Safe Mooring Operations
Safe Mooring Operations

1 – Statistics / Morraborg incident

2 – Zarga incident / MEG (Mooring Equipment Guidelines)

3 – Cadet training / OOCL Europe incident

4 – Best practice / Sea Centurion incident

5 – Mooring arrangement design

6 – Questions & answers
SHIP VISITS – PROBLEM AREAS
STATISTICS
Number of Claims 2010 to 2015 (all ships)

- Cargo: 53%
- Personal Injury/illness: 36%
- FFO: 5%
- Collision: 2%
- Pollution: 1%
- Fines: 3%
Cost of Claims 2010 to 2015 (all Ships)

- Personal Injury/illness: 43%
- Cargo: 26%
- Collision: 11%
- FFO: 13%
- Pollution: 5%
- Fines: 2%
UK P&I CLUB

Value of PI Claims by Ship Type (2010 to 2015)

- Passenger: 43%
- Tanker: 10%
- Tug & Barge: 4%
- Bulk Carrier: 21%
- Car Carrier: 1%
- Chemical Carrier: 2%
- Container: 8%
- Ferry: 2%
- Gas Carrier: 3%
- General Cargo: 0%
- Non-Oil Tanker: 2%
- Ore/Bulk/Oil: 0%
- Ro/Ro: 4%
- Reefer: 1%
- Specialist: 1%
Large Personal Injury Claims by Accident Type (Number)

1. Struck by motor vehicle
2. Burns
3. Drowning (04)
4. Fall (other)
5. Slip and fall
6. Struck by falling/loosing
7. MOODING INCIDENT
8. Strain by holding or carry
9. Burns by steam or fluids
10. Cruise cancellation
11. Explosion
12. Strain by pulling or push
13. Fall/slip from gangway
14. Caught in machinery
15. Passenger casualty
16. Fall from ladder or scaffold
17. Strain by lifting

7th highest in frequency
Type of Injury From Mooring Incidents

- Leg: 23%
- Head: 7%
- Multiple Injury: 11%
- Back: 14%
- Arm: 7%
- Shoulder: 3%
- Knee: 3%
- Hand: 3%
- Chest: 3%
- Pelvis: 2%
- Eye: 1%
- Thigh: 1%
- Ankle: 1%
- Wrist: 1%
CASE STUDY
Case Study - MORRABORG

"MORRABORG" at Holmsund, Sweden during mooring operations – Summer 2011
Position of Chief off.
Figure 3 – An Actual Mooring Deck Arrangement Illustrating Potential “Snap-Back” Zones

Figure 10, Snap-back zones as described in instructions onboard and in some other publications.
Figure 11. The calculated potential snap-back area of the spring line when parting at the spring line fairlead onboard the Morraborg when the spring line is lead only over the first pedestal fairlead. The position of the remote control unit, by which the deceased chief officer where standing, is within the immediate snap-back area. The snap back area would be increased towards the control box if both pedestal fairleads were used.
The chief officer of the *Morraborg* also had few options to safely move away from the position where he was standing when the master called out his warnings. The spring line blocked his escape to the aft and the fore end line blocked his escape forward. The way he possibly could leave the area was over or around the set of bitts by the starboard hawse pipe, stepping in piles of ropes and passing in the narrow gap between the two free drum ends of the windlasses.
Learning from Incidents: The Hazards of Snapback
Incident Outline

- Winch Operator
- 3/O Signal Relay
- 3/O OIC
- Fairlead
- Roller
- Rope Parting Point
- ZARGA
Snapback Zone
A finite element model of the vessel geometry and quayside was built to assess the dynamic trajectory of the parted rope.
Rope Trajectory
Rope Trajectory

Baseline Results - view from above – Velocity 0.24secs to 0.26secs

Approximate velocity of line whipping round fairlead rollers is ~200m/s
Mass of line is 1.133kg/m. Kinetic energy of line is approximately 23kJ/m
Hazards of Snapback

When connecting synthetic tails to HMSF and wire mooring lines, the elasticity of the tails introduces energy that can significantly increase the snap-back hazard.

Elongation is proportional to the length of the tail. The fitting of longer synthetic tails, e.g. 22m tails from 11m tails, proportionally increases the stored energy and the amount of snap-back that can be expected.

Mooring lines led around roller pedestals and fairleads have the potential to create complex snap-back zones.
What do we know from MAIB?

