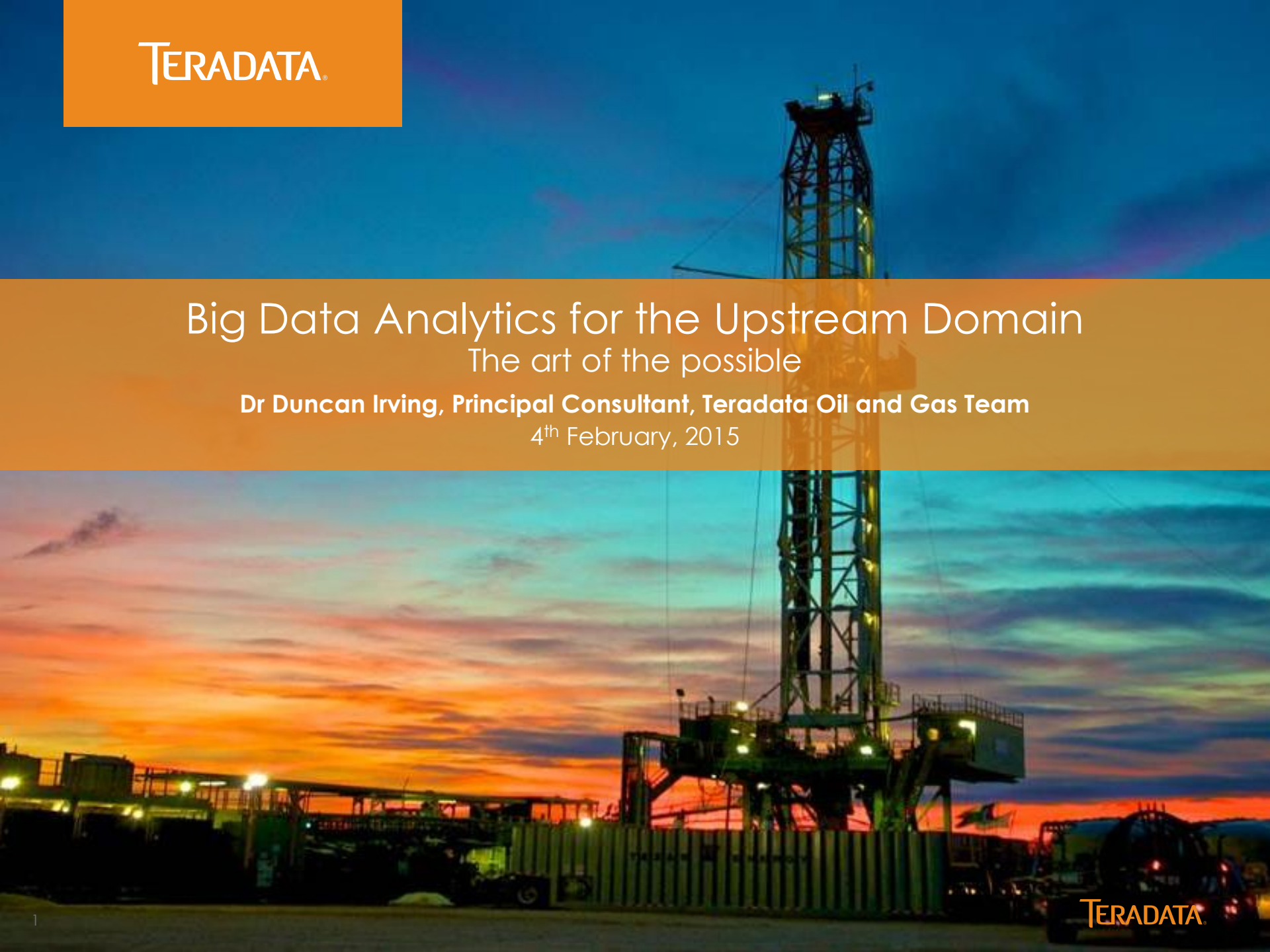

Big Data Analytics for the Upstream Domain

The art of the possible

Dr Duncan Irving, Principal Consultant, Teradata Oil and Gas Team

4th February, 2015

Teradata overview

Key facts about Teradata

- 1 focus: *Value from Data!*
  - ➢ **Analytic data platforms, applications and services**
- 30+ years of growth and innovation
- 1 **patent** per week since 2009
- **1,500+ customers** in 12 industries
- **10,000+ employees** in 70 countries
- **$2.6 billion revenue in 2013**
- ~$7-8 billion market cap Q3 2014
- Constituent of the S&P 500 index

Leading companies trust Teradata for data management and analytics

Chevron, REPSOL, ConocoPhillips, Statoil, GE, MAERSK LINE, SIEMENS, ERDF, GDF SUEZ, MURPHY OIL CORPORATION, OGE, Chesapeake, Xcel Energy, Pacific Gas and Electric Company

Activities within predictive maintenance

US Air Force, AIR FRANCE, BNSF, DELTA, Western Digital, NAVAIR, EADS, VOLVO, BOEING, NAVISTAR, McCain

Teradata's business model – key demarcations

We do…

- **Integrate and analyze any type of data** on our market **leading HW/SW platforms**
- Apply a **horizontal view of data** to release the value of **breaking down silos**
- Build analytical solutions in perspective of **data reuse**
- **IT/BI service** to enable our customers

We do not…

- **Sell** or advise on choice of **Oil & Gas equipment**
- Offer **"silver bullet" pieces of software** targeted for solving single business problems
- **Offer packaged program** solution "in a box"

Dealing with data in motion

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Data Lake…

…or more like a reservoir

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Many Lakes


What happens when your infrastructure needs a refresh?
TERADATA

Data Warehouse

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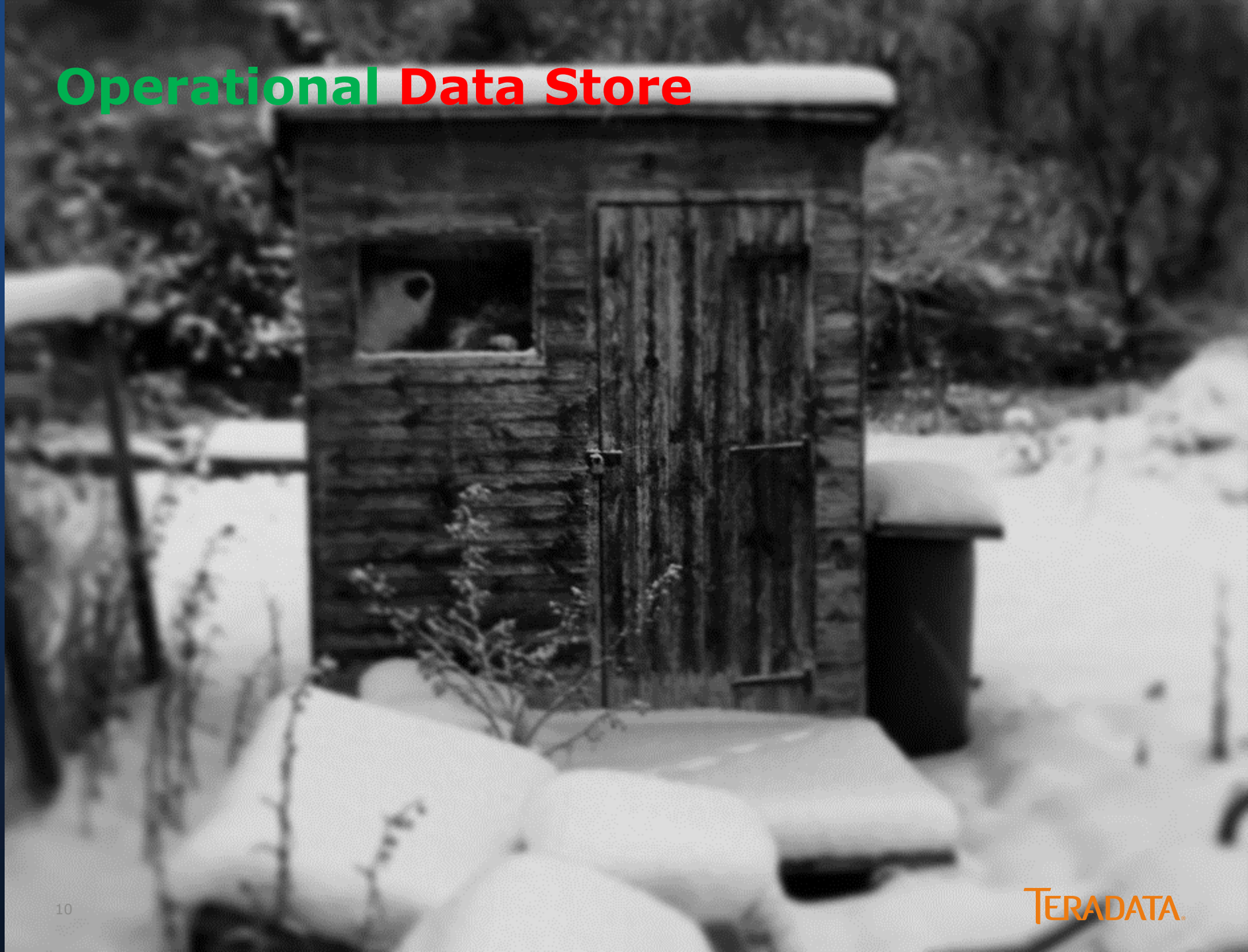
Operational Data Store



A proliferation of data marts

Information super*garden*

So what does Teradata do?

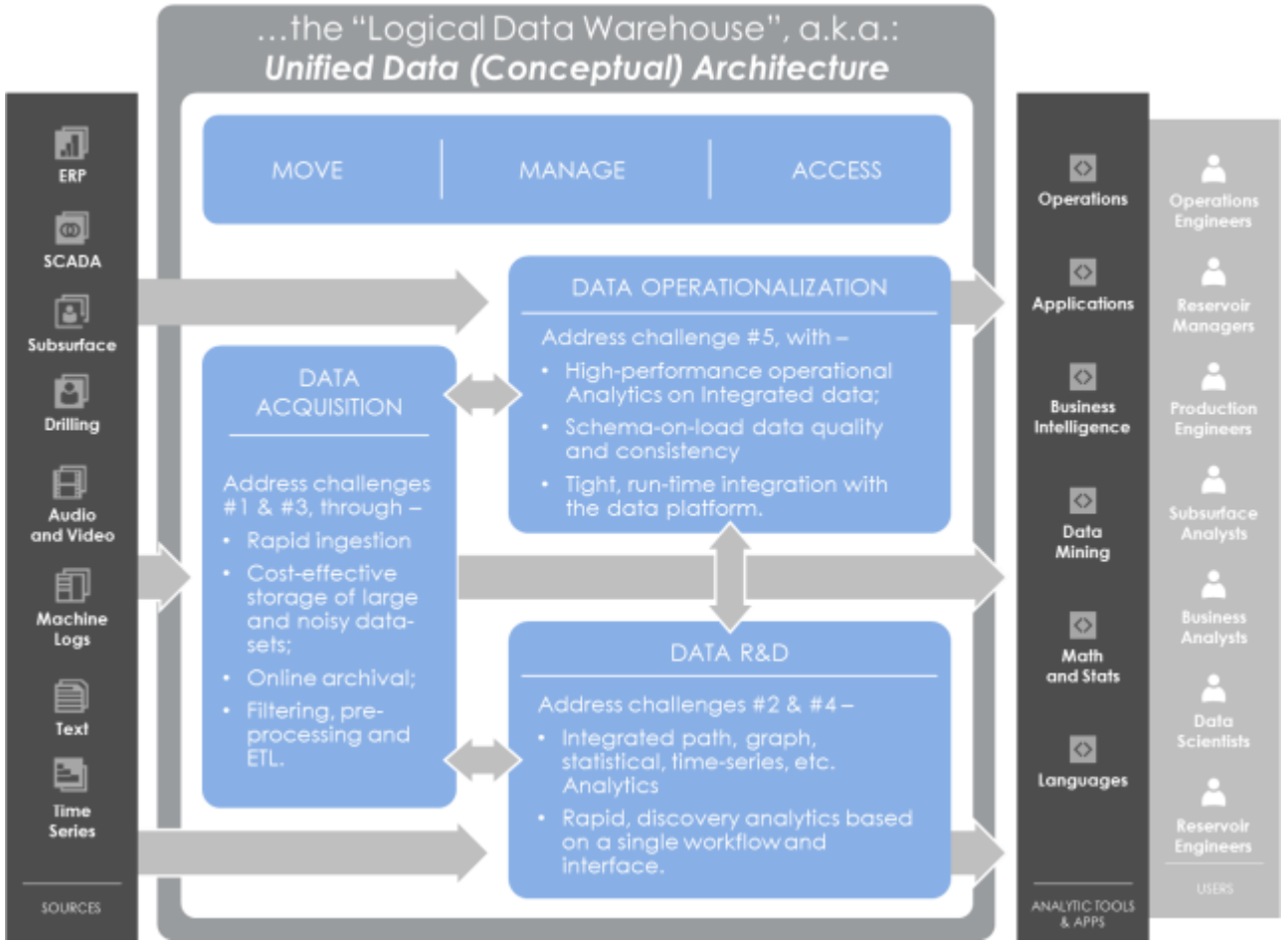
Put simply, our unified architecture advocates storage, discovery, operational decision support and event processing components.

Our clients use this conceptual architecture in part to understand how insight and value can be extracted from data assets across as many data and user domains as possible.

Each activity has a purpose and an envelope of cost-effectiveness; this extends to ease-of-integration.

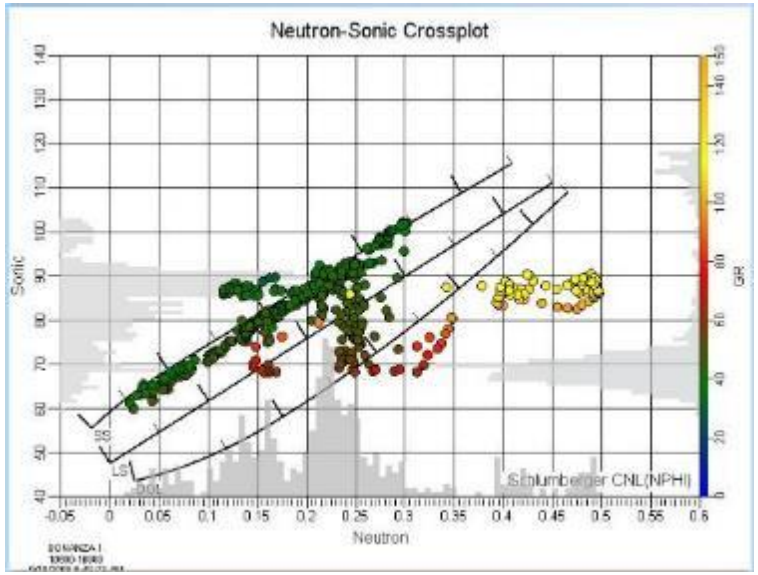
Teradata can provide architectural consulting with the wealth of experience from our wide client base – and most of our clients operate very mixed architectures indeed.

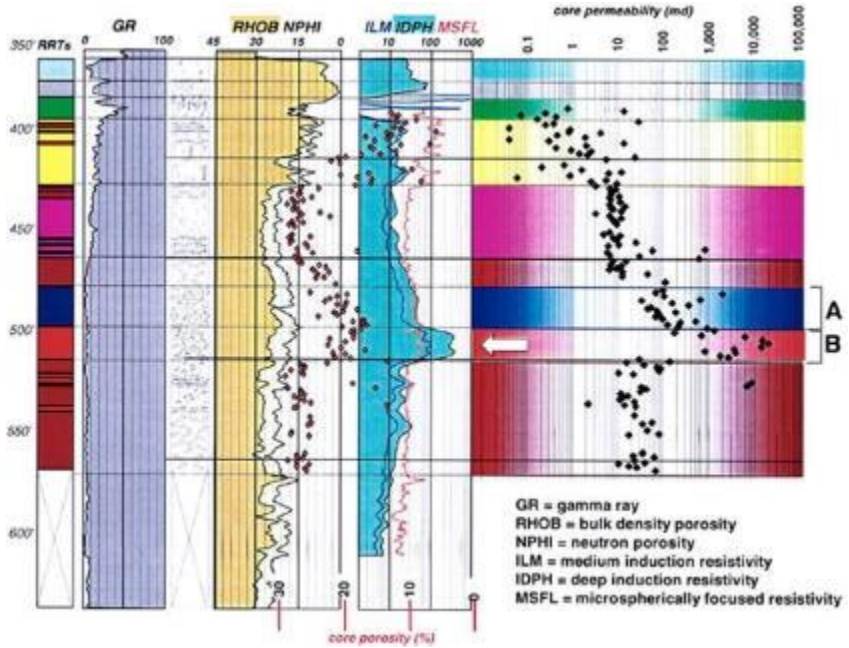
Big Data are plural – and managing and exploiting them effectively is about AND, not OR.



