Critical Infrastructure Contingency Communications

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NVIS Communications

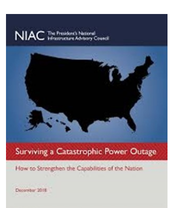
Communications are critical to responding to disruptive incidents of all magnitudes. Loss of commercial and proprietary communications systems often occurs during major disasters and cyber-security events. **Without the ability to communicate within your response team and with critical external support, supply chain members and government officials, your response team will be significantly impacted, perhaps to the point of inability to restore your systems in a timely manner.** This whitepaper explores the background and need for contingency communications systems for entities providing critical infrastructure. It also proposes a viable solution available to your team using of Long Range Digital Radio (LRDR). **LRDR is built on HF radio with advanced features providing an Infrastructure Independent Voice and Data** solution that can work when all other modes of communication have failed or are unavailable. Learn how LRDR radio can be included in your overall response command and control system to give you a highly resilient contingency communications system. We also discuss current deployment of LRDR radio within critical infrastructure sectors and an available source of support from the US Department of Homeland Security with the SHARES network.

The Challenge

Catastrophic incidents occur affecting small to wide areas on a regular basis in the US. These incidents damage/destroy/disrupt electrical power impacting the operation of critical infrastructure and injure/kill people in their aftermath. Critical infrastructure entities and their supply chain support need a resilient communications network supporting the operation, restoration and recovery of their critical infrastructure.

Catastrophic incidents include: massive earthquakes, massive tsunamis, Geomagnetic Disturbances (GMD), Electromagnetic Pulse (EMP) attack, and cyber-attacks. What these all have in common are:

- Little or no notice;
- Impact may extend across an extremely large geographic area and multiple states;
- Unparalleled damage to critical energy infrastructure and communications;
- Significant impact on response and recovery resources.



The National Infrastructure Advisory Council (NIAC) Catastrophic Power Outage Study of Dec. 2018 defined a catastrophic power outage and how it impacts critical infrastructure.

This definition included:

- Events beyond modern experience that exhaust or exceed mutual aid capabilities;
- Likely to be no-notice or limited-notice events that could be complicated by a cyber-physical attack;
- Long duration, lasting several weeks to months due to physical infrastructure damage;
- Affecting a broad geographic area, covering multiple states or regions affecting tens of millions of people, and
- **Causes severe cascading impacts that force critical sectors, i.e., drinking water and wastewater systems, communications, transportation, healthcare, and financial services to operate in a degraded state.**

Communications Impact

The impacts to communications systems from these events include: no dial tone and/or no last mile for landlines; cell phone sites damaged/destroyed or with no power; no last mile and backbone damaged/destroyed for the Internet; congested and delayed/no access for satellite phones; and public safety and utility land mobile radio systems damaged or with greatly reduced capacity.

Ham radio, which is almost always used to support disaster and recovery operations, will also be limited due to its dependence on volunteer licensed operators who may, themselves, be victims of the event.

Continuity Lessons Learned

Recent hurricanes identified that sustaining the performance of essential functions at all levels of government is dependent upon the availability of resilient communications systems. **"Out-of-band" communications, using more diverse systems, are essential.** The availability and access to resilient communication systems at primary and alternate locations must be ensured. Another lesson has been that infrastructure-related outages will endure for significant periods. The Federal government and industry are taking notice!

Critical Infrastructure Information Sharing and Analysis Centers (ISAC)

Critical Infrastructure Information Sharing and Analysis Centers (ISAC) help critical infrastructure owners and operators protect their facilities, personnel and customers from cyber and physical security threats and other hazards. ISACs collect, analyze and disseminate actionable threat information to their members and provide members with tools to mitigate risks and enhance resiliency. ISACs reach deep into their sectors, communicating critical information far and wide and maintaining sector-wide situational awareness. Sector specific contingency communications systems allow these ISACs to maintain communication with their sector entities during and after incidents impacting some or all of their sector entities.

