# Underlying Causes of Mooring Lines Failures Across the Industry

**Guy Drori**

**24th March 2015**

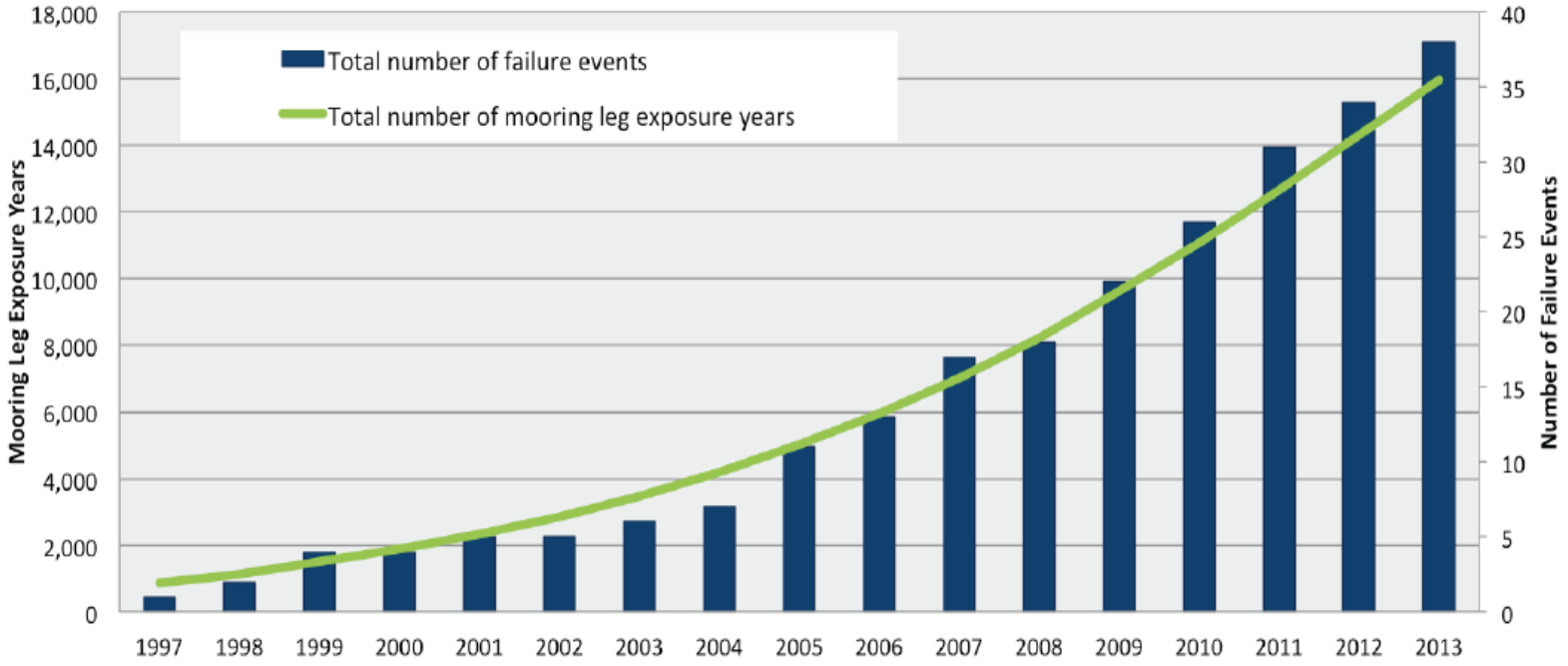
# Content

- Introduction
- Overview of industry failures in recent years
- Location of failures along the line
- Reliability of long-term moorings systems
- Line failures across the industry - contributing factors
- Mitigation measures
- Conclusions
- Audience Response Questions