How do we achieve insight today?

Analysis





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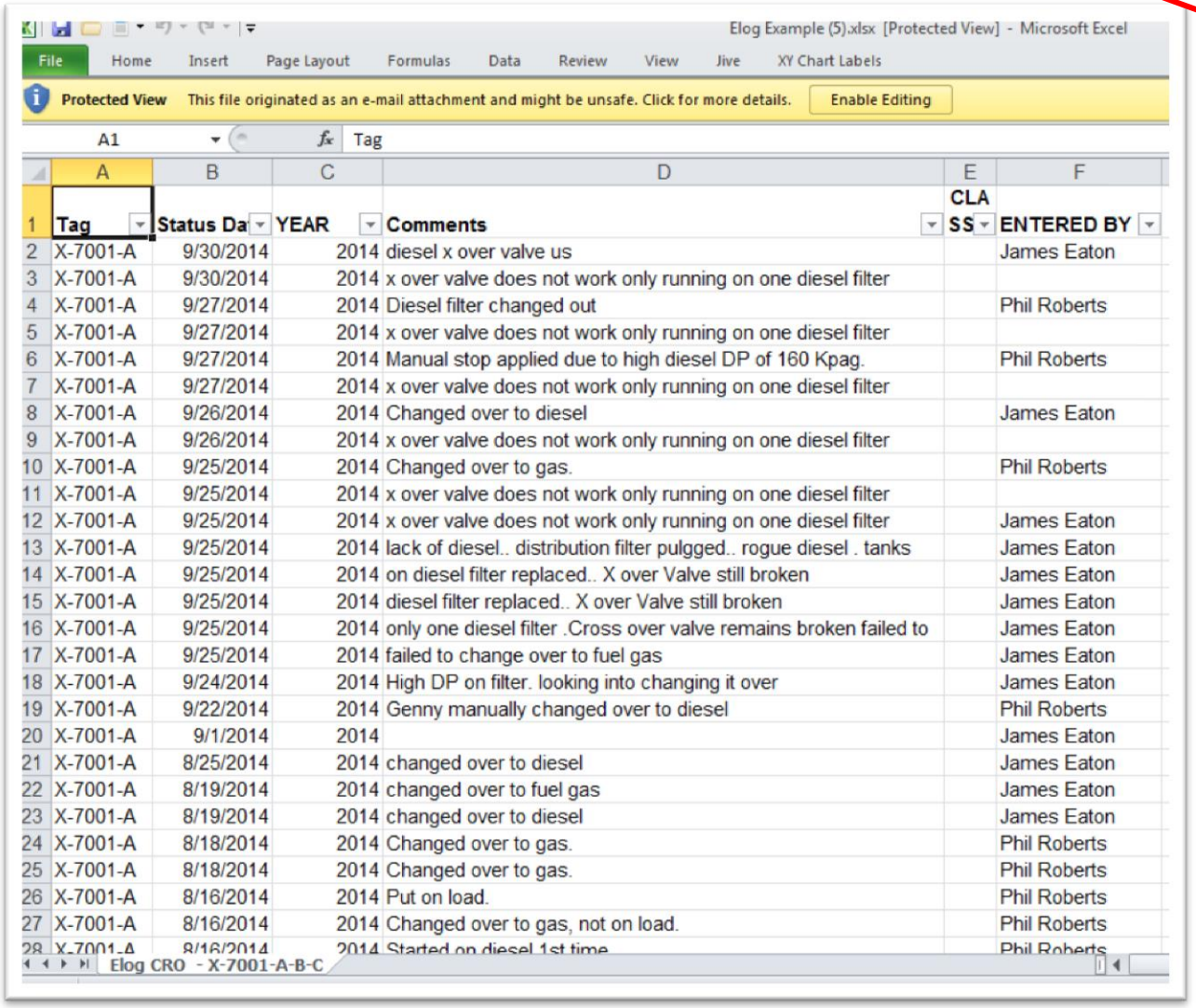
How do we achieve insight today?

Analysis



Elog Example (5).xlsx [Protected View] - Microsoft Excel

File | Home | Insert | Page Layout | Formulas | Data | Review | View | Jive | XY Chart Labels

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A1 fx Tag

	A	B	C	D	E	F
1	Tag	Status Da	YEAR	Comments	CLASS	ENTERED BY
2	X-7001-A	9/30/2014	2014	diesel x over valve us		James Eaton
3	X-7001-A	9/30/2014	2014	x over valve does not work only running on one diesel filter		
4	X-7001-A	9/27/2014	2014	Diesel filter changed out		Phil Roberts
5	X-7001-A	9/27/2014	2014	x over valve does not work only running on one diesel filter		
6	X-7001-A	9/27/2014	2014	Manual stop applied due to high diesel DP of 160 Kpag.		Phil Roberts
7	X-7001-A	9/27/2014	2014	x over valve does not work only running on one diesel filter		
8	X-7001-A	9/26/2014	2014	Changed over to diesel		James Eaton
9	X-7001-A	9/26/2014	2014	x over valve does not work only running on one diesel filter		
10	X-7001-A	9/25/2014	2014	Changed over to gas.		Phil Roberts
11	X-7001-A	9/25/2014	2014	x over valve does not work only running on one diesel filter		
12	X-7001-A	9/25/2014	2014	x over valve does not work only running on one diesel filter		James Eaton
13	X-7001-A	9/25/2014	2014	lack of diesel.. distribution filter pulgged.. rogue diesel . tanks		James Eaton
14	X-7001-A	9/25/2014	2014	on diesel filter replaced.. X over Valve still broken		James Eaton
15	X-7001-A	9/25/2014	2014	diesel filter replaced.. X over Valve still broken		James Eaton
16	X-7001-A	9/25/2014	2014	only one diesel filter .Cross over valve remains broken failed to		James Eaton
17	X-7001-A	9/25/2014	2014	failed to change over to fuel gas		James Eaton
18	X-7001-A	9/24/2014	2014	High DP on filter. looking into changing it over		James Eaton
19	X-7001-A	9/22/2014	2014	Genny manually changed over to diesel		Phil Roberts
20	X-7001-A	9/1/2014	2014			James Eaton
21	X-7001-A	8/25/2014	2014	changed over to diesel		James Eaton
22	X-7001-A	8/19/2014	2014	changed over to fuel gas		James Eaton
23	X-7001-A	8/19/2014	2014	changed over to diesel		James Eaton
24	X-7001-A	8/18/2014	2014	Changed over to gas.		Phil Roberts
25	X-7001-A	8/18/2014	2014	Changed over to gas.		Phil Roberts
26	X-7001-A	8/16/2014	2014	Put on load.		Phil Roberts
27	X-7001-A	8/16/2014	2014	Changed over to gas, not on load.		Phil Roberts
28	X-7001-A	8/16/2014	2014	Started on diesel 1st time		Phil Roberts

Elog CRO - X-7001-A-B-C

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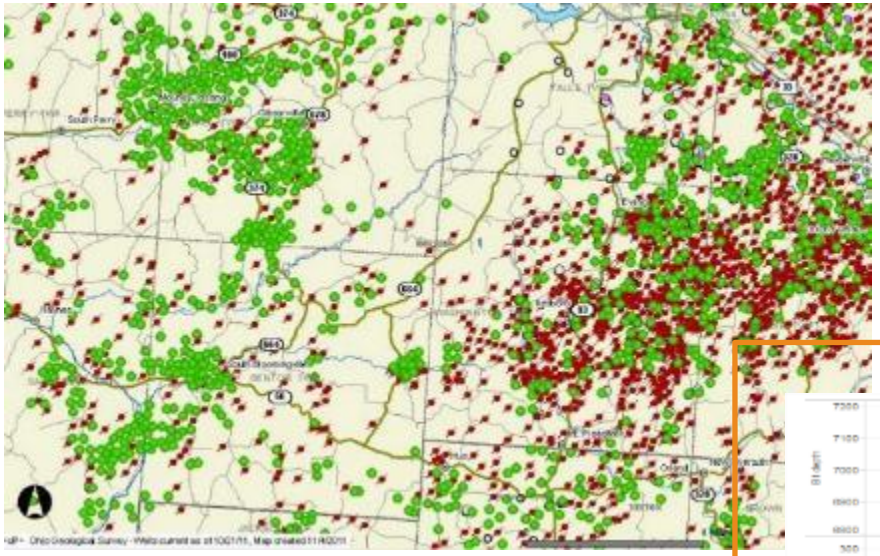
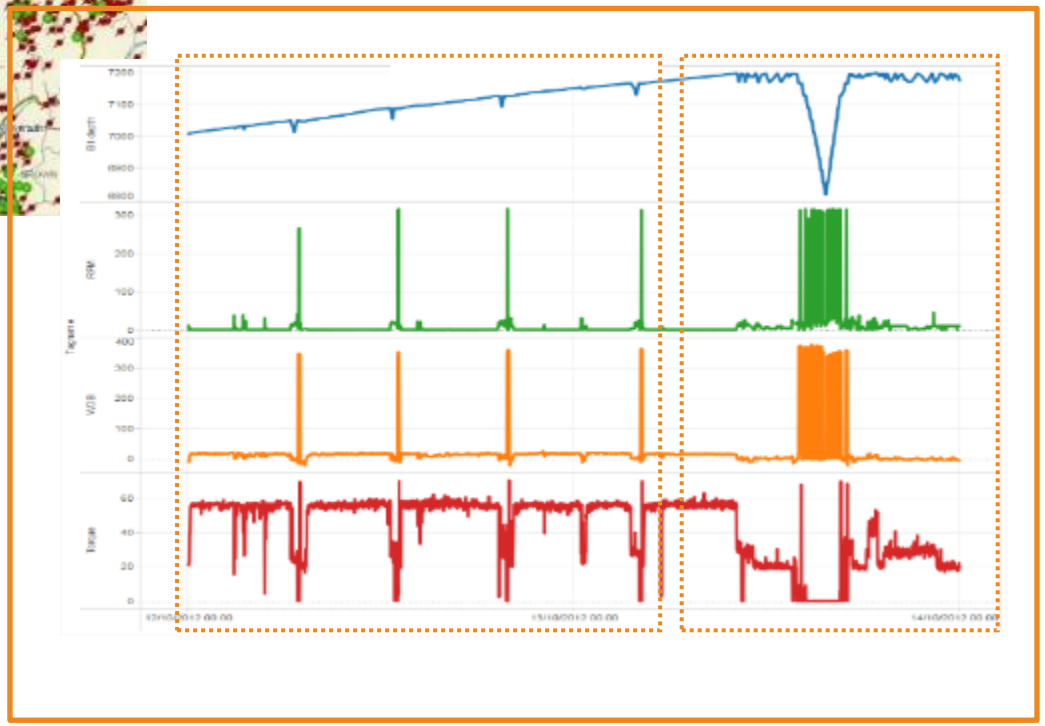
How do we achieve insight today?

Analysis





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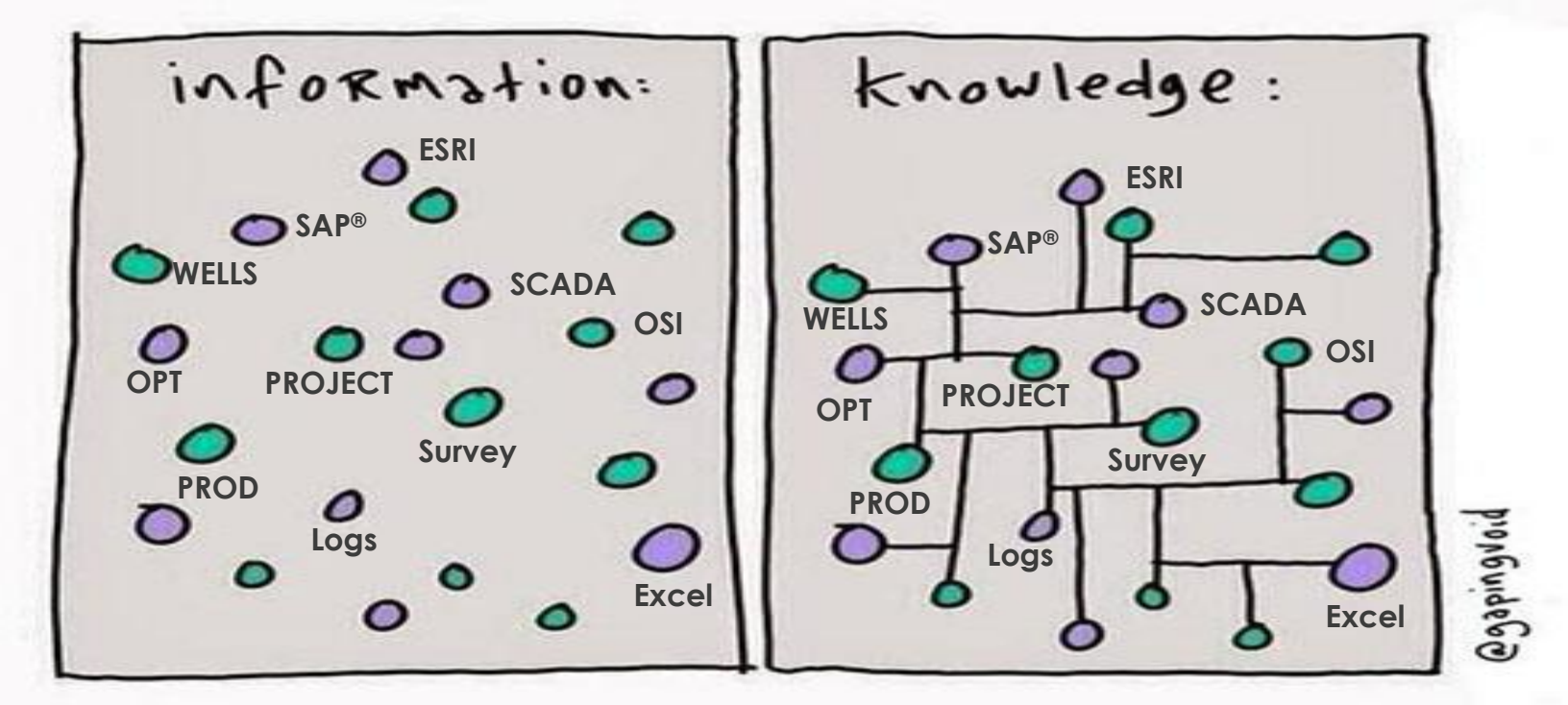
The answer: Data Integration

Cartoonist Hugh MacLeod nailed it with this cartoon:



There is a world of difference in the workplace between **knowing facts**, and **knowing how those facts fit together**. Even more important is **knowing what to do about it**.[1]

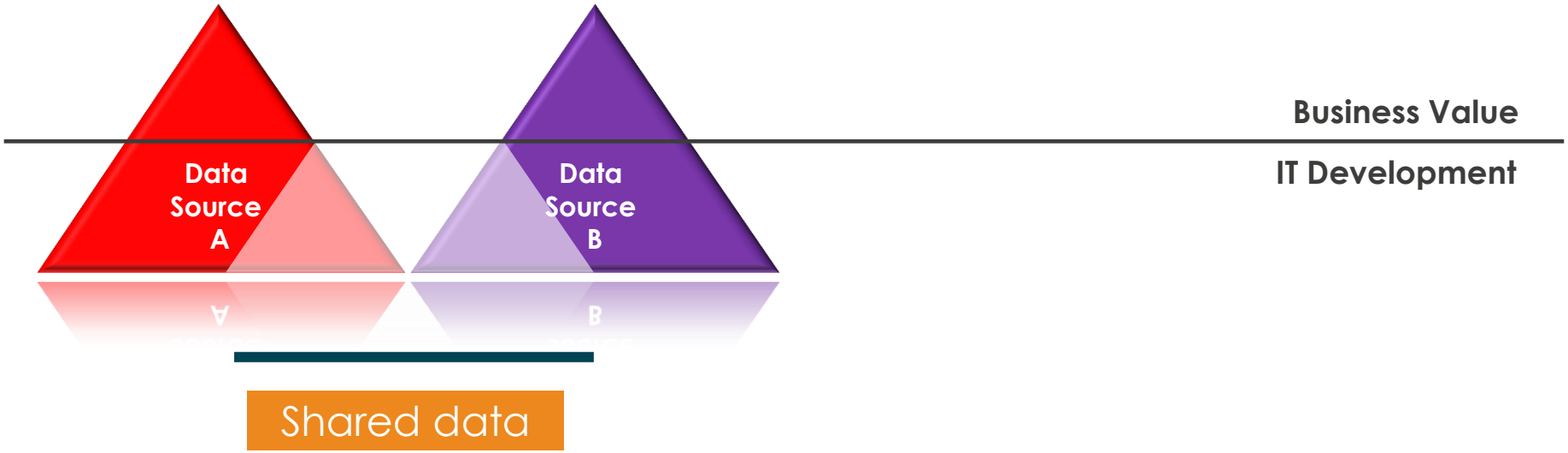
Source: [1] Marc Cenedella, Founder The Ladders

