High Current Drilling Experiences / Solutions

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Ref: "Drilling Riser Management on a Well in the North Brazil Current" by Greg Rheame (BP Brazil), James Brekke (GlobalSantaFe), and Julian Soles (GlobalSantaFe) - IADC World Drilling Conference & Exhibition Rome, Italy, 9-10 June 2005

Brazil Drilling Riser Management

Context

The BP Brazil DWPU Algodoal wildcat exploration well was spudded in August 2004 located in 760 meters of water in the Foz do Amazonas basin off the north coast of Brazil.

Problem

- North Brazil Current measured up to 5.0 knots with limited dataset.
- Exposure to significant operational risk and cost.

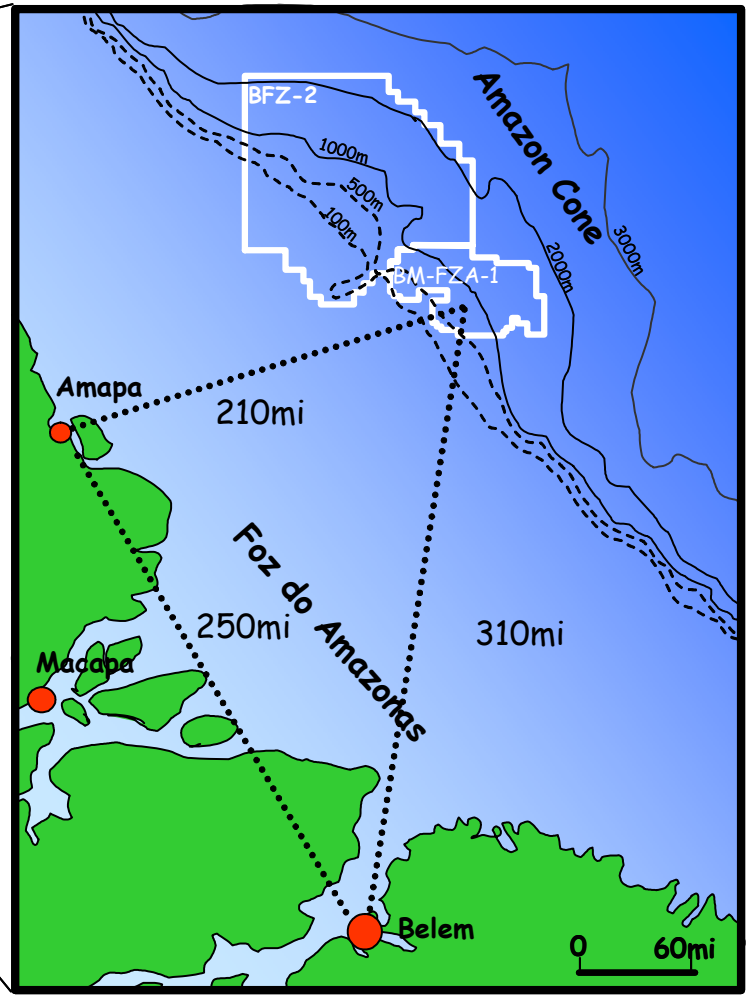
Technical Solutions

- Surveillance (ADCP / Riser Loggers)
- Open Water Operations - Drift-Running to Allow Deployment
- Riser Stack-Up for Vortex-Induced Vibration (VIV) and Weight
- Riser Fairings – VIV & Riser Drag/Angles
- Well & Riser Design for Vessel Drift-Off – Shallow Water Issue
- DEEPDRIFT Program & WSOC (Well-Specific Operating Criteria)

Execution

- Operate +4.0 knot current
- 2.6 days (2%) & $1.15mm NPT Wait on Current
- No failures

