Virtual Well Construction

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Offshore Drilling Rig

Complex System of Systems
- Dynamic Positioning
- Power System
- Derrick Hoisting
- Mud Systems
- Cementing Systems
- Racking Systems
- Blow out prevention
- Diverter Systems
- Cranes & Conveyors
- Deck Management
- Supply Warehouse
- Living Quarters
- Helideck

Operating in Remote and Harsh Environments
Well Construction Process Flow Chart

Mobilization

Surface Hole

Run BOP

Tripping

Drilling

Cementing

Casing

Completions

Deep Water Drilling

Reference: Center for Deep Earth Exploration
Well Construction Process Gantt Chart (Actual Log Data)

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Well Control Event
Time Depth Curve
What if we could simulate the process and predict the Time/Depth?

- Enables advanced planning capabilities for supply chain
- Enables strategic incentive based contracts
- Enables known performance bounds
- Enable ‘what if’ scenarios for machine/process/policy changes
- Enables optimization and performance improvement
Prediction Simulator – AnyLogic Process Logic
Prediction Simulator – Process Distributions

Depth Independent

Depth Dependent Rate

Section and Depth Dependent

Tripping - Open Hole

Tripping - Cased Hole

Drilling - Production

Drilling - Reservoir
Prediction Simulator – 3D Model

AnyLogic Model

API to Unreal Gaming Engine
Prediction Simulator – 2D Well Profile and Time/Depth
## IADC Time Log

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<tr>
<th>Process</th>
<th>Subcode</th>
<th>Start Time</th>
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Prediction Simulator – Activity Gantt Chart – Critical Path
**Application Front End**

<table>
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<tr>
<th>Select Parameters</th>
<th>Statistics</th>
<th>Well Construction Process</th>
<th>3D Simulation View</th>
<th>Down Hole View</th>
<th>IADC Auto Coder</th>
<th>Gant Chart</th>
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<tr>
<td><strong>Select Type Of Simulation</strong>&lt;br&gt;Oil, Natural Gas&lt;br&gt;Storage, Distribution</td>
<td><strong>Import Well Plan</strong>&lt;br&gt;Import Well Plan&lt;br&gt;Record Data in SQL</td>
<td><strong>Full Process or Partial</strong>&lt;br&gt;Full Process&lt;br&gt;Partial Process</td>
<td><strong>Select Auto / Manual Doper</strong>&lt;br&gt;Auto Doper&lt;br&gt;Manual Doper</td>
<td><strong>Select Manual / Power Slips</strong>&lt;br&gt;Manual Slips&lt;br&gt;Power Slips</td>
<td><strong>Select RN Model</strong>&lt;br&gt;No Model&lt;br&gt;M Model 1&lt;br&gt;M Model 2</td>
<td><strong>Roughneck Connection Reattempt Probability</strong>&lt;br&gt;0.0&lt;br&gt;0.2&lt;br&gt;0.3</td>
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<td><strong>Running Well Plan Simulation</strong></td>
<td><strong>Record Data in SQL</strong>&lt;br&gt;No NOT wanted&lt;br&gt;Record Data</td>
<td><strong>Select Riser Handler</strong>&lt;br&gt;Model 1&lt;br&gt;Model 2</td>
<td><strong>Select Skate</strong>&lt;br&gt;Model 1&lt;br&gt;Model 2</td>
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**Rig Name:** Deepwater Conqueror  
**Well Name:** SM P5007 OCS-G 21245 WR 678  
**Location:** X= 2,264,789.840', Y= 9,546,935.330'  
**Water Depth:** 10,000 ft  
**Total Depth:** 39,583 ft
Simulation Results: Planned - Predicted - Actual

Planned vs Predicted

Planned Contingency

With Simulated Contingency

Planned vs Predicted vs Actual

Reached 20k feet ~15 Days ahead of plan!

What Happened here?

Planned, Predicted and Actual all show well completion times about same time: ~80 days
Drill Floor Equipment - What If Scenario

Existing Drill Floor Package ~ 62 Days

New Auto Tripping Floor Package ~ 51 Days

Given ~11 Day Faster Well Delivery
- Justifies equipment CAPEX to improve efficiency effectively reducing OPEX
- Enables another well can be drilled per rig/year (51 days per well, 7 wells per year)
Future Enhancements: Interruptions and Off Nominal Trigger Events

- Failure to Function
  - Repeat Attempts

- Failure to Operate
  - Complete redo back to last process step or milestone

- Dynamic Downhole Conditions
- Out of Consumables Supply
- Equipment Failure
- Waiting on Third Party
- Weather Events
- Safety Events
- Many Others!
Future Enhancements

- Robust Architecture
- Simplifying logic to be rig/well agnostic
  - Multiple Rig Classes
  - Multiple Well Types
  - Multiple Regions
- Process Interruptions
- Off Nominal Trigger Events
Questions?
Jason Baker
Transocean - Principal Systems Engineer
Abram Hudson
Barrios Technology - Senior Systems Engineer