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

<table>
<thead>
<tr>
<th>State</th>
<th>Number of questionnaires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gujarat</td>
<td>38</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>33</td>
</tr>
<tr>
<td>Karnataka</td>
<td>14</td>
</tr>
<tr>
<td>Kerala</td>
<td>7</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>15</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>13</td>
</tr>
<tr>
<td>Orissa</td>
<td>7</td>
</tr>
<tr>
<td>Delhi</td>
<td>11</td>
</tr>
<tr>
<td>Goa</td>
<td>5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>143</strong></td>
</tr>
</tbody>
</table>

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).
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)

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.
<table>
<thead>
<tr>
<th>Tug Boat Power</th>
<th>Bollard Pull in tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>&lt; 30</td>
</tr>
<tr>
<td>Medium</td>
<td>30 – 70</td>
</tr>
<tr>
<td>High</td>
<td>&gt; 70</td>
</tr>
</tbody>
</table>

Table 4.2 - Tug Power distribution RO1-QU

![Chart 4.5 - Distribution of Tug Bollard Pull RO1-QU](image)

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).
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).
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).

![Towed Vessel Bow Form]

**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)

<table>
<thead>
<tr>
<th>Towed Vessel Size Category</th>
<th>Table 4.1</th>
<th>DWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td></td>
<td>&lt; 10,000</td>
</tr>
<tr>
<td>Handy</td>
<td></td>
<td>10,000 – 50,000</td>
</tr>
<tr>
<td>Large</td>
<td></td>
<td>50,000 – 160,000</td>
</tr>
<tr>
<td>Very Large</td>
<td></td>
<td>&gt; 160,000</td>
</tr>
</tbody>
</table>

**Table 4.3 Towed Vessel Size 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).
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 relationship between Consequence Severity and Risk Factor ROI-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 \((r\text{ value between } 0.30 - 0.39)\) 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)
<table>
<thead>
<tr>
<th></th>
<th>Pearson Correlation [Sig.(2-tailed)]</th>
<th>Consequence</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interaction</td>
<td>0.000</td>
<td>0.168**</td>
<td>Negligible</td>
</tr>
<tr>
<td>Girting</td>
<td>0.000</td>
<td>0.099**</td>
<td>Negligible</td>
</tr>
<tr>
<td>Tow planning</td>
<td>0.031</td>
<td>0.201*</td>
<td>Weak Positive</td>
</tr>
<tr>
<td>Tug Approach Maneuvres</td>
<td>0.044</td>
<td>0.07*</td>
<td>Negligible</td>
</tr>
<tr>
<td>Poor Tug Handling</td>
<td>0.000</td>
<td>0.393***</td>
<td>Moderate Positive</td>
</tr>
<tr>
<td>Speed</td>
<td>0.000</td>
<td>0.165**</td>
<td>Negligible</td>
</tr>
<tr>
<td>Poor Supervision</td>
<td>0.040</td>
<td>0.145*</td>
<td>Negligible</td>
</tr>
<tr>
<td>Tug type</td>
<td>0.036</td>
<td>0.322*</td>
<td>Moderate Positive</td>
</tr>
<tr>
<td>Navigational Obstacle</td>
<td>0.004</td>
<td>0.034*</td>
<td>Negligible</td>
</tr>
<tr>
<td>Swell</td>
<td>0.031</td>
<td>0.01*</td>
<td>Negligible</td>
</tr>
<tr>
<td>Current</td>
<td>0.000</td>
<td>0.015**</td>
<td>Negligible</td>
</tr>
<tr>
<td>Wind</td>
<td>0.001</td>
<td>0.01**</td>
<td>Negligible</td>
</tr>
<tr>
<td>Visibility</td>
<td>0.004</td>
<td>-0.040</td>
<td>Weak Negative</td>
</tr>
<tr>
<td>Safety Culture</td>
<td>0.040</td>
<td>0.472**</td>
<td>Strong Positive</td>
</tr>
<tr>
<td>Substandard Tug Equipment</td>
<td>0.003</td>
<td>0.447***</td>
<td>Strong Positive</td>
</tr>
<tr>
<td>Poor Mooring Equipment</td>
<td>0.024</td>
<td>0.083*</td>
<td>Negligible</td>
</tr>
<tr>
<td>Communication Procedure</td>
<td>0.000</td>
<td>-0.387</td>
<td>Moderate Negative</td>
</tr>
<tr>
<td>Human factor</td>
<td>0.041</td>
<td>0.464*</td>
<td>Strong Positive</td>
</tr>
<tr>
<td>Poor Training</td>
<td>0.001</td>
<td>0.496**</td>
<td>Strong Positive</td>
</tr>
<tr>
<td>Poor Seamanship</td>
<td>0.041</td>
<td>-0.060</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

**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) ROI-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 Maneuvres, 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.

