Ref. Ares(2021)3853080 - 12/06/2021

D1.5 KPI Report

Deliverable No	D1.5
Work package No. and Title	WP1 End User Requirements, KPI's and Adaptation
Version - Status	V1.2 – Final Submission
Date of Issue	06/06/2021
Dissemination Level	PUBLIC
Filename	OptiDrill D1.5 KPI

This project has received funding from the European Union's Horizon 2020 research and innovation action under grant agreement No 101006964

DOCUMENT INFO

Authors

Author	Organization	e-mail
Kevin Mallin	GEO	kevinmallin@geolorn.co.uk

Document History

Date	Version	Editor	Change	Status
10/06/2021	1.2	Shahin Jamali		Final

TABLE OF CONTENTS

ACRONYMS

AI	Artificial Intelligence
BHA	Bottom Hole Assembly – The section of the drill string from the bit to the drill pipe. The BHA, is designed to include any specialised tools, technologies etc., that allow the well to be drilled efficiently.
BUR	Build up Rate – term used to define the radius of curvature in a non vertical well
DA	Data Analysis/Data Analytics
DDR	Daily Drilling Report – a record of all operations over a 12 or 24 hour period
DST	Drill Stem Test – operation where the pressure in the drill pipe is lowered, in order for gases/fluids from the formations can flow, for analysis
EOWR	End of Well Report – a full and final report on all activities associated with a well.
KPI	Key Performance Indicators
LCZ	Lost Circulation Zone – zones where the drilling flush is lost to the formation.
LTI	Lost Time Incident – loss of operational time (rig shut-down), usually due to personnel having an accident or a dangerous occurrence takes place that requires investigating.
LWD	Logging Whilst Drilling – in-hole equipment that logs formations being drilled
MD	Measured Depth – the total length of the well from surface to bottom
ML	Machine Learning
MWD	Measurement Whilst Drilling – records downhole data, azimuth, position etc as drilling progresses.
NPT	Non-Productive Time – all the time when the bit is not on the bottom of the well and drilling (May also include LTI).
PP	Pore Pressure – Pressure due to compaction in the interstices of formations (Either fluids or gases). PP above hydrostatic may cause issues with drilling.
ROP	Rate of Penetration / Rate of Progress (This may either be “instantaneous drilling rate” or overall Time (Time/Depth plots)
RPM	Rotating speed of drill bit
SoA	State of the Art
TVD	True Vertical Depth – the depth difference from the top of the well to the base of the well, vertically, in order that hydrostatic pressure can be calculated for well control.
UCS	Unconfined Compressive Strength – Defines rock strength as derived from laboratory tests
WOB	Weight on Bit – the load applied to any drill bit to effect drilling

EXECUTIVE SUMMARY

The OptiDrill Advisory system aims to reduce drilling related risks for deep geothermal developments, through the implementation of newly developed in-hole data sensors and advanced Machine Learning, coupled with Artificial Intelligence, that will provide the drilling team with data in real-time, allowing for better informed decision making, rather than lag-time actions. These developments will help to reduce downtime and unnecessary costs.

Combining State of the Art, new and emerging technologies with existing in-hole drilling equipment and processes is a major target for the geothermal industry, and through the identification and continuous reviews of the project's Key Performance Indicators (KPIs), it is anticipated that major strides forward will be achieved within the project's lifetime and beyond. However, as deep geothermal drilling is in a transitional stage of development with major many hydrocarbon operators entering into the sector with a view to reducing their carbon footprint, and as most active plants are based upon steam-field generation sources, setting KPI's and objectives can potentially be quite challenging, with new outlooks and perceptions in the way things get done. This *working* document, in its *initial* version, provides a distinct starting point for the project and an initial direction for concentrating the focus on benchmarking the success criterion for sensors, Machine Learning and Artificial Intelligence that will result in the development of the system that will interact with current drilling components including testing and validation.

1. INTRODUCTION

"If you do not measure, you cannot manage!". Setting KPI's is an essential part of any project, especially within the fast-moving technology centre. Today's SoA, is tomorrow's history. Failing to adopt new technology is failing to adapt to a fast moving, ever changing world.

Drilling technology is no different, with continuing advancements and some technologies never quite breaking ground. From the mid-twentieth century, when there was basically one method of making a hole, to the first quarter of the twenty-first century, where there are a myriad of developed technologies and countless "drawing-boards" of "things-to-come".

What does remain unchanged is the variety of geological settings and what drilling methods are the most suitable for each lithology. While some drilling tools are absolutely perfect for a particular type of strata, if not used in the correct way, time and money will be lost. Variables such as WOB, RPM, Torque etc., need to be carefully monitored and continually adjusted to get optimal results at all stages of the well drilling process. Add to this the burgeoning number of non-mechanical drilling methods currently being developed (some near, some far) and the complexities the driller faces, grow exponentially.

