



HOW TERRAIN FOR DRILLING ENABLES MORE ACCURATE DRILLING

AND WHAT IT CAN MEAN FOR THE EFFICIENCY OF ALL YOUR MINING OPERATIONS.

As the first step in the mining value chain, drilling can have a profound impact on the efficiency of every other operation down the line. A well-executed drill pattern improves fragmentation while requiring less explosive material. Good fragmentation pays off in turn with reduced needs for rock breaking, better loader bucket penetration, higher haul truck fill factors and more efficient crusher operation.

There's a lot riding on the outcome of drilling operations. Fortunately, drilling technologies have taken dramatic leaps forward over the past several years, with automated operator assist functions and, in the case of Cat® MineStar Terrain for drilling, sophisticated guidance and strata reporting capabilities.

Terrain uses high-precision satellite guidance to help operators locate holes precisely according to plan. Accurate depth sensing ensures that holes are consistently drilled to exactly the right toe depth, regardless of collar height. Terrain also identifies variations in bench geology and provides comprehensive reporting on all facets of drill plan completion.

In this paper, we'll take a closer look at some of these capabilities, show you how Terrain for drilling can help your drill operators execute to plan more accurately and predictably, and offer some examples of how that accuracy pays off across your operation.

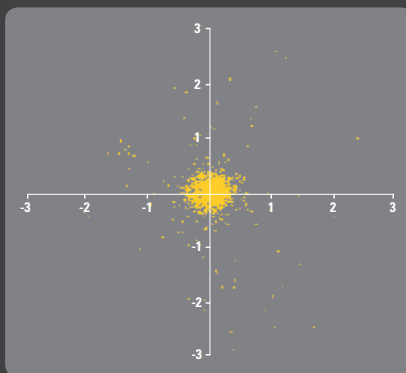
SATELLITE GUIDANCE ENSURES ACCURATE HOLE PLACEMENT

Terrain's high-precision GNSS guidance puts your operators right on target. An in-cab display shows when drills are aligned with the GPS coordinates of each planned hole. As a result, even relatively inexperienced operators can consistently drill within the designed location tolerance, producing optimal charge distributions and consistent powder factors.

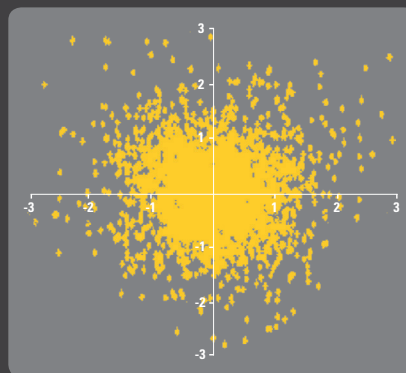
Studies show that Terrain for drilling delivers up to four times better pattern accuracy. As this illustration shows, drilling with precision satellite guidance results in much less variation in hole locations. Terrain guides drill operators to within centimeters of the planned location. It also reduces or eliminates the downtime and expense for survey work, which can result in substantial savings in both money and manpower.

To further reduce costs and improve drilling accuracy, drill-to-drill hole status sharing makes drill plan updates easy to implement, with less chance for "missed memos" and human error. Plus, as drills operate, real-time hole status data is transmitted to all the drills sharing the same pattern. This feature improves productivity by preventing operators from trying to rework previously drilled holes, saving time and improving drill fleet productivity.

DRILL POSITION ERRORS WITH GPS



DRILL POSITION ERRORS WITHOUT GPS



To measure the short-term payback of Terrain for drilling, a mine site in Brazil used the system alongside its traditional drilling methods. The two methods were tested for hole depth accuracy, hole alignment and inclination, and the spacing and placement of drill hole mouths. Using Terrain, drill operators were able to execute patterns more accurately, resulting in reduced explosive costs, better fragmentation and a nearly 5% improvement in downstream loading tool productivity.



Rope shovel productivity	3,075.00 tons/hr.
Rope shovel productivity with Terrain	3,226.85 tons/hr.
Gain in rope shovel productivity	4.94%
Total material moved	58,480,000 tons
Number of rope shovel hours needed (current)	9,508.94 hours
Number of rope shovel hours needed with Terrain (predicted)	9,061.46 hours
Hourly cost for rope shovel with 10,000 hours (manufacturer)	\$610.27 per hour
Annual reduction in rope shovel costs	\$273,082.73

DEPTH ACCURACY ON ROUGH GROUND

Just as important as hole location, toe depth plays a key role in the effectiveness of a shot. It also determines the grade of the resulting bench. A smooth, level bench is easier for equipment to work on, helping to reduce tire damage and machine component wear.

