MODU Mooring Design and Inspection Practice

Presented by Tom Kwan

MODU Mooring Environmental Criteria

(1) US – American Petroleum Institute
   - Design Environment: 1-year
   - Design Environment: 5-year (away from other structures)
   - 10-year (close to other structures)
   - The 1997 Revision was Based on Mooring Code Calibration JIP (1995)

(2) International Standard Organization (ISO 19901-7)
   - API criteria adopted
   - Norwegian annex: 10-year design environment
Tension Limits and Safety Factors

<table>
<thead>
<tr>
<th>Analysis Method</th>
<th>Tension Limit (Percent of MBS)</th>
<th>Equivalent Factor of Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact</td>
<td>Quasi-static 50</td>
<td>2.0</td>
</tr>
<tr>
<td>Intact</td>
<td>Dynamic 60</td>
<td>1.67</td>
</tr>
<tr>
<td>Damaged</td>
<td>Quasi-static 70</td>
<td>1.43</td>
</tr>
<tr>
<td>Damaged</td>
<td>Dynamic 80</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Chain for MODU and Permanent Moorings

Typical 3 in MODU Chain

6 in Chain for Permanent Moorings
Overview of Recent 2SK Revision

- Revision Began in 2002 and Completed in 2004
- To be Issued in 2005
- Major Revisions
  - MODU and Permanent Mooring
    - Add Pile and Plate Anchor FOS and Design Guide
    - Allow Higher Uplift Angle for Drag Anchors
    - Add Clearance Criteria
    - Revise Mooring Proof Load
    - Add Mooring Hardware Section
    - Revise Dynamic Positioning Section
    - No Change in Environmental Criteria
  - Permanent Mooring
    - Revise Chain Fatigue Design Curves
    - Add Global Analysis Guidelines
    - Add Spar VIM Design Guide
    - Add Discussion on Mooring Strength Reliability
    - Provide NPD and API Wind Spectrum

Comparison of MODU Mooring Practice

- Gulf of Mexico
  - Evacuate Drilling and Production Facilities
  - There were also Partial Failures
  - Primary Cause: Overloading

- North Sea and Other Areas
  - Manned Facilities
  - Partial Failures
  - Primary Cause: Overloading, Fatigue, Faulty Components
### DeepStar 4404 (2001) - Mooring Reliability Study for Permanent Moorings

<table>
<thead>
<tr>
<th></th>
<th>GOM</th>
<th>North Sea</th>
<th>W. Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_s$ (100 yr/10 yr)</td>
<td>1.5</td>
<td>1.15</td>
<td>1.18</td>
</tr>
<tr>
<td>$V_w$ (100 yr/10 yr)</td>
<td>1.5</td>
<td>1.14</td>
<td>1.18</td>
</tr>
<tr>
<td>Operation Procedure</td>
<td>Evacuate</td>
<td>Manned</td>
<td>Manned</td>
</tr>
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</table>

### Comparison of GOM Hurricane Environments

<table>
<thead>
<tr>
<th></th>
<th>10-year, MODU Mooring Design</th>
<th>100-year, Permanent Mooring Design</th>
<th>Ivan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sig. Hs (ft)</td>
<td>26</td>
<td>40</td>
<td>45 - 52</td>
</tr>
<tr>
<td>Wind Speed (1 minute, knot)</td>
<td>70</td>
<td>95</td>
<td>95 - 105</td>
</tr>
<tr>
<td>Current Speed (knot)</td>
<td>1.8</td>
<td>3.0</td>
<td>4</td>
</tr>
</tbody>
</table>
GOM Operations
Changes in the Last 10-15 Years

- More Floating and Subsea Installations
- More Permanent Deepwater Operations with Higher Production Rates
- More Deepwater MODUs with Taut Leg/Pile Mooring Versus Catenary/Drag Anchor Mooring Years ago
- Some MODUs Stay on One Location for Much Longer Period
- Bigger MODUs
- More Metocean Information

Some Fundamental Questions

- Have the Changes in GOM Operations Increased the Risk Sufficiently to Warrant Another Change of 2SK MODU Mooring Criteria?
- If the Answer is Yes:
  - What Level Of Change is Appropriate?
  - What is the impact of the Change on the Industry?
Long Term Plan for API RP 2SK

