# Air control

*The use of mobile mining equipment technology such as battery-electric vehicles and machine automation is influencing mine ventilation design, according to Stantec*

**With evolving requirements around providing 'adequate ventilation' underground and the need to decarbonise operations in line with stakeholder expectations, miners are continuing to look for innovative solutions from their ventilation suppliers, Dan Gleeson reports**

For underground mines looking to extend or establish new workings and adapt their ventilation systems, simulation technology can often be as important as the hardware available on the market.

For instance, at Glencore's Onaping Depth Project, the simulation advances involved with modelling an all-electric mine outlined many ventilation benefits the company will take through to engineering.

Reflecting on this in a presentation titled, 'Building the mine of the future through Craig Mine – Onaping Depth Project', at the *BEV In-Depth: Mines to Mobility* conference in Sudbury, Peter Xavier, Vice President, Glencore, Sudbury Operations, outlined a mine design configured around battery-electric vehicles without the need for a return air ventilation ramp, fresh air raise, three ventilation fans and five ore passes.

Similar observations were made by Goldcorp (now Newmont) when it was at the design stage of its all-electric Borden gold mine in Ontario, with the use of electric equipment enabling the design of smaller drifts and a reduction in the number of auxiliary fans, as well as the removal of a return air raise in the mine.

It is not just battery-electric vehicles influencing ventilation design on the mobile mining equipment side, according to Kim Trapani, Ventilation Engineer at **Stantec**.

"Autonomous technology is great for ventilation because it removes personnel from underground and, so, the air quality only needs to be good enough for the equipment to operate in," she told ***IM***.

Air quality, as well as air quantity, therefore, is increasingly becoming a consideration for mine operations looking to leverage such technology.

One also needs to factor in legislation – current and future – when designing ventilation systems.

This varies from region to region, with some major mining companies having guidelines they apply across all operations regardless of location, and others incorporating plans that try to predict where local regulations will likely go in the future.

Roberto Alvarez, Trapani's colleague and fellow Ventilation Engineer, favours the former approach given higher standards will most likely be adopted in jurisdictions where they are currently less strict.

Miners would do well to look to countries that have significant mining contributions to the economy as well as high safety standards for the 'gold standard' in ventilation regulations, according to Trapani.

"Canada, USA and Australia, to name a few, typically have well-defined ventilation practices and guidelines," she said. "These countries mostly have similar requirements, with some variations between the provinces and the states."

Arguably the biggest influence on mine ventilation design will be the environmental goals that miners have set themselves, which are integral to the wider industrial move towards electrification.

Alvarez explained: "I think the biggest questions out there are still around major emissions reduction goals. Many mining companies have stated their goals to be carbon neutral or zero emissions by some date 10 to 20 years out, but that's not just going to happen without intentional planning and action now."

For Alvarez, the pathway to meeting these goals requires mining companies to mix and match multiple carbon reduction methods that consider the whole mine design and not just individual elements.

"Yes, we can reduce emissions by switching to electric vehicles – which reduce some of the need for ventilation, which also reduces some of the emissions – but we still rely on ventilation for cooling and heating, so what else can we do to cool the mine?"

Considering natural cooling systems like seasonal thermal storage or lake water cooling is a good place to start in terms of mine cooling, he says. Trapani says miners should also more regularly consider the use of heat exchangers as a cleaner way of ventilating mines in cold climates (see **Almost carbon-neutral ventilation** for an example).

The ability to quantify carbon emissions across the mine site may help companies prioritise where the low-hanging fruit is and what aspects related to ventilation may require more design

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and engineering work to reach their ultimate net-zero goals, with Trapani expecting more miners to incorporate such thinking in mine design going forward.

## VoD demand

Against this backdrop it is hardly surprising Ventilation on Demand (VoD) platforms and related iterations thereof have continued to be spoken of in mine ventilation circles.

According to Trapani, interest around these solutions – which can adequately ventilate areas of an underground mine only when required, therefore, saving energy and costs – has remained steady over the last few years.

At the same time, she sees plenty of opportunities to apply the technology right now.

