GYROSCOPIC NAVIGATION IN THE HDD INDUSTRY

&

CURRENT GST TECHNOLOGY IN THE MARKET

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Involved in the HDD Industry since 1982 with experience in the Engineering and Development of Downhole Tooling. Served as Manager for a large HDD Contractor as well as VP/Manager for Brownline, a worldwide leader in Survey/Guidance Services and Downhole Tooling.
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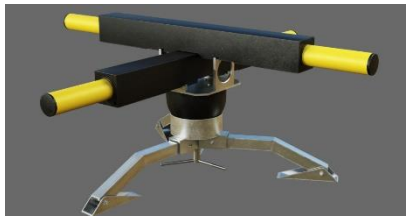
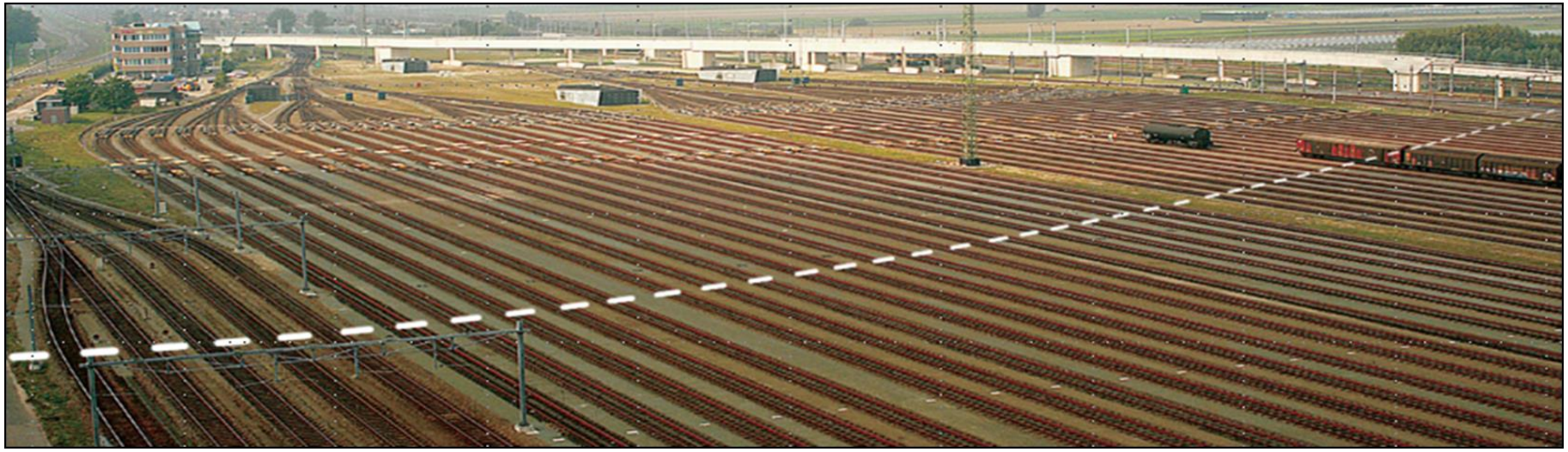


Approximately 20 years ago, I received an invitation to be a part of a panel discussion on the future of navigational technology in the Horizontal Directional Drilling Industry. It was at this DCCA panel discussion that Gyroscopic Technology was mentioned.

Some in the industry thought it would be the next "sliced bread" of our industry, while others thought that the Gyro Technology available at that time would never be viable in our industry. With my prior experience in the oilfield and some experience with Gyroscopic tools in the HDD industry, I also had doubts about the technology.

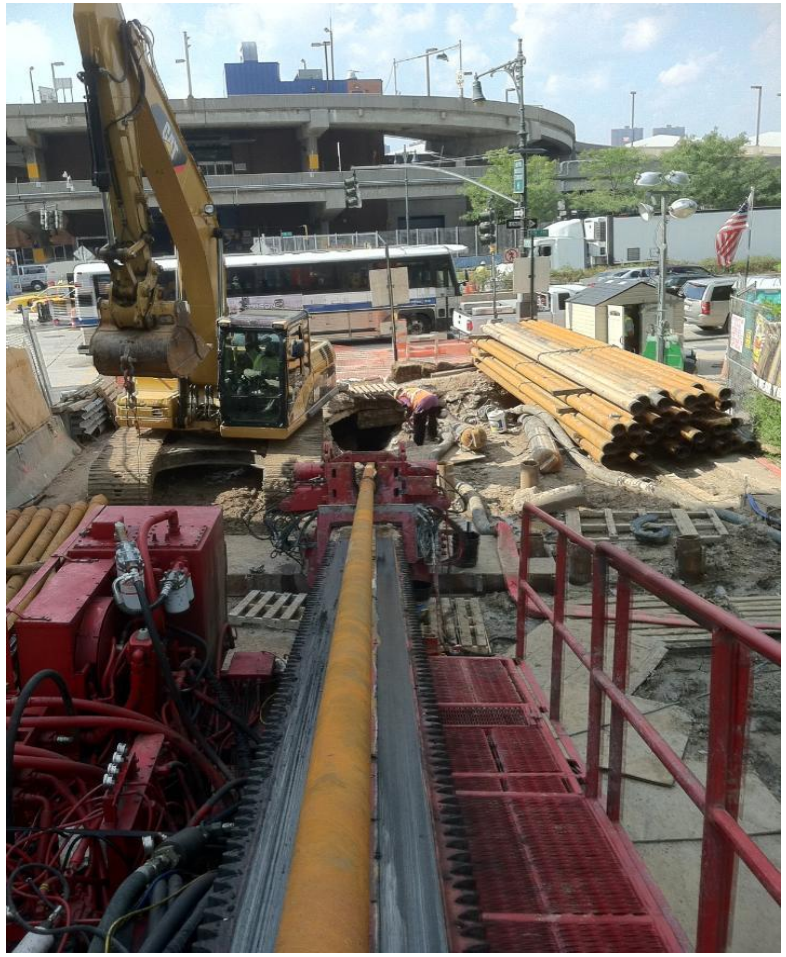
Since then the HDD Steering Industry has continued with the use of magnetic tools and did experience several technological advances including, High Res Tools, Software Advancements, AC Grid Tracking, etc. Even as Magnetic Steering Technology advanced, it seemed outpaced by the demands of the Engineers and increasingly complex and difficult projects we encounter today.