Several ISACs have started to build their sector specific contingency communications systems. The Electric Sector ISAC (E-ISAC) has acquired their initial LRDR equipment and are reaching out within the electrical industry to build their network. The E-ISAC was empowered to take this action based on several recommendations from the GridEx IV exercise that were focused on the need to increase communications resilience:

- Utilities should develop and maintain communication contingency plans that use multiple technologies so that communication resiliency is maintained in the event one or more channels are lost.
- **Additionally, the E-ISAC should gain its own organic high-frequency radio system and become a member of the SHAred RESources (SHARES) High Frequency (HF) Radio Program.**

Other ISACs and industry groups developing or investigating establishing their sector specific contingency communications systems include the cable telecommunications industry and the downstream natural gas suppliers.

LRDR for Contingency Communications

LRDR is ideally suited as a platform for a contingency communications system. LRDR does not require any man-made infrastructure to operate with the exception of the actual radio stations communicating with each other. There are no wire lines, central offices, relay stations, satellites, microwave towers, or cell sites. LRDR relies solely on the individual radio sets and the Earth's ionosphere.

LRDR operates in the HF (High Frequency) band of the radio spectrum with frequencies ranging between 1.6 MHz and 30MHz. Within this radio spectrum an efficient mode of transmitter modulation, SSB (Single Side Band), is used. An LRDR system consists of three basic components; the transmitter/receiver unit (commonly called the transceiver), the antenna and the power source.

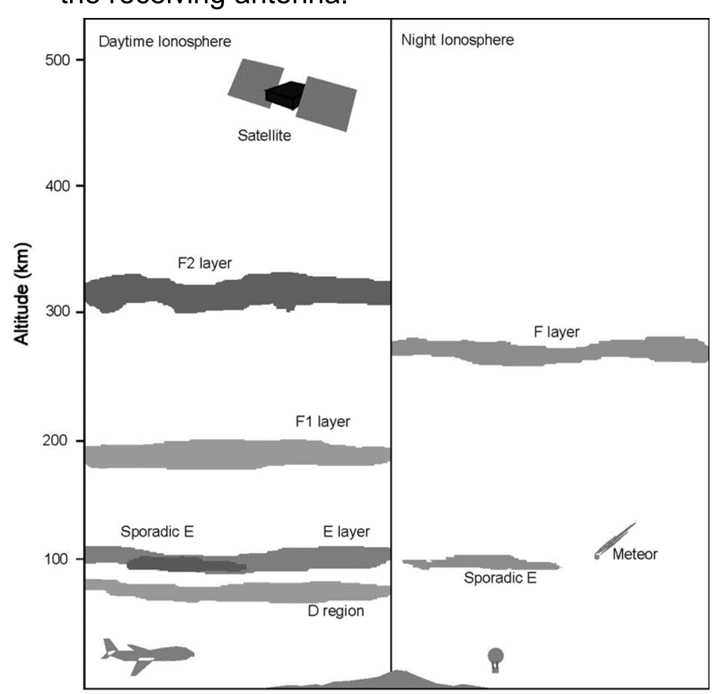
The antenna usually consists of a wire or metal rod which is mounted above the ground in a clear space, and is connected to the transceiver by means of a coaxial cable. When the unit is transmitting, the electrical signals it produces travel through the coaxial cable to the antenna, where they are changed into radio waves and radiated. When the unit is receiving, the antenna receives radio waves, translates them into electrical signals which travel through the coaxial cable and are heard through the receiver as voice or data signals.

The ionosphere is the ionized part of Earth's upper atmosphere, from about 37 to 620 miles altitude. The ionosphere is ionized by solar radiation. It consists of a number of layers which present different characteristics impacting radio waves: reflection, refraction, absorption and transparency. These impacts change and vary in intensity by frequency, time of day, latitude and seasons.

