Heavy Duty VoIP Telephones

White Paper:
Road Tunnel Safety

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Document Number: W10003

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1.0. Tunnel Safety

In recent years, safety in road tunnels has become a major issue globally. More and more tunnels have been constructed to develop new road network through mountainous ranges or to avoid environmental problems in urban areas.

Generally speaking, fewer accidents occur in tunnels than on open roads. However, if an accident occurs in a tunnel, the impact is often much greater th an on open roads. The consequences of a tunnel incident can be extremely destructive and dangerous, especially in the event of a fire, because the enclosed space hinders the dissipation of heat and smoke. In addition, access limitations for firefighting and rescue operation, difficulty in ensuring safe escape route of the tunnel users from an enclosed space increase the severity of the accident seriously.

Fires in tunnels not only endanger the lives of tunnel users, they can also cause the damage to the tunnel structure with the very prejudicial consequences on the capital represented by the tunnel. In view of this, it is essential to prevent accidents in tunnels and provide adequate measures for tunnel users to communicate with emergency services to be rescued by fire brigade.

Unfortunately, there is no such thing as absolute safety in road tunnels. Therefore, public road administrators must make every effort to reduce the risks to the greatest extent possible.

2.0. Reducing Consequences of Accidents and Fires inside Road Tunnels

A sustained campaign across Europe to improve safety in tunnels has seen significant improvements made in recent years. Over the last 5 years, tunnel safety has been driven to the top of the agenda as a key motoring issue, impacting not only personal safety but also of whole countries' transport infrastructure.

Many people point towards the back-drop of this as being the Mount Blanc accident in Charmonix, France. In March 24 1999, a horrific fire in the Mont Blanc tunnel linking Charmonix with Courmayeur, Italy, resulted in the deaths of 39 people. A shocked government and public alike raised questions as to the safety of other tunnels in the country, where 75% of the terrain is classified in mountainous and where use of road tunnels is a daily fact of life.

When we talk about reducing consequences of Accidents and Fires inside tunnels, the technologies that most frequently spring to mind are the provision of emergency roadside telephones (ERT), observation equipment such as closecircuit television (CCTV) and public address and voice alarm systems (PA/VA).

3.0. Tunnel & Road Traffic Technology Developments

The common ITS development in all these separate road tunnel technologies, is a technology-shift from conventional analog or "copper-cable" equipment towards modern IT-network-type equipment based on Internet Protocol (IP) that works by sending the information data or voice via fiber-optic network cables, also known as Ethernet cables.

IP networks allows wast amount of information to travel at the speed of light. This higher bandwidth also means that users can send images / video as well as sound / voice over the IP (VoIP) on the same network. This has led to IP-protocol networks becoming the main network type in all modern industrial and emergency tunnel installations, and as sales volumes has increased, the price is coming down fast.

Recent evidence also points towards IP technology being the more reliable communication network in case of emergency breakdown inside a tunnel. The failings of conventional analogue "copper" telephones were visibly demonstrated to the world in May 2008, in a 22-car pile-up in the Harvey Tunnel in New Orleans that saw 24 people injured. None of the emergency telephones were found to be working.

4.0. IP Technology = Cost Effective?

The technology shift from analogue to IP cost driven. Though IP products may be marginally more expensive at the outset, most end users recognise the cost benefit with IP because you do not need separate networks for sound (telecoms) versus data (IT), and conversely you can save both operational costs and maintenance through remote surveillance as well as by simplifying cable installations by IP networking.

Indeed, since electricity now can be sent over the Ethernet cable (Power over Ethernet - PoE), this often means that you do not need separate cabling for power either, which means even further cost savings on electrician bills.

So, IP networks are here to stay, and they will only become more important in the future. Indeed, inside road tunnels, we now find that also ventilation fans, smoke detection equipment, access control, traffic signs and PA/VA is also moving towards IP networks. So it is not only CCTV Cameras and ERT systems that are going through this technology shift.

This development, in turn, means that it is today much easier to deliver a total operational control solution or supervisory control access data administration system (SCADA) which can deliver a total control of all your equipment inside a road tunnel. This can only be a good thing for people concerned with improving tunnel safety.

5.0. Tunnel Telephones based on VoIP

Nowhere is tunnel safety taken more seriously than in Norway, a country where 75% of the terrain is classified in mountainous and where use of road tunnels is a daily fact of life. Tunnels provide many of the primary links between cities and communities. It is not surprising that Norway is home to the worlds longest road tunnel, the Lærdal Road Tunnel.

