and so long as he can observe this line above the water, it can be safely concluded that the barge's draughts have remained the same.

PARTICIPANT 6			
BUSINESS OF ORGANISATION	*TUG OPERATOR*	POSITION	*TUG MASTER*
WORK PROFILE/EXPERTISE	*TUG MASTER*	WORK EXP	*28 YEARS*
LOCATION	*SOUTHAMPTON UK*	DURATION OF INTERVIEW	*110 MIN*

REPLY TO QUESTION 1

Tugmasters ….. bear a responsibility for the safety of vessel and crew. This responsibility extends to those around them, the ships and crews, and to other users of the waterways on which they operate. A successful outworking of this responsibility means they all get to go ashore both fit and well.

Safety is a very broad subject on board a vessel and extends from the most mundane routines of ship's husbandry to the most complicated aspects of vessel operations. In its most basic and immediate sense it is as simple as think before you act. In the broader context it means managing the things we can control and planning for the things we can't.

There are many factors which have an influence over the way in which we 'do' safety. Not the least of these is culture and values. We have experts from many different backgrounds. This means that the concept of what is acceptable risk vary.

Organizations such as the International Labour Organization (ILO) through its 'Safework' program, The International Maritime Organization (IMO) and the International Transport Workers' Federation (ITF), are seeking to bring about a global perspective on safety at work.

Culture and values will certainly influence our attitude toward safety. Attitudes are a primary factor in the success or failure of safety programs. Attitudes that say 'we've always done it that way,' 'it costs too much,' or 'it's too slow' predicate failure. ….Whereas attitudes that adapt to change and learn from experience are necessary for success.

REPLY TO QUESTION 2

Training for safety.

One of the cornerstones of a successful safety program is that all participants are well trained. It cannot be expected that the uninitiated person will have an understanding of the hazards and risks involved in an occupation. Without that understanding mistakes are inevitable. Therefore it is important that training programs are implemented at all levels and disciplines. It is important to

ensure that in the hurly burly of high pressure operations, as well as in the doldrum of routine; when we are too stressed or tired to think on our feet, that the safe option becomes the default.
I well recall taking command of my first tugboat, a small single screw wooden vessel engaged in port services. The attitude of management then was, 'you've got the ticket, do the job'. So, left to my own devices, I learned more from the kindly old deckhand than from any of my peers. Thankfully attitudes have changed, but not everywhere. Any Master taking command of a tug should not be expected to do so without first being trained to operate the vessel safely.

Communicate.

Another cornerstone of safety is effective communication. Safety has no secrets. The old attitude of knowledge is power sought to contain knowledge. A better attitude is knowledge empowers, where the sharing of knowledge gives us all a better understanding of what is going on and what is required to work safely and efficiently. In an occupational health and safety aspect we need to ensure that the deckhand is aware of the right way to carry out a task. In an operational safety aspect it is important to communicate with crew, pilots, authorities and other vessels to ensure that the full picture is apparent to all.

Managing safety.

The fundamental elements of safety management are hazard identification and risk management. Hazard identification involves examination of a task in its elements to assess where it could go wrong. Effective hazard identification involves training, experience and communication. Safety Management Systems use tools such as Job Safety Analyses (JSA) and checklists to aid in hazard identification. Risk management involves assessment of the severity of the risk and implementation of risk control measures. The severity of risk is most often determined by evaluating the likelihood of a situation occurring and the expected outcome of such an event. A risk assessment matrix is a common tool used. Risk control means developing and implementing ways to ensure the hazard is not allowed to become an event. This is done by adopting the highest level controls from a hierarchy of control measures that range from elimination of the hazard by doing the task differently (or not at all), down to the use of personal protective equipment. Most often effective control will involve a selection of measures from various levels.
The application of managing what we can control and planning for what we can't is usually achieved through the use of the safety management system, i.e. standard and emergency procedures. Masters and crew alike should be well versed in these procedures which have been developed to facilitate

safe operations and work practices. The safety management system should include a process to be adopted for use when the unusual task presents, i.e. the JSA.

Leadership

Tugmasters need to show leadership in all areas of operation, it is fundamental to their position and role. The key to developing a successful culture of safety onboard is leadership. Leadership must be displayed by Masters and supported by shore management. Before leadership can be displayed it is necessary for the leader to believe in, and be committed to, safe work practices and operations. This means that 'cowboys' need not apply! There is an old attitude which says that a concern for safety is less than manly and that real men just get on with the job. Among today's tough tugboatmen such attitudes can still be found. It is my belief that toughness should be tempered with humanity and a concern for those we work with.

Safety makes sense (and cents)

A good safety record is now regarded as a commercial asset. It can help to win tenders and maintain contracts. Getting the job done safely means a gain for efficiency. Accidents have a commercial cost; but more than that, accidents disrupt, and sometimes steal, the lives of fellow mariners. They also have ongoing ramifications that will affect the lives of managers and supervisors, workmates, and family members. The sensible approach is to take action to avoid accidents at the outset.

PREPARING FOR TOWAGE OPERATIONS

a) Planning and Coordination

Before beginning towing operations, a comprehensive plan, as part of the ship's port passage plan and the Pilot's own plan, should be agreed by the Master and Pilot, where a Pilot is embarked. This should take account of all relevant factors, including tide, wind, visibility, ship size, type and characteristics, and specific berth requirements. A good knowledge of the type and capabilities of the tugs allocated to the job is important, in order that the Master / Pilot can ensure tugs are both suitable for the task ahead and positioned on the vessel so as to be most effective to facilitate a safe operation.

Any conflict or mismatch between the required manoeuvre and the tugs allocated must be resolved before the towage operation begins. Responsibility for co-ordinating a towage operation lies with whoever has the conduct of the vessel being towed, be that the Master or the Pilot. Communication with the tugs will be through the pilot. When berthing and unberthing, it is the duty of the Master / Pilot to ensure that the vessel is handled in a safe and controlled manner, having due regard to the safety of all those involved, including the assisting tugs, line-handlers or mooring gangs and other port users as appropriate.

The number of personnel employed in any towage operation should be determined having due regard for the size of the vessel and the prevailing operational and environmental circumstances. In all cases, sufficient manpower should be provided to ensure that individuals are not exposed to undue risk, and that the operation can be conducted safely and efficiently. Due regard should also be given to the size, weight and scope of the towing gear and lines to be handled.

All those with a responsibility for personnel or equipment involved in assisting the towage / mooring of vessels have a duty to ensure that safe working practices are followed, and that associated equipment is fit for purpose. They should also ensure that those involved are properly trained, adequately briefed in their duties and issued with, and use, suitable and effective personal protective equipment (PPE).

b) Pilot/Vessel Master Exchange

In addition to the standard information passed to the Pilot, it is recommended that the

Master provides the Pilot with a plan showing the layout and safe working load (SWL) of the mooring fittings and inform him:

- which fairleads, chocks, bollards and strong points can be used for towing;
- the SWL of this equipment;
- areas of hull strengthened or suitable for pushing by tugs and relevant identification marks employed;
- any special features (e.g. controllable pitch propellers, thrusters etc.);
- power available at fairleads

The Pilot should advise the Master of the following:

- the tug rendezvous time and position;
- the number of tugs and the mode of towage;
- the planned (optimum) ship speed when connecting the tugs' lines;
- whether the ship's or the tug's lines are recommended for use;
- the type of tugs to be used and their bollard pull;
- if escorting, the maximum towline force that the tug may generate at escort speeds;
- maximum planned speed for the passage;

- the method by which the ship's crew should heave and release the tug's towline;
- a dedicated crew member to monitor tug and tug's line during heave and release;
- the prohibition on the use of weighted heaving lines;
- that on release, the tug's gear should be lowered back under control;
- areas of the transit posing particular risks with respect to the possible use of the tug;
- intentions with regard to use and positioning of each tug for berthing manoeuvres;
- intentions with regard to use of tugs in an emergency (escort operations); and
- primary and secondary VHF channels for use in the operation.

c) Pilot/ Master/Tugmaster Exchange

The Pilot / Master and Tugmaster should, as a minimum, discuss the following issues:

- the SWL of the vessel's chocks, bollards and strong points to be used for towing;
- the tug hook up point, taking into account the prevailing weather and sea conditions, for escorting operation (if appropriate) and berthing;
- the planned (optimum) ship speed when connecting to the tug's lines;
- if active escorting, the start point of the escorted passage;
- the maximum speed of the tug;
- passage details in their entirety while accompanied by the tugs, particularly details of any swing, manoeuvre, release position and sequence of release;
- berthing details in their entirety, including tug positioning around the vessel's hull and the vessel's required position on the berth;
- intended and emergency use of ship's anchors;
- any unusual items regarding the particular vessel as gleaned from the Master / Pilot exchange;
- if appropriate, any shallow water or bank effect areas where significant surges may be experienced that might add to the tug loads;
- the Tugmaster should advise the Pilot / Master (as far in advance as possible of the scheduled manoeuvre) if the tug is experiencing a failure or reduction in its ability to manoeuvre or deliver full bollard pull;
- when confirming that the tug is fast and ready to assist, the Tugmaster should also confirm both the tug's name and her position on the vessel.

d) Preparations on-board the tug

Operations such as mooring and towing impose very great loads upon ropes or wires, gear and equipment. As a result of the imposed loads, sudden failure in any part of the system may cause death or serious injury to personnel. Tugmasters should avoid men being stationed at or unnecessarily near towing gear.

Working in the bight of a wire or rope formed by the lead from the winch or windlass round and through the fairleads and over-side should be avoided. In any case, the consequences of failure in any part of the system must be carefully considered and effective precautions taken.

All fixed and running gear including ropes shall be carefully maintained, tested, certified and regularly inspected against wear, damage and corrosion. Particular attention is drawn to the need to ensure that fairleads, lead bollards, mooring bitts etc. are used appropriately and within their design capabilities and effectively secured to a part of the ship's structure which is suitably strengthened.

The emergency release mechanisms on towing hooks and winches must be tested, both locally and, where fitted, remotely, at frequent intervals to ensure correct operation. All towing equipment in use should be inspected for damage before undertaking and after completing a towage operation. The release mechanism should be capable of being released on the bridge, locally and in a blackout.

Tug crews involved in towage operations on deck will always wear approved and in-date self inflating lifejackets and other appropriate PPE throughout the operation. They should ensure that the working area is safe and free from trip or slip hazards and remain alert to what the vessel crew is doing.

Mooring winches and other equipment shall be maintained to the manufacturers' specifications and be properly serviced. Equipment such as heaving lines and messengers should be of appropriate length and strength. All equipment shall be checked before the start of each operation. Life saving equipment shall be available for immediate use.

When a tug is engaged on any towage operation all watertight openings must be securely fastened. All watertight openings shall be marked with a sign stating that they are to remain closed during towage operations. Any such openings used whilst moving about the tug during a towage operation are to be re-secured immediately after use.

e) Communications

VHF Working Channels

VHF Channels signals, 8, 10, 9, 12, 15

Whistle Signals

Whistle signals to be used between tug and tow

A power driven vessel and any vessel being towed by it when signalling to each other by means of a whistle shall use the following signals and no others:-

a) Signals to or from a towing vessel ahead:

- Tow ahead – one prolonged blast followed by three short blasts.
- Tow to port bow – one prolonged blast followed by two short blasts
- Tow to starboard bow – one prolonged blast followed by one short blast.
- Cease tow – one prolonged blast followed by six short blasts in succession.

b) Signals to or from towing vessel astern:

- Tow astern – three short blasts.
- Tow to port quarter – two short blasts.
- Tow to starboard quarter – one short blast.
- Cease tow – six short blasts in succession.

c) Signals to all towing vessels:

- Hold in position – one prolonged blast followed by one short blast followed by one prolonged blast followed by one short blast.
- Let go – one prolonged blast followed by two short blasts followed by one prolonged blast.

f) Tow Master Requirements on Dumb Tows Routine and non piloted

A Towmaster should be nominated for each tow. The Towmaster will present a tow plan to the Harbourmaster in good time for a review and for permission to be given or other requirements to be accommodated.

The tow plan should include taking all the action a prudent Master or Pilot would in having conduct of the operation. This tow plan should include but not be limited to:

Risk Assessment

- Method Statement
- Number and position of tugs
- Type of tug (e.g. push/pull, on hip etc.)
- Use of particular tugs
- Position of tugs
- Use of release mechanism
- Manning
- Passage plan berth to berth

- Regular dumb tow operations e.g. barges, pontoons and leisure operations may be covered with a generic tow plan and details of Skipper/Master/Coxswain qualifications e.g. STCW, Voluntary Endorsement Scheme (MGN 486(M) or other.

Non Routine Dead Tows

The same principle applies to dead tows involving piloted or non piloted craft, e.g. large barges to Gelliswick Bay beach and large, disabled commercial vessels entering or departing Milford Haven. The nominated Towmaster should present the tow plan as before to the Harbourmaster for approval. This will not unreasonably be withheld but will involve marine staff from MHPA in the decision. To that end, sufficient time must be given for the tow plan to be reviewed.

In the case of complex dumb tows, a Harbourmasters Working Group may be convened consisting of appropriately skilled personnel to ensure that all risks have been considered.