The Power of Integration: No Integration…

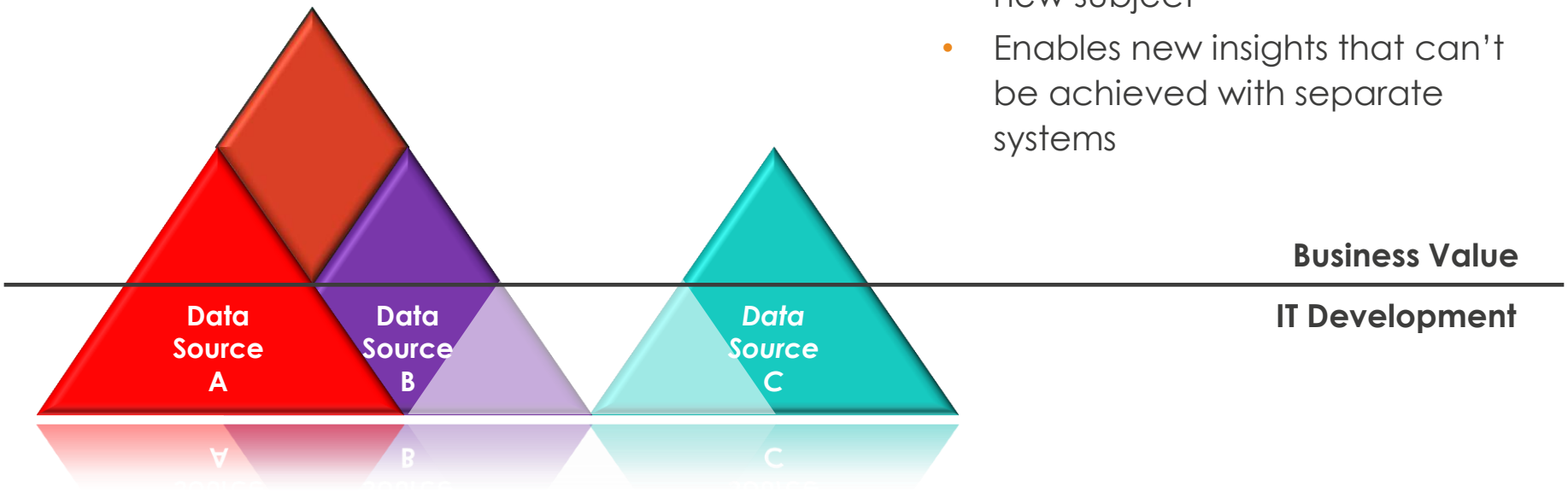
1+1=2

Limited Business Value

- Each data mart can provide answers to subject-specific questions
- With each new data mart, IT repeats its development efforts
- This includes sourcing data that already exists in another environment



The Power of Integration: With Data Integration…

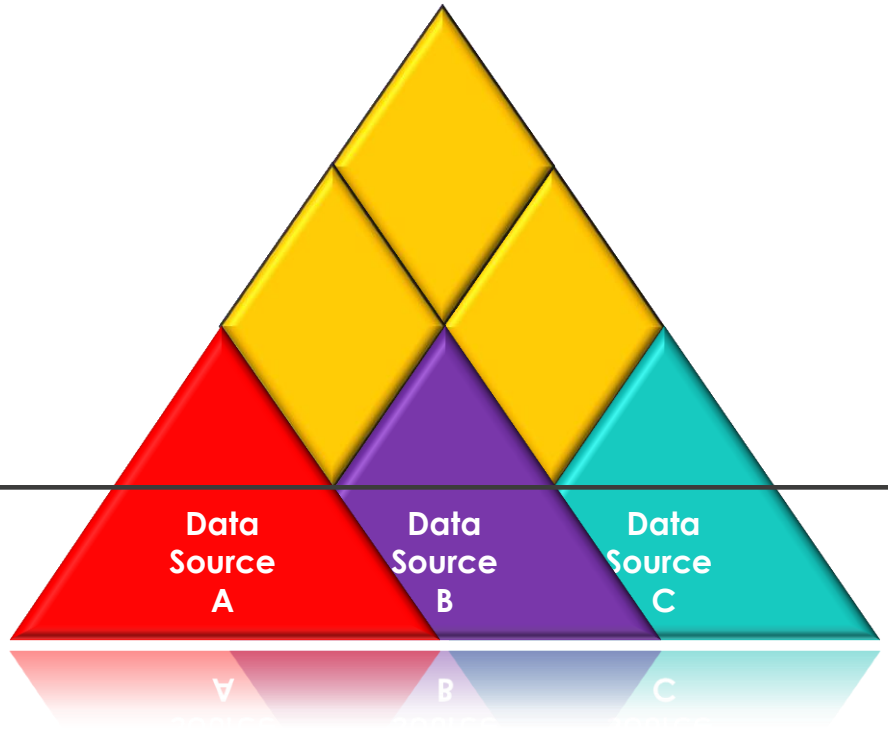


1+1=3

More Business Value

- Combining environments requires less new work for each new subject
- Enables new insights that can't be achieved with separate systems

The Power of Integration: More Data Integration…



1+1+1=6

Value to effort ratio increases significantly!

Business Value

IT Development

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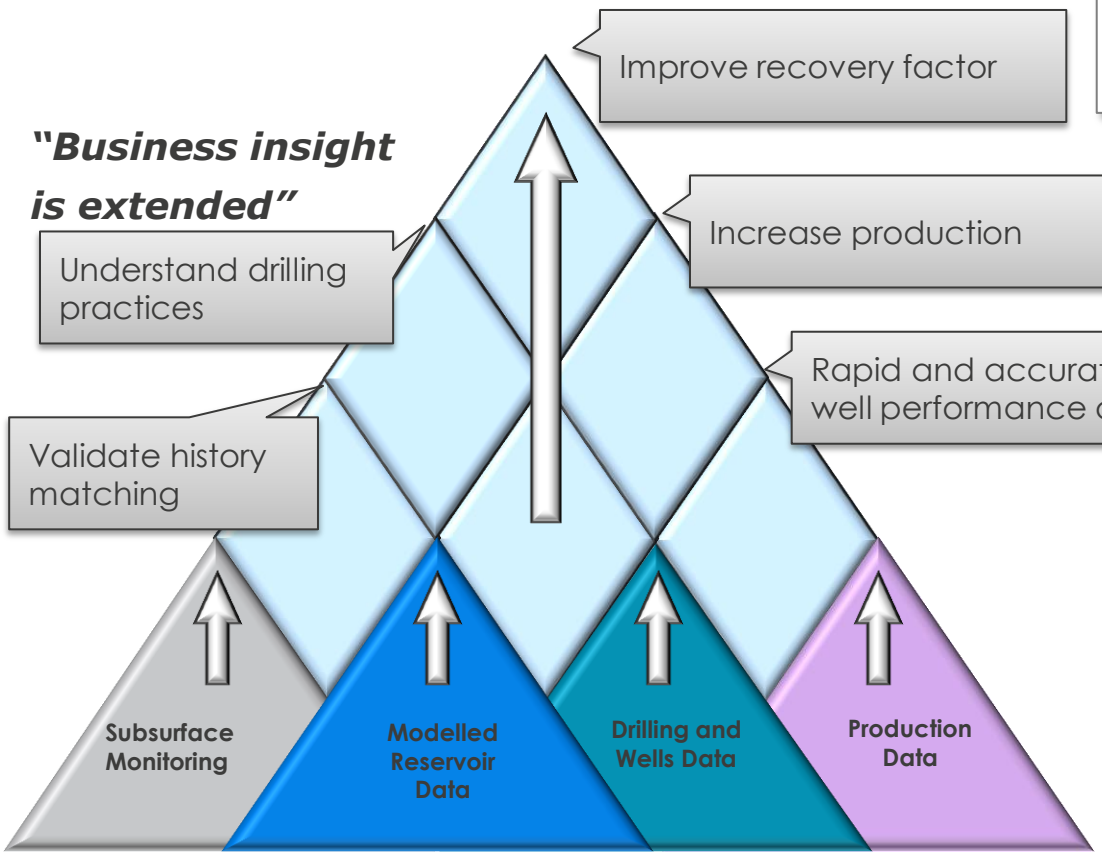
Data-centric approach to answer strategic questions in Field Monitoring operations



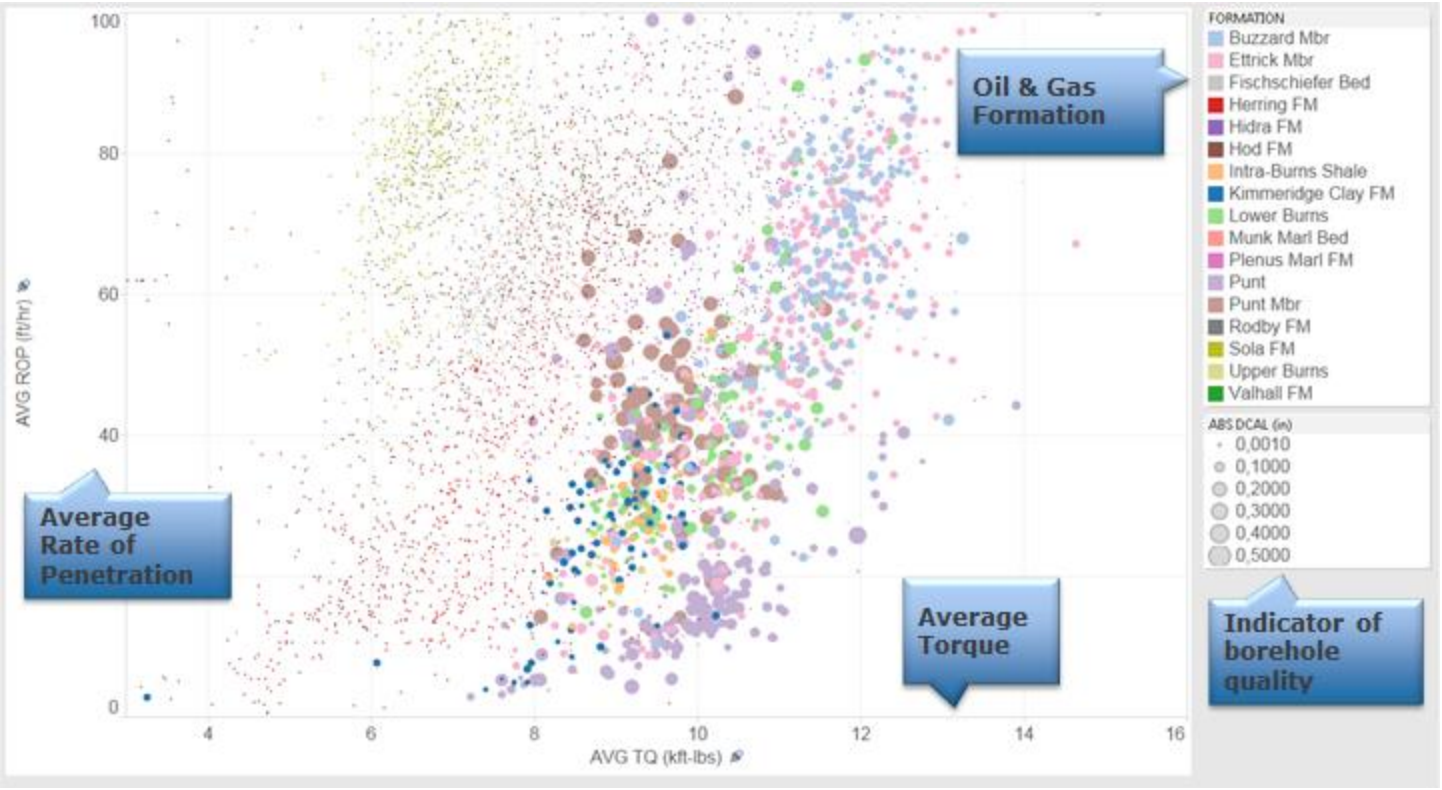
Selection of questions across 12 domains and 120+ data sources in ConocoPhillips

- What is the optimum well spacing to maximize reservoir drainage?
- What is the **optimum** number of frac stages per well, to maximize production at a reasonable cost?
- Can we **predict** production decrease based on the predictive maintenance plan and potential asset failures?
- Can we make **automated** adjustments to the wells, to optimize production, lower costs, and increase asset profitability?

What would you like to see?

Trends, patterns, and risks in D&W domains and suggest optimal parameters for planning and operations

Analytics!



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The power of becoming data-driven

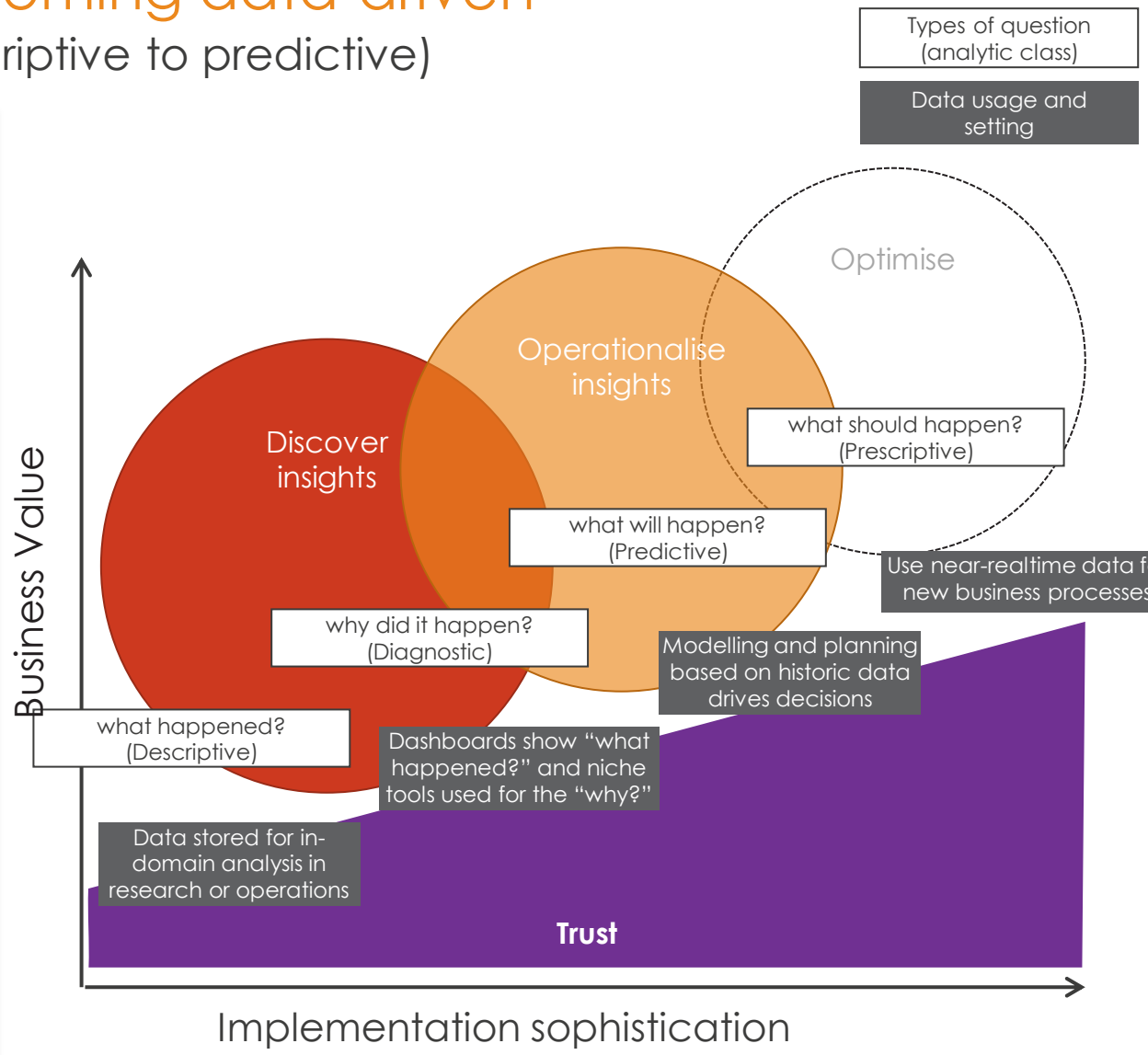
Analytics at scale (descriptive to predictive)

The journey to becoming data-driven

Turning the discovery of potential relationships in your data into validated insight requires careful contextualisation – the joint assessment of operational data with expected behaviours from interpreted and modelled data sets (e.g. seismic, flow models).