- Reactivate the 2SK WG to address GOM MODU mooring issue
- 2SK WG will work with OOC/industry to initiate a JIP to study the MODU mooring reliability and provide a first draft commentary
- The 2SK WG will finalize the commentary and seek API approval and publication (2006/2007)
- After 3-5 years industry practice, the commentary will be incorporated in the 4th edition of 2SK (2010)

Commentary on GOM MODU Mooring Practice

Potential Topics

- Basic considerations
- Current design and operation practice
- Historical GOM operation experience
- Risk assessment of current and future operations
- Comments on the use of 2SK environmental criteria for GOM MODU mooring
- Strategy to minimize mooring failure and damage to surrounding structures
- Indicative GOM extreme environments
Revision of API RP 2I
Mooring Inspection

Current API RP 2I
- Developed about 15 years ago
- Address inspection of mooring chain, wire rope, and connecting hardware mainly for MODUs

On-Going Revision
- Add Fiber Rope Inspection Guidelines
- Add Permanent Steel Mooring Inspection Guidelines
- Revise MODU Mooring Inspection Guidelines
- Schedule for Completion: Mid 2006
Design & Installation Improvements to Improve Reliability

Evan H. Zimmerman, JD
Delmar Systems, Inc.
Preface

• Every location is different.
• Every rig is different.
• Evaluate each situation.

• Available technology
• Maturing technology
• Evolving practices
• Risk management
• Impact management
State of the Industry

- API RP-2SK
  - Mooring line tension FOS
  - Anchor guidelines
  - Analysis methods
- 10-Year Hurricane
- >10-Year Survivability
Field Choices

- My Field:
  - Time of year?
  - Pipelines / umbilicals?
  - Other structures?
  - Seafloor conditions?
  - Well program?
  - Shallow hazards?

- My MODU Mooring
  - Conventional system?
  - Anchor change?
  - Preset mooring(s)?
  - Buoyed lines?
  - Synthetic inserts?
  - Probable break point?
MODU Mooring Failure

- Fairlead Break
  - Components fall to the seafloor
  - Vessel yaw influences leeward line failure
  - Rig floats free, limited seafloor impact

- Anchor Failure
  - Anchor drags in soil
  - Limited vessel yaw
  - Excess loading leads to anchor failure with continuous drag
  - Rig drifts free trailing anchor lines with anchors on the seafloor
Survivability by Design?

- Can MODU Moorings Survive Hurricane Ivan Events?

![Bar Chart: Hurricane Ivan (Max Wind, Max Wave)]

- Maximum Wind: 1.20
- Maximum Wave: 1.38

Environment Heading (degrees CCW off Stern)
MODU Risk Assessment

- Understand failure
- Quantify probability
- Prudently minimize impact of probable failure method
Pipeline Risk

- Moorings over pipelines?
  - As-is configuration
  - Buoyancy
  - Synthetics
  - Anchor selection
  - Catastrophic failure

- Moorings short of pipelines?
  - Anchor selection
  - Catastrophic failure
Facility Risk

- Proximity?
- Relative direction?
- Biased mooring system?
- Anchor selection?
- Hold-back systems?
“Limit State” Analysis

- Quantify system robustness
- Utilize results to determine risk level
- Comparative study with alternate systems / configurations
Anchor Selection
A pivotal choice
Conventional Anchors

- 100-year old technology
- Performance well understood
- Capacity limited with size
- Failure with anchor uplift
  - Some residual capacity upon failure
  - Enables load sharing among adjacent mooring lines
HHC Drag Anchors

- ~20-year old technology
- Performance well understood
- Large capacity versus size
- Failure with anchor uplift beyond 20-degrees
  - Residual capacity upon failure
  - Enables load sharing among adjacent mooring lines
HHC Drag Anchors
Suction Pile Anchors

- ~10-year old technology
- Performance understood
- Failure with excess loading
  - No residual capacity upon failure
  - Stationary foundation (no load sharing)
  - Probable failure method is local padeye structural failure
Suction Pile Failure
Vertically Loaded Anchors

- Maturing technology
- Performance understood
- Failure with excess loading
  - Increasing capacity with load
  - Enables load sharing among adjacent mooring lines
  - Probable failure method is with excessive rotational loading
Vertically Loaded Anchor

2005 Offshore Hurricane Readiness and Recovery Conference
New Anchors

- Maturing technology
- Performance under evaluation
- Failure with mooring component
  - Increasing capacity with load
  - Enables load sharing among adjacent mooring lines
  - Load arm follows mooring line spread angle