TOWAGE OPERATIONS

a) Connecting and disconnecting towing gear

Before arrival at the tug connecting position, the Pilot / Master shall establish effective communications with each tug and agree working channels. Likewise, effective communications must be established between the bridge and the vessel's crew at 'stations' and they should confirm that they are ready to receive the tug. The vessel's speed must be reduced to that which allows a safe rendezvous and connection with the tug. The required speed should be agreed in advance between the Master / Pilot and with all Tugmasters involved. At all times during the connecting process, the Pilot / Master should be aware of the position and intention of all relevant shipping movements in the area.

The Pilot / Master should ensure that his planning takes full account of the time taken to connect each tow, especially if adverse conditions are likely to extend this process. Account should also be taken of potential language difficulties, which may lead to confusion. Vessel mooring parties should be fully briefed and the Pilot / Master should check when in doubt and be confident that his instructions are being followed.

Ships heaving lines should be readily available and of a suitable make up. **Extra weights must NEVER be inserted in the 'Monkey's Fist' or attached to the heaving line.**

A small canvas sandbag is the towage industry's preferred option. Ship's personnel should wherever possible, agree with the tug crew the area where the heaving line is to be thrown, to allow the recipients to move clear. When connecting to the vessel, the tug crew should ensure that the towing gear is clear of any obstructions, able to run freely and is released from the tug in a controlled manner. The ship shall not test the bow or stern thrust controls prior to berthing at the time when the tug is under the bow or stern passing a line.

Changes in speed and or course should also be avoided while the towing gear is being connected as it may not be possible for tugs to react sufficiently quickly to sudden increase or decrease in a ship' speed/direction. Where a change in speed /course is necessary, the Pilot / Master should ensure that all tugs involved in the operation are advised in good time.

Svitzer Marine Ltd. tugs may use a compressed air line throwing apparatus to efficiently send a line from the tug to the ship's crew. Before any such exercise is undertaken, the Tugmaster will advise the Ship's Master and Pilot so that appropriate instruction can be passed to crew at stations.

The Pilot / Master shall maintain contact with the Tugmaster / vessel crew throughout the process. He should be ready to revise the intended tug position if the Tugmaster reports any restrictions at the chosen position, e.g. large flare, overhanging anchor or unsuitable push up point. The Pilot / Master must keep all those involved up to date on the plan and apprised of any changes to the agreed plan.

During disconnection, both the vessel's and tug's crew on deck should be aware of the risk of injury if the towing gear is released from the tow in an uncontrolled manner and avoid standing directly below. They should also be aware that any towing gear which has been released and is still outboard may 'foul' on the tug's propeller(s), steelworks or fendering, causing it to come tight unexpectedly. The towline should always be lowered onto the tug deck, never just 'cast off' and left to run, unless specifically directed by the Tugmaster.

The positioning of tugs on a vessel is a matter for discussion between the Pilot / Master and the Tugmaster, having full regard for the areas of the hull which should be avoided, e.g. watertight doors, between frames etc. The forward tug is especially vulnerable when passing up the tow line. This tug has to position itself very close under the bow, sometimes under 1 metre from the ship's water plane. The Tugmaster will be concerned about any bulbous bow or other underwater protrusion, the proximity of the flare of the bow etc. At the same time the Tugmaster is countering the hydraulic pressure wave that exists around the bow to avoid severe interaction.

Flares or cut-aways at the bow or stern are of particular concern and can increase the dangers of interaction. Extra caution should be taken by Pilots / Masters when the tug is making fast under a flare / cutaway, especially when the vessel is moving / swinging towards the tug. The danger is compounded at night with the risk of shadows from deck lighting.

b) Safe speed

Speed is a critical factor for the tug when making fast and letting go. When considering speed it is the **speed through the water** that is of concern. It is generally accepted that 5 to 8 knots is appropriate when making fast and letting go Svitzer tugs in the Haven; however, due consideration should be given to tugs manoeuvring astern.

For other, possibly smaller, tugs a safe speed may be lower and this should be discussed between the Master, Ship Master and Pilot. For Escort duties entering the West Channel, the optimum speed for the tug to be effective is 8 knots.

Caution must be exercised when using the engines whilst the tugs are working. The stern tug will be affected by the wash and every tug will be affected by the change of speed either up or down, and a rapid change in speed is all the worse. If the situation dictates the use of the engines, the minimum that the situation allows should be used and the tugs should be informed of what the ship is about to do as it will affect their own actions. In strong tidal conditions a high percentage of the tug's power may be utilised in maintaining position on the vessel before applying thrust to the vessel. If the tugs are made fast alongside they are at their most effective with a minimal ship speed through the water.

c) Interaction

Interaction and its effects on the tug and its handling are well known, and appreciated in port/harbour towage. Pilots, Masters and Tugmasters are reminded that these effects are multiplied as the vessel's speed increases. Areas of high and low pressure exist in and around the ship's hull and these areas can cause adverse movements of smaller vessels in close proximity. The speed of water flowing between the tug and the vessel increases at the last moment as the tug comes alongside. As this happens the tug therefore has to increase speed to maintain the same speed as the vessel. The Tugmaster has to compensate for the tug either being drawn in or pushed off the vessel.

In areas where interaction exists, and when manoeuvring alongside a vessel, the Tugmaster should be aware of the possibility of underwater obstructions such as bulbous bows, stabiliser fins etc.; and areas of the ship's side, such as pilot doors, which are to be avoided.

The Pilot/Master and the crew should be aware of interaction and the effect it may have on the tug. Marine Guidance Notice 199(M) – Dangers of Interaction – provides further guidance and information on the effects of interaction, including when manoeuvring at close quarters.

RUNNING AGAINST THE TIDE

Masters and Pilots should be aware that it is sometimes difficult to manoeuvre a tug into position against the tide without putting any weight on the towline. Sometimes it may be appropriate for a tug to run with the vessel stern first to make fast and thus be ready to tow in the same direction.

PRECAUTIONS DURING TOWAGE OPERATIONS

Once the towing gear is connected, the crew should indicate this to the Tugmaster and then clear the area. Any crew that are required to remain on deck should stand away from the towing gear in a safe position. If the crew are required to attend the towing gear during a towing operation, the length of time exposed should be kept to a minimum.

During towage operations the towing gear equipment and personnel should be continuously monitored and any change in circumstances immediately relayed to the Tugmaster. This is particularly important on tugs where the Tugmaster has a restricted view of the towing area/personnel. Tug and vessel crews should be aware that the towline may have to be release in an emergency situation, and that this may occur without warning.
Ships crew confirm with tug crew that tow is secure. The Tug master, having verified with the tug and vessel' crews that the towline is fast to the vessel, must confirm this with the vessel's bridge. The Pilot / Master should then re-confirm this to the Tug master, thus completing the communication loop. Sometimes it is not possible for the Tug master to see the crew on deck due to structural design or at night when they may be obscured by deck lighting on the ship.
Tug masters, Pilots and Masters should be aware, at all times, of the position and intentions of mooring boats, especially in strong tidal conditions, at night or during restricted visibility or adverse weather conditions. This is particularly important in circumstances where visibility is limited from the tug's wheelhouse and ship's bridge. Remember that bow and stern thrusters, and the wash from tugs and the vessel being assisted, can all cause significant problems for mooring boats, especially when they are in close to the vessel and/or tug(s), picking up and running with lines. Controllable pitch propellers are a separate but equally dangerous hazard.
The Pilot or Master should never use the vessel's engines without confirming with the Boatmen and / or Line handlers as to the position of the mooring boats. Sound signals can be used as a warning on occasions when vessel noise compromises VHF monitoring.

Towage in Restricted Visibility

Should visibility become restricted during a towage operation, the Pilot / Master and the Tug master will discuss the situation immediately and agree upon a course of action to
ensure the safety of all persons and vessels involved given the location, environmental and vessel traffic conditions, seeking the advice of Port Control as appropriate.
The Pilot or Master will advise Port Control of the circumstances and any decisions made immediately, keeping Port Control informed of any operational developments, or any improvement or deterioration of the visibility.
The Tug master should immediately inform the Pilot / Master and Port Control of any concerns that he may have as to the safety of his tug and crew. The Pilot / Master and
Tug master should take immediate action to ensure the safety of both the tug and the assisted vessel. If necessary the operation should be aborted as soon as it is safe to do so.

PROCEDURES WHEN RESTRICTED VISIBILITY EXISTS OR IS EXPECTED

- Towage operations should not normally take place in visibility of less than those described in Port Guidelines for visibility;
- The pick up speed in reduced visibility to be a maximum of 3-5 knots through the water;
- Tug masters may request the Pilot / Master to take all way off the vessel and the tugs manoeuver the vessel.
- Tugmaster to confirm watertight integrity of tug, Pilot / Master to inform tug if they observe any exterior openings on the tug that are not closed, and which affect tugs' watertight integrity.
- Pilot / Master and Tugmaster to agree the plan, which should be recorded;
- During operations in restricted visibility the Pilot / Master of the assisted vessel shall provide well in advance all engine movements, thrusters movements and alterations of course;
- Both Pilot / Master and Tugmaster shall inform the other of any changes in their circumstances that will impact on the agreed plan.

PARTICIPANT 7			
BUSINESS OF ORGANISATION	*TUG OPERATOR*	**POSITION**	*TUG MASTER*
WORK PROFILE/EXPERTISE	*TUG MASTER*	**WORK EXP**	*22 YEARS*
LOCATION	*GUJRAT/ DUBAI*	**DURATION OF INTERVIEW**	*110 MIN*

For ADMIRALTY GROUP
Verified By
Date - 12/11/15

REPLY TO QUESTION 1

There are different factors leading to safe tug use, and if one of these factors does not get proper attention or has not been handled carefully, operational risks increase and accidents will happen. The different factors are:

- Safe tug operators (towing companies).
- Safe tug and safe tug equipment.
- Safe tug operations.
- Safe working practices of pilots.

The four factors will be highlighted below.

Safe tug operators

Safe tug operators will take care of the following major aspects:

- Safe tugs.
- Well trained and experienced tug crews.
- Safe working schedules.
- Safe tug and safe tug equipment

It is the towing company's responsibility that their tugs are safe working tugs in the conditions and circumstances that can be expected in the relevant operating areas.

The tugs should comply with all relevant safety regulations.

The tugs should in all aspects be safe tugs. This applies to:

- operational reliability of engines, propellers/thrusters, steering equipment, deck equipment, etc.;
- Seaworthiness (if applicable);

- when rendering assistance;
- in case of engine/steering failures;

Other important aspects requiring serious attention are:

- stability and freeboard;
- tug performance;
- fendering;
- deck equipment;

wheelhouse: ergonomics, radar, communication systems, engine and/or rudder controls, winch control, quick release system, switching between manoeuvring panels, optimal visibility from the wheel house, clear windows, lighting, back-up systems, etc.... wheelhouse should be properly designed to minimize incidents with respect to human factor.

More items can be added, of which several may depend on the work to be done by the tug.
The tug should furthermore be suitable for the tasks to be carried out. Winch, fairlead and towing hook constructions and foundations should be strong enough for the forces that can be expected. The same applies to tow lines. Appropriate safety factors should be taken into account.
If one of the aspects mentioned is not treated carefully, not in a safe and reliable condition and/or not maintained properly, problems and accidents can be expected.

REPLY TO QUESTION 2

Safe tug operations

A safe tug and safe tug equipment alone is not sufficient. Tug operations can only be carried out safely if the tug's captain and crew have the right attitude, are well trained and have the right experience.
Towing companies therefore have the responsibility for suitable training programs and appropriate promotion systems. This is crucial for the safety of tug crews, the safety of the tug, as well as for the safety of the ships to be assisted, the environment and the port's infrastructure.

The training should not just be general training, but also focussing on *the specific tug -with its capabilities and limitations-* the captain, mate and engineer are sailing on, and on *the specific manoeuvres* to be carried out, for instance escort manoeuvres. *Proper tow line use* as well as the use of the most *suitable tow line lengths* should be part of the training. Training in *emergency procedures* is another important item, e.g. in case of a failure of one of the thrusters, and in the use of *back-up systems;* furthermore *in WiFi (if applicable), radar use, optimal communicating, first aid,* etc.

Suction forces and turning moments working on a tug when operating in close vicinity to a vessel, often a cause for accidents, should be addressed during training, as should another important aspect, viz. *safe speeds.* These factors are of specific importance when passing or retrieving a tow line, when coming alongside a vessel at speed and when rendering assistance.

Much can be *learned from accidents* that have happened, even from accidents that happened in other ports around the world. If relevant, such studies should be included in the training. Below are references to where information can be obtained about tug accidents.

It should also be clearly understood that training is only as good as the instructor. The instructor should not only have the capability to train other people but should also have the right experience regarding the aspects he is training.

The towing company should have a *safety manual.* Tug captains and crews should know the contents of it and should operate accordingly. For instance, doors and all openings on the weather deck should be closed during operations.

Tug maintenance is also an important factor to pay attention to.

Safe working schedules are a responsibility of the tug company as well. Tug crews should have sufficient rest in order to avoid accidents due to fatigue.

If a crew is well trained and has sufficient experience on a certain tug type, and fatigue does not play a role, towing operations can be carried out safely.

