RiMo Drill-Ahead Prediction

Summary

As a Drilling Engineer responsible for a cost-effective, upstream operation, one might use a proven toolbox to better understand directional hole quality. In other words, what do we have to work with considering the following work-flow to economically complete/produce this horizontal well?

Options to determine how hole smoothness includes a gyro-survey or wire-line sondes to get a fairly detailed "look" at the well. Drill-pipe conveyed LWD tools can do a similar job although there in physical caliper. We could rely upon the ultrasonic caliper but any of these choices are better than nothing. The bad part is that any option is going to take a day's worth of rig time. Don't forget the cost of Lost in Hole Insurance just in case. Maybe that's why we just won't run logs anymore?

Time domain models and the predictions they enable that visualize the tortuosity of the well-bore and accurately predict the AZI and INC of any drilling system are indispensable. It helps to plan operations better to create a smooth hole that we are comfortable tripping in/out of. It also helps plan a better completion with less time fighting torque and drag.

One can essentially design these unwanted characteristics out of the well from the beginning. Smart engineering!

RiMo Drill-Ahead Prediction

Drillers always want to know where the hole is headed. When a directional driller is actively steering the well-bore with a steerable motor or an RSS, he is always concerned about where the bit is headed. Directional drilling technology has taken some of the guess-work out of the science by moving the survey point inside the MWD closer to the bit, but it's always a projection to the bit and not a real measurement.

Not only is well position important, well-bore quality has come up more often, as a reason or excuse why surface torque is so high or why we can't get weight to the bit and drill faster. Or, why casing does not go to bottom quickly? Tortuosity and the cumulative dog-legs and other perturbations in the hole geometry can be the root cause of all of these things and more. Since caliper logs are generally not run many wells, conventional or unconventional, we really don't have much detail about the shape of the hole we have made.

For one thing, it's probably not guage and with some certainty we can make estimates of its' true average diameter as a function of measured depth. There are sections of hole that can be spiraled, oval-shaped, completely washed out (with a very large diameter), slightly under-gage due to swelling shale or plastic flow and ledges. Don't be surprised to "see" tortuous edges that are remnants of the steering mechanism used to make the hole in the first place.

Wouldn't it be nice to have a better visualization of what this looks like? Not only to support improvements in directional drilling itself but to focus on the geometry of the hole to keep us from performing secondary tasks such as wiper trips/clean up runs just to be able to POOH. These rough edges of well-bores can cause far more problems, so it's important to be able to "see" them to prevent or at least minimize them.

There have been earlier attempts to predict hole inclination and azimuth on the fly with limited success, much less so the ability to predict hole quality ahead of the bit. Now there is a way to "see" what's in front of you so that decisions can be made to reduce this rugosity and the actions needed to stay on target. Using advanced physicsbased models, RiMo's Drill Ahead Prediction offers real-time insights into what's right in front of us.

Using a familiar directional well plan with a well-bore diagram, casing details, drilling fluids, drill-string and BHA/bit type the user can quickly design into a wells' work space with an accurate digital twin. This will include details such as bit to bend length and bend angle for motor BHA's or push-the-bit/point-thebit details for a RSS assembly. Formations are also well characterized to include UCS, lithology, density and Poisson's Ratio to capture the mechanics involved in removing rock.

RiMo's drill-ahead functionality utilizes WOB, RPM and flow rate along with all the details listed above to characterize the physics and the drilling assembly's response incrementally ahead of the bit. The output from these calculations is derived from thousands of iterative calculations of the BHA/drillstring, its' touch points along the well-bore and the forces acting at each depth interval that drive the system towards its' next step.

It's possible to look ahead a single joint or several stands in user-defined increments (3' – 10') to accurately predict where the well-bore is going. It's no surprise that it is not a straight line and quite the opposite. Depending on the steering mechanism and the specific rock strength, the results can be rough enough to explain why we have so many problems trying to POOH or get casing back to bottom.

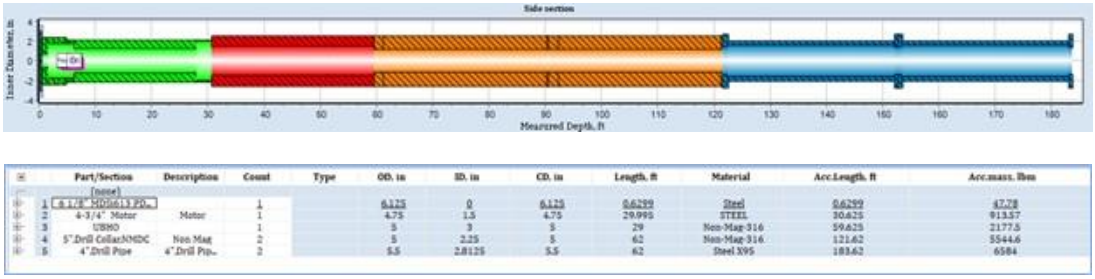
The good news is that in this same work space, one can re-drill that same section with a different motor bend angle, BHA or bit to see what the difference is like. Maybe try an RSS to see if this really creates a smoother well-bore?

