Purpose

- ALARP
- Risk Assessment
- Major Accident Events
- Bowties
- Safety Critical Systems
- Performance Standards
- Implementation
- Getting HSE Case accepted
- Gap Assessment and rig upgrades
Add energy HSE/Safety Case Experience

- Oracle Risk Consultants from 2001-2013
- Now part of add energy group
- Over 150 HSE/Safety Cases
- Offices worldwide
- Members of IADC
Definitions

- **ALARP** – Demonstrating that the safety Risks have been reduced to *As Low As Reasonably Practicable* (i.e. the operator can demonstrate that there are no practicable upgrades or changes that can be made to reduce risk further)

- **Major Accident Event** – one capable of multiple fatalities (e.g. blowout)

- **Control Measure** - any system, equipment or procedure that reduces risk

- **Risk Assessment** – Process for estimating the severity and likelihood of a Major Accident.

- **Safety Critical System** – one that has a benefit in preventing Major Accident Events

- **Performance Standard** – Specification of the performance required os a Safety System which is used as a basis for managing the risk
Key issues

- HSE Case produced by others but not followed (sits on shelf)
- No evidence of meeting the latest standards and gap assessment
- No performance standards produced
- No evidence of testing and maintenance of safety critical equipment
- No adequate demonstration of “ALARP”
Risk Assessment Process

1. Identify Hazards, causes, consequences and controls
2. Risk Screening using Risk Matrix
   - Major Accident Events
     - Identify MAE Controls and Develop Bowties
     - Implement MAE Controls to reduce risks to ALARP
     - Develop Performance Standards for MAE Controls
     - Ensure the controls continue to meet the Performance Standards under SMS
   - Other Events (Non-MAEs)
     - Implement controls under the SMS
# Hazard Register

We use a bowtie format:

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Dropped objects</td>
<td>Crane Safety Systems</td>
<td></td>
<td></td>
<td>Fire and gas detection</td>
<td>Emergency Response Plan</td>
<td></td>
<td>D</td>
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<tr>
<td></td>
<td>Crane Operations and Lifting</td>
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</tr>
<tr>
<td></td>
<td>Equipment, modification</td>
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<td>M</td>
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</tr>
<tr>
<td></td>
<td>Damage</td>
<td></td>
<td></td>
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<td>N</td>
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</tr>
<tr>
<td>Corrosion of</td>
<td>Environmental protection</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Hydrocarbon</td>
<td>Maintenance and inspection</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Erosion of hydrocarbon</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Mechanical failure</td>
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</tr>
</tbody>
</table>
# Risk Matrix

## Consequence

<table>
<thead>
<tr>
<th>People</th>
<th>Environment</th>
<th>Value</th>
<th>Reputation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple Fatalities (MAE)</td>
<td>Permanent impact</td>
<td>&gt;$100M</td>
<td>International concern. Major venture terminated company at stake.</td>
</tr>
<tr>
<td>Single Fatality or Permanent Total Disability</td>
<td>Long term (years) impact</td>
<td>$100M-$1000M</td>
<td>Persistent national concern. Long-term brand impact. Major venture asset operations severely restricted.</td>
</tr>
<tr>
<td>Major Injuriousness, Permanent Partial Disability or Lost Work Case &gt; 7 days</td>
<td>Medium term (months) impact</td>
<td>$10M-$100M</td>
<td>Medium-term national concern. Minor venture or minor asset operations restricted or outaged.</td>
</tr>
<tr>
<td>Minor Injuriousness, Restricted Work Case or Lost Work Case &lt; 7 days</td>
<td>Short term (weeks) impact</td>
<td>$1M-$10M</td>
<td>National/local mention. Short-term regional concern. Close scrutiny of Asset level operations/asset proposal.</td>
</tr>
<tr>
<td>Slight Injuriousness, First Aid or Medical Treatment Case</td>
<td>Localized (Immediate) Temporary impact (days)</td>
<td>&lt;$1M</td>
<td>Short-term local concern. Some impact on asset level non-production activities.</td>
</tr>
</tbody>
</table>

## Likelihood

<table>
<thead>
<tr>
<th>Frequency: (Continuous Operation)</th>
<th>Probability: (Single activity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than once every 10,000 years at location</td>
<td>1 in 100,000-1,000,000*</td>
</tr>
<tr>
<td>Once every 100-1,000 years at location</td>
<td>1 in 1,000-10,000</td>
</tr>
<tr>
<td>Once every 10-100 years at location</td>
<td>1 in 100-1,000</td>
</tr>
<tr>
<td>Once every 1-10 years at location</td>
<td>1 in 1000-10,000</td>
</tr>
<tr>
<td>More than once every year at location or continuously</td>
<td>1 in 10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Highly Unlikely</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Unlikely</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Possible</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Quite Likely</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Likely</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

