Digital Amateur Radio in Support of Situational Awareness, Common Operating Picture and Community Resilience for 21st Century Emergency Communications

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Abstract

The Department of Homeland Security has identified core capabilities necessary for rapid and effective response to man-made or natural emergencies. These include: (1) collecting real-time ***situational awareness*** of the emergency; (2) developing a ***common operating picture;*** and (3) building ***resilient communities*** capable of effectively adapting to changing circumstances. Amateur Radio operators--particularly those who are digital radio enthusiasts in ***wireless networking***--are ideally suited to help develop these core capabilities through current and future technologies.

Key Words

Wireless Networks, Situational Awareness, Common Operating Picture, Community Resilience

Introduction

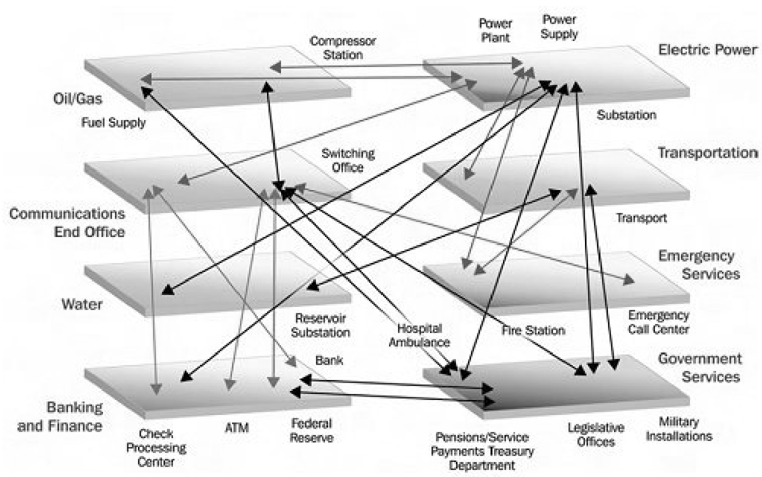
> *Disasters such as 9/11 and Hurricane Katrina have demonstrated…the ability and importance of communities to come together to help one another through difficult times and of effective information sharing and* ***situational awareness****… the importance of taking a more holistic approach when considering these activities to ensure greater* ***resilience in our communities*** *and for our Nation. Quadrennial Homeland Security Review Report February 2010.*[i]

The Department of Homeland Security (DHS) has highlighted core capabilities necessary to effectively respond to emergencies. These include: (1) collecting real-time situational awareness of the emergency; (2) developing a common operating picture to better share information and "synchronize [the] response operations and resources;"[ii] and (3) building resilient communities capable of effectively adapting to changing circumstances.[iii] A networked, integrated system for developing situational awareness, the common operating picture and community resilience is vital not only in the first moments of a disaster, when there is a lack of information that needlessly delays response actions, but also in the challenging days that follow. Some technology already exists to help DHS develop these core capabilities, but some technologies still wait to be developed. The Amateur Radio community's mission is to provide emergency communications, "when all is fails." Within this community are radio enthusiasts who focus on digital radio technology and particularly wireless networking. Combining 21st century skills with the mission to provide emergency communications, it seems only natural to enlist the assistance of this highly specialized and technologically advanced community to help DHS develop its core capabilities and realize its vision for a more holistic and effective approach to emergency response, whether to a local emergency or one of catastrophic proportions.

Local Emergency. On June 29, 2012, a violent storm called a derecho hit the metro D.C. community. It toppled thousands of trees and power lines. At least five people were killed in the local area with three heat-related deaths in Maryland alone[iv] and over a million and a quarter people were left without power or internet for up to one week.[v] The storm also knocked out Northern Virginia's 911 system for the weekend.[vi] However, Amateur Radio operators stayed connected, advising each other on such mundane but important things as where to find open grocery stores or gas stations that took cash because the automated teller machines did not function without power. Especially troubling, one older ham asked if anyone knew where he and his wife might go to escape the record heat. The Amateur Radio community stayed in contact helping each other but others outside this close Amateur Radio community did not have the same system of support.