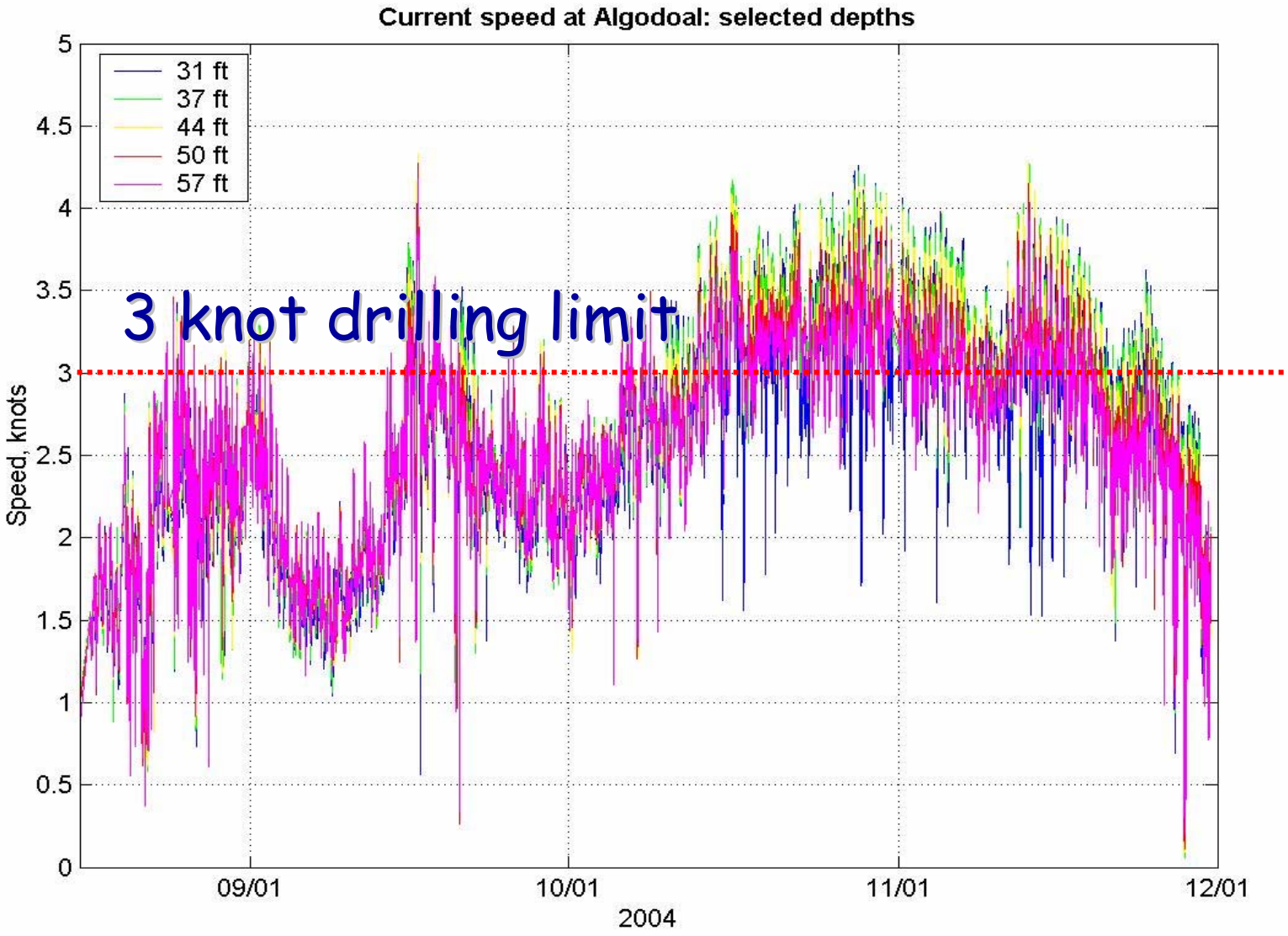
Brazil Well Site Operations



- **Operate in +4 knot surface current.**
- **Deepest Well off North coast Brazil.**
- **Highest Pore Pressure in Brazil.**

