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BEST PRACTICES AWARDS

SANDVIK

2020 GLOBAL AUTONOMOUS MINING SOLUTIONS PRODUCT LEADERSHIP AWARD

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Background and Company Performance

Industry Challenges

Hazardous operations in the mining industry can cause significant environmental, health, and safety risks to operators. Unsafe working conditions in mining operations lead to accidents, loss of human lives, damage to assets, and production interruption. As government regulations worldwide tighten and safety systems become more ubiquitous, the mining industry's operational safety has improved. While overall mining safety has improved, the interaction between human operators, equipment, and heavy-duty vehicles still poses a significant safety threat. More than 25% happen when a worker is handling equipment repairs or maintenance[1].

There is a continuous effort toward eliminating the industry's reliance on human-vehicle interaction with the rising use of fully automated mining equipment, thereby avoiding fatalities. Some mining equipment manufacturers have capitalized on this opportunity by launching autonomous mining trucks and loaders in recent years. These vehicles and technology have only recently started to witness increase in adoption. When determining the economic viability of new projects from the capital expenditure perspective, an autonomous vehicle becomes a liability when mining operators struggle to get a return on investment. The price of a fully autonomous 250-tonne surface mining haulage vehicle can be between US$6 million and US$10 million, including the cost of project planning, truck, software package, control room, communication upgrades, physical infrastructure, and implementation services. Though this price is affordable for large multinational mining companies, it could discourage small and medium-scaled companies from investing in autonomous technology. The cost of autonomous vehicles would be a hurdle even for larger companies maintaining more than ten operations across two or more continents.

Specific skillsets required to operate and maintain autonomous vehicles is another challenge. Since autonomous technology is new and evolving, even a small repair or service issue could cost a lot of money and time to fix. Some mining equipment and heavy-duty vehicle manufacturers lack in-depth expertise in digital technologies. Their autonomous solutions often lack the capabilities to address mining operators' digital integration challenges, with their legacy IT and communication infrastructure. If autonomous vehicles have more affordable prices, provide return on investment, and can address mining operators' current digital challenges, these vehicles will become the norm in mines of the future.

Product Family Attributes and Business Impact

Founded in 1862, Sandvik Group is a global provider of engineering tools and tooling systems for metal cutting, mining, and construction industries. The company operates three business areas, Machining Solutions, Mining and Rock Technology, and Materials Technology. Sandvik Mining and Rock Technology, under which it offers the mining automation solution, provide equipment for the mining and construction industries to help customers increase their productivity and profitability. One of the biggest competitive

[1] https://latam-mining.com/los-desafios-de-los-vehiculos-autonomos/

differentiating factors is that Sandvik is a mining equipment and mining process and digital solutions provider. This expertise in technical, industrial, and digital domains enables it to deliver compelling offerings that outperform peers' products to the market.

Matching Customers' Needs with the AutoMine® Portfolio

Sandvik offers two product groups as part of its advanced mining automation and teleoperation solutions portfolio, AutoMine® and OptiMine®[2].

The AutoMine® product portfolio provides an autonomous loading and hauling solution for underground hard rock mining. While competitors' products are suitable for only a specific application type, Sandvik designed AutoMine® for easy and successful adaptation to various mining applications ranging from small operations to large block caving operations. Designed to interface with other third-party IT systems at the mining site, AutoMine® is an out-of-the-box solution. This enables customers to use their existing IT infrastructure to deploy AutoMine® and benefit from its autonomous operations.

The AutoMine® system is an innovative automation solution. Instead of manually driving a heavy-duty truck or loader underground, it allows mining operators to sit in the comfort and safety of an above-ground, air-conditioned command center and track the movements of autonomous trucks hundreds of meters below the surface. Sandvik's loaders and trucks would autonomously travel between the load and discharge points under the control of a supervisory system that manages equipment traffic and monitoring. AutoMine® provides smart functionalities and intelligent capabilities. For example, if one of the trucks strikes a pothole on the pathway, AutoMine® would issue a speed restriction within the zone to ensure that autonomous trucks behind it slow down at the obstacle, decreasing potential damage to the trucks. AutoMine® for Trucks smart hand over technology that allows trucks to switch from underground to surface navigation mode seamlessly in real-time and operate in mining levels and mine declines including both underground and surface sections to complete full production cycle.