# Introduction

# Industry Failures In Recent Years

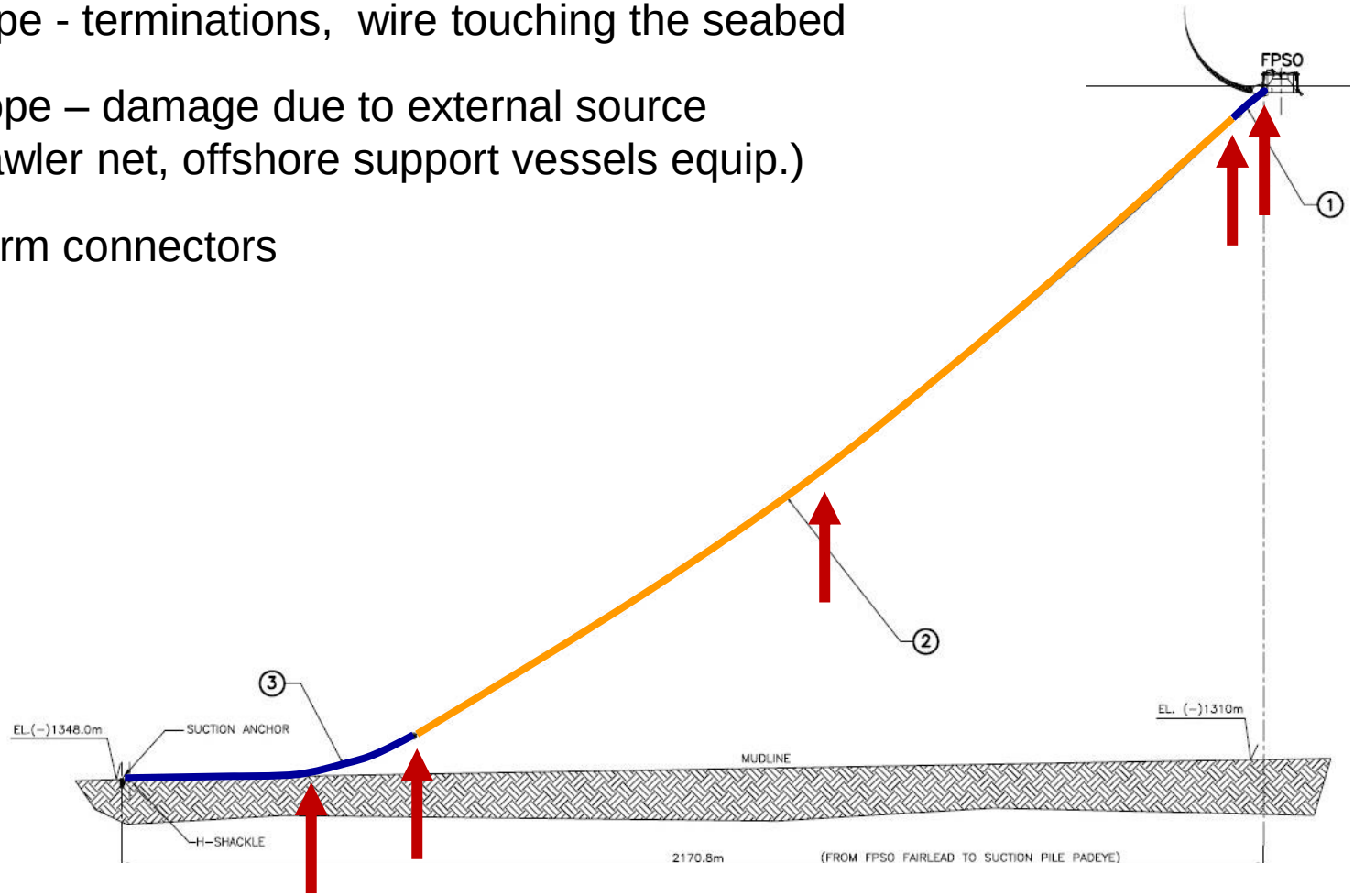
- Deepstar®: 107 mooring incidents from 73 facilities across the industry (1997-2012)
  - 51 single line failures,
  - 9 multiple line failures,
  - 38 pre-emptive replacement events
  - 9 reports of severe degradation