Belem – Rio 2200mi

Day-to-Day Currents - Algodoal



Hold Station in 2.0-Knot Current

Riser Management in High Currents

Appraise → Select → Define → Execute

Risk Identification

- **Problem Recognition**
- **Review data (20% > 3kn)**
- Rig Contractor Meeting

Structural Analysis

- **Conductor Design**
- **Wellhead Design**
- Drift-Off / Riser Analysis

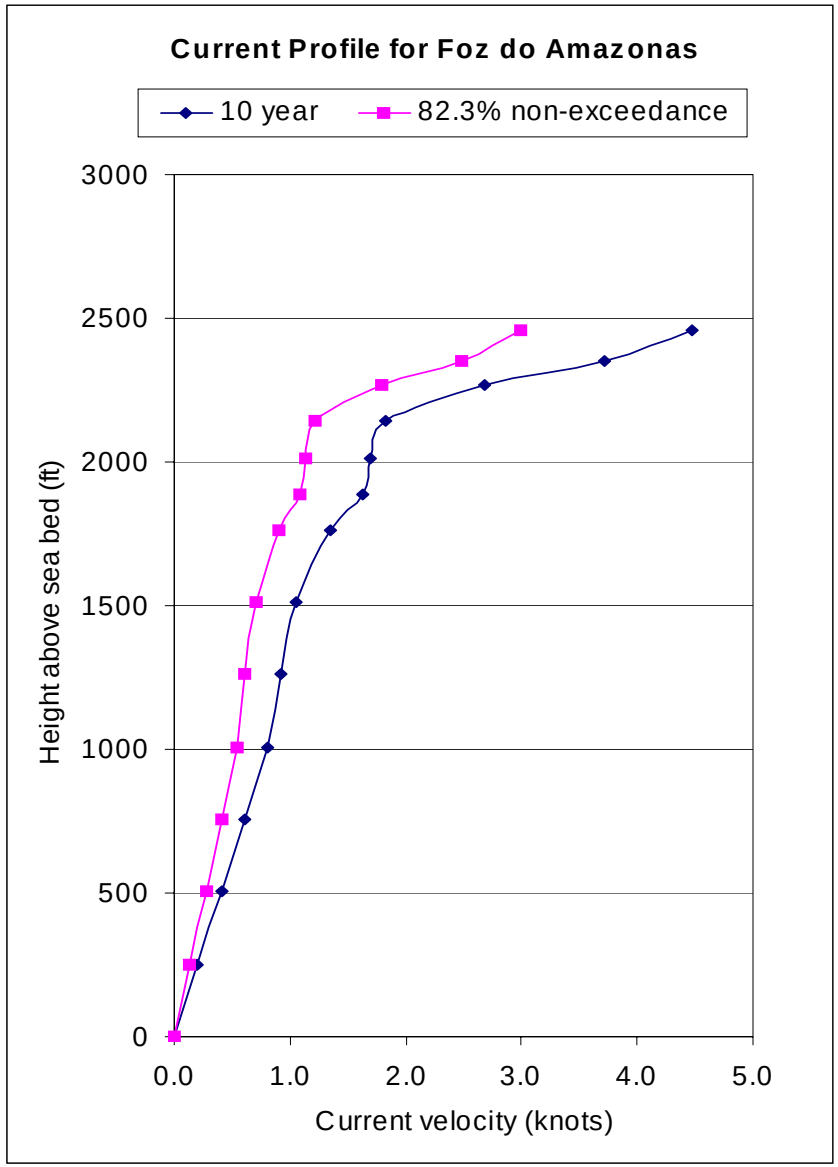
Operational Plan

- **Specific Peer Assist**
- Riser Fairings
- Open Water Plan (Drift-Running)
- Riser Inspection
- Surveillance (ADCP & Loggers)
- WSOC/DEEPDRIFT

Implementation / Operation

- **+ 4 knot Current Operation**
- Riser Fairings Installation
- Open water – Analysis, Plans, & Implementation (Drift-Running Csg & Riser)
- Bare & Buoyed Riser Joints
- Install Surveillance Systems
- Apply WSOC/DEEPDRIFT