Once an understanding of an underlying process is achieved, it can be built into operational decision support. Exceptions and advance signatures can be spotted, driving early warnings to catch issues before they become significant, allowing corrective action to be advised and scheduled.

To perform at this level of operationalization, real trust is paramount. This is driven not only through improved data quality, but also the clarity with which the relationship and its context is communicated.



Upstream Data Mining and Discovery Analytics

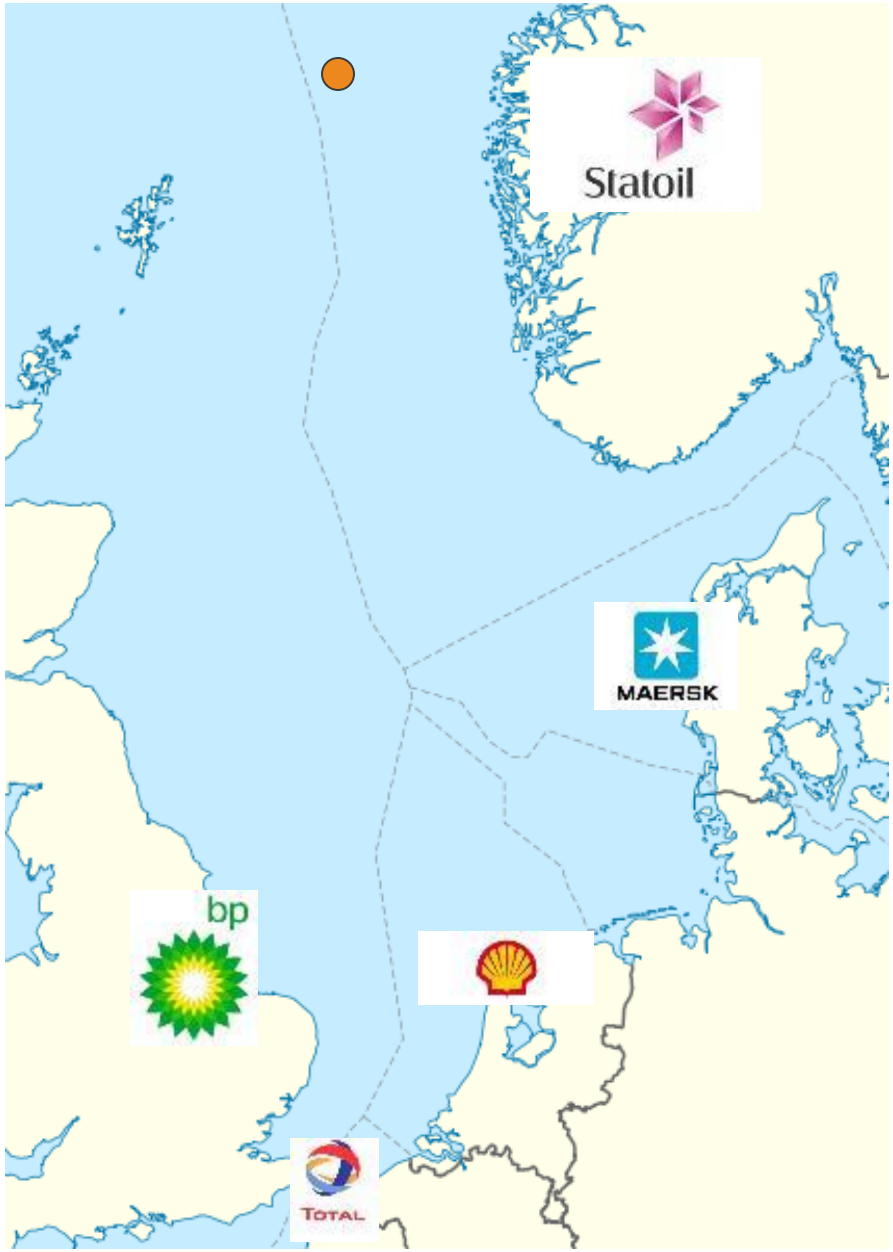
"The quickest way to find a needle in a haystack…is to burn the haystack" crunch ***all*** the data

Gary Class, Head of Digital Analytics, Wells Fargo

Statoil's new **Big Data** problem

Permanent Reservoir Monitoring investment on the Snorre and Aasgard Fields

- $800M in seafloor cable
- 38 wells, 2 platforms
- LOF: 1992-2040
- 5th largest field and 3% of PRs



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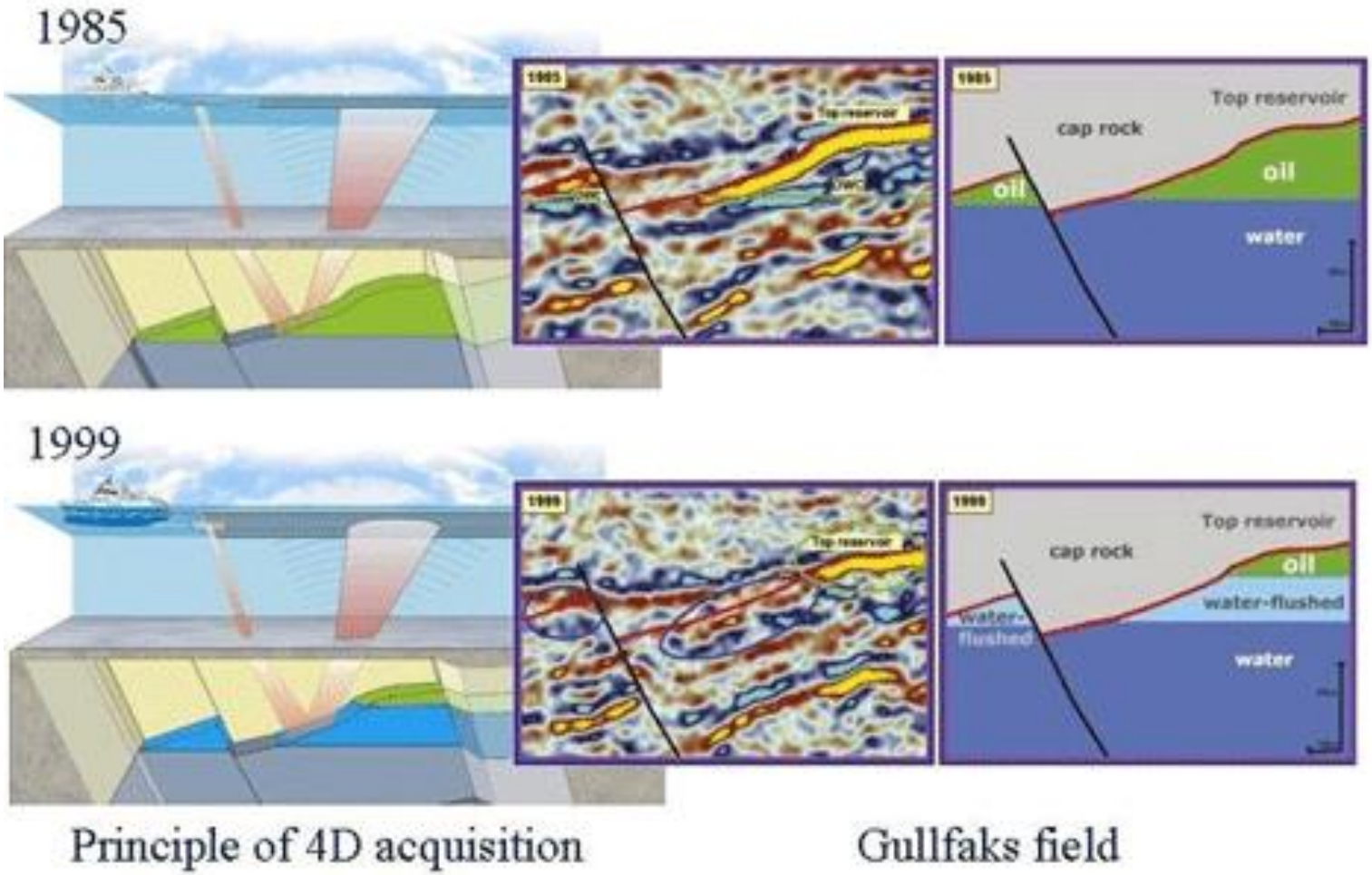
The Business Perspective

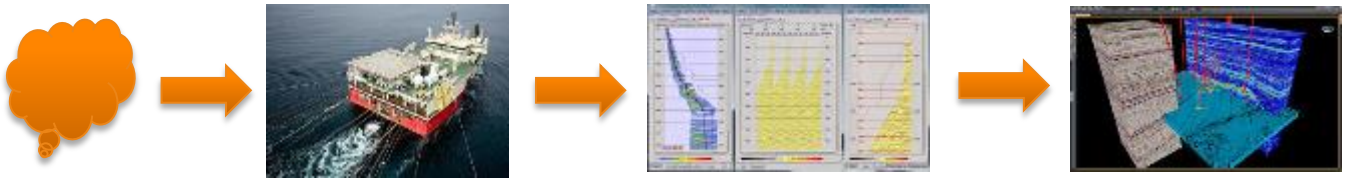
+442081505292

+44

4D Seismic – seeing what happened



Traditional Marine Seismic Surveys



Planning
1 year

Acquisition
1 month

Processing
6+ months

Interpretation
3-6 months

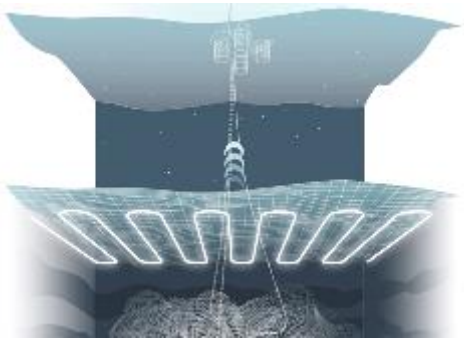
Average 2 years between "snapshots" of the reservoir

Permanent Reservoir Monitoring (PRM)

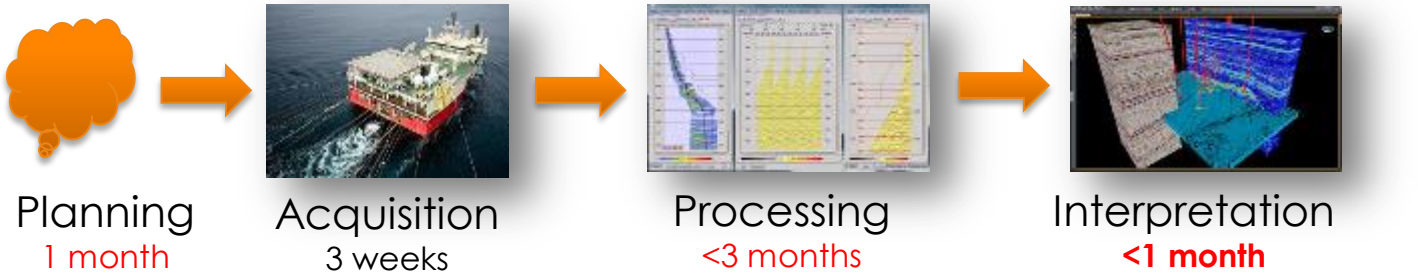
"Operationalizing" the workflow

With a fixed seabed receiver array:

- Simpler source vessel
  - Cheaper per survey
  - More weather independent
- Receiver geometry the same
  - Surveys are more repeatable
  - Faster processing turnaround
- Can do more frequent surveys

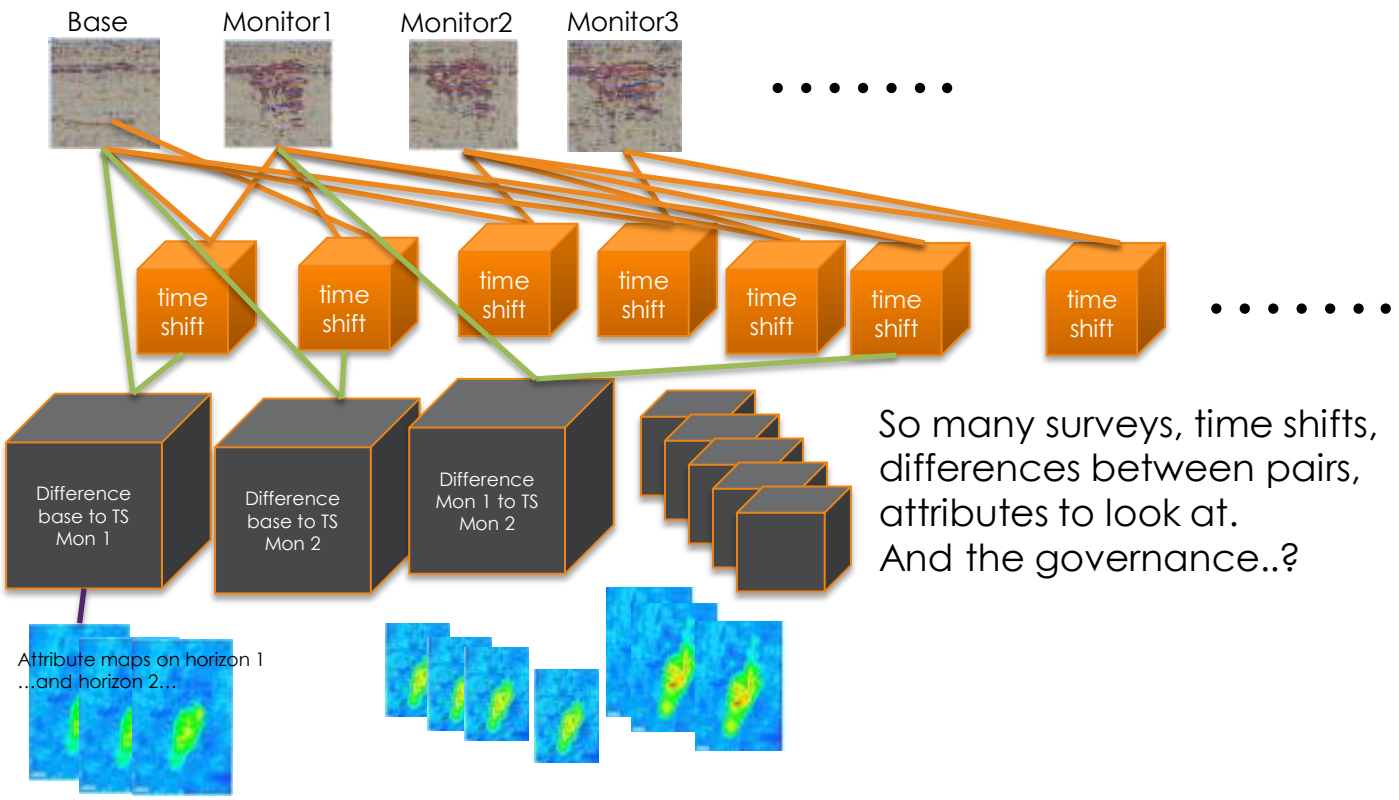


PRM: Shortens the time frame



- New survey at least every 6 months
- Decision making on the timescale of interventions
- Need a much more streamlined process for receiving new data and interpreting it

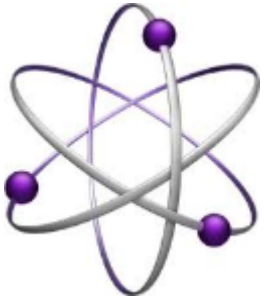
And brings so much data…



So many surveys, time shifts, differences between pairs, attributes to look at.
And the governance..?

Our Solution

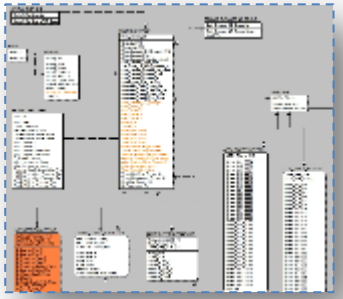
Learning from other industries…



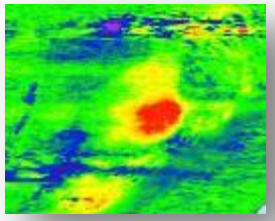
We made a Reservoir Data Warehouse!