Safe working practices of pilots

Three factors have been addressed. The last factor, safe working practices of pilots, is also important. Because pilots and tug masters work as a team, *optimal communication between pilots and tug captains is* needed. The manoeuvres a pilot is intending to carry out will affect the assisting tugs. This can be a positive or a negative effect.
A negative effect may include risks for the tugs. To have the tugs performing to their best capabilities it is necessary for a pilot to have knowledge of *the capabilities and limitations of the*

tugs. This applies in the first place to the *ship's speed* while tugs are making fast, when rendering assistance and in foggy conditions. A pilot should know w*hat safe ship speeds are for the attending tugs*. Otherwise, the tug captains must tell him.
Safe speeds are also of importance to reduce the *interaction effects* between ship and tug. The lower the ship's speed the smaller the forces and turning moments working on the tug due to the fact that the tug is operating in close vicinity to the ship. Interaction forces increase with the square of ship's speed. This means that interaction forces at 6 knots are more than two times as high as with a speed of 4 knots.

It is also important to keep the tug captains informed about *ship's propeller and rudder use*. To be aware of propeller use is especially important for the stern tugs.
If the pilot has sufficient knowledge of the capabilities and limitations of the tugs, he is also able to place the tugs where they are most effective. *Correct tug placement* is an important issue in handling a ship effectively.
Finally, a pilot should have knowledge of how *much tug bollard pull is needed*. This is not always easy, particularly with high sided vessels in windy conditions.
With increasing tug power it becomes more and more important that a pilot has knowledge of *the strength of the ship bollards and fairleads*.
From the foregoing it can be seen that a pilot plays an important role with respect to safe tug use and operational safety.

In the first place, the right attitude is needed to achieve operational safety with respect to tug use. This applies to towing companies, tug captains, tug crews and pilots. One person or one party alone cannot achieve a high level of safety. It requires a combined effort of the parties involved, all with their own responsibilities, but with the same goal: Safety of Operations.
Safety of operations can only be achieved by building safe tugs, by training and experience, and by teamwork.

Planning

Incidents may occur because no pre-planning was carried out. Incidents can occur if the operations are not thought through prior to commencing the towage operations. In some cases the local port authority was not informed of the proposed towage operation and therefore important impending traffic information was not received by the parties concerned.
In all incidents pre-planning may not have been carried out for a variety of reasons; sometimes it is because the task is considered routine or there is no time available. Often, the argument is made that

hands-on operational type work cannot be planned. However, in the form of a risk assessment it may effectively reduce the risk to personnel, damage to the environment and property.

Tow plan

Planning and preparation before a tow commences might include:

Assessing the size and type of vessels or barges to be towed and any limitations of the tow. Confirmation that the tug is of suitable; size, manning, sea-keeping, horse power (HP) and bollard pull (BP). Tow wire and towing equipment is suitable for the planned tow.

Route to be taken and passage planned, including safe transit times (day/night transits), times when passing through narrows, under bridges or areas of high traffic density, tight bends in rivers and adjacent river berths.

Noting any areas of reduced depth, tidal limitations and currents expected during the voyage. A list of bridges with maximum and minimum height; tide height for each arch to be passed under showing the bridge's maximum air-drafts.

Weather forecasts to include outlook for at least 48 hours. Confirmation of sufficient fuel, water, spares on board.

Preparations on board the tug

It is essential that checks should be completed on board the tug and vessel or barge to be towed, which should include:

All water/weathertight openings are securely closed with signs indicating that they should remain closed for the duration of the voyage. It is a reality that tugs have capsized as a result of doors and ports being left open when in difficulty, e.g. girting. down flooding is a real danger to small tugs.

Life-saving and fire-fighting appliances must always be operational.

Navigational equipment, wheelhouse whistles, horns, shapes for day signals and communication gear are fully operational.

All critical machinery prior to commencing a towing operation should be confirmed as operational – this would include; main engine, steering gear and towing equipment (winches, wires) etc.

All personnel are fully familiar with the intended towage plan and their responsibilities.

Any change of fuel and ballast to the tug and/or tow have been fully calculated and the crew are aware of any factors of concern.

Checks on board the towed vessel or barge

The tow should not proceed until a satisfactory inspection of the tow has been carried out by a competent party.

Checks should include:

- Condition of the towing arrangements.
- Condition of the anchoring equipment if fitted. If not fitted some authorities require a temporary anchor to be supplied of an adequate weight.
- Condition of tow including an inspection of the peaks and buoyancy spaces to check for water ingress.
- Watertight integrity of the unit to be towed; obvious signs of damage, especially in the hull and deck plating. Hatchways, ventilators, doors, scuttles, manholes and other openings are closed and sea valves shut.
- Fore and aft drafts, appropriate freeboard for the voyage and no evidence of a list. Generally a slight trim by the stern ensures that the tow is laterally stable when towed
- Air draft of the tow, appropriate for the voyage and bridge transits.
- Power is available for navigation lights.
- Safe method of boarding available (portable or fixed rungs).
- Emergency towline rigged.
- Life-saving and fire-fighting appliances are in good condition and in the regulatory number required.

Some bulk cargoes pose a serious hazard, including spoil and certain ore cargoes which are liable to liquefaction e.g. spoil cargoes can contain a high amount of moisture which can assume a liquid state in a seaway and can cause the barge to lose stability, list and even capsize. Reference should be made to the IMO International Maritime Solid Bulk Cargoes (IMSBC Code). When it is suspected that cargoes with high moisture content have been loaded onto a barge advice should be sought.

If cargo is liable to move e.g. vehicles and timber, the lashing arrangements and sea fastenings should be inspected.

Planning for rough water

Rough water in the context of a small tug or workboat is not restricted to being caused by strong winds. The Club has suffered many claims where the tug and tow unit have contacted a third party vessel, berth or other fixed floating object due to misjudging the prevailing weather conditions when manoeuvring. Adverse weather conditions can be caused by any of the following:

- The action of wind against tide.
- Tidal bores, rip tides or strong currents.

- Interaction of strong river currents and prevailing currents/winds e.g. at mouths of large rivers.
- Sudden changes in the current due to increased rains.
- Turbulence, undertows and/or wash reflected off river or channel banks.
- Wash from passing craft.
- Geographical/seasonal issues such as the freshet where operations on the Fraser River are affected by the seasonal ice flows.

The effects of rough water on a tug and tow can be appreciable and in extreme cases water over the bow of the tow can impact on barge stability. Extra strain on towing and mooring lines and potential damage to barges being towed alongside or in tandem can occur.

In order to reduce the potential of an incident due to rough weather the following should be considered:

Delay departure and wait for an improvement in weather or tide.

Anchor or tie up and wait for an improvement in weather or tide.

Reduce speed of tow.

Increase the length of the tow to compensate for power surge and wire tension due to tows movement in the seaway/swell.

Consider towing astern if tow is arranged for towing alongside.

Alter course.

Passage planning and bridge equipment

Reference material is available on passage planning, including IMO Res.893 - Guidelines for Voyage Planning, which states that the need for voyage and passage planning applies to all vessels. A large part of a towage risk assessment can be included in the appropriate passage plan. Even for experienced tug masters, plying familiar waters, the formal process of planning the voyage, however short, is a useful one.

A passage plan as a minimum should include and consider, but not necessarily be limited to the following:

- Plotting the intended route on appropriate, large scale and up to date chart.
- Reference to appropriate routing and passage information, publications, sailing directions and local information published by competent authorities.
- Towing draughts in relation to water depths and under keel clearances.
- Proximity of other shipping traffic and anticipated high traffic density areas.
- Manoeuvrability of tow in relation to the navigational channel constraints, including river and river bank operations e.g. construction or diving.
- Current and tidal information.
- Weather information and forecasts, in particular forecasted restricted visibility.

- Reporting positions and vessel traffic services information.
- Safe anchorages/places of shelter.
- Tow speed and adjustments to pass danger points.
- Consideration whether night-time transits should be restricted.
- Air-draft restrictions for passing under bridges.
- Navigational warnings, changes to navigational marks or lights.
- Available wheelhouse personnel, potential working hours and fatigue during the passage.

Current and tidal information may not be accurate even in well charted areas and therefore local knowledge may have to be relied on. Tugs work in all waters and at times extraordinary currents are a problem. In some rivers and inland waters where very high tides, heavy rains, or heavy ice melt has occurred, currents of 16 knots are not unusual (navigating through these areas, in and around slack water, is preferable if that option is available).

In addition it should be ensured that all critical bridge equipment must be in good working order prior to commencing any operation.

Emergency planning

A prudent towing plan includes 'what if' situations, unexpected events that could happen during the tow. This preparation could be a formal plan for specific contingencies and/or training.

Consideration should always be given on how to transfer personnel and equipment to the towed vessel or unit during an emergency. Personnel should always wear life-jackets and utilise communication equipment and portable lights during darkness. The safety of personnel is paramount and a transfer should not go ahead if considered too dangerous.

Contingency plans could include the following:

- Girting or girding situation
- Failure or parting of the tow wire.
- Failure of gob wire arrangements.
- Grounding of the tug or tow.
- Loss of hull integrity in either tug or towed vessel.
- Collision or contact with a fixed object or installation.
- Loss of main propulsion power or electrical power.
- Failure of steering and/or other critical control systems.
- Man overboard.
- Bridge, accommodation or engine room fire.
- Actions to take in the event of unexpected poor weather.

PARTICIPANT 8			
BUSINESS OF ORGANISATION	*REGULATORY*	**POSITION**	*SR SURVEYOR*
WORK PROFILE/EXPERTISE	*SURVEY/INSPECTION*	**WORK EXP**	*23 YEARS*
LOCATION	*USA*	**DURATION OF INTERVIEW**	*45 MIN*

REPLY TO QUESTION 1

We have procedures in place to assist the tug master in case of a serious accident, collision or oil spill. Seafarer has the right to expect from the authorities following a serious accident or incident, and some general advice for managers and mariners who may be faced with a criminal prosecution in a jurisdiction with which they are not familiar.

Harbour towage companies which work in a specific area for an extended period of time will be familiar with local procedures and will have a good idea what to expect if there is a serious accident, so this advice may be more useful for seagoing members and their managers, who could find themselves dealing with the authorities in a place where they do not have detailed local knowledge.

GENERAL GUIDANCE

Good record keeping is essential. It is much easier to prove what happened if logbooks are well kept and up-to-date, positions are regularly plotted and relevant publications are in use.
IMO and most flag states have standard accident report forms or frameworks, and these will offer valuable reminders of the information to be recorded after a serious accident. A camera can be an excellent tool if there is an accident. Contemporaneous photographs are extremely useful, so try to record as much as possible as soon as possible. Even a photograph of a GPS screen showing time and position in the immediate aftermath of a serious incident may be valuable if there is a dispute about the facts of a case. Photographs, videos, sketches and drawings can all be very useful evidence.
Similarly, a capture of AIS and radar information might prove to be invaluable later on. Radar data can sometimes be obtained from the local VTS or port control, and tugs which are fitted with a Voyage Data Recorder should ensure the data is saved if there is an accident.

Key personnel are likely to be extremely busy, and there will be a lot happening after a serious incident. One person in the wheelhouse should be tasked with keeping accurate records and, if possible, should not be given any other duties. All key personnel should also keep individual records if possible.

Entries in the log book should always be written clearly and neatly in ink. If a mistake is made, cross it out with a single line through the relevant passage, and initial the crossing out.

Contemporaneous notes made by individuals may be very useful in helping the company to build up a complete picture of what happened. They can also be very useful in a subsequent court case, because witnesses are normally permitted to read their notes when giving evidence. However, these notes should always be factual and objective, because all parties to a case may be permitted to see them.

It may be necessary for crew members to give statements or written accounts after a serious incident. These should always be factual e.g. where they were, what they saw and at what time they saw it. Subjective opinions should be avoided wherever possible.

It is important to note the details of other vessels in the vicinity or other people who may have witnessed a serious accident.

People who respond well in emergency situations are almost always the ones who have prepared for them. Emergency drills should be realistic and should cover all imaginable scenarios.

FAIR TREATMENT FOLLOWING AN ACCIDENT

In 2006, the International Maritime Organisation (IMO) adopted Guidelines on the Fair Treatment of Seafarers in the Event of a Marine Accident. Members should be aware of the Guidelines, the major points of which are outlined below. *Members are cautioned that this is a summary only, and should not be relied upon in the event of an accident.*

REPLY TO QUESTION 2

PORTS OR COASTAL STATES SHOULD:

1. Conduct investigations in a fair and expeditious manner.
2. Co-operate with other interested States, shipowners and seafarers, and grant seafarers' organisations access to the seafarers.
3. Preserve the human rights of seafarers, and the economic rights of detained seafarers.
4. Treat seafarers in a manner which preserves their basic human dignity.
5. Ensure or verify that detained seafarers are provided with adequate subsistence, including accommodation, food and medical care.
6. Give all seafarers the protection of due process without discrimination.

