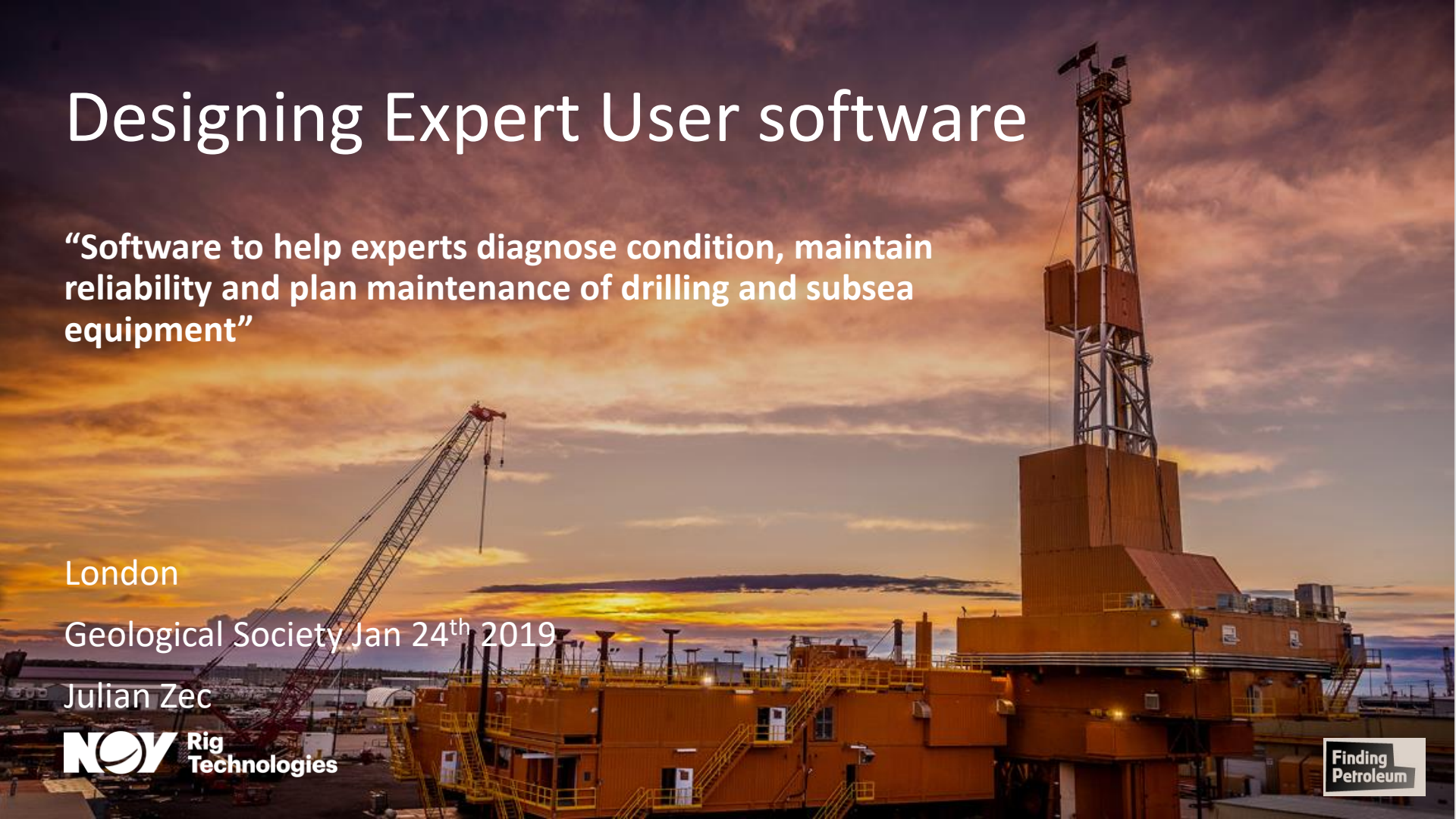
Designing Expert User software

“Software to help experts diagnose condition, maintain reliability and plan maintenance of drilling and subsea equipment”



London

Geological Society Jan 24th 2019

Julian Zec

NOV Rig Technologies

Finding Petroleum

Agenda

Expert in CBM

Concept of CBM

Challenge

Guide to software solution

Speaker

- Julian Zec
- National Oilwell Varco (NOV)
- Chief engineer condition monitoring & condition based maintenance/ Manager Maintenance & Reliability Engineering

- >50 countries , ~40000 employees
- Leading manufacturer & supplier of Drilling equipment and drilling automation
- Delivered 600 drilling rigs in last 12 years

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Finding Petroleum

Current CBM Programs

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CM/CBM software

- NOV have tested numerous 3rd party solutions for CM/CBM
- Plenty of these are too general
- Technical experts had to cover several areas
- Decision taken to build own package
- “Rigsentry”

Experts

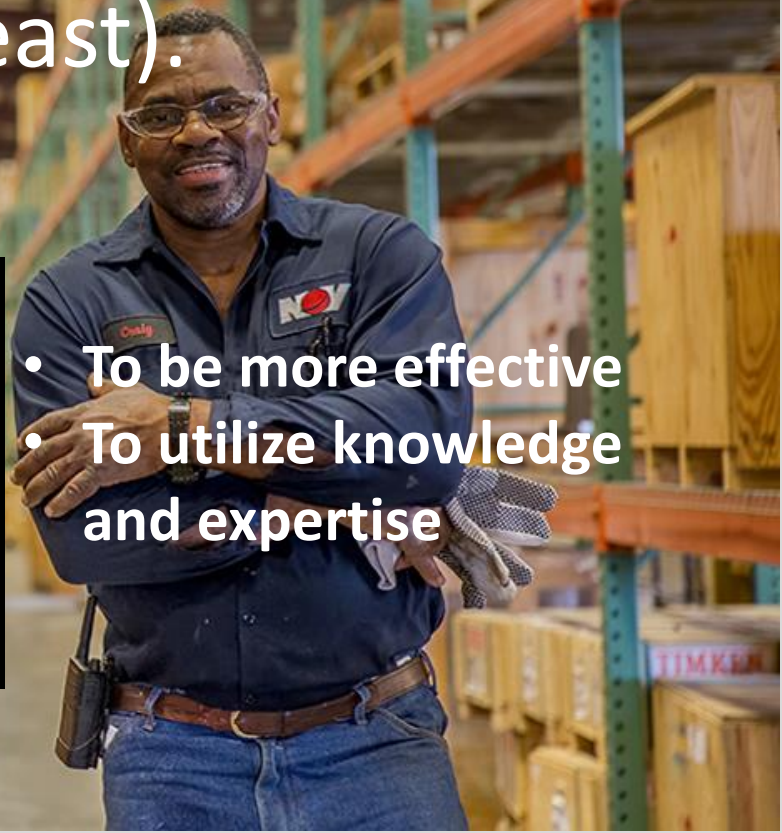
Few types of experts (at least).

- Domain experts

Does not require information sequentially, as DVD movie

Explores ever changing enviroment

- **To be more effective**
- **To utilize knowledge and expertise**



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“The most important thing is to be seen.”
Investing into effective tools is a quality improvement, valueing expert employees for that they do.
To stay
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CM/ CBM Domain expert

- Maintenance & Reliability Engineer
- Is expected to meet required business objective by solving problem in creative way.
- Is expected to shape enviroment

- Two sides of improved software tools

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25+ years of experience in drilling controls Integration and Automation

