Cisco Connected Digital Networks for the Mine Pit and Process

Productive and Secure Networks for the Next-Generation Mine

Mining business trends and priorities

Operations in today's mining industry need to be flexible and reactive to commodity price fluctuations and shifting customer demand. Digitizing the mine helps provide greater visibility, greater safety, better decision-making, and lower operational costs due to greater productivity.

Safety is paramount in nonstop, 24x7x365 mining production operations. Product grade, quality, and worker productivity are prime concerns that often align to a process manufacturer's Overall Equipment Efficiency (OEE) metrics. Mining has a lot in common with oil and gas "upstream" and "midstream" environmental requirements. Operators obtain licenses to mine from governments that impose strict environmental operational requirements, maintain the land lease, and obtain lease extensions for future operations. The mining process disrupts water tables (reduction, pollution, and redirection), generates dust, impacts flora and fauna, and consumes vast amounts of energy.

Mine train lines cross public boundaries and roads. Mine ports impact nearby towns (dust, pollutants to marine environments, noise, light). If things go wrong, entire ecosystems can be disrupted – as in tailings dam failures, toxified water tables, and permanently redirected water flows. Mine refineries do all of the above. Mines need both social and environmental licenses to operate. They also need to remediate land back to state government at the completion of the mining operations.

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The following key trends are behind the mining industry's drive to digitization.

Prioritize safe, healthy, and sustainable operations, with worker and environmental safety as the top priority. The ultimate goal is to achieve zero worker injuries and minimize human error. Autonomous, semiautonomous, and remote operations are helping achieve this goal today by removing people from high-risk environments. Machine autonomy demands a highly available, deterministic, and secure network infrastructure to support network-intensive applications.

Increase productivity and efficiency, with greater agility to react to production-impacting failures, market trends, industry fluctuations, and shifting demand. Digitizing the mining supply chain from pit to port through the adoption of Industry 4.0 and Internet of Things (IoT) sensor connectivity, and leveraging digital technologies such as analytics, machine learning, and Artificial Intelligence (AI), will help enable mine operators to make more informed decisions, improve productivity, and increase efficiency and safety.

Manage cyber risk in the Industry 4.0 era. The fourth industrial revolution is upon us, with the adoption of connecting the unconnected, and it is driving mine digitization by interconnecting the customer supply chain from pit to port. Because the production output from mining does not vary as much as in the discrete manufacturing world, the emphasis in mining is on the integration of internal supply chains – multiple mines, rail lines, ports, and refineries.

With that being said, cybersecurity is a prime concern for mining companies. Mine operation and production cannot risk being affected by cybersecurity breaches. In harsh industries, cyber attacks could lead to environmental incidents. These could result in hefty fines, penalties, and potentially a loss of license for a mine to operate.

Equally important in mining is the use of security and secure architectures to protect fragile control equipment from other equipment and to mitigate unintentional impacts – such as malformed packets, variances in equipment manufacturer protocol implementations, and probing loads, which may cause production failures. Therefore, mining companies are concerned about inadvertent intersystem communications causing production shutdowns or failures.

Improve the efficiency of high-impact resources such as water usage and power. This not only assists in the operational efficiency of the mine and cost reduction, it helps align the mine with environmental laws and legislations. As the world becomes more environmentally conscious, there is a move for the mining industry to examine and improve environmental impacts. Mines need to adopt measures to improve power utilization, reduce water consumption, improve water reclamation, reduce the carbon footprint, and become more eco-friendly. Enabling the digital mine, connecting IoT sensors, and leveraging digital technologies for real-time operational visibility and process optimization will assist in realizing this goal.

Technology and priority mining use cases

Due to the scale of the operations and the amount of output produced, small gains in efficiency and productivity can equal big gains in a mining operation's profitability. Mining companies today are thus heavy adopters and consumers of technology that drives greater safety and higher productivity.

The following use cases highlight areas where Cisco can help deliver results for mines using Cisco's secure wired and wireless infrastructure and edge compute capabilities.

Connected mine tailings ponds

Currently, many mining operations monitor tailings ponds manually. Operations management send personnel to tailings ponds; however, prior approval is typically required for access. Acquiring approval for access can take time, as does the drive to and from the tailings pond (which can take an hour in some facilities). Additionally, supervisors require that personnel check valves and place discharge hoses. Ultimately, a large amount of time is expended prior to the movement of any water or waste product.