Offering Product Value through the AutoMine® Underground and Surface Drilling Solutions

The AutoMine® product portfolio comprises AutoMine® Underground and AutoMine® Surface Drilling solution, enabling customers to scale up the mining automation at their own pace. While competitors' products only allow their trucks and loaders' autonomous operations, Sandvik designed AutoMine® to be equipment-agnostic, powering both Sandvik and non-Sandvik underground trucks and loaders. AutoMine® Access API (Application Programming Interface) gives customers the flexibility to automate their large fleet of multi-brand trucks and loaders.

The AutoMine® Underground (UG) includes sub-products such as AutoMine® Tele-Remote, AutoMine® Lite and AutoMine® Multi-Lite, AutoMine® Fleet. AutoMine®Tele-Remote provides a smart teleoperation capability, using which operators can control their underground trucks and loaders remotely. It offers features such as operator-assisted

[2] https://www.rocktechnology.sandvik/en/products/automation/

automatic steering and wall avoidance capability. While competitors' products require specific skillsets for operation, the AutoMine® Tele-Remote is easy to install, operate, and manage without needing any technical skills. Developed for quick deployment in the production area, it is suitable for continuously evolving applications such as mines with small stopes or mine development.

Sandvik designed AutoMine® Lite and AutoMine® Multi-Lite for mining operations that require repeatability of tasks such as sub-level open stopping, caving, or transfer levels. While the Lite solution enables a single operator to control single equipment, the Multi-Lite enables a single operator to control multiple autonomous trucks and loaders remotely. No competitors in this space provide a single interface for supervising multiple trucks. The Multi-Lite solution offers transparency of the loading or hauling processes through fleet reporting capabilities, optimizing the overall operations.

AutoMine® Fleet is a customized solution for mining operations needing high fleet performance in the field. Used in applications such as block caving, ramp haulage, and transfer levels, the solution's differentiating factor is the ability to interact seamlessly with external mining systems for functions such as mine planning for proper draw control. Another key differentiating factor is that it provides fully automatic advanced fleet traffic control for multiple equipment which are located in the same area.

AutoMine® Access API (Application Programming Interface) is a standard set of predefined interfaces for integrating other vendors' trucks and loaders with the AutoMine® solution. This allows Sandvik's customers to manage and control a mixed fleet of underground equipment through a single interface.

AutoMine® Surface Drilling is an automation solution available for a wide range of Sandvik's iSeries top hammer, down-the-hole and rotary drills. Competitors' solutions enable the remote control of drill rigs within a short range of the mining field. In comparison, AutoMine® Surface Drilling allows an operator to sit in a van, trailer, or control room miles away in another city and still manage multiple drill rigs with the same efficiency. This helps the operator avoid exposure to noise, dust, and vibration caused by hazardous drilling environments.

Achieving Reliability and Quality with AutoMine®

AutoMine® provides multiple benefits to mining operators, including increased fleet utilization, enhanced safety and working conditions, decreased maintenance costs, high production efficiency, and optimized tramming speeds. AutoMine® improves fleet utilization, which provides constant performance level improvements and optimum workforce usage. Thus, there are no intervals during shift changes. Users can reach high productivity through a continuous process allowing on-site information integration.

Its competitor's solution does not provide actionable data. On the other hand, AutoMine® offers real-time data to support the mine's planning processes by measuring, controlling, and decreasing bottleneck areas and providing visibility of mining operations to the top management on the surface.

AutoMine® has helped operators execute production plan, track draw point status, and accurately collect production data. This saves costs and improves safety, enhancing production control. Glencore plc, a leading mining company, adopted the AutoMine® Lite solution and increased its effective production hours per shift by 25% and transfer levels in daily production per loader by 52%.