What would you do with this new piece of information? Would it help you plan better?

Case Study Results

In this study, the focus was on predicting the drill-ahead tendencies for an unconventional shale well. The drill-ahead tendencies were predicted for BHA's with motor and an RSS on the same hole. Quantifying the predicted DLS, Build & Turn rates in terms of °/100' provide a guidance to hole quality and tortuosity for planning and real-time insights. During the drilling of the 6.125" curve and lateral, RiMo's Drill-Ahead Prediction's work flow was used to evaluate the hole tortuosity and deviations from plan. The planned wellbore trajectory and RiMo BHA details are shown below. Figure 1 shows the well plans in 2D and 3D. Figures 2 and 3 shows the BHA with motor and RSS systems used for the study. The surface parameters are shown in Table 1 and 2.

Figure 1 – Well plan views



	Part/Section	Description	Count	Type	OD, in	ID, in	CD, in	Length, ft	Material	Acc.Length, ft	Acc.mass, lbm
	[none]										
1	6 1/8" MDSi613 PD...		1		6.125	0	6.125	0.6299	Steel	0.6299	47.78
2	4-3/4" Motor	Motor	1		4.75	1.5	4.75	29.995	STEEL	30.625	913.57
3	UBHO		1		5	3	5	29	Non-Mag-316	59.625	2177.5
4	5".Drill Collar.NMDC	Non Mag	2		5	2.25	5	62	Non-Mag-316	121.62	5544.6
5	4".Drill Pipe	4".Drill Pip...	2		5.5	2.8125	5.5	62	Steel X95	183.62	6584

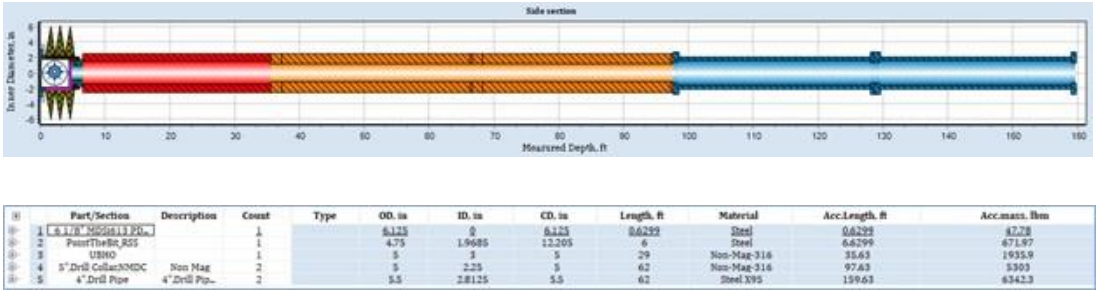
Figure 2. RiMo BHA with fixed bend angle motor

BHA with Motor	
Hole size	6.125"
Formation	Shale
Drilling Fluid	OBM 12.0 Lbs/Gal
4-3/4" 7:8 Motor	Bend angle 1.2° Bit to bend 75" Flow rate 300 GPM
WOB	15 K Lbs
Hole over gauge	0.15"
Drill ahead interval	270'
Prediction interval	3'

Table 1. RiMo BHA with motor

BHA with RSS	
Hole size	6.125"
Formation	Shale
Drilling Fluid	OBM 12.0 Lbs/Gal
4-3/4" Point the Bit RSS	15% Deflection Flow rate 300 GPM
WOB	15 K Lbs
Hole over gauge	0.10"
Drill ahead interval	270'
Prediction interval	3'

Table 2. RiMo BHA with RSS



	Part/Section	Description	Count	Type	OD, in	ID, in	CD, in	Length, ft	Material	Acc.Length, ft	Acc.mass, lbm
1	6 1/8" MDSi613 PD...		1		6.125	0	6.125	0.6299	Steel	0.6299	47.78
2	PointTheBit_RSS		1		4.75	1.9685	12.205	6	Steel	6.6299	671.97
3	UBHO		1		5	3	5	29	Non-Mag-316	35.63	1935.9
4	5".Drill Collar.NMDC	Non Mag	2		5	2.25	5	62	Non-Mag-316	97.63	5303
5	4".Drill Pipe	4".Drill Pip...	2		5.5	2.8125	5.5	62	Steel X95	159.63	6342.3

Figure 3. RiMo BHA with Point the Bit RSS

Each of the predictive outputs can be plotted separately to evaluate DLS, BUR and turn rate at intervals that offer increased granularity from MWD surveys. The predicted incremental changes in INC ands AZI give us a much closer look at how the hole moves forward with drilling progress.