Norphonic is a Norwegian company specialising on manufacturing SOS call box / VoIP tunnel emergency telephones. Norphonic started their business based around the need for modern tunnel safety telephones in 2003, and has been involved at the cutting edge of these developments ever since. The company has significant experience installing robust VoIP emergency roadside telephones inside some of the harshest road tunnel environments in Europe.

Having so many remote tunnels in Norway has driven the need to develop technology that also can be monitored from afar, ensuring that the ERT system actually work if a serious accident were to happen.

6.0. Success Story from Iceland – Tunnel Telephones

A practical example of the shift from analogue to IP technology can be found in Iceland, where the local Road Administration recently decided to standardise all their road tunnel emergency communication on the latest robust VoIP technology from Norphonic.

In this example, the Norphonic IP emergency roadside telephones (ERT) allows full redundancy and total power back-up in case of failure, at the same time as the ERT system can be upgraded from a central location, saving both maintenance and installation costs. The system is also future proof, being built on Open SIP Standards that can work with virtually any central telecom solution, whether it is Alcatel, Cisco, Asterisk, or any IP based PBX vendor.

The reason for the major tunnel emergency telephone system refurbishment in Iceland was based on a recognition that emergency telephones are a critical implementation inside road tunnels in case of emergency. In line with the latest EU directives, Iceland agreed that effective and reliable VoIP roadside telephones can drastically improve the chances of rescue in the event of serious accidents and tunnel fires. They therefore decided to replace all their telecommunication equipment with the latest VoIP system from Norphonic.

7.0. Best Practice, Regulations & Technology

There are no reason for why best practice, regulations and the latest technology can not live happily side-by-side. Modern IP based Emergency Roadside Telephones from Norphonic has an even better sound quality than standard analogue phones. And, the need for improved remote surveillance and automatic system control checks makes sure that this system correlates with the latest Best Practice guidelines on the market. The rugged performance further establish VoIP as the most efficient form of Emergency Roadside Telephones ERT systems on the market today.

In terms of tunnel-specific regulations, the European Directive 2004/54/EC states that the minimum safety inside tunnels are for the Emergency Stations (Emergency Roadside Telephones and Fire Extinguishers) to be installed at least every 150 meter. Water supply should be at least every 250 meter, and there should be automatic incident detection and/or fire detection in every tunnel above 500 meters. In addition, there should also be traffic signals inside the tunnel at least every 1000 meters where the tunnel is more than 3000 meters long.

8.0. Road Tunnel Emergency Exercise and Emergency Equipment Tests

For tunnels longer than 1,000m, and shorter tunnels with heavy traffic volume, the current EU regulation states that exercises on site should be carried out jointly with the police, the fire brigade and other organizations concerned once or more a year, to test brigade response times, tunnel operator, fire brigade and ambulance response times.

However, aside from the practical response and brigade tests, it is also important to check the equipment. With modern Norphonic Emergency Roadside VoIP Telephones, this can be achieved with automatic tests which can report on handset off/on positions, if the microphone is working if there is a line failure and much more. This enables a central control center to easily take action before a potential system faults can become a real health and safety hazard.

9.0. Key things to look for in IP Tunnel Phones

Here is a brief summary of items to look for when checking out a new ERT solution for your tunnel:

- Is the system based on Open Standards / can the system work with major existing infrastructure? The Norphonic ERT system is based on Open SIP Standards (RFC3261) which means the system can work with virtually any IP based PBX solutions including Alcatel, Cisco, Asterisk / Digium Switchvox, Sipgate, Pingtel, Broadsoft and much more.

- Can the system be monitored centrally by SNMP, Modbus UDP and/or Modbus TCP? Norphonic ERT phones can be monitored using either Modbus UDP, Modbus TCP or SNMP protocols, making it really easy to provide overall control and monitoring of the installation inside the tunnel.

- Does the system include buildt-in ToS - type of service and QoS -Quality of Service functionality? These protocols, which comes as standard in all Norphonic deliveries, prioritise voice signals in the dataflow, ensuring impeccable delivery of voice communications over the IP network (eliminates jitter, latency, out of order data-packets etc), ensuring good sound.

- Can the telephone status be read remotely? Norphonic offers self test and automatic health check on hookswitch, microphone and fiber ports, in addition to remote re-start and control functions.

- Does the system include a high performance hookswitch with no moving parts? The Norphonic hookswitch has no moving parts which is essential in tunnel applications where dust and grime quickly can become a problem.

10.0. Tunnel Network Topology, and Installation Options

When it comes to network topology, the Norphonic VoIP Emergency Roadside Telephones can be set up in a number of different ways, including star and ring-type formations. Due to best practice on redundancy though, we recommend installing ERT systems in ring formations.