![Risk Factor Rank Movement: Questionnaire Frequency Versus Pearson's r Number](image)

**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 Manoeuvres, 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 ROI-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, $A_1$, $A_2$, $A_3$,...$A_p$ into new variables, $B_1$, $B_2$, $B_3$...$B_p$ which are uncorrelated with each other and account for decreasing proportions of the total variance of the original variables defined as:

$$B_1=x_{11}A_1+x_{12}A_2+x_{13}A_3+\ldots+x_{1p}A_p$$
$$B_2=x_{21}A_1+x_{22}A_2+x_{23}A_3+\ldots+x_{2p}A_p$$
$$B_3=x_{31}X_1+x_{32}X_2+x_{33}X_3+\ldots+x_{3p}X_p$$

With the coefficients being preferred, so that $B_1$, $B_2$, $B_3$...$B_p$ are accounted for decreasing magnitudes of the total variance of the original variables $A_1$, $A_2$, $A_3$....$A_p$. (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 ($\chi^2_{(335)} = 5.091E3, p < .05$). 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.

\[
\text{a. Determinant} = 3.33E-02
\]

![KMO and Bartlett's Test](image)

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

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

Extraction Method: Principal Component Analysis

Table 4.7 Communalities (SPSS Software output) ROI-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%.
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

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared Loadings</th>
<th>Rotation Sums of Squared Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
<td>Cumulative %</td>
</tr>
<tr>
<td>1</td>
<td>4.532</td>
<td>22.662</td>
<td>22.662</td>
</tr>
<tr>
<td>2</td>
<td>3.030</td>
<td>15.149</td>
<td>37.811</td>
</tr>
<tr>
<td>3</td>
<td>2.496</td>
<td>12.482</td>
<td>50.293</td>
</tr>
<tr>
<td>4</td>
<td>2.100</td>
<td>10.499</td>
<td>60.792</td>
</tr>
<tr>
<td>5</td>
<td>1.788</td>
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</tr>
<tr>
<td>6</td>
<td>1.038</td>
<td>5.189</td>
<td>74.920</td>
</tr>
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<td>7</td>
<td>.900</td>
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<td>8</td>
<td>.891</td>
<td>4.455</td>
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<td>.765</td>
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<td>87.701</td>
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<td>3.011</td>
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<td>.544</td>
<td>2.718</td>
<td>93.429</td>
</tr>
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<td>12</td>
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<td>95.480</td>
</tr>
<tr>
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<td>97.164</td>
</tr>
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</tr>
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<td>15</td>
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<td>.733</td>
<td>98.804</td>
</tr>
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<td>.616</td>
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<td>99.783</td>
</tr>
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<td>.217</td>
<td>100.000</td>
</tr>
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<td>100.000</td>
</tr>
<tr>
<td>20</td>
<td>-1.99E-16</td>
<td>-9.948E-16</td>
<td>100.000</td>
</tr>
</tbody>
</table>

*Extraction Method: Principal Component Analysis.*

Table 4.8 Total Variance (SPSS Software output) ROI-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.

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

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)*

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

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)

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

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](chart)

*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, forty seven in Injury and eighty four in Damage.

![Chart 4.15 - Apportionment of Event Consequence (Percentage) RO1-CR](chart)

Seventy percent concerned Conventional tugs while twenty five percent undetermined tug type (See Chart 4.16) were involved in towage operation.
Sixty two percent of tugs were moderately powered while twenty percent were Medium powered and seventeen percent Unspecified (See Chart 4.17).

Thirty eight percent of events involved Towing from Forward, fifteen percent Pushing, while thirty percent were unspecified (See Chart 4.18).
The majority of events (fifty eight) concerned barges (See Chart 4.19).

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

![RST to NRST Incident Category Comparison (relative frequency)](chart)

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

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

![RST to NRST Comparison of Consequences](chart)

**Chart 4.23 - RST to NRST Comparison of Consequences ROI-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) ROI-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 ROI-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).