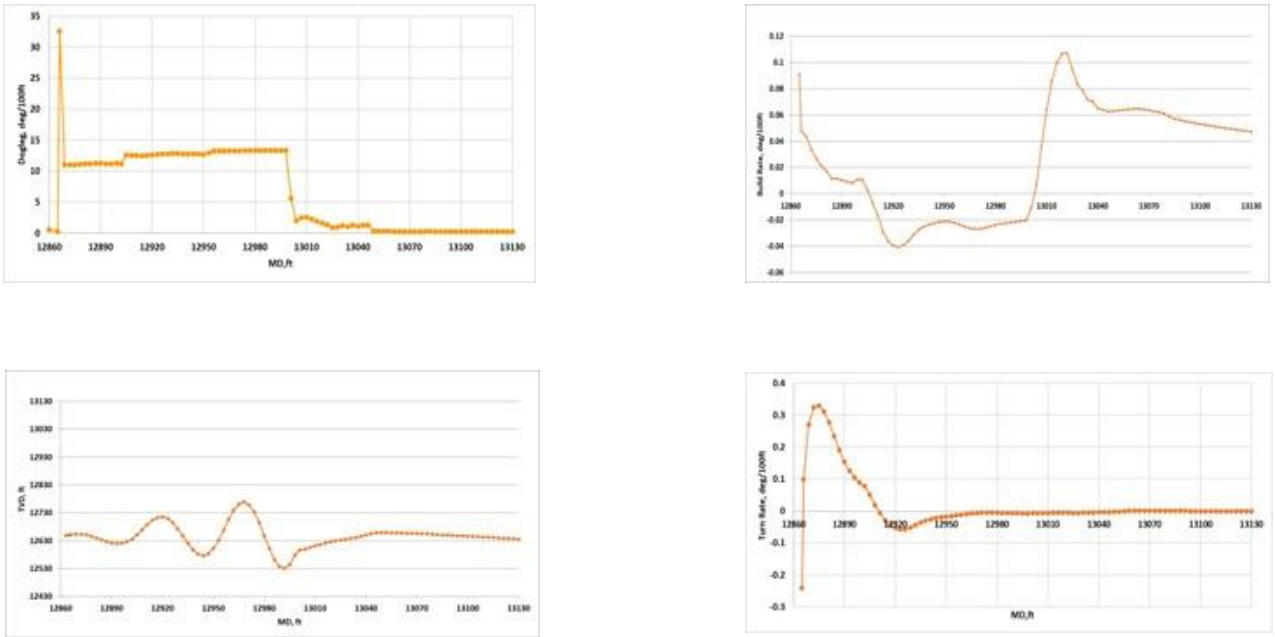


Figure 4 RiMo steerable motor Drill-Ahead Prediction

Each of the predictive outputs if Figure 5 can be plotted separately to evaluate dog-leg severity, build rates and rates at intervals as short as 3’ (maximum resolution) for a close look at the well-bore. These predicted incremental changes in INC and AZI give us a much closer look at how the hole moves forward with drilling progress.