Patent Pending
New Anchors
WELCOME

DRILLING BREAKOUT SESSION
Hurricane Readiness & Recovery Conference
Ivan Facts

Wave loads exceeded Design Criteria.
- 10 Yr Return Period Criteria Exceeded; (Hs ~26 ft)
  » ~100 Miles West (90.25°W)
  » ~150 Miles East (84.5°W)
- 100 Yr Return Period Criteria Exceeded; (Hs ~40 ft)
  » ~30 Miles West (88.8°W)
  » ~110 Miles East (86°W)

5 MODUs Incurred Damage to Moorings
- 4 MODU Moorings Failed & Rigs Drifted.
  » All failures due to overload
  » 100 Yr Storm Event exceeded in all cases.
  » 0.86 mile to 70 mile excursions reported.

2 MODUs survived > 10 Yr Return Period Event.
- Both rigs on West Side of Storm.
Close Proximity Needed

- 7 MODUs in Direct Path of Ivan
- Two undamaged.
- One damaged.
  - Still held in place.
- Four failures and free to drift.
  - > 100 Yr Wave & Wind.

Boundary > 10 Yr RP Wave Event
Boundary > 100 Yr RP Wave Event
## Summary of Moored Rig Incidents
### Transocean & Diamond

<table>
<thead>
<tr>
<th>Rig</th>
<th>Mooring Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transocean</td>
<td>Taut Mooring System – Synthetic Rope</td>
</tr>
<tr>
<td>Nautilus</td>
<td>9.55’ x 70’ SP Anchor</td>
</tr>
<tr>
<td>RB8-8M</td>
<td>3,500’ 3-3/4” HS Wire</td>
</tr>
<tr>
<td></td>
<td>500’ 3-3/4” HS Wire</td>
</tr>
<tr>
<td>Lorris Bouzigard</td>
<td>10 pt Conventional Mooring System.</td>
</tr>
<tr>
<td>Pentagone 85</td>
<td>2.75” IWRC EEEIPS Wire &amp; 3” QRC Chain</td>
</tr>
<tr>
<td></td>
<td>9 &amp; 12 MT Stevipris Anchors</td>
</tr>
<tr>
<td>Jim Thompson</td>
<td>Semi-Taut System</td>
</tr>
<tr>
<td>EVA – 4000</td>
<td>9 Point</td>
</tr>
<tr>
<td></td>
<td>30 – 60 Deg</td>
</tr>
<tr>
<td></td>
<td>Suction Pile &amp; Wire</td>
</tr>
</tbody>
</table>
# Summary of Moored Rig Incidents

## Noble Drilling

<table>
<thead>
<tr>
<th>Rig</th>
<th>Mooring Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean America</td>
<td>Conventional 8 Pt – 45°</td>
</tr>
<tr>
<td></td>
<td>10MT Bruce MK-4 Anchors</td>
</tr>
<tr>
<td></td>
<td>3-1/4” Chain &amp; 3-1/2” Wire</td>
</tr>
<tr>
<td>Odyssey Class</td>
<td></td>
</tr>
<tr>
<td>Ocean Star</td>
<td>Conventional 8 Pt – 45°</td>
</tr>
<tr>
<td></td>
<td>10MT Bruce Anchors</td>
</tr>
<tr>
<td></td>
<td>3-1/4” Chain &amp; 3-1/2” Wire</td>
</tr>
<tr>
<td>Enhanced Victory Class</td>
<td></td>
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</tbody>
</table>
PURPOSE OF SESSION

- Provide insight into mooring incidents.
- Disseminate knowledge across Industry.
  - Equipment & Methods.
  - Industry initiatives.
  - Risk management.
- Discuss
  - Additional industry needs & path forward.
  - New Technology & Applications.
Morning Agenda

- API RP2SK Standards Review & Update
- Deepwater Nautilus Mooring Incident
- Jim Thompson Mooring Incident
- Facilitated Panel Discussion

BREAK

- Proposed JIP on Reliability and Risk Assessment.
- Riser Management in Severe Environments
- Designs & Installation to Improve Reliability & Reduce Risk.
- Station Keeping Capabilities of the Development Driller
Afternoon Agenda

- Facilitated Panel Discussion & Open Forum
- Summarize Breakout Session
  - Panel Members
- Plenary Session
  - Reconvene All Breakout Sessions for Recap
“Despite the fury of Ivan, there were no reports of injury, fatalities or significant pollution associated with offshore facilities – a significant tribute to the programs in place for safeguarding life, property and the environment.”
Proposed MODU Mooring JIP

Hurricane Readiness & Recovery Conference
AGENDA

- Operating Philosophy & Historical Performance in GOM
- Genesis of the Proposed JIP
- Scope of Work Developed by Planning Committee
- Path Forward
During 13 years of operations, only 3 storms have caused mooring failures.