7. Provide interpreters where necessary, ensure seafarers are advised of their rights, and provide access to independent legal advice.
8. Ensure seafarers are informed of the basis on which the investigation is being conducted (i.e. IMO or national legal procedures).
9. Ensure the States of the nationality of all seafarers concerned are notified, and that consular access is granted.
10. Ensure that detained seafarers are provided with the means to communicate privately with family members, welfare organisations, the shipowner, unions, national representatives and legal representatives.
11. Promptly conduct interviews for the coastal State investigation, taking into account the physical and mental condition resulting from the accident.
12. Take steps to ensure the seafarers, once interviewed or otherwise not required for the coastal State investigation, are re-embarked or repatriated without undue delay.
13. Consider non-custodial alternatives to pre-trial detention.
14. Promptly conclude the investigation and, if necessary, charge seafarers suspected of criminal actions. Ensure due process protections are provided to all seafarers charged.
15. If national laws allow, ensure there is a process for posting a reasonable bond or other financial security to permit the release and repatriation of detained seafarers pending any investigatory or judicial proceedings.
16. Ensure any court hearing, when seafarers are detained, takes place as quickly as possible.

THE FLAG STATE SHOULD:

i. Ensure that any investigation to determine the cause of a marine accident is conducted in a fair and expeditious manner.
ii. Co-operate and communicate with other interested States, shipowners and seafarers, and give seafarers' representative organisations access to seafarers involved.
iii. Participate directly in any casualty investigation.
iv. Ensure shipowners honour their obligations to seafarers involved in a marine accident or investigation.
v. Verify that adequate provisions are in place to provide each detained seafarer with wages, food, accommodation and medical care as appropriate.
vi. Assist seafarers to secure fair treatment.
vii. Fund the repatriation of seafarers where shipowners fail to fulfil their responsibility.
viii. Ensure consular officers are permitted access to the involved seafarers, regardless of their nationality.

ix. Ensure the fair treatment of seafarers employed on a vessel flying its flag.

x. Ensure no discriminatory or retaliatory measures are taken against seafarers because of their participation during investigations.

THE SEAFARER STATE SHOULD:

1. Co-operate and communicate with all interested States.
2. Monitor the physical and mental well-being and treatment of seafarers.
3. Fund the repatriation of their seafarers where shipowners and the flag State fail to fulfil their responsibility to repatriate.
4. Assist in the service of legal documents and the return to the port of seafarers needed as witnesses in any proceeding following a marine accident.
5. Ensure its consular officers are permitted access to the involved seafarers.
6. Ensure no discriminatory or retaliatory measures are taken against seafarers because of their participation during investigations.

With regard to investigations, shipowners have an overriding duty to protect the rights of the seafarers they employ, including the right to fair treatment and to avoid self-incrimination.

SHIPOWNERS SHOULD:

1. Ensure that no discriminatory or retaliatory measures are taken against seafarers because of their participation during investigations, and ensure that such conduct by others is not tolerated.
2. Take steps to expedite the efforts of any investigation.
3. Encourage their employees to co-operate with an investigation, with due regard to any applicable rights.
4. Use all reasonable means to preserve evidence and minimise the need for the continuing physical presence of any seafarer.
5. Fulfil their obligation to repatriate or re-embark their seafarers.
6. Ensure provisions are in place for the subsistence of each seafarer, including wages, suitable accommodation, food and medical care as appropriate.

GUIDELINES FOR SEAFARERS

SEAFARERS SHOULD:

1. Ensure they have appropriate translation services.

2. Ensure they understand their right not to incriminate themselves, and they understand that when statements are made to investigators these may potentially be used in future criminal prosecution.
3. If necessary, ensure they have access to legal advice prior to deciding whether to give statements.
4. Participate to the extent possible by providing truthful information to the best of their knowledge and belief.

CRIMINALISATION OF SEAFARERS FOLLOWING A SERIOUS ACCIDENT - ADVICE FOR MANAGERS AND MASTERS

Casualties which involve pollution and/or serious injury normally result in investigations by the local maritime authorities AND the police. These investigations may run in parallel, so it is important for seafarers to know which interview is taking place, and the purpose and possible consequences of giving the interview.

IN MOST COUNTRIES IT IS AN OFFENCE TO:

- breach COLREGS
- cause death or injury
- cause pollution
- cause damage to property.

Invariably, an offence has been committed during a serious accident and the local police may have wide powers to interview crew members, seize documents and inspect a vessel. Do not expect fair treatment or the application of natural justice - these are relative terms and may vary from place to place.

There are normally two types of interview which will be conducted. Witness statements are normally taken to establish the facts, and there is no guarantee of legal representation. Then there may be suspect interviews, at which legal representation is normally guaranteed and the interviews are conducted under caution. In some jurisdictions, a refusal to cooperate in a witness statement or a request for legal representation during a witness statement may be considered to be an admission of guilt.

In all such cases, specialist local legal advice should be obtained. The best local lawyers should be engaged, and it is worth remembering that the best for a particular case may be criminal lawyers rather than maritime lawyers.

Police forces may have little or no concern for the ship's operational requirements or repair schedule. There may be long delays, and key witnesses may be removed from the vessel for extended periods. It is essential that owners send additional senior officers and superintendents, so that the ship can still be run in a safe and efficient manner, even if key people are taken ashore for questioning or become exhausted following their ordeal.

The crew should be given legal support, and their morale should be maintained. Their families should be kept informed, and suitable financial measures implemented to safeguard crew members and their families.

Complex cases, particularly those involving deaths or serious pollution, are the most difficult to deal with. There will often be a perception among the general public that 'somebody must be to blame' and it is easier to find a scapegoat when a foreign vessel with foreign crew is involved.

One way to sway public opinion is to quickly set up a claims procedure, so local people who have been affected by the accident have a way of gaining compensation without undue delay. The support of the vessel's insurers is vital if this is to be done effectively.

Finally, some thought must be given to who will pay the costs of the case. P&I Club cover does not include the costs of defending criminal acts by seafarers, although the Clubs may offer support on a case by case basis. Owners should discuss this aspect with their insurers at an early date.

PARTICIPANT 9			
BUSINESS OF ORGANISATION	*PORT OPERATION*	**POSITION**	*HARBOUR MASTER*
WORK PROFILE/EXPERTISE	*PORT OPERATION*	**WORK EXP**	*31 YEARS*
LOCATION	*MUMBAI*	**DURATION OF INTERVIEW**	*90 MIN*

REPLY TO QUESTION 1

The cause of an accident is seldom just bad luck. In general, an accident is the total sum of a series of events which finally leads to an unfortunate outcome. Therefore, it is important to investigate the reasons behind an accident, the so called root causes, in order to be able to prevent such accidents happening again.

The assisting ships and floating objects with tugs requires specific knowledge and competence, and that agreement about safe speeds and proper communications between parties are extremely important.

A nautical accident which involves loss of life is the worst nightmare for every harbour master, since he or she is responsible for nautical safety in their port. There is little comfort in knowing that risks can never be completely eliminated and must be considered in terms of making them ‘as low as reasonably possible’. This means that accidents, and the eventual dramatic aftermath, may still happen no matter how hard we try to eliminate them. Shipping without risk does not exist, but we still have an obligation to continuously strive for safety improvement and risk reduction. It is an essential element in the role of a harbourmaster.

On the other hand, severe accidents may also be seen as wake up calls. The harbour master is frequently challenged by politicians, the public and commercial parties to prove the necessity for investment in risk control options and measures or regulations which may cost money or limit entrepreneurial short term goals. Of itself, there is nothing wrong with that, but a severe accident immediately makes every takeholder aware of the necessity for constant improvement. Statistics and research are important, but do not have the same emotional effect as actual pain and damage. Beyond that, accidents often lead to new insights, lessons learned or comprehensive new research.

The port industry and the nautical service providers have the professionalism and responsibility to learn from accidents in order to improve safety.

Quality in the safety context is about being able to reflect on your own operations and procedures, and being open to assessment by others. Nautical safety is not a project with an ending, it is a continuous process which involves many human factors. Learning and being aware are key elements in reducing risk.

REPLY TO QUESTION 2

Manning and Training

The International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW Code) is often not applicable to towage operations carried out in some jurisdictions, particularly for non-international voyages, such as river passages. The manning of the towing vessel may be determined by an appropriate regulatory authority; however it is the responsibility of the owner/operator to ensure that the tug is manned with adequately certified and experienced personnel for the voyage. Following an accident it has sometimes been found that the cause was due to unqualified personnel, in which case P&I insurance cover could be compromised.

The towing master should be aware that inexperienced personnel must not be exposed without training and supervision to carry out high risk tasks, such as hooking up or releasing the tow. It is also the custom and practice in many areas that personnel supplied by barge operators are often part-time, contracted in and therefore possibly inexperienced and poorly trained. Their actions can therefore impact on the safety of a towing operation.

Training should be frequent and recorded in ship's log books. This should cover safety aspects such as lifesaving and fire-fighting, and:

- Dangers of and the safe practices for hooking up and releasing a tow.
- Capabilities and limitations of the towing equipment.
- Controls of the winches and use of the emergency quick release mechanism.
- Emergency contingency plans for if the wire/rope parts during a tow. Dangers associated with reconnecting the tow.
- Dangers associated with girting (girding) situations.
- Dangers associated with main engine or electrical failures.
- Risks associated with working in heavy weather and strong currents.
- Shortening the tow line.

An effective safety management system (SMS) allows these training requirements to be formalised and become second nature.

Planning for an emergency should include:

- Actions in bad weather
- Hove to arrangements
- Available anchorages and safe ports for shelter
- Emergency towline rigging or bridle recovery.

In order to allow an effective and safe recovery, a bridle recovery system should be rigged. The most effective method is using a winch and recovery line as above. The winch should be able to lift 100% of the weight of the bridle, wire and attachments. For large barges the power for the winch should be available on the barge. For smaller barges alternative arrangements will have to be made, including manually operated recovery systems. It is recommended that the breaking load of the recovery wire be at least six times the weight of the recovery gear.

Emergency towline rigging

In the event of a towline or bridle failure, or the inability to recover a bridle, an emergency tow wire should be rigged. This is usually fitted to the bow and a suggested arrangement is as in the Figure 19.

Prior to departing on a voyage the emergency arrangement may include:

- Towing connection through a centre closed fairlead
- Length of wire, with similar breaking strength as main tow wire, at least the length of the barge, plus an extension wire long enough to allow the float line to extend over 75 metres astern of the barge
- A high visibility pick-up buoy, with reflective tape attached with a self-activating light to the end of the float line
- The emergency towline should be led over the main tow bridle and secured to the barge side with soft lashings
- Precautions taken to prevent chafe of the wire ropes
- Spare re-connection gear should be available on the barge.

In the event of any failure of the main towing arrangement, the tug must first retrieve the balance of the broken towing wire on board so that it does not foul the tug's propulsion systems. If it is possible for the tug's crew to board the barge, then they must attempt to retrieve the towing bridle on board. However, if this is not possible, then they must consider disconnecting it and slipping it to the seabed. Having the main bridle trailing over the side can cause it to foul with underwater obstructions or simply dredge the seabed and act as an anchor thereby making emergency towing

difficult. The tug must then approach the stern of the barge at a safe distance and retrieve the float line. The use of a boat hook can also be made to assist in the retrieval of the float line. Once the float line has made its way on board, it can be further hauled in with the use of the winch. This will help it break the soft clips which secure the towing pennant (spare towing wire) on the barge's deck. Once the eye of the pennant comes on board the tug, it must be made fast to the towing hook. The tug must then gradually take weight on the towing pennant and commence towing the barge with her emergency towing system.
It must be borne in mind that the emergency towing systems are not designed to continue towing the barge on her ocean passage but only to tow the barge to nearby safety such as a holding area or a port of refuge.

Speed estimates

Regarding speed estimates following remark has been made by a tug master "With matching ship's speed, it is clear what safety margin you have with respect to tug power"

The approach when making fast to the bow of a containership -Keeping pace with the ship allows you to feel the pressure wave. The pressure wave (in front of the bow) gives the tug additional speed. Be aware.

The approach when making fast to the bow of a bulk carrier or tanker-Overtaking the ship and then manoeuvring carefully towards the bow is acceptable, but keep clear of the pressure wave near the shoulder.

Voith Schneider tugs

- Safe ship's speed, skilled captain and proper communications are crucial factors.
- Good training is essential.
- Ship crew should be ready with heaving line.
- When connected ship's speed will increase; carefully monitor changes to ship's speed.
- Tug-ship contact near shoulder is ok, but tug-ship contact further forward is dangerous.
-

ASD-tugs operating over the bow

With respect to training and tug knowledge:

- Compulsory simulator training for all tug masters is a must, as well as certification of tug masters; it will make tug operations safer.

- Know your tug, the capabilities and limitations, the local conditions and the interac-tion effects. Tug master skill and ship's speed are key elements.
- Training on interaction is a must.
- With respect to speed:
- Know the speed, ask the pilot/ship's captain to slow down if speed is considered too high.
- Always keep enough reserve power in order to be able to drive out of danger.
- Towing companies and harbour authorities should set maximum speed for bow-to-bow operations.
- Pilot organisations, port authorities and towing companies should set a maximum speed.
- Maximum 6 knots is safe.
- Do not be afraid to ask pilot to slow down if speed is considered too high.
- The slower the safer. Patience is a virtue.

With respect to safe tug operations:

- Why bow-to- bow? Use only tractor tugs.
- Why on the bow and not push-pull, which is much safer?
- Read Henk Hensen's `Bow tug operations by Azimuth Stern Drive tugs'.
- Keep distance and use line thrower.
- Safe speed to be based on what speed a tug master can drive his/her tug in a controlled manner (particularly going astern for bow-to-bow) on one engine. Once this speed is established for the specific tug, prevailing conditions and competency of the tug master, I recommend taking one knot off the figure and we are getting close to determining the safe connection speed.

