USC CONSULTING GROUP™

Empowering. Performance.

EXYNAERO VS TRADITIONAL CMS:

A Study of Mining's Top Innovations

The great philosopher Plato once said "Necessity is the mother of invention," and every once in a while, there is a bright example that embodies this perfectly. The mining industry has long been a poster child for necessity driving innovation, with most mines operating with one (or few) portals or shafts and a deep want for hazards to be mitigated. From the advent of remote muckers working under high-hazard uncontrolled ground to shaft skips that could drop 100+ miners in a single trip, the name of the game has always been pushing boundaries to allow crews to work more safely, faster, and more efficiently.

Our evaluation of a new product developed by Exyn Technologies highlights another pivotal advancement in the industry. The ExynAero full autonomous robot pairs a rotating LiDAR unit with a flight platform in order to perform cavity mapping surveys within open stopes. This hardware, combined with what is now the highest level of aerial autonomy, Level 4A Autonomy (AL4), allows survey teams to map deeper, more accurately, safer, and faster than before.

In September of 2022, **USC Consulting Group** (USCCG) conducted an independent evaluation of the AL4 Autonomy being utilized at the Northern Star Resources Limited's Pogo mine site in Alaska. Over the course of a two-day study **USCCG** was able to observe the survey team mapping live stopes utilizing the new drone technology on the ExynAero and compare it to the traditional boom and scanner CMS method. The analysis of operations and data showed the ExynAero to be significantly better specifically in the areas of safety, survey quality, and time savings.

Safety

Working at or around the brow is widely regarded as one of the most hazardous places in any mine. So much so that even with all the precautions taken to keep miners away from the hazards of falling ground, the National Institute of Safety and Health (NIOSH) still lists it as one of the top five major causes of lost time injuries in underground mining, accounting for almost 10% of reported injuries. Additionally, NIOSH lists Handling of Materials as the number one cause, accounting for 33% of lost time injuries. By replacing the traditional CMS' boom and scanning system with the ExynAero, both of these high-frequency incidents can be mitigated.

In traditional CMS surveying, the surveyor is required to work very close to the brow in order to get the boom positioned appropriately under the stope and get a quality survey. The time spent working in this area is all time spent at risk of a ground fall (stope material sloughing) impacting the surveyor(s) and/or their equipment. During **USCCG**'s analysis, the traditional CMS survey took an average of 30 minutes to complete. That is 30 minutes of exposure to a hazardous area where both human and capital equipment have the potential to come into contact with falling ground.

"It (ExynAero) is infinitely safer to use … we're nowhere near the brow now, doing jobs around the corner in some cases. The safety aspect is definitely one of the driving factors to why we purchased the gear."

–Andrew Loomes Chief Mine Surveyor, Pogo Mine

Current capabilities of the ExynAero allow the unit to be placed 40+ feet away from the brow, and the surveyor(s) to position themselves even further away than that. The AL4 allows the unit to take off from its starting position, fly its survey mission in the high-risk area, and return to the safety of the takeoff point completely

autonomously, thus mitigating the risk of fallen/sloughed ground coming into contact with personnel or equipment. Prior to the implementation of the ExynAero by the survey team, Pogo mine was experiencing damage or total loss to the boom and scanner due to sloughed ground approximately once per year at a unit cost of $60,000 USD.

The other major safety advantage is seen in manual handling (or lack thereof) that is done when using the ExynAero. The standard boom and scanner survey requires the technician to assemble the boom, attach the scanner, and manually move and position them into place, all while standing at or near the brow. In cases where the cavity is deeper or more complex, in order to get a quality survey, additional equipment (i.e., telescoping boom, man-lift, etc.) is required to place the scanner in the proper position. Working alone, the length and awkward nature of the boom increases the risk of an incident either damaging equipment or hurting the operator, so as a result it is common for a mine site to mandate surveys be performed in teams of two, thus doubling labor requirements. This process must be repeated at each heading, all of which doubles the opportunity for drops, strains, slips, trips, and falls. The drone system, however, requires no such labor-intensive work. The ExynAero unit itself packs into its carrying case mostly assembled, requiring the surveyor only to attach the four propellers and two legs prior to each flight - a process that takes less than a minute. The drone is then simply placed in position at its starting point by one person, and is then ready to fly.

