

### REAL-TIME ROP OPTIMIZATION AGENT

## Optimize ROP in real time and increase drilling and operational efficiency

Rate of penetration is a major contributor to drilling time and costs. The Exeбенus Current ML™ Real-Time ROP Optimization agent uses multiparameter machine learning to advise and help crews make informed decisions that will improve drilling speed and efficiency.

### RATE OF PENETRATION IS A MAJOR FACTOR IN CONTROLLING DRILLING COSTS

In general, optimizing the rate of penetration (ROP) in drilling is achieved by adjusting the weight on bit (WOB), RPM and fluid flow. The allowed ranges for these parameters are typically obtained prior to the operation using complex, time-consuming simulation models.

Simulation models depend on the input of configuration parameters that cannot be predetermined accurately. In addition, there are many uncontrollable factors such as bit dulling, vibration, buckling and variable formation strengths, all of which need to be considered when trying to optimize ROP. Consequently, the ability to plan and make effective drilling adjustments to enhance ROP is largely dependent on the experience of the rig crew.

### MACHINE LEARNING OFFERS BETTER, MORE RELIABLE ADVICE IN REAL TIME

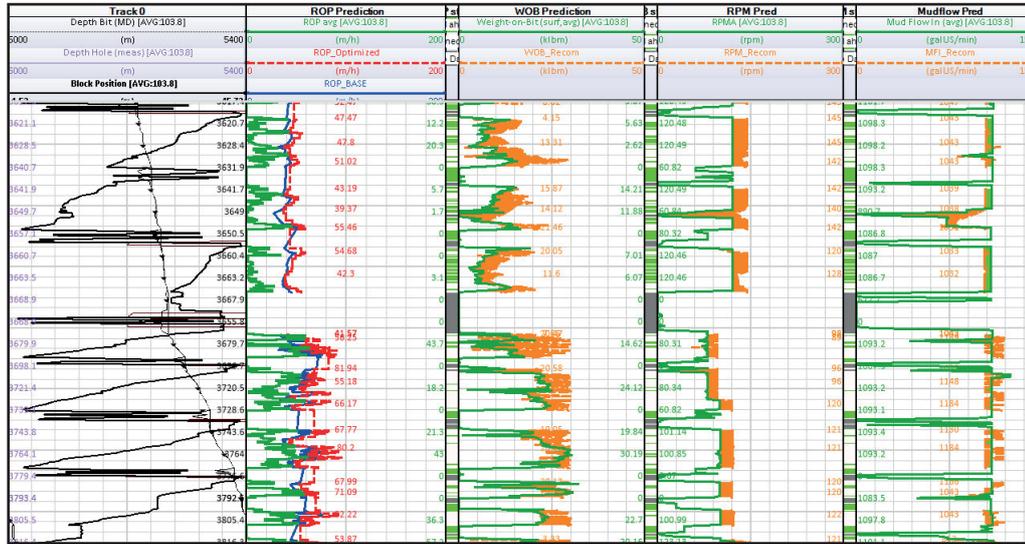
The Exeбенus Current ML Real-Time ROP Optimization agent is unique in its ability to decipher the relationships between controllable and uncontrollable drilling parameters. Using machine learning, the agent provides parameter recommendations for the drilling crew in real time. No complex mathematical models and hard-to-get configuration data are required. Just plug the agent into your WITSML data stream and be amazed at the output.

Machine learning is the perfect tool for the job of interpreting and seeing the relationships between multiple parameters. The Exeбенus ROP optimization agent adapts to well formations, mud flow, BHA and bit type, and identifies combinations of factors and changes to parameters that may not be obvious to the human operator relying on traditional routines.

The real-time advice provided by the Exeбенus ROP optimizer has been shown in field operations to increase ROP and reduce drilling time significantly.

### EXCEPTIONAL BENEFITS

- > Multiparameter recommendations not obvious to human eyes
- > Usable anywhere; no customization required
- > Consistent and reliable
- > Reduces risk of human error



Exeбенus Current ML calculates the optimized ROP and the ROP baseline. When the two logs coincide, ROP is optimal. If they do not coincide, the WOB, RPM and mud flow recommendations shown (in orange) are used to further optimize ROP. In this operation, the rig crew optimized in two steps as seen by the ROP jump at 5668 m depth. Data courtesy PETRONAS

### AN OUT-OF-THE-BOX SOLUTION

The Exeбенus ROP optimization agent is an out-of-the-box solution, adaptable to any field or well type using standard WITSML setups and familiar WITSML viewers. Because it adapts to well formations, BHA, bit type and mud flow, the solution reduces the risk of human error by removing the need for manual configuration. The agents provide additional logs to be visualized in the WITSML showing recommended RPM, WOB and mud flow to obtain the optimal ROP. As the recommended parameters are implemented, the agent updates in real time, reflects the new situation, and continues to give advice.



#### ROP Optimization

<b>Well trajectory</b>	0-90 deg*
<b>Operation types</b>	Drilling
<b>Hole sizes</b>	8.5" - 17.5"
<b>Bit type</b>	PVC, roller cone, diamond bit
<b>Depth range</b>	0 - 6000 m*
<b>Formation type</b>	Sandstone, clay, limestone, shale

\*Not including horizontal wells

#### Data Input / output

Input	Output
Bit depth	ROP Base line
Hole depth	Optimized ROP
Surface RPM	Recommended RPM
Surface torque	Recommended WOB
Weight-on-bit	Recommended mud flow
Standpipe pressure	
Mud flow rate in - volumetric flow rate	
Mud density in	



# EXEBENUS

## ▀ CURRENT ML

### THE POWER OF EXEBENUS CURRENT ML AGENTS



Exeбенus Current ML agents are cloud-based, stand-alone software as a service (SaaS) solutions. The agents can be hosted on a public cloud (e.g. Microsoft Azure), installed on your corporate cloud or on your premises.

The agents are designed based on our deep understanding of drilling and completions operations and the associated data.



In one year, approximately 12% of our drilling time per well was spent drilling on bottom—a total of 480 days. Improving ROP by just 10% would have saved 48 days and from \$5 million to \$40 million USD. We've since started using the Exeбенus real-time ROP agent. It is one of the most value adding applications our company has ever deployed.

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