Disasters of Catastrophic Proportions. While most emergencies are of relatively short duration and limited lingering impact, some disasters need to be included in the planning process even though they are less likely, but because their destructive impact can be so devastating. NASA funded a study in 2009 that reviewed the history of solar storms including the largest recorded storm in 1859, the "Carrington Event," whose "geomagnetic activity triggered by the explosion electrified telegraph lines, shocking technicians and setting their telegraph papers on fire…"[vii] While the two most notable solar storms of the 20th century (May 1921, and the 1989) were not as powerful as the Carrington Event; because our modern society is so much more dependent on technology, such as "smart power grids, GPS, and satellite communications," we are that much more vulnerable to even weaker solar events.[viii]

Experts have calculated the probability of occurrence of a catastrophic solar storm at about 12% in the next 10 years.[ix] If that were the case, any significant damage to "transportation, communication, banking and finance systems" would result in the inability to provide even basic provisions of food, water and fuel for days, months, or even years before full recovery.[x] As the below figure depicts the dependent interconnectivity of our critical resources, including power, fuel, communications, transportation, emergency services, food, water, banking and finance and government services.

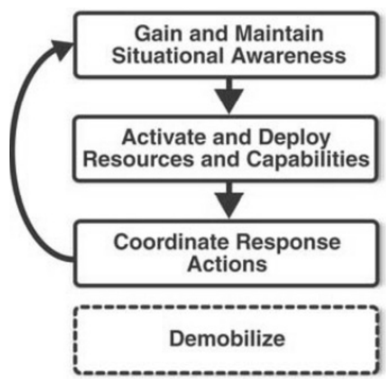


Source: Dept. of Homeland Security, 'Severe Space Weather--Social and Economic Impacts'[xi]

Former Speaker of the House Newt Gingrich, in an editorial to the Washington Post recently, warned of the consequences if we do not now begin to prepare ourselves against the consequences of a major solar storm or electromagnetic pulse (EMP) attack.[xii] "Suppose that, rather than being a temporary disruption in our lives, the power outage lasted weeks or months, or even years. Consider what state all of us, from the richest to the poorest, would be in if we were still literally in the dark. Millions could be trapped in houses or apartments that were never designed for this climate without air conditioning. No cool air; months with no food shipments and every pharmacy shut down — no refills for life-sustaining medications."[xiii] He urged Congress to act to harden the power grid to prevent such a disastrous outcome. Likewise, erring on the side of caution because of the possible consequences, it would seem wise to plan for such an event, just in case. Coincidentally, readiness to respond to local as well as catastrophic emergencies can be greatly improved by implementing technology and processes that implement situational awareness, a common operating picture and community resilience.

Situational Awareness

DHS defines situational awareness as "providing the right information at the right time" to accurately inform decision-makers. Effective immediate response and long term management of an emergency situation require that decision-makers, as well as first responders, have real-time detailed information of the full extent of the developing situation, so that they can make better informed decisions on how to most effectively respond--to the right locations with the right kind of people and equipment. As illustrated in its response process (see figure below), DHS prioritizes achieving "Situational Awareness" as the first step to effectively respond to man-made or natural disasters.[xiv]



The Response Process

According to the DHS Framework, achieving situational awareness requires the participation of all levels of government, local, state and federal, as well as private entities—a emergency network of like minded partners working together to save lives and property. This information would include not only the topographic and atmospheric conditions, but also other information required to array the right resources and direct them to the locations in priority of most need.

The emergency communications process leading to situational awareness also needs to include communications from private citizens if an accurate assessment of priority needs is to be obtained, because they know better than anyone what is happening in their own communities. True situational awareness can only be achieved with the participation of the private citizen in the response process, not only as victim, but more importantly as partner. Two-way communications directly with private citizens can provide first responders the information they need to act quickly—plus send to private citizens the critical information they need to help themselves and provide mutual support to their families and neighbors. Once information to achieve situational awareness is collected, it needs to be presented to the decision-makers in a format that allows a synchronized and rapid response.