"The power cost for ventilation or refrigeration has always been a significant percentage of the overall power consumption, so I anticipate that we'll continue seeing steady interest," she said.

This opinion is shared by total ventilation solutions provider, **Howden**.

The company recently added Cooling on Demand (CoD) functionality to its Ventsim CONTROL software, which reflects this market demand.

Ventsim CONTROL uses intelligent software connected to Howden or third-party hardware devices to remotely monitor, control and automate airflow heating and cooling to deliver safer, more productive, and lower cost ventilation for mines, the company says. The Ventsim CONTROL solution also offers a 3D modelling capability within the software, which helps users to better predict and control air flows based on what is evidenced in the simulation.

In the case of CoD, this means users can monitor temperatures at deeper levels and push back cooled air more efficiently.

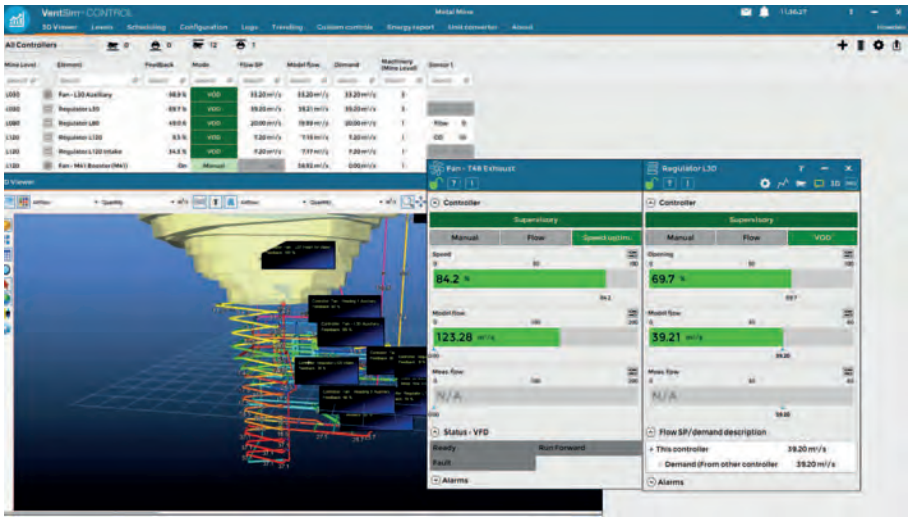
Upon release of the solution last year, Howden said the CoD update aligned with trends it was seeing in the industry towards deeper mines requiring cooled air to achieve higher standards of health and safety for workers.

"Currently, many mines put a cooling plant at surface level and cool air regardless of its destination or where it's needed as there aren't intelligent controls to pinpoint the localised need, which is often at deeper levels," Howden said. "These new controls ensure the cool air goes where it is required, saving operating and energy costs."

The company is currently in the process of lining up a trial of this new functionality with an existing Ventsim CONTROL customer.

Howden has also won several Ventsim CONTROL contracts across the globe, including in South America, Asia Pacific and Europe, of late.

Jose Pinedo, Ventsim Sales Manager, said most of these contracts reflected the mining sector's ongoing focus on cost control, as well as those 'net-zero' commitments.




*Howden recently added Cooling on Demand (CoD) functionality to its Ventsim CONTROL software*

"All the different sites had a payback target in mind, but some of the sites also wanted to know what the implementation of the system would do for their $CO_2$ emissions," he told ***IM***.

Within Ventsim CONTROL, there is an in-built energy reporting tool to show clients their ongoing energy consumption. Following customer requests and in-house development work, Howden has been able to adapt this to generate a rolling $CO_2$ emission indicator that clients can monitor.

"The reduction in energy correlates directly to a reduction in tonnes of $CO_2$ emissions," Pinedo said of the reporting tool. "This means, in addition to what the system will provide in operational terms and operating costs, it can also outline to clients how it will assist them in meeting environmental goals."

Leo Botha, Ventsim General Manager, said the ability for Ventsim CONTROL to reduce the energy consumption associated with ventilation and the direct correlation between these savings and $CO_2$ emission reductions is allowing Howden to assist miners in hitting their environmental goals.