With respect to communications:

- Communicate with pilot.

Various:

- Do not oversteer when waiting in front of the ship.
- When vessel swings, first push her round before connecting.
- Never connect side tugs before front tug is connected so it can run along the side in case of engine failure.
- We have problems with vessel crews not using heaving lines; so we need to wait in a critical position before an appropriate line is presented. Safe use of tugs and how to (dis-)connect properly should be part of the SMS

Finally:

- Speak up if you dislike a job, situation or pilot.

ASD-tugs operating over the stern

- Proper simulator training and refresher courses are absolutely vital.
- Some ASD-tugs are not suitable for operating bow-to-bow.
- Knowledge of towing in the conventional way is being lost and this can be dangerous.
- Planners must know tug's limitations.
- Designate a maximum speed, and send tug masters for training.

ATDs

- Training is needed, including knowledge of interaction effects.
- Push-pull is safer.
- Always be aware that pilots are not familiar with tug types, and you are in command of the tug, not the pilot
- Vessel crew has most difficulty in getting the heaving line on the tug, due to lack of sea-manship of crew and improper heaving lines.

ROTOR tugs

- Approach from side to estimate ship speed and have spare power available.

Interaction effects

- All ship captains, tug masters and pilots know about interaction effects and the risks for tugs when operating in close vicinity to a ship.
- Several ship captains experienced interaction effects and a large percentage of pilots and tug masters had critical experiences with these effects.
- For ship captains and pilots, interaction effects were covered during their studies. However, some of the tug masters had not been trained or instructed about interaction effects. A large proportion of these are tug masters on ASD-tugs that operate as a conventional tug
- The majority of pilots, tug masters and ship captains say that interaction effects are not represented in a simulator in a realistic way.

Communication

- All pilots and most of the tug masters prefer to communicate in the local language. Possible mistakes and errors are mentioned by the pilots as reasons.
- On the other hand, all captains say that communication with the tugs should be done in English.
- Information communicated to tug masters includes SWL of bollards, where to secure tugs, mooring plan, etc.
- A majority of the pilots/ship captains discuss safe ship speeds with tug masters. It must also be noted that several ports already have rules regarding safe speeds. Please, see below.

Speed regulations in ports

- Half of the tug masters say there are speed limits in their ports, either through regulation, by guidelines, or established practice.
- A maximum speed of 6 knots is most common, with 7 or 8 knots in a very few ports.
- Pilots report that some ports have a pre-agreed speed of 6 knots through the water, or 5 knots for bow-to-bow operations. Some pilots say that they usually reduce speed to 6 knots, while others trust the tug masters' insight.
- some tug masters reported that their towing companies have maximum speed restrictions or guidelines. A maximum speed of 6 knots is mentioned most often, and 11 knots for escorting.

Safe procedures for securing tugs

- About most of the pilots and all ship captains say they have safe procedures for securing tugs.
- It should be noted that several pilots complain about lack of good experienced crew members on board ships today.
- All ship captains say they have instructed their officers to keep an eye on the tugs in general and when they are not visible from the bridge.
- Most pilots do not ask the captain to keep an eye on the tugs when securing even if they might not be visible from the bridge. They expect the ship's crew to do so since it should be standard procedure. Some pilots find it a good idea and will do so in future.
- Almost all captains and pilots state that when tugs are making fast the ship should be on a steady course and the tugs should be warned about engine manoeuvres.

Tug approach manoeuvres

- Most captains say that tugs should only approach the ship for securing when the crew is ready. More than half of the pilots prefer to instruct the attending bow tugs to approach the bow only when the ship's crew is ready to send a heaving line. Some rely on tug masters' experience.
- In general most tug masters keep pace with the ship; some will approach the securing position at the ship from behind.
- If securing at the bow of a container ship, almost half the tug masters will keep pace with the ship and will steer slowly towards the bow, regardless of tug type.
- tug masters may wait right in front of the ship till it comes closer, while some will wait in front of the bow and somewhat to port or starboard, which is much safer in case the tug suffers engine failure.
- ASD-tugs that operate in the conventional mode will overtake the ship and will then carefully manoeuvre towards the bow.
- If securing at the bow of a loaded bulk carrier or tanker, the same approach manoeuvres as with container ships are used by approximately the same percentage of tug masters.
- There are a large variety of answers regarding the preferred location to pick up the heaving line, due to the different tug types and operating modes.

In case of securing at the bow of a container ship, the position straight in front of the bow is often preferred, but the position near the forward shoulder is also popular, particularly for ASD-tugs operating in the conventional way. For bulk carriers and tankers there is more preference for the forward shoulder. Most prefer to pick up the heaving line at the most forward position. The lee side is often mentioned as the preferred location, which is understandable.

Safe connecting procedures

- Regular meetings between port authority, pilots and tug masters about proper procedures.
- Day-to-day communication between pilots and tug masters to alert tug masters to problems e.g. high Dead Slow speeds, deep draft vessels, SWL of bollards, poor seamanship on board ships, etc.
- Optimum communication needed between ship's crew and tug.
- Training should include safe procedures.
- Ship should have safe procedures and implement them.

Complaints:

- Improper heaving lines used.
- Ship's crew often creates unsafe situations.
- Towline eye is not positioned on the lowest part of bollard.
- Knowledge of towing in the conventional way is being lost.

Safe speeds

- Safe speeds depend on tug type. For instance, safe speeds for tractor tugs can be higher than for conventional tugs. Weather conditions and tug master experience play a role as well.
- Discussion between pilots and tug masters is very useful.
- Not all ports operate with bow tugs towing on a line.
- Safe speed to be based on what speed a tug master can drive his/her tug in a controlled manner (particularly going astern for bow-to-bow) on one engine. Once this speed is established for the specific tug, prevailing conditions and competency of the tug master, it is recommended to take one knot off the figure and that will be close to the safe connection speed.

How to reduce speed

The following manoeuvres are mentioned to reduce speed if it is too high:

- Stop engine frequently for as long as safety permits. If there is sufficient room, use fish-tailing with rudder. Abort approach and prepare anchors if necessary.
- Apart from the above suggestions a very good solution is to make a stern tug fast to assist in reducing speed.

Complaints:

- Many container ships have a Dead Slow Ahead speed of 10 knots or more.

Final remarks

- Proper communication and information exchange needed (and emergency communication sets).
- Proper heaving lines should be used.
- Training is a must for everyone involved. Refresher courses. Experience.
- Know your tug capabilities and limitations (this applies to planners as well), local conditions and interaction effects.
- Tugs should be on time and ship's crew ready.
- Know the speed and ask to slow down if speed is too high.

- Sometimes tug masters make fast if speed is too high, even if they are told by the pilot not to do so.
- Young tug masters are sometimes too shy to ask the pilot to slow down.
- Keep sufficient reserve power.
- Towage companies, port authorities and pilot organisations to set maximum ship speeds for tug operations in general and for bow-to-bow operations in particular.
- Line throwing systems needed.
- Released towlines to be lowered carefully and slowly to the tugs.
- Lighter towlines with higher SWL needed.
- Set up an International Incident/Accident database. Set up a means of Formal Safety Assessment. Instigate Failure Mode & Effect Analyses for tugs to avoid single point failures, especially at the design stage. All these will help to avoid possible catastrophic failures for the forward tug.
- Why bow-to-bow? Use tractor tugs, or push pull method.
- Never connect a side tug before front tug is connected.
- Knowledge of towing in the conventional way is disappearing, and the knowledge is not being passed on, which can be dangerous.

PARTICIPANT 10			
BUSINESS OF ORGANISATION	*SHIP OWNER*	**POSITION**	*MASTER MARINER*
WORK PROFILE/EXPERTISE	*SHIP OPERATION*	**WORK EXP**	*19 YEARS*
LOCATION	*SINGAPORE/MUMBAI*	**DURATION OF INTERVIEW**	*70 MIN*

For ADMIRALTY GROUP
Verified By
Date : 12/11/15

REPLY TO QUESTION 1

The worst case scenario is of course a crew member getting injured.... Accidents always happen while you are unprepared, believing the operation to be going smoothly and efficiently.

You think you are in control doing what you always do while mooring and suddenly you are in the middle of a situation you never thought as possible with a major crisis to be managed – immediately and afterwards....

Ship handling towage from conventional single-screw tugs is giving way to increasing choices of technologies matching tug types to individual port profiles.... ASD drive, tractors, reverse tractors and Rotor Tugs are modern examples but it is important that ship's crews understand their different operating modes, the guidelines explaining not only what you see but what is below the waterline.

Making the towing connection is critical considering the close vessel proximities and human physical involvement with best practice being explained including an alarming picture of items of heavy marine hardware used as heaving line weights.

Ensuring a safe conclusion to what in many ports is an evolution occurring many times daily depends however not only on the vigilance of the ship's deck crew: decisions taken in the isolation of the wheelhouse (from where the tugs are often not visible) can have serious outcomes if not communicated adequately and the consequences of certain manoeuvres understood.

Pilots will be familiar with ship-assist operations, often accompanying tugs as part of their training but a detail as simple as referring to the tug's name rather than its skipper's name when conveying instructions is highlighted in assisting the vessel's bridge team understand what is happening.

Situations including reduced visibility and foul weather are explored along with the merits of towing winches versus towing hooks. The "do" and "do not" section provides a virtual checklist, items intentionally repeated in both sections (in opposite ways) to increase the chances they will be noted and remembered.

Mooring is the operation performed first and foremost by the deck crew as the ship reaches the port – but it is also one of the most difficult, complex and dangerous jobs on board. Mostly things turn out safely. But sometimes an accident occurs and this usually has severe consequences.

Several cases have been reported in the past about accidents during mooring operations and many of them have led to severe injury or death of seamen.

Mooring, towing and hauling impose enormous strains on lines, warps, gear and equipment and major forces are involved. Therefore – take care and think carefully when mooring – especially ships with structures that make it hard to oversee

what is happening. Also on ships calling at different ports the specific mooring arrangements may differ considerably.

As humans we tend to believe that things are safe if nothing happens. You might say that the norm for what we believe is dangerous decreases over time. Normally mooring goes well, but as time goes by, the level of safety slowly declines. Maybe you lose concentration, maybe you slacken your procedures just a little bit, maybe you get a little complacent. And then it suddenly happens – not because of one fact to Factors can be found in

- Equipment
- Work processes
- Crew qualifications
- Crew concentration
- Ship's safety culture
- Weather

Preventing accidents is about reducing the risks of those factors. The only parameter that is hard to overcome in this respect is the weather.

Please describe various safety issues in towage operation and your recommendations to deal with those?

THREE COMMON REASONS FOR ACCIDENTS

- Seamen standing in bights or snap back zones and when lines part, those involved are often injured.
- Insufficiently trained crew are used during mooring operations and they are often seriously injured if something goes wrong.

- The person supervising the mooring is also involved in the operation and is unable to carry out his role effectively.

Although a routine job, mooring often involves huge stress for the teams. There is often little time to prepare, so it is important that all are involved and fully aware of the limitations of the mooring process and that all use their best efforts so that the crew involved in mooring can act as a team.

There are very few rules that apply to all mooring operations, but the following dangers should be absolutely avoided in any situation.

It is also important to remember basic seamanship. Take the time to consider your own and your shipmates' work and the work of those who are new or unfamiliar with the ship.

Overall, the mooring operation should have a fixed rhythm and coordination, with crew both fore and aft depending on each other. Timing is often a vital factor when making fast the various lines and if it is not done right the first time, it can put safety at risk.

The owner and/or master must develop a procedure to ensure that the vessel can be moored safely. The master is responsible for mooring the ship and to ensure that suitable mooring equipment is provided and properly stored. Before leaving the ship the master must ensure:

- allowance is made for tide conditions and weather
- unauthorised entry is restricted
- legitimate access of other vessels to facilities and navigation channels is not restricted
- the ship is secured to prevent any movement which could cause damage to the ship, it's berth, any other ship, or property
- the ship is moored in the traditions of good seamanship
- all machinery and associated systems, including LP gas installations are isolated and/or secured to prevent accidents or pollution.

Towing

The master must have procedures in place and must consider the following before towing another ship:

- ships at sea are only obligated to attempt to save life. Property rescue should only be considered when, in the master's opinion, there is no perceived risk to the crew and ship
- the vessel should be capable of towing or being towed by a vessel of similar size
- the tow should be made fast to the towing ship forward of the rudders and propellers so the ship will retain steerage. If this is not practical, a bridle using a running block can be arranged to move the effective towing point forward and retain steerage, even though the tow is attached to the stern of the ship

- the towing load should be distributed evenly across cleats and bollards, or if a strong point is provided for that purpose the tow should be attached to it
- messenger lines or a dinghy can be used to carry the towline to the tow if it is difficult or dangerous to come in close to the tow
- a means of communicating between the two ships must be established (radio, voice, flags, hand signals)
- the master will make provision for the rapid slipping or cutting of the tow in an emergency situation
- ensure the appropriate day shapes and lights are displayed
- consider contacting insurance companies/owners.

