Towards the Future of Automated Operations

Autonomous operations are looking to be the future of the mining industry. But is the industry really ready for an autonomous environment? ***By Jason Nitz***

Much like the boom in autonomous agricultural equipment during the 1980s and 1990s, autonomous equipment has well and truly made its entrance in the mining sector. Over the past decade or so, various OEM and miners have been working together to test and trial various autonomous mining equipment, including haul trucks, drills and shovels. Autonomous equipment is not a relatively new development. Apart from the real genesis in farming 30 years ago, autonomy has been found in other industries for just as long. So why has the uptake in mining taken so long? For other industries like oil and gas, and farming for that matter, the ability to use human operators has been restricted for several reasons and this has seen the development and uptake exceed that of mining. For oil and gas, using operators for high-risk tasks is simply not an option, so the need for autonomous equipment like submersibles for offshore rigs has driven this necessity. For farming, the need for precision ploughing and cultivating, in other words producing more with less, drove the need for equipment that could navigate itself.

But before we get in-depth into any discussion on autonomous equipment in mining, let's talk about what 'autonomy' is. In general terms, there are two stages of autonomy with regards to mining equipment: semi-autonomous and fully autonomous, often referred to as just autonomous. With semi-autonomous, the equipment is still operated by a human for some tasks, but for others, the equipment performs all the tasks by itself. In autonomous equipment, no human operators are involved in the operation of the equipment. In the case of autonomous haul trucks, no operator is present in the cab nor is there an operator sitting in a control room driving the truck at various points of its hauling route — the complete cycle is performed without operator intervention. The trucks are monitored in a control room, either on site or remotely, but this monitoring is purely to ensure the trucks are running efficiently in terms of production.

And to add to the confusion around autonomy is remote-controlled equipment. This machinery can be operated by close-range remote control such as dozers working in dangerous or unstable ground. An operator standing on the ground but out of harm's way operates the equipment using a set of controls similar to that in the cab. This equipment is not autonomous as it does not do any work on its own so

Rio Tinto's autonomous haul trucks

therefore we usually exclude this from discussions on autonomy (though it does get included on some occasions).

Locating the assets

So how does autonomous equipment — the size of a small house — navigate itself around a mine while there are numerous other pieces of equipment all doing the same? The answer lies in geospatial awareness through the use of high-precision GPS positioning. When boiled down to its basics, the fundamental process of mining is all about knowing where key important 'assets' are. As the location of the ore is the primary focus for the actual mining process, knowing the location of this makes positioning the associated mining equipment easy. Or does it? For surface mining, the key to geospatial awareness is good positioning. For non-autonomous haul trucks, low precision GPS is enough to serve the purpose. By low precision we mean within 5-10 metre accuracy. But, for autonomous haul trucks driving themselves in close proximity to other operating equipment, low precision just doesn't work. You need high-precision GPS for these types of tasks where centimetre accuracy can allow the positioning of trucks next to shovels for loading as well as other close proximity tasks.

And herein lies the problem for open pit mines. In order to have high precision GPS positioning, you need visibility of many satellites to provide a high dilution of precision, or spread, in order to give the best fix. But with open pit mines, this visibility is often restricted by the high pit walls. The deeper you go, the more these high walls block satellite visibility with the result being your autonomous haul truck no longer has the accuracy it needs for close proximity tasks like shovel loading. Other technologies like radar and lasers can and do allow these close proximity tasks to occur, however the fundamental geospatial awareness of an autonomous system is based on high-precision positioning through GPS. This is why we currently see the largest uptake of autonomous equipment in mining is at mines where their operating environment is able to exploit high precision positioning like the flat, open iron ore mine of the Pilbara in the NW of Western Australia. Here most pits are long, relatively flat, or have been purposely designed to allow the use of autonomous mining equipment.

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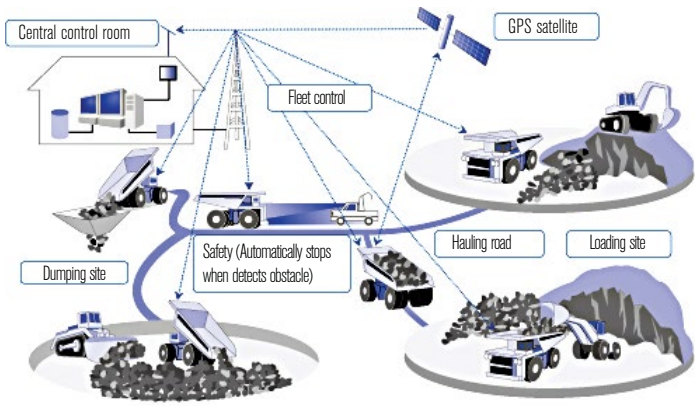
Profit mining & job loss