*In tolerability

## Intolerable

1. ALARP (AS LOW AS REASONABLY PRACTICAL) REGION
2. Reduced to ALARP (AS LOW AS REASONABLY PRACTICAL)
3. BROADLY ACCEPTABLE
4. INTOLERABLE

Asia Pacific HSE&T 2015
Potential Major Accidents

The definition of a **Major Accident Event (MAE)** is an accident with the potential for **multiple fatalities, eg.**

- Blowouts
- Shallow Gas
- H2S
- Fire in Machinery Space
- Fire/explosion in mud return area
- Fire in well test area
- Fire in Accommodation
- Loss of stability
- helicopter crash
- H2S
- Dropped objects
- Ship collisions
- Loss of position
- lifeboat/billy pugh accident
A “bowtie diagram” is simply a pictorial representation of a Major Accident.
Bowtie Example

Prevention controls:

- Description
- Responsibility
- Document Ref. (Procedures, Performance Standard)

Description

Equipment

Procedure

Design

Feature

Inadequate formation data

Seismic survey prior to drilling

Offset wells

H.02 Reservoir Hydrocarbons

Potential Shallow gas pocket

No drilling in known shallow gas zones

Seismic survey prior to drilling

Well information and design (Well Program)

Shallow gas procedures

Drilling pilot hole

Adherence to well control procedures

Mud system (heavy mud)

SCE 04 Mud and Cement System

Formation failure

Seismic survey prior to drilling

Well information and design (Well Program)

Cementing procedures

Operator

Procedure

Equipment

Design

Feature

Document Ref. (Procedures, Performance Standard)
Do we have enough Controls?

- Driller rule of thumb: *two independent tested barriers*
- But the more barriers the lower the risk
- Some controls are more effective at reducing risk than others – but all are important

[Diagram of Hardware (Safety Critical Systems) and Other Controls (procedural and administrative)]
Output from Bowtie

Outputs from the “Bowtie” include:

- List of Control Measures that can be divided into:
  - Safety critical systems (Equipment)
  - Safety critical procedures
  - Safety critical competencies
- List of responsibilities for each key person regarding control measures
- Checklists for use prior to starting a task or regularly checked during task

“Implementation of the HSE Case involves ensuring that all control measures are in place and remain effective (maintained and tested) – not just documented in the HSE Case”
Typical Safety Critical Systems

- Blowout Preventer, well control and diverter system
- HP mud and cement systems
- Choke and Kill systems
- The hull and primary structure
- Watertight integrity
- Ballast and Bilge systems
- Propulsion and station keeping (DP)
- Anchors & winches
- Towing system
- Fire & Gas Detection
- Emergency Shutdown
- Emergency power and lighting
- Ventilation system, including shutdown to prevent gas/smoke ingress
- Fuel and Lube oil system
- Hazardous Area Zoning and Ignition prevention
- Active and Passive Fire Protection
- Escape, Temporary Refuge, Evacuation and Rescue Systems
- Helideck and helicopter refuelling
- Navigation and communications systems
- Lifting systems including cranes, derrick and tubular handling
- Hydraulic and Pneumatic systems including Heave compensation
Performance Standards

- Design basis/ specification for each system
- They define the parameters against which the control measures for MAEs can be measured and tested to ensure risk are managed to ALARP.
- They specify function, survival requirements (e.g. fire resistance) and reliability/sparing requirements (e.g. 2 x 100% fire pumps required)
- Based on Codes, Standards, operations experience or risk assessment.
- **Implementation is via the Preventative Maintenance System (PMS) which should contain** maintenance and testing procedures which align with the Performance Standards.
- Performance standards contain both design and operational requirements:
  - 2 x 100% fire pumps (at least one fire pump always available)
  - Minimum delivery pressure at helideck = 5bar
  - Minimum survival time of ring main = 1 hour
  - Minimum blast resistance = 1 bar
  - Minimum coverage rate = 10 litres/m2/min
  - Maximum time to deliver water 15 sec
Typical Safety Critical Procedures

- Operating and Maintenance Procedures
- Well control procedures
- Training and Competency
- Permit to Work/Isolation procedures
- Integrity Management
- Technical Change Management
- Emergency Response
- Audit and review
Example for Preventative Management system:

- All Safety Critical Equipment identified in the HSE Case to be flagged as Safety Critical in the PMS;
- All maintenance and testing of SCEs is logged within the PMS;
- The maintenance and testing procedures for SCEs are aligned with the Performance Standards and refer to them;
- No operations have been performed that rely on SCEs have not been confirmed to meet the Performance Standards (e.g. due to a backlog of maintenance tasks or a failed function test) unless a risk assessment has been performed to verify that the risks are acceptable.
- All personnel responsible for operations maintenance activities have the necessary competence and training in the concept of SCEs and Performance Standards and the importance of ensuring that the safety critical equipment is regularly tested in compliance with the Performance Standards.
How difficult is it to get Case Accepted?