Thanks to AMOG & Deepstar®

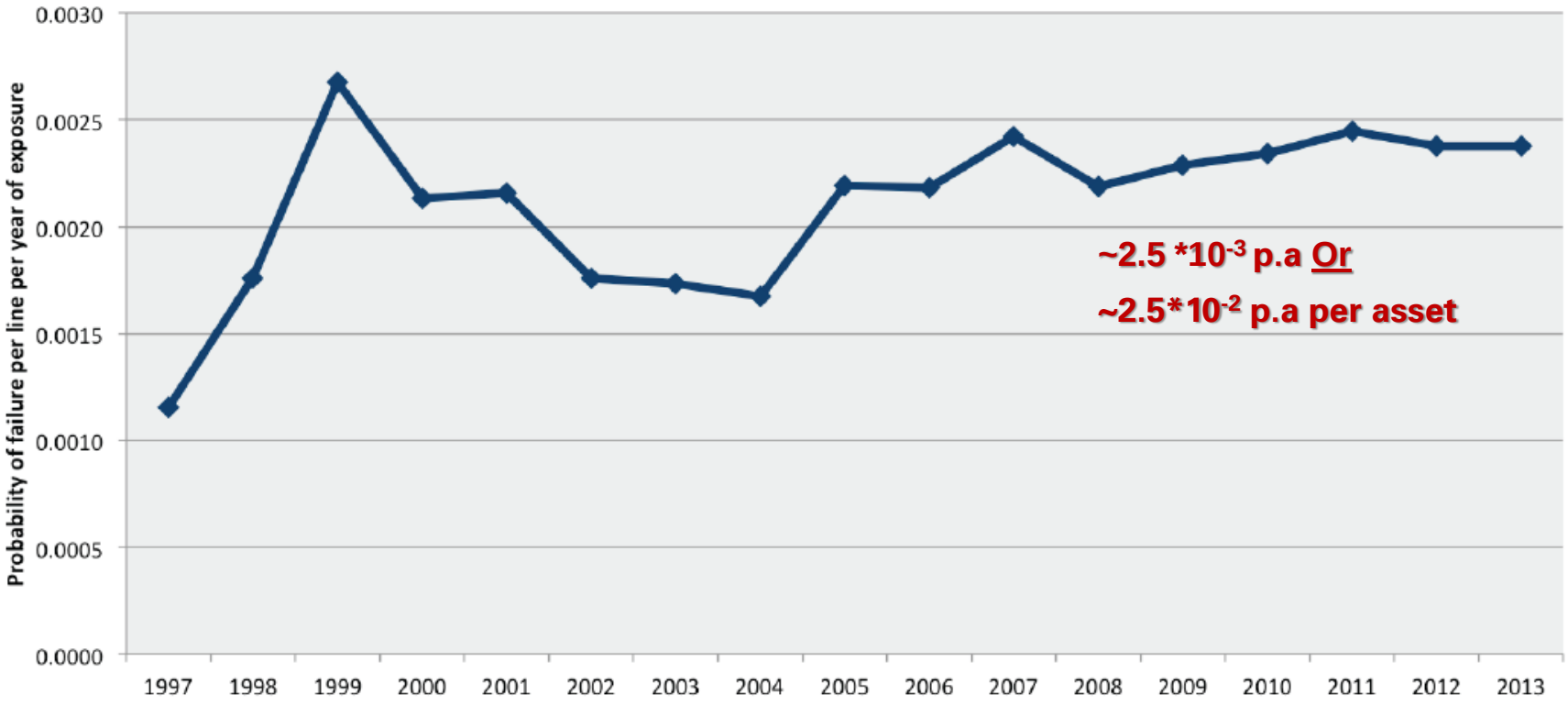
# Location of Failures Along The Line

- Chain - splash zone and thrash zone
- Wire rope - terminations,  wire touching the seabed
- Fibre rope – damage due to external source
  (e.g. trawler net, offshore support vessels equip.)
- Long term connectors