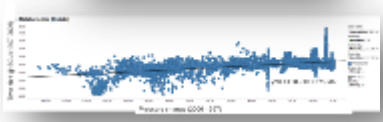
We store detailed subsurface data in an MPP Analytical database

We integrate it in space and time as well as logical relationships



And users can visualise detailed data and analysis, calculated on-the-fly





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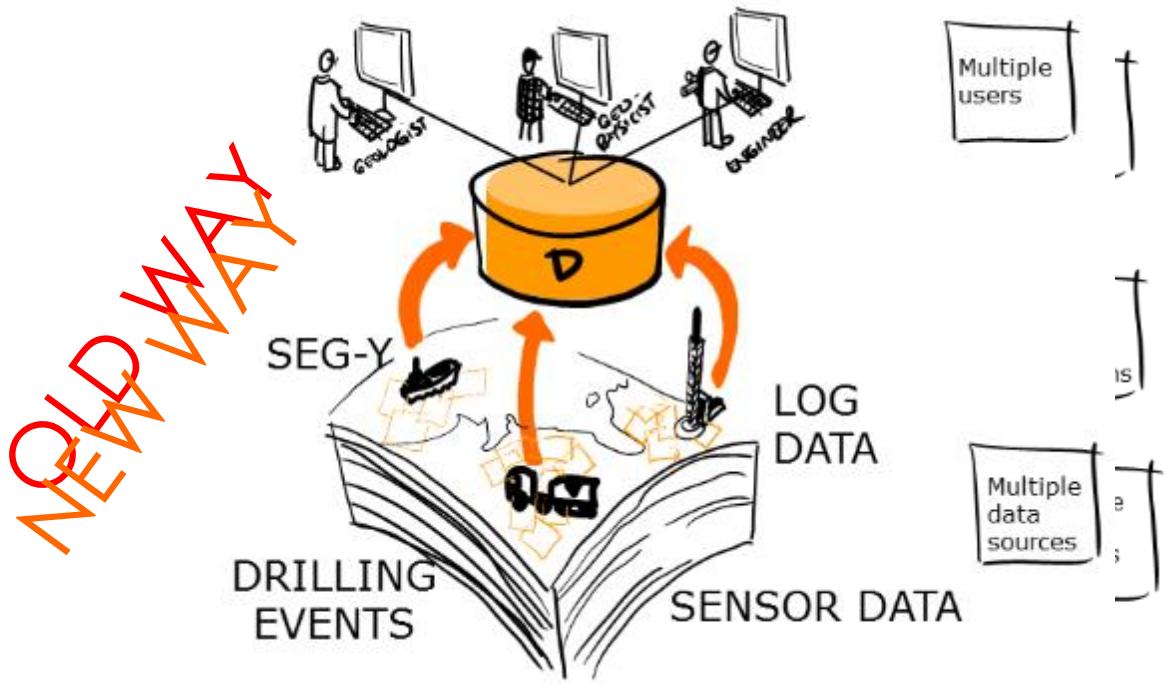
to bring the disciplines together

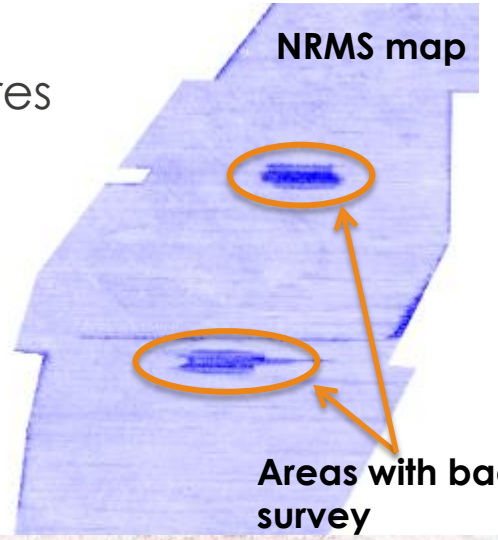


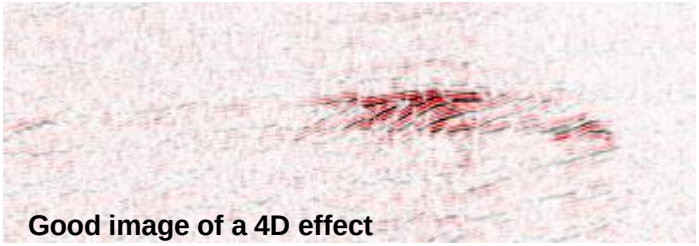
We brought Analytics to the Subsurface

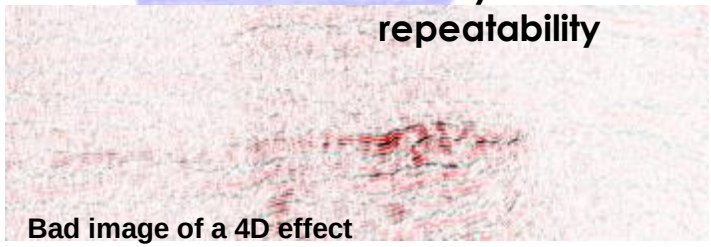
- 4D workflows not fully supported by today's tools
- Explaining 4D "effects" requires other data
  - Identifying artefacts of processing or acquisition
  - Identifying events that correlate

Example 1: Repeatability Analysis

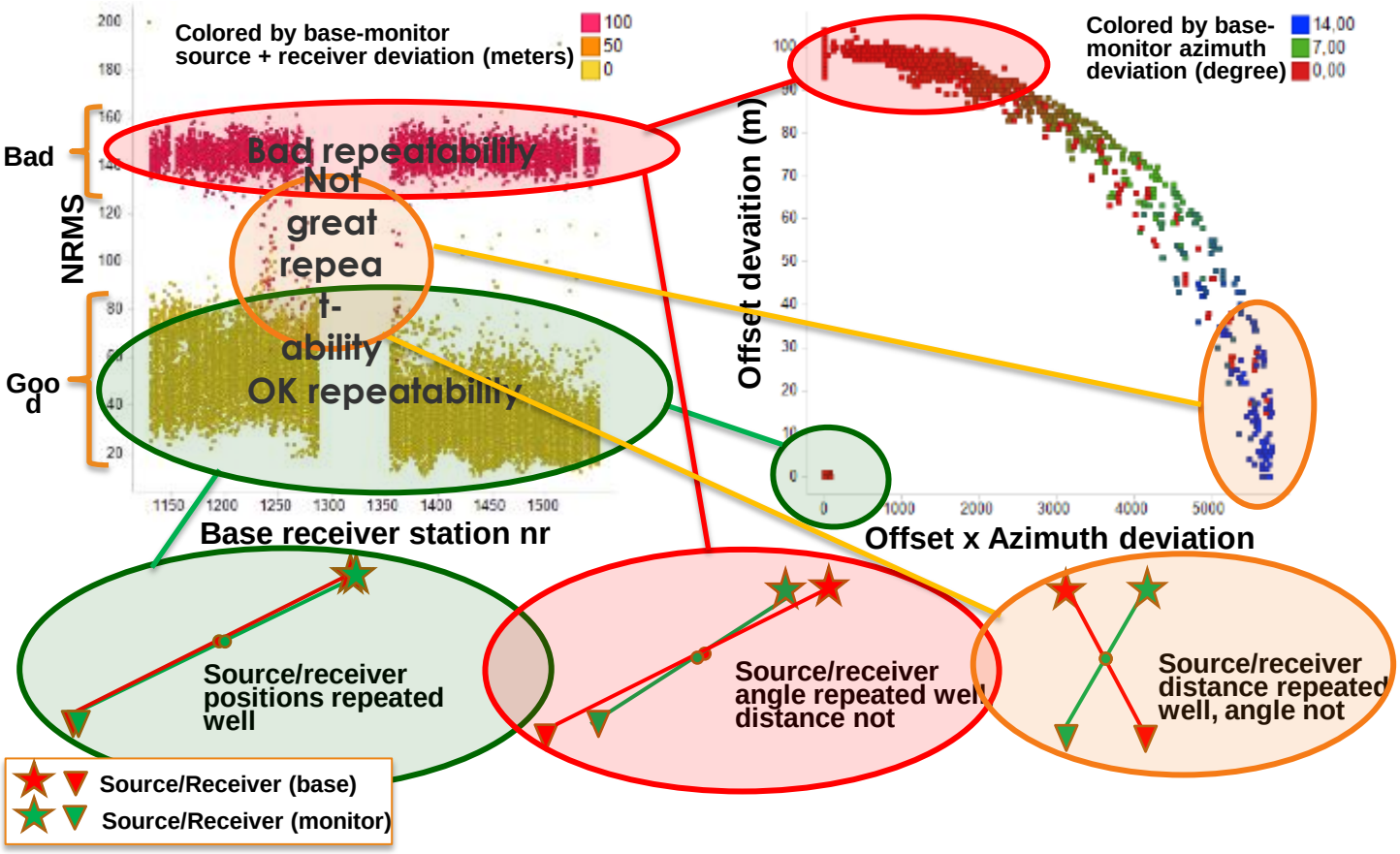
- Good image of 4D effect requires seismic image taken 'from the same position'.
- NRMS is measure for survey 'repeatability'.




Good image of a 4D effect


Bad image of a 4D effect

Example 1: Repeatability Analysis



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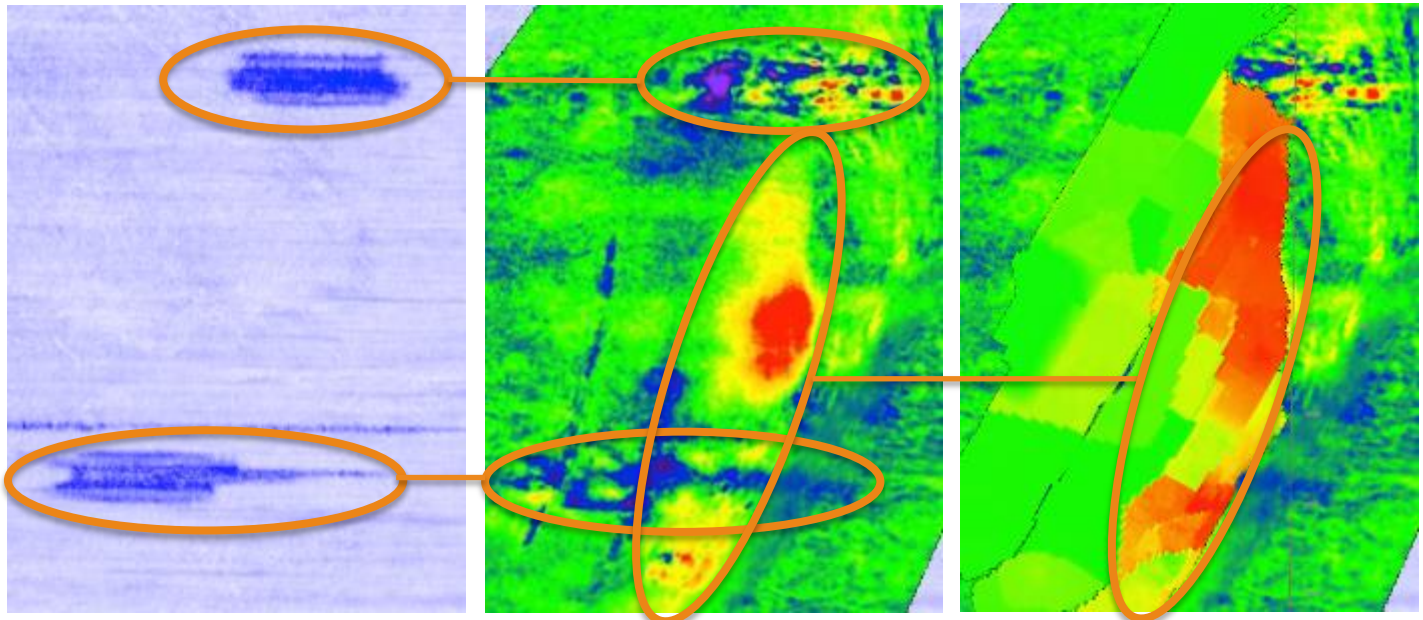
Example 2: Subsurface Analytics

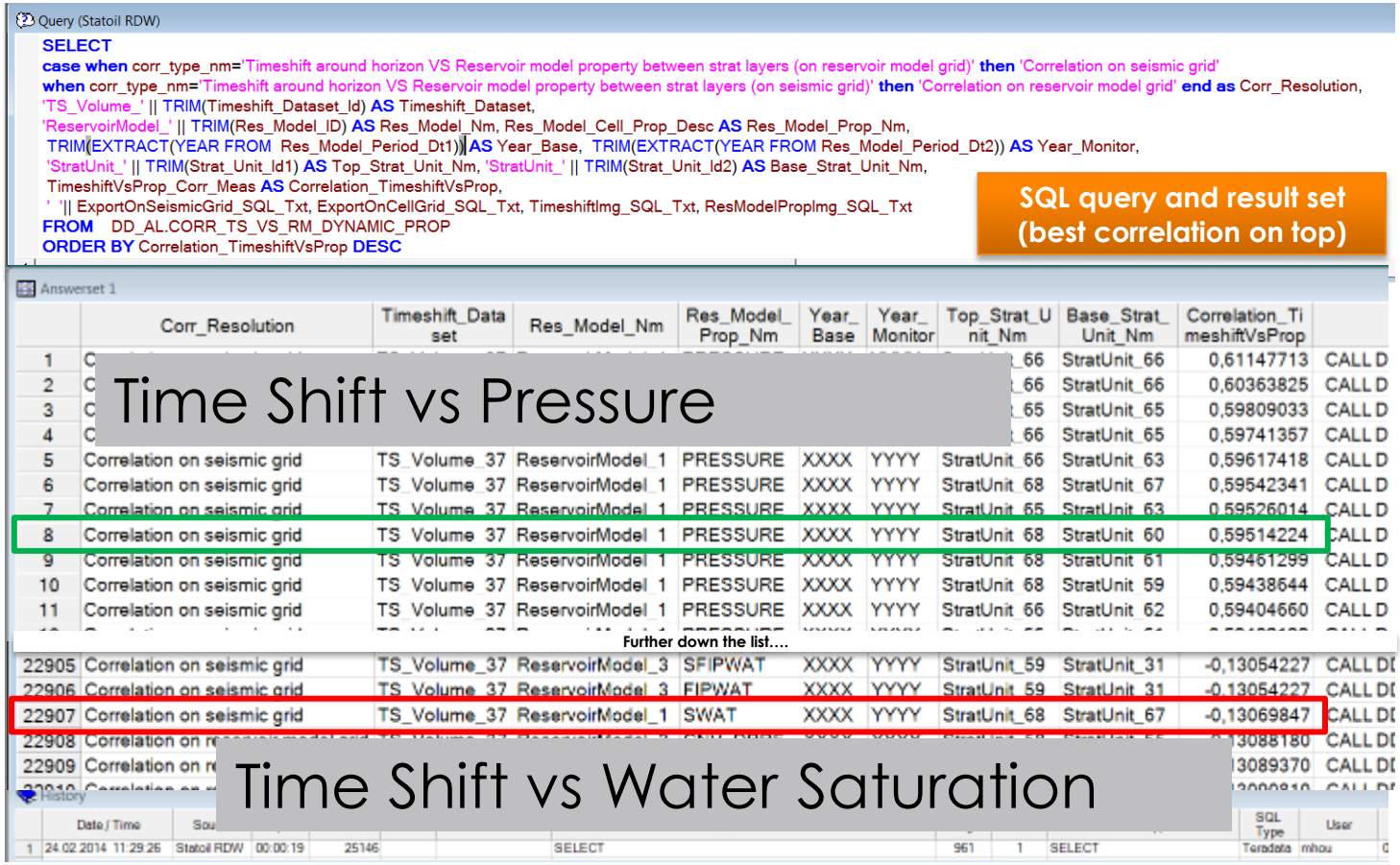


Repeatability (NRMS)