Enabling connectivity and visibility into water and waste flow from the process plant to the tailings ponds will improve production efficiency, resource utilization, monitoring for safety, and environmental compliance. Being able to monitor valve positions remotely allows operators to proactively identify where waste would be delivered without having to dispatch personnel to visually inspect valve conditions along the lengthy pipes that run between the processing plant and the tailings ponds. This capability will speed up the waste management process and improve safety with the knowledge that waste is being sent to the correct location. Otherwise, waste could cause instability if sent to an incorrect tailings pond and may potentially lead to environmental impact.

Tailings dams require seismic and dam wall monitoring. Mobile mine workers want full coverage via remote access to production and corporate systems when working in and around tailings dams.

Dust control is another major concern around mines in general and at tailings areas specifically, because tailings ponds are made of very small particles of earth. Environmental impact is a major concern, as not only could dust have a negative impact on the environment but it also could result in large fines from the local environmental supervisory agency. By automating dust control sprays and using video to demonstrate dust control, a mining operation can limit the financial impact from penalties imposed should dust-related issues occur. Other places where automated dust control is needed include ore heaps and shipping ports.

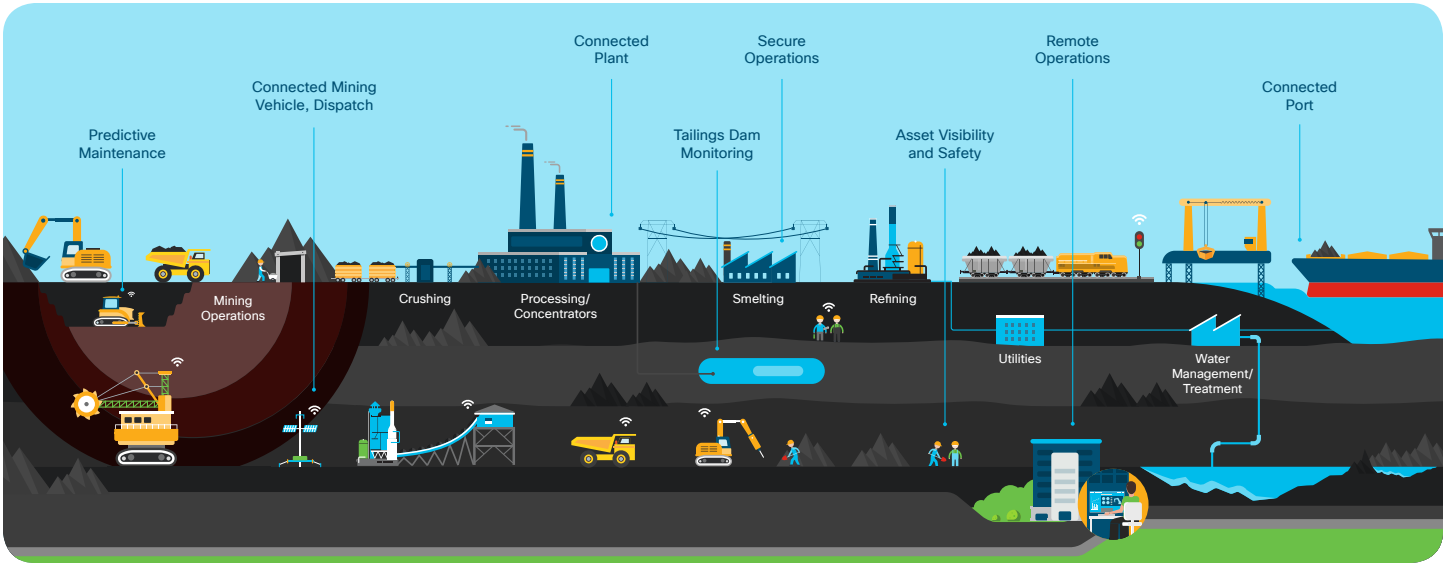


Figure 1. Tailings pond at an open pit mine

Cisco® technology that enables the digital transformation of tailings ponds includes LoRaWAN to reach areas with no LTE or Wi-Fi coverage, Wi-Fi mesh or Point-to-Point (P2P) connectivity for locations where existing infrastructures exist, Cisco Workgroup Bridge (WGB) on the Industrial Wireless (IW) 3702 Access Point for sites where Wi-Fi is currently located, and Cisco Video Surveillance Operations Manager (VSOM) for video monitoring.