By combining HF SSB modulation along with the Ionosphere, an efficient, cost effective mode of communication can be achieved over short medium and long distances. In many remote areas (such as Australia's outback), HF/SSB is the only form of communication possible.

When HF/SSB radio waves are generated by the transceiver there are three main components:

1. Ground Wave - which travels directly from the transmitting antenna to the receiving antenna following the contours of the Earth.
2. Sky Wave - which travels upward at an angle from the antenna until it reaches the ionosphere (an ionized layer above the Earth's surface) whereupon it is refracted back down to Earth to the receiving antenna.



The Ionosphere

3. Direct Wave (LOS Wave) – this wave may interact with the earth-reflected wave depending on terminal separation, frequency and polarization.

Ground Waves are used to communicate over short distances, usually less than 30 miles. They follow the contours of the Earth and are affected by the type of terrain they pass over. They are rapidly reduced in field strength when they pass over heavily forested areas or mountainous regions.

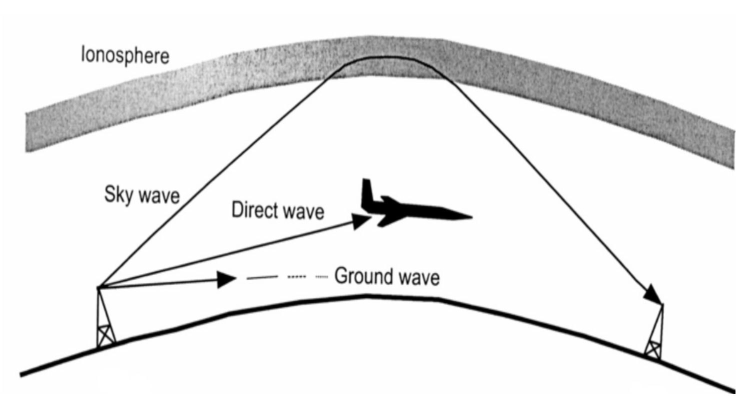
Sky Waves are used to communicate over medium to long distances, up to 1860 miles in a single hop. Sky waves are affected by Ionospheric characteristics which affect the received signal quality. Correct frequency selection is critical to establishing and maintaining reliable communications.

Direct Wave, or line of sight (LOS), go directly between the transmitting and receiving stations and are affected by ground terrain which will block signals if located in the signal path. Land mobile radio systems exclusively use LOS waves.

HF propagation is affected by:

- Frequency Selection
- Time of day
- Weather conditions
- Man-made electrical interference
- Poor system configuration and installation

Frequency selection is perhaps the most important factor that will determine the success of your HF/SSB communications. Generally speaking the greater the distance that you wish to communicate, the higher the frequency that is needed. In addition, the energy level of the Ionosphere is modulated by the Sun so the higher the Sun (higher energy level) the higher the frequency needed.



LRDR Networks Handle the Complexity

You may be saying, “this sounds way too complex!” The radio operator has to know all about the ionosphere, radio wave propagation and keep track of a lot of variables in order to talk on HF. LRDR Networks are modern, properly designed and implemented commercial HF radio systems that have taken over these complex tasks leaving the radio operator needing only to select who they want to talk or send data to. Using an industry standard capability called “Automatic Link Establishment” or “ALE”, the radio’s onboard computer system manages all this information and will automatically select the proper frequency to enable to radio operator to communicate with the desired station(s).

ALE uses the four S’s: a **S**mart radio; a **S**uite of frequencies to form a net; **S**ounding other stations in the net to check connectivity and frequencies; and **S**electing (automatically) the best frequency for transmitting to the desired station. These features provide improved operational capability without requiring an operator with specialized knowledge of propagation.

The basic operation of ALE is as follows:

- Radio scans all frequencies in the net.
- Radio transmits (sounds) on all net frequencies and logs responding stations on a preset schedule;
- Radio receives and responds to soundings from other stations in net. No operator is required.
- Radio maintains data base of responding stations which includes the Self-ID of stations in the net, frequencies, and link quality (signal strength).