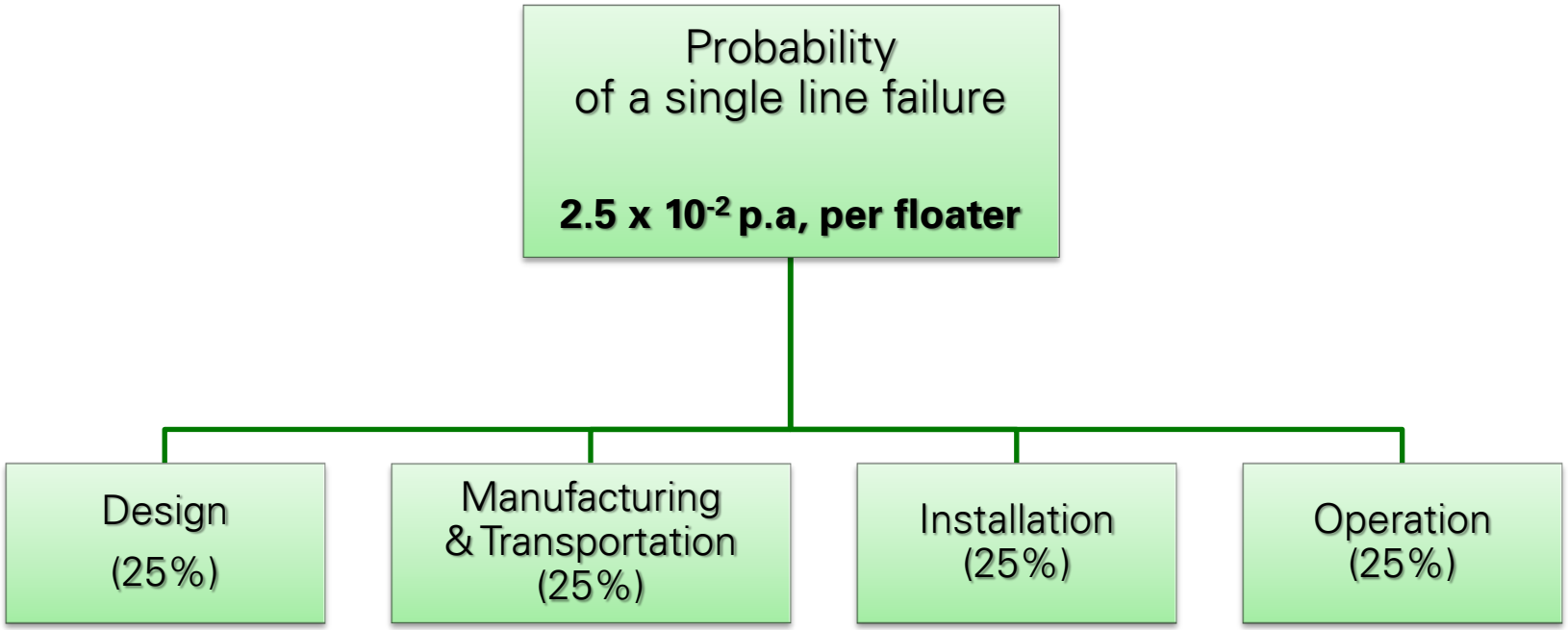
# Reliability of Long-term Moorings

Industry Mooring line failure rate, per line, per year of exposure (1997-2013)

