GLOBAL MINING GUIDELINES GROUP

20161117_Mine Communications Infrastructure I-GMG-UMuci-v0.5-r1

UNDERGROUND MINE COMMUNICATIONS INFRASTRUCTURE GUIDELINES

Part I: Positioning and needs analysis

SUBMITTED BY
Underground Communications Infrastructure Sub-Committee
of the Underground Mining Working Group

VERSION DATE
17 Nov 2016

APPROVED BY
Vote of the Underground Mining Working Group
20 Jan 2017
and
GMG Governing Council
04 Feb 2017

EDITED BY
Janice M. Burke
30 Nov 2016

PUBLISHED
15 Feb 2017

DATE DOCUMENT TO BE REVIEWED
20 Jan 2022

ORGANIZATIONS INVOLVED IN THE PREPARATION OF THESE GUIDELINES

Representing organizations from the Underground Mining Working Group include: Agnico Eagle, Atlas Copco, Barrick Gold, Cisco, Newtrax, Rio Tinto, Sandvik, Yamana Gold, University of the Witwatersrand, and Vale.

DISCLAIMER

Although these guidelines and other documents or information sources referenced at http://www.gmggroup.org are believed to be reliable, we do not guarantee the accuracy or completeness of any of these other documents or information sources. Use of these guidelines or the above documents or information sources is not intended to replace, contravene or otherwise alter the requirements of any national, state, or local governmental statutes, laws, regulations, ordinances, or other requirements regarding the matters included herein. Compliance with these guidelines is entirely voluntary.

COPYRIGHT NOTICE

This document is copyright-protected by the Global Mining Guidelines Group (GMG). Working or committee drafts can be reproduced and used by GMG participants during guideline development. GMG hereby grants permission for interested individuals/organizations to download one copy. Written permission from GMG is required to reproduce this document, in whole or in part, if used for commercial purposes.

To request permission, please contact:

Global Mining Guidelines Group
Heather Ednie, Managing Director
hednie@gmggroup.org
http://www.gmggroup.org

Reproduction for sales purposes may be subject to royalty payments or a licensing agreement.

Violators may be prosecuted.

TABLE OF CONTENTS

1. FOREWORD

The Global Mining Guidelines Group (GMG) is a global, multi-stakeholder community to advance the availability and use of standards and guidelines for the international mining industry. This GMG document was prepared by a GMG working group. Draft documents are checked and approved by working group members, prior to approval by the GMG Governing Council.

Formed as part of the Canadian Institute of Mining, Metallurgy and Petroleum (CIM), GMG is supported by CIM and three other Partner Organizations: the Australasian Institute of Mining and Metallurgy (AusIMM), the Southern African Institute of Mining and Metals (SAIMM), and the Surface Mining Association for Research and Technology (SMART), as well as its Member Companies and participants.

Please note: if some of the elements of this document are subject to patent rights, the GMG and CIM are not responsible for identifying such patent rights.

2. DEFINITIONS OF TERMS, SYMBOLS, AND ABBREVIATIONS

BLE	Bluetooth® Low Energy
IP	Internet Protocol
IT	Information Technology
LTE®	Long Term Evolution
TCP	Transmission Control Protocol
VOIP	Voice over Internet Protocol
VPN	Virtual Private Network
WAN	Wide Area Network

3. KEYWORDS

Communications technology, Digital network, Infrastructure, Maturity lifecycle diagram, Underground mine

4. INTRODUCTION AND BACKGROUND

The rapid development of industrial and communications technology in recent years increasingly benefits mining activities around the globe and has affected nearly every facet of the mining process. Companies are rapidly deploying these new tools and applications to gain the associated productivity and financial benefits. However, they face a key challenge in that they require the appropriate infrastructure to support data communications technology in the mining environment, particularly underground mines.