Sandvik's customer-centric approach has enabled it to develop a modular system to suit specific mining industry customer requirements. The modular system comprises a Production Control System (PCS) for planning and executing production in block cave mines and a Mission Control System (MCS) for managing autonomous processes such as traffic management. It also includes MineLAN broadband for high-speed connectivity between autonomous underground equipment and the control room, and the Access Control System (ACS), which separates the autonomous operating zone to ensure personnel safety. Furthermore, AutoMine® system can be used with any Internet protocol-based wireless network, such as Wi-Fi or 4G LTE, as long as AutoMine's® performance requirements for the network are met.

New Gold Inc., a Canada-based mining company, struggled to handle the intense mud rush in its New Afton mine. The company stopped manual mucking and adopted a line-of-sight tele-remote loading solution to ensure workforce safety. However, that solution failed to keep up with the growing production demand. New Gold Inc. adopted Sandvik's AutoMine® Multi-Lite system to automate its fleet of loaders. Within a week of commissioning, the company achieved 55% productivity increase and saved US$10,000 worth of collision damage per loader per month caused by the line-of-sight loaders.

Enabling Operational Efficiency and Positioning with OptiMine® Suite

Sandvik offers OptiMine®, a comprehensive suite of software platform solutions, to analyze and optimize underground mining processes. The OptiMine® platform integrates all equipment and workforce, including non-Sandvik assets, and provides descriptive and predictive insights to enhance mining operations. While competitors offer close-system and proprietary integration capabilities, OptiMine® is based on open system architecture. This enables seamless data integration between different mining equipment from various vendors.

OptiMine® is integrated with Newtrax's IoT devices, a suite of purpose-built devices that automatically collect real-time data and send it to the OptiMine® platform for further analysis. The OptiMine® platform is scalable, giving customers the flexibility to integrate a full range of equipment, systems, and networks. This enables miners to remove bottlenecks, simplify operations, and facilitate safer, smarter, and efficient mining operations.

Competitors' solutions cannot provide a detailed overview of production impediments. In contrast, OptiMine® analyzes the Overall Equipment Effectiveness (OEE) and displays bottlenecks and segments for fleet and operation enhancement in terms of mechanical availability, utilization, and production quality. Combined in one smart, modular package, the OptiMine® suite also provides industry-leading features such as predictive and

descriptive analytics, location tracking, task management, scheduler, drill plan visualizer, mine visualizer and monitoring with integrated My Sandvik Productivity.

OptiMine® enables customers to achieve operational improvements in mining processes, offering easy-to-use real-time dashboards with detailed process overview. A differentiating factor is Sandvik uses proprietary predictive models in the OptiMine® platform to provide process optimization. OptiMine® analyzes source data from many mining management tools, equipment, and other connected vehicle fleets. With the combined equipment and application data, OptiMine® automatically detects patterns in the data and provides mining process efficiency improvements. This allows operators to have up-to-date equipment health information, reducing potential risks. It can also be improved with the 365 OptiMine® Services for mining process optimization to provide a fulfilling customer ownership experience. Sandvik's skilled data scientists help customers determine critical points in their process and convert the findings into actions. While competitors lack digital integration capabilities, Sandvik has enhanced its ability by collaborating with IBM. IBM's analytics technology, combined with its predictive modeling capabilities, enables Sandvik's OptiMine® customers to gain insights on mining optimization and achieve actionable process improvements.

Achieving Growth Potential

Sandvik commercializes its autonomous mining solutions through the Sandvik Mining and Rock Technology Business Area, which recorded good business outcomes in 2019 and registered stable growth up to Q2 2020. The Business Area earned US$5.1 billion in 2019, growing 9.1% compared to 2018. While the overall market witnessed an average year-on-year (YoY) growth of 5%–6%, Sandvik's 9.1% growth indicates its focus on automation and digitization of mining technologies.