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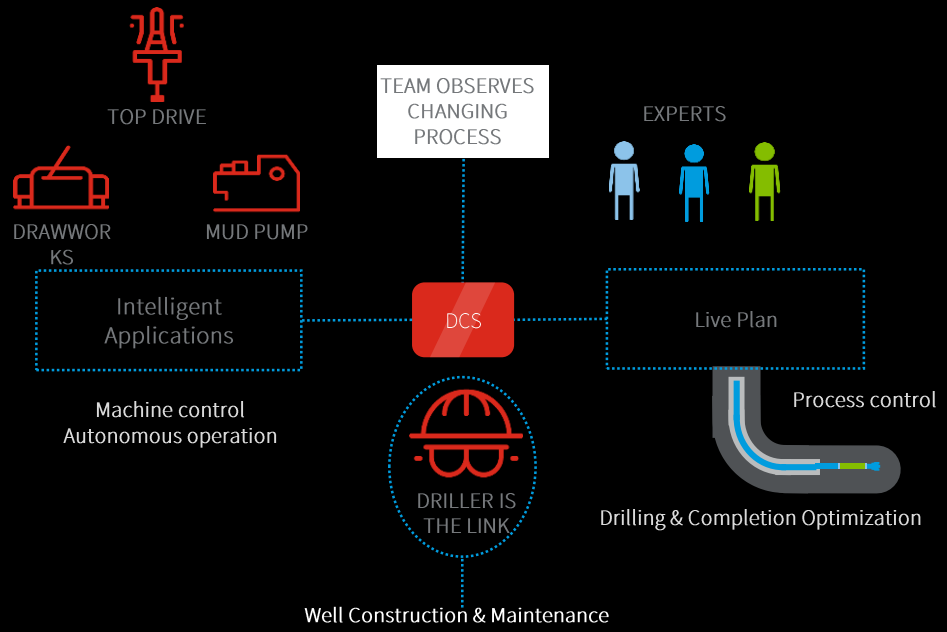

ms

DHT

Multivariate & Multidimensional

Well Fluids

People

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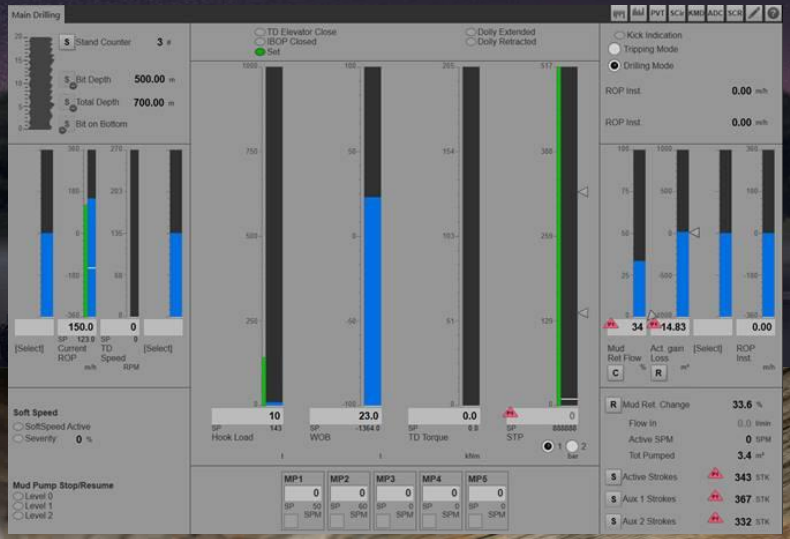
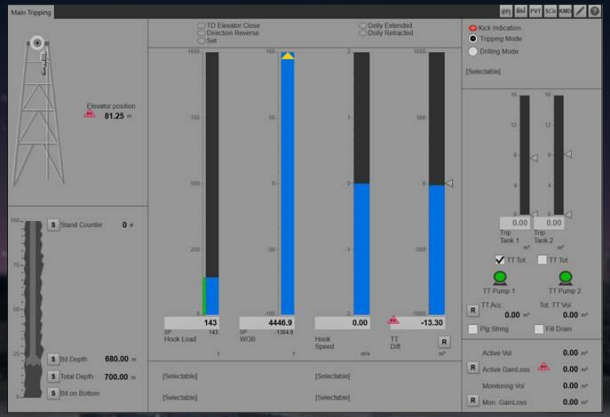
Correct and Timely decisions





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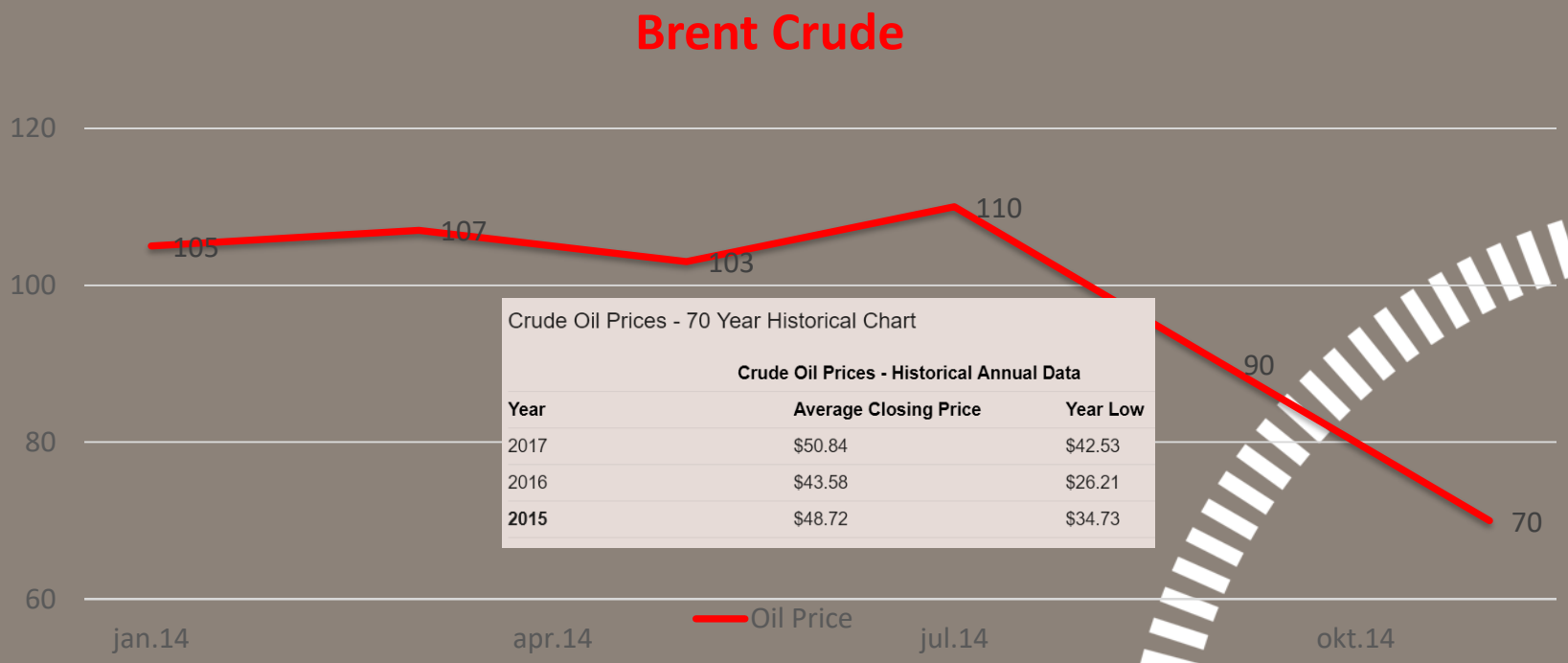
2014- The Downturn amplified need for optimization measures



Crude Oil Prices - 70 Year Historical Chart

Crude Oil Prices - Historical Annual Data		
Year	**Average Closing Price**	**Year Low**
2017	$50.84	$42.53
2016	$43.58	$26.21
2015	$48.72	$34.73

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Crystal ball -Barrell economy