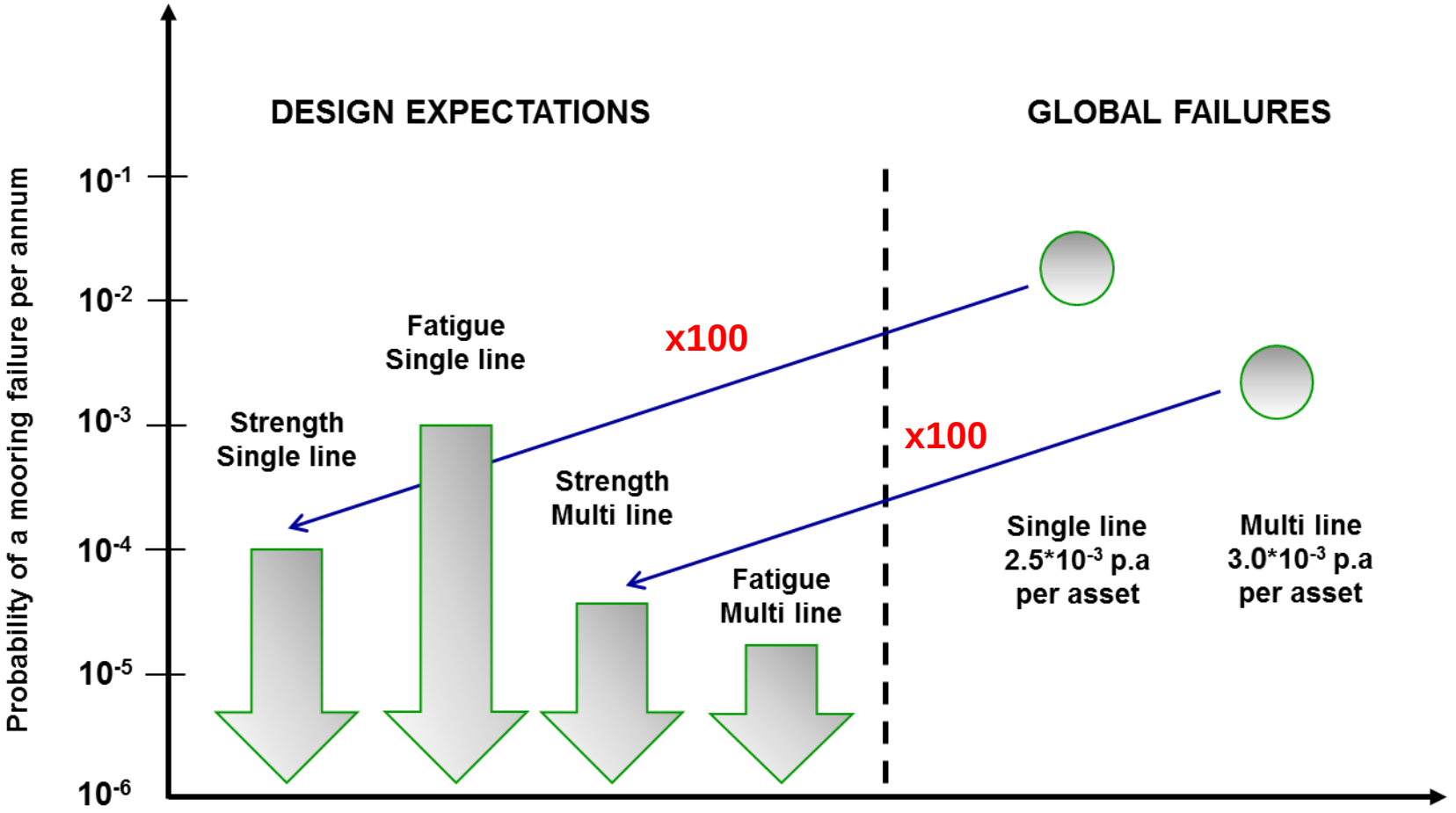



- Long term Mooring system design life is approximately 15 to 25 years
- In context, 1:50 chance of a failure per asset, per annum. If a design life of a floater is in about 25 years, than there is a 1:2 chance of a failure during its life cycle

# Likelihood - Loss of One Mooring Line



# Reliability of Long-term Moorings

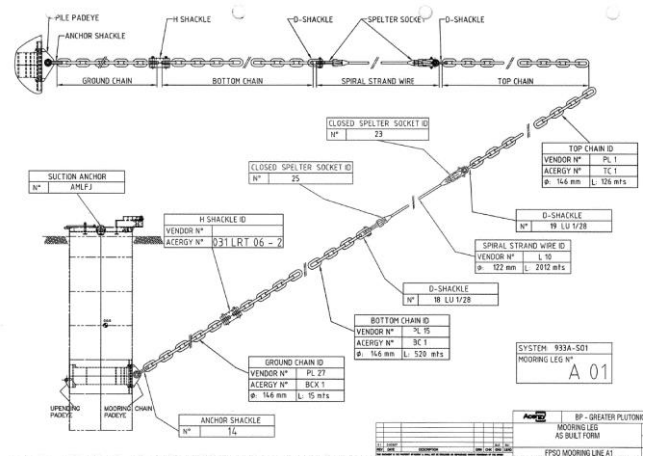



Ref: Offshore Standard DNV-OS-E301, October 2010 -
Table H1, probability levels (for ultimate limit state)

