Blowout Preventer Monitoring

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Business Case

- Domain
- Journey

Solutions Overview

- Pressure Monitoring
- Annular Degradation

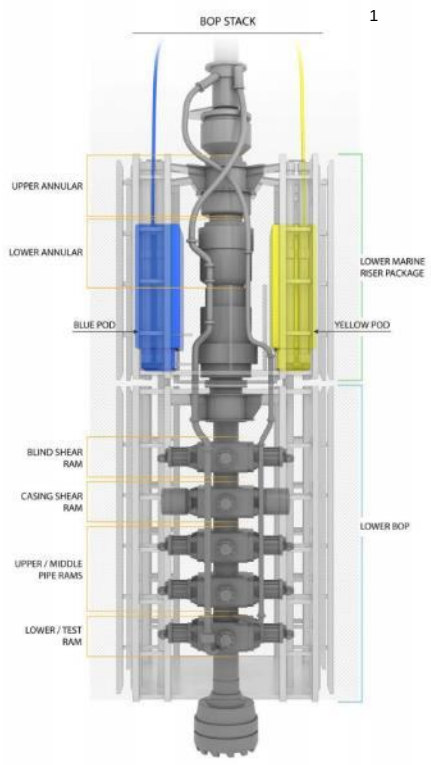
Results

- Findings
- Testing Improvements

Business Case

Blowout Preventers are Really Important

Especially in Deepwater!



- **Pressure Control Safety Equipment**
- **Used for Deepwater Drilling and Completion**
- **Installed on the Subsea Wellhead**
- **Operational Uses (Well Control)**
- **Emergency Uses (Shear and Seal)**

1. U.S. CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD (2014), REPORT NO. 2010-10-I-OS, Volume 2, p

Why a Digital BOP?

Non-Productive Time (NPT)

- Testing & Certification
- Unplanned Maintenance
- Component Failures
- Stack Pull Decisions

Digital BOP Objectives

- Provide Operational Guidance Based on BOP Condition
- Introduce Safer Operating Procedures

Shell BOP Reliability Group

Mission statement

The BOP RELIABILITY TEAM supports Shell's deep-water drilling operations globally by increasing BOP reliability through engineering & operations support, and analysis of BOP performance data.

Operations

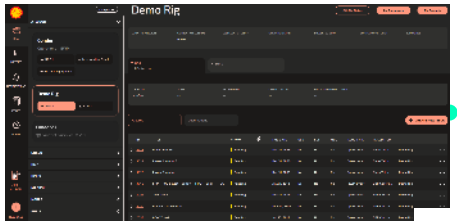
- Troubleshooting and Maintenance Support
- Regulatory Compliance Support
- Fleet Failure Tracking
- Real-time Operating Center (RTOC)

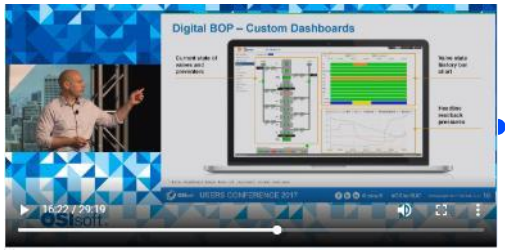
Engineering

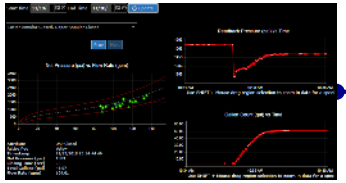
- Shear Testing Support
- Accumulator Sizing
- Future Designs / Special Projects

Technology & Data

- Real-time Analytics
- Monitoring Dashboards
- Failure Tracking System
- Expert Systems







2013
"Dark Data"

2014
Journey Begins

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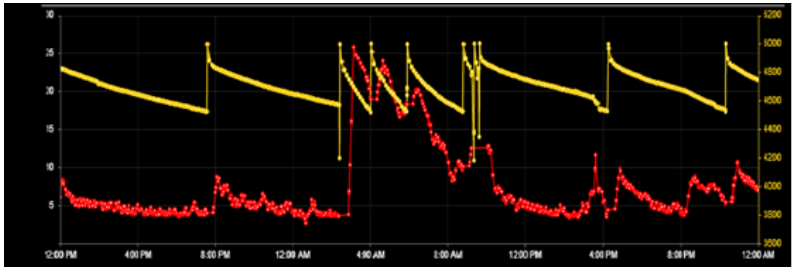
2015
Failure Tracking & Analysis