![Comparison of Towed Vessel Size](chart1.png)

**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.

![Comparison between RST and NRST Bow Form Distribution](chart2.png)

**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).
<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>RST Frequency</th>
<th>NRST Frequency</th>
<th>CHI^2 Stats</th>
<th>P-value</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interaction</td>
<td>42%</td>
<td>0%</td>
<td>Test NA</td>
<td>-</td>
<td>Invalid</td>
</tr>
<tr>
<td>Girting</td>
<td>37%</td>
<td>0%</td>
<td>Test NA</td>
<td>-</td>
<td>Invalid</td>
</tr>
<tr>
<td>No Tow Planning</td>
<td>82%</td>
<td>16%</td>
<td>16.9030</td>
<td>0.0000390</td>
<td>Significant</td>
</tr>
<tr>
<td>Tug Approach Manoeuvres</td>
<td>42%</td>
<td>76%</td>
<td>12.6810</td>
<td>0.0003690</td>
<td>Significant</td>
</tr>
<tr>
<td>Poor Tug Handling</td>
<td>67%</td>
<td>4%</td>
<td>40.9240</td>
<td>0.0000000</td>
<td>Significant</td>
</tr>
<tr>
<td>Speed</td>
<td>69%</td>
<td>9%</td>
<td>39.4610</td>
<td>0.0000000</td>
<td>Significant</td>
</tr>
<tr>
<td>Poor Supervision</td>
<td>15%</td>
<td>0%</td>
<td>Test NA</td>
<td>-</td>
<td>Invalid</td>
</tr>
<tr>
<td>Tug Type</td>
<td>34%</td>
<td>0%</td>
<td>Test NA</td>
<td>-</td>
<td>Invalid</td>
</tr>
<tr>
<td>Navigational Obstacle</td>
<td>38%</td>
<td>9%</td>
<td>10.5650</td>
<td>0.0011520</td>
<td>Significant</td>
</tr>
<tr>
<td>Swell</td>
<td>15%</td>
<td>10%</td>
<td>5.1420</td>
<td>0.0253100</td>
<td>Significant</td>
</tr>
<tr>
<td>Current</td>
<td>21%</td>
<td>0%</td>
<td>Test NA</td>
<td>-</td>
<td>Invalid</td>
</tr>
<tr>
<td>Wind</td>
<td>39%</td>
<td>10%</td>
<td>8.8925</td>
<td>0.0028630</td>
<td>Significant</td>
</tr>
<tr>
<td>Visibility</td>
<td>26%</td>
<td>7%</td>
<td>4.6312</td>
<td>0.0313960</td>
<td>Significant</td>
</tr>
<tr>
<td>Safety Culture</td>
<td>19%</td>
<td>0%</td>
<td>Test NA</td>
<td>-</td>
<td>Invalid</td>
</tr>
<tr>
<td>Tug Equipment</td>
<td>10%</td>
<td>23%</td>
<td>4.0989</td>
<td>0.0429110</td>
<td>Significant</td>
</tr>
<tr>
<td>Poor Mooring Equipment</td>
<td>19%</td>
<td>0%</td>
<td>Test NA</td>
<td>-</td>
<td>Invalid</td>
</tr>
<tr>
<td>Communication</td>
<td>66%</td>
<td>42%</td>
<td>5.3393</td>
<td>0.6208500</td>
<td>Significant</td>
</tr>
<tr>
<td>Human Factor</td>
<td>83%</td>
<td>70%</td>
<td>10.6450</td>
<td>0.0012320</td>
<td>Significant</td>
</tr>
<tr>
<td>Lack Of Training</td>
<td>78%</td>
<td>60%</td>
<td>4.9688</td>
<td>0.0258090</td>
<td>Significant</td>
</tr>
<tr>
<td>Poor Seamanship</td>
<td>35%</td>
<td>0%</td>
<td>Test NA</td>
<td>-</td>
<td>Invalid</td>
</tr>
<tr>
<td>GP Manning</td>
<td>6%</td>
<td>0%</td>
<td>Test NA</td>
<td>-</td>
<td>Invalid</td>
</tr>
<tr>
<td>Loss of propulsion power</td>
<td>89%</td>
<td>72%</td>
<td>5.1318</td>
<td>0.0236160</td>
<td>Significant</td>
</tr>
<tr>
<td>Insufficient Manpower</td>
<td>12%</td>
<td>10%</td>
<td>0.0005</td>
<td>0.031560</td>
<td>Significant</td>
</tr>
<tr>
<td>Bridge Equipment Ergonomics</td>
<td>20%</td>
<td>14%</td>
<td>0.1921</td>
<td>0.661150</td>
<td>Significant</td>
</tr>
<tr>
<td>Watch Keeping Or Lookout</td>
<td>58%</td>
<td>66%</td>
<td>1.0520</td>
<td>0.0012670</td>
<td>Significant</td>
</tr>
<tr>
<td>Wrong Operating Procedure</td>
<td>62%</td>
<td>48%</td>
<td>2.4351</td>
<td>0.1186480</td>
<td>Significant</td>
</tr>
<tr>
<td>Personal Safety</td>
<td>15%</td>
<td>0%</td>
<td>Test NA</td>
<td>-</td>
<td>Invalid</td>
</tr>
<tr>
<td>Condition of Mooring Line</td>
<td>60%</td>
<td>38%</td>
<td>5.2894</td>
<td>0.0214560</td>
<td>Significant</td>
</tr>
<tr>
<td>Navigation System Failure</td>
<td>48%</td>
<td>22%</td>
<td>6.3582</td>
<td>0.0116840</td>
<td>Significant</td>
</tr>
<tr>
<td>Securing And Releasing of Tug</td>
<td>42%</td>
<td>0%</td>
<td>Test NA</td>
<td>-</td>
<td>Invalid</td>
</tr>
</tbody>
</table>