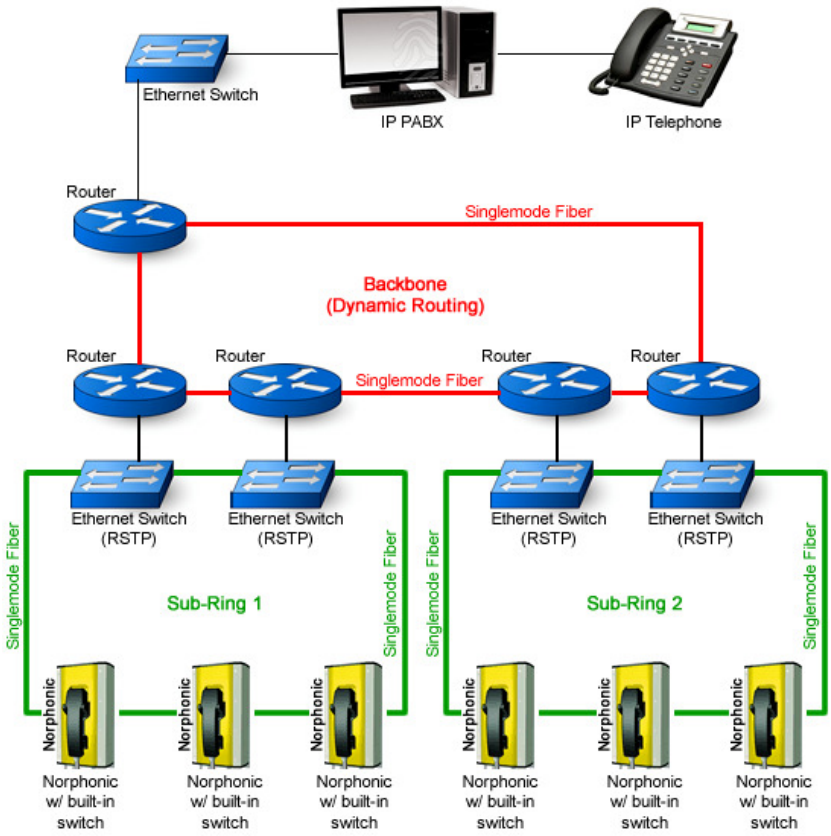
The Norphonic IP Emergency Roadside Telephone comes with an option to include two built-in single mode fiber optic ports (LC Connectors) which enables redundant networking with Rapid Spanning Tree Protocol (RSTP). This means that you do not need an external fiber switch to enable redundancy, which is a cost effective inclusion. The phone could also be used in a network with external switches, and the phone would then be connected to the switch via Ethernet (RJ45) port on the Norphonic telephone unit.

The below figure shows how the telephones could be split into a backbone ring and then sub rings, with each ring having phones connected to it. As shown in the figure below, the phones are looped to provide a high degree of redundancy in case of failure of either the fiber link or the phone itself.

Since the phones can be equipped with 2 fiber ports as a product option, a break in the fiber link in one direction will not affect the phone, since the system will reconfigure to the alternate path. And if one of the telephone is faulty, it will not affect the other phones from functioning.

When organising phones into rings, we do not recommend placing more than 20 phones in each ring because, with increasing ring size, the recovery time also increases. In European tunnel installations there is a hard requirement of 30 second recovery in case of network failure. Therefore, we recommend to split the phones into several primary rings, introduce one extra RSTP-capable switch in each, and join these into a bigger backbone ring. This will also have the added benefit that the overall degree of fault-tolerance improve.

Example Norphonic Heavy Duty VoIP Telephone Network Topology



As you can see from the image on the previous page, the ring network structure is used to form a backbone ring (illustrated in red in the schematic). The sub-rings (colored in green) are connected to the backbone ring (colored in red), and there are in effect no limitations how many such sub-rings you add on the system. However, as noted before, we do not recommend adding more than 20 phones to each sub-ring, keeping in mind RSTP limitations and also network recovery time. This means that the network recovery remains quick whilst ensuring excellent overall fault-tolerance.

In most modern road tunnel applications, it is required that the network shall be made to be redundant, immune against noise and built on open standard protocols. This is achieved by use of Ethernet over fiber, usually coupled in a ring formation with a protocol which controls the ring. Of open protocols, typical alternatives include Spanning Tree Protocol (STP), Rapid Spanning Tree Protocol (RSTP) and Multiple Spanning Tree Protocol (MSTP).