Existing Dataset of Currents

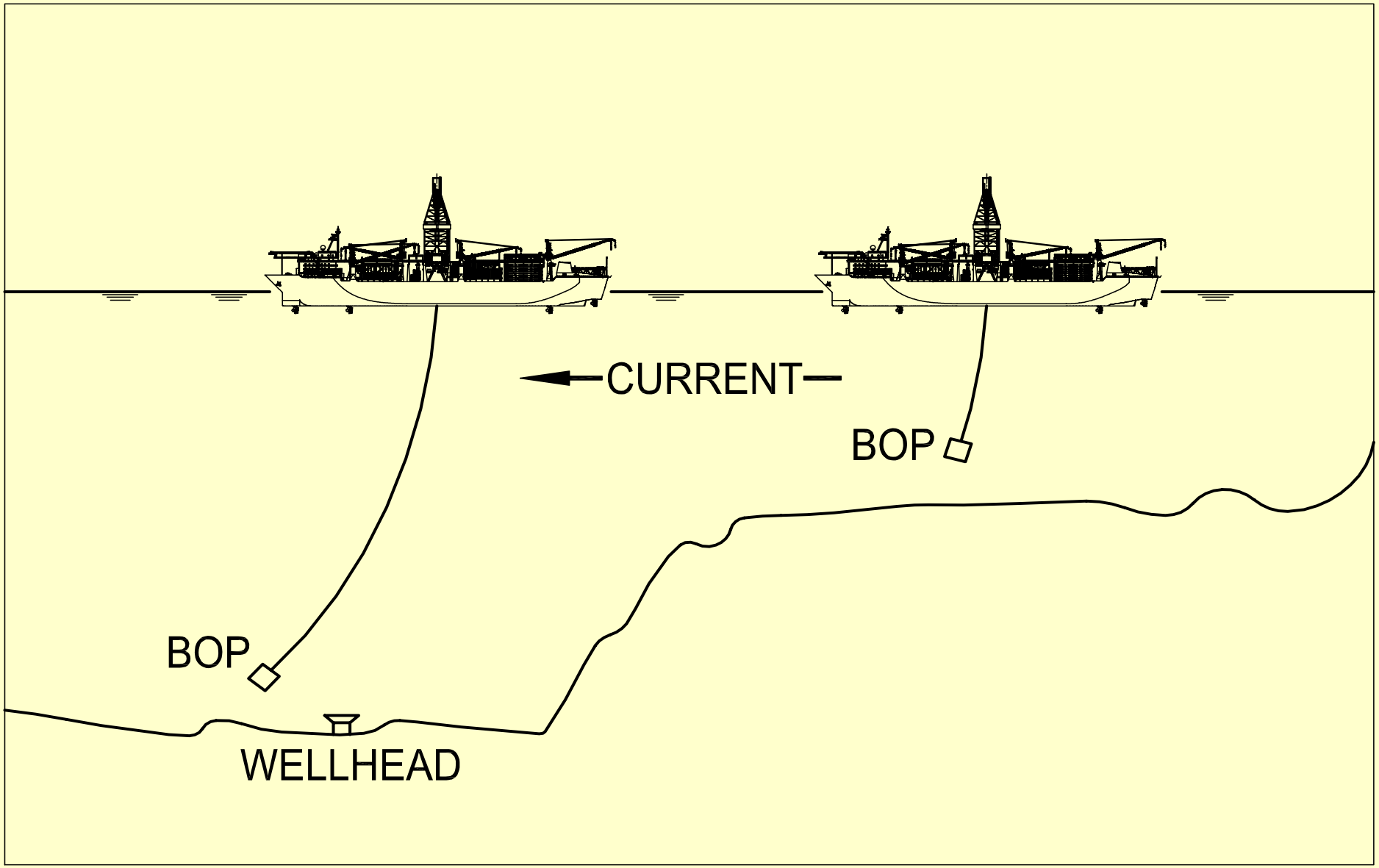


- 2001: ADCP buoy & rig deployed ADCP data collection – full year data
- Exxon 1980 – 2.5m/s or 4.85 knots max current (13 months at 100m, 400m, 1200m).
- GROW dataset (30yr hindcast wind/wave)

Technical Solutions

- Open Water Operations
  - Drift-Running to Allow Deployment
- Bare/Buoyed Joint Configuration for VIV and Weight
- Riser Fairings
  - VIV Suppression
  - Reduced Riser Drag/Angles
- Well & Riser Design for Vessel Drift-Off
  - Shallow Water Issue
- DEEPDRIFT Software
  & WSOC (Well-Specific Operating Criteria)

Drift-Running



Drift-Running for Open-Water Operations

Operations (various shoe or BOP depths)

- Running 36” Conductor
- Running 28” Casing
- Running 22” Casing
- Running Riser w/BOP