Not all counties have a Regulatory regime that requires a HSE Case, however, many operating companies also require a HSE/Safety Case to be submitted for approval as part of the contract/selection process.

- **New rigs** – relatively straightforward since the MODU generally built to latest Codes & Standards

- **Older rigs** - come under particular scrutiny, particularly if built prior to the ‘89 MODU Code. This is because Codes are continuously updated in response to accidents or new technology.

- A **“Gap assessment”** against the latest codes (MODU Code, Class, API, etc) is generally required for older rigs as part of demonstrating **ALARP**.

- Generally Operating Companies are less stringent than Regulators!
Examples of Updates to Codes and Standards

- Replacement of API RP 53 with API Std 53 covering BOP systems post the Macondo incident. Now requires dead-man and auto-shear systems on all subsea BOPS, including semis

*subject to risk assessment
Gap Assessment

- Use **checklists** to identify the differences between the design codes and the latest versions;
- Determine the **practicability** of upgrading the rig to comply with the latest requirements (i.e. cost versus benefit);
- Select upgrades which give most **“bang for the buck”**
- Identify alternative measures in lieu of code compliance which would have a similar risk reduction (e.g. procedural controls);
- Produce an implementation plan for the upgrades and agree with Regulator/Company.

**Note:** - it may not be practicable to upgrade an older rig to the latest standards, but at least understand the reasoning between the latest codes and its impact on reducing safety risk.

**Note:** - Gap assessment is not the same as a Modu-spec Survey.
Gap Assessment

Examples of some key changes introduced in the ‘89 MODU Code:

- central ballast control room provided and located above damaged water line
- no windows or port-lights below deck
- chain lockers to be fitted with remote detection of flooding and means of dewatering to prevent flooding
- all essential equipment including evacuation systems and bilge system designed to operate under maximum inclined angle
- ability to de-ballast semi to survival draft within 3 hours
- 2 x 100% ballast pumps available, both powered via the emergency generator
- ballast system designed to prevent inadvertence transfer of ballast water from one compartment to another resulting in stability problem
- ability to monitor wind conditions and anchor tensions for the control room
- A60 fire rating for accommodation walls facing the drill centre wand within 30m with any windows also A60 rated or protected by water curtain or steel shutters
- smoke detectors in all cabins
- remote shutdown of fuel supply from safe location
- 00% capacity lifeboats each side. end of unit plus 100% liferafts (total)
- at least 2 widely separated stairs or ladders from deck to sea level
- additional life jackets provided in suitable locations for persons on duty
- on load lifeboat hooks with hydrostatic release
BOP System Design

There are several differences of opinion:

<table>
<thead>
<tr>
<th>Item</th>
<th>30 CFR 250.442 (July 2012)</th>
<th>API Std 53 (Nov 2012)</th>
<th>UK WLC PF (May 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deadman/Autoshear</td>
<td>DP rigs only</td>
<td>All rigs</td>
<td>DP rigs only</td>
</tr>
<tr>
<td>Annular Preventers:</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Pipe Rams:</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Shear Rams:</td>
<td></td>
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</tr>
<tr>
<td>DP Rigs:</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Moored Rigs with Riser Margin:</td>
<td>1</td>
<td>1*</td>
<td>1</td>
</tr>
<tr>
<td>Moored rigs: without a riser margin:</td>
<td>1</td>
<td>1*</td>
<td>1*</td>
</tr>
</tbody>
</table>

*subject to risk assessment
Is it practicable to upgrade the BOP to comply with API S53?

Typical 5-ram with subsea accumulator (DP Rig)

Typical 4-ram without subsea accumulator (Moored Rig)
**Summary**

*Implementation of the HSE Case* involves:
- Making sure we have *sufficient controls* in place to prevent and mitigate Major Accident Events
- Developing *Performance Standards* for Safety Critical Controls and *aligning the PMS procedures* with the Performance Standards
- *Maintaining and testing* safety critical equipment to the Performance Standards
- *Ensuring all controls are effective* before commencing tasks and regularly during the task
- For older rigs - performing a *gap assessment* against the latest Codes and Standards and identifying safety critical upgrades
- Incorporation of *lessons learned* from previous incidents
- Brainstorming and discussion of potential *risk reduction measures* by project/crew and implementation where practicable
- Producing *Implementation plan* for upgrades that are cost effective
Questions?