



WHITE PAPER

Navigation Requirements for Mining

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Navigation of mining equipment in open-pit mines and quarries can bring a series of challenges. Mapping (geospatial) of a mine and the activities at a mine site are vast and complex.

For example, large haul trucks that transport ore and rock from the bottom of mine to the processing facility must be navigated with precision for both safety and efficiency reasons. One manufacture of large haul trucks claims that automated mining trucks can save 15% on operational costs and reduce tire wear by over 40%, and these vehicles are dependent on GPS/GNSS. Excavation equipment, blasting, fleet management, survey drones, and security also all use GNSS to help deliver the precision and reliability each of these functions needs. Many mines have RTK/PPP systems and private LTE/5G networks to ensure precision and reliability. However, that doesn't solve all of the GNSS challenges, such as signal blockage.

Since an open-pit mine is dug into the ground the equipment is often operating "below grade" and sometimes next to the pit shell. The walls of the mine block GNSS signals just like a building in a city, reducing the accuracy and availability of GNSS. Making it more complex, the satellites are in orbit and constantly changing positions. As the lines of sight change, GNSS can be good one minute and poor – or even unavailable – the next. Moreover, the topography of a mine is constantly changing and thus changing the GNSS coverage in the mine. Knowing where and when GNSS will meet a mine's various operational requirements has significant impacts on safety and efficiency.

The use of GNSS (Global Navigation Satellite System) technology has many potential advantages for autonomous mining operations. Here are some of the key benefits of GNSS technology:

1. **Accurate Positioning:** For precise positioning of mining equipment, which is essential for autonomous mining. By accurately determining the location of mining vehicles and equipment, companies can optimize the movement of resources and minimize collisions and downtime.
2. **Real-Time Tracking:** Real-time tracking of mining equipment and vehicles, allowing mining operators to monitor operations from a centralized location. This can help improve efficiency, reduce costs, and enhance safety.
3. **Improved Safety:** By monitoring the movements of mining vehicles and equipment, companies can identify potential hazards and take preventive measures to avoid accidents.
4. **Increased Efficiency:** By tracking the movement of mining vehicles and equipment, companies can optimize routes, reduce fuel consumption, and minimize downtime.
5. **Data Collection:** Providing valuable data on the movement of mining equipment and vehicles, which can be used to optimize mining operations, improve planning, and inform decision-making.
6. **Remote Operation:** Enabling remote operation of mining equipment and vehicles, reducing the need for on-site human operators. This can improve safety, reduce labor costs, and enhance efficiency.

What's the Impact?

Mining operators using autonomous or assisted vehicles and equipment need to know where and when GNSS will meet their requirements in terms of signal quality, understanding the location and duration of any degradation or outage. They need to have this information for the mine in real-time, and as a forecast as the topography of the mine changes.

Without GNSS forecasting mining operators may have unexpected failures of equipment, inaccurate survey, the wrong equipment for the environment, and poor utilization.

Recommendation

Spirent's recommendation for reliable GNSS positioning in open-pit mines is to perform a geospatial forecast of GNSS performance using 3D maps of the mine and precise orbital models to determine where and when GNSS satellites are line-of-sight (LOS). The forecasts can determine where GNSS will always work, where degradations occur, how long they are, and how severe they are. This information can be customized to the performance capabilities of the machinery to determine where and when it is safe to operate. Moreover, this information can eventually be used in real-time to improve performance.

Foresight Risk Analysis (stay where it is always good)

Spirent provides a Foresight Risk Analysis that includes best case, worst case, and 90th percentile GNSS performance heatmaps for every square meter of the mine. A GNSS operational heatmap is also provided including the longest single degradation and cumulative degradation over a GNSS performance threshold.

The worst-case Risk Analysis can be used to determine areas that are always safe to operate for any equipment, survey, and RTK base station placement. The longest single degradation can be used with equipment that has inertial or other backup PNT systems that can withstand short interference, such as automated trucks. See example in Figure 1.

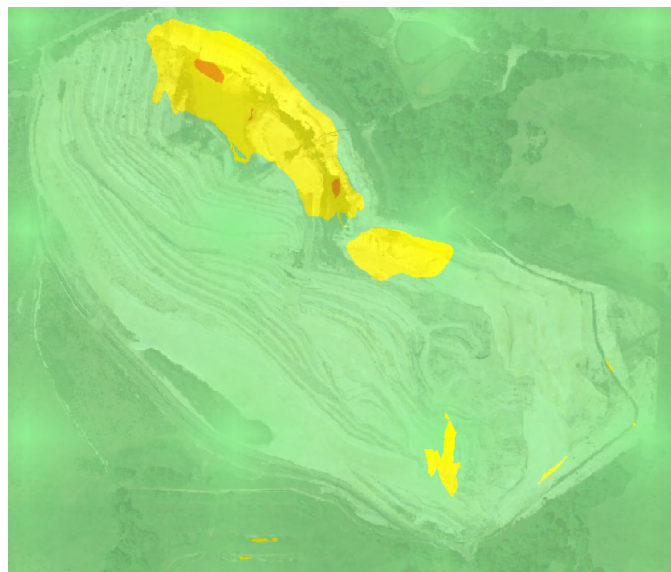


Figure 1 – Example of Foresight Risk Analysis Worst Case (UK Mine Site)

The best case Foresight Risk Analysis can inform the mining operator if GNSS is ever good in an area of interest or if it is consistently degraded. This helps the operator know if other technology or traditional human operation is required in that area of the mine. If a mine operator has CAD renderings of different evolutions of the mine, these can be used to determine whether performance will be improved or degraded. See example in Figure 2.



Figure 2 – Example of Foresight Risk Analysis Best Case (UK Mine Site)

To help make the GNSS information actionable for a mine site operator and supplier Spirent provides degradation reports. Figure 3 illustrates the areas that will have a PDOP better than 4 for 0-1 minutes in dark green. The lighter green areas are higher risk as the GNSS+INS may not be able to handle a longer term degradation.



Figure 3 – Example of Foresight Degradation Duration (UK Mine Site)

About Spirent

Spirent Communications (LSE: SPT) is a global leader with deep expertise and decades of experience in testing, assurance, analytics and security, serving developers, service providers, and enterprise networks. We help bring clarity to increasingly complex technological and business challenges. Spirent's customers have made a promise to their customers to deliver superior performance. Spirent assures that those promises are fulfilled.

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Conclusion

GNSS is critical for mining operation. However, GNSS satellite signals can be blocked by the walls and topography of the mine. This reduces the reliability and accuracy, and, therefore, the overall useability of GNSS. GNSS Foresight Risk Analysis provides a comprehensive prediction of GNSS performance over time at a mine, for every square meter. The prediction of GNSS performance enables automated trucking, mining, survey, and fleet tracking by avoiding areas of degradation and/or knowing how long durations exist in the mine as it exists today, or in the future.

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