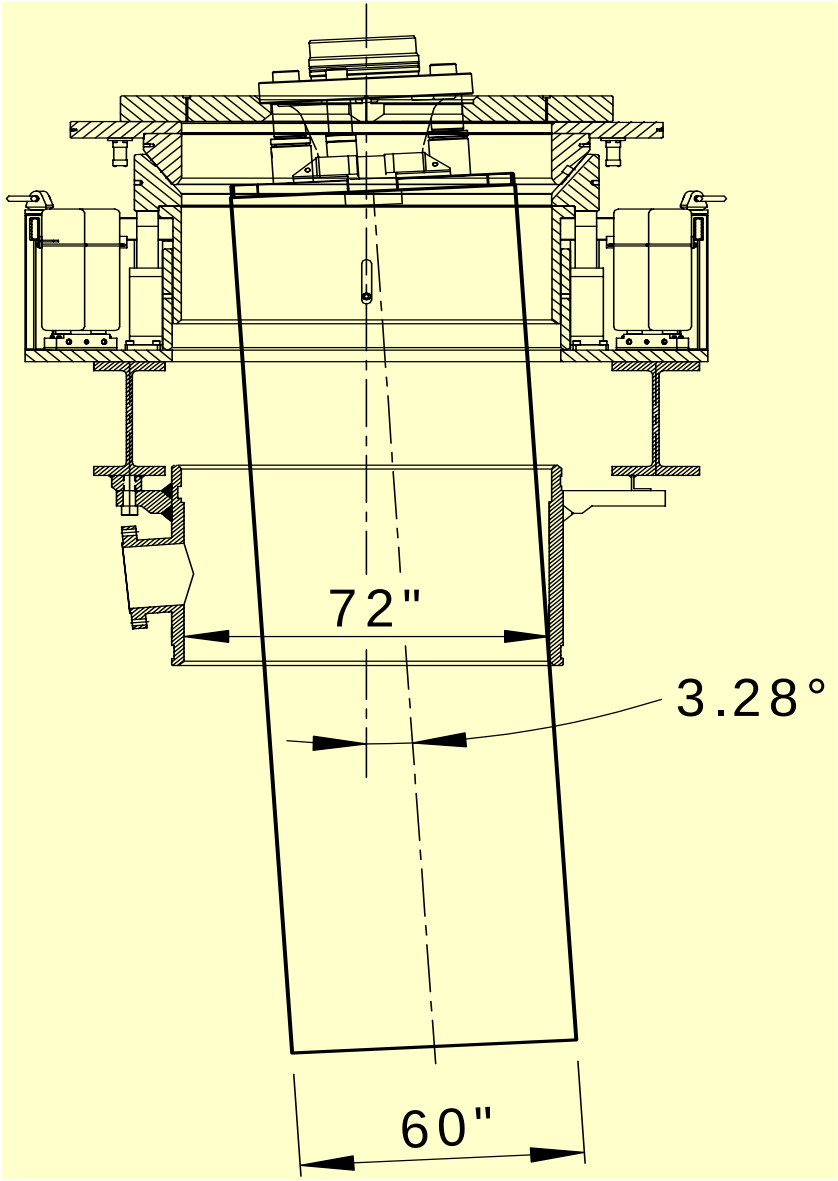
Decision-Making Process

- Gather Current Profile Data
- Determine Anticipated Riser Angles
  - Is Drift-Running Required?

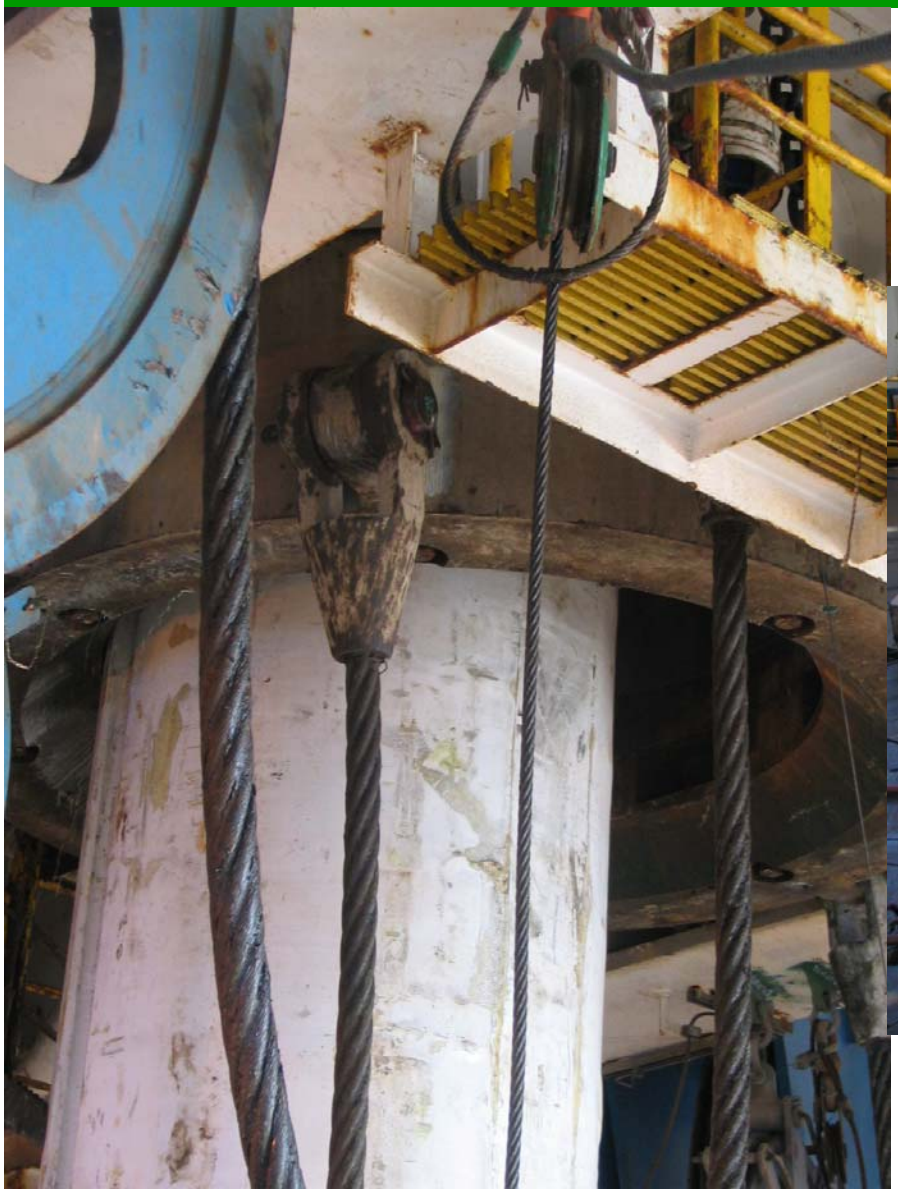
    i.e., Will Riser Contact Diverter Housing?
- Determine VIV/Fatigue Concerns
  - Can String Be Deployed?