Common Operating Picture

> *For an effective national response, jurisdictions must continuously refine their ability to assess the situation as an incident unfolds and rapidly provide accurate and accessible information to decision-makers in a user-friendly manner. It is essential that all levels of government, the private sector (in particular, owners/operators of critical infrastructure and key resources (CIKR)), and NGOs share information to develop a common operating picture and synchronize their response operations and resources.*[xv]

Building situational awareness is only the first step. The information needs to be summarized and presented in a way that informs decision-makers quickly as to the right course of action. While detailed information of unfolding crises is critical, it can quickly become overwhelming, resulting in wrong or delayed decisions at critical junctures. Therefore, to avoid information overload and needless delays, the vast amount of information received needs to be consolidated into an effective, real-time decision making tool called the common operating picture. The common operating picture takes the information collected for situational awareness, filters it, makes computations as necessary and presents the resulting findings in an intuitive format mutually shared by first responders, government officials and private citizens in the local communities.

The categories of information that would inform situational awareness and then be consolidated within the common operating picture would be selected and tailored based on regional risks associated with natural and man-made disasters. This might include regional topography and atmospheric conditions, GPS locations of citizens and first responders, priorities of response activities as they develop, including resources required and where they are available.

What this picture ultimately looks like and what format it takes is still to be determined. But it must be more than just an emergency operations center portal where reports are filed. What needs to be shared is not archival, but real-time awareness that informs the next steps in response—i.e., informing real-time command, control, coordination and cooperation in response operations. It also needs to be accessible in a mobile format for real-time response. Everyone within the emergency area—private citizens within the affected communities, first responders and other emergency personnel need to have access, informing their actions in a consolidated and integrated approach. Collecting information for situational awareness and developing a common operating picture through an integrated approach with the active participation of private citizens ultimately builds community resilience.

Community Resilience

> *"Timely, appropriate, and reliable communication with the public before, during, and immediately after disasters is a key component of societal resilience."*[xvi]

What makes us strong as a nation is our American resolve and commitment to fundamental values nurtured and sustained within thousands of local communities nationwide—friend helping friend and neighbor helping neighbor. Recognizing this critical local resource in furtherance of national security, DHS emphasizes the need to build "capable, resilient communities."[xvii] According to RAND, "community resilience is a measure of the sustained ability of a community to utilize available resources to respond to, withstand, and recover from adverse situations." [xviii] People need to know where to go to get gas, food and water; whom to contact when their babies are sick and their parents need medicine, where their neighbors are assembling for mutual support and coordination, to get news on what is happening outside their immediate vicinity and what they can do to help.

Community resilience forms the basis of life-saving resources during emergency situations. If private citizens within their communities become integrated into the knowledge base and are active participants in the response and rebuilding process, they are more likely to know how to help each other and less likely to fray, to succumb to fear, to act rashly and outside their best interests. In the simplest terms, they would know how to band together to find gas stations that are open, shelters from the storm, food, water and comfort. In the outside chance of an emergency of catastrophic proportions and prolonged period of recovery, they will have the ability to plan, ration, share and cooperate in a concerted effort of survival.

A Role for the Amateur Radio Community

Amateur Radio operators are uniquely positioned, because of their people, presence and purpose to play an integral role in the development of situational awareness, a common operating picture and community resilience.

> People with unique skills and interests. Amateur Radio operators have a love of technology and experimentation that sets them apart for their ingenuity and altruistic motives. With all the tinkering, testing and "rag chews" they are constantly preparing and staying ready. While Amateur Radio enthusiasts have many different types of skills and interests, one group of particular importance for the development of 21st century information technology are those with a special interest in digital communications. The most prominent organization within the digital Amateur Radio community is TAPR (originally the Tuscon Amateur Packet Radio[xix]), one of whose stated goals is "to support R&D efforts in the area of amateur digital communication."[xx]
>
> Presence dispersed nationwide. There are Amateur Radio operators and Amateur Radio clubs dispersed nationwide within the thousands of local communities in which they live and work. They are also in many places already embedded into local response organizations, plans and operations, ready at a moment's notice to provide emergency communications, "when all else fails."
>
> Purpose federally recognized. The Amateur Radio mission is federally recognized to provide emergency communications and "contribute to the advancement of the radio art" through communications and technology.[xxi] Because of the vital emergency communications mission, the Federal Communications Commission has dedicated bands of the radio frequency spectrum for their exclusive use.[xxii] These dedicated frequencies become critical in times of emergency, keeping open vital communications lanes to pass life-saving information.