Norphonic VoIP Tunnel Telephones support RSTP and STP. Today, STP is rarely used, so in practical terms RSTP is the main protocol which is used. Seeing that almost all administration switches today support RSTP, this means that you can construct network rings where you can mix and match different Ethernet switches from different manufacturers, and you can also be free to select whatever switch you want when you are upgrading or maintaining your network. Norphonic does not support proprietary solutions, as we cannot see that a customer will have any benefit whatsoever by being bound to only one product.

11.0. Different Network Topologies – Flexibility

The network topology can obviously be installed in many different ways in addition to the the example explained earlier. The technology is very flexible to accommodate different set up and network formations. For example, the phone could also be used in a network with external switches, and the phone would then be connected to the switch via Ethernet (RJ45) port on the Norphonic telephone unit.

However, the example given in this document nevertheless shows a typical tunnel network topology which have been installed in numerous road tunnels in the past, including the major E18 road construction project in Norway which included 7 tunnels and 3 bridges. This is a highly robust installation and will adhere to all the best practice / international requirements on redundancy when it comes to road tunnels.

12.0. Remote Software Configuration of Tunnel Emergency Telephones

The Norphonic software can be configured either via Web interface or via a set up of configuration files. In case of the latter, a configuration file for each phone is placed on a TFTP server, and upon boot-up, phones retrieve the configuration. If TFTP server is not accessible (e.g. removed after initial site configuration), telephones use the settings downloaded previously.

All configuration and firmware updates can be done remotely over the network, including re-starting telephones. Firmware update is performed by placing an update bundle on TFTP server. The phones on the installation detect new firmware and perform the upgrade within 24 hours, with normal distribution in the time frame. This avoids peak loads on the network, avoids RSTP tree deterioration due to mass reboots of equipment, and ensures that only a fraction of the telephone park will be down at any given moment. This is a great benefit for the end user regarding ensuring optimal Mean Time Between Failure records (MTBF).

13.0. Tunnel Emergency Telephones - Alarm Monitoring

One extremely valuable feature with Norphonic is that the system is flexible to include several ways to accessing the telephone to read its component status / the "self monitoring and fault check function". This could be done either via SNMP Protocol, or via open protocols Modbus UDP or Modbus TCP.

Norphonic offer surveillance capabilities of:

- Hook sensing (ie: hook off/on)
- Audio Self Test (microphone / headset check)
- Fiberport 1 status (link check)
- Fiberport 2 status (link check)
- RJ 45 port status (link check)
- Firmware version and firmware update status

Explanation of the Self Test on Norphonic units: The self-test involves testing the function of the SIP software, audio circuits and the handset by playing and recognizing a set of DTMF tones in the handset at pre-configured time intervals. The alarms are reported over the fiberoptic or cat5 Ethernet (where applicable).

The phone can provide Modbus UDP, Modbus TCP or SNMP traps for the self test and on-hook / off-hook event. Fiber link failure does not generate a trap but it can be polled. The advantage of using SNMP or Modbus protocols is that these are standardised tools for monitoring other network equipment, including switches, routers, PBX systems, VoIP gateways and pretty much anything you want to monitor inside a tunnel environment.

14.0. Tunnel Telephone Reliability: Medium Time To Recovery (MTTR)

Time To Recovery from an outage varies depending on circumstances (particular network setup, whether the phone address is configured with with static or DHCP, if firmware update was performed, etc), but it is normally is in low minutes. Replacing a wall-mounted Norphonic telephone with a total failure, assuming you are there with a spare and can reach mounting screws, is about 15 minutes.

15.0. Recommended Further Reading on Tunnel Safety

The installation of modern VoIP technology will play a key role in raising the levels of safety in tunnels, at a time when road traffic is increasing exponentially and when the potential for accidents is higher than it has ever been.

Norphonic has a long history of installations in tunnel environments, and we have issued a number of white papers and application guides which will be helpful to read if you are considering to invest in tunnel emergency SOS-type VoIP telephones.

We recommend that you take a moment to visit the Norphonic website at www.norphonic.com where you can access a document library which contains some relevant information, including:

- Emergency Roadside Telephone (ERT) – Application Guide
- Designing Fiber Networks – White Paper
- Road Tunnel Installation Case Studies
- Glossary of technical terms
- And much more.

You may contact Norphonic directly with questions or if you need further information on this topic:

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16.0. About Norphonic

Norphonic is a privately held company, manufacturing Heavy Duty VoIP Telephones used in a wide range of industrial and emergency environments worldwide, including transport applications (rail, air, road, underground and metro systems), car parks, mines, production floors, public spaces and heavy duty industrial applications such as offshore wind farms and power manufacturing sites.

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