    i.e., Can Fatigue Be Kept to a Minimum?
- Implement Drift-Running Plan

Diverter Housing Clearance



Diverter Housing Clearance



Bare/Buoyant Riser Stack-Up

Riser Stack-Up

- Top 1/3 Covered with Fairings
  (suppress VIV, reduce drag force, angles)
- Middle 1/3 Covered with Alternating Bare/Buoyant Joints
- Bottom 1/3 Covered with Bare Joints

Advantages

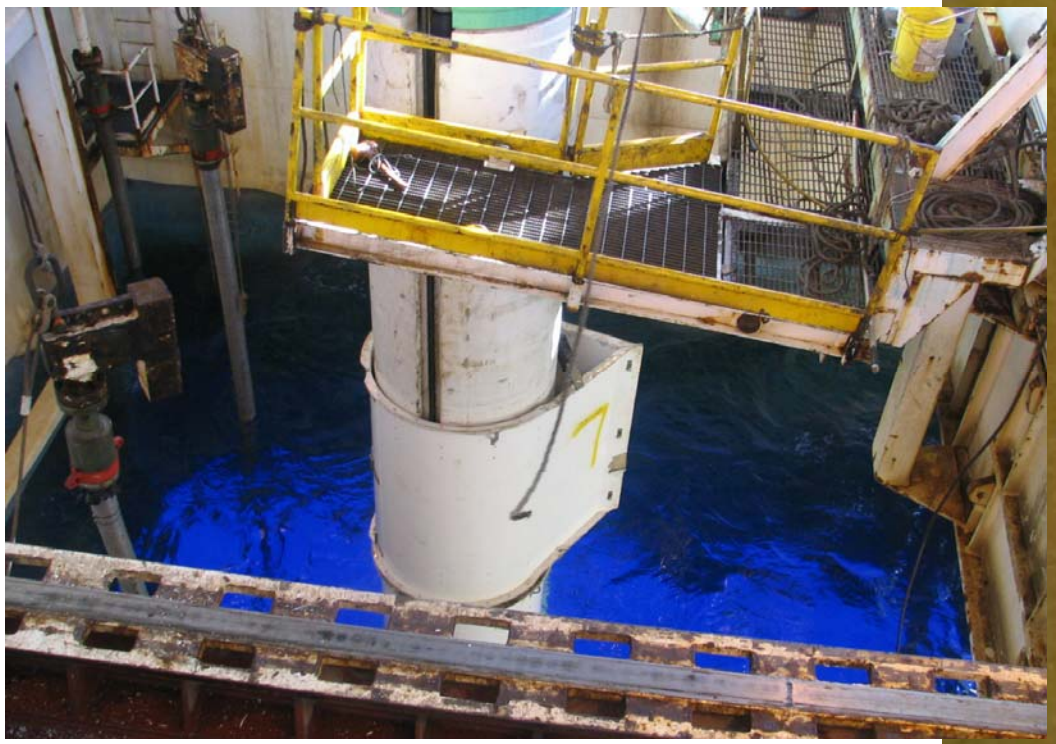
- Heavy Weight for Drift Running
- Heavy Weight Riser for Recoil Performance
- VIV Suppression