Storms since 1992 resulting in MODU mooring failures.
- Andrew (1992); Category 4 Offshore & 3 at Landfall.
  » 2 Rigs Broke Loose
- Lili (2002); Category 4 Offshore and 2 at Landfall.
  » 1 Rig Broke Loose
- Ivan (2004); Category 4 Offshore and 3 at Landfall.
  » 4 Rigs Broke Loose
GOM Operating Philosophy

Safety Procedures during Hurricane Season:

- Protect human life:
  - Evacuate Drilling and Production Facilities.

- Minimize Pollution Risks:
  - Secure wells on drilling rigs and shut wells in below mudline on production facilities.
  - Pipelines shut in where necessary.

Minimize Business Interruption:

- Design moorings to meet or exceed API 2SK criteria.
- Perform risk analysis when mooring near infrastructure.
- Common techniques used to minimize risk.
  - High hold anchors utilized when mooring near pipelines.
  - Utilization of suction piles.
  - Utilization of synthetic mooring systems.
### Operational Considerations

<table>
<thead>
<tr>
<th>GOM Philosophy:</th>
<th>North Sea Philosophy:</th>
</tr>
</thead>
</table>
| - Evacuate Drilling & Production Facilities.  
  » Protect Human Life.   
  - Secure wells.  
  » Reduce pollution risk. | - Facilities not evacuated. |
| - Hurricane intensity has high variability. | - Active winching if possible. |
| - Aerial distribution of maximum wind & wave is more localized. | - Thruster assist. |
| - Storm track and resulting direction of environmental forces are less predictable than North Sea. | - Storm intensity is more predictable. |
| | - Storm patterns are less random. |
| | - Extreme Winter Storm < Extreme Hurricane |
Conclusion

- **Current practice & industry standard code has produced an acceptable level of risk.**
  - Few mooring failures in the GOM.
  - The industry has had years of successful operations in the GOM.

- **Industry has been innovative in developing new methods which provide adequate moorings in deeper waters.**
  - As deeper water opportunities challenge mooring limits, it will be necessary to quantify risk using scientific methods.

- **Expansion of GOM deepwater infrastructure will require additional risk management tools.**
<table>
<thead>
<tr>
<th>Event Description</th>
<th>Date</th>
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<tbody>
<tr>
<td>OOC presents – Ivan findings to MMS</td>
<td>10-March-05</td>
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<tr>
<td>Industry JIP Kick Off Meeting;</td>
<td>06-April-05</td>
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<tr>
<td>-MMS Attended</td>
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<tr>
<td>JIP Planning Committee Meeting</td>
<td>26-April-05</td>
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<tr>
<td>Update OOC Membership on Proposed JIP</td>
<td>01-June-05</td>
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<tr>
<td>Final JIP Planning Committee Meeting</td>
<td>02-June-05</td>
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<tr>
<td>JIP – RFP Introduced to Contractors</td>
<td>13-June-05</td>
</tr>
<tr>
<td>Proposals Received by Planning Committee</td>
<td>13-July-05</td>
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<tr>
<td>JIP Planning Committee</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
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<tr>
<td><strong>Craig Castille</strong></td>
<td><strong>Dominion (OOC)</strong></td>
</tr>
<tr>
<td><strong>Dave Loeb</strong></td>
<td><strong>Shell</strong></td>
</tr>
<tr>
<td><strong>Greg Walz</strong></td>
<td><strong>BP</strong></td>
</tr>
<tr>
<td><strong>David Smith, Nelson Tears &amp; John Heideman</strong></td>
<td><strong>ExxonMobil</strong></td>
</tr>
<tr>
<td><strong>Charlie Theriot</strong></td>
<td><strong>Marathon</strong></td>
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<tr>
<td><strong>Jenifer Tule</strong></td>
<td><strong>Kerr McGee</strong></td>
</tr>
<tr>
<td><strong>David Wisch &amp; Kai Tung Ma</strong></td>
<td><strong>Chevron</strong></td>
</tr>
<tr>
<td><strong>Darrel Pelley &amp; Riddle Steddam</strong></td>
<td><strong>Transocean</strong></td>
</tr>
<tr>
<td><strong>Scott Marks &amp; Jitendra Prasad</strong></td>
<td><strong>Noble Drilling</strong></td>
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<tr>
<td><strong>Karl Sellers &amp; Rodney Eads</strong></td>
<td><strong>Diamond Offshore</strong></td>
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<tr>
<td><strong>Momen Wishahy</strong></td>
<td><strong>Global SantaFe</strong></td>
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<tr>
<td><strong>Alan Quintero</strong></td>
<td><strong>Atwood Oceanics</strong></td>
</tr>
<tr>
<td><strong>Fred Hefren &amp; Glen Woltam</strong></td>
<td><strong>MMS</strong></td>
</tr>
</tbody>
</table>