# Line Failures Across the industry - Contributing Factors

## Design

- Design of supporting systems & end terminations
- Unreachable areas for maintenance and overhauls
- Out of plane bending (OPB) effect
- Implementation of passive and active corrosion prevention systems
- Seabed – chain interaction affect on chain abrasion (soil properties - stiffens, damping, etc.)
- The use of new technologies
- Late changes to the original design




# Line Failures Across the industry - Contributing Factors

**Manufacturing and Transportation**

- Material properties and traceability for QA
- Quality control procedures, inspections and testing methods
- Approval process by classification societies
- Preservation after manufacturing – storage, handling, loading, etc.
- Transportation to the installation site via general cargo ships

Thanks to Ramnäs Bruk

# Line Failures Across the industry - Contributing Factors

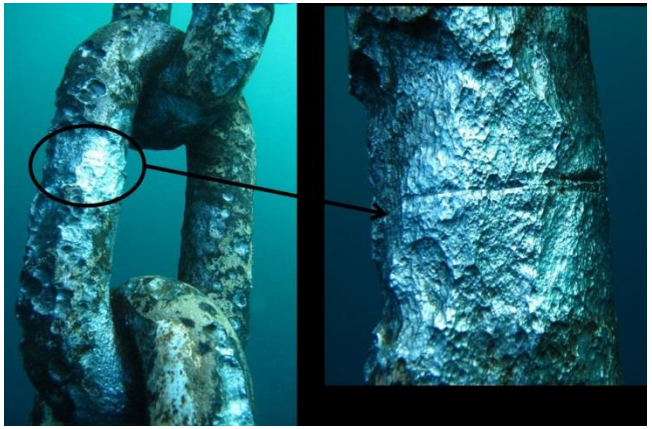
**Installation**

- Physical damage due to poor handling
- Operator skill-level and equipment used including Installation aids
- Cold bending or local heating (spot welding) causing reduced fatigue life
- Inappropriate deployment, anchors non-aligned to pull direction, lines dog-legged, hockles, twists, wire kinking, bird caging**,** etc.
- Storage of fibre ropes on board the vessel
- Incorrect tension in the lines

# Line Failures Across the industry - Contributing Factors

**Operation and Maintenance**

- Excessive corrosion and wear
- Pre-emptive maintenance activities
- Lack of system knowledge and inadequate training for operators
- Quality and efficiency of offshore inspections
- Deferral of inspections
- Dropping lines / re-tensioning of lines
- Reusing mooring components
- *Lack of proper monitoring systems



Thanks to SCORCH & AMOG

# Mitigation Measures

**Design, manufacturing and installation of new systems**

- Design Standards are fit for purpose but a common approach to local stresses (e.g. OPB) and analysis methods can add value
- Manufacturing needs honest and realistic expectations by all parties in terms of quality and reliability delivered
- Operators need better quality assurance and level of engagement from the contractors and manufactures
- Installation needs more awareness and emphasis on maintaining long term integrity and costs arising from poor installation
- Operators should continue to share their knowledge and experiences with the rest of the industry

# Mitigation Measures

**In service measures**

- Improve the inspection and supervision during installation and in the first five year of operation
- Maintain the mooring lines supporting systems on-board the floater (e.g. fairlead, winches)
- Use the information generated in various cross industry activities to improve the integrity management plans
- Operations understanding of design and need to maintain integrity
- Use of the measured data (e.g. met-ocean, line tensions, offset, etc.) as a feed for a more dynamic mooring Integrity management plan

# Conclusions

- Single mooring line failure on production floater maybe on average around 2 x $10^{-2}$ p.a. (1 in 50) (~5 events/yr) globally
- Multiple mooring line failure on production floater maybe on average around 3 x $10^{-3}$ p.a. (1 in 350) (~1 event/yr) globally
- For any individual floater, mooring system, location, etc. the risk and contribution of causes can be / will be different
- Improvements in standards and increased operator awareness are expected to reduce causes in design and operation
- Manufacture and Installation phases need increased planning assurance


Thanks to SCORCH & AMOG

# Thank you,
# Any Questions?

**Guy Drori**

**Naval Architect & Floating Systems Engineer**

**Email:** guy.drori@uk.bp.com