So what are the benefits of autonomous mining equipment? The usual image associated with an autonomous mine is one of large job cuts due to the reduction in the number of people. Whilst job cuts will ultimately occur, job transition is a better way to describe the evolution of jobs in an autonomous environment. Where there used to be operator-driving the equipment, they will now move into monitoring and overseeing positions at remote operations centres located thousands of kilometres away. This will see the up-skilling of operators into more technology focused roles, which is where the future of mining is heading and firmly lies. At Rio Tinto's West Angelas mine in the Pilbara, driverless trucks have been trialled since 2008 with over 58 million tonnes of ore moved. And it's here one of the tangible benefits of driverless trucks, or any driverless equipment for that matter, is realised — without human operators, mine planning and scheduling can be achieved with greater certainty which amounts to lower costs and greater production. This is because many people-related issues like sick and annual leave are removed allowing for greater consistency and utilisation of equipment. The cost savings of this are clear for all to see — given the average truck operator's salary is

How Automation Works



Courtesy: Komatsu

A$120,000 ($111,066) per year and it takes four operators to keep a truck running 24 hours a day, seven days a week, moving one truck to autonomous operations can save nearly A$500,000 ($462,775) alone, not to mention the other costs associated with a fly-in, fly-out workforce.

Putting the human resource aspect aside, the real key advantages associated with autonomous equipment are from a safety and productivity perspective. Mining operations can be a dangerous environment, and whilst there are many procedures and engineering process in place to reduce associated risks, removing people from high-risk tasks is the ultimate rung in the hierarchy of controls ladder. Autonomous equipment allows this to occur by removing the risk to operators as it leaves the high-risk tasks to the equipment. Another human-centric issue is fatigue — wherever you have people working according to shift-based rosters, which are not always sleep friendly, fatigue is bound to occur to some degree. Autonomous equipment isn't impacted by this for obvious reasons and hence fatigue no longer becomes an issue — it's been eliminated accordingly to the hierarchy of controls.

In terms of production, autonomous equipment provides increases that are just not possible using human operators. For example, twice per day shift change at mines around the world occurs as regular as clockwork. During this time, most mining equipment is stopped so operators can be changed out. This change out time can range from 30 minutes to over an hour depending on how it is performed. For a mine with a fleet of 20 trucks, an hour of down time each shift change equates to 40 equipment hours per 24 hours. If the average truck tonnes moved per hour is 450 tonnes, this equals to 18,000 tonnes per day lost through equipment unavailability. Over a year this is a staggering amount at 6.4 million tonnes. And one hour lost per day is on the conservative side with real-world figures more like 2-3 hours. So as you can see, the figures add up both in terms of lost production and increased costs. Likewise with drill rigs — during times of blasting nearby, most drill rigs have to be moved for the duration of the blast. This requires the drill to stop operating most times and is simply to remove the operator out of the danger zone should fly-rock happen to hit the rig. In both these previous examples, if autonomous equipment was being used, it would continue operating and no time would be lost which means more production and lower costs.

What's the future

So what the future for autonomous mining equipment? Given the big miners' interest in autonomy, it's clear the trend is here to stay and will feature heavily in the decade to come. Apart from autonomous equipment being taken up by more miners, making it the norm rather than the exception, there are clearly improvements that need to be made in order to make it all that more robust. And one of these areas is in the geospatial arena in terms of positioning reliability and accuracy. Currently, high-precision GPS is the primary method of guiding large pieces of equipment around a mine autonomously. But what happens when we get issues with GPS signals like we did earlier this year with the GLONASS outage? Granted, the reason there are several independent constellations is to avoid complete outages, but the loss of one undoubtedly had an effect on overall positioning capability which was felt worldwide. It's obvious we need something other than GPS to provide positioning; something that can work independently of GPS. And for the past decade or so, this type of technology has been in development and more recently trialled and deployed at a mine site in Western Australia. The technology, which is made up of ground-based stations that provide a local positioning network, also has applications in other industries, which for now are commercially sensitive.

In its current form, the technology from Locata Corporation, a Canberra-based company, requires a GPS signal for initialisation. However, in the not too distant future, this need for GPS will be removed, making it a truly independent system, says Nunzio Gambale, CEO of Locata. This independence is what makes the technology exciting as it removes the reliance on GNSS. Automation in mining, and the requirement for geospatial solutions, is now at an epoch, one which we will see mature over the next decade into the future of mining.

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