Strategy for the Future

> *In today's environment of speed-of-light communications and pervasive social networking technologies, homeland security partners must take full advantage of cutting-edge tools and capabilities to promote widespread situational awareness. As such, information sharing and public alert and warning must be viewed as mutually supportive efforts in seeking to combine the networked power of new media and "Web 2.0" technologies with existing homeland security information-sharing capabilities such as fusion centers, emergency operations centers, and joint terrorism task forces. Moreover, emergency information must be accessible through as many pathways as possible, to include multiple languages, through social networks in low-income areas, and to those with special needs.*[xxiii]

The author's intent in this paper is not to present a comprehensive summary of state-of-the-art digital radio technology, but to highlight some current technologies and enlist the help of the digital Amateur Radio community in advancing these technologies as well as other relevant technologies (including applications software) in furtherance of situational awareness, the common operating picture and community resilience. Before technologies can be developed, however, we need to identify the abilities these technologies need to possess to be effective. Planning assumptions help to identify these required abilities. For example, in planning for emergency conditions, one planning assumption should address the availability of power, which based on previous experience in disasters may be disrupted, rendering useless any equipment that cannot operate on low power batteries or using alternative power sources such as solar.

Assumptions for Planning and Development Purposes

The following planning assumptions are suggested as a start point for selecting abilities against which to rate relevant technologies in furtherance of situational awareness, the common operating picture and community resilience.

> Low power operations. Lack of power disrupts normal services and the ability to power electrical equipment. Therefore, any equipment selected or designed to operate within emergency situations needs to be considered for its ability to operate on low power batteries or through alternative power sources, such as solar energy. Equipment must be grid-independent and hardened against the elements of nature—water, wind, fire, and even solar storms.
>
> Broadband applications outside of the Internet. Damage to communications and power infrastructure can disrupt Internet service, affecting not only individual communications but also critical information necessary to the survival and sustainment of the larger community. The ability to run broadband applications outside of the Internet is vital and necessary to provide for public safety, healthcare, transportation, financial transactions, etc.
>
> Not reliant on cell phone service. Cell phone service, if overwhelmed, can be disrupted and therefore should not be relied upon as a primary source of communications during a disaster. Therefore, alternate sources of communications not reliant on cell service for continuity or connectivity need to be considered.
>
> Real-time situational awareness and common operating picture. Lack of real time information results in needless delays, potentially risking additional lives and destruction of property. Any relevant technology needs to be able send and receive signals quickly and without needless delay.
>
> Integration of local communities. Real time information requires participation of private citizens and their communities within the emergency network, as active participants to aid and assist as well as potential victims to be rescued. Private citizens within their communities know first when disaster strikes in their area. They need to be able to communicate that within an emergency network to provide real-time knowledge that informs situational awareness and prevents needless delays. Further, citizens can also be trained and informed to act in furtherance of community resilience--helping and supporting each other to successfully adapt and survive during emergency circumstances even before the arrival of the first responders and for as long as the emergency continues.
>
> Mobile. As the situation develops, people need to be mobile. Citizens need to be able to stay connected even when they are evacuating or simply running next door to help a neighbor. First responders need to stay connected so that they have real-time awareness of a situation even as circumstances change and evolve.

Dispersed. The more widely dispersed and concentrated the coverage, the less likely that there will be gaps in visibility. Therefore, items that are inexpensive or already reside in private homes become particularly important in terms of helping more communities quickly connect in times of emergency.