CAPEX

$ 22 mil Rig purchase +
$ 6 mil replacement=

$= 28 mil

Life Cycle

25 yrs x 80% Utilization x 17 wells
= 340 wells

Well Cost

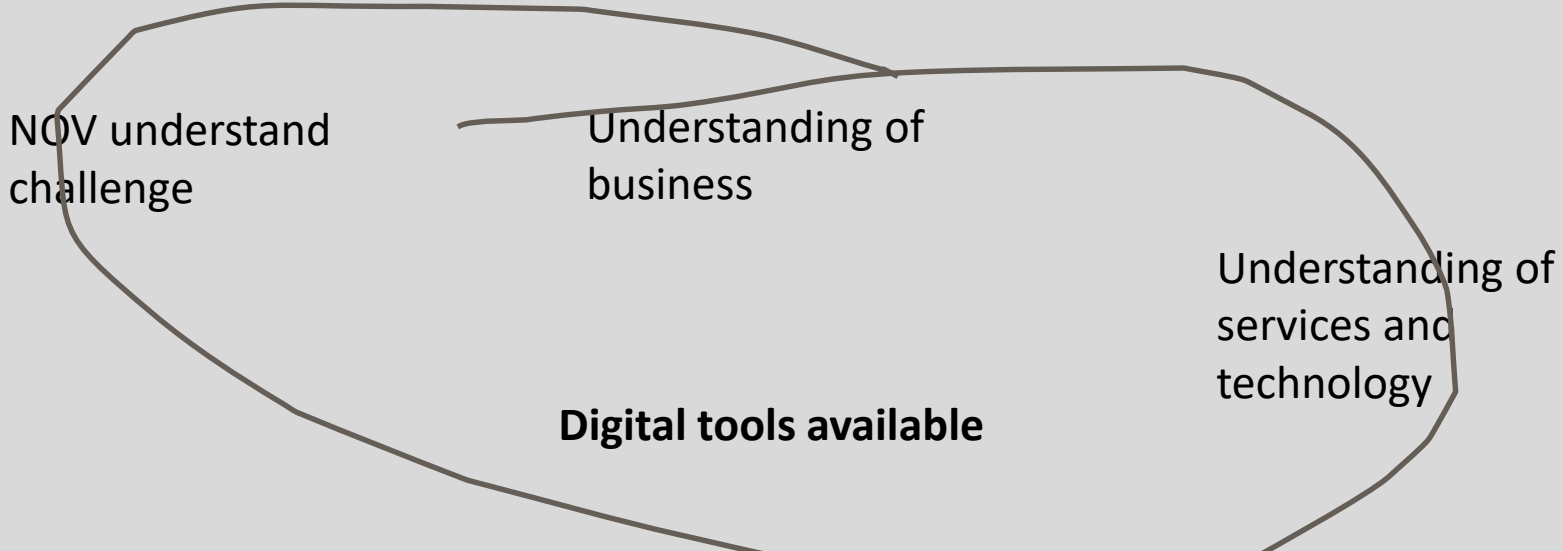
$ 6,25 mil / well
700,00 bbl EUR

340 wells =238 mil bbl

Cost by bbl

$ 8.93 bbl

OPPORTUNITIES



Our CBM Vision

Increase reliability (safety) of equipment and decrease total (customer) customer cost of ownership by optimizing maintenance activities.

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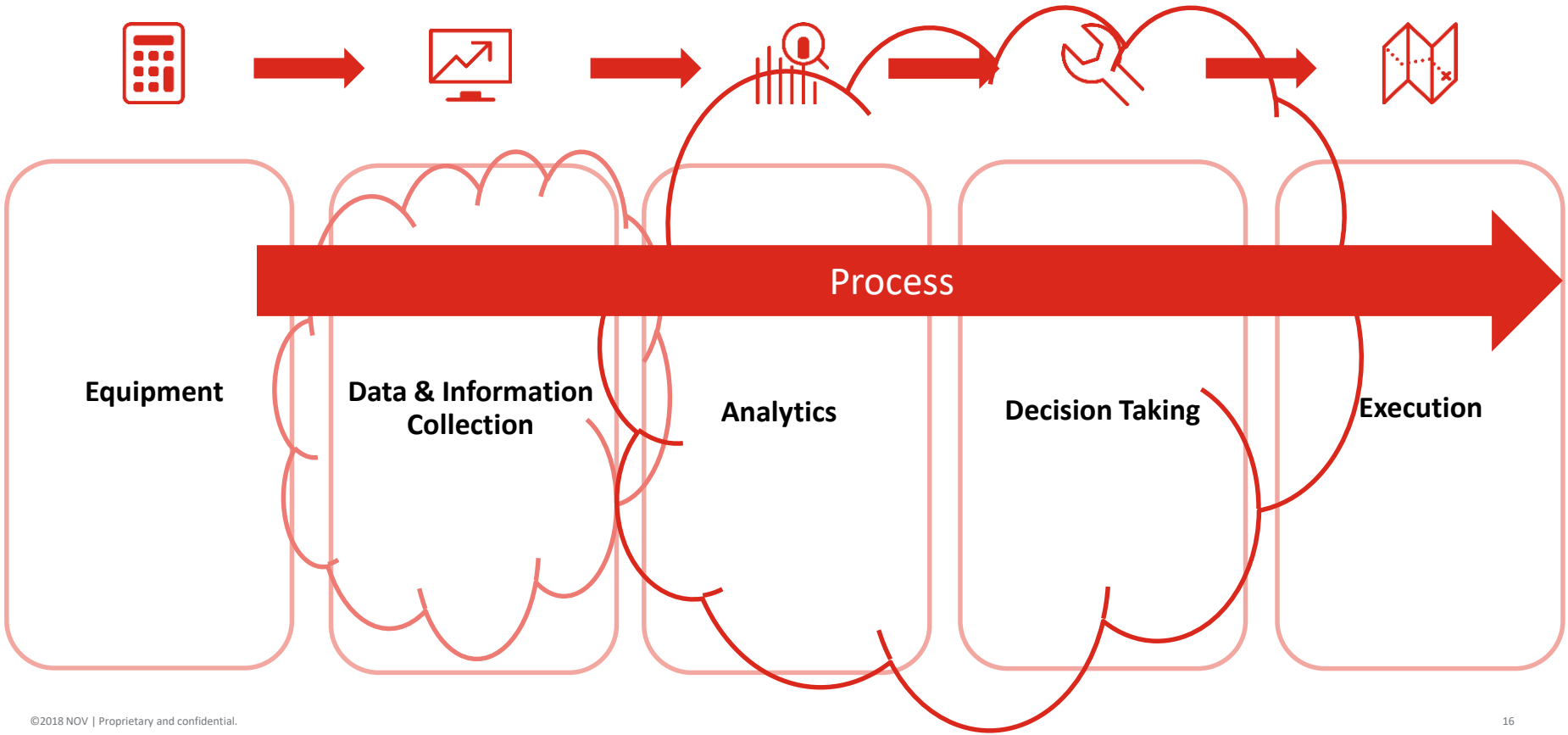
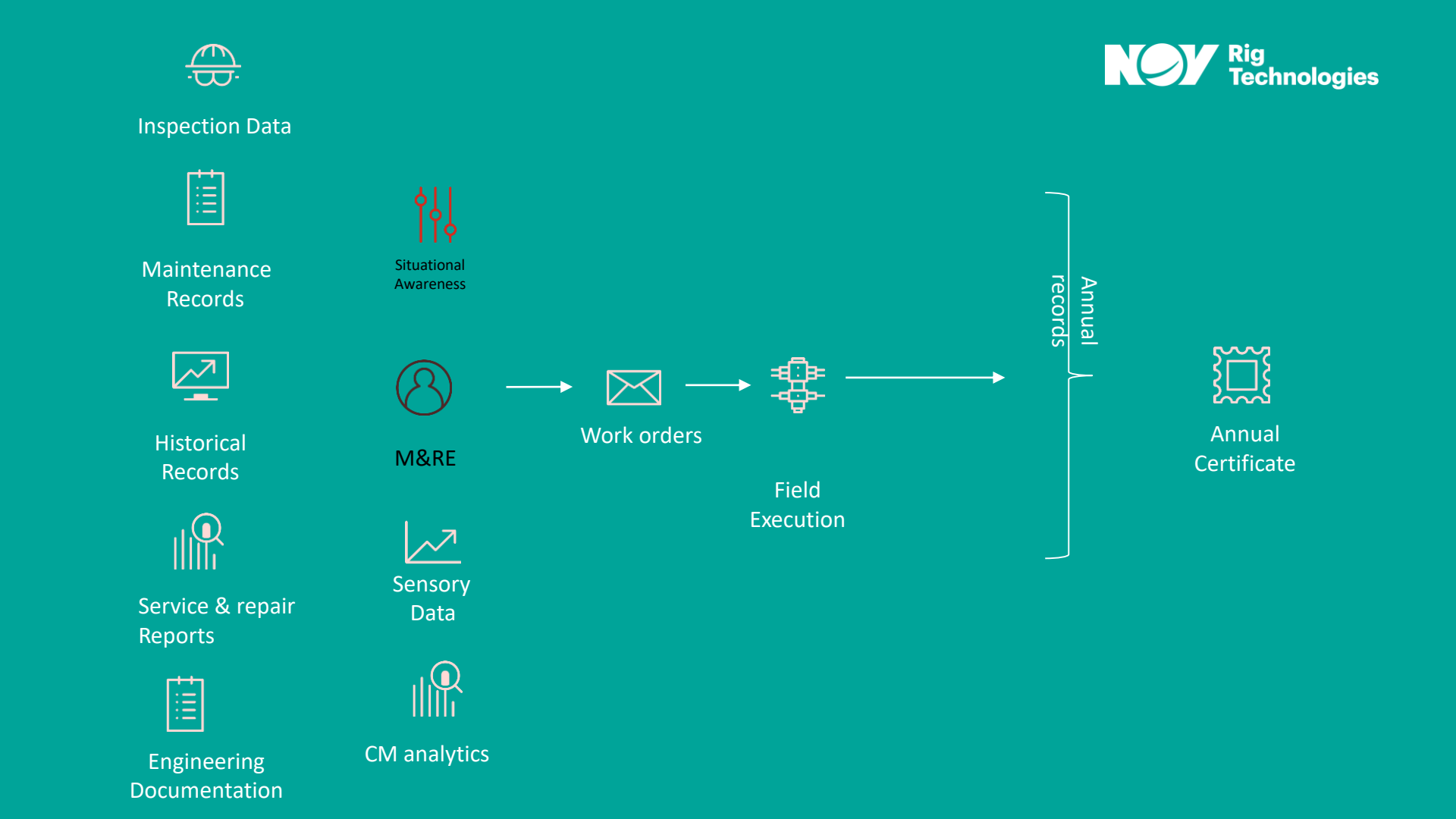
Mission

Develop set of optimized methods and procedures that will allow diagnosis and certification of the equipment within a Program based on condition, utilization or inspection criteria.