While automation seems to be the goal for technology driven companies, the geological sub-surface does not readily lend itself to a digital process. Yes, for example, sedimentary rocks will have certain characteristics that are similar, they will also have distinct variations not possible to predict until you have drilled through them. Experienced drillers who have drilled in all types of formation, gradually start to understand and "feel" what is going on down the well, even when things happen that were not expected. So, imagine then all those good drillers sharing their knowledge with young drillers or even algorithms that learn on a well-by-well basis; how good would that be? And what would be better if that algorithm made suggestions, just like a good driller helping a young driller learn all the skills and knowledge to get the best out of the drilling tools in all types of formations!

Still, we need to know that everything and everybody is performing as best as they can. Poor data inputs, will give poor outputs, good data used poorly is a waste. So the OptiDrill Advisory system sets out to learn from others and become that friendly voice on the drill floor.

2. CHAPTER 1 Defining the KPI's

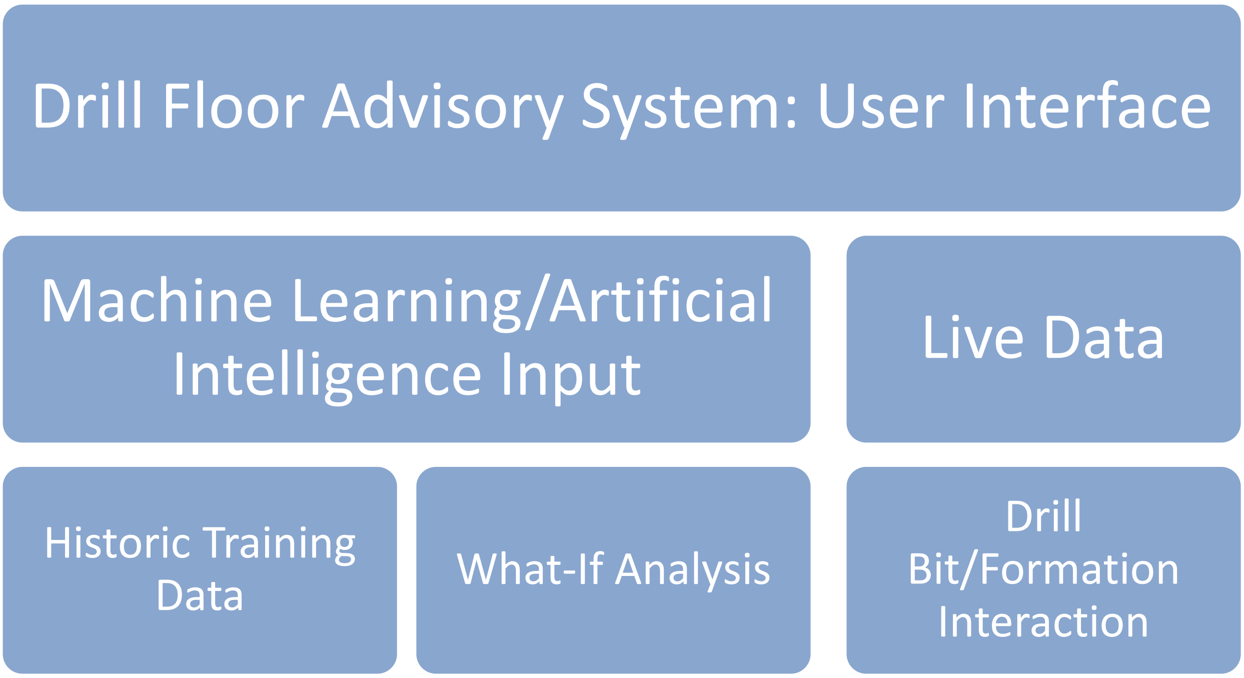

Fig. 1

In order to establish robust KPI's that will evolve in parallel with the project, it is probably best to rank them into "bronze, silver and gold standards", as this will allow KPI's established at the start of the project where data, data analytics, downhole data devices and the advisory system are still quite weak, to mature as the project progresses, with a view to getting all KPI's within the gold standard.

Fig. 1 shows how the data used in the project, links together so that the end result is a fully functioning Rig Floor advisory system that drilling contractors, sub-surface resource developers/operators and academics are fully involved with, helping the system continually grow in efficacy and therefore helping to minimise drilling related risks, reduce NPT issues and deliver lower cost wells. These things combined will also result in increased safety and lower environmental impacts, and hopefully a greater uptake of geothermal heat and power.

What is important to understand is that far more deep wells have been drilled for hydrocarbons, predominantly in sedimentary basin settings, than those drilled for geothermal exploitation, although with a greater variety of formations and drilling related problems being encountered. At the time of writing, offshore geothermal wells are near zero.