"Up front, when you are having the discussion and talking to mines about energy savings, you are also directly talking about $CO_2$ emission reductions and how this can be used in ESG reporting," he said.

This increased carbon emission visibility, plus expectations of stricter regulations in key mining jurisdictions, is likely to lead more clients towards the use of VoD solutions, according to Pinedo.

"For instance, with Australia adopting stricter diesel particulate emissions, the industry is facing two options in terms of keeping up with legislation: either you retrofit your fleet so you're running more efficient and 'cleaner' diesel engines (US Tier 4 F/EU Stage V) or electric equipment, or you increase your ventilation flow to meet the new emission requirements," he said.

Even if a mine chose Option A – retrofitting their fleet – the ventilation flow requirements may still need to increase, Pinedo explained.

"Without a VoD system, you must have a ventilation system set up based on the required air for x number of vehicles and personnel, regardless of if they are operating at all times," he said.

A VoD system, however, allows mines to push air only to where it is needed based on the vehicles, personnel and infrastructure in place and operating at that given time.

With more mixed fleets of mobile mining equipment expected in the future made up of battery-electric, hybrids and diesel-powered equipment, the benefits of a VoD system able to tap into existing infrastructure for telematics and positioning will be highlighted further, enabling mines to ventilate based on the type of engine/battery the machine is powered by and if there is an operator in the cab.

"What we're offering through Ventsim CONTROL is to use all these existing tools and optimise everything to comply with where legislation is heading and the evolution of 'net zero' mining," Pinedo said.

Agnico Eagle's Fosterville mine is looking to do exactly this in what Howden says is an Australian mining first.

The operation, having already installed Ventsim CONTROL Level 3 (scheduling and flow control), is progressing to an installation that will see the mine's tracking system integrated to Ventsim CONTROL Level 4. This will provide real-time feedback on the vehicle locations in Ventsim CONTROL to adjust the ventilation automatically based on demand.

Ventsim CONTROL software also continues to gain appreciation from customers for its safety capabilities.

"One of the features we have in Ventsim CONTROL is related to fire simulation," Pinedo said. "We also have this in our Ventsim DESIGN software with scenario-based simulations, but the facility on Ventsim CONTROL connects to all your communication infrastructure underground to take an instant snapshot of the status as a fire is happening.

"From a planning point of view, this allows operations to have a much quicker response time based on an accurate, real-time picture of what is going on underground. This provides another tool to allow them to take the right decisions when and if needed."

## On the move monitoring

Improving operator safety underground has also been behind recent collaborative moves from **Maestro Digital Mine**.

The Sudbury-based company has, over the last decade, become synonymous with improving underground mine ventilation safety as well as reducing blast re-entry times, with an offering that includes air quality stations, automated regulators and "fail-safe" LED displays. Its core remains IIoT devices and last mile digital networks for underground mines.

At the recent *2022 Investing in African Mining Indaba*, in Cape Town, South Africa, Dwyka Mining Services, an authorised reseller of Maestro, made a splash, premiering a new robotic solution fitted with Maestro's IIoT gas sensor.

The Boston Dynamics Spot Enterprise robot, equipped with Maestro's IIoT gas sensor, can be operated on mine sites to detect hazardous gases like carbon monoxide, without putting mining and ventilation teams in danger. Ventilation and mining teams will easily be able to add different gas sensors onto the connected Zephyr Air Quality Station, capturing critical environmental data to proactively identify gas or temperature challenges, according to the companies.

The Boston Dynamics Spot Enterprise is designed to navigate all types of terrain, allowing organisations to automate routine inspection tasks, capture data securely and safely, and allow for streamlined operations in complex and dangerous environments.

Using Spot Enterprise on-board processing, the data is shared wirelessly over Wi-Fi, and gas and temperature sensor readings are captured while the robot is in operation and displayed in real time via the Maestro Link™ Server application. With the addition of a SLAM scanning unit sensor, like the Emesent Hovermap, readings can be saved with precise coordinates in a high-fidelity point cloud that can be exported and examined in a variety of mining software packages, Maestro and Dwyka say.