2016-17
Real-time Surveillance

TODAY
Analytics and Event Notifications

Solutions Overview

Leak Detection Analytic



Business Case

- Control system fluid must maintain a high pressure to ensure that preventers close properly
- Leaks in the control pods can bleed pressure from the control system and degrade function.
- Identification of leaks allows operational guidance to isolate the leak and continue operations.

Algorithm

- Leak rates are deduced by pressure changes in the system using a physics-based modeling approach.
- Events representing normal fluid rates are removed from consideration as potential leak faults

Output

- The user is notified when an abnormally high leak rate that is indicative of a leak fault is detected.

Annular Condition Analytic

Business Case

- Annular preventers rely on an elastomer packer element to flex closed across the wellbore
- These elastomer packers lose elasticity over usage
- Identification of degraded packers allows operational guidance when multiple annular preventers are available, and guide maintenance plans for in-between drilling operations

Algorithm

- A profile of a healthy annular closing is created, considering factors such as pressures, flowrates, and closing times.
- When a new annular close event is detected, it is compared against the profile.

Output

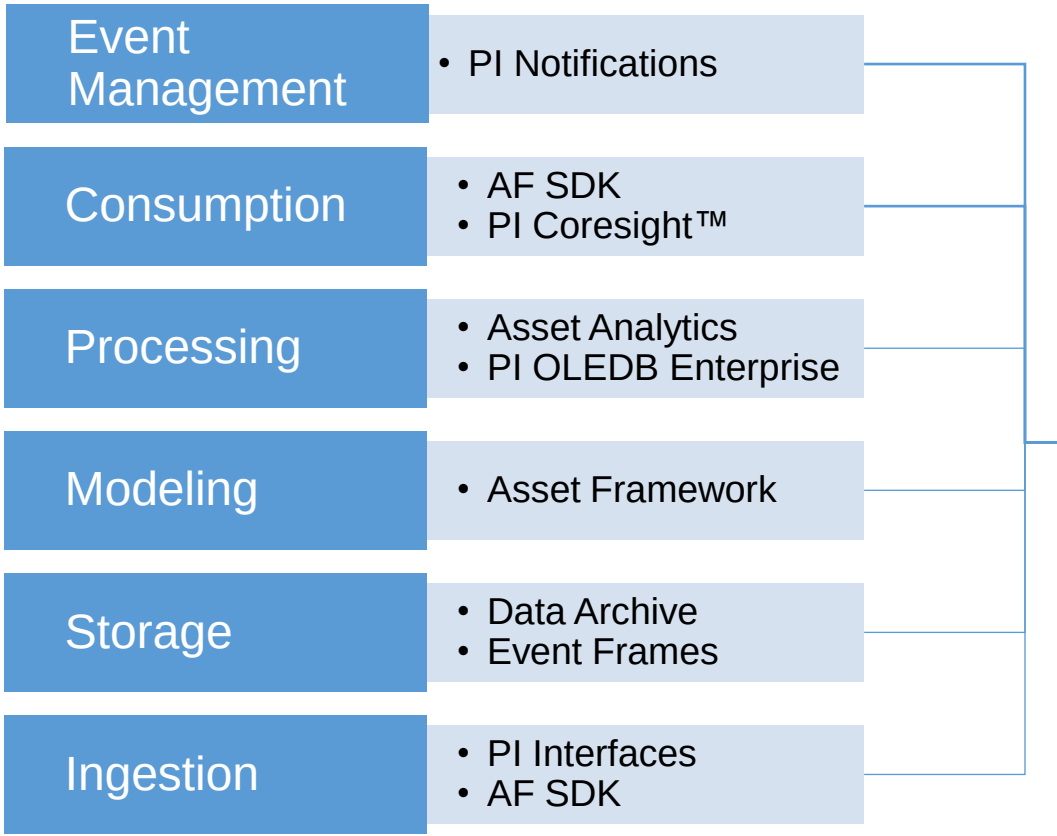
- If a recent annular close event exceeds a deviation threshold from the healthy profile, a notification is sent to users.