Figure 2. Cisco Wireless Gateway for LoRaWAN

Figure 3. Cisco Industrial Wireless 3702 Access Point

Note that Cisco can provide (with partners) a private LTE wireless network for mine sites and for rail, river, and port infrastructure.

Autonomous and semiautonomous systems

Currently, most heavy equipment operations in a mine are performed with an operator located within the mining equipment. Not only is this costly, but it also puts personnel into potentially hazardous situations such as equipment rolls or collisions.

For underground mines, transportation from personnel housing to mine operator staging areas can take over an hour (one way). Workers might be required to wear special Personal Protective Equipment (PPE), which requires a significant amount of time to maintain and change into. In some underground areas that are extremely dangerous and unstable, such as wet muck underground tunnels, or even in extremely hot or cold mine locations, mine personnel can be directly exposed to dangerous environments for only limited amounts of time.

Mining operations are driving toward fully autonomous operational models throughout the supply chain. Removing humans that manually operate equipment not only will improve productivity, but also will improve product quality, increase worker safety, and help reduce the overall cost of operations. Use cases today involving autonomous vehicles and equipment are either fully automated, without any direct human interaction, or semi-automated, with equipment that is remotely operated and monitored. Remote operations centers can be either located close to the mine site or located completely offsite and away from the mine.

The first step in the evolution from manual to semi-automated or fully automated mining operations is **digital dispatch**. Digital dispatch processes connect mobile fleets to the mine network, thus allowing for proper route calculations and ensuring that operators unload the correct materials in the right spots, properly sending only high-grade ore to the crusher and appropriately delivering overburden to the correct dump. Digital dispatch requires connecting the mine fleet over a wireless network.

Semi-autonomous machine operations include loaders in a one-to-one or one-to-many remote operator to machine ratio. One use case is a haul truck operator who can control a loader from inside the cab of the truck to load ore into his truck, thus eliminating the need for an additional operator who would be sitting idle the entire time that the truck is in transit. A ratio of one-to-one or one-to-many allows remote personnel to operate the equipment from a safe location.

Allowing operators to work from a control room located **aboveground** while operating machinery located in a high-risk environment **underground** improves operational efficiency by eliminating some of the travel time, removing the need for PPE, and most importantly, removing personnel from harm's way. In addition, remote operators can now simultaneously manage more than one machine, thus reducing the number of operators needed.

Likewise, autonomous trucks can haul resources from shovels or front-end loaders in a mine to a crusher area. When fully automated, trucks may continuously operate at optimum performance, thus reducing engine wear and improving tire performance and fuel efficiency. This reduces maintenance costs and downtime, and increases productivity.

Predictable network performance is critical to ensure continuous operation of equipment. Computer network operators strive to minimize packet loss and roaming times to achieve optimal application performance. Any computer network issues or prolonged roaming times can initiate safety systems that result in the vehicle or equipment stopping, ultimately affecting productivity and production. Cisco's portfolio of industrial and outdoor wired and wireless products plays an integral part in providing a high-performing, highly available, and secured networking infrastructure for supporting autonomous systems in the mine.

Connecting the mine vehicle fleet to the network allows Vehicle Intelligent Monitoring Systems (VIMS) to feed a large data engine. Analysis of VIMS data by mine operators enables better equipment monitoring and proactive maintenance. Cisco's solution has helped mining companies improve predictive maintenance, and it has also provided visibility into issues such as problems with engine oil pressure or faulty cooling systems before they escalated. Discovering and addressing these issues before a failure occurs can save up to 72 hours of downtime or a $500,000 engine replacement cost.