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)

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

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.

![Diagram of data analysis steps]

*Figure 4.1 - Approach to analyze transcribed interviews (ROI-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)

<table>
<thead>
<tr>
<th>Parent Node</th>
<th>No. of Participants quoted</th>
<th>Child Node</th>
<th>No. of times node is coded for in data</th>
<th>No. of sources the node appears in</th>
<th>Recommendations in Exemplar quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor Maintenance/ Substandard condition of Equipment’s</td>
<td>P2, P7, P9, P10</td>
<td>Poor Mooring Equipment</td>
<td>5</td>
<td>4</td>
<td>“Auxiliary towage equipment, such as wire towage protectors and thimbles should be regularly inspected and should be form a part of the PMS.”</td>
</tr>
<tr>
<td></td>
<td>P3, P7, P10,</td>
<td>Bridge Equipment Ergonomics</td>
<td>3</td>
<td>3</td>
<td>“...wheelhouse should be properly designed to minimize incidents with respect to human factor.”</td>
</tr>
<tr>
<td></td>
<td>P7, P9</td>
<td>Navigation System Failure</td>
<td>2</td>
<td>2</td>
<td>“Unexpected events, such as navigational equipment failure or unusual traffic movements. Led many accidents in past.”</td>
</tr>
<tr>
<td></td>
<td>P2, P7, P9, P10</td>
<td>Condition of Mooring Line</td>
<td>5</td>
<td>4</td>
<td>“…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.”</td>
</tr>
<tr>
<td>Poor Work Process</td>
<td>P7, P9</td>
<td>Loss of propulsion power</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>--------</td>
<td>--------------------------</td>
<td>----</td>
<td>----</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P2, P9, P10</td>
<td>Wrong Operating Procedure</td>
<td>7</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P9</td>
<td>Interaction</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P2, P7, P9, P10</td>
<td>Speed</td>
<td>11</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P9</td>
<td>Girting</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

“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...”

“..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...”

“Several ship captains experienced interaction effects and a large percentage of pilots and tug masters had critical experiences with these effects.”

“With matching ship’s speed, it’s clear what safety margin you have with respect to tug power”

“There are many dangers associated with girding (giring) situations...it is the most prevalent reason for tugs to capsise and can cause fatalities...”
<table>
<thead>
<tr>
<th>Incompetency</th>
<th>Poor Tug Handling</th>
<th>2</th>
<th>2</th>
<th>“. . . ships’ crews, pilots and tug-masters must repeatedly be made aware of such possible forces and the inherent dangers.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2, P9, P10</td>
<td>Securing And Releasing of Tug</td>
<td>6</td>
<td>3</td>
<td>“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...”</td>
</tr>
<tr>
<td>P9, P10</td>
<td>Poor Seamanship</td>
<td>4</td>
<td>2</td>
<td>“. . . 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.”</td>
</tr>
<tr>
<td>P3, P7, P9, P10</td>
<td>Lack Of Training</td>
<td>11</td>
<td>4</td>
<td>“. . . 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...”</td>
</tr>
<tr>
<td>P3, P9, P10</td>
<td>Communication</td>
<td>8</td>
<td>2</td>
<td>“. . . 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...”</td>
</tr>
<tr>
<td></td>
<td>Watch Keeping Or Lookout</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Rough Weather</td>
<td>P9, P10</td>
<td>Current</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>---------------</td>
<td>---------</td>
<td>---------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>P7, P9, P10</td>
<td>Swell</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>P7, P9, P10</td>
<td>Visibility</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>P7, P9, P10</td>
<td>Wind</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

"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."