ExynAero block model rendering

CMS block model rendering

Survey Quality

The critical differentiator of the ExynAero versus other similar products in-market is its unique application of Level 4A Autonomy (AL4) to pilot the unit. AL4 provides the ability for all spatial and computation mapping to be done onboard the unit, rather than relying on GPS or requiring remote connection while in flight. This distinctive capability means the ExynAero can be sent in to "explore" an area without the need for line-of-sight from an operator or any other external inputs to fly.

This represents a leap forward in survey technology by changing what was previously a static observation and making it dynamic. No matter how well set up the boom and scanner, the traditional CMS method required the survey to "reach" into the stopes in order to provide the spatial and volume data from a single scanning point. The limitations of this type of scanning introduces errors due to factors such as shadowing in the cavity, gas pockets, and dust which can cause significant inaccuracies in the map.

In one example, while surveying the same stope, the ExynAero flew a survey mission and returned volumetric data for a solid measuring **30,965ft³**. The stationary CMS, however, was not able to recognize a recessed cavity in the hanging wall and measured the same stope at **27,322ft³, a 12% reduction** in volume.

In another case, it was found post-surveying that a pocket of gas had built up in the stope and created a "false-back" in the reading. The ExynAero was able to fly beyond this point and returned a survey data set that was fully **35% larger** than what the constrained CMS reading gave; **15,119ft³** for the drone, **9,893ft³** for CMS.

Purple dots represent CMS reading, White dots represent ExynAero reading

In both cases, had the ExynAero not been available, there would have been a significant amount of rework and/or additional work required to reconcile the solids and capture an accurate data set. In the past, the Pogo team employed a myriad of methods to do these reconciliations including mass balance counts from scoops/trucks of muck moved, blast factor assumptions, re-shooting the surveys, etc. Now, with the benefit of the GPS/Comms-denied exploration capabilities of the ExynAero, these remedial actions are no longer necessary, and the added benefit of being able to mount a camera on the drone and pair live video of the stope with the survey data, "*it's been a game changer for us … now we can actually see the type of material sitting on the footwall,*" says Loomes.

Time

The final major advantage found with the ExynAero was time savings, realized in multiple ways. Across the observations of physically completing a survey in active headings, surveying using the drone proved to be **45% faster** than surveying the same area using the traditional CMS (27.3 minutes on average compared to 15 minutes). This is due to a significant reduction in equipment requiring setup, faster geo-referencing, and faster actual surveying times when using the drone.

Additionally, there are improvements to be seen in both the first-time accuracy of the scans, as well as the lesser amount of logistics and setup required to perform them. It is a universal truth that it's cheaper to do something right the first time than to pay to re-do it, and surveying is no exception. For each of those examples of the volume less seen by the boom and scanner CMS, additional work or rework would have been required had the ExynAero not existed. Quite often, this additional work would involve adding labor resources as well, whether it be assistance from the engineering team, an operator to assist in using a tele-handler or lift, or another surveyor, all of which add cost and slow down the mine planning and production cycle.

Finally, as previously mentioned, the AL4 autonomy makes it possible to safely work in areas while being further removed from hazards. This means that far less coordination and planning is required between the survey team and operations in order to prepare areas to be worked in safely, further reducing the time investment over the course of a year.

In the end, the ExynAero autonomous drone quantifiably outperformed the traditional boom and scanner CMS method in USCCG's analysis. Through safety, quality, time, and cost-reduction factors, AL4 autonomy and the ExynAero are proof that the future of mining technology is available today.

"Even though [CMS] takes twice as long, from a quality standpoint to get the same data from a CMS would take even longer with more equipment ... the data doesn't even compare"

–Andrew Loomes Chief Mine Surveyor, Pogo Mine

USC CONSULTING GROUP™

Empowering. Performance.