Cisco technology that enables the digital transformation of autonomous and semi-autonomous machinery includes:

- Wi-Fi mesh with Cisco Aironet® 1572, 1562, and 1532 access points, WGB, IW 3702, and IP67-rated Industrial Ethernet (IE) switches on board a mobile fleet
- IW 3702 and IP67-rated IE switches in underground mines for infrastructure
- Cisco Catalyst® IW6300 Series in areas where hazard location (HazLoc) equipment is needed

Asset tracking

Mines are interested in tracking equipment and personnel.

Maintaining the location of assets is a challenge for large mining operations. An open pit mine can have large geographic areas with various equipment (light plants, generators, communication trailers, portable restrooms, etc.) scattered over several square miles. Tracking down these assets is not only time-consuming, but also costly. Time could be wasted by employees, and extra equipment might be procured in the event needed equipment cannot be tracked. Also, maintenance is sometimes overlooked when equipment is placed in hazardous areas (such as a leach pad being exposed to acid).

Tracking of vehicles in underground mines can assist with traffic management around congestion points. In an underground mine, equipment could be scattered across hundreds of miles of tunnels. Countless hours are sometimes spent looking for equipment, leading to wasted time for personnel. Personnel transports get misplaced, and simply increasing the number of transports increases capital expenses (procurement) and operational expenses (maintenance). Vehicle batteries die for many reasons. Equipment sensors that monitor vehicle information could monitor battery life. Alerts could then be sent upon battery-level surges, indicating that someone had powered on the equipment. If equipment maintenance is due, sensors can alert the operator for corrective action.

Enabling location services on equipment can reduce the numbers of each type of device that are needed, and knowing where the equipment is at all times can also save time. Safety is improved by eliminating the need to send personnel into the field to look for equipment, and fewer man-hours are wasted.

Cisco technology that enables the digital transformation of autonomous and semi-autonomous machinery includes: LoRaWAN to reach areas with no coverage and Wi-Fi mesh with Cisco DNA Spaces for location services.

Worker mobility

Enabling the digital worker is a key operational improvement that mining companies are looking to capitalize upon. Today, many mines rely on paper-based processes for checking equipment sensor values and signing off on tasks. Leveraging the mine's wireless mesh infrastructure can extend connectivity to the workers, enabling them to streamline their daily activities via rugged tablets. Paperwork can then be digitized and even eliminated altogether. Work orders can be easily assigned, acknowledged, noted upon, and completed from anywhere in the mine site. Worker data entered can be captured and accessible in near real time.

The real savings lie in the fact that without data communications across the mine, workers must travel long distances to get back to areas where they can obtain information, then travel back the same distance to put the information they sought into action. Time savings and productivity improvements, which are achieved by eliminating travel time and manual processes, result in higher wrench time for mine employees and contractors.

With worker mobility enhancements, field workers can collaborate with key resources more easily to optimize their safety, reliability, and efficiency. With a rich collaboration environment, field crews are not left to try to solve problems on their own. Centralized subject matter experts can quickly and seamlessly be engaged at the worksite. Job aids, documentation, vendor resources, and information systems can be accessed for faster and more efficient completion of work orders, thus reducing operating expenditures and avoiding costly re-dispatches. Health sensors can be used to track worker biometrics, send an alarm if a worker is inactive, and notify operations in the event of a man-down scenario. Operations can monitor worker analytics and view trends on whether or not they are wearing safety gear such as hard hats and vests, thus extending safety capabilities. Worker assets such as tablets, hard hats, vests, and hand tools can be tracked by sensor networks, minimizing asset losses.

Cisco technology that enables the digital worker transformation includes LoRaWAN to reach areas with no coverage and Wi-Fi mesh with Cisco DNA Spaces for location services. This includes:

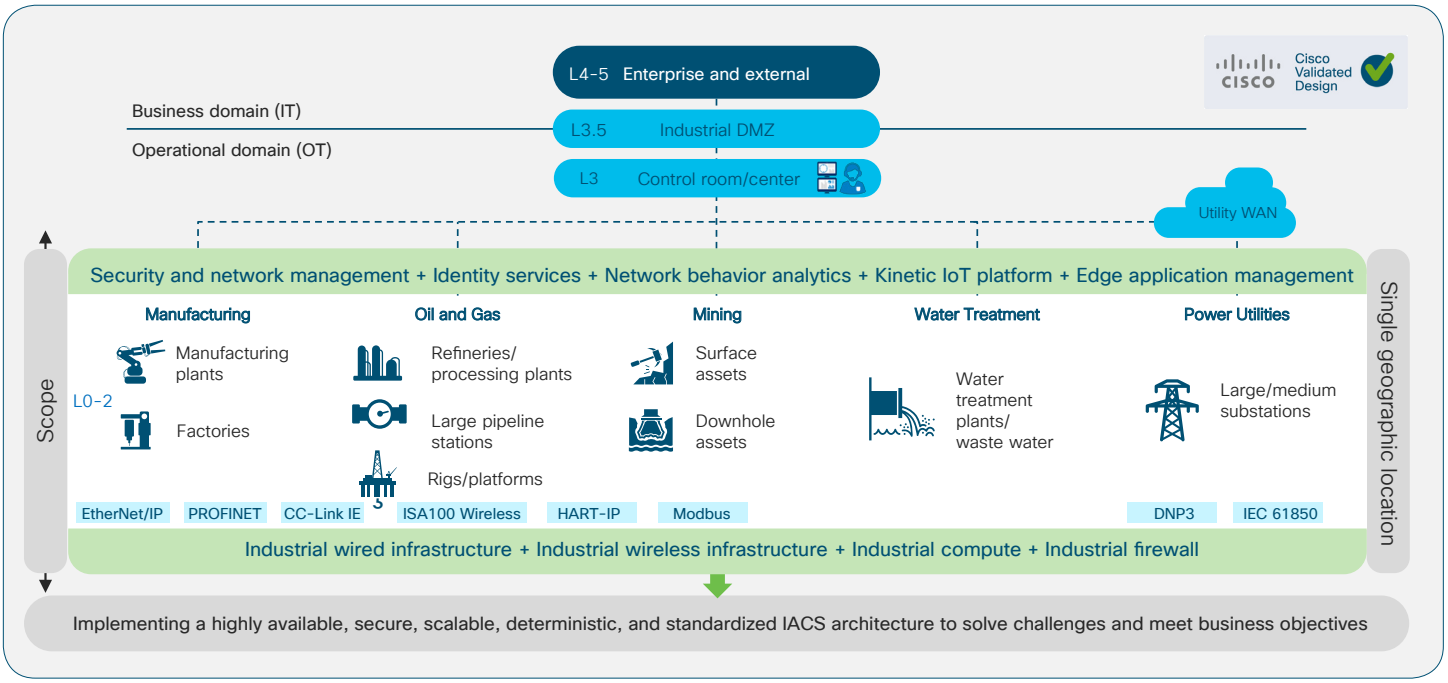
- Wi-Fi mesh with Aironet 1572, 1562, and 1532, WGB, IW 3702, and IP67-rated IE switches on board mobile fleet
- Cisco Catalyst IW6300 Series where HazLoc equipment is needed
- Cisco DNA Spaces

Industrial automation solution for process manufacturing in mining

Mining plants have a lot in common with process manufacturing facilities, only on a much larger geographic scale. The mine plant process environment can potentially span tens of kilometers, from crushers at the pit to conveyers and mills, to concentration and extraction facilities. In contrast, a typical manufacturing line may span only hundreds of meters.

Cisco's Industrial Automation Cisco Validated Design is a cross-industry architecture covering industrial plant environments for both process and discrete manufacturing operations. Although size, applications, and the devices in use may vary across the industries, many of the core networking and security concepts are applicable. Cisco's industrial automation solution can provide for a secure, reliable, ruggedized operational communications network framework suitable for the demands of mines.

Figure 4. Cisco Industrial Automation solution overview



Mining plant requirements

Network availability and security are at the heart of providing safe and sustainable operations in the mine, driving continuous operations and increasing productivity. Mining applications at their core are focused on maintaining the stability, continuity, and integrity of industrial processes. Sensors, devices, controllers, and actuators must be available and managed to properly operate the industrial processes. Today's mining operational networks need to support the following key networking requirements:

A high level of availability, as applications and mining operations often have to run 24x7x365.

Deterministic network performance to support challenging autonomous mining applications and provide a secure network infrastructure for mining operations, complying with standards such as IEC 62443 to reduce risk in the production environment.