- Prevent failures
- Avoid over maintaining
- Avoid cliff events
- Proactive support for operations
- Remove SPS

Condition Based Maintenance




Inspection Data
Maintenance Records
Historical Records
Service & repair Reports
Engineering Documentation
Situational Awareness
M&RE
Sensory Data
CM analytics
Work orders
Field Execution
Annual records
Annual Certificate


How to build the software supporting user in such environment?
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Hollistic approach

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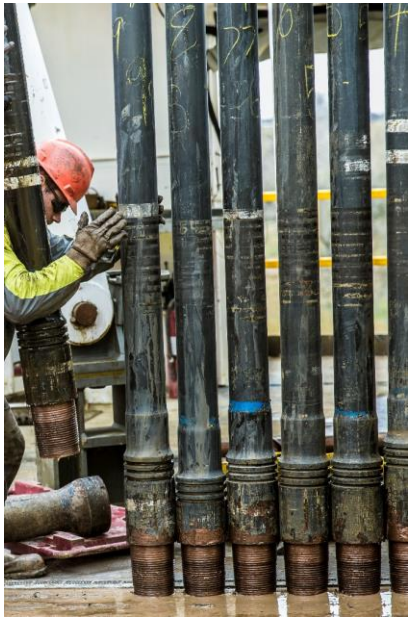
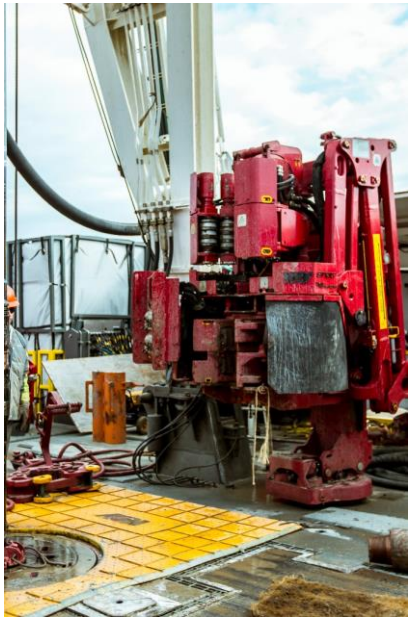


- Take care of Data Quality

- Ensure knowledge adaptation and transition to software

- Multipurpose teams
- Domain User is part of the development group
- IT is a tool



- Journey is Transformative for software and expert user

Focus on common goal, unifying human and machine

How does it help reach the CBM goal?

How does it support domain user?

Define what do you know to know.

Define what you know that you do not know.

Accept that there are unknown unknowns

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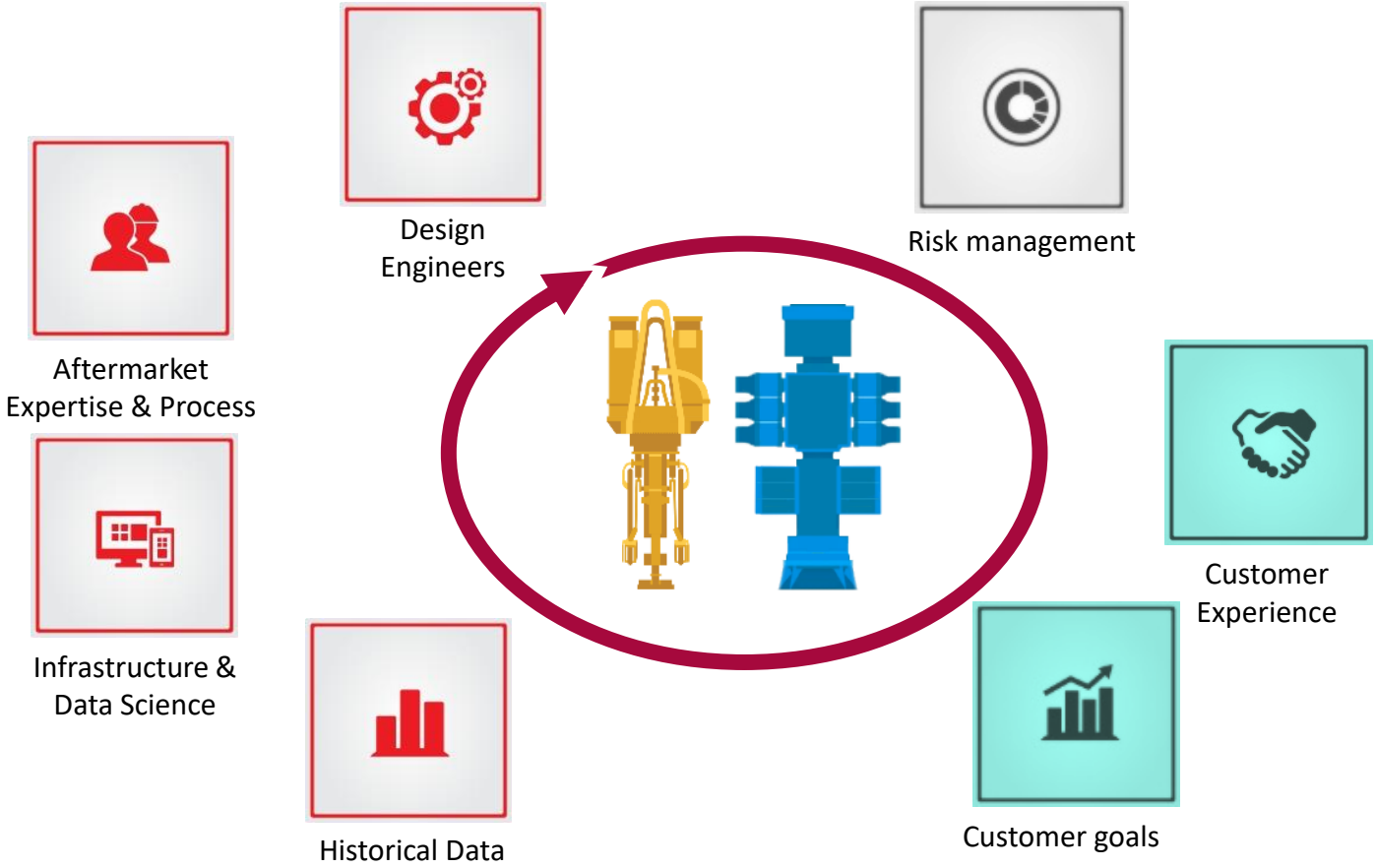
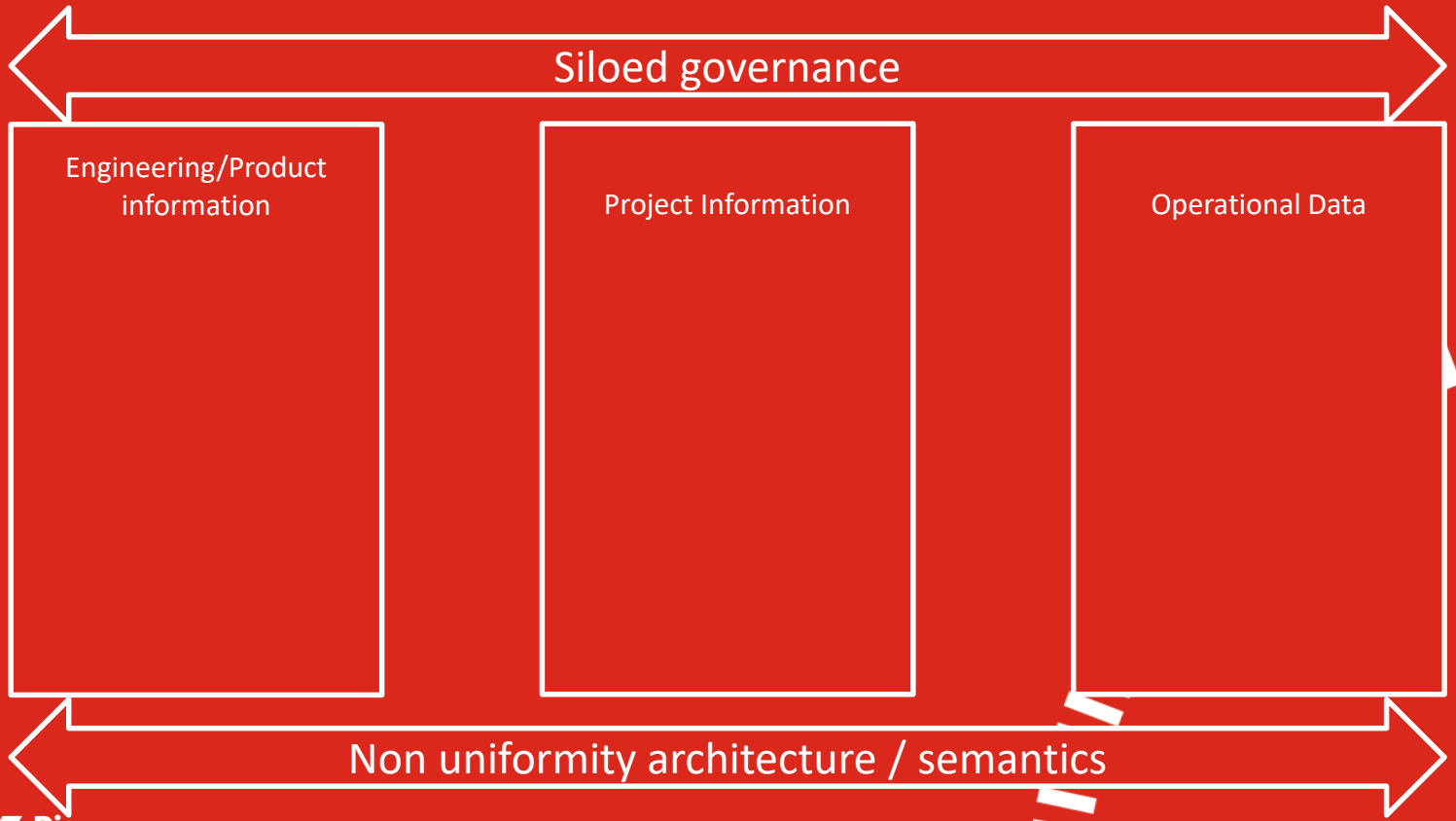
Collaboration is the key

