Early Field Trials of MotarySteerable™ Performance Drilling Tool

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Agenda

- Targeted Bit Speed (TBS) Theory
- System Specification
- Early Field Trials
- Conclusions

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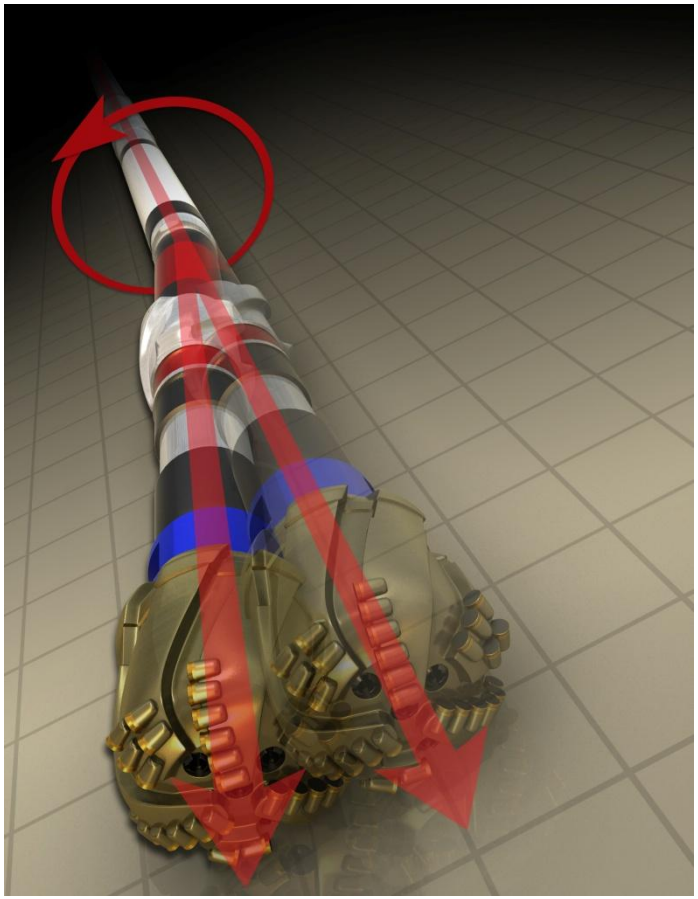
Targeted Bit Speed (TBS) Theory

General Theory - SPE 139925

(Controlling Well Path Trajectory with Rate of Penetration Modulation)

- A bent housing down hole motor works off of two different drilling centerlines
  - Rotational
  - Oriented
- During continuous string rotation, different bend orientations will drill the well bore at different times
- Controlled modulation of bit speed through the motor should cause the well path to move.
  - Higher RPM & ROP toward target
  - Lower RPM & ROP away from target



Why is This Important?

- Can use conventional mud motors and MWD tools to provide continuous rotation with full 3-D directional control
- If desired build rates are not obtainable, can always stop and orient using conventional directional drilling methodology – very low risk technology
- Lost-in-hole cost is substantially less than traditional motorized rotary steerable systems
- Have opportunity to increase ROP and hole quality by sliding less using TBS technology
- Use legacy technology (mud motors and MWD) with proven reliability to increase their functionality, utility and applications