Michael Gribbons, CEO and Co-Founder of Maestro Digital Mine, said: "Collaborating with our mud-in-boots partner, Dwyka Mining Services, who are always pushing the envelope with technology integration with pioneering brands like Boston Dynamics, is in turn pushing us to innovate and collaborate with our core purpose of enhancing lives by the pursuit of productivity and safety excellence.

"This relationship will open up immediate opportunities to Dwyka Mining Services and Maestro in Africa and extend mobile environmental monitoring to our current installations at over 170 mines in 38 countries globally using our patented edge-based IIoT sensor technologies once the solution is fully embedded."

Jamie van Schoor, CEO of Dwyka Mining Services, added: "We are excited about extracting value from 'no-go' and 'fly-low' mining areas typical at the majority of narrow-reef mining operations in southern Africa where the use of enterprise GPS-denied drones become limited. The Spot Enterprise package allows us to access confined spaces and this information could be used to undertake remote gas inspections so that we can accelerate re-entry to target getting ore to surface sooner without compromising safety."

The debut of the Spot/Zephyr AGS™ combination follows hot on the heels of another partnership with Exyn Technologies that has seen an aerial drone with a Maestro gas monitoring IIoT device fitted on it come to the fore.

## Almost carbon-neutral ventilation

Sweden-based mining major Boliden is evaluating many solutions in its quest to achieve its goal of reducing its carbon intensity by 40% by 2030, with underground ventilation being one developing area.

The recent installation of a heat exchanger in the Kankberg gold and tellurium mine, in northern Sweden, marks a giant step toward carbon-neutral ventilation at the operation, according to Andreas Markström, Mine Engineer at Boliden.

Heat exchangers are already used for ventilation purposes at Boliden's Garpenberg mine, south of Kankberg, but, after extending Kankberg's ventilation system, the right conditions have recently been met to incorporate this at the gold and tellurium mine.

At Kankberg, in the winter, ventilated air must be heated using LPG to prevent the shaft freezing. The exhaust air from the mine is heated further, both by geothermal heat in the rock and the vehicles used in the mine. Using the heat exchanger, Boliden can lead the warmer exhaust air past the inlet air on either side of plates such that the heat is transferred.

This process allows the reduction of Kankberg's LPG consumption by 85%.

Since this is the first time the technology has been used in such a cold climate, the Swedish EPA's Climate Leap is subsidising 28% of the circa-SEK20 million ($2 million) investment.

***IM*** put some questions to Markström to find out more about this cold-climate first.

**IM: How does this system differ to the one at Garpenberg? What different systems/components have been put in place to deal with the extreme cold climate experienced in the Boliden area where Kankberg is located?**

**AM:** Garpenberg has several intake and exhaust shafts, which create the opportunity to draw the ventilation through several different paths in the mine.

Boliden have two heat exchangers (HE) running from the same supplier in Garpenberg. In Garpenberg, we can, for instance, increase the exhaust airflow at the shafts connected to HEs to get sufficient heat to avoid the need for other heat sources. The external heat needed is added at the other shafts where we don't have HEs.

The main difference with the HE in Kankberg compared with the one installed in Garpenberg is the distance between the intake and exhaust shaft. The distance between the shafts is a maximum of 50 m in those installations at Garpenberg. The HE in Kankberg proves that this technology will be suitable even where there is a medium distance (230 m) between the intake and exhaust shaft.

The energy lost over the duct system is very small; the main disadvantage is the increase in capital expenditure.

Another difference is the balance of airflow between the intake and exhaust over the HE at Kankberg. Two kilometres from the HE, exhaust air reaches the surface from the main ramp. Some air will always be controlled to go to this path to have plus-zero temperatures in all ramps and avoid icy roads underground.

A third difference is that since there is only an exhaust and intake shaft at Kankberg, we have installed valves after the HE and at the intake station to be able to turn off all airflow from the HE to the mine in case of a fire.

