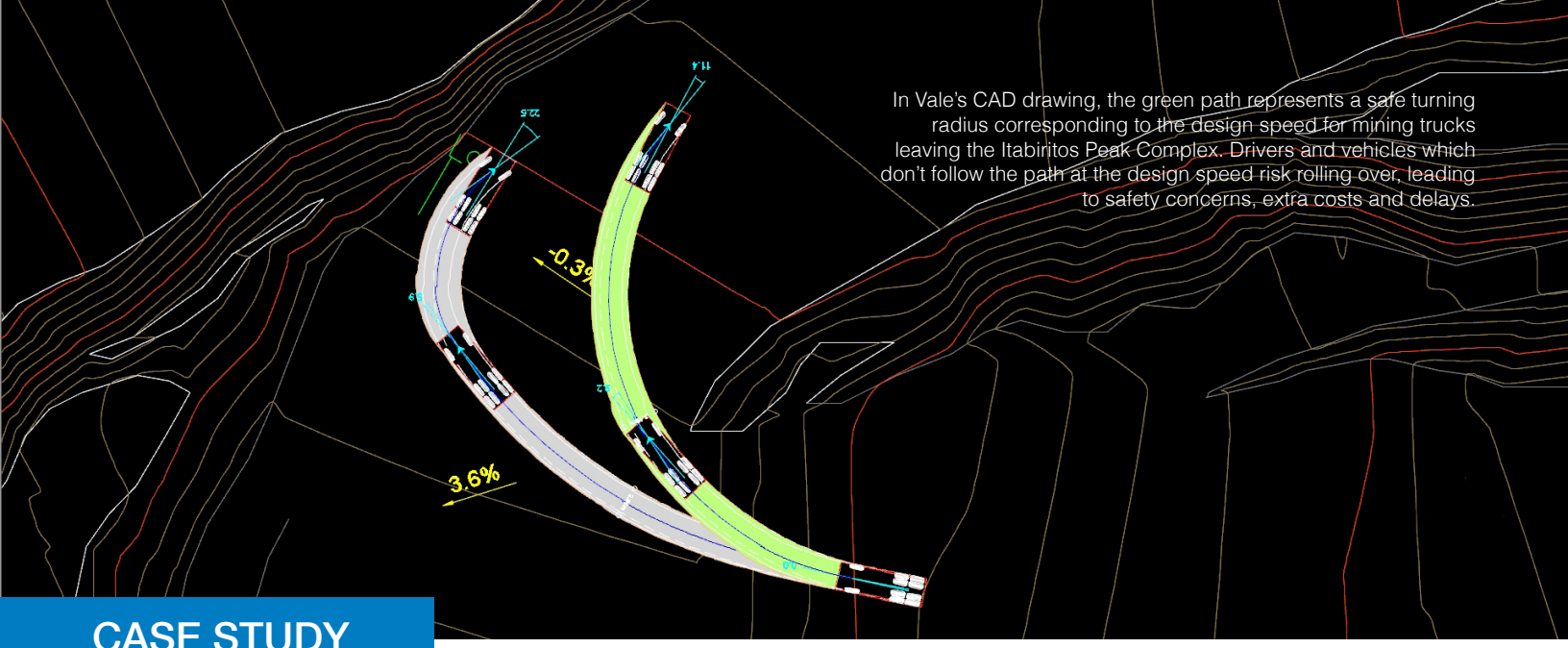


In Vale's CAD drawing, the green path represents a safe turning radius corresponding to the design speed for mining trucks leaving the Itabiritos Peak Complex. Drivers and vehicles which don't follow the path at the design speed risk rolling over, leading to safety concerns, extra costs and delays.

CASE STUDY

AUTOTURN®

Mining Companies Use Technology to Avoid The Tipping Point

Planning safe routes down the mountain with AutoTURN

By Chris Johns, Transoft Solutions

When mining trucks and steep, winding roads meet, more emphasis must be placed on safety.

Around the world, mining companies face enormous time and financial pressures to get the natural resources out of the ground. If a truck tips over on the way from the mining site to the processing plant, the consequences can be serious. With today's road design software technology, that kind of mistake is a preventable one.

Vale S/A is one of the biggest mining companies in the world and they operate several mines in Minas Gerais in the eastern part of Brazil. In addition to iron ore, they have nickel, copper, coal and manganese mines throughout the country. With hundreds of trucks making trips to the various mines daily, the route they take must be planned carefully and Vale S/A relies on AutoTURN to plan the vehicle paths. The engineers and planners need to know how vehicles like the Mercedes 6x4 truck loaded with iron ore will behave when faced with sharp turns and changing terrain.

As one of the BRIC nations' (Brazil, Russia, India, China) leading the world in economic production, Brazil is developing its natural resources to fuel its growth. With wind turbines in the northeastern states and coffee, soy bean, citrus plantations and beef ranches in the south, Brazil has a variety of resources to sell to the world. In Minas Gerais, the fourth largest state in the country, the mountains and valleys are rich with iron ore deposits, which fuel the steel mills further to the south of the capital of Belo Horizonte. With dozens of mines in the area, big mining trucks are a very common sight on the roads. Roads are built based on the kinds of trucks needed for the mining operations and keeping them safe is an important job for the trucking companies.

One of the country's oldest ore deposits is located at the Itabiritos Peak Complex, consisting of the Chicken Coop, Pico and Sapecado iron ore mines. According to Antônio Carlos De Miranda Francisco, one of Vale S/A's production engineers who help design roads for the mines, there are many years left of production at the site.

"The operation began in the early years of the 1940s, so they have already had 74 years of operation of the project," said Mr. Francisco. "The expectation is that the mines in Sapecado and Galinheiro will be exhausted in 2035 and 2039, respectively."