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System Specifications

Specifications

Tool Size (in.)	4-3/4	6-1/2	6-3/4	8-1/4
HyperLine 250 Power Section (lobe, stage)	7:8 5.0	7:8 3.0	7:8 5.0	7:8 4.0
Capable hole diameter (in./*mm*)	5.875 to 6.750 *149 to 172*	7.875 *200*	8.500 to 9.875 *216 to 251*	10.625 to 12.250 *270 to 311*
Maximum rotary dogleg severity (DLS) (°/100 ft or °/*30 m*)	3.0°	2.0°		1.5°
Tool length (ft/*m*)	63.94 *19.49*	64.50 *19.66*	64.99 *19.81*	65.42 *19.94*
Top connection	3-1/2 API IF Box	4-1/2 API IF Box		5-1/2 API IF Box
Bottom connection	3-1/2 API Reg Box	4-1/2 API Reg Box		5-1/2 API Reg Box
Minimum vertical kickoff angle	0°			
Flow rate range (gpm/*Lpm*)	150 to 300 *568 to 1,136*	200 to 600 *757 to 2,271*	300 to 600 *1,136 to 2,271*	300 to 900 *1,136 to 3,407*
Bit speed range (rpm)	50 to 335	40 to 160	45 to 240	300 to 1,000
Maximum torque output (ft-lb/*N•m*)	5,620 *7,622*	6,810 *9,234*	12,780 *17,330*	18,320 *24,842*
Maximum power output (hp/*kW*)	300 *224*	175 *131*	370 *276*	490 *365*
Maximum differential pressure (psi/*kPa*)	1,200 *8,274*	600 *4,137*	1,200 *8,274*	1,000 *6,895*
Maximum body overpull (static load) (lb_F/*daN*)	185,000 *82,000*	288,000 *128,000*	387,000 *171,000*	444,000 *197,500*
Maximum bit overpull (static load) (lb_F/*daN*)	51,000 *23,000*	81,000 *36,000*	95,000 *42,000*	112,000 *49,800*
Maximum operating temperature (°F/°*C*) *	356° *180°*			
Maximum operating pressure (psi/*kPa*)	30,000 *206,843*			25,000 *172,369*
Maximum sand content	2%			

Considerations

- Technology only as good as the individual pieces
  - Mud motors
  - MWD tools
  - Bits
  - Stabilization
- Best performance comes with a neutral BHA using compliant bits
- Low build up rate (BUR) assist
  - Smaller the bit size – the greater the effect
  - Excellent low angle tool face control
  - Can always stop and orient to get higher BUR’s

