AADE-20-FTCE-032

A Data Analytics Platform Dedicated to Drilling Fluids

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Abstract

Data analytics has become a common discipline in the industry with potential to revolutionize drilling efficiency. Data analytics primarily utilizes upon growing volumes of sensor data and reports, which capture only general information associated with critical fluid performance factors. A new, fluids-dedicated data analytics platform has been designed to address factors that general platforms fail to capture, such as the means of delivering these performance factors at the lowest possible cost.

A drilling fluid specialist can quickly characterize the limits of the basic fluid properties and generic cost information utilized in broad analytics offerings. To maximize drilling fluid performance, a data analytics platform requires tracking fluid properties in much greater detail. This information also requires knowledgeable interpretation to correlate fluid events and drilling events in the same analysis.

Using visual dashboards, service providers and customers can compare performance between wells, rigs, and entire drilling campaigns. Technical specialists can easily identify offset wells and modify the drilling fluid programs to mitigate newly identified risks. Customers can review their well data to review trends in consumption, losses, and other key performance indicators.

This paper will review the data analytics platform and the challenges through a discussion of the implementation process. Lessons learned regarding visualization, communication, and data access will be reviewed along with their resolution. The authors will review the current offering and the anticipated future of data analytics for the drilling fluids discipline.

Introduction

Throughout the oilfield, there are numerous initiatives highlighting the potential of "big data" to transform our industry. A GE/Accenture report shows that 81% of senior executives consider big data analytics a top priority (Mehta 2016). However, the applications and impacts of "big data" are very broad; opportunities range from basic efficiency improvements to complex neural network systems.

Larger and enhanced data sets, particularly from sensors and the Internet (Mills 2018), along with greater computing power, continue to alter the way in which data contributes to drilling operation decisions. The sheer volume of data collection usually means much of the data gathered remains in storage until someone identifies a use. New data tools facilitate manipulation of these large data volumes and create the potential to gather even more data.

There is confusion between the topics of data analytics, machine learning, and artificial intelligence. Robinson (2018) offers that while there is some overlap, it's possible to break down each topic by type of contribution as shown in **Figure 1**.

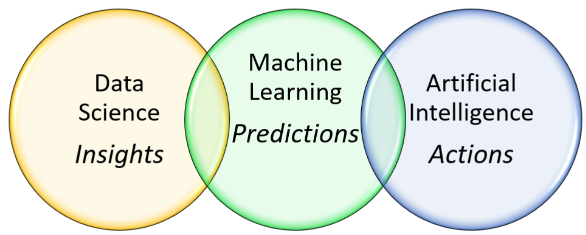

Figure 1: Comparison between *data science*, *machine learning*, and *artificial intelligence*

The role of a data scientist is similar to the role of a statistician, who traditionally performs analysis on large data sets to gain insight to complex problems (Press 2018). As computing technology and software platforms improve, data analytics is transforming into a widely accepted discipline.

A key to effective data analysis is a close relationship between the data scientist and a domain expert – preferably, they are the same person or have overlapping knowledge (Gefferie 2018). An effective data analytics platform for drilling fluid data cannot exist without domain experts who understand the subtle nuances of drilling fluids. Some fluid knowledge, such as optimal fluid properties for hole-cleaning and pump pressure have been easy to model for years. Sensor data aids to validate downhole conditions, but there is little mystery to the ideal rheological profile for best performance. There is potential for incremental enhancement but it is unlikely the fundamentals will change without data analytics.

A daily mud report features critical mud properties reported once or twice daily. This information is somewhat limited in utility due to its lack of resolution. While automated mud check equipment continues to advance, it is far from displacing what is in reality a minor task in the overall role of a drilling fluids specialist (Taugbøl et al. 2019). In all likelihood, this instrumentation will not have a transformative impact until it is part of reliable fully-automated systems (Smith et al. 2010).

The authors believe that the greatest impacts for drilling fluid data analytics exist in delivering target properties and optimizing well planning to mitigate risks. In the same way that data might reveal drill bit data merits further investigation leading to uniquely better performance, the properties of the drilling fluid merit further investigation to identify the traits that deliver better performance. It is these areas where a dedicated, expert-based suite of data analytics tools provides the greatest impact.