**IM: How much of the required heat for the exchanger comes from vehicle heat and how much from the geothermal heat from the rock? With the transition towards battery-electric equipment, for instance, how will you compensate for the heat loss?**

**AM:** Approximately 3% of the total heat exchanged comes from diesel vehicles and the rest from other sources (eg geothermal, blasts and heat from electrical motors).

With a transition towards battery-electric equipment, the total heat will indeed decrease, but the airflow needed to dilute contaminants from diesel will decrease to a larger degree.

By the time we use such equipment, the mine will be even deeper, which will compensate for the loss of heat from diesel equipment.

The propane gas burners used to heat the air before the HE was installed is still in place to heat the air on very cold days and has more than enough capacity to heat the air if battery-electric equipment is used.

It is, of course, also possible to electrify this source of heat, but for the time being the incoming power line does not have enough capacity to add this load to the mine.

A new power line will be constructed at Kankberg by 2024.

**IM: Do you also have a VoD system installed at Kankberg? Does this further improve the efficiency of the operation?**

**AM:** We have had a VoD system installed in Kankberg since 2015, which is position based. It is supplied by ABB (800xA), with vehicle positioning based off the closest access point within the Mobilaris platform.

A geofence of all access points in each production area is created in Mobilaris and an external ID is created for the corresponding fan in the ABB system. When a machine enters the production area, information about the activity type and which fan requires activation is transferred from Mobilaris to the ABB system.

When connection is lost, the fan runs for a pre-set time to ventilate the contaminants from the activity performed.

When the VoD system was installed, it decreased the Kankberg electrical energy input for the ventilation system by 50%, as well as reduced the propane gas use by 20%. The total energy reduction was 30%.

This new gas monitoring drone, which will integrate critical gas sensors onto the ExynAero™ and ExynPak™ platforms, is, effectively, the "quickest and safest mobile gas monitor on the planet", Gribbons says. "The drone is able to automatically launch and log targeted gases directly on the point cloud in any confined area without deploying mine rescue personal with Scott Air-Paks."

This, in turn, improves worker safety and accelerates the time to obtain accurate data in emergency conditions or for more granular data at the headings for reducing blast re-entry times, he added.

Powered by ExynAI's multi-sensor fusion capabilities, gas sensor readings are captured while the robot is in flight and displayed in real time via a ruggedised tablet, Exyn explained. These sensor readings are saved with precise coordinates in a high-fidelity point cloud that can be exported and examined in a variety of mining software.