Many new technologies developed and sold by vendors require high-speed digital networks to manage the increasing volumes of data generated in the underground mining environment. The data range from video and voice communications to vehicle telemetry, dispatch, and other critical systems and services. In the past, each vendor required separate networks for their proprietary solutions. Today, industrial control and mining solution vendors are moving towards a single standardized, consolidated communications infrastructure based on the digital Ethernet (transmission control protocol/internet protocol or TCP/IP) network framework—or at least are developing communications interfaces to allow their devices to interconnect with this type of network—in mine sites to improve production and cost optimization. This allows mining companies to run multiple services over a single backbone, thereby improving management while lowering deployment and support costs. The rapid shift from traditional, legacy analog systems (e.g., leaky feeder) to high-speed digital networks has created a lag in the knowledge and experience that is required to properly plan, design, deploy, and maintain such systems.

This Underground Mine Communications Infrastructure Guidelines series is intended to provide a high-level view of the processes needed by mine personnel to meet planning and design requirements when creating or replacing underground mine communications infrastructure. The series of five parts is intended to step the user through the general tasks and components needed to define the technical requirements for an underground communications infrastructure that supports mine services now and into the foreseeable future.

4.2 Part Descriptions

The five parts within the Underground Mine Communications Infrastructure Guidelines series are arranged so the user learns a fundamental concept and then builds on their knowledge in each consecutive part. The following is a brief description of each part of the document series.

4.2.1 Positioning and Needs Analysis Part I (this document) provides a general overview of the guideline objectives, audience, and mine communications maturity lifecycle diagram. This diagram provides a high-level overview of the services and supporting technology that is generally used in each phase of the mine lifecycle. The diagram initially shows business services and communications technology on the surface in the exploration phases and then shifts to the underground environment as the site develops.

4.2.2 Scenarios and Applications Part II provides scenarios of practical applications in underground mining today and in the near future. The scenarios relate how different communications infrastructure designs can be used and combined to achieve key technology goals. The business services design requirements comprise a series of checklists to step through the general tasks and components needed for each phase of underground mine planning and development. The checklist helps mine personnel and contractors identify the appropriate network communications technologies to support required services and solutions.

4.2.3 General Guidelines Part III compiles information to help the reader better understand the general concepts, techniques, and methods used in the industry to create and maintain a communications infrastructure. The content is designed to help non-information–technology (IT) personnel identify high-level requirements, and to provide resources to learn more the technologies.

4.2.4 Business Case Development Part IV is focused on the development of the business case and charter.

4.2.5 Planning, Deploying, and Support Considerations Part V provides more detailed project management practices, communications infrastructure technical design information, and sustainability support information.

5. SCOPE AND DEFINITION

The scope of Part I is to provide a planning and sustainability tool for mining personnel who are responsible for designing, operating, and maintaining the communications systems and services used for safety and production purposes in an underground mine environment. This document:

- helps non-IT personnel better understand basic communications requirements during mine planning, construction, and production phases;
- provides a standard reference for mine staff, engineering consultants, and solutions vendors when planning new—or maintaining existing—communications systems; and
- helps identify the communications assets to support current and future mine technologies.

Several questions need to be addressed within the process of designing a communications infrastructure:

- What are the business goals to be achieved from the underground development?
- What specific objectives must be achieved to meet the defined business goals?
  - What do you need?
  - Where do you need it?
  - Who needs it?
- What is the value proposition of the objectives (how do we show the value of implementing these technologies)?
  - What are the cost benefits?
  - What specific deliverables (business outcomes) are identified for each value proposition?

The deliverables achieved by using this document will help complete planning and support documentation, such as

- scoping and feasibility documents
- business case
- project charter
- operational technology sustainability model for life of mine plans

5.1 Audience

1. Mine planners
2. Mine engineers
3. Technical services teams
4. Mine construction teams
5. Mine operations managers
6. Mine operations: maintenance and instrumentation
7. External engineering firms (construction projects)
8. Underground mine solutions vendors

6. STANDARD ORGANIZATIONS

The primary standards organizations considered in this document include, but are not limited to the following:

- Internet Engineering Task Force (IETF) https://www.ietf.org
- Institute of Electrical and Electronics Engineers (IEEE) https://www.ieee.org
- International Telecommunications Union (ITU) https://www.itu.int
- Telecommunications Industry Association (TIA) https://www.tiaonline.org
- National Institute of Standards and Technology (NIST) http://www.nist.gov
- International Standards Organization (ISO) https://www.iso.org
- International Society of Automation (ISA) https://www.isa.org