Time shift

Pressure difference

Example 2: Subsurface Analytics



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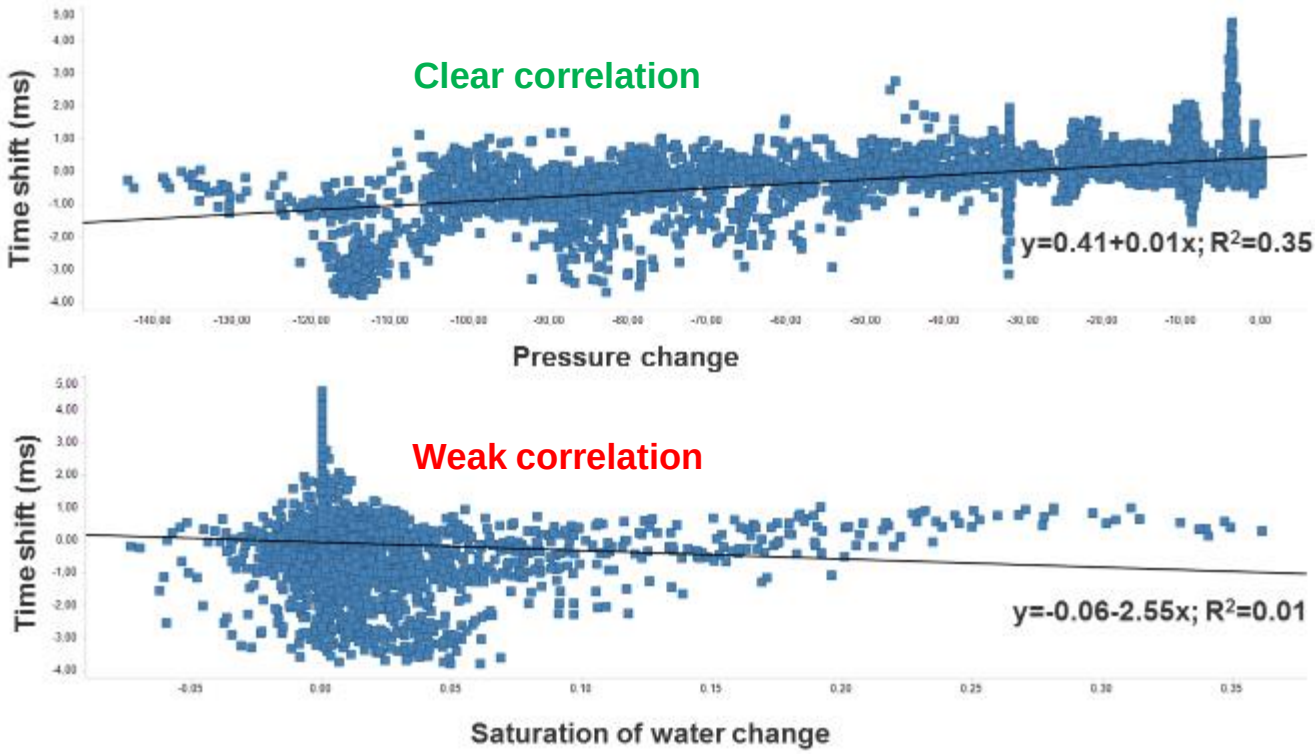
Example 2: Subsurface Analytics



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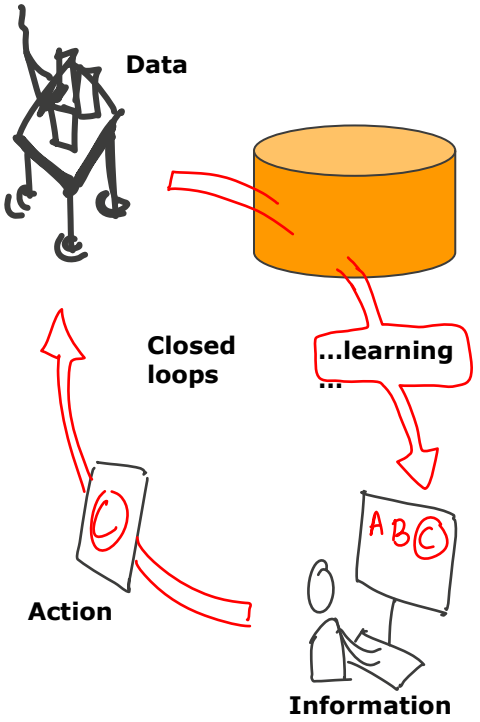
What we learned

- ✓ Yes, you can put detailed subsurface data into a relational database and do analytics
  - If you use a High Performance Analytical Database
  - If you **model** and integrate the data in time, space and logical relationships

- ✓ Yes, new analytical workflows can change how we do business

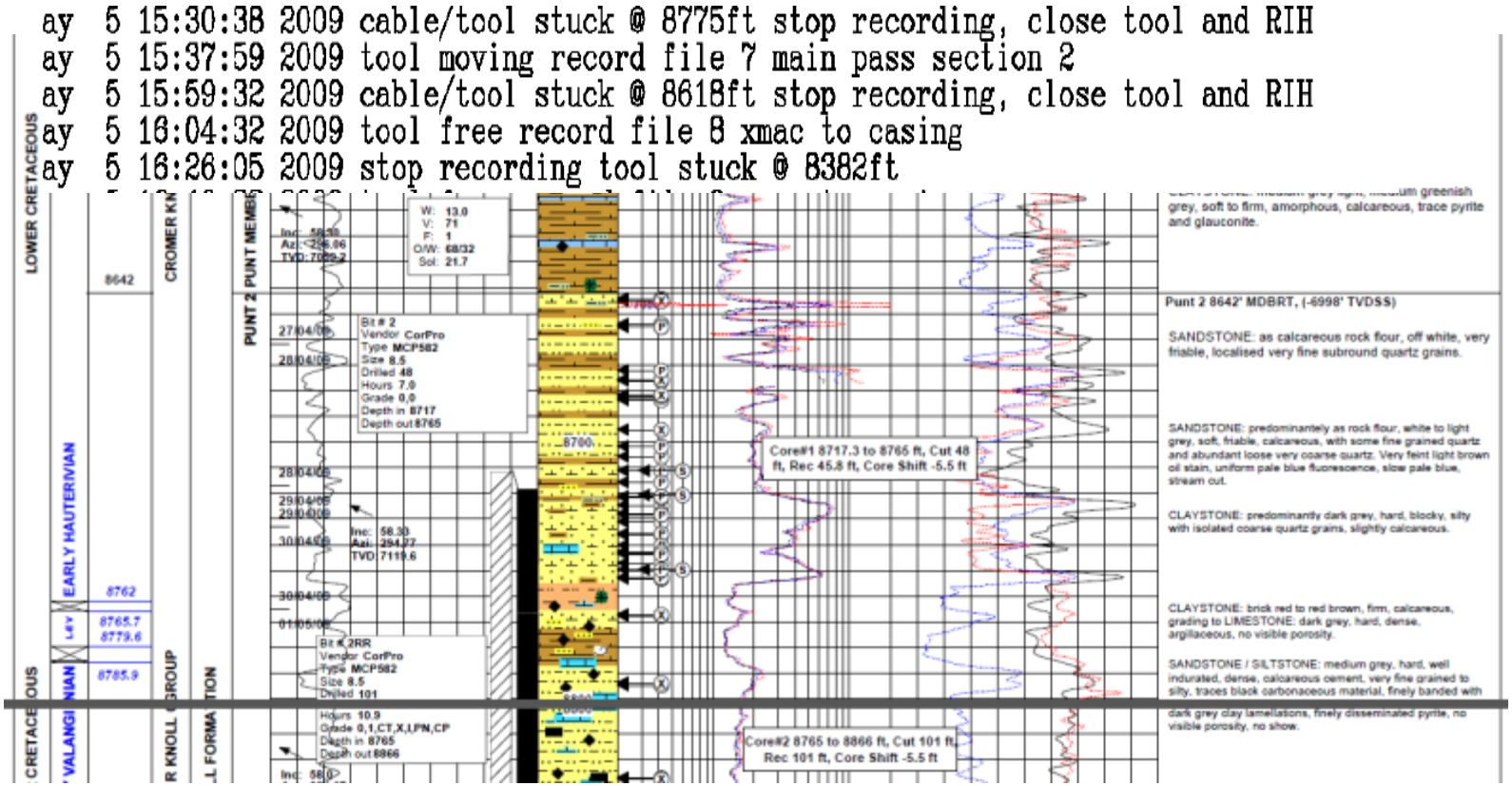


Drilling Effectiveness Case Study

Drilling Efficiency/Safety

- Stuck Pipe = NPT = cost
- Why stuck?
  - Geology (link) e.g. swelling shales
  - Rock properties e.g. weak rocks
  - Deviation/deviated wells
  - Bit type
  - Mud type WBM vs OBM
  - Other
- If we can analyse the conditions causing stuck pipe we can reduce the risk/cost
- Pilot for Big Data Analytics partnership between Teradata and CGG

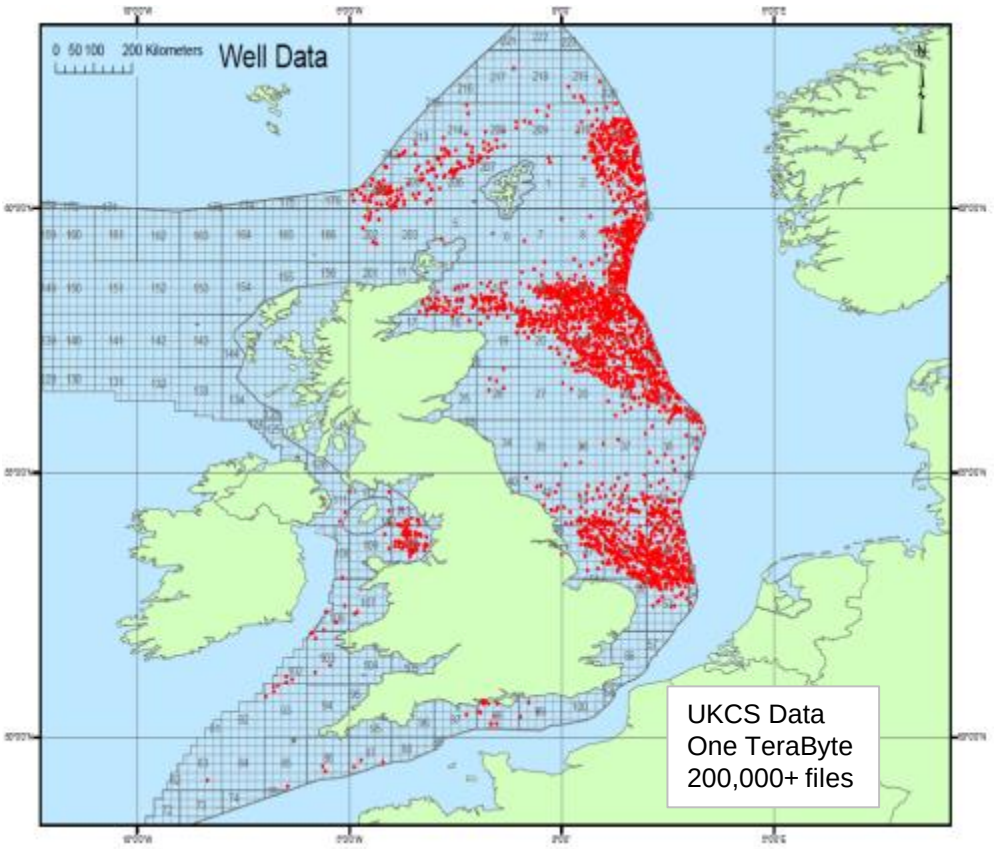
Bad Hole Example – Single Well



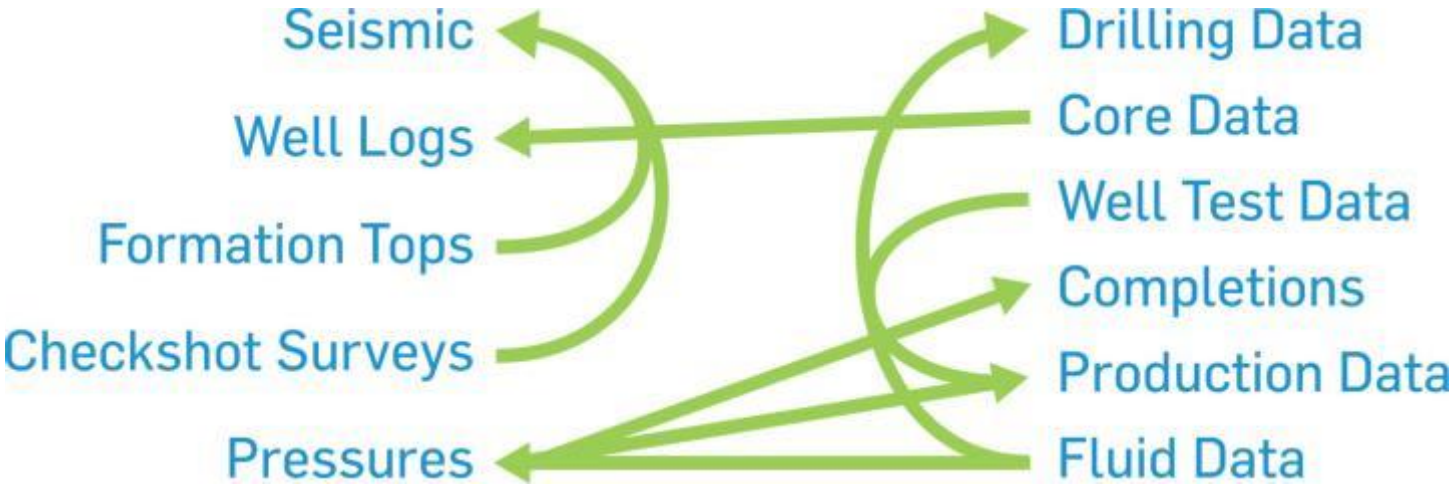
The completion log gives no clues to the problems encountered.

Data Quantity

- It is widely recognised that data quantities have ballooned and continue to do so :
- O&G Data is:
  - Seismic
  - Well logs
  - Formations tops
  - Checkshot surveys
  - Pressures
  - Drilling data
  - Core data
  - Well test data
  - Completions
  - Production data
  - Fluid data

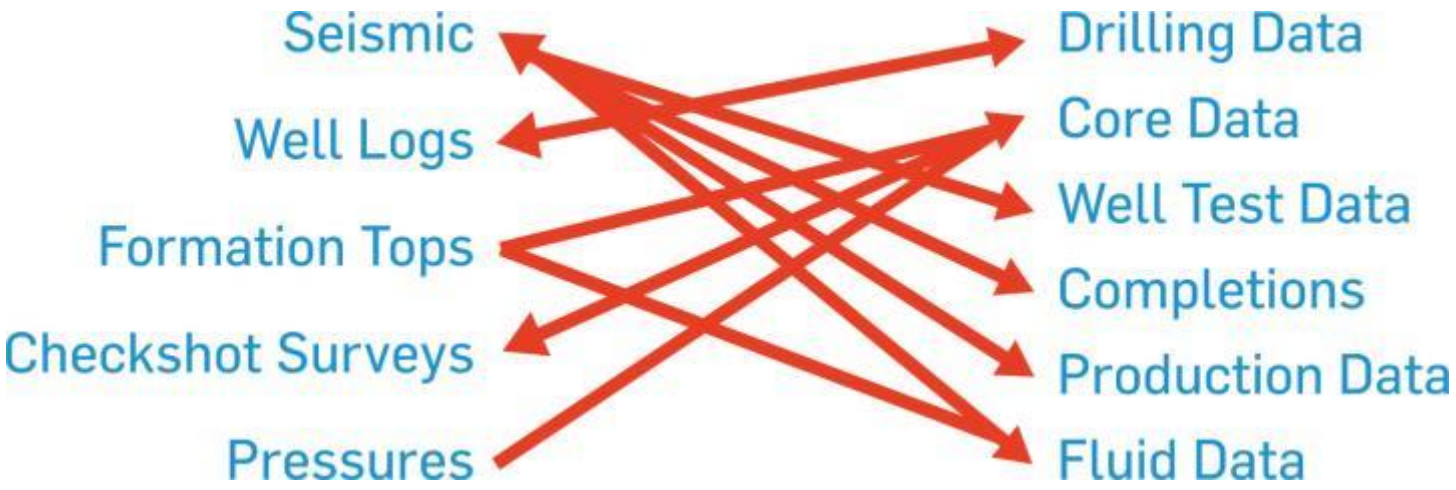


Data Links



A lot of these connections are routine, check shots and seismic, fluids and pressures. Some of this data is used in combination in reservoir studies, seismic, well logs, formation tops, pressures, fluids, core data. However these are single instances, single wells or a field study.

Data Not Linked



- A lot of data types are not-linked or only linked occasionally. Why?
- Are all links equal or are some ridiculous?