Reducing speed

Regarding reducing speed pilots made following remarks:

- If speed is too high I refuse to let tugs make fast.
- I try to slow down by stopping engine frequently.
- Stop engine for as long as possible and, if there is sufficient (sea) room, use fishtailing with rudder.
- Slow down or abort approach.
- Immediately make a dramatic change in ship's engine settings or stop.
- Maybe there is a possibility to connect stern tug to reduce speed.
- Put wheel hard over several times and stop engine (kick ahead if necessary to maintain required heading).
- Slow down the ship. If necessary, stop engines and/or prepare anchors for letting go.
- Many container vessels have a Dead Slow speed of 10 knots or more. Very dangerous!!

Safe speeds

Pilots made following important remarks regarding safe speeds:

  - Speed to be 6 kn.
  - Some ports have a pre-agreed maximum speed of 6 knots, or 5 knots for bow-to-bow connection.
  - Some pilots say that they usually reduce speed to 6 knots, while others trust the tug masters' insight.

- One pilot has the opinion that tugs should always approach from the side so they can judge the ship's speed more accurately, much better than when approaching from ahead.

Too high ship's speed

- Even if I tell the tug masters about speed and when to make fast, they make fast when they like, even when ship's speed is too high.
- I don't expect any tug master to make fast at speeds he considers unsafe.
- Some (young) tug masters are too shy to say: SLOW DOWN. I WILL NOT CONNECT. Everything is on tape and after an accident the tug master can explain.
- No need to approach ships doing a high speed: they can be controlled easily and don't need the assistance of tugs; tugs cannot assist at high speed.
- Communications and information exchange
- Better communication between pilot and tug. If I sometimes want to delay the securing of the tugs, the tug master is already making fast. I don't need them at 9 kn speed.
- Don't know if towing companies have guidelines for maximum speed to approach a ves-sel, depending on tug type, etc. Better communication needed between tug master and pi-lot about safe speed.
- Always discuss any manoeuvre with the tug skipper before starting. Have regular pi-lot/crew seminars.
- Tugs should never approach a ship before being in VHF contact with master or pilot.
- Good communication is very important. Tug master should inform pilot if he thinks speed is too high. Pilots should inform crew to use good heaving lines, to follow instructions from tug master, tell tug crew when the line is on the bollard and keep the pilot informed.
- More and better communication and never assume!!!
- Clear and proper communication! Use line throwing guns on (bow) tugs. Use standard communication phrases for tugs and pilots. Have proper emergency communication procedures in case of communication breakdown (e.g. VHF failure) like in Rotterdam.
- Tug master should keep the pilot informed about what is going on. A camera at the bow is another possibility.
- Tugs should be on time. If not, inform pilot so he can slow down.

Safe procedures for connecting and releasing

- Use line throwing guns, so tug can stay out of danger zone while connecting.
- Too often tow lines are caught in tug propellers when tugs are released on ships making way. With respect to this one pilot gives several recommendations.
- When letting go the towline of a stern tractor tug, instruct crew to lower towline and messenger slowly on the tug, to keep it out of the thrusters.
- In the future I will have a final check whether the crew is ready before the tug is approaching.
- Tug should always have enough reserve power to escape. The use of proper heaving lines prevents the tug approaching too close to the bow. Make ship captains aware of the danger for tugs when making fast.
- Tugs should never secure when sailing astern, as with the ASD-tug `Fairplay 22', if the tug is not able to stay safely in that position.
- In case wave height has a large influence on tug manoeuvring when approaching the bow, make it possible to pass towlines inside the port area; pass heaving line from the forward panama fairlead to the tug when sea conditions improve and allow.
- Don't approach bow to bow, but from the side, and get the ship's crew to run the heaving line from the shoulder to the centre lead.

Training

Better training of tug masters, with focus on PEC holders with limited training and less experience in tug use. More training for deck crew on this specific issue.

Finally

Set up an international incident/accident database. Set up Formal Safety Assessments. Use Failure Mode & Effect Analysis for tugs to avoid single point failures, especially at the design stage. All to avoid possible catastrophic failures for the forward tug.

PARTICIPANT 11			
BUSINESS OF ORGANISATION	*TUG BUILDING*	**POSITION**	*SR NAVAL ARCHITECTURE*
WORK PROFILE/EXPERTISE	*NAVAL ARCH/TUG OPS*	**WORK EXP**	*22 YEARS*
LOCATION	*SOUTHAMPTON UK*	**DURATION OF INTERVIEW**	*130 MIN*

For ADMIRALTY GROUP
Verified By
Date - 12/11/15

REPLY TO QUESTION 1

Being a good employer we live up to our responsibility and commitment to ascertain healthy and safe working conditions for all personnel engaged in our operations.

We always try to limit their impact on the environment and committed to deliver quality always on time. It is the company's goal to ensure safety in ships operations, to ensure the safety of the crew and to avoid damage to property and the environment.

All owned and managed vessels are operated in such a way as to minimize Health and Safety risks of the crew and to protect the environment in accordance with international conventions and with national and flag state regulations.

To achieve these goals a safety management system has been implemented. Applicable codes, guidelines and standards as recommended by administrations, classification societies and organizations within the maritime industry, will continuously be taken into account.

Training, equipment and procedures are provided to minimize the impact to the environment during all operations, whether it be towage, offshore support, salvage or other operations.

Every employee ashore and onboard our vessels has to contribute to our goals as it is a team effort.

Recent accident investigation reports suggest that merchant seamen continue to be injured during mooring and towing operations. A clear plan of operation and good communications between the tug and tow, prior to operations commencing, will reduce much of the risk. Ship managers need to ensure their crews are fully briefed to ensure the successful performance of the operation and that all safety issues have been highlighted.

Although all ships are different to some degree, with varying equipment for mooring and towage, there are some basic principles which are common to all and which allow the towing or mooring operation to be done in a safe and efficient way.

It is easy to become complacent, when the towing or mooring operation is a frequent event and, because, of this, there is a constant need to be reminded of safe practice. When towing and mooring operations are less frequent, crew have an equal need to be reminded about associated hazards and safe practice prior to the operation.

Stability

Conventional tugs in particular can experience very large tow line forces, sometimes in excess of the bollard pull. Good static and dynamic stability is required to accommodate the high forces likely to be experienced.

The IMO has established criteria, including statical stability curve requirements applicable to vessels over 24 metres in length on international trades. Other administrations and classification societies have set their own standards for small tugs and workboats. The International Association of Classification Societies (IACS) in 1998 recommended additional stability criteria, but these are not mandatory. The stability requirements, especially for smaller tugs and work boats, are not internationally harmonised and do not always take account of high towline forces. Even though the amount of stability data available may be regulated by the flag state or classification society, it is possible that no specific data is available on board accounting for the high towline forces. The tug master should be aware of the safe stability requirements for his vessel.

The stability of a tug is determined by the heeling moment occurring during towing and what safety margin is applied. Authorities can judge safety margins differently.

The heeling moment is caused by:

- The tow, when the tug is dragged by the tow line.
- The tug, when the heeling moment is caused by the combined action of its rudders, propellers, towline or hydrodynamic lateral force on the hull.
- A combination of the above.
- Water ingress.

Tug masters must be alert to the danger of capsizing which can occur when the tow wire/rope reaches a large angle to the centre line of the tug and the quick release cannot be activated and girting occurs. If girting is experienced tugs with towing hooks forward of the propeller system can find it difficult to recover. Contributory causes allowing a tug to capsize in a girting situation include:

- Small freeboard.
- Poor stability curve of righting levers.
- Weathertight and watertight openings not secured correctly.

To reduce the dangers associated with girting, particularly with small tugs, the following is recommended:

- The towing gear should minimise the overturning moment due to the lead of the towline, including the position of the tow hook and winch.
- The towing hook should have a positive, reliable means of quick release able to operate in all conditions.
- The release mechanism should be designed to be activated locally and from the wheelhouse. All crew members must be familiar with the characteristics of the system and it must be tested frequently.
- Maintenance of the towing gear must be carried out by competent persons.
- Openings such as watertight doors and ports must be kept closed during towing operations.
- Engine rooms should be fitted with high coaming ventilators; air pipes should be fitted with automatic means of closure.
- Utilisation of a gog/gob wire.

REPLY TO QUESTION 2

Stability of towed unit

We have experienced numerous claims that have arisen from inadequate stability of the barge, in particular those used in the carriage of containers. How to calculate the stability of a barge with cargo stowed on deck is important. The stability of the barge or towed unit should be assessed by the tug master or recognised organisation. This would include checking if tanks are empty or full to reduce free surface effects (FSE), all openings are closed and appropriate freeing ports operational. Effects of any ballasting needed during the voyage should be taken into account.

Some organisations have produced guidelines on the intact stability of the towed object and Members should check and verify this with their overseeing authority.

Other considerations should include:

- The Metacentric height (GM) should be positive throughout the intact range. The GM should include a margin for calculation error. GM should never be less than 0.15 metres.
- FSE should be considered, including cargo and ballast free surface.
- Effects of potential icing evaluated.
- Dynamic stability requirements for the barge/barges are met.

Maritime New Zealand 'Barge Stability Guidelines' provides information on the subject of pontoon barge stability. In respect to barge stability the following information should be ascertained before towage commences:

- Know the lightship displacement of the barge before loading.
- Know the lightship centre of gravity (KG) for the barge.
- Know the weight and centre of gravity of the cargo.
- Be aware of the block co-efficient of the barge.
- Be aware of initial metacentric height (GM) and know how to calculate it for the loaded barge using the rectangular block formula.
- Know how to calculate the combined KG for the barge loaded with its cargo.
- Be aware of the limiting KG curve and have one available for guidance in loading your barge.

It is important to ascertain that the stability information set down for the vessel being towed is current.

Bollard pull (BP)

When a tug is hired the chartering party requires knowledge of the BP of the tug i.e. the pulling capability of the tug. The charterer will know what the required BP is for the contract, either through experience or it will have been calculated. When newly built the pulling capability of the tug is measured using a load cell under certain conditions, including the main engines being at the manufacturers maximum recommended torque for a continuous period of 30 minutes. The classification societies have their guidelines on how the BP should be measured.

Problems can arise where the tug is chartered to carry out a task that requires a certain BP rating. The specification given to the charterer will usually be as per the BP certificate. The tug will have on board documentation, including a certificate issued by a competent authority proving the BP. It is not unexpected that as the tug gets older, the efficiency of the main engines and equipment will decrease the BP. It is generally accepted that if the BP certificate is less than 10 years old the BP rating is as stated on the certificate. Surprisingly some older tugs have actually produced a higher bollard pull than that recorded when the tug was built and this is often thought to be due to unsuitable conditions at the testing site which may have included one or more of the following conditions: insufficient depth of water, insufficient length of towing gear, high wind speeds, poor tidal conditions or a damaged load cell.

Other factors may also affect the tugs efficiency, e.g. age, appreciable hull growth, propeller condition and high sea water temperatures. Another factor identified in fatal accidents is when a tug is using a shaft alternator during a tow. Therefore the main engine output will be reduced and consequently the BP is reduced. This fact should always be taken into consideration when in an operational mode.

For tugs less than 10 years old with no valid BP certificate the BP can be estimated as (1 tonne /100) x Brake Horse Power (BHP) of the main engines. For tugs over 10 years old without a valid BP certificate the BP value can be estimated as 1 tonne/100 x BHP reduced by 1% per year of age greater than 10 years4.

A tug master should always be aware of the commercial demands made of his tug and that the tug is able to comply with those demands.

Pivot point

It is important to understand the effect of the pivot point on any vessel but particularly with tugs when towing. Knowledge of the pivot point assists the tug master to understand how the unit being towed will steer in different situations. A floating unit rotates about a point situated along its length called the pivot point and when a force is applied, it will turn about this point. These forces could be rudder movements, the tug pulling in one direction, wind or current. The position of the pivot point will change due to speed, draught, under keel clearance, rudder size/type, tug construction and hull form.

It is also important to understand how the pivot point of the towed unit changes. A ship or barge stopped in the water, with no external forces applied, will have a pivot point coinciding with the centre of flotation which is approximately amidships. When a vessel is making headway the pivot point will move forward. Generally it will move about 25% of the towed unit's length towards the bow when moving ahead and vice versa if moving astern.

For example if a barge is moving forward towards a berth being assisted by a tug 'breasting' the barge alongside and the tug is positioned at the barge's pivot point there will be no turning of the barge. If the tug is positioned away from the pivot point there would be a turning motion on the barge; the further away from the pivot point the greater the turning momentum.

A moving barge or ship will travel laterally or drift across the water when turning because the pivot point is not located at the craft's centre when moving forward. It is useful to be aware where the pivot point lies on the assisted vessel and how lateral movement can cause sideways drift. This awareness is crucial when manoeuvring close to hazards.

Position of tug and interaction

The position of the tug is always important especially when assisting a barge or vessel. The safe position of the tug relative to the assisted unit depends on many factors which include the size and pivot point of the unit, the number of tugs assisting, the speed of the unit being assisted, the depth of water, and amount of manoeuvrable room, currents and winds. Often when assisting a barge or vessel the tug will have to make fast with a towline. If the tug is to make fast to the barge with its own crew the risks are obviously increased, more so in poor weather.