We have all heard the saying, "all the easy ones are done". Well, this statement could not be more accurate. The Steering Industry has recently experienced an increase in the following.

- **Tighter tolerances due to less easement space and owner requirements.**
- **More Complex Profile Drills**
- **Less access to land for the installation of Wire Tracking Systems**
- **Longer Reach projects**
- **Increase in projects with extreme Pipeline/Utility congested areas.**
- **Increase in high degree horizontal turns.**
- **Increased monitoring of bore radius during the drilling process.**
- **No more "Buy the easement when we get to the other side."**
- **Budget restraints on time to complete projects**

HIGHLY CONGESTED & REMOTE LOCATIONS
0% WIRELINE TRACKING AVAILABILITY



HIGHLY MAGNETIZED IRON ORE MINE DRILL

MGS UNABLE TO TRACK OR MAINTAIN AZIMUTH

CROSSING UNDER NUMEROUS OVERHEAD POWERLINES

NO ACCESS FOR TRACKING & HEAVY MAGNETIC INTERFERENCE

LIMITED LAND ACCESS & HIGH DEGREE HORIZONTAL TURN

4500m INTERSECT – LIMITED LAND ACCESS

GYROSCOPIC NAVIGATION & INTERSECTS

- **HIGHER DEGREE OF ACCURACY = QUICKER INTERSECT TIMES**
- **ACCURATE MONITORING OF INTERSECTING POINT ANGLES**
- **INTERSECT (DG RADAR) TECHNOLOGY – FASTER LOCATING TIME.**
- **SURFACE WIRE LOCATING NOT REQUIRED**

With the growth of the HDD market and the ever-increasing demands of the Pipeline & Utility Owners, it was necessary for Steering Tool Manufacturers and Service Companies to provide more precise and accurate steering systems. While Mechanical Gyroscopes have been available for decades, they were not considered a viable option for HDD drilling operations due to their inability to maintain accuracy while withstanding the rigors of drilling and their inherent costs.

For these reasons, the Drillguide Gyroscopic Steering Tool (GST) was developed. The GST was the first tool designed specifically for use in the HDD industry. Brownline BV out of the Netherlands introduced the Drillguide tool to the European market in 2005, and later to the U.S in 2007. Since its introduction, the Drillguide Gyro Steering tool has successfully completed over 20,000 HDD projects Worldwide.

Initial acceptance of the Gyro Steering Tool was difficult at best to achieve due to the prior experiences and the technological advances to Magnetic Tracking Systems. However, Gyro Navigational Tools are becoming more acceptable and have been specified on more and more projects.

As acceptance and demand for Gyroscopic Technology has grown, there have multiple other companies that have introduced their own Gyro Steering Tool to the industry with varying degrees of success. It is not our intent to leave any current tools out of the discussion. However, for this presentation, the following GST's are being used for comparison.

Brownline

INNOVATION, PRECISION AND RELIABILITY

Drillguide
GYRO STEERING TECHNOLOGY

Brownline's Drillguide Gyro Steering Tool is the original, and only, Gyro Steering Tool specifically designed for HDD operations. The industry leading technology consists of highly accurate components and software which provide a proven accuracy of 0.01° in pitch and 0.04° in azimuth. The Drillguide GST provides real time, highly accurate navigational information which allows for a smoother bore trajectory and has proven to reduce drag and stress during installation.