Mooring Line:
HMSF
44mm
Jacketed
275m length
MBL = 137 tonnes
Life expectancy = 8 years

Source:
https://assets.digital.cabinet-office.gov.uk/media/56b8c217e5274a0369000013/MAIBSafetyBulletin_1-2016.pdf
What do we know now?

Mooring Line:

MBL = 137 tonnes **failed at 24 tonnes**
Life expectancy = 8 years **failed at 5 years**

Source:

What do we know from MAIB?

Source:
What are our next steps?
MEG – Desired Outcomes

- Incorporate lessons learned from the Zarga incident and update section on HMSF ropes
- Provide guidance when loads have been exceeded for both ropes and fittings.
- Incorporate relevant publications into MEG
- www.ocimf.org/MEG4
MEG – Desired Outcomes

- Keep target audience in mind
  - Operators, Ship Staff, SIRE Inspectors

- Provide Clarity
  - Safety Factors, Terminology, Tail Length, Snapback Zones

- MOC Process
  - Alternate and Emerging Technology, Changing Ropes, Record Keeping

Human Factors
MEG – Desired Outcomes

- Keep target audience in mind
  - Ship Staff

- Provide Clarity
  - Safety Factors, Terminology, Tail Length, Snapback Zones

- MOC Process
  - Alternate and Emerging Technology, Changing Ropes, Record Keeping
Full EDH Training

External Courses

Fishing, Yachting, Ferries, ex-Royal Navy & Stand-By/Supply

HND Cadets

Full EDH in Phase 3
H.N.C. Cadets
Seamanship: E.D.H. (SCQF level 6)

Outcomes 3 & 4

Majority of course work in Phase 1

Rope/wire splice in Phase 3
CARE OF ROPES

NATURAL FIBRES

SYNTHETIC FIBRES

ADVANTAGES & DISADVANTAGES
COMPONENTS

BITTS/BOLLARDS
MOORING ROPES
HEAVING LINES
USE OF EACH MOORING ROPE
SNAP- BACK ZONES

WINCHES
SToppers
ROPE GANGS
RAT GUARDS
HEALTH & SAFETY
BAD
PRACTICES
CONSEQUENCES
RESOURCES

Safety DVDs & Images

Rope Samples & Practical Work

Bow & Bitt Models

COSWP, MAIB, M - Notices and P & I Club publications

Instructor & Individual Experiences
THANK YOU!
Safe Mooring Operations

Gillan Locke – Clyde Pilot
Bill Mullan – Clyde Pilot
John Nelson – Svitzer Tug Master
**Pilot’s Perspective**

Ship Design – SWL bollards / fairleads / etc

‘HR ENDEAVOUR’
Deadweight of 12,828 tonnes
Built in 2004.
Gross tonnage is 9611.
665 TEU capacity.

What would you expect the SWL of her mooring equipment to be?

138m x 21m x 7m
Displacement ~16,000t

Tug = ASD 60t BP
Pilot’s Perspective

Ship Design – SWL bollards / fairleads / etc

‘HR ENDEAVOUR’
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Built in 2004.
Gross tonnage is 9611.
665 TEU capacity.

138m x 21m x 7m
Displacement ~16,000t

What would you expect the SWL of her mooring equipment to be?

Tug = ASD 60t BP

12 tonnes
Pilot’s Perspective

Mooring Lines – Ready for use?
Pilot’s Perspective

Heaving Lines - safe?
Competent to throw?
**Pilot’s Perspective**

Lines in the water?

Emergency Engine Stop?

CPP – 120 rpm / time to act?
**Pilot’s Perspective**

Lines in the water?

Emergency Engine Stop?

CPP – 120 rpm / time to act?

Radius: 0.8m

RPM: 120

Linear Velocity: 10m/s
Pilot’s Perspective

- Chapter 26 ANCHORING, MOORING AND TOWING OPERATIONS

MOORING – DO IT SAFELY
- Danish SEAHEALTH publication
- http://www.seahealth.dk/
Pilot’s Perspective

YOU WOULDN’T STAND HERE

SO WHY WOULD YOU STAND HERE?
IT’S JUST AS DANGEROUS
Pilot’s Perspective

“MoorMaster™ is a vacuum-based automated mooring technology that eliminates the need for conventional mooring lines. Remote controlled vacuum pads recessed in, or mounted on, the quayside, moor and release vessels in seconds.”

The end of traditional methods of ship handling?
Tug Master’s Perspective

John Nelson – Master ANGLEGARTH (Svitzer Marine)
Tug Master’s Perspective

If the tug exerts a force of 50 tons at an angle of 20 degrees, the actual force on the line is $50 \times 1.06 = 53.0$ tons.