In most drilling operations, machine operators are given a single drill depth for all of the holes in a pattern, but that can lead to problems on a rough or irregular bench. If the operator drills all holes to the same hole depth, the blasted surface will replicate the initial, irregular bench surface.

With Terrain for drilling, no matter the condition of the bench surface, the system automatically identifies the collar elevation and calculates the correct drill depth and inclination for each hole. By delivering toe depth accuracy within 10 cm, even on rough ground, the system dramatically reduces over- and under-drilling for predictable shot results.

Measuring from the toe of the hole and projecting upward to indicate the hole collar start position enables Terrain to dynamically alter the depth of each hole to be drilled—allowing for precise drilling on uneven benches. When a Brazilian mine site drilled a pattern without Terrain, the average hole depth error was 38 cm. When using Terrain to drill a similar set of holes, the margin of error was reduced to 1.4 cm.

Number of holes per year	72,006.32
Average depth of hole	15.44 m
Total meters drilled	1,111,777.52 m
Average error of sub-drilling without Terrain	0.93 m
Average error of sub-drilling with Terrain	0.02 m
Average hole depth with Terrain (predicted)	14.53 m
Total meters drilled with Terrain (predicted)	1,046,251.77 m
Total meters saved per year with Terrain	65,525.75 m
Total reduction of planned meters drilled	5.89%



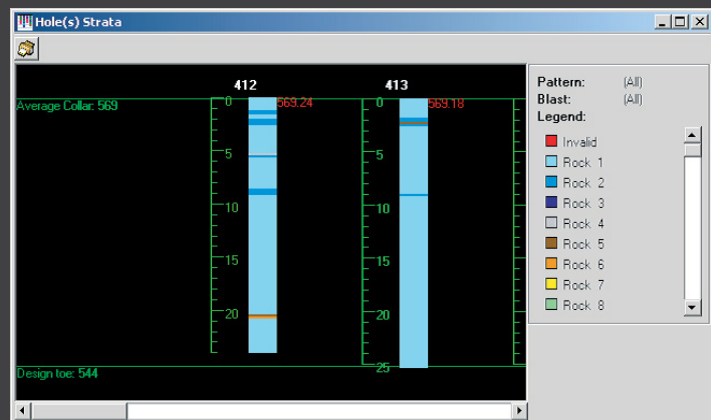
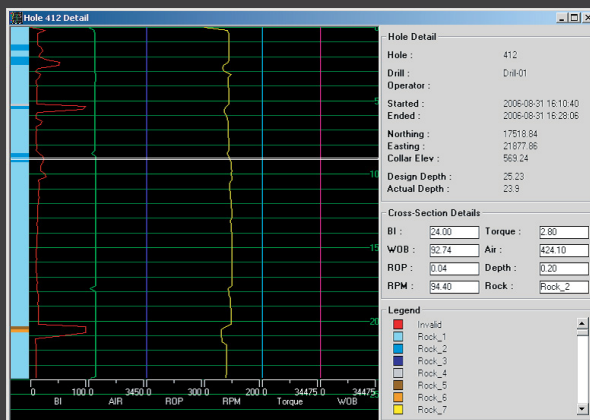
STRATA RECOGNITION & REPORTING

Cat Terrain for drilling includes Strata Recognition and Hole Profile options that work together to provide real-time online analysis of drill operating parameters. These tools show how hard the drill is working and how fast it is able to move through various strata, enabling the system to analyze the makeup of the rock mass.

An exclusive algorithm within the Terrain office software then produces a Blastability Index, which gives a clear understanding of the relative rock hardness at that site. It also identifies elevation of strata structure and changes.

With the Blastability Index in hand, you can better match powder factors and other hole-loading criteria to the characteristics of the rock mass to obtain optimal fragmentation upon blasting. Strata information can also be used to fine-tune other downstream processes for improved blending and optimized crushing, as well as for planning future mine site expansion.

Strata Recognition displays real-time variations in the rock mass of the bench, allowing you to better plan hole-loading for optimal blasting. In drill-to-coal applications, the onboard rock mass information enables operators to better determine the location of coal seams and react accordingly.



GREATER ACCURACY IS JUST THE START

Along with helping your crews execute drill patterns with unprecedented accuracy, Terrain for drilling offers features such as consumable tracking that help you monitor and control costs.

There are a wide range of safety features, too, including avoidance zones, pipe-in-hole alerts, and a Bootleg Display that allows designers to indicate the location of previous bench bootleg locations on the current bench, helping to prevent potentially dangerous redrills.

These topics and others are covered in depth in webinars and white papers from Caterpillar Mining.

For more information, visit www.cat.com/terrain or contact your local dealer.