Collaborating to combine data, technology & experiences



Information (and overload)



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Data Quality as part of Data Management Strategy, not domain expert subtask


```
DW1_AI_058,11-nov-14 09:00:02,80538.04
DW1_AI_058,11-nov-14 09:00:06,80555.52
DW1_AI_058,11-nov-14 09:00:07,80533.59
DW1_AI_058,11-nov-14 09:00:08,80551.39
DW1_AI_058,11-nov-14 09:00:09,80549.41
DW1_AI_058,11-nov-14 09:00:10,80533.2
DW1_AI_058,11-nov-14 09:00:11,80529.54
DW1_AI_058,11-nov-14 09:00:12,80550.16
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DW1_AI_058,11-nov-14 09:00:33,80541.74
DW1_AI_058,11-nov-14 09:00:34,80546.03
DW1_AI_058,11-nov-14 09:00:35,80546.06
```
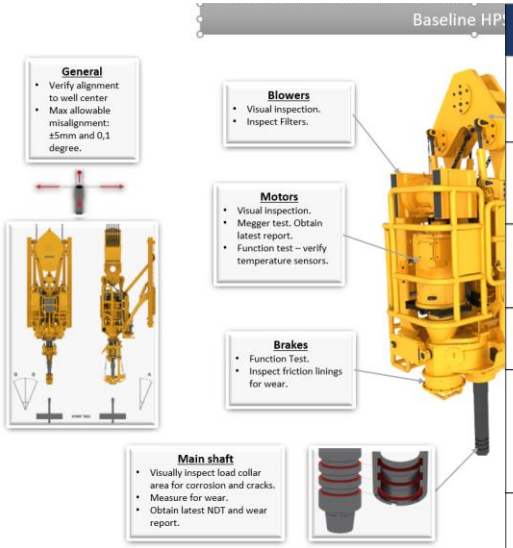

Transition from Time Based Maintenance is design issue

A collated set of Maintenance Routines compiled in comparison with NOV recommended actions, available for implementation in software



Unit	Maintenance Task ID	Maintenance Task Summary	Source	Optional	Ref. ID	CBM Philosophy (See Tab)	Classification	PM Reference
hours	TDX_015.UTL	Visually inspect becket/adapter and lifting assembly.	✓		TDX-1250_015 TDX-1250_023	**Utilization Model**	A	Top Drive NOV TDX 1250 6M Item 1
hours	TDX_016.UTL	Perform MPI on exposed surfaces of becket/adapter and Bails and Links using the "wet fluorescent method".	✓		TDX-1250_016 TDX-1250_017 TDX-1250_024	**Utilization Model**	A	Top Drive NOV TDX 1250 Y TP Item 4
hours	TDX_018.UTL	Inspect counterbalance cylinders linkage and lugs for leakage, wear, deformation and mechanical damage.	✓		TDX-1250_018 TDX-1250_020 TDX-1250_021	**Utilization Model**	B	
ML	TDX_019.UTL	Inspect counterbalance cylinders for wear or damage. Replace or rebuild (replace seals) if necessary.	✓		TDX-1250_019	**Symptom Model**	B	
months	TDX_022.STD	Visually inspect fasteners to check for missing fasteners. Replace any missing secondary retention.	✓		TDX-1250_022	**Standard PM**	B	Top Drive NOV TDX 1250 M. Item 1 Top Drive NOV TDX 1250 3M Item 1 Top Drive NOV TDX 1250 Y TP Item 1
hours	TDX_026.UTL	Perform MPI of Bail Pins.	✓		TDX-1250_026	**Utilization Model**	B	

DIAGNOSTIC AND PREDICTION STRATEGY

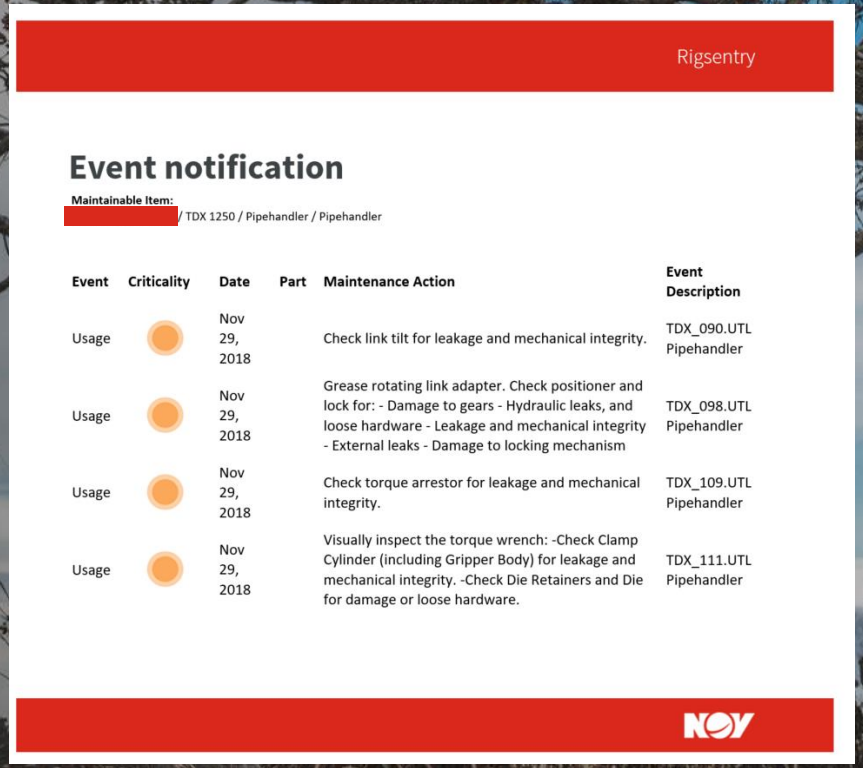
Visual Inspections	• Manual Measurements • Digital Checklists
Expert Analysis	• Vibration analysis certified CM teams • Oil Analysis in laboratory