Bollard Pull at 45° angle: $50 \times 1.41 = 70.5$ tons.

<table>
<thead>
<tr>
<th>Angle</th>
<th>Load Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>1.00</td>
</tr>
<tr>
<td>10°</td>
<td>1.02</td>
</tr>
<tr>
<td>20°</td>
<td>1.06</td>
</tr>
<tr>
<td>30°</td>
<td>1.15</td>
</tr>
<tr>
<td>40°</td>
<td>1.31</td>
</tr>
<tr>
<td>45°</td>
<td>1.41</td>
</tr>
<tr>
<td>50°</td>
<td>1.56</td>
</tr>
<tr>
<td>60°</td>
<td>2.00</td>
</tr>
<tr>
<td>70°</td>
<td>2.92</td>
</tr>
<tr>
<td>80°</td>
<td>5.76</td>
</tr>
</tbody>
</table>

http://www.samsonrope.com/
Tug Master’s Perspective

Powering Indirect: Towline 90° to Tanker

Line Tension ~ 125% x Winch Reading

Examples:
- Speed: 5 Knots
- Tug 60° to Flow
- Winch Reading = 49 tons
- Line Tension = 62 tons
- Steering Force = 62 tons
- Braking Force = 0 tons
- Speed: 7 Knots
- Tug 35° to Flow
- Winch Reading = 32 tons
- Line Tension = 40 tons
- Steering Force = 40 tons
- Braking Force = 0 tons

60° @ 5 kts
35° @ 7 kts
150°

http://www.towingsolutionsinc.com/technology-escort_tugs.html
Bill’s story: RFA Sea Centurion (A98)
A clear call has been sounded by Petar Modev of the UK P&I Club for the industry to “update its deck layout solutions for something more flexible”.

According to him it’s not just human error that is contributing to a number of mooring injuries; outdated deck kit arrangement needs to take a share of the blame.

“Yes, the forces are getting bigger and the lines are stronger, so if they break they release much more energy... but the layout of equipment is still the same old layout – which has been around for at least 50 years.” And this, he added, doesn’t take into account the new reality that vessels are moving around from port to port, often doing their best with less than suitable berths without the right bollards or dolphins.

This leaves lines dangerously angled and loaded, and more, smaller boats which often work very hard with a limited crew “don’t always have the manpower to have the right number of people fore and aft to carry out the mooring safely”. He added that “18% of all mooring incidents we have recorded were on vessels of less than 6,000 gt”.

There is good reason to think again about the basics, he explained: “These accidents are almost always severe “something which is reflected in the statistics”, he explained: the 25 years to 2013 saw no less than 13% of these large fatality claims linked to mooring incidents.

“What I would hope for is a different kind of deck equipment design that allows for a better mooring layout. You can devise something to be safe that doesn’t require as many people to handle it,” he said, although he is aware that “there will be some costs involved... and it obviously needs to be low maintenance”.

“I do believe a flexible layout could go some way to mitigate against human error. You can’t get rid of it entirely, but it could change things considerably,” he told MJ. “It can’t be beyond the industry to find a solution.”

By Stevie Knight for Maritime Journal
29/06/2016
Mooring Arrangement a Design Perspective.
Mooring Design

Similar ships having different owner and different mooring arrangements
Mooring Design

The level of risk is influenced by the design of the arrangement.

It's unlikely a designer will have sea going experience and operational awareness.

Just like on a vessel there is great variety on experience and expertise.

Designers rely on guidelines, rules & regulations to do their work.

Little available guidance on layout.

Designers have access to powerful analytical tools. (3D rendering, Finite Element Analysis,)

Difficult to design for ALL possible mooring scenarios.
Mooring Design Principles

• Mooring lines should be arranged symmetrically about ships centreline.

• Breast line should be perpendicular to the longitudinal axis of the ship and far aft and fwd.

• Spring lines should be parallel to the longitudinal axis of the ship.

• Vertical angle of mooring to be kept at minimum.

In General

• Larger ships with more available deck area have more options.

• Smaller ships or ones with cargo on deck mooring space is limited.
Typical Design Process to Meet Classification Society's Requirements

A typical process will have the following step

1. Determine the equipment number – Calculation factoring displacement, breadth, profile area above waterline,
2. Determine Towline & Mooring line Minimum Breaking Strength from tables. Tables are based on empirical
3. Winch brake to give way at 80% of Minimum Breaking Strength.
4. Design Load for foundations to be 1.25 – 1.3 times stronger than Minimum Breaking Strength
5. Safe Working Load of equipment to be 80% of design load.
6. Corrosion addition.
7. Submit plans for comments and approval.