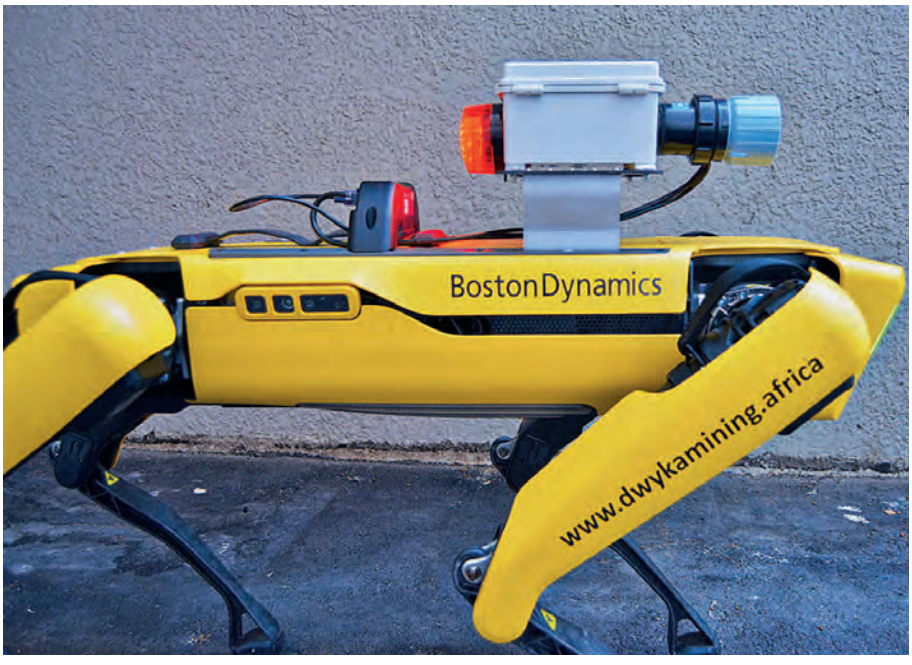
## Performance across the fan curve

Maestro is also involved with ventilation developments at the Odyssey Mine in Quebec, Canada, which will develop the continuity of the deposit of the Canadian Malartic Mine, managed by the Canadian Malartic Partnership (CMP).

This mine, owned and operated by the CMP through a 50:50 joint venture between Yamana Gold Inc and Agnico Eagle Mines Ltd, will see an underground mine developed near the existing Canadian Malartic Mine open pit. The Odyssey Mine will be accessed by a ramp and a shaft estimated to be 1,800 m deep.

The owners of the mine have already gone on record to say that Odyssey Mine will feature an LTE mobile communication network, an automated fleet of 65 t trucks operated from the surface and on-demand ventilation.

Maestro is set to provide 4 x 4 m MaestroFlex™ regulators to the mine, which will be used as backdraft dampers on the two underground booster fans from Spain-based **Zitrón**.




*The Boston Dynamics Spot Enterprise robot, equipped with Maestro's IIoT gas sensor, can be operated on mine sites to detect hazardous gases like carbon monoxide, without putting mining and ventilation teams in danger*

Louis van Wyk, General Manager of Zitrón North America, says these 3-m diameter, 1.6 MW booster fans are quite big for an underground installation, but not the largest the company has supplied to underground mines to date. It has supplied horizontal fan units of up to 5.2-m diameter, 9.5 MW have been supplied in the past.

"This is quite a big installation underground," he said. "Normally booster fans – which mostly assist the primary fans sitting on surface – are 500-600 kW and smaller in diameter."

van Wyk said the company was about 80% through manufacturing these fans, with – at the time of ***IM***'s call – factory performance testing at the Zitrón facility in Spain coming up.

This performance testing milestone is worth reflecting on as it highlights part of Spain-based Zitrón's unique offering to the market.

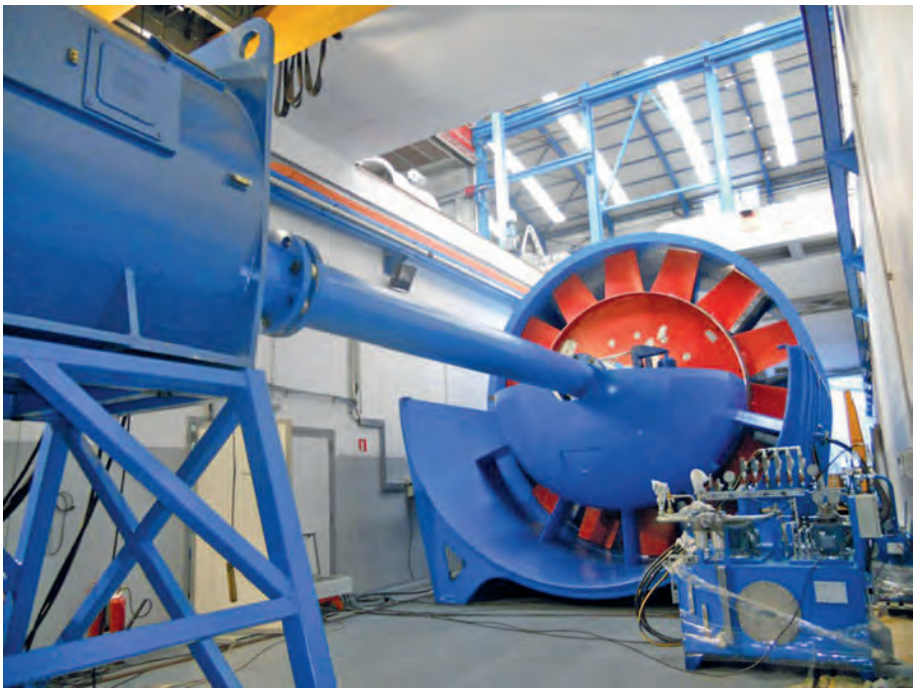
Zitrón's test bench measures in at 100 m in length, with a cross-section of 52 sq.m, making it the largest facility of its type in the world. It is importantly certified as an Air Movement and Control Association International Inc (AMCA) approved laboratory, capable of reaching an AN1 level of performance tolerance.