7. MINE COMMUNICATIONS MATURITY LIFECYCLE DIAGRAM

The mine communications maturity lifecycle diagram is focused on the digital communications systems within a mine site (Figure 1). It is intended to provide a high-level picture of the communications infrastructure requirements at the earliest development phases, and how it progresses to become an integral part of mine security and productivity in the underground environment. It also shows the importance of maintaining this infrastructure, and the need to regularly evaluate its capabilities and effectiveness over time.

7.1 Maturity Phase Descriptions

7.1.1 Early Exploration Phase Most exploration activities initially are very mobile and take personnel to a broad array of areas where communications services can range from very good, to very sporadic, to nonexistent, depending on the level of coverage by telecommunications providers in the exploration areas. The communication needs of exploration personnel in the field are generally restricted to voice with limited data requirements, and can be met by cellular or satellite services. In some circumstances, communication needs include human safety concerns, therefore additional features may also be required (e.g., global positioning systems, emergency beacons, Bluetooth® low energy (BLE)).

Historically, data communications have been limited to a "home base", such as a remote office or hotel with appropriate internet services. Most field data collection uses a computer or tablet to input the data into an application and then upload them to the company network once back at the home base.

However, this situation is changing as newer technologies (e.g., 4G LTE® cellular, wireless internet services) are deployed into rural and remote regions. Some companies use a remote communications utility trailer to provide a satellite uplink, a localized wireless connection (within approximately 100 m of the trailer), basic electronics to provide connectivity and cybersecurity, and a mobile power generator. Some versions even have a small office built onto the trailer.

7.1.2 Advanced Exploration Phase The advanced exploration phase is more static than the early exploration phase and creates the initial foundation for the future mine communications network. It is assumed that the activities of geologists and mining engineers increase as the exploration phase progresses and that temporary or permanent structures are in place for office and field work. Most communications needs are focused within a defined radius of these semi-permanent buildings.

Advanced exploration sites usually begin to build out more complex digital communications systems once the