The phenomenon of interaction is well known to mariners and it is particularly dangerous in situations where there is a larger vessel or barge moving at speed in close proximity to another smaller vessel, such as a tug. The effect is increased further in confined and shallow waters. Tugs and smaller vessels have capsized as a result of this, particularly when being overtaken by a larger, faster vessel in a confined waterway, such as a river or channel.

When a tug approaches a vessel or barge that is going at a moderately fast speed through the water there are various suction and pressure forces around the vessels hull – the greater the speed, the greater the effect.

Approaching the forward end of a ship or barge

If a tug approaches a vessel going ahead at speed forward of the pivot point it will be pushed away and if approaching from aft of the pivot point there will be little or no suction effect. This suction effect will increase as the tug approaches the vessel's stern or quarters, as the water flow increases due to the hull shape or increased water flow from the ship's propellers. The amount of force felt is related to the distance from the hull of the vessel. The force can also be increased by reduced water depths or confined water areas such as narrow channels.

Approaching the aft end of a ship or barge

When a tug approaches the aft end of a ship or barge there is considerable suction effect. This effect is dependent on how close the tug is to the barge or ship, speed and the shape of hull form around the stern. The suction effect can be huge and the tug is unable to manoeuvre away. This can result in damage to the tug as it is dragged beneath the ship's counter (when the ship is in ballast) or towards the ship's propellers.

Another effect of interaction is water flow around larger moving vessels acting on the under hull of the tug. This can cause a decrease in effective stability and increases the possibility of the tug capsizing if the two vessels come into contact.

Accidents occur if the tug and unit being assisted are not similar in size and the speeds are relatively high, in one case a tug with a 2 metres draught was making fast to the starboard bow of a ship with a draught of 3 metres. The tug was proceeding at about 4 knots parallel to the ship, gradually pulling ahead until about 6 metres abeam of the ship's forecastle. As the tow line was being passed the tug took a sudden shear to port and the two vessels touched before the tug master reacted. The impact was minimal in this case however, in seconds, the tug took a starboard list and capsized resulting in a fatality. Research confirms that the following consequences happen with hydrodynamic interaction:

- Interaction effects are increased in shallow water.
- Rudder effectiveness can be reduced in shallow water.
- Squat effects are increased in shallow water and the risk of grounding is enhanced.
- Transverse thrust of the propeller changes in shallow water.
- Changes in manoeuvring characteristics are experienced in shallow water.
- A large vessel or barge with small under keel clearance which is stopped in an enclosed basin can experience strong turning forces.

Towing Equipment

Towing equipment generally includes the equipment on the towing vessel and towed object which may include: towing winch, hook, drum, fairleads, towing pins or hydraulic jaws (if fitted) and towing gear. Towing gear includes tow lines, wire ropes, gob wire, bridles, chains, pennants, eye plates, towing rings and shackles.

General

Again, before every towing operation the towing gear should be visually inspected and tested.
Towing arrangements and equipment should conform to the following:

- All the towing equipment and gear, towing hook and fittings should be strong enough to withstand all loads imposed during the tow and fully certified with up to date tests in place.
- Ideally the towing hook or towline should have a means of release which can operate in all conditions. The release mechanism should include both remote and local controls. The operation of this equipment is to be fully understood by the crew.
- Navigation lights are rigged and are capable of remaining alight during the hours of darkness for the duration of the voyage. Navigational shapes are to be made available for daylight navigation as appropriate.

To reiterate, for the equipment to be in good order there has to be a regime of inspection and maintenance on board the tug as part of a company planned maintenance system (PMS). It is not possible to operate a tug safely without an effectively operating PMS. The PMS should include other critical systems on board, such as the main engine and electrical power systems.

Planned maintenance system (PMS)

Planned maintenance systems can be sophisticated computer based, giving real-time data back to the technical office and sometimes these systems are approved by a classification society. Or, they can be simpler paper based systems, but no less effective. Whichever PMS is in place, it is important that maintenance of critical equipment is monitored and recorded and this includes the towing gear. If no records are kept and there is no reliable knowledge on what has been inspected or overhauled, in good or poor order.

The PMS should include:

- Towing hooks and arrangements.
- Towing hook quick release systems.
- Hydraulic systems, pins, sharks jaws or equivalent.
- Towing winches.
- Bollards, fairleads and sheaves.
- Ropes and wires.
- Ancillary equipment, i.e. shackles, thimbles, eyes, rings, plates.

All PMSs require a structure to ensure equipment inspections on a regular basis, weekly, monthly or annually – whatever is considered suitable by the company or by legislation. The time between inspections of equipment will depend on their criticality and their amount of usage. The PMS should also include the maintenance, testing and keeping of test certificates for the different equipment.

New lifting and towing equipment and wires should always be received on board with approved test certificates. It is important to maintain an ordered system for all test certificates including wires, pennants, stretchers, ropes, towing plates, shackles, rings, bridles and other towing or lifting equipment.

It should be noted that whenever accidents have occurred as a result of equipment failure it has been found that the equipment was not maintained correctly and/or was repaired incorrectly by an unauthorised or inexperienced person. The use and failure of welded fittings where the welding was carried out by unqualified staff or the welds were not inspected or tested by an appropriate person has often been the cause of personal injuries.

Many port and river authorities will require that inspections and testing of towing equipment should be regularly carried out and appropriate records maintained.

Testing and certificates

It is important that the company and tug master are aware of the regulations required for the testing and inspection of the towing gear and equipment. Regulations may differ depending on location and the following is usually an accepted guideline if no other guidance is available.

All towing gear, hooks, shackles, winches and wire ropes should always be provided with test certificates when new and kept as a record. All gear should be tested and re-certificated by an approved contractor every five years or after any significant repairs have been carried out. Mooring ropes also should be issued with certificates when they are new.

Keeping track of wires and shackles (with their certificates) is important and the PMS should allow for this. Apart from the visual inspection of all gear before a towing operation commences, all gear should be formally inspected annually by a competent person. This could include the tug master or experienced crew person.

In the event of an accident the ability to prove that the gear was in a good condition with all the certification and tests in order is a strong indication that the tug was operating to the correct standards and in addition assists the Club with the defence of any related claim.

All damaged equipment should be isolated and removed from operation. If it cannot be repaired properly by a competent person it should be condemned and discarded. Damaged equipment should never be used.

Towing winch

Towing winches come in different designs and sizes and the workings of winches should be understood by those using them. The manufacturer's manual should always be available on board to refer to. If the tug is provided with additional secondary winches these should also be included in the PMS.

Clear operating instructions in the appropriate language should be available near all the manual and emergency controls. The working of the winch emergency release system (ERS), if fitted, should always be understood by those operating the winch.

Checks on the towing winch should include:

- Effective operation of the braking system.
- Winch power and hydraulic systems.
- Signs of corrosion or fractures on the holding bolts, welds and supporting deck.

- Effectiveness of the emergency release from the wheelhouse and/or the local activation point.
- Effectiveness of the spooling mechanisms.
- Connection end of the towline should always be fixed but with a force of less than 15% of the breaking load of the towline.

The towing winch brakes should provide a static holding capacity of at least 1.1 times the breaking load of the tow line.
There are no accepted international standards for tug tow line ERS. Following many accidents, particularly those that have been caused by girting, it has been found that the ERS for the towing winch or the towing hook failed or did not operate quickly enough to prevent the tug from capsizing. It is important for the crew to be aware of the operating limitations of the ERSs on board their vessel. There have been cases where some older types of manual ERSs have not released when there was an excessive load on the tow wire/hook. These should be tested at the earliest opportunity to ascertain the operating parameters and if necessary then prominent notices must be put up at the winch/towing hook and on the bridge that some weight must be taken off the tow line before the emergency release can be activated.

Towing hook

The maintenance of the towing hook should be included in the PMS and thus inspected regularly and visually before each tow. The towing hook release mechanisms should be tested and recorded to ensure that the hook releases properly.
Damage to the towing hook (or other essential equipment) must be reported and not used until the damage is rectified.
Generally it is not regarded as good practice to utilise towing hooks for ocean passages.

Bollards, fairleads and sheaves

Checks should include:

- Regular inspection for wear, excessive corrosion and wastage.
- Inspection for fractures to welds and supporting structures.
- Ensuring that all rotating sheaves are properly greased and free.

Towlines, wire and synthetic ropes

The care of wire and synthetic ropes, including stretchers, is an important part of the PMS. Formal guidance on how to inspect, stow and maintain ropes and wires should be provided.

A major issue is trying to maximise the service life of rope and still maintain safety. All tug's deck crew should be trained in rope inspection and gauging when a rope is damaged and is no longer fit for purpose and safe for use.

Maintenance guidance and checks on ropes should include:

- Pennants inspected prior to every use, annually and tested after a suitable period or five years.
- Main tow wire 'end for end' every year, and replaced when appropriate.
- Main tow wire physically inspected every month and/or before each tow.
- Main tow wire physically inspected after every deployment for damage and abrasions such as:Ultra violet (sunlight), heat or chemical degradation.
- Wear, broken, cut or fused strands.
- Overstretched rope (can reduce the effective diameter of the rope).
- Distortion and kinking of the rope, particularly wire rope indicating that the wire has been severely stressed.
- Rope not properly stowed can degrade, for example synthetic rope can deteriorate, become mouldy if stowed wet with no proper air flow.

All towing pennants should have the same lay as the tow wire with a Minimum Breaking Load (MBL) of not less than the tow wire.

The tow wire minimum breaking load should never exceed the breaking loads of the connecting points or equipment. A suggested general rule is that the tow wire and springs and towing hooks should have a Safe Working Load (SWL) of at least 2.5 times (some suggest 3 times) the bollard pull of the tug.

Ancillary equipment

Ancillary towage equipment, such as wire towage protectors and thimbles should be regularly inspected and form a part of the PMS.

Sufficient tow wire protectors should be on board to prevent the tow wire from excessive chafe. These can be in the form of custom-made polyurethane sleeves which are exceptionally durable/resilient and are usually employed as a protection on tow wires. The simpler method for short towing voyages is just by wrapping the chaffing part of the tow rope with a piece of hawser or gantline and coating it with a bit of grease. Care must be taken to not to overdo the grease in case it causes an oil sheen in water during adverse weather including rain.

A powered workboat which the administration may accept as being a part of the life saving equipment should be available for use as an inspection boat when towing a barge. The tug should be

fitted with adequate launching devices to lower the boat in open sea conditions. All personnel should be wearing appropriate PPE at all times and be trained in the launching of the boat.
An operational searchlight should be available to illuminate the tow at night.

Navigation lights and shapes

The tow shall carry the lights and shapes required by the International Regulation for Preventing Collisions at Sea, 1972 amended 1996 and any local regulations.
Navigation lights should be independently powered and the fuel or power source should be adequate for the maximum duration of the towage with reserve. It is also advisable for a searchlight to illuminate the tow to be available.
Towed objects where necessary should be fitted with a radar reflector mounted as high as practical.

Safety factors

There are no statutory international guidelines.
A tug master should always be aware of the condition of his tug and its equipment. As a guideline, steel and fibre tow wires/ropes should have a Safe Working Load (SWL) of at least two to three times the BP of the tug. This safety factor can also be used when considering the towing hooks and fittings.

PARTICIPANT 12			
BUSINESS OF ORGANISATION	*MARINE CONSULTANCY/TRAINING PROVIDER*	**POSITION**	*SR TRAINER – SIMULATOR*
WORK PROFILE/EXPERTISE	*TRAINER/SAFETY ANALYST*	**WORK EXP**	*23 YEARS*
LOCATION	*SOUTHAMPTON UK*	**DURATION OF INTERVIEW**	*60 MIN*

REPLY TO QUESTION 1

As tugboats become more sophisticated in design, resulting in powerful and highly manoeuvrable tugs that are servicing larger ships with less assets, a superior standard of tugmaster competency and operational knowledge is required, especially when considering current manning levels. Time and time again on my travels as a consultant, I see how tugmasters' skill-sets are insuffi cient to safely, effectively and competently operate today's new generation of tugboats. By the very nature of the work, tugmasters tend to remain in a port and have little, if any, outside influence or stimulus, in effect becoming inwardly focused.

Only over the last decade or two have omni-directional tugboats become the norm in ports; to a large extent the original tugmasters were left to their own devices, with no formal or appropriate training to figure out how to operate omni-directional tugs effectively. This has resulted in mixed abilities, usually based on an adaptation of conventional twin-screw knowledge. This original generation of omnidirectional tugmasters, with the best of intentions but in ignorance, has then passed this inferior skill-set on to the next generation of omni-directional tugmasters.

Previously this was to some extent manageable, as the earlier classes of omni-directional tugs were more forgiving owing to their:

- heavy deadweight;
- higher length/width ratio, giving good course stability;
- relatively low horsepower; resulting in, by today's standards, a slow-responding tug.

The new generation of highly manoeuvrable, lightly built and powerful tugs, commonly around 30m LOA or less and upwards of 6,000hp, are far less forgiving of inferior or inadequate skills and driving techniques. These tugs are best described as the 'Ferraris of the sea' and, as with any high-performance vehicle, require specialised skills, both to operate to their full potential and also to use safely at the same time. Literally every time the tugmaster moves the control levels, even minutely, the tug responds instantly, particularly in the case of individual controls.

Of the many variables the controls can create, there is only one correct combination and this changes all the time that the tug is operational. A tugmaster does not have the luxury of time to fi gure out how to get it right.