HUMAN

AUTOMATIC

Analytic Models	• Symptom Indicators • Wear / Fatigue Models
Machine Learning	• Multi signal Correlations • Behavioral Analysis

Do not waste expert time on what you already know



Rigsentry

Event notification

Maintainable Item:
[redacted] / TDX 1250 / Pipehandler / Pipehandler

Event	Criticality	Date	Part	Maintenance Action	Event Description
Usage		Nov 29, 2018		Check link tilt for leakage and mechanical integrity.	TDX_090.UTL Pipehandler
Usage		Nov 29, 2018		Grease rotating link adapter. Check positioner and lock for: - Damage to gears - Hydraulic leaks, and loose hardware - Leakage and mechanical integrity - External leaks - Damage to locking mechanism	TDX_098.UTL Pipehandler
Usage		Nov 29, 2018		Check torque arrestor for leakage and mechanical integrity.	TDX_109.UTL Pipehandler
Usage		Nov 29, 2018		Visually inspect the torque wrench: -Check Clamp Cylinder (including Gripper Body) for leakage and mechanical integrity. -Check Die Retainers and Die for damage or loose hardware.	TDX_111.UTL Pipehandler

NOV

Deploy known knowns

Prescriptive Level

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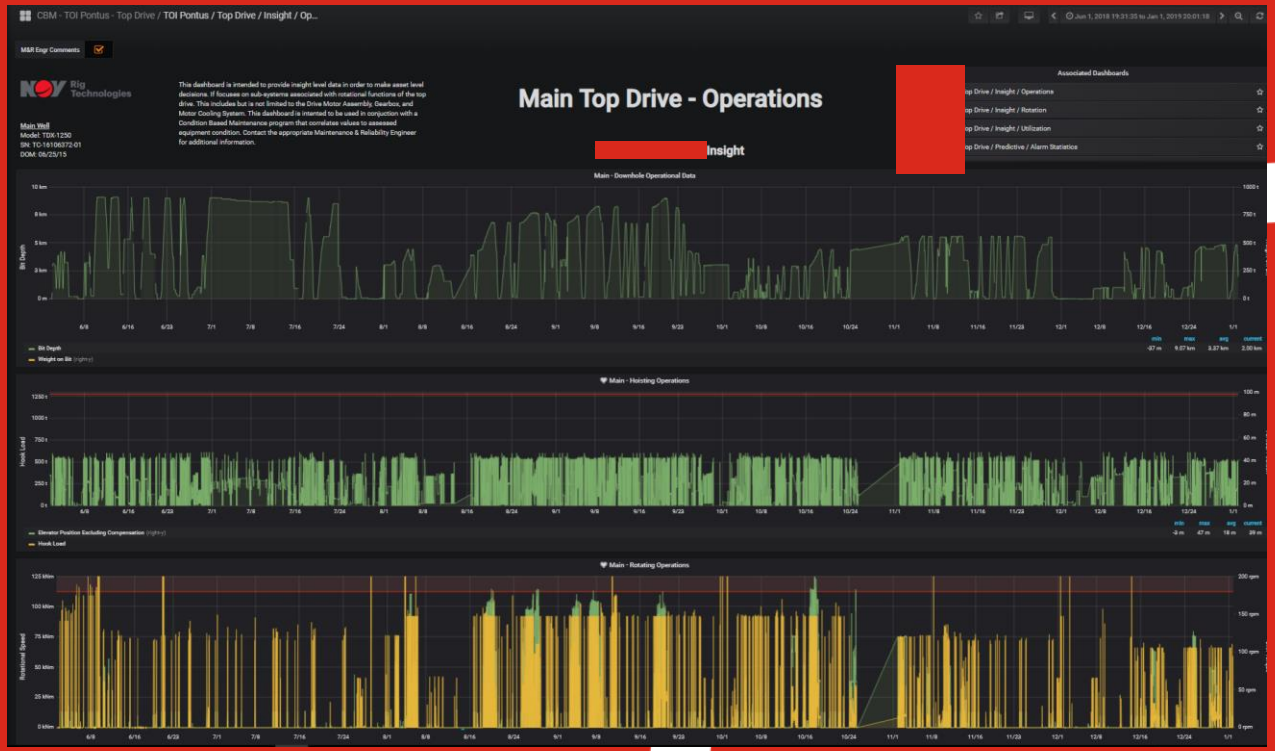
Approach known unknowns

- Advanced degradation,wear and fatigue models
- Use Domain experts early
- Use rapid prototyping



Preventative Tasks ☑ | M&R Engr Comments ☑ | Predictive Tasks ☑ | Corrective Tasks ☑

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This dashboard is intended to provide insight level data in order to make asset level decisions. If focuses on sub-systems associated with various utilization models of the top drive. This dashboard is intented to be used in conjuction with a Condition Based Maintenance program that correlates values to assessed equipment condition. Contact the appropriate Maintenance & Reliability Engineer for additional information.

Main Well
Model: TDX-1250
SN: TC-16106372-01
DPM: 06/25/15

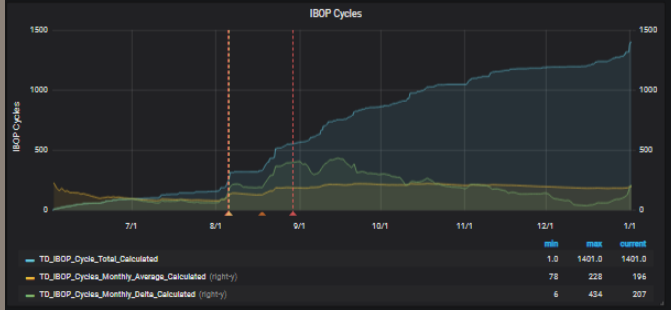
Main Top Drive - Utilization

Transocean Pontus Insight

Associated Dashboards

- TOI Pontus / Top Drive / Insight / Operations
- TOI Pontus / Top Drive / Insight / Rotation
- TOI Pontus / Top Drive / Insight / Utilization
- TOI Pontus / Top Drive / Predictive / Alarm Statistics