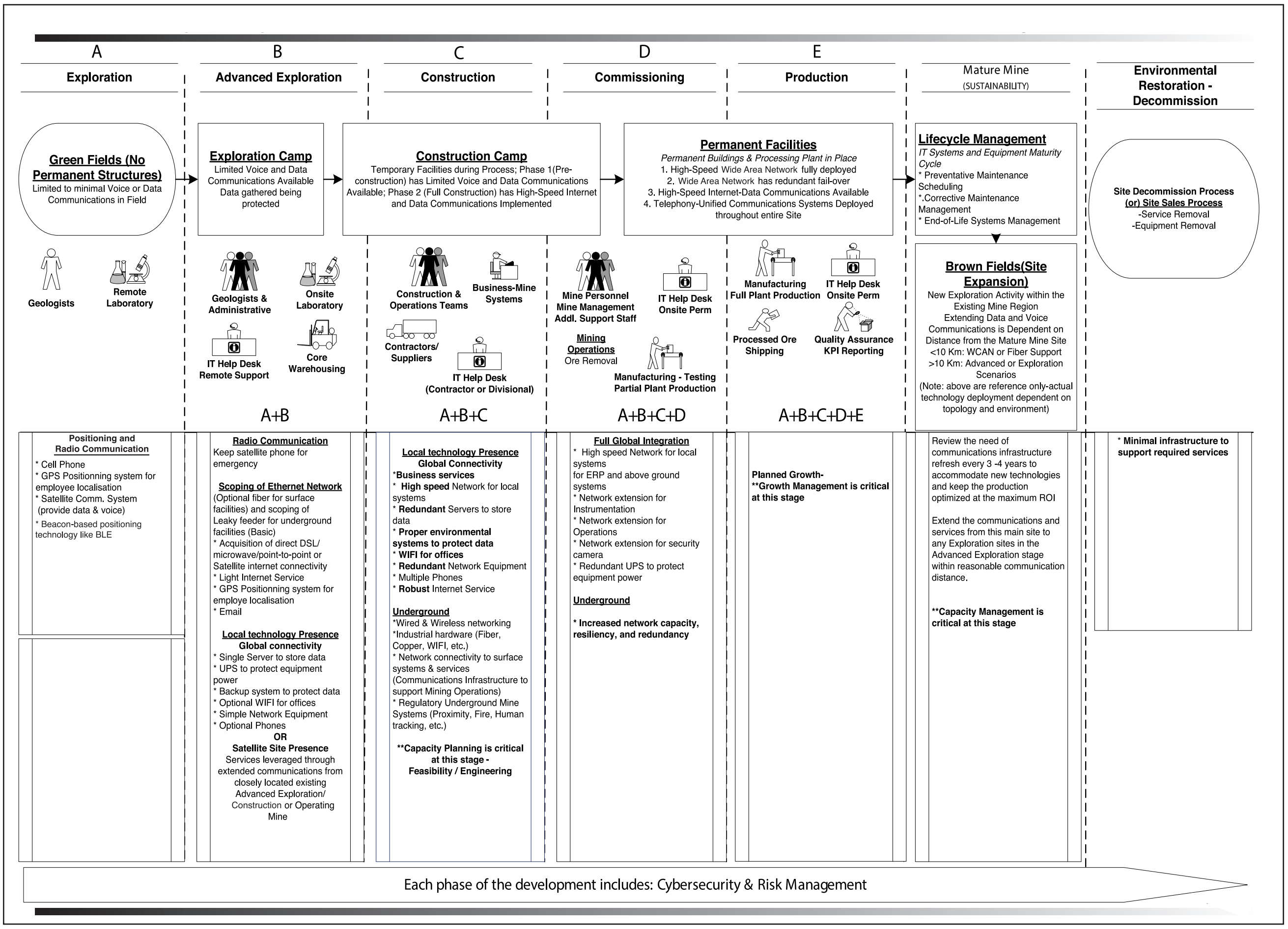

Figure 1. Mine Maturity Lifecycle Example: Communications and Services Structure and Management

site becomes more established. This may include a two-way digital radio system, wireless hotspots, cellular services, and connecting the site to the corporate network via satellite or some wireless service, such as an internet connection using a virtual private network (VPN) tunnel. Additional networking equipment is typically installed to support site personnel computers and telephones. This equipment may be centrally kept in a dedicated room for management, environmental control, and security—it becomes the initial communications hub for the site. The IT department usually becomes responsible for implementing and maintaining these communications systems, and supporting the users at the site as part of the corporate environment.

Later in the advanced exploration phase, it is common to see a tunnel drilled for more detailed orebody assessment, which could potentially extend several kilometers. It is critical to provide basic communications in the underground at this point for human safety purposes. This tentatively begins the underground communications lifecycle. It is important to implement the wide area network (WAN) communications solution for the mine site during the latter half of this phase once the feasibility study has been approved.

7.1.3 Construction Phase Stable, high-speed WAN communications, either via the internet or a private circuit, should be in place by the onset of the construction phase to support the growing needs of employees and vendors as they ramp up for construction. During the construction phase, the digital communications infrastructure expands dramatically both on the surface and underground as the campus builds and underground tunnels are expanded to begin extracting ore. It is important to understand that the underground communications infrastructure is critical to the productivity and safety of mine personnel.

The engineering design of the orebody is defined early in the construction phase. The primary mine plan shows the locations of tunnels, shafts, and stopes to be implemented during a large portion of the mine lifecycle. This information provides critical design criteria for the proper design of the underground communications infrastructure, along with the expansion and sustainability model of the communications systems. This multi-year plan and associated budget can now be incorporated into the life-of-mine process.

There can be considerably more site personnel during the construction phase than during the subsequent production phase, which means the demand for internet and telephone services can be high. The quality and performance of the WAN and local connectivity can dramatically affect the quality and timeline of the project. Poor communications can result in order delays, miscommunication between construction teams and equipment providers, system deployment issues, and other problems.