- Sometimes new techniques are found by linking diverse data types for example

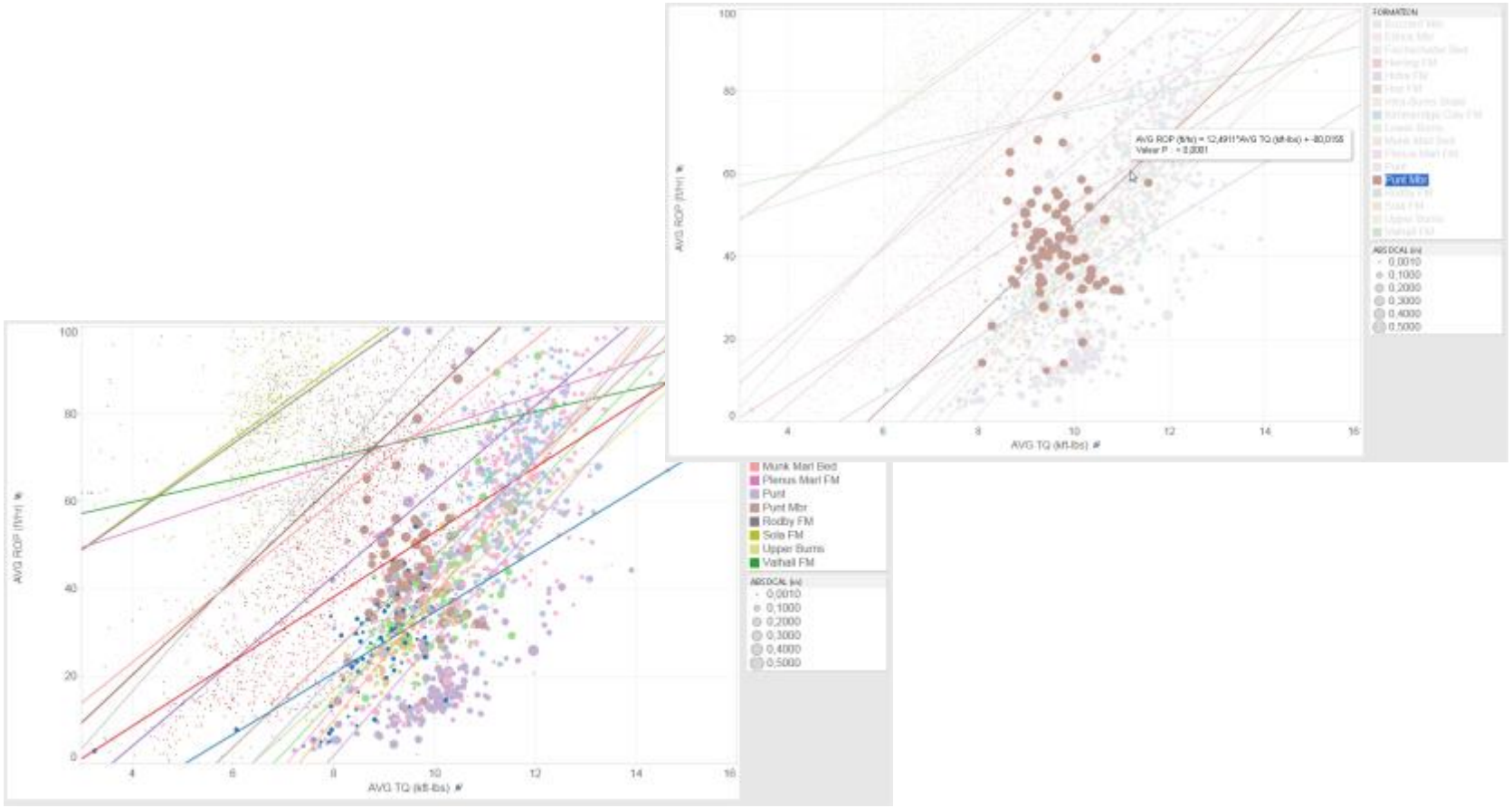
  - Seismic to Fluids is AVO

  - Seismic to pressures is overpressured zones

Data Visualisation Multi Well

- Visualisation of a number of parameters simultaneously.

Data Analysis



Analysis of the data gives correlations and probabilities.

Drilling NPT Case Study: integrating geomechanics and engineering data

More efficient development drilling

Fewer bit failures | Fewer Trips |Reduced Opex

Goal: consistently drill horizontal section in a single trip in hard formations

As-is: "It's just hard formation – that's the way it is". Unpredictable and repeated failures occur. Some single-trip sections achieved, but success/failure criteria not understood.

To-be: find combinations of a wide range of drilling parameters likely to avoid bit failure and model alarms to ensue efficient drilling insights.

How? look for patterns to that will inform better operational decisions: increase drilling efficiency to avoid catastrophic bit damage

What data was used?

Source data sets and derived properties

- surface and downhole drilling data
  - MWD/LWD time series
  - Logging notes
- metadata relating to well and drill string configuration
  - Wellview schema
  - CSD
- bit damage severity and profile
  - Synthetic scoring from IADC codes
- well position and trajectory
  - LAS, DLS and x,y,z trajectories
- petrophysical information
  - Formation strength, density, elastic moduli
- Operations data
  - Project logging (time allocations and costing) from ERP

BIT DAMAGE TO ROCK HARDNESS

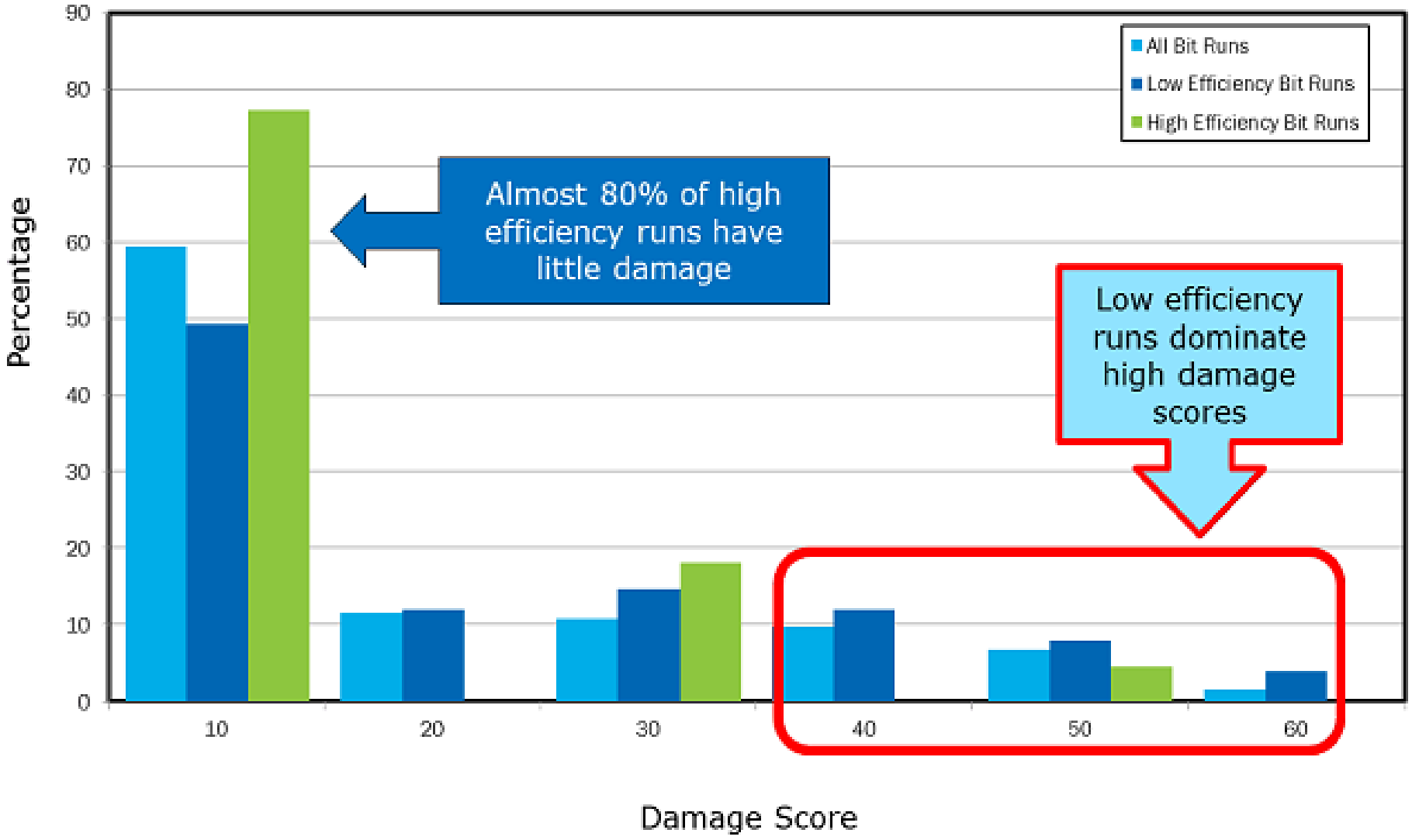
Chesapeake ENERGY

- Calculating both a Bit Damage Score and Rock Hardness allows us to compare them looking for insights.
  - > Example, compare bit damage score to 'total rock hardness' of the bit run

propno	bitrun	damage_score	total_rock_hardness
649954	9	60	204
646195	5	60	339.6
648407	7	52.5	763
649954	5	50	120
649954	6	50	56
649556	4	50	490.8
649026	5	50	442.4
645305	5	50	240
645305	4	50	140
651595	6	48.75	580
647070	7	45	108
647070	8	45	216
649947	5	45	354
645986	7	45	104
642068	4	45	358

Some high bit damage scores are with low rock hardness scores

BIT DAMAGE SCORES AND EFFICIENCY



EVENT CORRELATIONS TO BIT DAMAGE SCORE

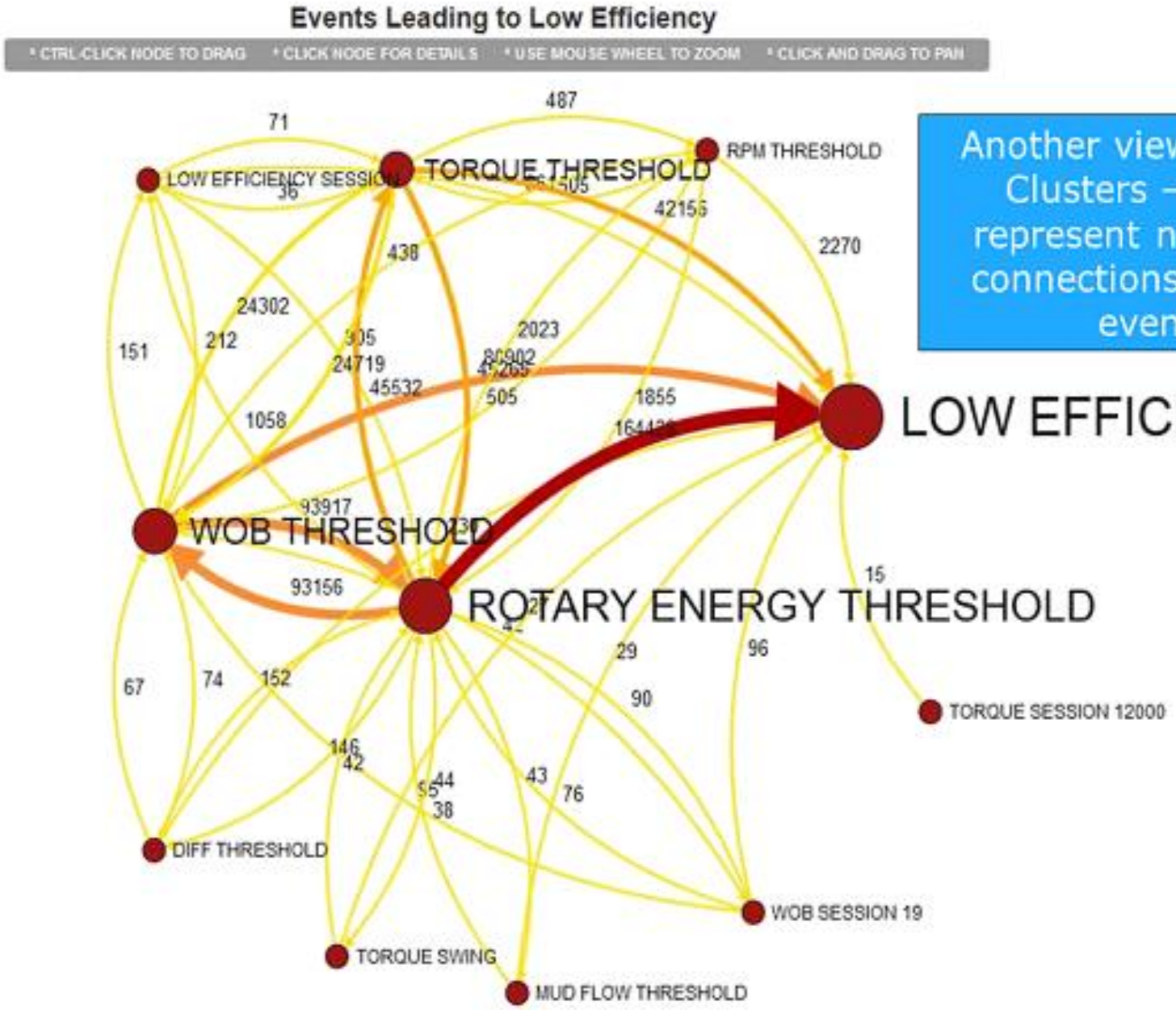
Bit Damage Score <= 25		Bit Damage Score > 25		Bit Damage Score > 45	
corr	value	corr	value	corr	value
damage_score:efficiency_session	11.373	damage_score:efficiency_session	31.297	damage_score:wob	68.101
damage_score:rpm_session_80	8.174	damage_score:rotary_energy	31.258	damage_score:efficiency_session	51.892
damage_score:weight_energy	7.406	damage_score:efficiency	31.134	damage_score:efficiency	51.684
damage_score:rpm	6.087	damage_score:total_energy_mjoules	24.537	damage_score:torque	50.357
damage_score:weight_swing	2.879	damage_score:drilling_seconds	22.216	damage_score:total_energy_mjoules	41.908
damage_score:rotary_energy	2.731	damage_score:diff_session_1000	20.35	damage_score:wob_session_40	37.137
damage_score:torque_[illegible]_17000	1.551	damage_score:torque	15.45	damage_score:rotary_energy	32.824
		damage_score:wob	15.192	damage_score:drilling_seconds	25.903
		damage_score:wob_session_19	13.857	damage_score:wob_session_19	21.655
		damage_score:torque_session_12000	11.357	damage_score:torque_session_12000	17.17
		damage_score:torque_session_15000	11.357	damage_score:torque_session_15000	17.17
		damage_score:mud_flow	9.151		
		damage_score:torque_session_17000	8.09		
		damage_score:wob_session_40	7.526		
		damage_score:rpm	6.489		
		damage_score:total_rock_strength	4.557		
		damage_score:rpm_session_80	4.514		
		damage_score:wob_80_seconds	2.863		