Data Sets

Insightful data analytics requires that the data is useful, representative, and correct (Gefferie 2018; Mehta 2016). The data requires consistent formatting and structure, regardless of its source. In some cases, this can require managing a stream of historical data, referred to as "data at rest", and real-time data, known as "data in motion" (Thambynayagam 2019).

The initial scope of the data analytics platform for drilling fluids focused on historical data. Portions of older data sets did not contain consistent structure due to different data collection methods or an unanticipated need for currently collected data. Fortunately, most of the data featured consistent structure throughout its history and did not require any form of conversion. The existing structure of these historical data sets was already used for case-by-case queries and manual compilation of the information was possible.

Database queries typically required the few individuals with access rights and programming knowledge to perform the search and transfer the information in an unformatted spreadsheet. From there, the user reviewed the data and transferred it into their own presentable format.

This method was time-consuming, limiting the number and scope of answerable questions within reasonable timeframes. Visualizations varied by the skillset of the user and any updates required a repeat of the process to provide time-sensitive answers to a customer. It also eliminated any collective benefit to be gained by other users of the same information.

Data Analytics Platform

Data analytics continues to evolve – so do the available software tools and hardware to process information. The historical method utilized by the organization is no different from most aging approaches at data analysis.

The new drilling fluids data platform leverages advances in communications, data security, and customizable interface design to offer a rapid overview of information available from a variety of communication devices.

New Platform Scope

The potential of big data – be it data science, machine learning, or artificial intelligence – creates a substantial challenge in determining the appropriate scope. "Scope creep", a well-known problem with software initiatives, is a concern because with big data so many things are possible. Attempting to adopt and change too many features at once can result in project failure so a clearly defined objective is critical. (Ockree et al. 2018; Rogati 2017)

For the initial release of the platform in this case study, critical features were identified based upon historical queries. Most queries originated from performance benchmarking requests from internal and external customers. These metrics were consistent in nature – product consumption, losses, and cost were common areas of interest. Most indicators overlapped across operators or were mathematical functions of one another.

The launch target was set to deliver those key features, but if new promising ideas came up in the development process, they were documented and set aside as future opportunities. This assisted to maintain the project within the design scope, thus avoiding problems which many experts cite: poor commitment to the scope and shifting objectives leading to delays and ultimate failure (Ockree et al. 2018; Rogati 2017).

Data Sourcing and Harmonization

Because of the focus solely on customer key performance indicators, it was possible to source all of the data from a single reporting database. Future features may require cross-platform communication and further complexity.

The database centralizes the company's proprietary reporting system, known as the Rig File. The Rig File provides typical drilling fluid reporting information, including mud checks, volume accounting, product inventory, and cost tracking.

The Rig File updates with the central server multiple times daily to capture the latest information. At the end of the well, final reconciliation closes the file for that specific well (**Figure 2**). The data has a consistent structure and quality control features; new features (data points) can result in null data points for legacy files that pre-date the introduction of this platform.