"Working in coastal areas or tidal areas is particularly hazardous due to strong swells, currents and unexpected change of current direction..."

"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..."

"Preventing accidents is about reducing the risks of those factors. The only parameter that is hard to overcome in this respect is the weather..."

"...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 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."
<table>
<thead>
<tr>
<th>Poor Safety Management System</th>
<th>P2</th>
<th>Personal Safety</th>
<th>1</th>
<th>1</th>
<th>&quot;Personnel working on tugs have a responsibility for their own and their colleagues’ safety...&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2, P10</td>
<td>P2, P10</td>
<td>Safety Culture</td>
<td>3</td>
<td>2</td>
<td>&quot;Why a Safety Culture? ... the most sophisticated safety system is useless without a supportive culture...&quot;</td>
</tr>
<tr>
<td>P2, P9, P10</td>
<td>P2, P9, P10</td>
<td>Poor Supervision/ Command</td>
<td>4</td>
<td>3</td>
<td>&quot;...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. ...&quot;</td>
</tr>
<tr>
<td>unsuitability of Tug</td>
<td>P2</td>
<td>Tug Equipment</td>
<td>1</td>
<td>1</td>
<td>&quot;...Again, before every towing operation the towing gear should be visually inspected and tested...&quot;</td>
</tr>
<tr>
<td>P2, P9, P10</td>
<td>P2, P9, P10</td>
<td>Tug Type</td>
<td>9</td>
<td>3</td>
<td>&quot;...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...&quot;</td>
</tr>
</tbody>
</table>
| No/Poor Risk Assessment | P2, P3, P7, P9, P10 | 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 | 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 ‘ug 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 ‘ug 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...”
| 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...”
<p>|                     |    |   |   | “it's always someone leaving the door open...” |</p>
<table>
<thead>
<tr>
<th>Wash/Squat effect</th>
<th>P9</th>
<th>1</th>
<th>1</th>
</tr>
</thead>
</table>

"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.

![Comparison of CS and QU Events](chart)

**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%).

![Comparison of Consequence Frequency](chart)

**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%).

![Comparison of Tug Type](chart1.png)

**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%).

![Comparison of Tug Power](chart2.png)

**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%).

![Comparison of Tow Position](chart.jpg)

**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%).

![Comparison of Towed Vessel Type](chart2.jpg)

**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
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)

<table>
<thead>
<tr>
<th>Parent Node</th>
<th>No. of Participants quoted</th>
<th>Child Node</th>
<th>No. of times node is coded for in data</th>
<th>No. of sources the node appears in</th>
<th>Recommendations in Exemplar quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor Maintenance/Substandard condition of Equipment’s</td>
<td>P2, P4, P5, P6, P7, P9, P10, P11</td>
<td>Poor Mooring Equipment</td>
<td>11</td>
<td>8</td>
<td>“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 bits etc. are used appropriately and within their design capabilities and effectively secured to a part of the ship’s structure which is suitably strengthened.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bridge Equipment Ergonomics</td>
<td>5</td>
<td>5</td>
<td>“Ancillary towage equipment, such as wire towage protectors and thimbles should be regularly inspected and should be of a part of the PMS.”</td>
</tr>
<tr>
<td></td>
<td>P3, P5, P7, P10, P11</td>
<td>Navigation System Failure</td>
<td>4</td>
<td>4</td>
<td>“Unexpected events, such as navigational equipment failure or unusual traffic movements...פד many accidents in past...”</td>
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<td></td>
<td></td>
<td>“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.”</td>
</tr>
<tr>
<td>P1, P2, P4, P5, P6, P7, P9, P10, P11</td>
<td>Condition of Mooring Line</td>
<td>13</td>
<td>9</td>
<td></td>
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</tbody>
</table>

"...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."