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Early Field Trials

Eagle Ford Shale

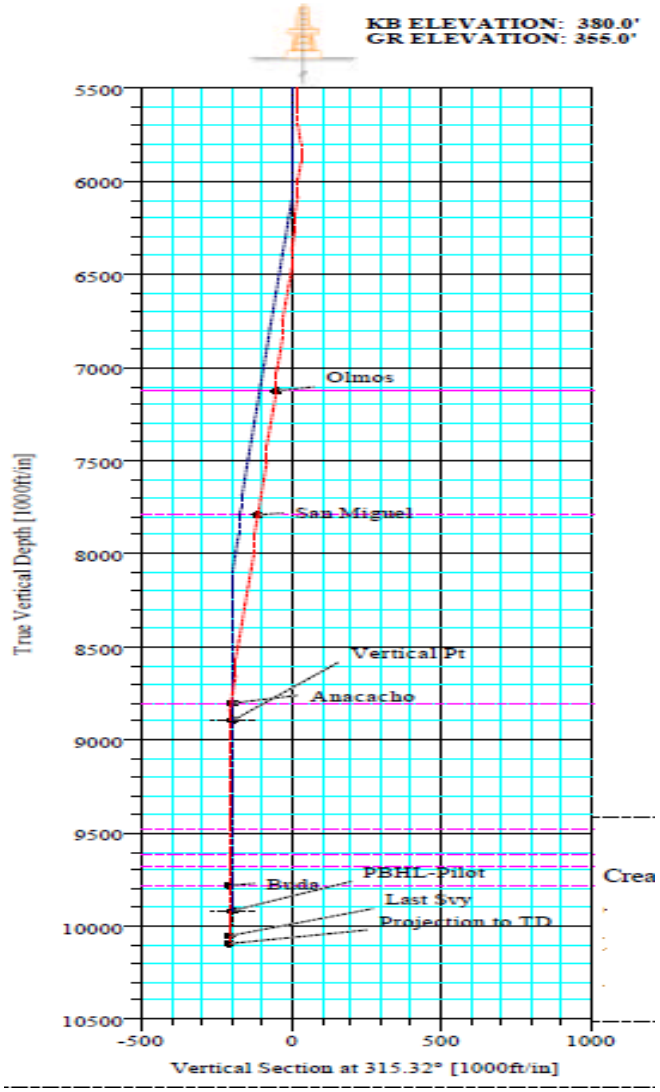
Field Trials

Job	State	County	Field	Start Date	End Date	Start Depth (MD)	End Depth (MD)	Ft Drilled	Mud Type	Well Type	Comments
1	OK	Rogers	Catoosa	1-Sep-08	5-Sep-08	240	1471	1231	WBM	S-Type w/ Tangent	Up Down Control Only (w/ EM)
2	OK	Rogers	Catoosa	1-Dec-08	5-Dec-08	185	1600	1415	WBM	crap	Went Terrible/No Control, Black Box
3	OK	Rogers	Catoosa	12-Jan-09	29-Jan-09	210	1716	1506	WBM	S-Type w/ Tangent	Lots of Rig Issues, Shock Sub, IDS failure, 2 weeks
4	OK	Rogers	Catoosa	11-May-09	15-May-09	200	1785	1585	WBM	S-Type w/ Tangent	5 BHA's, Reasonable control w/ some
5	TX	Tarrant	Barnett	20-Jul-09	30-Jul-09	1200	13505	12305	WBM	Turn-a-zontal	Held low tangent in upper, lots of tool problems
6	OK	Rogers	Catoosa	30-Sep-09	6-Oct-09	630	1768	1138	WBM	S-Type w/ Tangent	Pulse Patterns, Vary Bends & Bits
7	UT	Uintah	Uintah Basin	10-Dec-09	20-Dec-09	2800	9470	6670	WBM	S-Type	Good performance in vertical
8	UT	Uintah	Uintah Basin	2-Feb-10	6-Feb-10	1815	8360	6545	WBM	S-Type	Good performance in vertical
9	TX	La Salle	Eagle Ford	21-Apr-10	24-Apr-10	3691	8100	4409	Invermul	Vert Ctl w/ low angle tangent	100% run;
10	TX	Webb	Eagle Ford	2-May-10	6-May-10	4705	10066	5361	Invermul	Vert Ctl	Back to back MM failures
11	TX	La Salle	Eagle Ford	8-Jul-10	14-Jul-10	3440	10100	6660	Invermul	Vert Ctl w/ low angle tangent	100% run; 4% slide/96% PDS; good perf in vertical
12	PA	Greene	Greene County	12-Aug-10	25-Aug-10	2662	9441	6779	WBM	Vert Ctl w/low angle tang, build to horiz	First 2 runs had junk in the hole.
13	OK	Pittsburg	Kiowa	4-Sep-10	2-Dec-10	725	16165	15440	WBM & OBM	Verical Control, build to horizontal	High dip; multiple BR's; 90 day well
14	LA	DeSoto	Brushy Bayou	7-Dec-10	17-Dec-10	106	8477	8371	WBM	Tangent and then vertical	MWD failure; good control in vertical
15	LA	DeSoto	Oxford	9-Jan-11	20-Jan-11	106	8628	8522	WBM	Tangent and then vertical	100% run; 5% slide/95% PDS; good perf in vert/tang
16	TX	Tarrant	Barnett	25-Jan-11	6-Feb-11	1291	14662	13371	OBM	Vertical Control and Lateral	Assisted in tangent, reduced sliding time by 67% in late

- Have tested the system in 6”, 7-7/8”, 8-1/2”, 8-3/4”, 9-7/8”, and 12-1/4” holes
- Run in low angle tangent, vertical control, horizontal lateral sections
- Tested in OK, UT, TX, and PA
- Highlights include:
  - Delivered tight azimuth control for 2,500’ in a 3° tangent section
  - Successfully drilled 5,500’ with vertical control maintaining under 1° inclination
  - Substantially increased ROP by being able to maintain optimal drilling parameters, eliminating sliding requirements