Tom Kwan (DTCEL/API) & Evan Zimmerman (Delmar) participated in Planning Committee activities until work scope established.
Proposed JIP

Study Objectives

Task 1; Metocean

- Establish baseline USGOM Deepwater Metocean Criteria.
  
  » > 600’ WD
  
  » For Hurricanes (Tropical Revolving Storms)
  
  ■ 5, 10, 25, 50 & 100 Year Return Periods
  
  » Empirical relationships for wind, wave and current.
  
  ■ Joint Directional Probabilities.
  
  » Will utilize GOM ISO Draft as Starting Point
Proposed JIP
Study Objectives

Task 2; Historical Reliability

  » Categorize causes of failure.
  » Categorize resulting damage to surrounding equipment.
- Determine FOS on mooring components using Hindcast Environments.
- Determine mooring reliability for study period.
  » All moored MODUs in operation.
  » MODUs impacted by 5, 10, 25, 50 & 100 RP Storms.
Proposed JIP

Study Objectives

- **Task 3; Calibration Study**
  - Deterministic FOS Study for Fleet Cross Section of Semi-submersibles.
    - Water Depth and Spread Type Matrix
    - Intact and 1-Line Damage with Collinear Environment.
  - Evaluate the reliability of existing code of practice using directional environmental data.
    - Based upon deterministic study above and various Return Period Storms defined in Task 1.
Proposed JIP
Study Objectives

■ Task 4; Comprehensive Risk Assessment
  - Conditional Probabilities of Mooring Failure and Surface and/or Subsea Damage.
  - Develop a risk ranking method or matrix to summarize results.
  - Outline workflow for risk assessment so it can be updated as GOM infrastructure changes.
  - Assess consequential damages caused by collisions between typical MODUs and GOM Deepwater Production Facilities.
Proposed JIP
Study Objectives

- Task 5; Recommendation to API Committee 2
  - Appropriate recommendations to API-RP-2SK Subcommittee.
Proposals Tendered

- **ABS – Joint Proposal**
  - Energo Engineering, Inc.
  - ORTC; (Offshore Risk & Technology Consulting)
  - MCOT; (Metocean, Coastal & Offshore Technologies)
  - Delmar Systems
  - OceanWeather

- **DNV**
  - OceanWeather, Inc.

- **DTCEL – Joint Proposal**
  - Energo Engineering, Inc.
  - ORTC; (Offshore Risk & Technology Consulting)
  - MCOT; (Metocean, Coastal & Offshore Technologies)
Proposals Tendered

- **Granherne** (A Halliburton Company) - Richard D’Souza
  - ORTC – Malcolm Sharples
  - University of Texas Austin
  - OceanWeather, Inc.
  - MCOT

- **Noble Denton** - Dr. Bader Diab
  - OceanWeather, Inc

- **Sea Engineering** - Dr. Pieter Wybro
  - Ken Schaudt – Metocean via OceanWeather
  - ORTC – Malcolm Sharples
  - Energo, Engineering Inc.
<table>
<thead>
<tr>
<th>Path Forward for JIP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proposal Review by JIP Planning Committee</strong></td>
</tr>
<tr>
<td><strong>Select JIP General Contractor</strong></td>
</tr>
<tr>
<td><strong>Secure Funding</strong></td>
</tr>
<tr>
<td><strong>Begin Work on JIP</strong></td>
</tr>
<tr>
<td><strong>Conclude Work on JIP</strong></td>
</tr>
<tr>
<td><strong>Present Findings to API 2SK Work Group</strong></td>
</tr>
</tbody>
</table>
JIP Funding

- Funding will be from:
  - Drilling Contractors.
  - Operating Companies.
  - Service & Supply Sector.