"We're the only fan company in the world capable of such testing on a regular basis," van Wyk said. "AN1 is effectively a lab test that has much stricter and narrower tolerance levels than the industry standard AN3/AN4 test."

According to van Wyk, the AN3/AN4 performance tests typically carried out at mine sites only test the fans at one specific duty point and come with a "generous" allowance for hitting said duty point.

"In AN1 tests at our test bench, we test the fully assembled fan and configure and replicate the mine resistance and then, with the help of a calibrated fan fitted with auto-variable pitch blades and automatic dampers, recreate resistance conditions across the entire fan curve, testing any duty point on that curve," he said. "We even go as far as testing and recording the fan's stall limit."

This allows the company to prove to the client that the fan will perform at not just the chosen



*Zitrón's test bench measures in at 100 m in length, with a cross-section of 52 sq.m, making it the largest facility of its type in the world*

duty point it is expected to operate at in the mine, but across a range of different resistance points.

"As a mine evolves, resistance requirements change and impact fan performance," van Wyk said. "With these AN1 tests, we're able to prove to the clients how the fan will perform with these changes over the entire fan curve."

Consultants and ventilation engineers appreciate the results of these tests, providing them with increased confidence that the fans they specify in long-term mine plans will perform over the long term.

Alongside this upcoming delivery to Odyssey Mine, van Wyk said the company already supplied primary exhaust fans to another gold mine, this time in Ontario, fresh air fans to two mines in Nunavut and vertical fresh air fans, connected to heaters, to a potash mine in Saskatchewan. Another two primary exhaust fans are being installed at a mine close to Sudbury.

Having only been setup to operate in Canada some three years ago, Zitrón North America was experiencing growing demand for its products, he said. The Zitrón subsidiary locally manufactures all static components, with full mechanical and electrical installation and commissioning as well as fan service and maintenance being provided.



## Ventilation 'partners'

Another company experiencing global growth for its products is South Africa-based **TLT-Turbo Africa**.

Following what it says is unprecedented resilience throughout the past 18 COVID-affected months, the company's growth is now accelerating.

It has secured orders from six new major clients in the copper, platinum and gold sectors for the supply of mining ventilation equipment. These include clients based in Australia, the US and Kazakhstan. Closer to home, TLT-Turbo Africa has retained 20 clients in the mining, mineral processing and automotive industries – predominantly based in the sub-Saharan region.

According to Vusi Madlopha, TLT-Turbo Africa Head of Sales and Business Development, the company has managed to maintain and expand its market share despite the challenges presented by the global pandemic.

"We've focused on our strategy of increasing sales and maintaining the quality of our product offering," Madlopha said. "Our strategy also included growth into new territories outside Africa using the global network of our parent company, TLT-Turbo GmbH. Twenty-twenty-one posed unique supply chain challenges that affected the whole world. Our internal processes allowed for efficient use of limited resources to produce quality products for our customers throughout the year."

A major contributing factor to this success was the leadership and vision of TLT-Turbo Africa Managing Director, Christo Gelderblom, according to Madlopha. Gelderblom's vision is to position the company as a global supplier of air movement technology.

Gelderblom said: "Over the last few years, TLT-Turbo Africa has meaningfully scaled our core portfolio of mining ventilation solutions, invested in the research and development needed to advance our technology, and enhanced our customer consultation and care culture."