Eagle Ford Shale Wells - Background

- Eagle Ford Shale
- Vertical hole with a slight negative section
- 9-7/8” hole
- Oil based mud
- Drilled 3 wells with same well plan
- All 3 wells drilled with good vertical control, build and tangent hold
- Drilled ~16,000 between the 3 wells

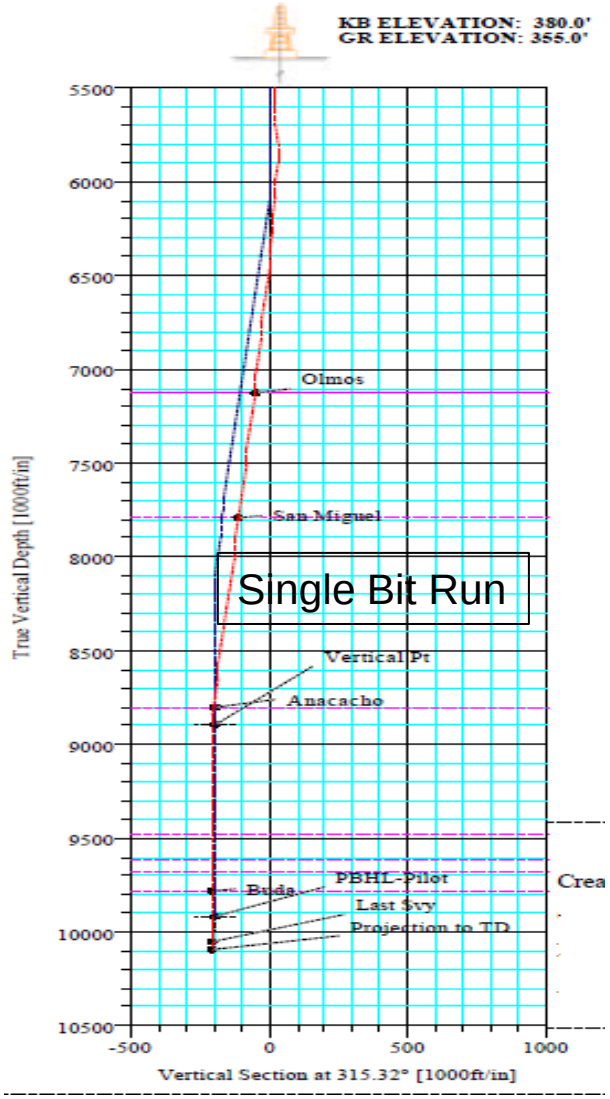


Results – Wells 1 and 2

Run No.	Hole Section	Footage Drilled	Hours Drilled	Avg ROP (Ft/hr)	Comments
Well 1					
1	Pilot hole	4,409	28.74	153.00	Used for vertical control, build, hold and drop back to vertical
Well 2					
1	Pilot hole	3,894	37.43	104.03	Good directional control and hold tendencies throughout but run – POOH to check mud motor
2	Pilot hole	1,467	18.48	79.00	Good directional control and hold tendencies to TD

Results – Well 3

Well 3	
Hole Section	Pilot hole
Footage Drilled	6,660
Hours Drilled	72.58
Avg ROP (ft/hr)	91.79
Comments	✓Drilled pilot hole in 1 run ✓Only two short slides during entire bit run ✓Excellent low angle tool face control ✓96% rotating time; only 4% sliding



Conclusions

- TBS methodology can provide good 3-D directional control of up to 3 degrees per 100 feet
- Always have the option stop and orient to increase build rates
  - Oriented BUR's comparable to conventional mud motor tool
- Rotating BUR's vary on tool size
  - The smaller the tool the larger the impact
- System capitalizes on two proven technologies
  - Mud motors
  - MWD
- Hole sizes range from 6 inch to 12-1/4 inches, including 7-7/8 inch hole size
- LIH can be significantly less than traditional 3-D rotary steerable assemblies

Questions?