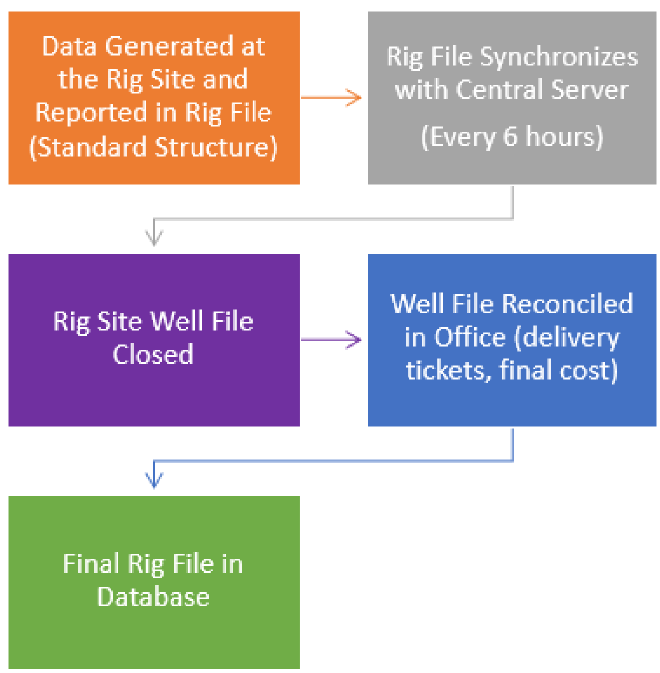

Figure 2: Data storage and synchronization

Quality Control

Data quality is critical for reliable information and a system laden with errors eliminates user confidence to use the platform. Prior to any customer-facing deployment, the original well files required extensive review for errors that could compromise data quality.

Historically, field personnel could inadvertently leave seemingly inconsequential data out when closing out a well and this could go unnoticed until data analytics visualizations demonstrated missing information.

The strategy for historical data review led to the decision to limit historical data to two years or less for introductory work and to deploy the information on a customer-by-customer basis. This way each account manager could verify the data sets and correct any issues given their firsthand knowledge of events. Managers and those with oversight roles have the ability to view data across regions and reassign access as needed.

Most errors were simply entry issues requiring minimal intervention. The historical data set was expanded beyond the original time horizon after the initial rollout of the data analytics platform. The greatest impact for error control was simply increasing direct accountability. Initial reporting corrections were assigned to those entering erroneous data, resulting in improved discipline. Additional oversight is enhanced because the data is easier to review in the platform dashboards.

Design Considerations

The new data analytics platform for drilling fluids provides quick access to a wide variety of information. There were a number of design considerations requiring careful attention beyond preparing data visualizations.

Security and Access Control

Data security is an essential component to any data analytics offering. The outside party that provides the supporting structure for the platform manages data security and assists with access control. This insures that professional, industry standard methods are utilized and remain current.

When data becomes dramatically easy to access and view, its inherent value changes. New questions arise about who should be able to access the information and to what level of detail. Prior to launch, the data science team reviewed job requirements relative to access levels. The permission structure was approved by management and development continued.

Customers have access to their own data sets and their account managers can see the accounts for which they are responsible. At higher levels, users can compare information across the data sets that they have inherent rights to view.

Any new feature requires a review of who will use the data and consideration of any added risk. Where necessary, control measures are implemented.

User Base

The initial design tracks multiple benchmarks that both customers and account managers rely upon to measure performance. Separate dashboards are used for quality control and audience needs. For example, if appears, the account manager dashboard flags this information quickly so it can be corrected before reaching the customer dashboard. In most cases, erroneous data is clearly apparent as it dramatically varies relative to the flow of graphs and other visuals in the data sets.

Visual Features and Utility

While internal personnel receive regular training, external personnel may have different background and comfort levels. A training module was prepared within the platform to maximize user engagement with all of the different functions.

Visually, data sets must be clear and concise to have value. This is particularly challenging when the volume of data is unknown. A line graph of properties across 1-2 wells appears extremely sparse compared to 5-6 wells, while 15 wells may appear illegible.

The interactive nature of the design allows the use to isolate a point of interest by clicking on it. In many menus, additional details appear with another click. A slide of the mouse over a point of interest provides a specific value (**Figures 3, 4, and 5**). This simplified engagement with the data makes it considerably more useful than tracking through separate menus to find detail.

Data categories are broken down across dashboards. For example, one dashboard covers the aspects of product consumption, including cost by product and usage by product category. A loss dashboard separates losses by mud lost on cuttings versus other loss categories. Additional details can be revealed by sliding the mouse to “drill down” into the raw data.