Selected Technologies for Initial Consideration

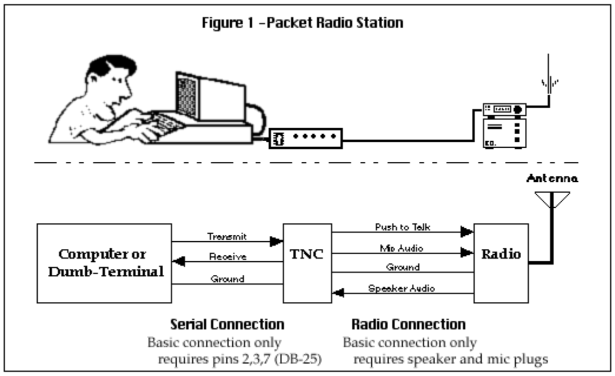
Oklahoma City in the 1990s explored new and better ways to connect their public safety officials not only at headquarters, but also while in the field, so that they could better respond to emergencies. They were dissatisfied with the limitations of their two-way packet radios with their limited 4,800 baud rate, resulting in a low bandwidth capable of transmitting little more than text and voice successfully. They wanted a better way to receive and transmit relevant data, such as "the ability to download photos, input fingerprints, file reports and access public safety databases while out in the field. In addition, they desired to have video capabilities, enabling them to record police activity, monitor situations and get early warnings of potential problems. The fire department wanted the ability to download building preplans, hazardous material information, and water hydrant infrastructure information while en route to an emergency situation."[xxiv] To address their growing list of requirements, they needed a flexible broadband solution and selected to implement a wireless mesh technology, to deliver a "seamless, scalable broadband connection to users over a wide outdoor area."[xxv]

The Oklahoma City experience provides a start point for analysis into relevant technologies—packet radio and mesh networks—that, along with some integrating features provided by household routers and two-way radios, might be considered for their ability to achieve situational awareness, the common operating picture and community resilience. This is not meant to be an exhaustive list, only the beginning of the discussion.

Packet Radio

Packet radio is a digital mode of Amateur Radio communications. It is composed of a computer, a hardware or software terminal node controller (TNC), and an Amateur Radio transceiver with attached antenna to transmit the radio signals (see figure below).[xxvi] The packet radio sends out and receives data from another packet radio in short bursts (packets) and then listens for a response. An additional capability especially advantageous during emergency situations, is the ability of any packet radio station to act as a repeater (aka "digipeater"), automatically linking to any other packet radio close enough to receive its signal. This allows a packet radio station to create an ad hoc wireless network to extend transmission range across multiple packet radios.[xxvii] Common packet frequencies are located on the two meter band.[xxviii]

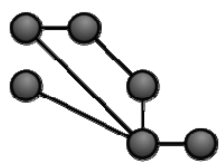
Figure 1 –Packet Radio Station



Disadvantages of packet radios are that they are slow, mostly operating at 1200 baud,[xxix] and because they operate in half-duplex, cannot send and receive at the same time. Digipeaters can add to the problem by retransmitting the same message multiple times, clogging the airwaves and delaying transmission by other users.[xxx] Also, the higher frequencies transmit shorter distances and are vulnerable to physical obstructions such as buildings."[xxxi] Therefore, in selecting locations for digipeaters to create the linkages between stations that form the ad hoc networks, factors such as walls, trees and higher ground become important. There have been advancements to overcome these delays, including newer equipment that operates at a higher baud rate, but problems remain and packet radios are not frequently used during actual emergencies.[xxxii]

Wireless Mesh Technology

> *"Wireless mesh networks often consist of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may but need not connect to the Internet. The coverage area of the radio nodes working as a single network is sometimes called a mesh cloud. Access to this mesh cloud is dependent on the radio nodes working in harmony with each other to create a radio network. A mesh network is reliable and offers redundancy. When one node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more intermediate nodes."*[xxxiii]



A wireless mesh network is a digital communications network made up of radio devices ("mesh nodes"), communicating with each other and routing messages within an organized mesh topology.[xxxiv] Much of the technology for mesh networks is based on IEEE 802.11 standards that implement wireless local area network computer communication in the 2.4, 3.6 and 5 GHz frequency bands using low power radio systems, reserving certain frequencies for exclusive use by Amateur Radio operators.[xxxv] When connected to mesh nodes, computers can communicate with each other similar to packet radio. Of more significance, when properly configured, they can act as access points to retransmit signals much as digipeaters do in packet radio, to form a wireless network, but with expanded broadband capabilities. With the addition of a dual port node (bridge) and a gateway circuit, they can "move wireless packets off the radio frequency and onto a wired Ethernet network and even onto the Internet."[xxxvi]