IBOP Cycles



Past 30 days: **207** Cycles

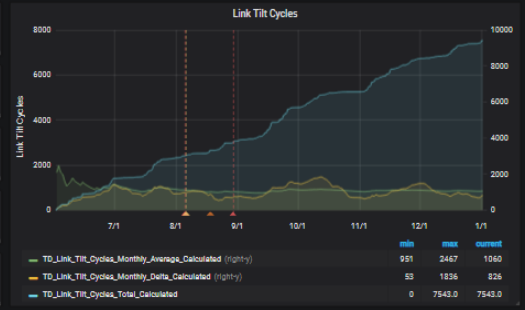
Avg 30 days: **196** Cycles

Past 24 hrs: **42** Cycles

Avg 24 hrs: **6.9** Cycles

Past Yr: **1400** Cycles

Link Tilt Cycles



Past 30 days: **826** Cycles

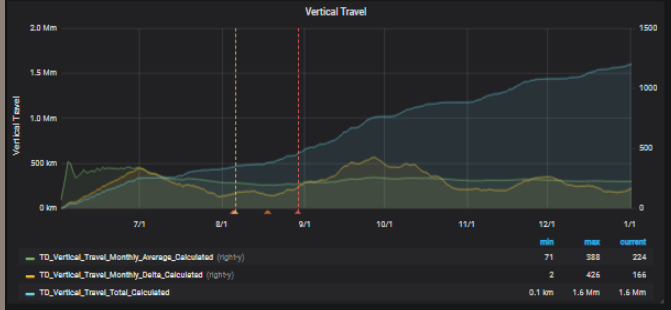
Avg 30 days: **1060** Cycles

Past 24 hrs: **88** Cycles

Avg 24 hrs: **27.5** Cycles

Past Yr: **7571** Cycles

Vertical Travel



Past 30 days: **166 km**

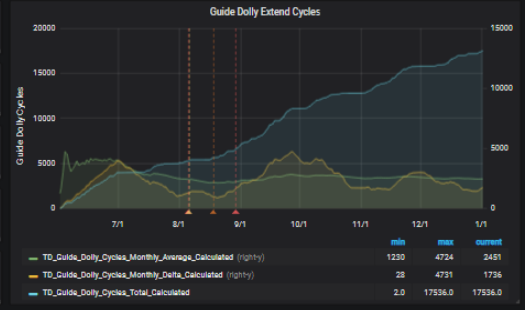
Avg 30 days: **224 km**

Past 24 hrs: **11 km**

Avg 24 hrs: **5.5 km**

Past Yr: **2 Mm**

Guide Dolly Extend Cycles



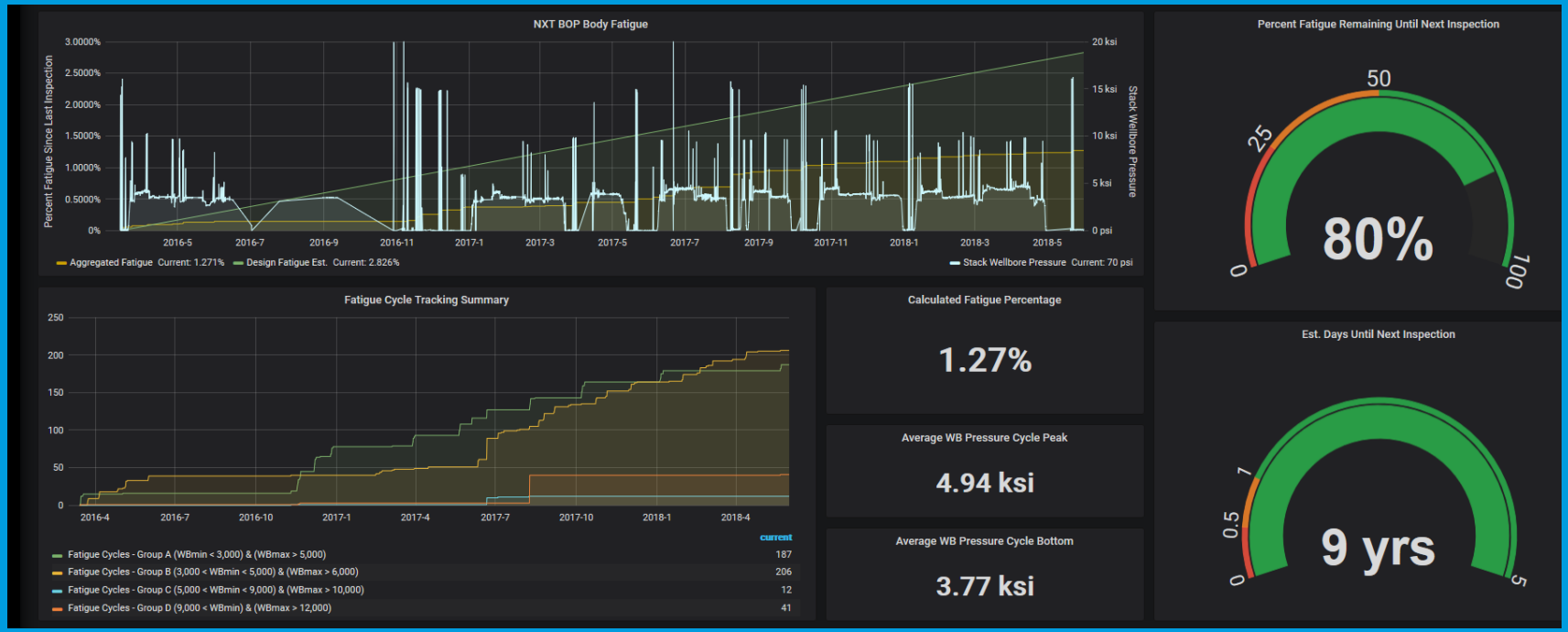
Past 30 days: **1736** Cycles

Avg 30 days: **2451** Cycles

Past 24 hrs: **113** Cycles

Avg 24 hrs: **57.9** Cycles

Past Yr: **17530** Cycles



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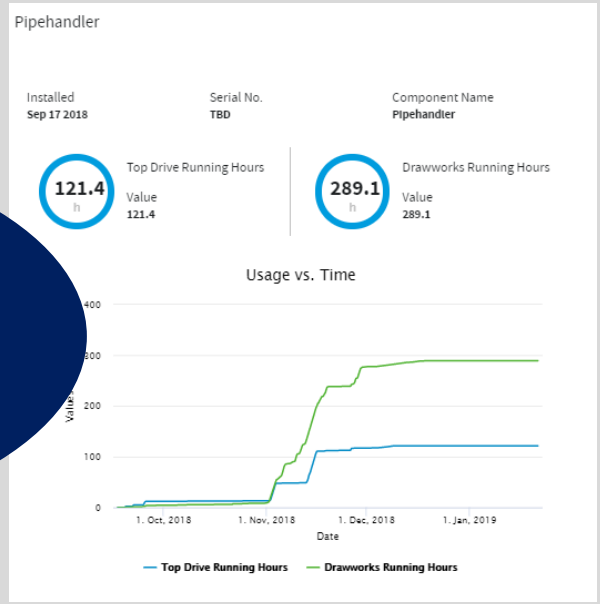
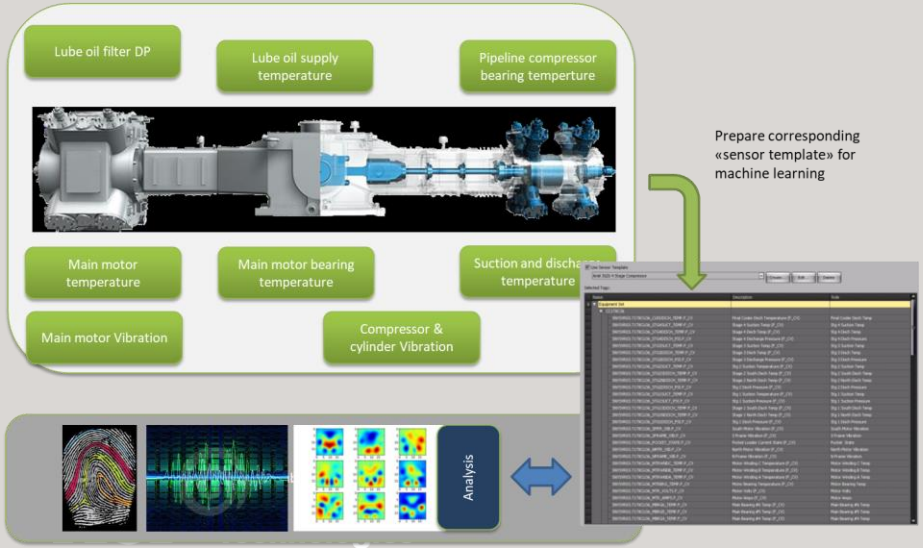
Iteratively agree on additional relevant information