Technical Implementation

PI Features used for BOP Monitoring

- AF Hierarchies allow easy deployment and configuration management across assets
- Cleansing and pre-processing steps are built in to the hierarchy so that data scientists can focus on building algorithms
- Data access technologies allow accessible programmatic interfaces
- Notifications allow alerting to external applications through a standard web API
- Event Frames provide a query-able database of operationally relevant events

How Individual Product Capabilities Solved Our Business Challenge



The PI System® provides an integrated suite of software tools that implement a **data engineering** platform for **time-series data**.

Data engineering is the multi-disciplinary practice of **engineering** computing systems and algorithms to derive **information** from **data**.

 Disciplines	 Considerations	 Principles	 Examples
Systems	Scales well?	Modularity	Active BOP
Data Quality	User needs?	Immutability	Unit Scaling
Data Processing	Future-proofing?	Conformity	Valve States
Data Modeling	Technical debt?	Fit-for-Purpose	AF Hierarchy
	Support?	Rawness	Data Outages

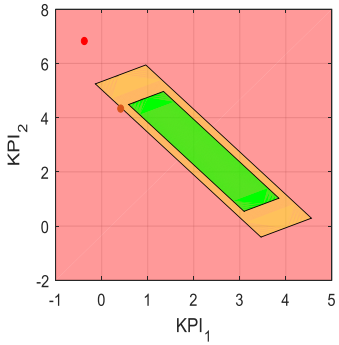
Results

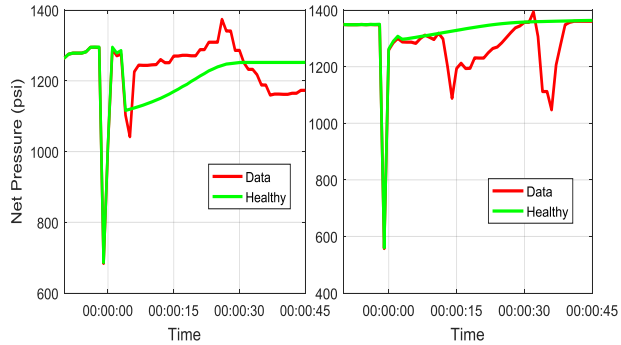
RTM Tool: Regulator Trending & Performance Comparison
Impact: OEM Maintenance Procedure Change

- **Problem:** Repeated failure of regulators
- **Solution:** Researched similar failures using RTM tools
  - Traced failures back to components that had recently been maintained
  - Pinpointed poor handling of tungsten carbide components as cause
- **Impact:**
  - Join audit by OEM, incl. participation from Shell, industry partners and drilling contractor
  - Drilling contractor and OEM have changed maintenance procedure for rebuilding regulators

RTM Tool: Annular Degradation Analysis
Impact: Replacement of Aged Annular

- **Problem:** Deteriorated annulars not found until failure
- **Solution:** Developed an Annular Degradation Analysis
  - Determine signature of healthy annular functions based on operating pressures
  - Establish a “healthy bounds” around that signature
  - Compare functions to signature in real-time
- **Impact:**
  - Identified multiple deviations in the annular signature during last functions prior to a maintenance phase
  - Instructed the rig to investigate during maintenance
  - Rig inspected and found substantial damage
  - Replaced the element and resumed operations
  - Condition tool has proven success and findings have become cause for action