**For Intersecting Projects, Brownline has developed the RADAR System.
As the bore paths reach the point of intersect, the RADAR Systems are activated and the two systems actively communicate with each other to establish their relative position.
The RADAR system allows for longer drill trajectories with extreme accuracy at the intersect point.**

Radar

GPS track

**For additional verification, Brownline has developed the GPS track.
This easy to operate, portable unit can be placed in any position along the bore path to confirm the location of the GST. This system has proven to be essential to tight tolerance windows along the bore trajectory and provides on target Punch-Outs. GPS track makes it possible to punch out safely in the middle of existing, dense infrastructure.**

Having been deployed on thousands of projects since 2004, the Drillguide Gyro Steering Technology and add-ons have a well-documented record for providing safe and cost-efficient pilot hole operations. Contact Brownline to discuss how we can assist with your project.

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Opti-Trac

A Sharewell HDD Product

STATE OF THE ART, HIGHLY ACCURATE GYRO SPECIFICALLY DESIGNED FOR HDD.

- Gyro sensor unaffected by magnetic interference
- Integrated magnetic ShareTracker system provides secondary position confirmation
- 2 ⅛” OD barrel compatible with customers’ standard tooling, no special BHA required
- Easy setup and transport, tooling ships in hard cases
- Can be run in smaller 4 ¾” drill collar and larger
- Downhole pressure monitoring included
- Pressure barrel rated up to 12,000 PSI
- Proprietary fiber optic gyro design handles the harshest drilling environments

PGM

PARATRACK GYRO MODULE

- Precision pilot hole guidance for HDD in challenging surface locations
- Compatible with the full line of ParaTrack HDD guidance tools
- No specialized handling or personnel required
- Available for purchase worldwide

VECTOR™ MAGNETICS

SPECIFICATION COMPARISON	Drillguide by Brownline	Opti-Trac A Sharewell HDD Product	VECTOR MAGNETICS
Date of Introduction (US)/Netherlands	July 2007/2005	Jan-19	2017
Projects Completed (worldwide)	+20,000	20+	200+
Pitch Angle Accuracy	+/- 0.02 degrees	+/- 0.05 degrees	+/- 0.02 degrees
Azimuth Angle Accuracy	+/- 0.04 degrees	+/- 0.15 degrees	+/- 0.15 degrees
Sensitivity to Magnetic Disturbance	Insensitive	Insensitive	Insensitive
Surface Access - over installation	Not Required	Not Required	Recommended for secondary verification on some bores
Pressure Monitoring	Annular & Internal	Annular	Annular & Internal
Communication	Two Way - Sensor to Surface & Surface to Sensor	Bi-Directional : Sensor to Surface & Surface to Sensor	Two Way - Sensor to Surface & Surface to Sensor
Data Acquisition & Recording	Real Time	Real Time	Real Time,not recorded
Continuous Monitoring of Inc. & Azm while drilling & rotating	Yes	Yes	Yes
Bore path Survey & Setup	No Additional Land Survey Work Required	No Additional Land Survey Work Required	No Additional Land Survey Work Required
Bore Intersect Capable	Yes - Active Ranging Technology	Intersect capability in development	Yes - multiple methods available including Active and Passive
North Seeking Capable	Yes - Minimum 12 Minutes every two hours	Yes - 4 minutes	North Seek performed per-shot as part of regular survey
Grid Wire Tracking Capable	No - Currently in R&D	Yes, Trutracker	Yes
Secondary Tracking Capable	Yes - Trackable from Stationary Receiver	Beacon system in development, not yet operational	Yes
Survey Time	2 to 4 Seconds	10 - 20 seconds	3 minutes
Multiple Surveys per Joint Capable	Yes - at any time	Yes - at any time	Yes - at any time
Power - Input / Output	110 or 220V AC / 56V DC	110 Volts or 220V AC / 110 DC	110 or 220V AC / 46V DC
Hole Size - Minimum / Maximum	7-7/8" to 17-1/2"(17 1/2" with Maxi Hsg.)	6 1/2" and up (Smaller with custom assemb	6" to 24"
Minimum Pipe Size	3.5" Drill Pipe	2 7/8"	3.22"
Vibration Monitoring	Yes	No	Yes, Real Time
Minimum Radius	150m - 492'	110M - 328'	Function of customer assembly
Retrievable	No	Yes - Sharewell Proprietary System	No
Can be shipped in standard hard cases.	N/A	Yes	Yes
Runs in standard collars, with standard BHA's.	BHA provided by Drillguide	Yes	Yes

CONCLUSION

- **Gyroscopic Navigation is an emerging market within the HDD industry and will continue to grow with it. Its believed that Gyroscopic Steering Technology will someday be considered the new standard for a major portion of the HDD Guidance sector of the industry.**

- **Gyroscopic Steering Technology will continue to expand and improve with even higher demands and the need for higher accuracy in any drilling conditions or design factors.**

- **Engineers, Owners, and Contractors need to have the correct information and to ask the right questions when specifying Gyroscopic Steering technology needed for their upcoming projects. As more steering companies enter the Gyro Steering sector, it will be even more important to know the exact specifications and project history of each tool being presented. As discussed and seen in this presentation, not all Gyroscopic tools are equal. Each has its advantages and limitations.**

- **Pick Right be Right(Or On Target)**

THANK YOU FOR ATTENDING

QUESTIONS