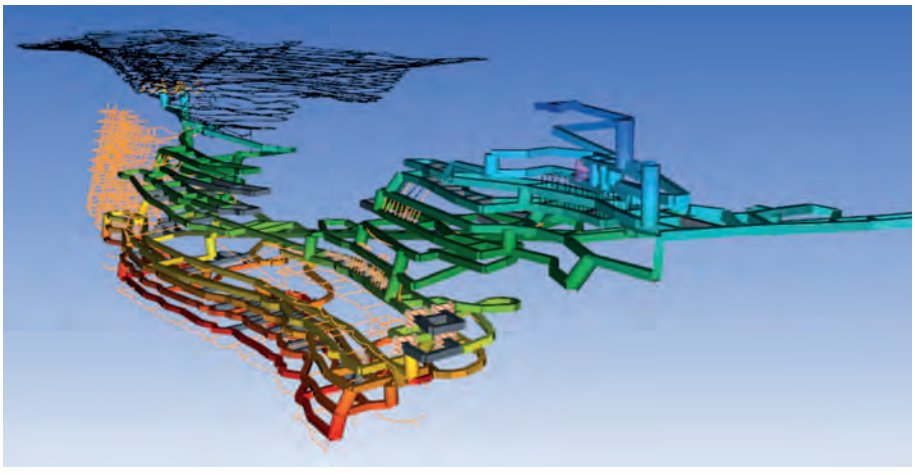
## No-cost simulation

Another South Africa-based company, **BBE Group**, is looking to expand across the globe by offering the recently released version of VUMA-network software to the industry at no cost.

This move, the mine ventilation, refrigeration and cooling engineering consultant says, puts an advanced interactive mine ventilation network simulation tool in the hands of mine and ventilation engineers across the world.

Miguel Coelho, Ventilation Engineer at BBE, said: "Intense temperatures, humidity, diesel fumes and gases are health hazards for underground miners. This makes good ventilation non-negotiable.

"However, with so many complex factors impacting environmental conditions, dangerous



*VUMA-network software has been developed and used by BBE engineers for over 20 years to plan, design, operate and troubleshoot ventilation and cooling systems in underground mines around the world*

shifts can be hard to predict. BBE's VUMA-network software, with its ability to simulate multiple variables, addresses this issue. It also drives system optimisation and energy efficiency, a critical cost and operational factor for mines in South Africa.

"Making it available to industry at no cost puts everyone ahead."

Built on a Microsoft platform, VUMA-network's most recent upgrade advances it to 64-bit computing with a supercharged graphics engine. The solution has also been enabled for global use, with support for different languages, namely Chinese, Polish and Spanish, and the integration of country-specific features and design criteria. In addition, the software is vendor agnostic, integrating will all major industry software and solutions. Users are also not required to have to have a relationship with BBE to use it.

VUMA-network software has been developed and used by BBE engineers for over 20 years to plan, design, operate and troubleshoot ventilation and cooling systems in underground mines around the world. It is already in use at most mines in South Africa, according to the company.

"With advanced simulation technology, mining and ventilation engineers can gain complete control over the crucial ventilation and cooling aspects of mining processes across a range of mining methods," Coelho noted. "This is especially important as energy costs rise and safety regulations ramp up. With mine planning software becoming increasingly sophisticated, the kind of graphic ventilation network detail and troubleshooting that software like VUMA-network can provide is becoming invaluable."

VUMA-network simulates airflow, heat loads, gases (including radon), dust, diesel particulate matter from diesel machinery, and impacts of blast clearances and underground fires. Simulations are based on the specific conditions in a mine – the type and intensity of work, the performance of cooling infrastructure, use of machinery and mining method employed.

These inputs may be collected from mine systems and sensors, imported directly from various mine-plan formats, or defined by mining engineers. This facilitates planning and design of systems, energy optimisation, fault finding and troubleshooting, what-if scenario analyses, dust and/or gas tracing, refrigeration cooling system design and verification of environmental performance. Importantly, it allows engineers to identify hinge points where infrastructure can be improved and to test hypotheses before acting.

Initially developed by the CSIR in the early 1990s for use in South African mines, the software was acquired by BBE in 2009. IM