Maintaining technology and solution leadership is not easy in a market with thin operational margins. Sandvik's ability to deliver cutting-edge solutions has allowed it to meet customers' expectations. The company made two acquisitions in 2019 to accelerate its growth in the digitization segment. It acquired US-based Artisan Vehicle Systems, a leading provider of battery-powered electric mining vehicles, in February 2019. This acquisition enabled Sandvik to become the first company to own the world's largest electric vehicle fleet in underground mines. In June 2019, Sandvik acquired Canadian-based Newtrax, a leading IoT-device manufacturer and wireless connectivity solution supplier to monitor and offer insights on underground mining operations[3]. This acquisition has allowed Sandvik to strengthen its OptiMine® software platform. Sandvik now has the most comprehensive offering for process optimization and analytics in the market.

The company has been focusing on strengthening its core businesses by investing in research and development to develop new products and work in collaboration with its partners. For example, Sandvik deployed Nokia's 5G SA industrial-grade wireless network at its test mine in Finland in July 2020 to test and prototype wireless connectivity in

[3] https://www.home.sandvik/en/news-and-media/newslist/news/2019/04/sandvik-acquires-digital-mining-technology-company-newtrax/

digitized mining operations. Once commercially available, this technology will enable mining equipment to communicate from ultra-deep mines, provide enhanced safety and increased productivity.

Conclusion

The market has been registering an increasing number of autonomous mining solutions from different vendors in recent years. These solutions have not been widely adopted because of their high cost and complexities in deploying and maintaining. Sandvik's AutoMine® portfolio offers a broad range of products to enable the autonomous and remote operation of underground trucks and loaders. While competitors' products can only power their vehicles, AutoMine® is equipment-agnostic, capable of powering both Sandvik and non-Sandvik underground trucks and loaders. This benefits customers who manage large fleets of multi-brand trucks and loaders. Sandvik's software platform, OptiMine®, enables operators to analyze and optimize processes through the descriptive and predictive insights gained from mining operations. One of the differentiating factors is that AutoMine® seamlessly integrates with the OptiMine® platform, providing efficient production planning and automatic dispatching of tasks to the AutoMine® system. The progress of the production tasks is reported back to the OptiMine® system. Thus the operations can be adjusted accordingly based on the real-time status information.

For its strong overall performance, Sandvik Mining and Rock Technology is recognized with Frost & Sullivan's 2020 Product Leadership Award.

Significance of Product Leadership

Ultimately, growth in any organization depends on customers purchasing from a company and then making the decision to return time and again. A comprehensive product line filled with high-quality, a value-driven option is the key to building an engaged customer base. To achieve and maintain product excellence, an organization must strive to be best in class in three key areas: understanding demand, nurturing the brand, and differentiating from the competition.

Understanding Product Leadership

Demand forecasting, branding, and differentiating all play critical roles in finding growth opportunities for your product line. This three-fold focus, however, must be complemented by an equally rigorous focus on pursuing those opportunities to a best-in-class standard. Customer communication, customer feedback, pricing, and competitor actions must all be managed and monitored for ongoing success. If an organization can successfully parlay product excellence into positive business impact, market share will inevitably increase.

Key Benchmarking Criteria

For the Product Leadership Award, Frost & Sullivan analysts independently evaluated 2 key factors, Product Family Attributes and Business Impact, according to the criteria identified below.

Product Family Attributes

Criterion 1: Match to Needs

Requirement: Customer needs directly influence and inspire the design and positioning of the product family.

Criterion 2: Reliability and Quality

Requirement: Products consistently meet or exceed customer expectations for performance and length of service.

Criterion 3: Product/Service Value

Requirement: Products or services offer the best value for the price, compared to similar offerings in the market.

Criterion 4: Positioning

Requirement: Products or services address unique, unmet needs that competitors cannot easily replicate or replace.

Criterion 5: Design

Requirement: The product features an innovative design, enhancing both visual appeal and ease of use.

Business Impact

Criterion 1: Financial Performance

Requirement: Overall financial performance is strong in terms of revenue, revenue growth, operating margin, and other key financial metrics.

Criterion 2: Customer Acquisition

Requirement: Product strength enables acquisition of new customers, even as it enhances retention of current customers.