LRDR Advanced Features

In addition to ALE, there are other advanced features available in LRDR networks. These features may include:

- Digital voice which will cut through interference providing call quality approaching that of a cell phone.
- Data operations supporting file transfers, email-like messaging, SMS text messaging, SCADA and general data transfer.
- Bidirectional internal and internet email.
- Bidirectional telephone interconnect to make and receive calls with the public switched telephone network including cell and satellite phones.
- Bidirectional automatic interconnection with land mobile radios.
- Encryption for message privacy.

FEMA Community Lifelines

SHARES

The **SHA**red **RES**ources (SHARES) High Frequency (HF) Radio program, administered by the Department of Homeland Security's (DHS) National Coordinating Center for Communications (NCC), provides an additional means for users with a national security and emergency preparedness mission to communicate when landline and cellular communications are unavailable. SHARES members use existing HF radio resources to coordinate and transmit messages needed to perform critical functions, including those areas related to leadership, safety, maintenance of law and order, finance, and public health.

The SHARES Program was approved by the Executive Office of the President in 1988. The SHARES Program brings together existing HF emergency radio resources of Federal and federally affiliated organizations when normal communications are overwhelmed or destroyed. Federal, state, and industry entities that request access to the SHARES nationwide network identify their HF radio stations for inclusion in the SHARES station directory. These stations agree to use standard radio operating and message formatting procedures when handling SHARES message traffic, and participate as they see fit in "on-the-air activities" such as quarterly national exercises and weekly tests to maintain SHARES operational readiness.

SHARES resources can augment Federal, State and local governments, critical infrastructure / key resource providers, and non-governmental organizations (NGOs) with backup communications, interoperability, and situational awareness.

SHARES is available 24/7 to provide a radio communications link to support intra/inter-agency mission requirements with backup communications.
SHARES can support voice and data operations including file transfers.

Critical Infrastructure entities, including critical supply chain suppliers, are eligible for SHARES participation and they are encouraged to do so. SHARES radio spectrum is available to support recovery operations being conducted by Critical Infrastructure entities.

In Summary

Catastrophic events, thank goodness, are usually few and far between. But in the event that one occurs, the consequences can be dire, even with preparation. Communications amongst the response team and outside to other teams and critical vendors and resources is critical to the success of the response and recovery efforts. Since communications platforms can be damaged, destroyed or rendered inoperable by the event or as the actual target of the event, it is prudent to have a resilient contingency communications system that has multiple layers of capability.

Long Range Digital Radio networks have significant capabilities to include: both voice and data modes; encryption for information transmission security; IP network support for distributed operations and system management; and simple to use menus for unlicensed operators to use. These features help you to manage and operate your system, train your users and maintain your system preparing it for use when your other communications systems are degraded, compromised or unavailable.

A properly designed and implemented LRDR network should be a component of your overall communications system so that you can insure some level of internal, external and interoperable communications under almost any circumstances. As the development and deployment of LRDR networks at the entity as well as regional levels expands, the capabilities become greater and more resilient. Becoming a SHARES participant brings an existing network of stations into your overall system. Further expansion within the various critical infrastructure sectors will further strengthen and expand the capabilities for each sector as well as for each member.

About NVIS Communications, LLC

NVIS Communications is a Systems Integrator and the Exclusive Partner/Distributor for Codan HF equipment in the US, Mexico and The Caribbean. NVIS works with Critical Infrastructure, i.e. Electricity, Gas, Oil, Water, Telecommunications and Cable TV Broadcasting, as well as Public Safety at the Federal, State, and Local Levels to help them design and implement resilient communications systems built on a HF-ALE core. NVIS also works closely with the Department of Homeland Security's SHARES program to further critical infrastructure entity participation in SHARES.

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