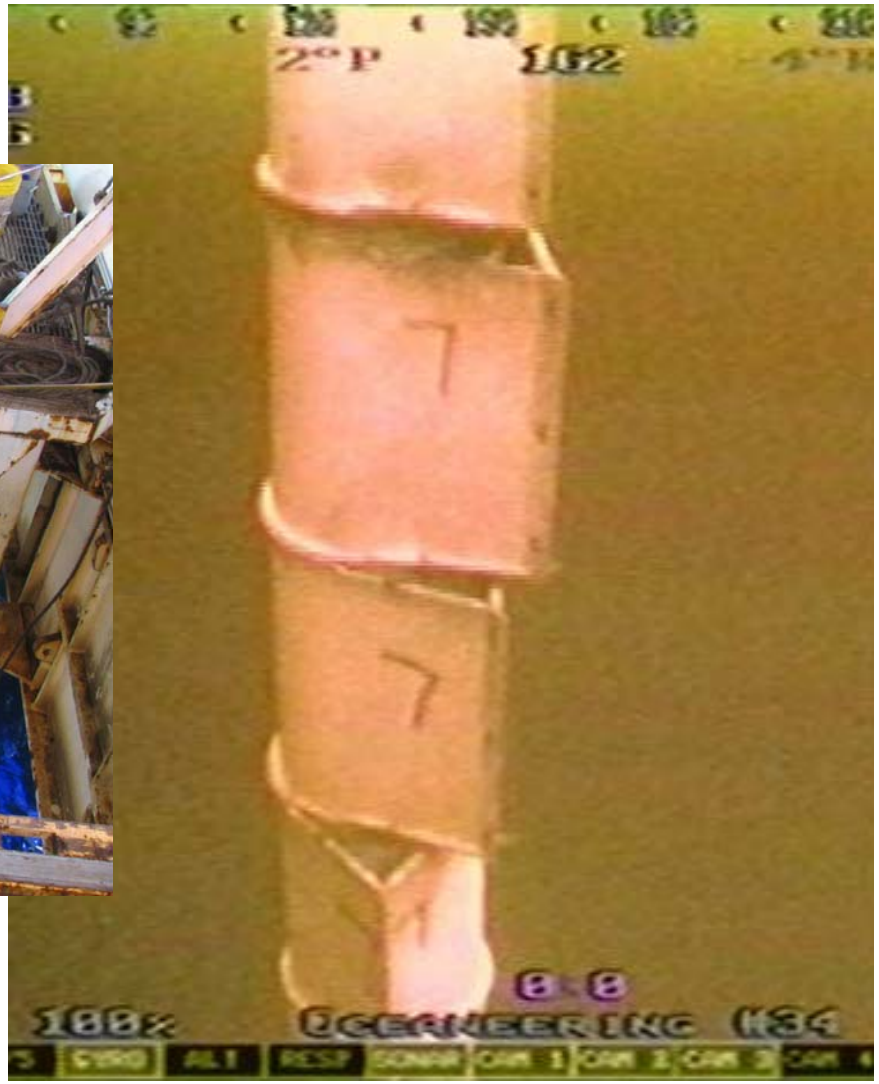
Disadvantages

- Requires High Top Tension
  (Sufficient Rig Capacity in Shallow Water)
- Requires High Hook Load Capacity (Sufficient Rig Capacity)