During the construction phase, more than 90% of the entire digital communications infrastructure is implemented at the mine site—both surface and underground. The foundational infrastructure design for the underground environment must allow for rapid expansion of the systems and services as the mining regions extend farther from the initial tunnels. The infrastructure will usually incorporate a combination of wired and wireless communications components such as fibre optic, twisted pair copper wiring, wireless, hybrid leaky feeder, and other methods.

By the end of the construction phase, the underground communications infrastructure is fully operational and supports a variety of protocols and services, such as vehicle telemetry, vehicle remote control, avoidance detection, human tracking, voice over internet protocol (VOIP), vehicle dispatch, ventilation control, and many others.

7.1.4 Production Phase The production phase—sometimes called commissioning or startup—is the final phase of initial mine development. This transition from construction to production can range from several months to more than a year, depending on the size and complexity of the mine. The underground communications infrastructure is fully implemented and operational: all services that were designed to operate within the underground mine are now in production and are being used by mine personnel. The communications systems and digital services are adjusted during the production phase to gain optimal operating efficiency. It is important to verify all of the infrastructure documentation during this transition phase and document the updated configurations for those systems. This information is critical for the maintenance and repair needs during the mature mine phase.

7.1.5 Mature Mine (Sustainability) Phase The mature mine phase constitutes most of the mine lifecycle. The mine is operating at or near full capacity and the output is included in the company's revenue statements. All surface and underground communications infrastructure is actively used and is essential for effective and efficient mine operations. The focus on the underground communications infrastructure shifts from development and implementation to expansion and sustainability.

The underground mine becomes a growing and dynamic environment of expanding tunnels, shafts, and stopes as production progresses into new areas of the orebody. Previously mined areas are left vacant or backfilled depending on the mining methods used. The communications infrastructure must constantly adjust to meet the needs of the production environment. Some areas remain as permanent access and to maintain vehicle and personnel traffic flow throughout the underground. These high-traffic areas are ideal for fixed, high-speed communications infrastructure (e.g., fibre optic cable, twisted pair Ethernet cable). Communications junctions along these paths (e.g., fibre distribution, Ethernet switches, wireless access points) provide distribution of the digital data traffic to current production areas within the mine.

Most mine activities occur in production areas outside of high-traffic areas, where the communications infrastructure must be flexible and mobile, so it can be moved out of retired tunnels and stopes and into new sections as production moves to new locations. This continuously changing communications requirement becomes the normal pattern throughout the life of the mine. Modular and durable wireless systems are fast becoming the primary solution for these challenges. Vendor maintenance agreements, contractor labour costs, and equipment replacement for remedial events should be built into the plan and budget annually.

Depending on the projected mine life, there may also be a need to replace or update equipment. There should be a milestone within the roadmap during initial communications infrastructure planning to designate when such an event would occur. This type of update would be managed as a project to re-evaluate current business needs and technical requirements. The mine plan would then be updated based on the updated project to reflect changes to technology and cost.

7.1.6 Decommissioning During the decommissioning phase (sometimes called reclamation), the mine site is removed from production, including disassembly of the plant, mining equipment, and buildings. The intent is usually to meet governmental compliance in restoring the mine site to a state prior to development. This phase can take many years of effort before the decommissioning process can be considered complete.

In most cases, there is still a need for a limited level of communications infrastructure during decommissioning. Services such as VOIP, environmental monitoring, and two-way radio services require both local network and WAN systems. In many cases, field monitoring telemetry data are collected at a central location on the site and archived. Archived data might be accessed remotely by the company or potentially transferred or copied to an offsite backup location.

8. RESOURCES, REFERENCES, AND RECOMMENDED READING

Bandyopadhyay, L. K., Chaulya, S. K., & Mishra, P. K. (2010). *Wireless communication in underground mines: RFID-based sensor networking.* New York, NY: Springer US. http://dx.doi.org/10.1007/978-0-387-98165-9

Miśkiewicz, K., Wojaczek, A., Frączek, S., & Krasucki, F. (2012). (2012). *Electromagnetic compatibility in underground mining: Selected problems* (Vol. 7). Amsterdam: Elsevier.