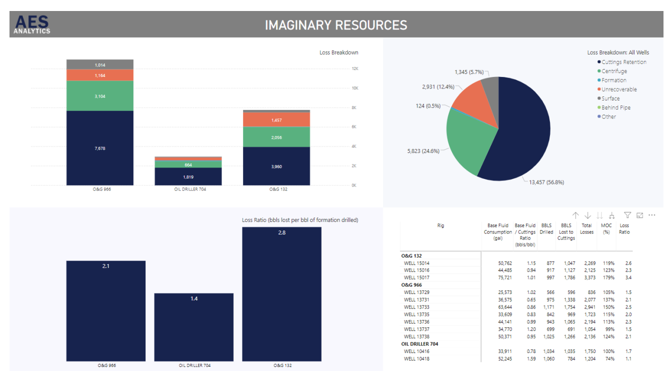

Figure 3: Analysis of losses across 12 wells drilled by 3 rigs

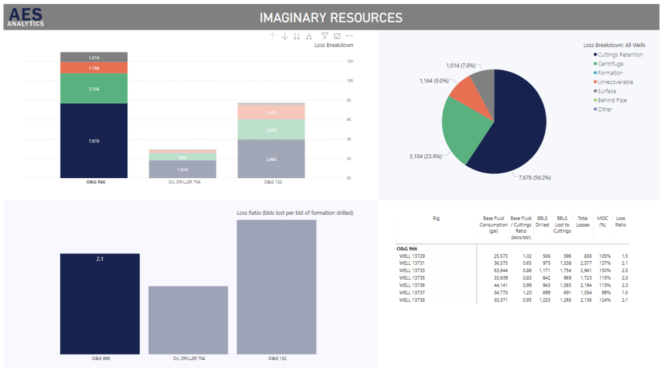

Figure 4: Click to isolate loss categories on one rig (slide mouse for raw data)

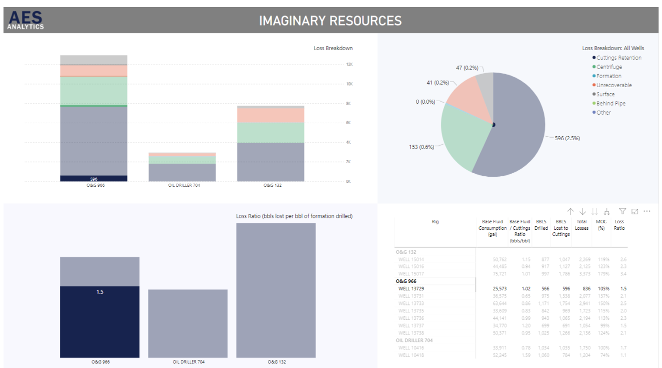

Figure 5: Click to review data on a single well (slide mouse for raw data)

The level of detail available goes into the details of economic well delivery. For example, efficient hole-cleaning properties are evident from hydraulic data and minimal days on an interval. This is important, but from a drilling fluid cost perspective, the most efficient way to achieve these properties is the next step in cost reduction.

Customization

New features continue to enhance the user experience. Customization can occur at an individual user level or across several users. In many cases, new features benefit the entire user base and become globally available within the platform. The best features to date are responses to real problems from the domain experts.

Well Planning Optimization

Historical data and experience are key to preparing for upcoming wells, particularly when the service provider has experience where the operator does not. While new data tools may substitute for some of this experience, delivery and interpretation still requires domain expertise to capture the most efficient practices.

A special offset mapping tool (**Figure 6**) aids to identify nearby wells and the associated challenges or properties. Filters narrow to target formation and depth, which is particularly useful in areas with stacked reservoirs.

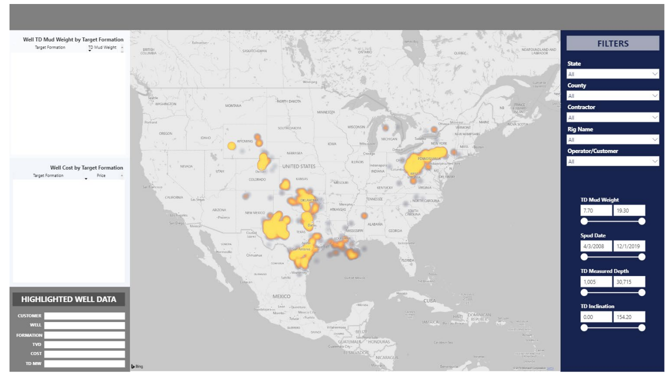

Figure 6: Offset mapping tool dashboard

Field Introduction and Observations

The data analytics platform for drilling fluids was introduced on a case-by-case basis internally and externally. The design team prepared training to explain the opportunities and risks of the new tool. Special emphasis was placed on reliable reporting and accountability. The risk of inaccurate data was managed by performing tasks manually alongside the new platform to verify data sources were producing the expected information.