Intent-based manageability, providing simple and easy-to-use management tools to facilitate deployment and maintenance, especially by Operational Technology (OT) personnel with limited knowledge in the IT space.

Accessible diagnostic and telemetry information from control system devices for IoT-based applications.

Scalability from tens to thousands of sensors and devices.

Reliance on open standards to facilitate vendor choice and enable protection from proprietary constraints.

The Cisco mining solution aligns with mining business trends and priorities for digitizing the modern mine. This is achieved with risk reduction through industry-leading security, improved sustainable operational asset utilization, and increased control system and asset visibility.

Secure Industrial Ethernet switching

Industrial plants and processing facilities generally require environmentally hardened devices that are designed to be placed in active areas of the mine, such as crushers, mills, and beneficiation systems. Mines are subjected to harsher environmental conditions than a typical networking platform designed for use in carpeted space can withstand. Hardened platforms are operationally equipped to sustain extended temperature ranges, shock and vibration, and intrusive elements. Cisco's Industrial Ethernet suite of products is built to withstand these environments and include the Cisco IE 2000, IE 4000, and IE 5000 Series, and the new Cisco Catalyst® IE3200, IE3300, and IE3400 lines of network switches. Cisco has Ingress Protection rated products (IP67) to address the most extreme harsh environments.

Look for IP67-rated network switches designed to withstand dust and water submersion. The IP67 designation meets the most rigorous industrial and safety standards for extreme temperature and vibration, humidity, electromagnetic emissions, and other factors.

Mining companies can benefit from two Cisco IP67-rated Industrial Ethernet switching products: the IE 2000 Series and the new Cisco Catalyst IE3400H models. These products enable software features such as NetFlow and Cisco TrustSec® for greatly improved security capabilities. IP67-rated Ethernet switches can be leveraged in mine processing plants and underground pits where ingress water protection, vibration protection, or dust protection is needed. Alternatively, IP67-rated switches can be leveraged in outdoor environments, such as on haulage trucks, to connect multiple onboard video, dispatch, and tire pressure management systems.

Figure 5. Cisco Catalyst IE3400 Rugged Series

Next-generation Industrial Ethernet switching: Mine operators love automation, and they are moving heavily into automated processes in mine sites with Autonomous Haulage Systems (AHS) such as trucks and drills. Miners are demanding autonomy of the communications network as well. Cisco Software-Defined Access (SD-Access) is Cisco's solution for providing autonomous networking and ease of use. The Cisco Catalyst IE3200, IE3300, and IE3400 switch platforms are next-generation Industrial Ethernet switches. As part of SD-Access readiness, the Cisco IE3400 will be the Industrial Ethernet switching platform that will support the SD-Access fabric edge switch functionality. The Cisco Catalyst IE3400 and 9000 families of switches will provide a foundation to move toward SD-Access for wired infrastructures and provide intent-based networking built for operations environments. These switches will provide a platform for SD-Access as the products mature. Today, these platforms are deployed as non-SD-Access-enabled switches, performing traditional network switching functions.

Network visibility and OT management: Visibility and identification of network devices and industrial assets in OT networks is enabled by Cisco Industrial Network Director (IND). A problem within industrial plant environments is not having visibility into what is connected. It becomes very difficult to manage and secure the infrastructure and to apply security policies without visibility. A key component to implementing security, and part of an ongoing risk assessment, is to understand what is connected. Cisco IND provides operations-centric network management for Industrial Ethernet networks. The system supports industrial protocols such as ODVA, Inc. Common Industrial Protocol (CIP), PROFINET, OPC-UA, Modbus, BACnet, etc. to discover automation devices and delivers an integrated topology map of automation and networking assets to provide a common framework for operations and plant IT personnel to manage and maintain the industrial network. This information can be presented to our security applications such as Cisco Identity Services Engine (ISE) and Cisco Stealthwatch® to provide context to assets and help manage security policies.

Cisco TrustSec and enhanced segmentation: A key component for security implementations, detailed in IEC 62443-3-3, is segmentation of assets into group-based policies. These policies define which assets and users communicate within or across the mining operations. Cisco IND gives Cisco ISE visibility into the industrial assets. Cisco ISE creates and administers the policies defined by the security and OT teams across a Cisco infrastructure, using Cisco TrustSec Scalable Group Tags (SGTs).