Improve
To predictive level

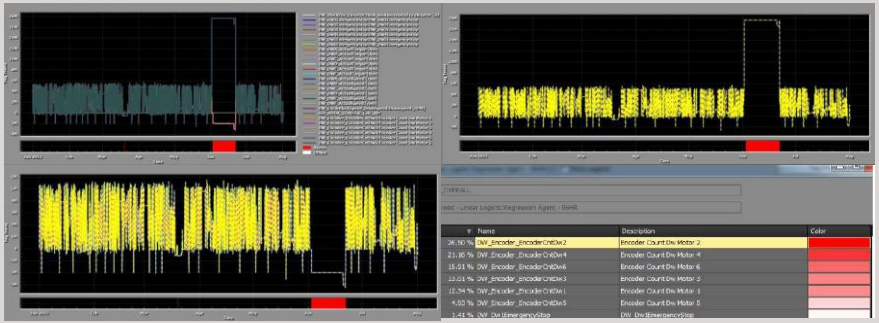


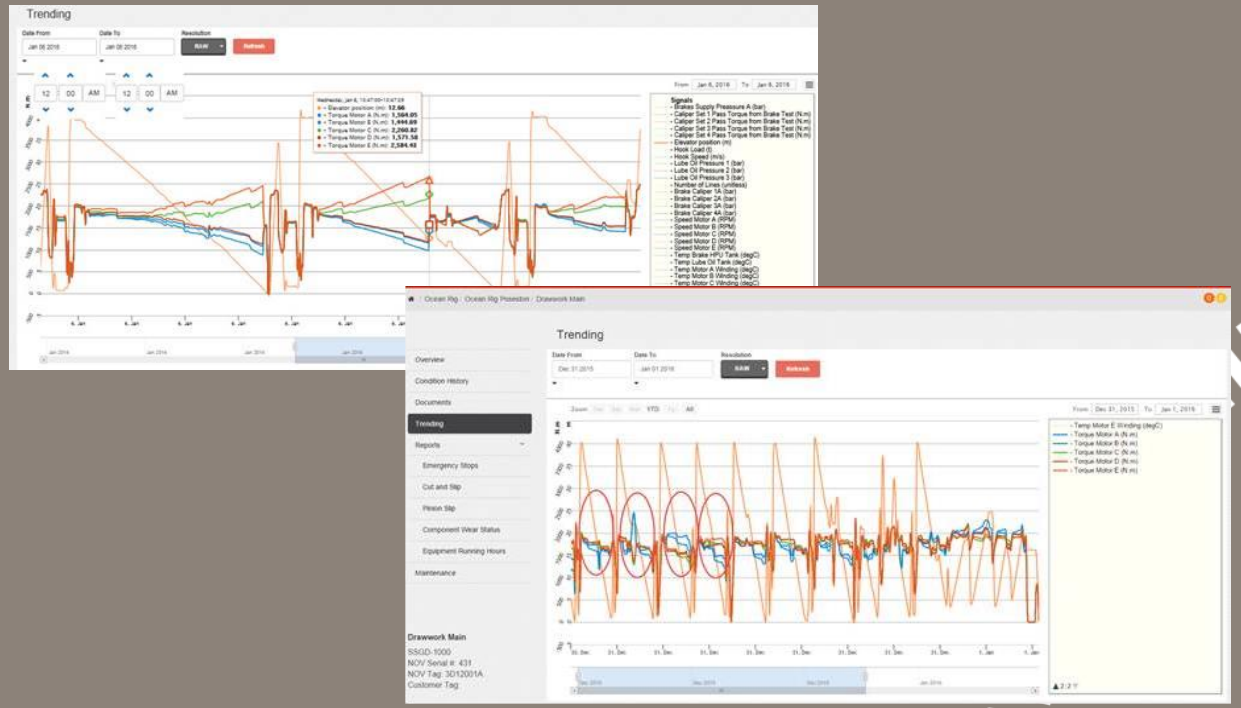
100	Past Due	Pipehandler	Visually inspect the torque wrench: -Check Clamp Cylinder (Including Gripper Body) for leakage and mechanical integrity. -Check Die Retainers and Die for damage or loose hardware.	DONE
100	Past Due	Pipehandler	Visually inspect IBOP to check for missing fasteners. Replace any missing secondary retention.	DONE
55	41 Days	Pipehandler	Check link tilt for leakage and mechanical integrity.	DONE
68	59 Days	Pipehandler	Visually inspect IBOP to check for damaged guards.	DONE
68	59 Days	Pipehandler	Visually inspect link tilt pins, check for wear and/or movement.	DONE

Provide ability to identify and analyse unknowns



Prepare corresponding «sensor template» for machine learning



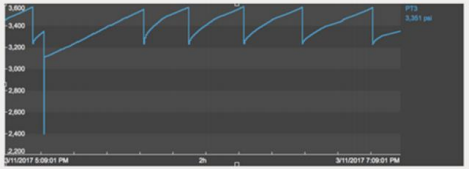

Trending
Date From
Date To
Resolution
Refresh
Trending
Overview
Condition History
Documents
Trending
Reports
Emergency Stops
Cut and Slip
Pinion Slip
Component Wear Status
Equipment Running Hours
Maintenance
Drawwork Main
SSGD-1000
NOV Serial #: 431
NOV Tag: 3012001A
Customer Tag:

Exploit Domain experts to guide, verify, validate and enrich findings

Noble Globetrotter I **PROGNOSTIC FINDINGS**

EVENT TYPE	REPORTED DATE
Regulator Model (Shark Fin)	Mar 14 2017 12:00:00 GMT
Regulator Model (Sawtooth)	Nov 13 2017 12:00:00 GMT
Leakage Detection	Nov 17 2017 12:00:00 GMT
Leakage Detection (Surface)	Nov 29 2017 12:00:00 GMT
Open Under Pressure	Jan 25 2018 12:00:00 GMT

- **Symptoms**
  Shark fin signals have been detected on the Rig 322 Blue pod PT3 (Supply Regulator) pressure sensor.



Impact Gauge

- **Diagnosis**
  Suspect supply regulator faulty supply seal
- **Symptoms start**
  The recent red alarms triggered around March 11th, 2017. The shark fin patterns have been detected constantly since then.
- **Prognosis**
  This type of failure will usually either lead the regulator to malfunction, or cause the HPU pumps on surface to run while no commands are activated. Please check the regulator as soon as possible.

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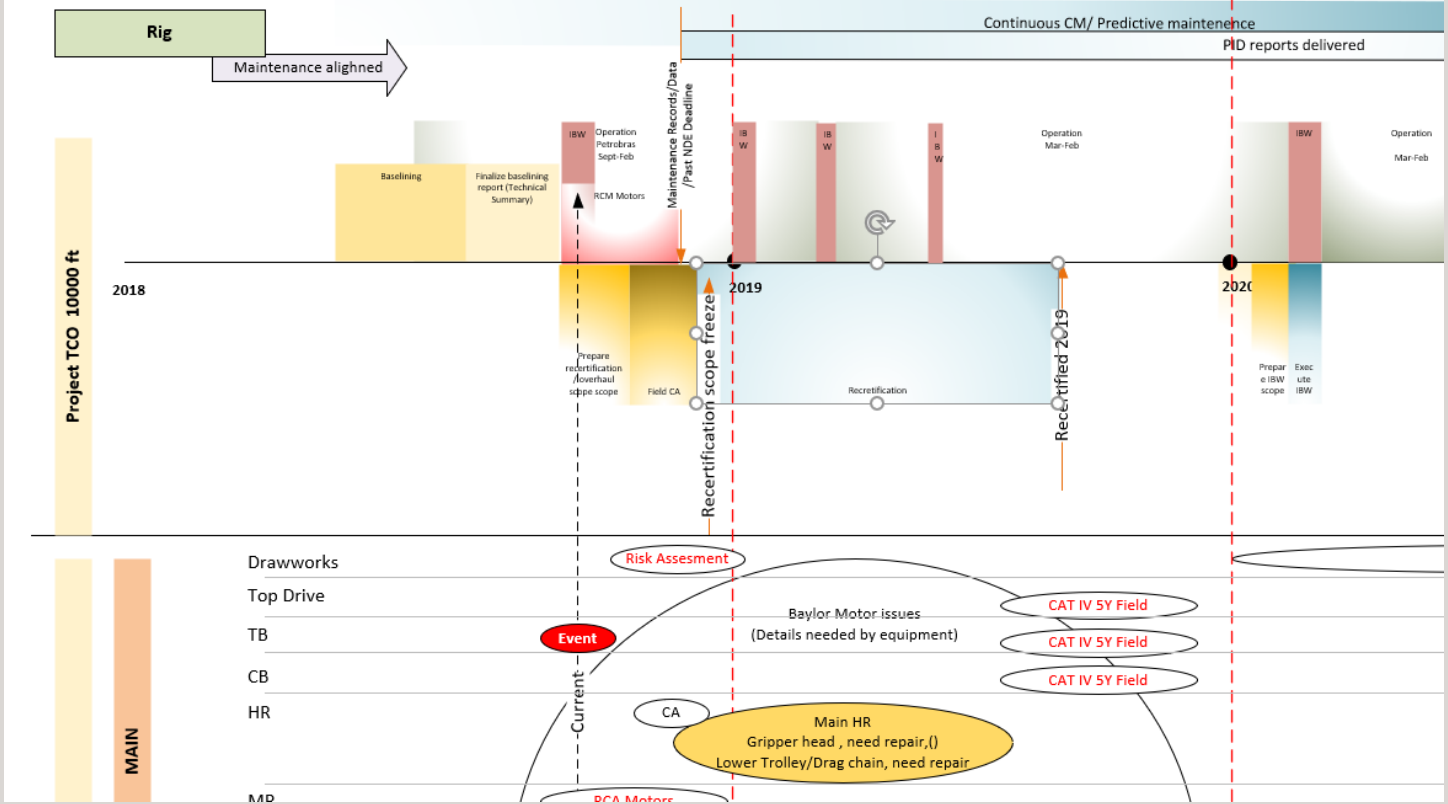

Long term Asset management control and planning

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Summary- Rigsentry

- Is expert system simplifying and supporting decision taking in CBM
- System is designed to gradually automatize accumulated knowledge while allowing CBM experts to dig in the condition situation, down to the data
- It normalizes relevant information sources, presenting user with information he needs to see
- Provide confidence and control over situation
- Make time and motivation to push for advanced development
- User and the system are in constant change

Source: Calibri 8pt regular with manual bold applied.
Source citations are right aligned and wrap up the slide from the bottom.