- OOC – Has & will support efforts, however will not contribute to funding.

- MMS – Is supportive of efforts and has funded ORTC to review incidents.
  - MMS will participate, but will not fund beyond white paper awarded to ORTC.
Funding Model

- Companies funding JIP will form the; “JIP Steering Committee”.
- Will have three levels of participation in Steering Committee;
  - Tier 1: Funding with Voting Rights
  - Tier 2: Funding with No Voting Rights
  - Tier 3: No funding or voting rights.
  » Participation encouraged by Industry; MMS & USCG
- Currently have information on JIP at OOC Website;
  - www.offshoreoperators.com
- Planning Committee RFP (Scope of Work) is available along with funding structure.
- If interested, contact myself or log into OOC Website.
THANK YOU!

Questions?
Riser Management in Severe Environments
Managing Risk
What is a Severe Environment?

- Tropical Revolving Storm (Hurricane, Cyclone)
- Oceanic, Wind-driven or Eddy Currents

The severity of the environment is directly related to the operations being performed.

- Drilling
- Tripping
- Running Casing
- Drill Stem testing

Some type of operations have more stringent weather limitations.

- Drilling ahead is a good example
The area affected by the storm is much larger than the path of the eye wall.

There are no discernable patterns in the landfall probabilities and intensity of hurricanes affecting the continental United States.
The concept of riser management is such that when properly executed, we don’t have to manage marine drilling risers in the storm environment.

Purpose of Riser Management (Why)

To Minimize Risk -
- of pollution from unplanned discharges
- of equipment damage
- of infrastructure damage
- of personal injury

Key Riser Management Issues relating to Storm Preparedness:
- Understanding equipment and people limitations
- Proper planning
- Timely execution
Managing Risk in Riser Operations Everyday:

- **DO** - obtain credible site-specific data, including metocean and bathymetry.
- **DO** – have a site-specific riser management plan.
- **DO** – minimize differential riser angles.
- **DO** – have a reliable means for sensing currents throughout the water column and for monitoring riser angles during operations.
- **DO NOT** – unlatch BOP in any environmental conditions under which the riser cannot be retrieved.
- **DO NOT** – attempt to run or retrieve BOPs in high surface currents unless reliable current measurements through the water column indicate that riser angles can be managed within recommended limits.
Storm preparedness planning, mitigating risk:

- **DO** – Have a predefined plan for storm preparedness.
- **DO** – Retrieve the LMRP and marine drilling riser prior to encountering tropical storm environments.
- **DO** – Review and update T-time estimates on a routine basis during storm season to reflect changing operating and environmental conditions (such as high currents and well construction operations).
- **DO** – Maintain the ability at all times to manoeuvre a DP installation out of the path of a tropical storm environment to sufficient distance to protect personnel and equipment. This means allotting sufficient time to retrieve and stow the riser system onboard.
Riser Management in Severe Environments

What if a riser cannot be retrieved?

There are situations where well construction operations prevent unlatch and pulling the riser at the best opportunity, resulting in all or part of the riser suspended beneath the unit.

While it is always preferable to retrieve and secure the marine riser on deck, riser systems are designed to survive severe storm environments in a suspended state.

This a routine practice in other harsh-environment operating areas.

Mitigating Risk while Suspended

• Pull as much as possible. Shorter riser strings have shorter natural periods and less severe dynamic response.
• Properly support the marine riser
  ✓ Gimbaled Spider
  ✓ Shared Load Path (hook/tensioners or hook/substructure)
• Use of a landing joint (when possible) to increase the annulus around the riser in the diverter housing and prevent damage to buoyancy and peripheral lines.
Conclusions...

- Riser Management is a methodology that we practice every day. Storm preparedness is one aspect of riser management.

- The importance of site-specific data can never be underestimated.
  - As an example, simultaneous occurrence of tropical cyclone and eddy current must be considered.
  - Site-specific bathymetry is crucial for DP rigs which may unlatch and drift while retrieving risers.

- Consistent application of riser management strategy minimizes exposure to risk associated with severe storms.
  - A plan is only useful if it is executed in a timely manner and an organized fashion.