21-Day Project Summary

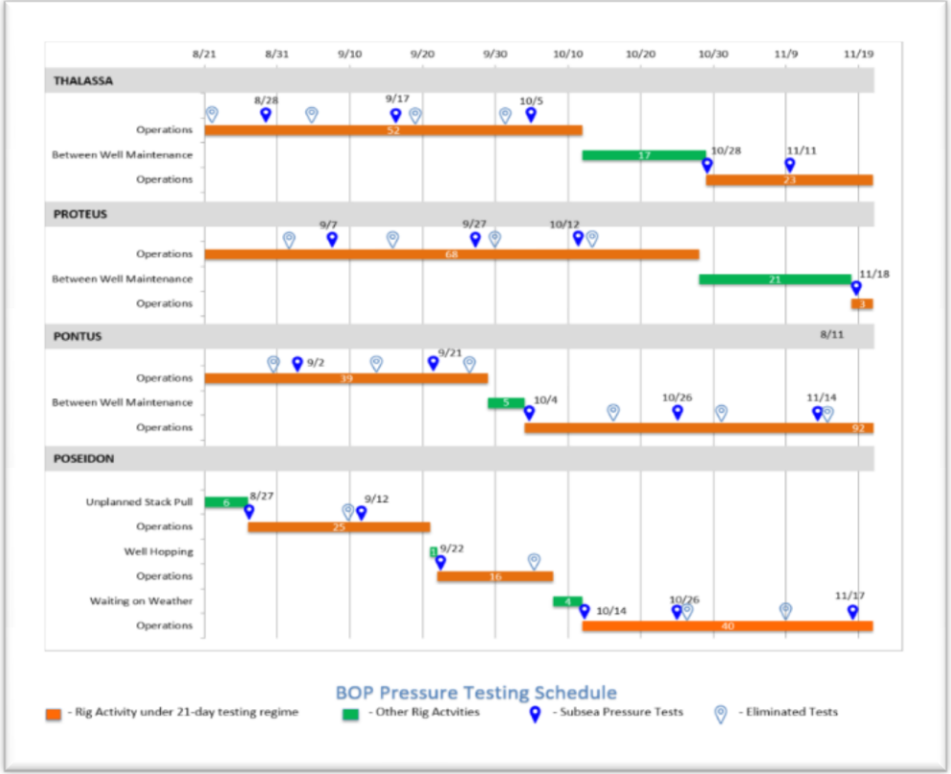
•BSEE granted Shell operational changes during the pilot:

- Pressure test BOP's every 21 days instead of 14
- Function test shear rams every 21 days instead of 14
- Function test from one control panel only for weekly function tests

•Shell committed to conduct the following activities during the pilot:

- Operate continuous condition monitoring tools on the BOP's
- Execute a failure propagation analysis (fault tree analysis) for every discovered failure
- Capture and track resolution for each failure
- Continue to develop condition monitoring tools and analyses
- Prepare quarterly progress reports

Pressure Test Schedule



Quarter	# Tests Required at 14-day Frequency	# Tests Performed at 21-day Frequency	Test Savings
Q1	7	7	0
Q2	21	13	8
Q3	29	27	2
Q4	18	14	4
Total	75	61	14

- Q1 – not all rigs yet operable
- Q3 – unplanned stack pulls and short operations affected test reduction
- Estimated rig time saved: 13.5 days
- Eliminated minimum 70 equipment functions (2 AP, 3 PR per stack)

Function Test Savings since Project Start

Test Type	Tests Saved	Functions Saved	Hours Saved
BOP Pressure Test	14	70	168
Weekly Function Test	123	615	123
Shear Ram Function Tests	34	68	34
TOTAL	**171**	**753**	**325h = 13.5d**

Significant number of equipment functions were saved

- Less wear and tear
- Expected to contribute to higher reliability
- Reduced time spent on tripping, operations changes

Speakers

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Blowout Preventer Monitoring

CHALLENGE

BOP's are safety-critical equipment and a leading cause of Non-Productive Time in drilling.

- Highly redundant systems are safer, but harder to troubleshoot
- Control system fluid leakages can degrade operational reliability
- Preventer mechanisms wear over time and with additional usage

SOLUTION

Earned a 21-day regulatory testing extension through advanced monitoring and analytics, powered by PI.

- New analytics, such as Leak Detection and Annular Degradation Analysis
- New surveillance tools that merge real-time history with operational procedures

RESULTS

Reduced equipment wear, higher incidence of issue identification, and improvements introduced across the industry.

- Updates to operational procedures based on data analysis
- Feedback into OEM equipment design
- New best-in-class regulatory regime

Questions?

Please wait for the **microphone**

State your **name & company**

Please remember