Riser Fairings - Installation

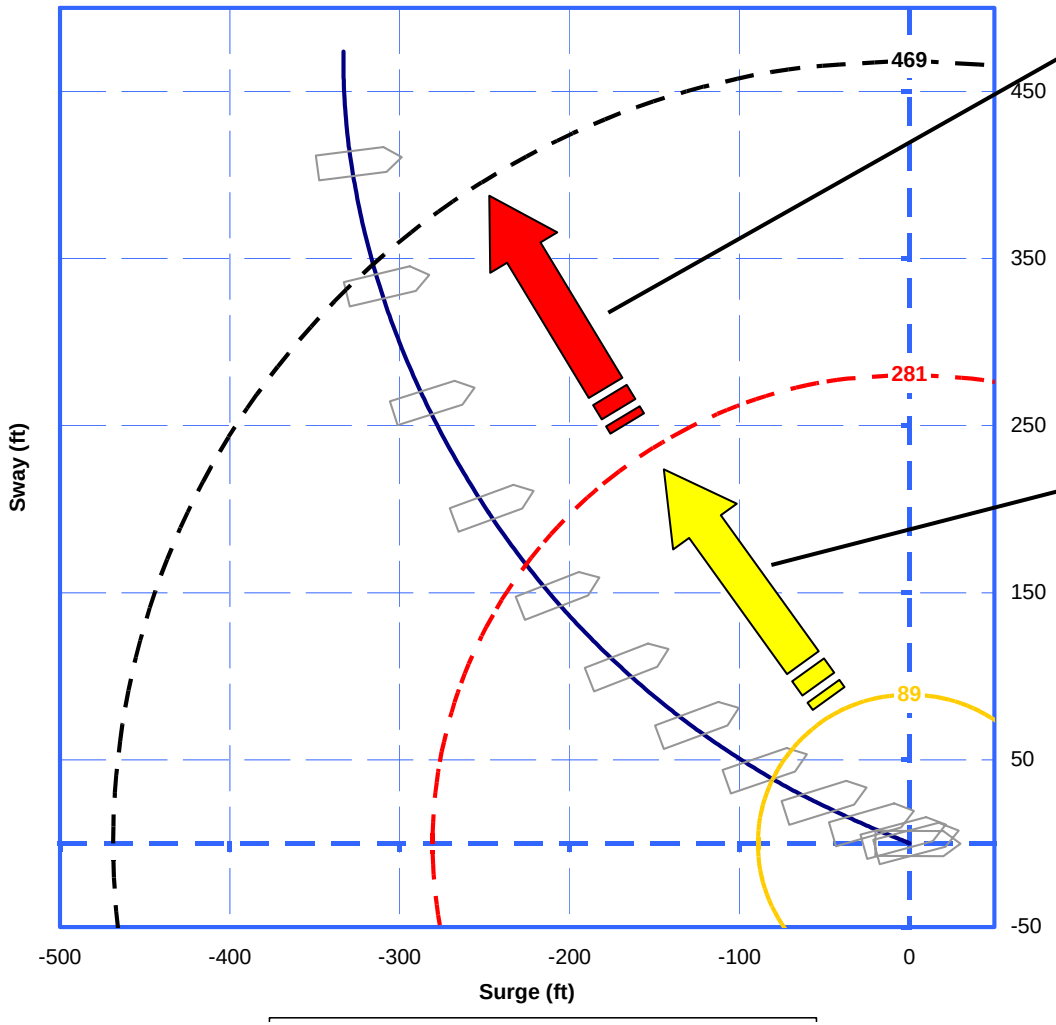
Riser Fairings – In Place





DEEPDRIFT Software Links Shore-Based to On-Board

Drift-Off Path & Alert Offsets



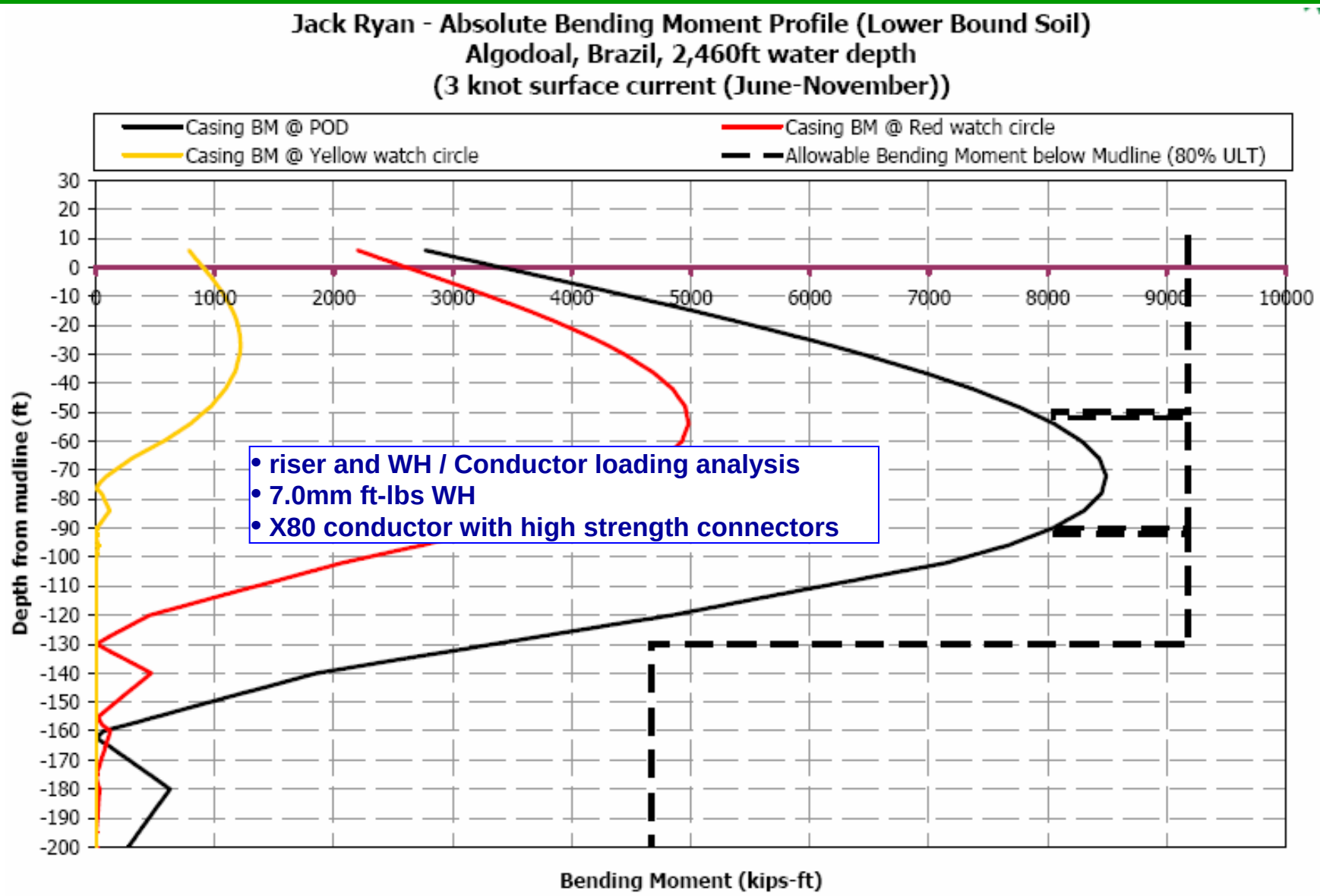
Distance between Red Alert Offset & POD

Time = EDS time (sec)

Distance between Yellow Alert Offset & Red Alert Offset

Time = 90 sec

Wellhead / Conductor Design



High Currents
Risk Weighted Decision Results