TECHNICAL ARTICLE

Wellbore Integrity SOLUTIONS

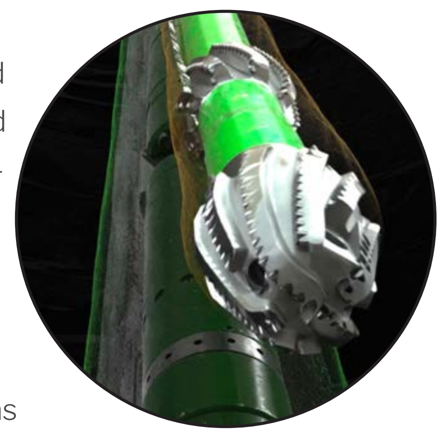
TrackMaster Nexus™

Pioneering a New Era in Single Trip Wellbore Sidetracking Operations

TrackMaster Nexus™ System

The TrackMaster Nexus™ Advanced Whipstock System enhances wellbore sidetracking efficiency by significantly reducing trips and emissions.

TrackMaster Nexus has been developed from the need to enhance operational efficiency, reduce costs, and improve reliability in sidetrack operations. Traditional whipstock systems often required multiple trips and faced challenges with higher-grade and heavy-wall casing, leading to increased rig time and operational expenses. TrackMaster Nexus was created to address these issues, offering a robust, single-trip solution that combines milling and cleanout operations, significantly reducing CO_2 emissions and meeting the rigorous demands of modern drilling environments.



TrackMaster Nexus™

Key Changes and Innovations

The new TrackMaster Nexus System delivers a step-change in operational efficiency during cased hole wellbore sidetracking operations to open a window. Building on the success of the current TrackMaster Select System, TrackMaster Nexus has incorporated numerous design changes and innovations to further improve performance.

To determine and prioritize design changes, a comprehensive study of cased hole wellbore sidetrack operational reports were reviewed and analyzed. The data sample used in this study comprised of over 360 cased hole sidetracks over a 2-year period, both onshore and offshore with varied casing sizes and grades.

Key criteria analyzed included:

- Number of trips required.
- Operational time and cost.
- Emissions produced during operations.
- Supplementary runs required to achieve the desired window geometry.

Full-scale laboratory testing was conducted on a horizontal test gantry to validate design changes and expected results.

As a result of the study, design activities were focused on:

(a) faster system conveyance into the wellbore
(b) integration of wellbore cleaning in the sidetracking bottom hole assembly (BHA)
(c) a revised methodology of predictive modeling of the desired window geometry
(d) changes to the slide profile, mill design, and cutting structure configuration to enable an improved window geometry and drilling BHA pass-through