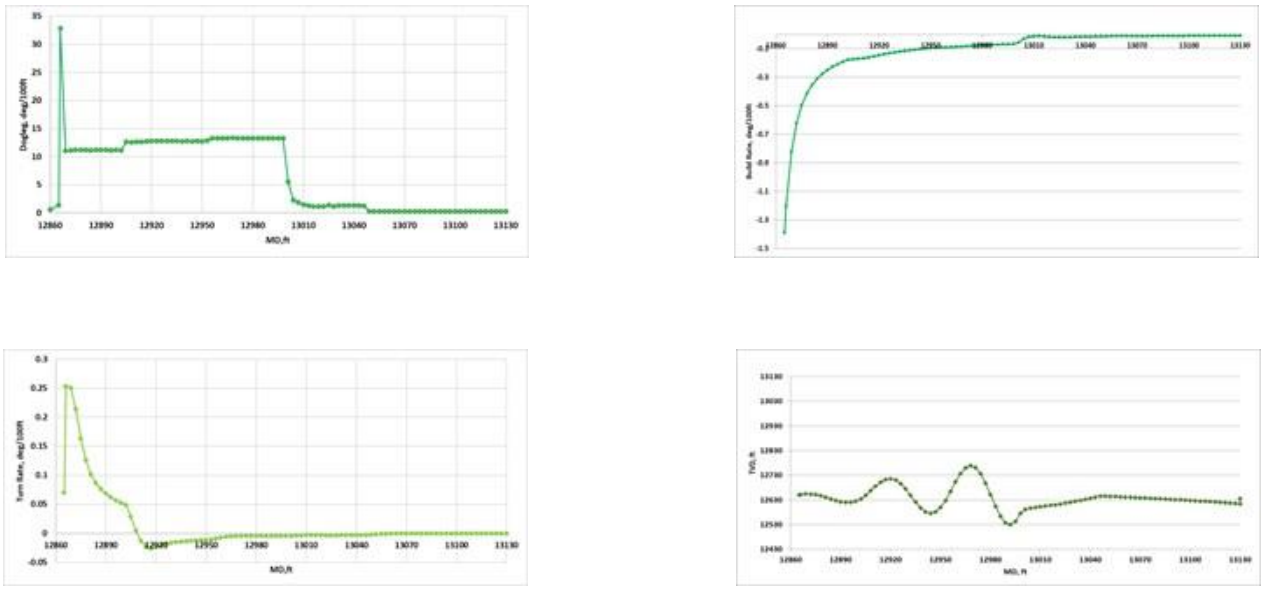


Figure 5 RiMo RSS Drill-Ahead Prediction

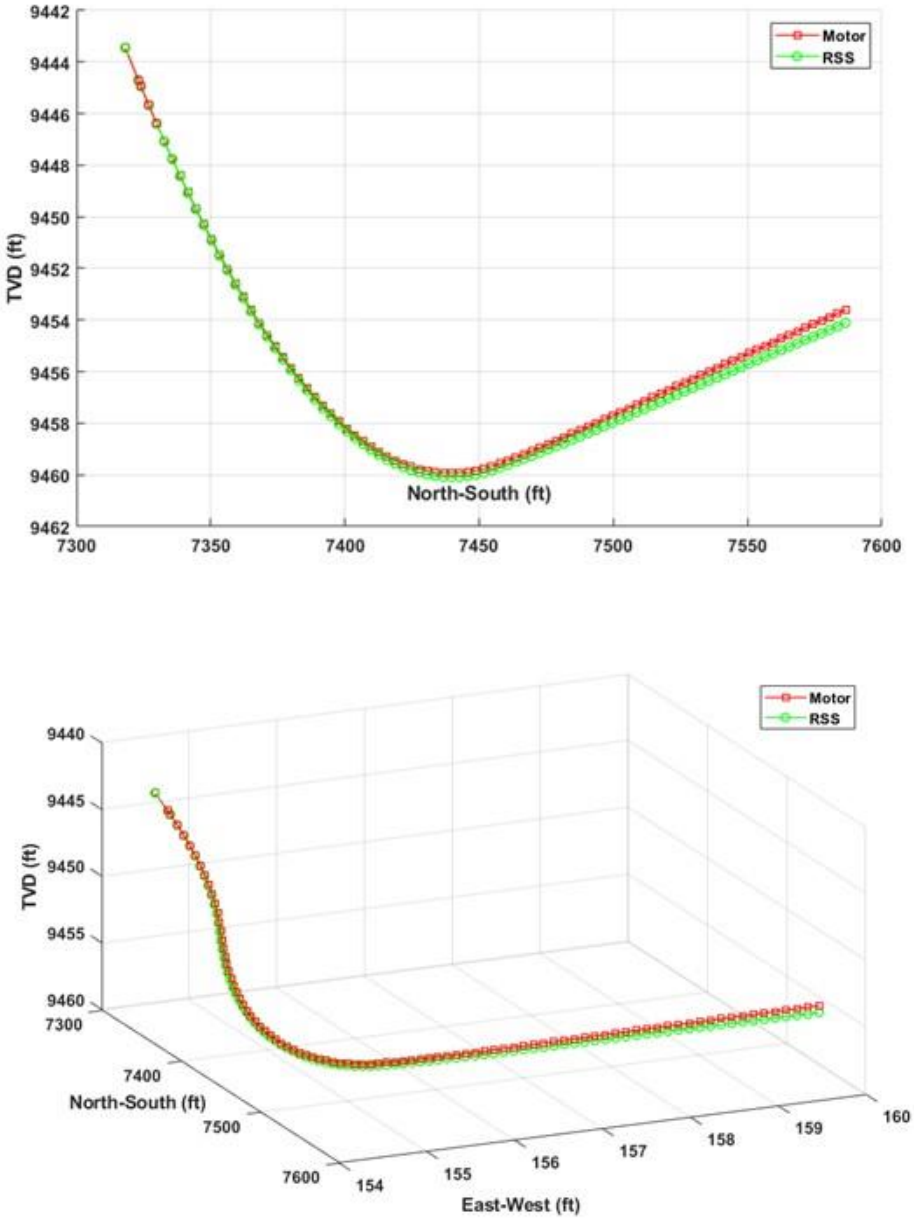


Figure 6 Predicted well trajectories with Motor and Point the bit RSS

The predicted well-bore trajectories with the Motor (red) and RSS (green) are shown in Figure 6. The motor curve shows a higher build rate compared to the RSS. The higher build rate in the motor's curve also leads to deviation from the well plan in the lateral.