Security using NetFlow and Stealthwatch® for anomaly detection: Further visibility into the traffic traversing the mining infrastructure can aid in troubleshooting and highlight abnormal behaviors such as detection of malware that is sprawling across a mine's operations. NetFlow can be enabled on the Cisco Catalyst IE3200, IE3300, and IE3400 platforms, the Cisco IE 4000, IE 4010, and IE 5000 Series, and the Cisco Catalyst 9000 family, and can provide data flow metrics to Stealthwatch®. Stealthwatch® takes the flow data from the network and has many built-in machine learning algorithms that can assist an IT security professional in detecting possible malware propagation in the network.

Availability of the industrial automation process affects the business directly and is therefore a critical component. Ensuring the uptime of the Integrated Administration and Control System (IACS) applications requires a robust, resilient network. Predictable network performance is a requirement. Cisco Industrial Ethernet platforms support Quality of Service (QoS) to provide preferential network treatment to critical industrial process traffic. The switches support various redundancy protocols, including IEC 62439-3:2016 Resilient Ethernet Protocol, High Availability Seamless Redundancy (HSR), and Parallel Redundancy Protocol (PRP) to help preserve uptime under failure.

Figure 6. Cisco Industrial IoT networking portfolio

Cisco Industrial Ethernet wireless for mining environments

Cisco Catalyst IW6300 wireless outdoor models with Cisco CleanAir® technology are Class I, Div 2/Zone 2 certified IEEE 802.11ac Wave 2 access points designed for hazardous locations. They offer flexible, highly secure, and scalable mesh network capabilities for high-performance mobility across oil and gas refineries, chemical plants, mining processing plants, and mining pits. As well as supporting use cases over traditional IEEE 802.11 infrastructure, the IW6300 has add-on module capabilities. Emerson and Honeywell support wireless gateways to provide ISA 100 Wireless and WirelessHART-compliant radio to provide a seamless solution for wireless sensor networks. Wireless sensors are connected to plant assets, measuring and monitoring temperature, vibration, and pressure sensors. The wireless gateway consolidates data from the wireless sensors and passes the data over the Cisco Catalyst IW6300 wireless mesh infrastructure.

The Cisco IW3700 Series provides IEEE 802.11ac rates of up to 1.3 Gbps, mesh networking, and pervasive coverage in a compact form factor. It is qualified for extreme industrial environments (IP67 rated) and ideally suited for rail, transportation, mining, oil and gas, manufacturing, and other outdoor applications.

Deployed as a WGB, the Cisco IW3700 Series access points provide an arsenal of features and capabilities to help ensure continuous connectivity for static and mobile industrial applications. With their IP67-rated housing and ruggedized enclosure, they are deployed in mining as a WGB to provide truck connectivity to the IEEE 802.11 Wi-Fi mesh. Deployed as lightweight access points underground, they provide Wi-Fi connectivity throughout the mine, supporting multiple essential mining applications. These access points deliver a highly reliable solution for applications that cannot tolerate even the shortest losses in wireless connectivity, including in a roaming environment.