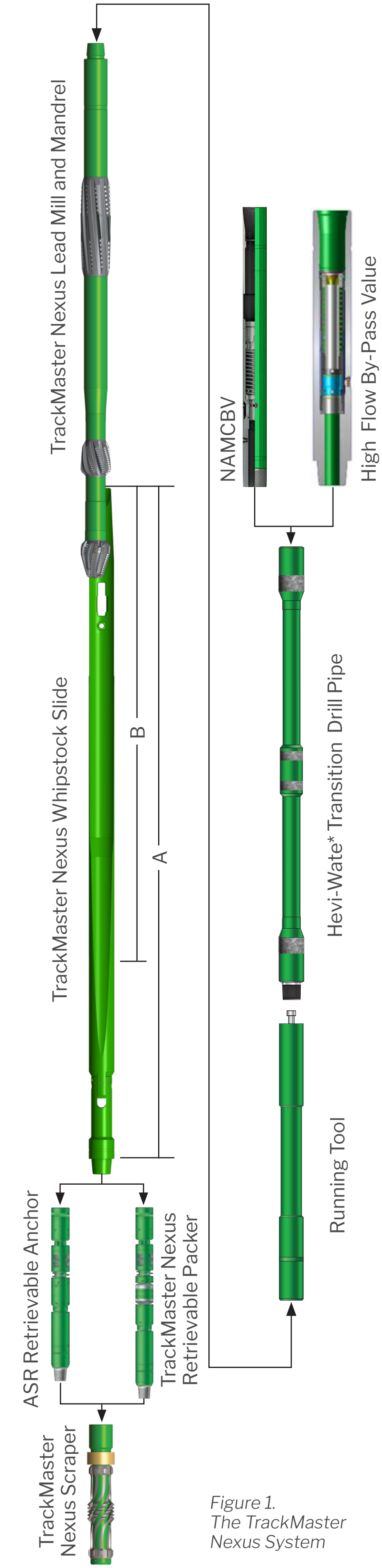


Figure 1. The TrackMaster Nexus System

Key System Design Features

Rapid Conveyance

To reduce the operational time required to convey the system to the desired depth, a new method of mechanically attaching the milling assembly to the slide was developed. Historically, trip speed has been restricted to mitigate risks associated with the shear bolt mechanism that attached the milling assembly to the top of the slide. This new design feature enables full tripping speed, similar to speeds used in standard drilling practices while running in directional wellbores. The rapid conveyance feature also effectively doubled the axial and torsional load carrying capacity of the mechanical attachment mechanism in comparison with the standard wellbore departure systems. Design improvements were implemented without reducing the number of cutters brazed in the mill head or requiring any additional space for the connection. Finite Element Analysis (FEA) and full-scale laboratory testing as shown in Figure 2 were used to validate the design improvements and load ratings. This design significantly reduces operational time and, thanks to its higher load capacity, eliminates the need for drift runs before deploying the TrackMaster Nexus™ System.

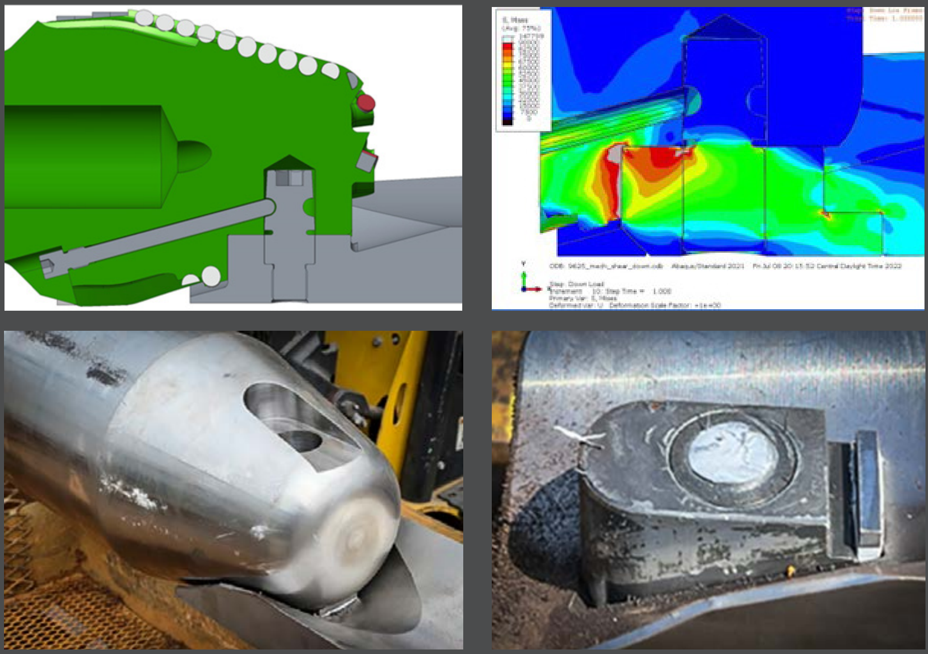


Figure 2. Rapid Conveyance Feature with FEA and Testing Validation

Integral Wellbore Cleaning

The effective cleaning of the casing internal diameter is essential to ensure that a secure anchoring of the casing exit system is achieved. To date, cleaning the wellbore internal diameter (ID) has been done in a dedicated, separate trip with a cleaning BHA. With the reinforced connection between the whipstock and the mill, the incorporation of the specialized TrackMaster Nexus Scraper run as part of the TrackMaster Nexus System, offers an integral cleaning device that is attached below the system anchor or packer. The cleaning device incorporates both a metallic, unibody, non-rotating scraper and brush that provides 360 degrees of coverage that ensures a clean surface prior to anchor setting. The elimination of a dedicated, separate trip to clean the represents a significant reduction in rig time consumed.

Figure 3. TrackMaster Nexus Scraper, integral cleaning device attached to the packer or anchor

WhipSim™

Advanced Predictive Modeling — WhipSim™

A proprietary, predictive modeling software, WhipSim, shown in Figure 3, has undergone several revisions to complement the features and requirements of the TrackMaster Nexus System. The use of WhipSim provides an accurate prediction of the casing exit window geometry for a given set of wellbore criteria. Additionally, critical aspects of liner and BHA passthrough are also evaluated. Design improvements to the whipstock ramp profile and its effect on the window geometry and passthrough parameters were analyzed in WhipSim to ensure compliance to customer requirements such as maximum dog leg severity (DLS) of a drilling BHA passing across the window. The use of WhipSim proved to be invaluable in comparing historical operational report results versus the projected results after design changes.