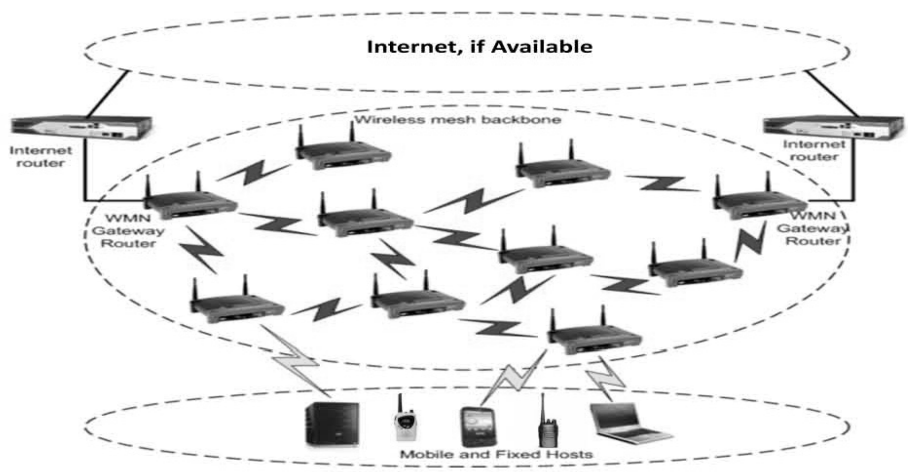
> *Nodes can also provide Internet connectivity to wired devices within the network like VoIP phones, video cameras, servers, and desktop workstations using traditional Ethernet cables. Most nodes come with two or more Ethernet ports, and through a technology called Power Over Ethernet (PoE), the node can provide power to stand-alone devices like surveillance cameras without having to plug the camera into an electrical outlet.*[xxxvii]

In the event there is not a deployed antenna to extend transmission range, mesh networks can further expand their reach and disperse their network over a wider area quickly through the positioning of portable "drop boxes," equipped with a router configured as part of the mesh network, antenna and a power source.[xxxviii] However, area of coverage relies on transporting drop boxes to the designated locations requiring time and transportation, which may be compromised during an emergency. Further, the amount of drop boxes available in advance of an emergency is a factor of cost and priorities resulting in limited resources when either cost or other priorities become overriding factors.

Due to the frequencies at which mesh networks operate, they also have line-of sight limitations similar to packet radios. However, previous experimentation has shown promising results using low power radio systems to "establish a reliable high-speed wireless data network across long distances."[xxxix] More work is needed to develop and implement a reliable, survivable broadband "transport layer," able to operate on low power. It needs to also include a plan for integration of private citizens within their communities as part of the development of the network.

Additional Technologies to Integrate Private Citizens and Communities into the Mesh Network

Comprehensive situational awareness relies on comprehensive information—from government officials, first responders AND private citizens. Therefore, private citizens within their communities need to have access to the emergency network and moreover, become active, integral contributors and users. Logically, as citizens are better informed and better able to inform, they are also better able to effectively respond and aid their affected communities; i.e., building community resilience as they help develop situational awareness and a common operating picture. This requires developing hardware and software applications that need to be low cost, easily accessible, easily integrated and capable of operating on low power. Listed below are two suggested methods that still need further development but promise much value by integrating citizens into the mesh network. They involve the use of easily accessible household routers or two-way radios.



Adapted from Illustration by Brigham Young University, Information and Decisions Algorithms Laboratories, 2006[xl]

<u>Mesh networks integrated with household routers.</u> Many homes throughout our nation's communities already have routers connected to their Internet service to extend the reach to other wireless devices throughout the household. They are an already dispersed asset that can be leveraged in powerful ways to create networks within local communities, if the technology is developed to make this happen. Household routers can be configured to default to a community network of household routers during emergency situations so that they can talk to each other and

connect into a wider mesh network or even the Internet if available. We need to develop and implement the technology that allows this integration so that communities can come together and help each other during emergencies, while simultaneously become "force multipliers" extending the reach and coverage of the mesh networks to provide broadband applications necessary to the sustainment of basic services. However, because routers are energy dependent, most likely plugged into a home electrical outlet, we need to also figure out how these routers can be quickly and easily taken off the grid and made operational in a low power mode—e.g., working off generators, batteries, solar power, etc.