Figure 7. Cisco outdoor wireless portfolio

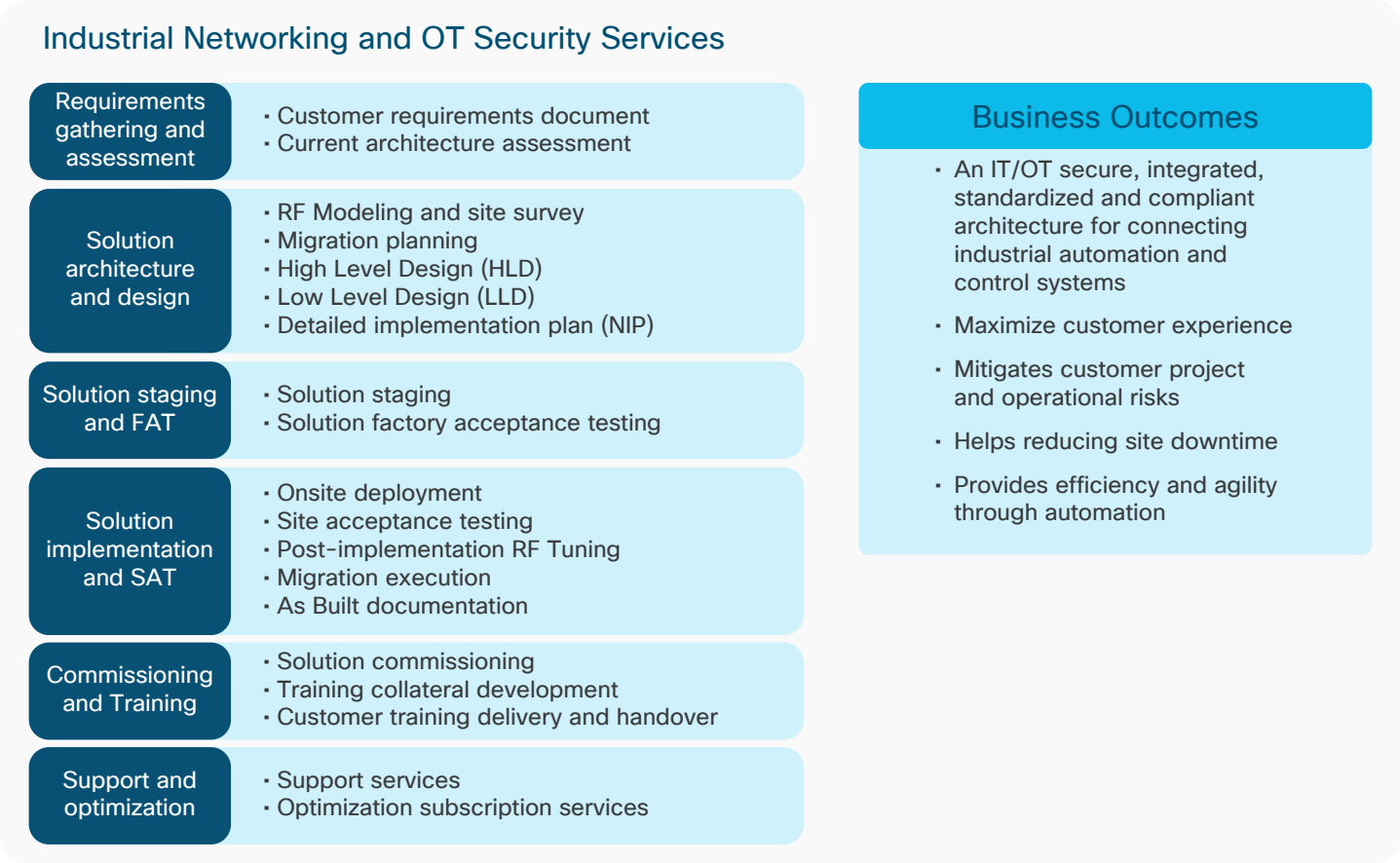
Cisco Customer Experience

Thanks to a unique architectural based approach, Cisco CX Industrial Networking and Security services help mining operators to accelerate the digitization of their existing operations. Through strategy development, architectural assessments, network design, migration and deployment assistance, and support services; Cisco and key ecosystem partners plan, build and manage solutions. These solutions focus on business outcomes resulting in improved work site safety, risk mitigation, higher productivity, improved operational efficiency, deeper intelligence and insights, with security at the core of the end-to-end solution.

Cisco CX offers a broad range of services that are scaled and customized to meet any operator's objectives. Relying on a proven methodology, CX partners with customers as they progress through their innovation and digitization journey, helping them achieve tangible results.

Cisco CX services and key partners in the industrial space maintain high standards for expertise and experience. Cisco CX Industrial Networking and Security Services consists of business and technical experts, with expertise within the mining industry. Our proven processes and tools deliver consistent results based on best practices and strong communication. Our experts deliver services that allow organizations to accelerate the integration and transformation of their current infrastructure to the next generation network, capable of evolving operations to continue to meet the evolving demands of the business.

Figure 8. Cisco CX industrial networking services



Next steps

To learn more about Cisco Connected Mining solutions, contact your local Cisco representative, or go to https://www.cisco.com/go/mining. Data sheets are available for all products mentioned here at https://www.cisco.com.

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