Weakest part is the winch break followed by the line and then by the equipment foundations. **No layout guidance or requirements.**

Source: DNV rules Part 3 Chapter 3 Section 3
IACS Mooring requirement UR-A
MCA’s Suggestions

The layout of the installations should be such as to avoid the need for anyone to...work in the bight of warp or rope...The consequences of failure in any part of the system should be carefully considered and effective precautions taken.

It is often difficult to achieve an ideal **mooring layout**, but ship’s equipment can be employed to the best advantage if the following general principles are borne in mind:

a) Breast-lines provide the bulk of athwartships restraint;
b) Back-springs provide the largest proportion of the longitudinal restraint; and,
c) Very short lengths of line should be avoided where possible, as such lines will take a greater proportion of the total load when movement of the ship occurs.

Source: MCA MGN 308
OCIMF Layout Guidelines

- Piers and sea islands
- Single Point Mooring
- Emergency Towing, Escorting and Pull-Back
- Multi Buoy Mooring
- Harbour Towing
- Barge Mooring
- Canal Transit
- Ship to Ship
- Mooring Augmentation in Exceptional Conditions.

Source: MCA MGN 308
OCIMF Environmental Criteria & MBL

60 knots wind from any direction simultaneously with:

- 3 knots current at 0 deg or 180 deg or
- 2 knots current at 10 deg or 170 deg or
- 0.75 knots current from the direction of maximum beam current loading.

Source: OCIMF Mooring Equipment Guidelines 3rd Edition
OCIMF General Design Load Guidelines

1. Calculate MBL
2. Apply Geometry Factor \((1 - 2)\)
3. Apply Safety Margin \((1.18)\)
4. Deduct Design Load for the fitting.

Source: OCIMF Mooring Equipment Guidelines 3rd Edition
OCIMF General Principles

- Suggestion of factors and locations to consider when deciding the layout.
- Weakest Part is the winch’s brake holding capacity which is 60% of MBL and its design capacity which is 80% of MBL.
- The mooring line is the next weakest item at MBL.
- The fittings and their foundations are the next in terms of strength which ranges from 118% of MBL to 236% of MBL.
- In general the Safe Working Load of the fittings is equal to the MBL.
- Structural reinforcement suggestions
- Keeping mooring areas clear
- Avoid mooring lines on areas which personnel normally works.

It’s a detailed guide on mooring arrangement but could it be improved?
CyClaDes Framework

EU funded research project on Crew Centred Design and Operation of ships and ship systems.

Source: CyClaDes, Mooring Deck Guidelines
CyClaDes Framework

Current regulations:

• Swedish Maritime Administration has a number of sections that address mooring deck occupational safety.
• MCA guidance (see previous slide)
• The ILO Maritime Labour Convention has a number of applicable clauses cantered around occupational health and safety.

Source: CyClaDes, Mooring Deck Guidelines
CyCladEs Framework Design Guidelines

- Sightlines
- Deck Layout
- Stowage
- Winch Control
- Communications
- Equipment design
- Ropes, wires and stoppages
- Bunkering

Source: CyCladEs, Mooring Deck Guidelines
CyCladeS Framework Key Guidelines

- A position for supervising mooring operations should provide visibility of the whole operation.
- A bird’s eye view of the mooring deck arrangement is recommended to more readily identify danger areas. This may require an elevated platform.
- The operating area for mooring windlasses should be so designed that the operator is well protected and has a good overview of the working area.
- ...the whole deck is a potential snap-back zone. Designs that use a small consistent set of snap-back zones are likely to place lower demands on training and supervision.
- Adequate space for those who work with mooring lines to stand in a protected position, avoid all snap back zones,
- The layout of the installations should avoid the need to work in the bight of warp or rope.
- The design should provide means of reducing exposure to hazards; Provide protective cages, railings, bars round fairleads, pulleys, bollards to catch whipping lines. Fall protection e.g. from mooring stations.