The KPI's are tabulated into distinct sections, so the quality of each can be assessed and quantified, relevant to their inputs/outputs. Each stage is key to the overall success of the project and whilst each stage will have its own sets of criteria and measurements, an overall KPI will be that the OptiDrill Advisory system achieves or better, excels expectations.

KPI's will be constantly reviewed and updated, both for internal developments, but also to reflect external developments that take place over the lifetime of the project.

Table 1

KPI	Bronze	Silver	Gold
Historic & Training Data			
Historic Drilling Data from Sedimentary Basin(s)	O&G wells, low temperature, but full suite of data. Varied drilling technologies deployed.	O&G Wells, plus hydrothermal geothermal brine wells. Possibly radiused and Extended horizontal section.	O&G Wells, plus hydrothermal geothermal brine wells. Possibly radiused and Extended horizontal section. Varied drilling technologies deployed. Well issues including overpressure (fluid/gas flows encountered) and well bore stability issues (breakout).
Historic Drilling Data from wells in active volcanic settings.	Wells drilled with no issues, but complete suite of data.	Wells drilled with partial/complete losses, some steam kicks and quenching.	Wells drilled with "flash boiling", partial to full loss of control, stuck/lost pipe.
Historic Drilling Data from wells in igneous formations	Wells drilled with no issues, but complete suite of data.	Wells drilled through fault zones, possible fluid Lost Circulation Zones. Both percussion and rotary drilling methods deployed.	Wells drilled completely with percussion. Wells drilled completely with rotary. Drilling issues encountered.
Historic Drilling Data from wells in meta-sediments and igneous, contact/transition zones	Wells drilled with no issues, but complete suite of data.	Wells drilled through fault zones, possible fluid Lost Circulation Zones. Both percussion and rotary drilling methods deployed.	Wells drilled completely with percussion. Wells drilled completely with rotary. Drilling issues encountered.
Historic Drilling Data from wells in complex geological settings – pyroclastic flows, igneous intrusions in sedimentary basins, Basalt flows over sediments etc.	Wells drilled with no issues, but complete suite of data.	Wells drilled through complex faulted and folded formations. Well stability issues. Possible previous human activity – mining, depleted hydrocarbon wells.	Wells drilled through complex faulted and folded formations. Well stability issues. Well control issues. Possible previous human activity – mining, depleted hydrocarbon wells. SoA drilling methods.

KPI	Bronze	Silver	Gold
What-If Analysis			
What-If Analysis of historical well data	Full data set(s) available in complex geological setting(s) and training data fully validated in test wells (simulated/actual)	Partial data set(s), with enhanced analysis, in variable geological settings, fully validated in test wells (simulated/actual)	Poor data set(s) or data that has poor outcomes. What-If analysis provides full optimal outcome, fully validated in test wells (simulated/actual)
Drill Bit Sensors and Formation Interaction			
New OptiDrill Sensors	Provide real-time data for most drilling methods	Provide real-time data for most drilling methods and operate with existing MWD systems	Provide real-time data for most drilling methods and operate with existing MWD systems across complex and harsh geological settings
Live Data			
OptiDrill Sensors	Basic data transmitted in real-time	Lithological data, formation characteristics and basic drilling data transmitted in real-time	Complex drilling and predictive formation data transmitted in real-time
OptiDrill Sensors & MWD/LWD systems	Basic data transmitted and recorded in real-time. Works in tandem for directional drilling programmes	Works with other advanced down hole sensor systems e.g. seismic while drilling, Electron Pulse etc., to provide enhanced well data in real-time	Able to work with complex drilling systems e.g. Rotary Steerable Systems and provide high quality real-time data.
Advisory System User Interface			
Training Data/Real Data	ML System provides basic, previously lag-time, information in real-time	ML system provides information with a "menu" of options	ML system provides information and optimisation options in real-time
Industry Adoption	20%	30%	>50%

2.1 Conclusions

The KPI list is far from exhaustive but will set checks and balances to monitor the overall progress of the key aspects of the project.

Central to the ML/AI outcomes is the range and quality of training data, coupled with the analysis of the data by the OptiDrill team and potential extensive "decision making trees", something that many drillers, contractors and operators will already be familiar with.

It stands to reason that developing an advisory system that is too complex for end-users or is patchy in its outputs, needs to be avoided. A successful outcome will be a system that invokes the response "this is what we do anyway", yet unwittingly be continuously setting new standards for the interpretation of new drilling data and comparing to "lessons learned" from other wells, geological formations and the drilling problems encountered/overcome.

At this point of the project, the KPI's are guiding principles and whilst they are robust benchmarks they will evolve as both the sensor system improves and the training and validation data, increases positive improvements to drilling activities.