<table>
<thead>
<tr>
<th>P5, P6, P7, P9, P11</th>
<th>Loss of propulsion power</th>
<th>5</th>
<th>5</th>
</tr>
</thead>
</table>

"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..."
“...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”
<table>
<thead>
<tr>
<th>P1, P5, P6, P9, P11</th>
<th>Interaction</th>
<th>7</th>
<th>5</th>
</tr>
</thead>
</table>
| "...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 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 (girdling) 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.”

ships’ crews, pilots and tug-masters must repeatedly be made aware of such possible forces and the inherent dangers” |
| P1, P2, P10 | Poor Tug Handling   | 5  | 3  | “...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 tug’s crew are required to access the towed unit plans must be made so that it can be carried out safely in the prevailing circumstances...” |
<p>| P2, P5, P6, P9, P10 | Securing And Releasing of Tug | 9  | 5  |</p>
<table>
<thead>
<tr>
<th>Incompetency</th>
<th>Lack Of Training</th>
<th>20</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1, P3, P5, P6, P7, P9, P10, P12</td>
<td>Poor Seamanship</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

"...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."

"...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..."
<table>
<thead>
<tr>
<th></th>
<th>Poor tow Planning</th>
<th>2</th>
<th>2</th>
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</thead>
</table>
| "...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/Co's/owner qualifications."
|    | Current | 10 | 5 |
| Rough Weather | P1, P4, P5, P9, P10 |    |    |
| "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..."
|    | Swell | 11 | 6 |
| P1, P4, P5, P7, P9, P10 |    |    |    |
| "...Working in coastal areas or tidal areas is particularly hazardous due to strong swells, currents and unexpected change of current direction..."
<table>
<thead>
<tr>
<th>Poor Safety Management System</th>
<th>P1, P4, P5, P6, P9, P10</th>
<th>Visibility</th>
<th>15</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1, P4, P5, P7, P9, P10</td>
<td>Wind</td>
<td>12</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

"...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..."

"...Not appreciating the effects of the wind when towing can result in collisions, groundings, towlines parting, injury and goring. 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 these 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 slip or spill hazards and remain alert to what the vessel crew is doing..."
<table>
<thead>
<tr>
<th>Source (P1, P2, P4, P5, P6, P10, P12)</th>
<th>Topic</th>
<th>Page</th>
<th>Column 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Culture</td>
<td>11</td>
<td>7</td>
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</table>

"...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...”

<table>
<thead>
<tr>
<th>Source (P1, P2, P4, P5, P6, P9, P10 P12)</th>
<th>Topic</th>
<th>Page</th>
<th>Column 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor Supervision/Command</td>
<td>17</td>
<td>8</td>
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</tbody>
</table>

"...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!”
<table>
<thead>
<tr>
<th>Cause</th>
<th>Effect</th>
<th>Page</th>
<th>Line</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unsuitability of Tug</strong></td>
<td><strong>Tug Equipment</strong></td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>P1, P2, P4, P11</td>
<td>...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...”</td>
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<td></td>
<td><strong>Tug Type</strong></td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>P2, P4, P5, P9, P10, P11</td>
<td>...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...”</td>
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<td></td>
<td><strong>Navigational Obstacle</strong></td>
<td>2</td>
<td>2</td>
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<tr>
<td>P1, P5</td>
<td>...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...”</td>
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<tr>
<td></td>
<td><strong>Ship handling towage</strong></td>
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<td>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...”</td>
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<td>**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...”</td>
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<tr>
<td>No/Poor Risk Assessment</td>
<td>P1, P2, P3, P5, P6, P7, P9, P10, P11</td>
<td>No Tow Planning</td>
<td>21</td>
</tr>
</tbody>
</table>

"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 towing 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..."
...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 tug 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...
<table>
<thead>
<tr>
<th>Fatigue / Commercial Pressure</th>
<th>P4, P10, P12</th>
<th>Insufficient Manpower</th>
<th>2</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;...The International Convention on Standards of Training, Certification and Watchkeeping 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...&quot;</td>
<td></td>
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<tr>
<td>&quot;...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&amp;I insurance cover could be compromised...&quot;</td>
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</tbody>
</table>

| "...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:
Obvious 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 PMSSs 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/weather tight 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 manœuvre) if the tug is experiencing a failure or reduction in its ability to manœuvre 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 Harbormaster 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 Harbormaster 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 Harbormasters 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’s 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 crew 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 girtng. 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 tides 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:
  o Small under keel clearance of the assisted unit.
  o Hull form of the assisted unit.
  o Length of tow line.
  o 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 pickup 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 manoeuvre 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 girding (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 fistfuls, 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 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, 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.

Girding 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 girding 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 girding 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 girding a gob wire or similar arrangement can be used. When the tug is fast ast and used as a brake the tug master should concentrate on the following:

Risk of girding 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 ast 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, mannas, 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 briddles or shackle the briddles 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 briddles 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.