Optimization of the Window Geometry

An important finding from the comprehensive study that was conducted was the need for further optimization of the window geometry. As drilling BHAs have evolved to incorporate new features and measurement capabilities, they have often increased in length, relative stiffness, and with additional points of stabilization. The consequence of this is that the windows created during cased hole sidetrack operations must ensure that these larger BHAs passthrough the window freely. The bending stresses incurred by these BHAs, while passing through the window, must also be minimized to maintain reliability.

For the TrackMaster Nexus™ System, a FEA baseline study was done during the design process to identify potential passthrough issues, as shown in Figure 4. When the design was concluded, the resulting window length was increased by 5% and bending stresses for a typical drilling BHA, passing through the window was reduced by 10%.

Mill design and cutting structure configuration plays a critical role in achieving the required window geometry and quality objectives. Heavier walled casings are becoming increasingly common in the industry to ensure adequate burst and collapse safety factors. As an example, 9-7/8 inch and 10-1/8 inch casings are replacing conventionally used 9-5/8 inch casing sizes for 8-1/2 inch mills. This often implies milling 50 to 100% excess steel in the same trip. Additionally, the preference for higher grades such as Q125 or T140 over grades such as L80 or P110 places a greater demand on the cutting structure.

As part of the results of the operational analysis completed and the comprehensive FEA scenarios,

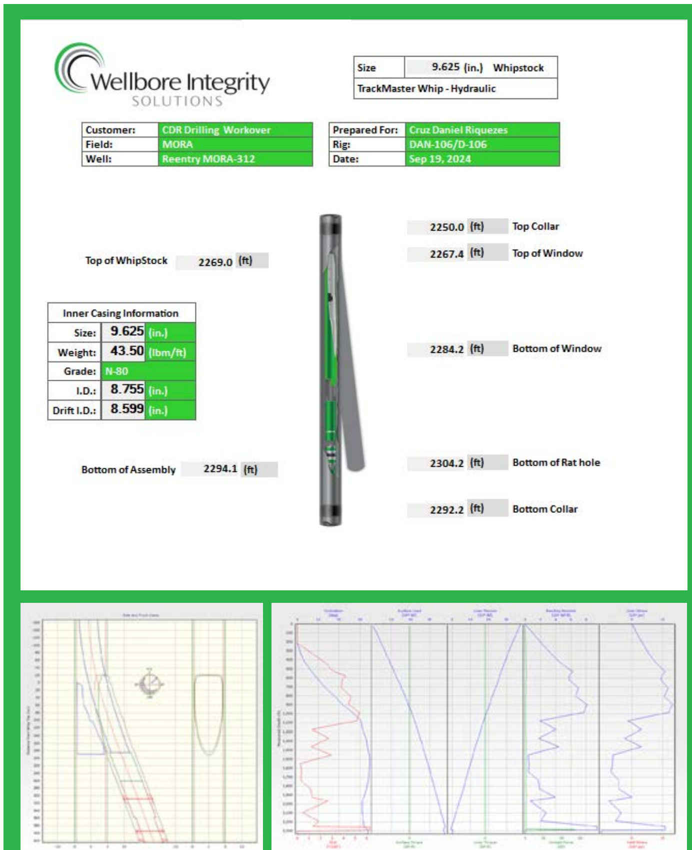


Figure 4. Example, Predictive Modeling – WhipSim

milling performance was found to play a crucial role in determining the quality of the window. The TrackMaster Nexus System addresses this with a state-of-the-art one-piece mill mandrel, featuring integrated blades for both the follow and dress mills. This design is complemented by a robust, high-torque, double-shoulder, proprietary connection. This connection is specifically engineered to have the highest make-up torque within the entire sidetrack bottom hole assembly (BHA), seamlessly linking with the innovative TrackMaster Nexus lead mill, reminiscent of a drill bit in its design.

Emphasis has been placed on ensuring that the lead mill gauge diameter was maintained, thereby minimizing the risk of unnecessary mill runs to enlarge the window, which would impact the overall time and efficiency of the sidetracking operation. Wellbore Integrity Solutions' (WIS) exclusive TruEdge™ technology was strategically incorporated in critical locations, as shown in Figure 5, on the lead mill ensuring both gauge protection and window precision. In addition to the use of TruEdge™ Technology, the TrackMaster Nexus lead mill incorporates brazed-in wear blocks strategically placed in the gauge area, facilitating a smoother cut-out and effective depth-of-cut control. These design elements work in tandem to ensure a high-quality, efficient milling process. As referenced previously, full scale testing on a horizontal gantry system was conducted to both verify and validate the designs.