Mr. Francisco began using AutoTURN in 2013 to perform investigative analysis when a Mercedes Benz 6x4 truck tipped over leaving the Itabiritos Pico mine area. The accident occurred at night, when the operator of the truck entered a roundabout too fast where the maximum recommended speed is 17km/h or less. In addition to the roundabout investigation, he has used AutoTURN to plan road geometry around the Itabiritos Peak Complex.

Mining companies in Brazil must follow guidelines from the Ministry of Labour and Employment, including NR-022. This

guideline states that the minimum width of lanes in open cast mines should be twice the width of the largest vehicle used in single lane roads and three times greater than the width of the largest vehicle used on a dual carriageway.

“The AutoTURN software played a key role in the analysis of road geometries in the mines, mainly in the width parameter of the curves, where we know there is a need to have a larger size than in the straight sections,” said Mr. Francisco. “Although we have to follow the NR-022 regulations of the labor ministry, it usually occurs in situations where the roads need to adjust to the various models of vehicles traveling to the mine. AutoTURN helps us streamline operations in determining bottlenecks in the flow of transport vehicles and also helps us improve the safety aspect.”

After the accident, Mr. Francisco used AutoTURN vehicle swept path, to evaluate the speed at which the truck was travelling and the turn radius the driver was using. The Vale S/A safety committee wanted to learn what speeds were acceptable within the safety ranges. He gathered data from the trucking company and from local authorities to make his calculations for the AutoTURN simulation.

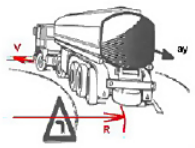
“It was a question regarding the speed of the operator at the time of the accident,” said Mr. Francisco. “The safety committee approached us to help them identify the radius of the trajectory performed by the truck in order to then calculate the average speed.”

Engineers at Transoft Solutions have applied extensive research to the relationship between vehicle speed and turning radius and transportation engineers value this unique feature of AutoTURN. The software demonstrates that the higher the speed of the vehicle entering the turn leads to a larger turning radius. Mr. Francisco used the vehicle libraries within AutoTURN to find key measurements for the Mercedes Benz 6x4 truck and recreated the road geometry where the accident took place. With AutoTURN providing insights on the optimal path and speed of the vehicle, he could show what needed to change.

“The starting point of the work was to identify the correct position of the truck at the instant that the accident took place,” said Mr. Francisco. “This was achieved by simulating the overturning truck, placing it in the normal position, with all wheels on the ground and calculating the offset distance from the curb of the median island of the roundabout. This measure was taken by the safety team when the truck was still overturned. The actual distance was determined by subtracting the width of the vehicle,” he continued.

According to the limit of tipping and the coefficient of friction of the pavement, vehicles always **overturn before skidding**.

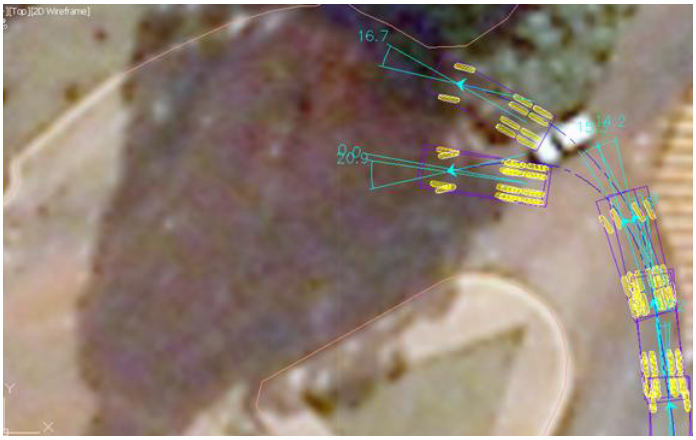
And this difference is crucial: if the truck driver is at a wrong speed on a curve, the truck will simply overturn.



Whenever the relationship of speed and radius to the curve provides an acceleration above 0.3 g’s (and there isn`t any correction of a superelevation) overturning will occur frequently at this point.

Truck of the drivers going to and from the Itabiritos Peak Complex sometimes contend with a lack of visibility on some of the turns and lane widths which are too narrow on some sections of road. Mr. Francisco studied the accident data carefully and showed the Vale S/A safety committee what speeds were recommended for safe transport of the iron ore to the processing facility. The use of AutoTURN puts important safety information at his fingertips.

“Our technical team can evaluate the truck routes to our iron ore mining sites with greater accuracy and confidence,” said Mr. Francisco. “We now know critical points along the route that must be changed to make things like the turning radii and working width safer.”



The vehicle swept path of the Mercedes Benz 6x4 illustrates the optimal path versus the path on a roundabout where the truck turned over.

Before starting his career with Vale S/A, Mr. Francisco used AutoTURN as a graduate student at Faculdade Pitagoras. He knew firsthand that the software could help him with his work with Vale S/A.

“We learned about AutoTURN through a term paper that I wrote with some other students as part of my program to graduate with a production engineering degree. After combining AutoTURN with InVision, we could analyze the safety considerations of our transport fleet of small, medium and large off-road trucks.”

From the early days of AutoTURN, accurate and reliable results and engineering controls have always been in place to give road engineers confidence that their designs were safe. If the software helps companies like Vale S/A operate more safely and efficiently, it has done its job.

“At Transoft, one of our most important design philosophies is to provide design and analysis tools that enable the designer to make their designs safer and more efficient,” said Steven Chan, Director of Product Management at Transoft Solutions. “Mining operations can be dangerous and we’re gratified that Mr. Francisco had used AutoTURN in his university studies and transferred his knowledge to his work with Vale S/A. The relationship between speed and turning radius is a key concept that is considered in AutoTURN. With this tool, an engineer can design with confidence.” ■

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