As with any software release, a number of bugs immediately appeared, requiring attention before offering customers access. Customer by customer, the data analytics form was presented and adopted.

While the offering of customer access is attractive, most customers request the data from their account manager. The information is available with little to no delay in most cases, providing rapid turnaround for decision-making.

One evening, the drilling fluids specialist called as the rigsite drilling consultant wanted to add hundreds of gallons of extra wetting agent beyond the programmed amount. Using the data analytics platform, the account manager was able to demonstrate that current product consumption was in line with historical wells, saving thousands of dollars in unnecessary product additions.

Since the platform is mobile-friendly, an account manager can provide information during a meeting. In one instance, the customer requested barite cost as a percentage of the overall mud bill to aid with barite recovery economics. The account manager already had this information from the data analytics platform, pulled it up on his mobile device, and no second meeting was required.

Future Improvements

The established framework for data management allows for rapid deployment of new features. Many features result from user requests and become available as a unique option for a specific need or globally available when the concept benefits the entire user base.

Probabilistic Modeling

New features focus on probabilistic modeling and performance evaluation. Probabilistic modeling will aid in identifying the necessity and value of risk mitigation. For example, if offset data reveals a high probability (expressed as a percentage) of losses for an upcoming well, the customer can determine the cost and benefit of preventative treatments, such as wellbore strengthening, relative to the risk and cost of losses while drilling without the mitigating action.

Peer Benchmarking

Performance evaluation features will aid to identify relative performance based upon key benchmarks against the industry. In many review meetings, operators request comparisons between well-to-well performance, seeking to continually lower cost trends. While continued improvement is part of any operation, this strategy leaves the door open to remain worst-in-class relative to one's peers, especially if the operator wants to always use only previously tried techniques. Performance evaluation tools seek to set expectations for signature performance. From there, the current technical limits are challenged as true limiting elements are identified and addressed.

Machine Learning and Artificial Intelligence

The data structure and analytical tools set a foundation for future developments in machine learning and artificial intelligence. **Figure 7**, highlights a number of new opportunities advancing into machine learning and artificial intelligence as well as growing the base of the pyramid with more data (Rogati 2017).

More and more machine learning and artificial intelligence tools are available in an accessible form – as long as the domain expertise is there to apply the information correctly.

Machine learning may help predict costs and product consumption. Artificial intelligence can aid to automatically address input errors and prepare drilling fluid programs with the most cost-effective fluid systems, maintenance plans, and risk-mitigation techniques.

It is early, but new opportunities are under consideration as the data analytics platform for drilling fluids continues to answer more and more complex questions.