Source: CyCladeS, Mooring Deck Guidelines
CyClades Framework Key Guidelines

- For a minimum of two people to each mooring station throughout the operation.
- The design should take account of the small crews available for mooring.
- The design should consider environmental aspects of working on the mooring deck.
- The ILO preventive principles appear to be a sound basis for using design to reduce risks to the crew.
Special mention to Nautical Institute's “Mooring and Anchoring Ships”

Excellent resource with in depth analysis of mooring.
Good Design

Source: CyCladeS Framework
Good Design

Source: CyCladEs Framework
Good Design
Good Design
Good Design
Good Design
Possible Improvements

- Promotion of new technologies. (analytical tools on-board, centralized mooring control panel, alternative mooring methods, spooling devices)
- Remote control operation (portable control panel)
- Bird’s eye view of mooring operation (raised platform)
- Safe areas for crew to take cover.
- Update of regulatory framework with human centre elements.
- Research on snap back of lines under various scenarios. (Better designation of snap back zones)
The Future?

The mooring actuator 5m 33s

Shore Side Mooring Innovations 1m 6s
INTERNATIONAL MARINE TRANSPORTATION

SAFETY ALERT BULLETIN

NUMBER: 02/2016

Mooring operations – Key findings

During a recent IMT forum, a ‘workgroup session’ on mooring operations was conducted. It focussed on a number of mooring related incidents including vessel break outs, injuries, man overboard etc. The purpose of this safety alert is to share the best practices captured during this work group session.

Measures considered to reverse this trend of incidents were classified into INDICATORS, STRATEGIES & ENHANCE SAFETY CULTURE.

INDICATORS – To assess mooring hazards by means of the following:

• Near Miss reporting – e.g. Person standing in impact zone / poor stowage of ropes
• On board inspections (Condition of ropes and equipment) - e.g. Broken rope strands / hydraulic leaks
• Hazard identification during toolbox talks – e.g. Unusual mooring patterns & rope leads, language barrier
• Lessons learnt from incidents / experience sharing / best practices from fleet
• Assessment of the mooring operation – e.g. by designated crew member, superintendent, auditor etc.

STRATEGIES – To eliminate hazards / incident causal factors

<table>
<thead>
<tr>
<th>Focus</th>
<th>Key Hazards / causal factors</th>
<th>Possible Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilities and Equipment</td>
<td>• Rendering limits set incorrectly</td>
<td>• Robust procedures (including below)</td>
</tr>
<tr>
<td></td>
<td>• Poor mooring leads due to berth configuration</td>
<td>• Chafing prevention</td>
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<tr>
<td></td>
<td>• Hazards posed by specific properties of mooring rope/wire (High modulus, composite etc.)</td>
<td>• Weather / Tide / Current monitoring</td>
</tr>
<tr>
<td></td>
<td>• Type and strength of mooring equipment not appropriate for operation</td>
<td>• Risk Assessment (including below)</td>
</tr>
<tr>
<td>Management Systems</td>
<td>• Poor communications (mooring parties, tugs, shore gangs, pilot, bridge team)</td>
<td>• Simultaneous operations (Mooring / Hose connection)</td>
</tr>
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<td></td>
<td>• Lack of understanding of roles and responsibilities</td>
<td>• Consider effect due to passing vessels</td>
</tr>
<tr>
<td></td>
<td>• Failure to tend moorings or poor mooring management alongside</td>
<td>• Crew experience and manning</td>
</tr>
<tr>
<td></td>
<td>• Strong currents / tidal streams / passing traffic</td>
<td>• Toolbox meeting / Task allocation</td>
</tr>
<tr>
<td></td>
<td>• Environmental conditions (wet / cold etc.), slippery deck &amp; poor illumination</td>
<td>• Effective supervision by a Responsible person - Intervention</td>
</tr>
<tr>
<td>Human Element</td>
<td>• Fatigue, inadequate PPE</td>
<td>• Effective communication procedure</td>
</tr>
<tr>
<td></td>
<td>• Personnel incorrectly positioned, false sense of security due to snap back zones</td>
<td>• Knowledge of berths mooring layout</td>
</tr>
<tr>
<td></td>
<td>• Officer in charge become actively involved leasing oversight</td>
<td>• Shore gang support on the berth</td>
</tr>
<tr>
<td></td>
<td>• Incorrect use of stoppers</td>
<td>• Training / Frequency of training</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Mooring equipment included in PMS (including mooring tails)</td>
</tr>
</tbody>
</table>

ENHANCE SAFETY CULTURE – Cultivate safe mooring behaviour

An effective buddy culture on board needs to be cultivated wherein each crew member actively cares for others.

Mooring operation requires a high level of situational awareness and personnel engaged should exercise utmost caution. This can be achieved by means of a robust training regime, adequate supervision, effective communication and a strong stop work culture.
Questions & Answers
Thank you

send comments to

CPD@nautinst.org