Added to this, tugs have now been de-manned to a point where tugmasters have a lot more on which to focus, and multi-function items with which to contend, than previously.

Given the varying and constantly changing forces, infl uences and requirements while operating in close proximity to a ship, the tugmaster is continually assessing and making alterations to control settings.

To do this correctly and effectively in a timely manner, say when it is 2am and you are tired, there is a howling gale and the pilot is demanding responses, requires competencies of an extremely high standard.

Remember that when a tugmaster gets it wrong, people can get hurt and assets damaged.

REPLY TO QUESTION 2

As with all industries, times and standards are changing. In ours, commercial pressures are demanding safe operations, higher skill-sets, lower operating costs but, at the same time, shorter training periods.

The first step to resolving any problem is recognising there is an issue to address; reassuringly things are improving as managers and authorities are now realising the need for proper professional competency based training for tugmasters, while accountants are realising training is an investment that pays dividends. This commercial need is further supported by Resolution 8 of STCW95 – promotion of technical knowledge, skills and professionalism of seafarers, which basically states: "A seafarer must not only be qualified to fulfil an operational role on board a vessel, but also be competent to perform the assigned role."

Following investigations into a number of tug incidents, in 2005 the UK Marine Accident Investigation Branch (MAIB) strongly urged:

1. All tug operators review their training schemes to ensure that tugmasters receive comprehensive familiarisation training before taking control of a tug that is equipped with significantly different

propulsion systems. Such training should incorporate instruction and validation on all manoeuvres that the master is likely to undertake in their port or operations;

2. All harbour authorities, pilots and tug operators regularly review the capabilities and limitations of their harbour tugs and their crews;

TRAINING PROGRAMMES

Professional towage companies have come to the conclusion that the cost of training is an investment.

There is no doubt that training is vastly more cost effective than repairing people, vessels, third party assets and the company's reputation. Furthermore, in the event of a serious incident, companies are now being called upon in court to prove their operating standards are appropriate and their tugmasters are competent.

As an example of a professional training programme, the Seaways Tugmaster Training Program has six differing modules that clients can elect to take. All have unique skill-sets to suit differing towage operations, ie training for a harbour towage operation involves four streams of training taking place simultaneously:

- ASD Tug Handling;
- Undertaking Harbour Towage Operations;
- Learning the company's Safety Management
- System (SMS) and procedures;
- Learning the management of the tug, including PMS, booking system, ordering system, crew management etc.

The process is about setting high competency standards and then having tugmasters operate on a day-to-day basis well within their skill-sets. This ensures that when operations start to become more challenging, the tugmasters remain within their skill-sets, resulting in appropriate and safer outcomes.

Humans are genetically programmed for 'flight' or 'fight' when overly challenged. In the tugmaster's case this often results in the tugmaster, when scared, failing to respond at the controls (in some cases I've actually seen them taking their hands off the controls) or giving the controls fistfulls, and thus dramatically overdriving the tug. Both scenarios are equally dangerous.

Proper training helps to manage this. Importantly, having a highly developed and diverse skill-set helps prevent tugmasters going into sensory overload. Furthermore, if this should happen their reactive subconscious instinctive actions are the ones that have been preset via the training.

TUGMASTER TRAINING

A good training system should:

- Lay out clearly in writing the whole structure of dos, don’ts, whys and wherefores;
- Design the structure to protect the rights of all parties concerned, ie:

— the trainee;

— the training master;

— the competency check master;

— the clients (pilot and ship-owner);

— owners of third party assets (port authorities
etc);

— the towage company.

- Ensure competency-based training starts with the basic steps and works its way through listed and identified steps one by one, thus climbing a ladder of competency and confidence to an agreed predetermined standard;
- Use skilled, respected and qualified trainers who can ‘walk the talk’, who have empathy with the trainees and are adapt at getting the message across to colleagues;
- Include repetitive training that fixes the basic moves in the subconscious minds of the trainees;
- Ensure trainees are trained to competently drive the tug before undertaking towage operations;
- Give equal emphasis to operational and procedural knowledge;
- Develop a tugmaster’s professionalism in all facets of the job;
- Be designed to cope equally with timid,apprehensive trainees as well as over confident egomaniacs;
- Be based on an effective ‘style’ of tug driving using a combination of authority, control and finesse.
- Some of the inferior training programmes I have seen on my travels have included:
- Attempting to train a tugmaster to undertake harbour towage without training him first on how to effectively and instinctively handle an omnidirectional tug to its fully capacity;
- Training programmes that are time- or job-number governed;
- Training given in-house by tugmasters who are passing on their own bad habits, albeit in good faith and intent, and who have no experience or qualifications as trainers;

- Insufficient time given on controls to ensure base competency is firmly entrenched in the subconscious mind of the trainee;
- Training masters pushing the trainees way beyond their comfort zones and, in so doing, taking away their confidence and raising stress levels to an unacceptable level;
- Lack of formal structure and record keeping;
- *Ad hoc*, non-standardised training that has differing levels of skill, knowledge and competency outcomes between graduating trainees;
- Too much subjectivity in assessing whether a trainee is competent or not;
- Overestimating the benefits of simulator training, particularly in the case of trainers with questionable towage skills, experience, respect and qualifications;
- Not understanding or recognising the limitations of a simulator and the handling behaviour of tug models and that, as good as they may be, they do differ from real on-board operations.

COMPETENCY CHECKING

At the completion of training, and every 12 months thereafter, the Seaways Training Programme graduate has a formal competency assessment.

There are two parts to this assessment, operational competency and procedural competency.

A good competency checking system should include:

Operational competency

Driving the tug through a non-subjective competency circuit that comprises all the basic manoeuvres that an omni-directional tug can perform and in a style of driving that is based on a combination of:

— Authority: to ensure timely responses to the pilot's orders and minimization of effects around a ship;

— Control: to ensure safe and effective operations at all times;

— Finesse: to ensure no damage or injury when touching down alongside or to push up;

Driving on the secondary steering system;

Driving on one engine;

Emergency response exercises;

Onboard equipment and systems operation;

If 'Undertaking Harbour Towage' is a component, observing a towage operation;

If 'Undertaking Escort Towage' is a component, observing an escort towage operation;

Driving standards and skills set at an appropriate level that all tugmasters can realistically achieve;

Tug driving competency checks that are carried out in real time on board a tug, not in a simulator;
Issues which are identified, dealt with and remedied immediately by the competency check master.

Procedural competency

Recording the company's SMS, which has been read and understood by the tugmaster, within the previous six months;
Nine questions from the SMS to ensure there is a thorough working knowledge;
Three questions from the Security Manual to ensure there is a thorough working knowledge;
The questions should be relative to issues that have occurred in the company during the previous 12 months, or likely to occur in the coming 12 months;
The nine questions should be chosen to bring focus, education and better understanding and, as such, time taken by the competency check master to fully explain incomplete or incorrect answers;
Word-perfect answers are not a requirement, but a meaningful working knowledge is;
There is no failure involved; the process is about development of the tugmaster's knowledge and understanding.

A sub-standard competency check system

- Overly subjective in assessment;
- Peer group self-assessment-based;
- Has no outside influence to establish industry best standards;
- Has no outside influence to stimulate broadening of experience and knowledge base;
- Has driving standards and skills set at a level that only the better tug-masters can achieve;
- Uses simulators for the operational tug driving assessment;
- Requires word-perfect answers, rather than a sensible, pragmatic working knowledge;
- Is used as a policing tool;
- Is driven or influenced by internal politics;
- Has competency checks that are not totally without 'fear or favour';
- Has too long between competency checks, allowing bad habits to become entrenched.

BENEFIT OF ANNUAL COMPETENCY CHECKING

Annual competency checks ensure standards and skills are maintained, especially those that are rarely used, ie driving on one engine. Furthermore, in the event of an incident, both the company and the tugmaster can clearly demonstrate they have been trained and assessed to operate competently and professionally to recognised industry best practice standards and these competencies have been regularly maintained via a structured, pragmatic and independent assessment.

In my experience, it is rare that a tugmaster can undertake an annual competency check without requiring some additional training to reset skill-sets or correct bad habits. Any issues can be dealt with immediately via training as part of the competency check. As such, there is never failure attached to competency checks, because training is given to correct the issues and then the competency check redone. The whole process is about development, education and growth, not about policing or penalising, and takes some eight to 10 hours per tugmaster. A number of marine authorities, organisations, and client companies are now starting to require towage companies to have proof of professional operating standards and competency of operational personnel. The very nature of a professionally developed and administrated tugmaster training and competency-checking programme ensures this can be readily established.

Critical to the success of any training programme is that it educates and develops individuals for the common good. Specifically, competency checking must never be used in a negative or penalising manner or it will become counterproductive owing to a loss of support, credibility and effectiveness.

If a towing company decides to carry out annual competency checking internally, it is imperative it invests in training and qualifying its competency check master to ensure he is a skilled, respected and qualified trainer. The alternative is to engage an outside specialist consultant.

PROFESSIONAL DEVELOPMENT

- In many cases, tugmasters have a background either in the small boat industry, as a seaman or deckhand, or in the fishing industry. Personnel coming from this background have many enduring traits:
- Can-do attitude;
- Small boat handling experience;
- Professional work ethic;
- Small boat husbandry skills.
- But some do not necessarily have a high degree of:
- Safety culture;
- Towage industry knowledge;
- Personal presentation;

- Administrative and computer skills;
- Crew management skills, particularly in a unionised environment.
- An effective and well thought-out training programme should endeavour to address these points so as to
- ensure a fully rounded, competent and professional tugmaster who has the mindset and skills to be the
- company's on-board line manager of the facility.
- A component of SeaWays Tugmaster Training Programme is specially designed to address this.

PSYCHOMETRIC TESTING

The basis of the SeaWays Tugmaster Training Programme came from my experience in the 1990s while observing my son learning to fly F18 Hornet fighter jets. In my view, the process for tugmaster
selection can be similarly structured.
Candidates for fighter pilot training go through a rigorous selection process, including psychometric testing of the natural abilities required to fly a jet fighter in stressful circumstances. We have all met tugmasters whom we assess as 'naturals' or 'wire to drive tugs'.

PROFILE OF THE AUTHOR

Abhijit Singh is a Doctoral student with University of Petroleum and Energy Studies (UPES), Dehradun, India. He has done his Marine Engineering from Birla Institute Technology & Science, Pilani, India and MBA specialization in Maritime Management from University of Greenwich, London (UK); Post Graduate Diploma in Maritime Law from Lloyds Maritime Academy, London (UK). He is a Fellow member of Institute of Chartered Shipbrokers(ICS), London; Associate Fellow member of Nautical Institute, London; Member of Council committee for ICA(Indian Council of Arbitration, Government of India) as Maritime Arbitrator. He is Ex-Marine Engineer Officer under D.G. Shipping India and sailed widely onboard merchant tankers and bulk carriers.

He is accomplished maritime professional with more than a decade of multifaceted work experience in shipping, on-shore and as well at sea, which also includes full time initiative for higher academic credentials & various professional courses of Maritime industry. A Result oriented decisive leader, with proven success in operations, strategic planning and problem solving. He has been awardee of highly commended position in Lloyds List Awards 2015 (MEIS) in 'Next generation shipping' category. He is adept at carrying out Wet & Dry Chartering and Shipping operations with standard knowledge of International Trade practices, Port State policies & regulations and various statutory acts. He worked with many international maritime organizations of repute. As a Maritime consultant and researcher, he worked on a numerous consultancy projects including economic and environmental impact studies and market analyses.

He has published research papers in journal of repute and has authored two case studies in related to commercial shipping. He has also presented papers at various international conferences held in India.

Paper Publication

- Published research paper "Hazards analysis of Routine Ship Towage operations in Indian Coastal Waters" in International Journal of E-navigation and Maritime Economy, July 2016
- Published research paper "Critical analysis of hazards associated with Routine Ship Towage operations: Survey of Cases from Indian Coastal Waters" at International Conference on Management of Infrastructure (ICMI) 2016. It has been awarded as best research paper in Transportation category.

Paper/Case Study Presentation

- Abhijit Singh, T Bangar Raju, "Low Carbon Shipping – Hurdles on Application of Sustainable operational Solution – Admiralty Group", at International Conference on Management of Infrastructure (ICMI) 2014, held on 14-15, February 2014 at UPES, Dehradun.
- Abhijit Singh, T Bangar Raju, "Bill of Lading Dispute – Freemantle Port Australia", at International Conference on Management of Infrastructure (ICMI) 2014, held on 14-15, February 2014 at UPES, Dehradun.
- Abhijit Singh, T Bangar Raju, "Major Trends and the Possible Effects of Technological Advancements of Global Natural Gas Trade ", at International Conference on Management of Infrastructure (ICMI) 2014, held on 14-15, February 2014 at UPES, Dehradun.
- Abhijit Singh, T Bangar Raju, "Charter Party Dispute – MV Sea Pulse", at International Conference on Management of Infrastructure (ICMI) 2014, held on 14-15, February 2014 at UPES, Dehradun.

Paper Under Review

Abhijit Singh, T Bangar Raju, "Occupational Safety of Routine Ship Towage Operation in Indian Coastal waters: Hazards Identification" International Journal :Transportation Research Part A: Policy and Practice . Submitted in April, 2016.

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