Mesh networks integrated with two-way radios. While household routers could provide readily available access into a larger mesh network, they lack the mobility necessary for "on-the-fly" operations; whether to evacuate or respond to evolving circumstances. "Short-distance, two-way communications using small, portable hand-held devices that function similar to walkie-talkies"[xli] can be deployed to address this gap. These systems offer families and communities a low cost option to provide mobility and citizen access into the mesh network. Two of the services available include the General Mobile Radio Service (GMRS) and the Family Radio Service (FRS). "FRS devices have a maximum power of ½ watt (500 milliwatt) effective radiated power and integral (non-detachable) antennas…GMRS devices generally transmit at higher power levels (1 to 5 watts is typical) and may have detachable antennas."[xlii] Both operate in the 462 - 467 MHz spectrum range.[xliii] They are low power, high frequency radios, which is beneficial in terms of needing little power to operate, but lack the ability to transmit beyond line of sight. The GMRS offers the advantage of repeater-capable radios[xliv] to extend reception distance,[xlv] but requires that the head of household obtain an FCC license (no test required) for him and immediate family members.[xlvi] They already can provide GPS positioning and with more technological developments, they can be adapted to provide additional information critical to effective emergency response.[xlvii]

The above list of technologies is by no way exhaustive but only offers a start point for further discussions. The below decision matrix is also offered also as a start point to suggest a possible list of technological abilities against which to measure the most suitable technologies for additional research and development. As work continues on developing situational awareness, the common operating picture and community resilience, the list of abilities and their relative rankings should be amended accordingly.

Decision Matrix

To begin the process of selecting the appropriate technology for digital emergency communications upon which to develop situational awareness, the common operating picture and community resilience, below is a suggested start point for selecting and comparing abilities in the existing and proposed technologies discussed above. If a comparison of abilities concludes that current technology is adequate to build situational awareness, the common operating picture and community resilience, then further development of additional technologies would not be necessary. However, if current technology in its present form is found to be inadequate, then additional research and development would be justified. Included are some rough assessments, categorized as red ("no go") yellow ("some concerns") and green ("good to go") offered as a start point for further discussion and analysis. They are of course subject to further investigation and more detailed calculations.

	Low Power	Broadband Applications	Not reliant on cell phone service	Real-time SA/ COP	Integration of Local Communities	Mobile	Dispersed
Packet Radio							
Mesh Networks							
Mesh Networks w/ Drop Boxes							
Mesh Networks w/ Household Routers							
Mesh Networks w/ Family Radio Service							

Summary

Once the incident occurs, the people are in the water, near the fire, inside collapsed buildings, dying of their wounds. But in the first hours, it is many times difficult to get a true picture that quickly informs rapid and effective response operations. Odds increase for achieving comprehensive situational awareness more quickly if there is a strong interactive and ongoing communications network between the Amateur Radio operator coordinating the mesh network, the first responder and the private citizen. Even if, as happened recently during a storm in the D.C. metro area, the 911 system goes down for several days, there would exist a method to substitute the disrupted 911 system with an alternative system residing on the mesh network and therefore not reliant on existing infrastructure. Further, neighbors would also be better informed and better able to help themselves and each other. This becomes especially important if the disaster has long term impact on delivery of necessary systems and services, such as gas, food, and water.

The mesh network, with its embedded citizen and community tentacles can form a powerful emergency communications alternative to the Internet across which vital information can be transferred. Once this network is implemented, regardless of the technology applied, the next challenge will be how to develop the applications necessary to quickly and comprehensively collect the information necessary to achieve situational awareness, develop the common operating picture and build community resilience. There is much more that needs to be done to truly explore all the potential technological possibilities and the promise they bring for a more powerful emergency response system.

Finally, we need to get an integrated approach to research and development including funding and support from the federal government, for what is rightfully a federal domestic mission, regardless of which local community it affects. What happens in Oklahoma, or New York, or Florida, happens to all of us and affects all our lives. Local municipalities cannot operate in a vacuum—they need guidance, assistance, and most importantly funding, to insure that they are interoperable in every sense of the word and their communities remain resilient regardless the challenges.