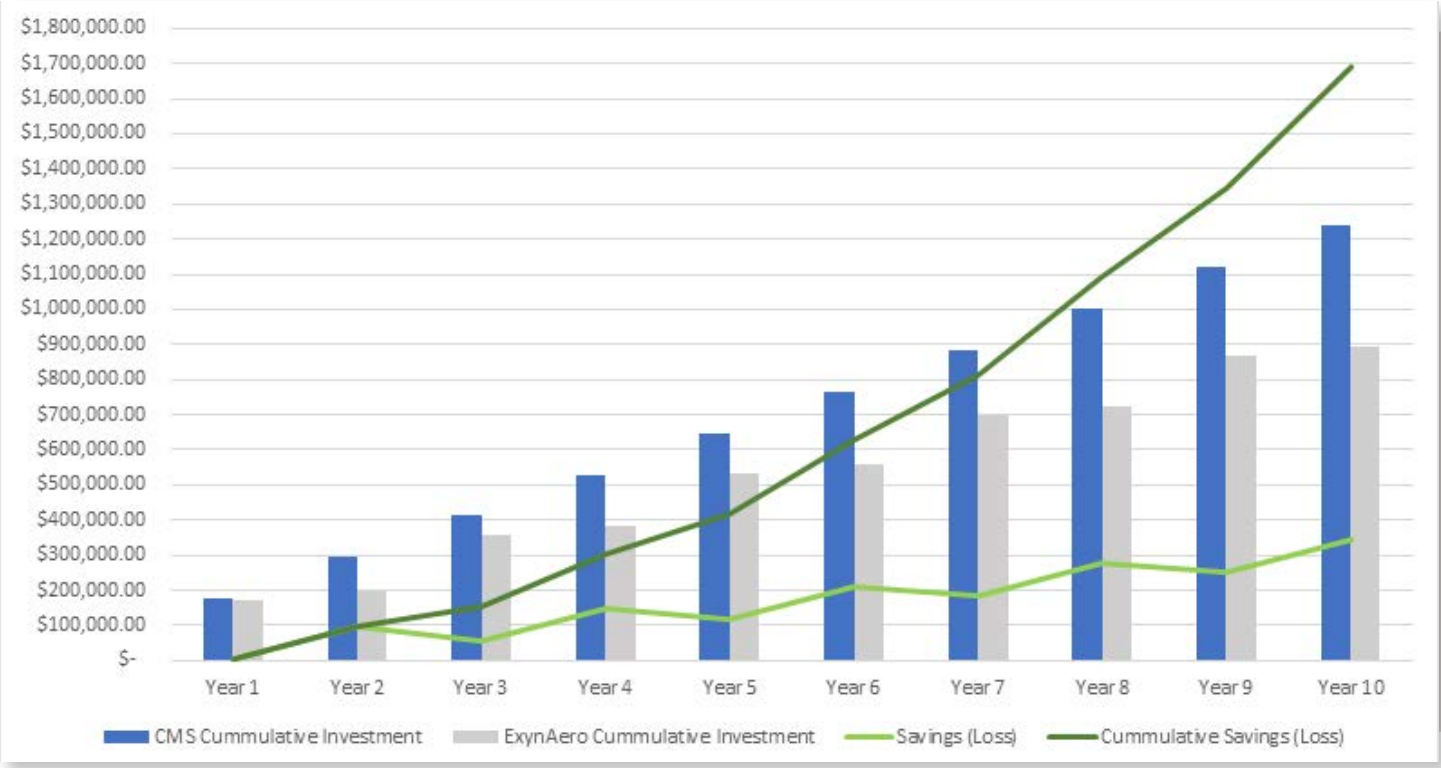
Contact Us:

1-800-888-8872

info@usccg.com

10-Year Savings

ExynAero vs CMS with 2 Surveyor Team



**Assuming a 2-year lifespan of the ExynAero with discounted unit replacement every second year. Yearly replacement of the Boom and Scanner for the CMS valued at $60,000. Costs include labor cost to perform the actual surveys considering a fully burdened hourly rate of $65.68 and investment cost in hardware/ software for each respective device.*

** Survey Data captured time savings; does not include other operational or material savings.*

Cost per Survey

Avg over 10-Year Period

**Average cost per survey is the average cost of a single survey over a 10-year period if performed that number of times a day, for 365 days. CMS cost includes a 33% re-shoot requirement.*

Surveys Per Day	CMS - 2 Surveyors	ExynAero
4	$120.59	$61.11
5	$120.59	$52.17
6	$120.59	$46.22
7	$120.59	$41.96
8	$120.59	$38.77
9	$120.59	$36.28
10	$120.59	$34.40