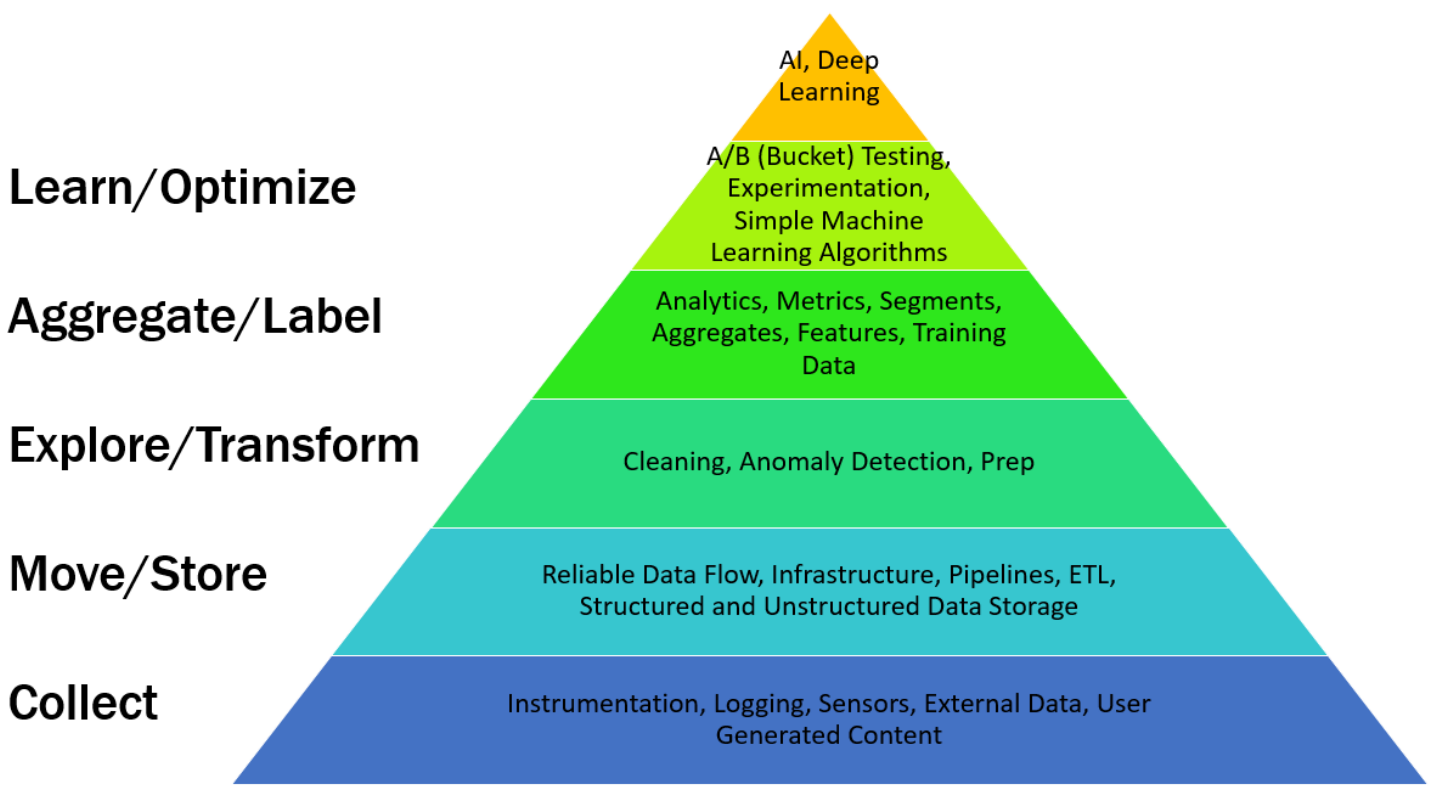

Figure 7 – The data science hierarchy of needs as characterized by Rogati (2017). The authors believe that the future of the data analytics platform includes both reaching the top levels of the pyramid (machine learning and AI) while also expanding the base with more comprehensive data sets.

Conclusions

Data analytics and associated technologies to process information will continue to transform the oil and gas industry. In many cases, changes will be incremental improvements in efficiency, while in others, dramatic shifts will alter long-held practices. The process of establishing a data analytics platform has led to a number of observations:

- Sophisticated measurement devices are capable of identifying fluid properties for best performance; however, they do not provide insight into the most efficient means to achieve these properties. Data analytics is capable of this.
- A defined scope and limited data set facilitates initial deployment of a data analytics platform.
- Data sets require rigorous quality control for efficient analysis. Older information may require modification or re-structuring to avoid misrepresentation.
- Data security spans across internal and external controls. Ease of access to information helps to make decisions, but also exposes vulnerabilities.
- Enhanced data visualization allows for straightforward analysis of large data sets with the ability to investigate specific points in deep detail.
- The relationship between domain experts and data scientists is essential for a useful platform.
- Data analytics provides a foundation for exciting new features from new data streams and tools like machine learning and artificial intelligence.

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