Successful passing of the BHA across the window is one of key metrics of a successful casing exit operation. The drilling BHAs have evolved generally to become more complex, and in doing so, they have also become increasingly stiffer. This can create an issue when passing across a milled window, which is a point of higher DLS. An improperly designed, planned and executed casing exit operation can result in serious service quality incidents due to failure to pass across the window. During the engineering design phase, FEA analysis was conducted to understand the impact of changes to the whipstock geometry, mill design, casing specifications on the weight on bit (WOB) required to traverse across the window, as shown in Figure 6 to achieve the objective of minimizing the BHA drag.

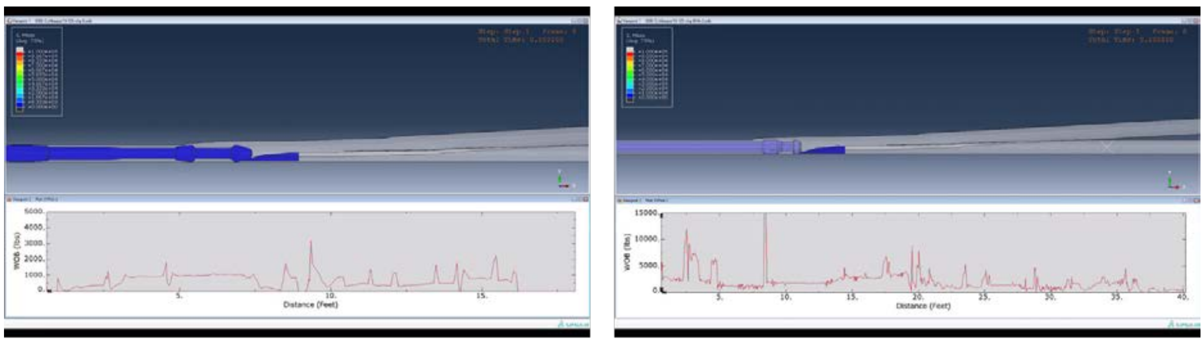


Figure 6. BHA Passthrough Analysis

Operational Efficiency Results

Improved efficiency through reduced rig time and trips are derived from the following key design features:

- **Robust Whipstock-to-Mill Connection:** Integral lug design is twice as strong as the original design, providing enhanced durability.
- **Simplicity on Whipstock Connection:** Keeping a break-bolt design as the standard whipstock, reducing make-up times and eliminating the need to mill complicated collars or apparatus downhole while milling the window.
- **Faster Tripping Times:** Achieves tripping speeds up to 19 standards per hour, enhancing operational efficiency.
- **Optimized Whipstock Slide Geometry:** Extended ramp without increasing overall whipstock length for better performance delivering a 5% longer window with 10% less equivalent DLS for pass-through BHA.
- **Advanced Predictive Model:** Performed during the planning process and prior to wellsite operations which resulted in greater execution reliability.
- **High-Grade and Heavy-Wall Casing Milling Capability:** Efficiently mills through higher-grade and heavier casing, all mills are reinforced with TruEdge™ cutters for gauge assurance.
- **True Single-Trip Operations:** Combines milling and cleanout in one trip, reducing operational time and cost.
- **TrackMaster Nexus™ Follow and Dress Mill Mandrel:** Advanced mill mandrel design with integral blades, getting away from welded blades increasing durability, delivering the highest resistance to torque and bending among commercial systems.