Energy efficiency is a leading factor to bit damage

Total rock strength as a factor is almost zero

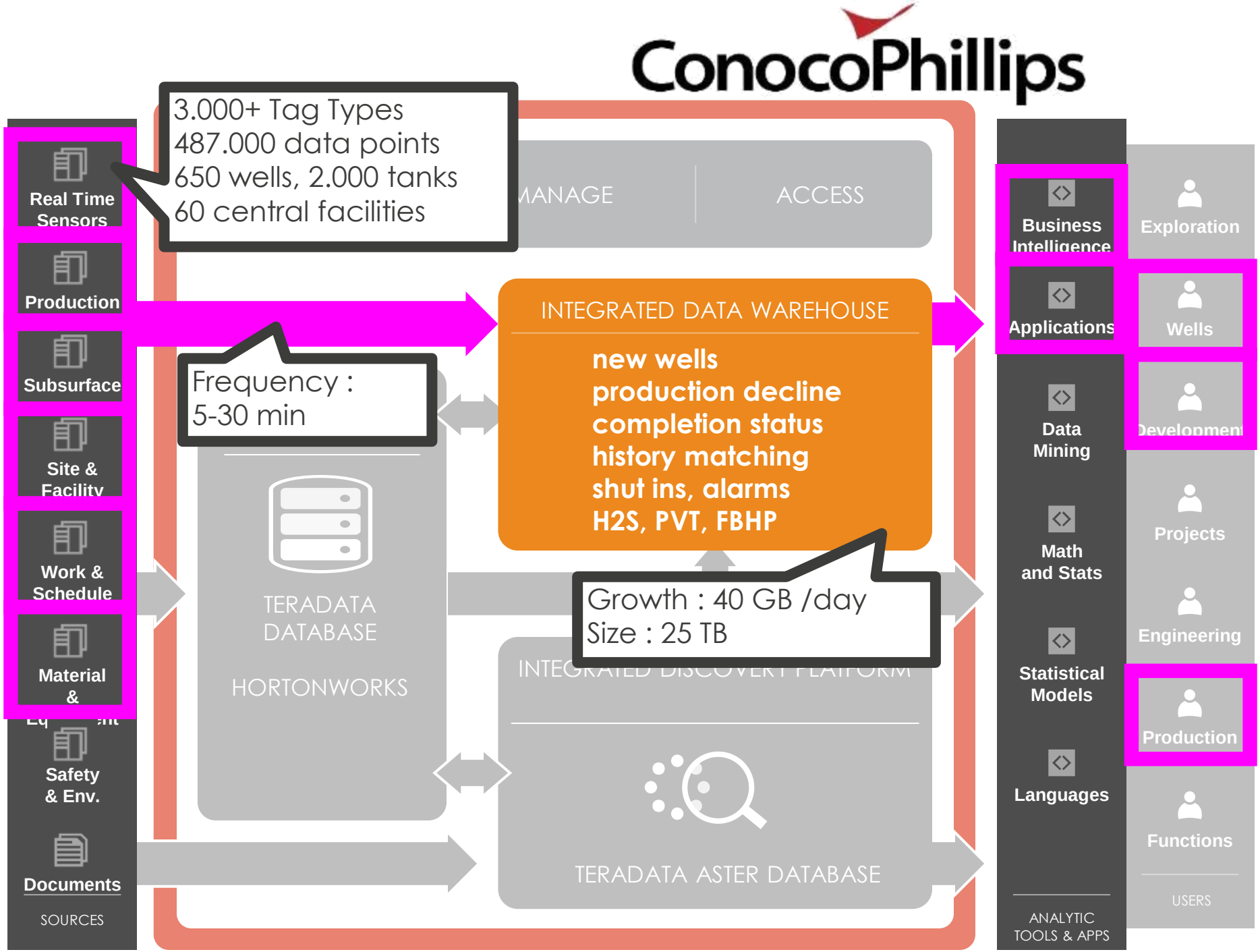
TREE DIAGRAM SHOWING DOMINANT PATHS

EVENTS LEADING TO LOW EFFICIENCY

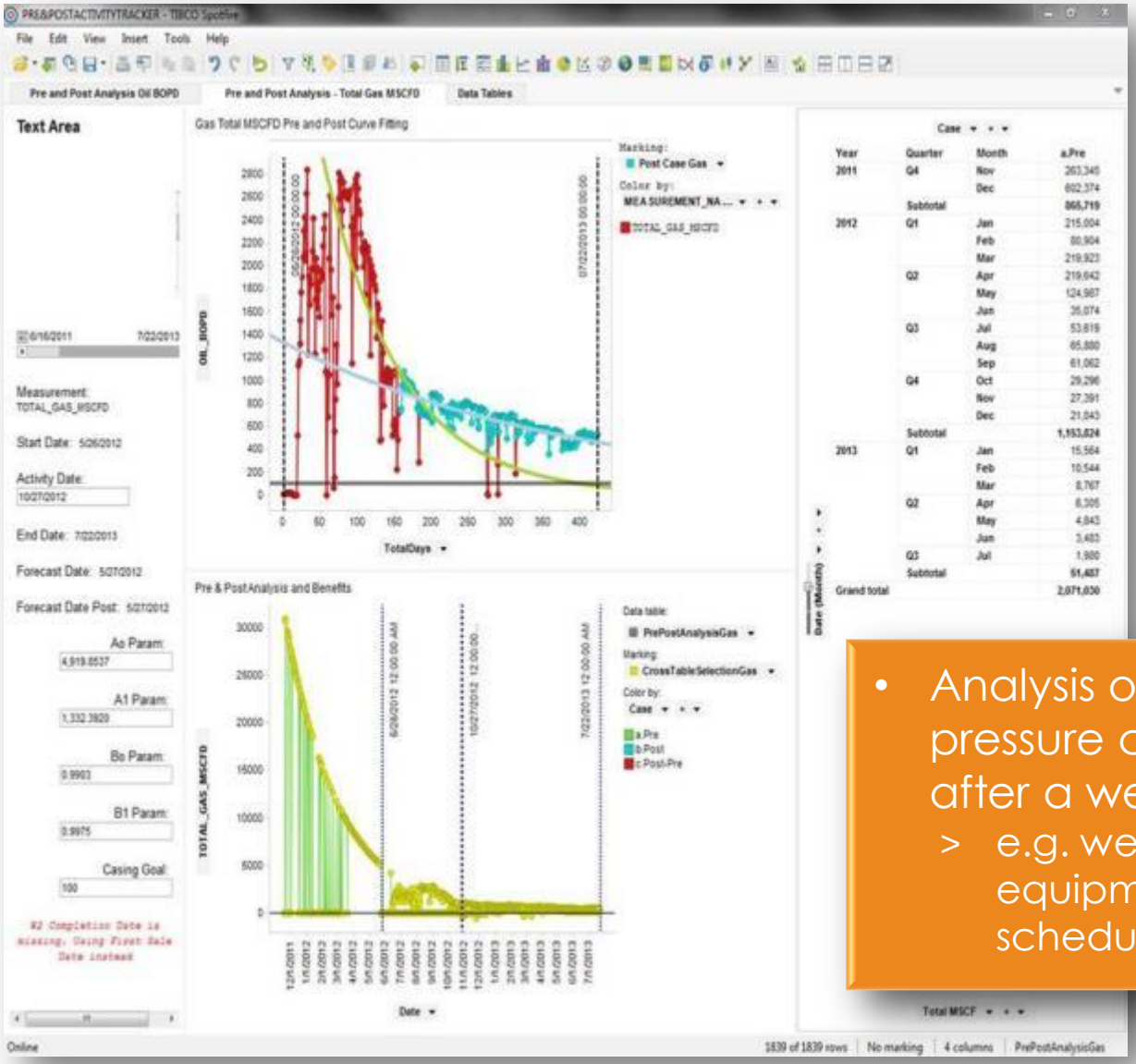


Another view of Event Clusters – values represent number of connections between events

Putting insights into operation: integrating across all the domains


ConocoPhillips
3.000+ Tag Types
487.000 data points
650 wells, 2.000 tanks
60 central facilities
Real Time Sensors
Production
Subsurface
Site & Facility
Work & Schedule
Material &
Safety & Env.
Documents
SOURCES
MANAGE
ACCESS
Frequency : 5-30 min
INTEGRATED DATA WAREHOUSE
new wells
production decline
completion status
history matching
shut ins, alarms
H2S, PVT, FBHP
TERADATA DATABASE
HORTONWORKS
Growth : 40 GB /day
Size : 25 TB
INTEGRATED DISCOVERY PLATFORM
TERADATA ASTER DATABASE
Business Intelligence
Applications
Data Mining
Math and Stats
Statistical Models
Languages
ANALYTIC TOOLS & APPS
Exploration
Wells
Development
Projects
Engineering
Production
Functions
USERS

Pre/Post Activity Tracker



- Analysis of production and pressure curves prior to and after a well event
  - e.g. well stimulation, equipment modification, scheduled maintenance, etc.

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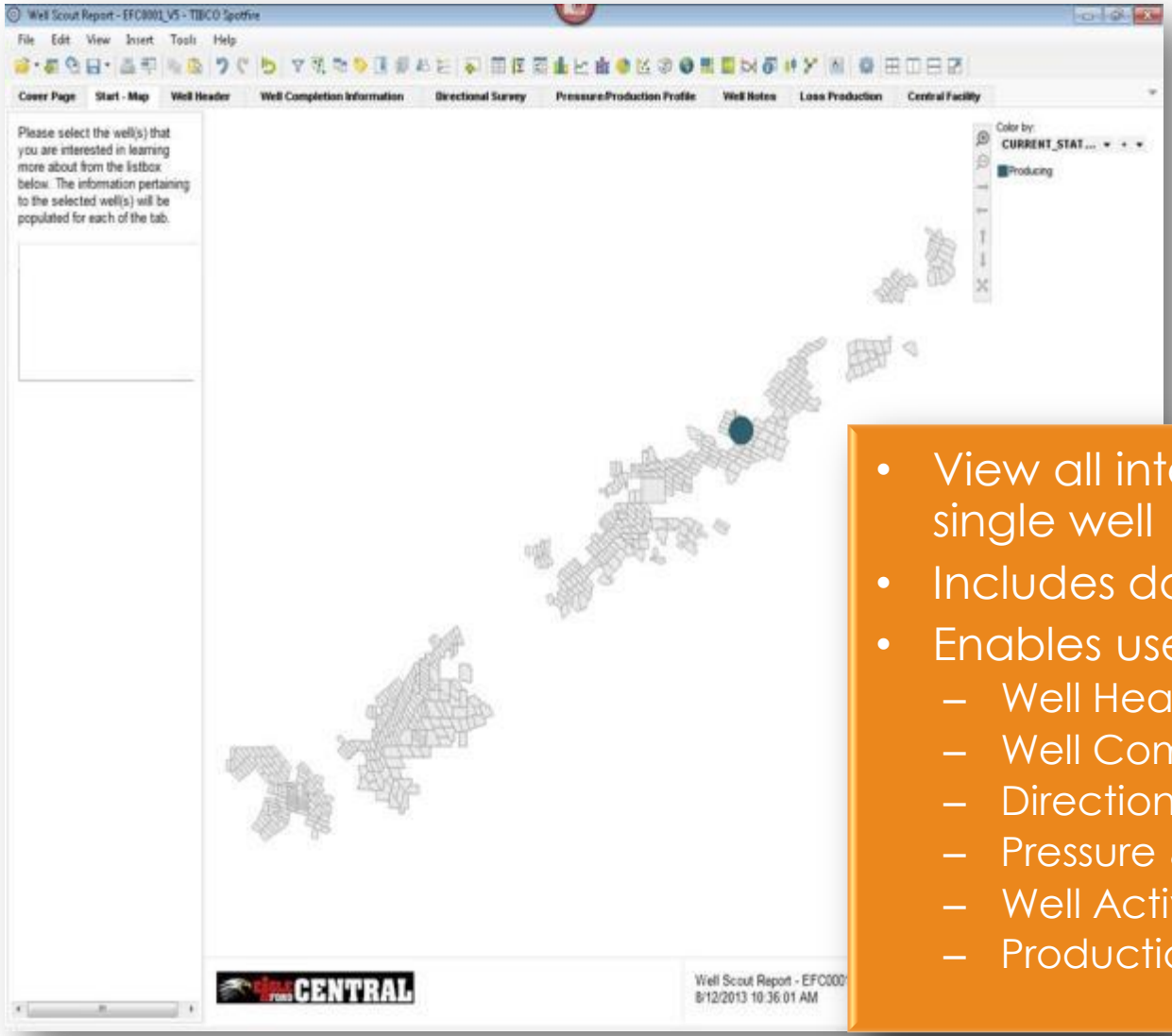
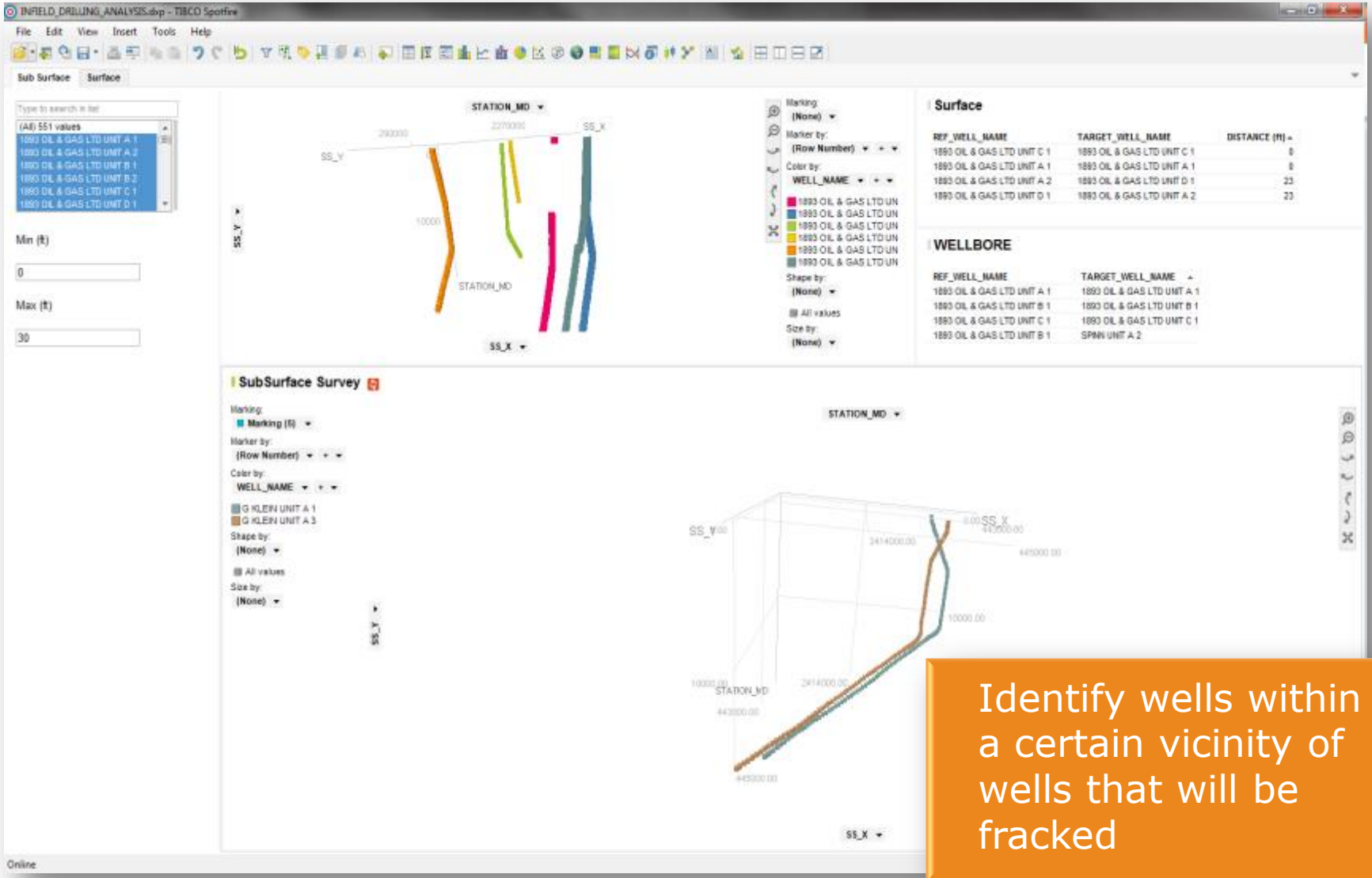
Well Scout Analysis



- View all integrated data for a single well
- Includes data from all sources
- Enables users to view
  - Well Header
  - Well Completion
  - Directional Survey
  - Pressure & Production Profiles
  - Well Activity Notes
  - Production Losses & Reasons

Infill Drilling Analysis



Identify wells within a certain vicinity of wells that will be fracked

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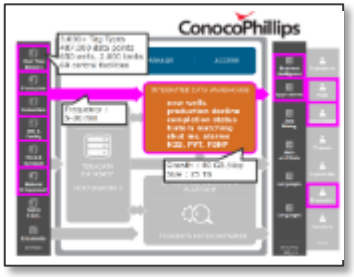


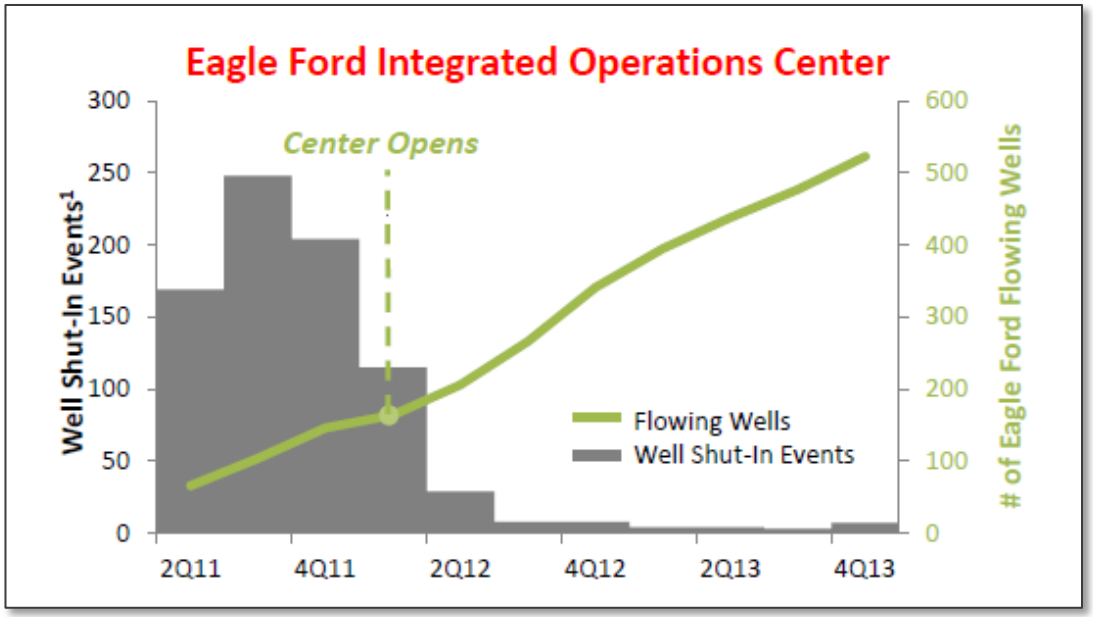
ConocoPhillips

Value

- 6.600 BOE/d production increase (5%)
- Unnecessary downtime avoided
- Increase reliability of downhole equip.

Enablers

- Identified optimal well spacing
- Near real time intervention & adjustment
- Accelerated improvement in reservoir management



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