About the Author

Aleksandra (Aleks) Rohde is a former Colonel and lawyer in the United States Army. She has held critical strategic planning and legal positions that have influenced policy and law at the national and international levels. In 2004, while deployed to Iraq as the Military Assistant to the Ministry of Interior, she led a team that designed a national 911 emergency communications system for Iraq—the first of its kind in the Middle East—integrating operationally and technologically from private citizens in local jurisdictions to the National Operations Center in Baghdad. In 1998 she coined the phrase "Homeland Security" as part of her Homeland Security White Paper, key recommendations of which were subsequently incorporated by the U.S. Commission on National Security/21st Century ("Hart-Rudman Commission") into its final report (most notably the creation of the Department of Homeland Security). Aleks Rohde is licensed to practice law in the District of Columbia and Illinois, is a licensed Amateur Radio operator and holds a Top Secret clearance.

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[i] Quadrennial Homeland Security Review Report, Department of Homeland Security, February 2010, p. 31, 32.

[ii] National Response Framework, Department of Homeland Security, January 2008, pp. 32-33.

[iii] Quadrennial Homeland Security Review Report, p. 31, 32.

[iv] "As Fourth nears, so does fifth day without power," by Michael E. Ruane and Ted Trautman, The Washington Post, July 3, 2012, p. A6.

[v] "D.C. thunderstorms knock out power across region, leaving at least 5 dead," by Emma Brown, Clarence Williams and Martin Weil, The Washington Post, June 30, 2012. See also "The great derecho disconnect," Italian Mother Syndrome, July 10, 2012.

[vi] "911 Outage Failure alarms officials; N.Va. service still spotty," The Washington Post, by Patricia Sullivan, July 3, 2012, p. A1.

[vii] "Severe Space Weather--Social and Economic Impacts," Nasa Science, January 21, 2009, http://science.nasa.gov/science-news/science-at-nasa/2009/21jan_severespaceweather/

[viii] "Getting Ready for the Next Big Solar Storm." NASA Science – Science news, June 21, 2011 http://science.nasa.gov/science-news/science-at-nasa/2011/22jun_swef2011/. "Modern society depends on high-tech systems such as smart power grids, GPS, and satellite communications--all of which are vulnerable to solar storms." See also "Massive Solar Flare 'Could Paralyse Earth in 2013," MailOnline, 21 Sept 2012, http://www.dailymail.co.uk/sciencetech/article-1313858/Solar-flare-paralyse-Earth-2013.html "NASA has warned that a peak in the sun's magnetic energy cycle and the number of sun spots or flares around 2013 could generate huge radiation levels…knocking out electricity grids around the world for hours, days, or even months, bringing much of normal life grinding to a halt."

[ix] "1 in 8 Chance of Catastrophic Solar Megastorm by 2020," by Adam Mann, Wired Science, February 29, 2012.

[x] Severe Space Weather Events—Understanding Societal and Economic Impacts – A Workshop Report, Space Studies Board, National Research Council of the National Academies, Washington , D.C. The NRC concluded that a longer-term outage would "likely include, for example, disruption of the transportation, communication, banking, and finance systems, and

government services; the breakdown of the distribution of potable water owing to pump failure; and the loss of perishable foods and medications because of lack of refrigeration." It also estimated anywhere from 4 to 6 years for full recovery.

[xi] "Severe Space Weather--Social and Economic Impacts," Nasa Science, January 21, 2009, http://science.nasa.gov/science-news/science-at-nasa/2009/21jan_severespaceweather/

[xii] "Preparing for the next outage," by New Gingrich, The Washington Post, July 12, 2012.

[xiii] Ibid.

[xiv] National Response Framework, p. 33.

[xv] National Response Framework, pp. 32-33.

[xvi] Homeland Security Review Report, Department of Homeland Security, February 2010, p. 62.

[xvii] Department of Homeland Security Strategic Plan, Fiscal Years 2012-2016, February 2012, p. 23.

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