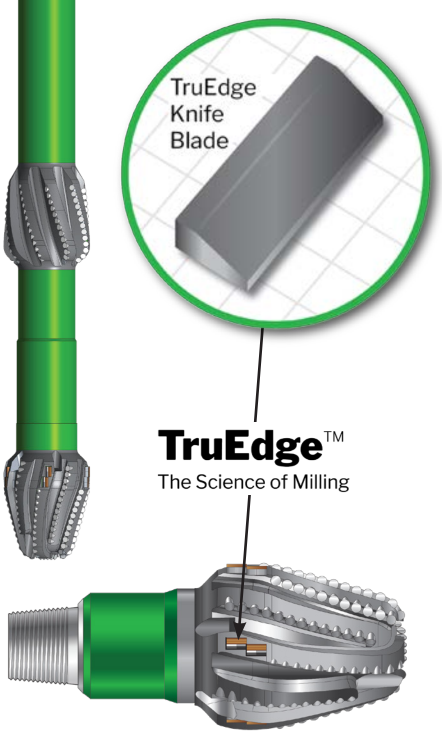
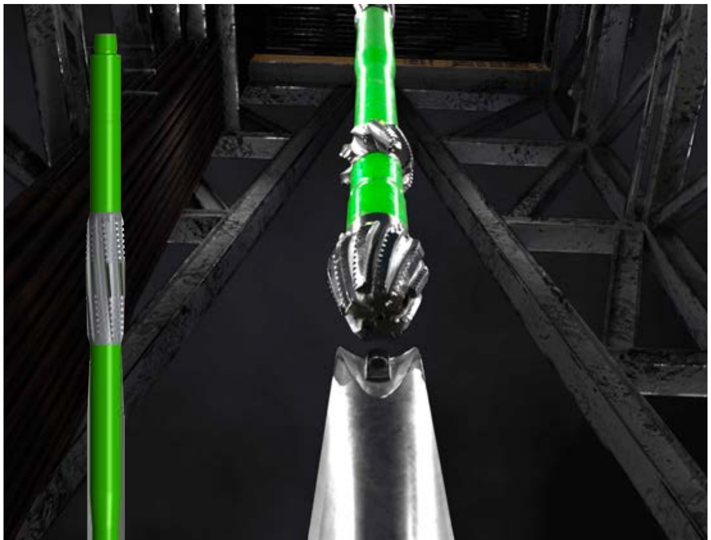


Figure 5. The Use of TruEdge Technology



- **Sealing Capability Below Whipstock:** Reliable anchoring mechanism to ensure stability during operations can also be run with retrievable packers, for sealing capabilities below whipstock.
- **Total or Partial Losses Setting and Milling:** Can be deployed in wells with total or partial losses, while isolating the hole below the whipstock.
- **Low-Side Capabilities:** Can be set to the low-side if require without sagging of the slides (shims are required).

When applied to the data sample of over 360 cased hole sidetracks, the time saving per sidetrack averaged 21 hours.

Environmental Impact

The TrackMaster Nexus™ System fosters environmentally conscious operations by significantly reducing CO_2 emissions right from its manufacture. Its integral mill design minimizes welding emissions during both construction and repair processes, avoiding the use of crushed carbide for the cutting structure and welded blades in the mill structure. The whipstock's length also reduces waste when handling raw bar stock. The most significant environmental benefits arise during rig operations, where the system reduces both the number and duration of trips. This reduction in operational time, combined with the reductions while manufacturing the system and the sidetrack assurance features of the TrackMaster Nexus System, leads to a notable decrease in CO_2 emissions.

When analyzing data from over 360 cased hole sidetracks, only the operational impact of the system is estimated to reduce CO_2 emissions by a total of 7,000 metric tons.

Feature	CO_2 reduction per sidetrack (MT)	Notes
Integral Wellbore Cleaning	42	Average value, offshore and onshore data
Rapid Conveyance	10	

Figure 7. Emissions Reduction – Integral Wellbore Cleaning and Rapid Conveyance

The **TrackMaster Nexus System** introduces a new era in whipstock technology, aiming for enhanced performance and significant reductions in CO_2 emissions. This next-generation system sets a new benchmark for wellbore sidetracking operations, building on robust experiences and lessons learned from legacy systems. Through thorough analysis, Finite Element Analysis (FEA), and real milling validation, the TrackMaster Nexus System has demonstrated substantial improvements. The system enhances operational efficiencies and significantly cuts emissions. Its innovative design and advanced predictive modeling capabilities also increase reliability and reduce risks during the casing exit process at the wellsite.

OPERATIONAL EFFICIENCY

ESG

Reduced Safety Risk

Over **360 cased hole sidetracks**

21 hours time savings per sidetrack

Equivalent CO_2 Emissions:

7K METRIC TONS **CO_2 REDUCTION**

This is equivalent to greenhouse gas emissions from:

17,955,991 miles driven by a gas-powered passenger vehicle

OR

1,386 homes' electricity for 1 year

This is equivalent to greenhouse gas emissions avoided by:

304,952 trash bags of waste recycled instead of going into a landfill

This is equivalent to carbon sequestered by:

8,197 acres of U.S. forests in one year

TRIP FAST | SCRAPE | SET | MILL | ALL AT ONCE

Source: United States Environmental Protection Agency (EPA)

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Specifications are current at the time of printing.