Criterion 3: Operational Efficiency

Requirement: Staff is able to perform assigned tasks productively, quickly, and to a high quality standard.

Criterion 4: Growth Potential

Requirements: Product quality strengthens brand, reinforces customer loyalty, and enhances growth potential.

Criterion 5: Human Capital

Requirement: Company culture is characterized by a strong commitment to product quality and customer impact, which in turn enhances employee morale and retention.

Best Practices Recognition: 10 Steps to Researching, Identifying, and Recognizing Best Practices

Frost & Sullivan analysts follow a 10-step process to evaluate award candidates and assess their fit with select best practices criteria. The reputation and integrity of the awards are based on close adherence to this process.

STEP		OBJECTIVE	KEY ACTIVITIES	OUTPUT
1	**Monitor, target, and screen**	Identify award recipient candidates from around the world	• Conduct in-depth industry research • Identify emerging industries • Scan multiple regions	Pipeline of candidates that potentially meet all best-practice criteria
2	**Perform 360-degree research**	Perform comprehensive, 360-degree research on all candidates in the pipeline	• Interview thought leaders and industry practitioners • Assess candidates' fit with best practices criteria • Rank all candidates	Matrix positioning of all candidates' performance relative to one another
3	**Invite thought leadership in best practices**	Perform in-depth examination of all candidates	• Confirm best practices criteria • Examine eligibility of all candidates • Identify any information gaps	Detailed profiles of all ranked candidates
4	**Initiate research director review**	Conduct an unbiased evaluation of all candidate profiles	• Brainstorm ranking options • Invite multiple perspectives on candidates' performance • Update candidate profiles	Final prioritization of all eligible candidates and companion best practices positioning paper
5	**Assemble panel of industry experts**	Present findings to an expert panel of industry thought leaders	• Share findings • Strengthen cases for candidate eligibility • Prioritize candidates	Refined list of prioritized award candidates
6	**Conduct global industry review**	Build consensus on award candidates' eligibility	• Hold global team meeting to review all candidates • Pressure-test fit with criteria • Confirm inclusion of all eligible candidates	Final list of eligible award candidates, representing success stories worldwide
7	**Perform quality check**	Develop official award consideration materials	• Perform final performance benchmarking activities • Write nominations • Perform quality review	High-quality, accurate, and creative presentation of nominees' successes
8	**Reconnect with panel of industry experts**	Finalize the selection of the best practices award recipient	• Review analysis with panel • Build consensus • Select recipient	Decision on which company performs best against all best practices criteria
9	**Communicate recognition**	Inform award recipient of recognition	• Announce award to the CEO • Inspire the organization for continued success • Celebrate the recipient's performance	Announcement of award and plan for how recipient can use the award to enhance the brand
10	**Take strategic action**	Upon licensing, company is able to share award news with stakeholders and customers	• Coordinate media outreach • Design a marketing plan • Assess award's role in strategic planning	Widespread awareness of recipient's award status among investors, media personnel, and employees

The Intersection between 360-Degree Research and Best Practices Awards

Research Methodology

Frost & Sullivan's 360-degree research methodology represents the analytical rigor of our research process. It offers a 360-degree view of industry challenges, trends, and issues by integrating all 7 of Frost & Sullivan's research methodologies. Too often companies make important growth decisions based on a narrow understanding of their environment, resulting in errors of both omission and commission. Successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. The integration of these research disciplines into the 360-degree research methodology provides an evaluation platform for benchmarking industry participants and for identifying those performing at best-in-class levels.

360-DEGREE RESEARCH: SEEING ORDER IN THE CHAOS

About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, helps clients accelerate growth and achieve best-in-class positions in growth, innovation and leadership. The company's Growth Partnership Service provides the CEO and the CEO's growth team with disciplined research and best practices models to drive the generation, evaluation, and implementation of powerful growth strategies. Frost & Sullivan leverages nearly 60 years of experience in partnering with Global 1000 companies, emerging businesses, and the investment community from 45 offices on 6 continents. To join Frost & Sullivan's Growth Partnership, visit http://www.frost.com.