12-14-2005

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## Recommended Citation
Critical Care 2006, 10:207 doi:10.1186/cc3944

Review

# Disaster and emergency communications prior to computers/ Internet: a review

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Published: 14 December 2005
This article is online at http://ccforum.com/content/10/1/207


*Critical Care* 2006, **10:**207 (doi:10.1186/cc3944)

## Abstract

When communications are needed the most desperately and most urgently, the difficulty of effecting the desired communications increases exponentially. Recent natural disasters in different parts of the world have provided eloquent testament to this. The history of disaster or emergency communications can provide us with a foundation for understanding the problems encountered today, and can offer us insight into how we might improve the systems and processes for communications. The first applications of communication technology that allowed messages to be sent more rapidly than the fastest form of transportation were mainly military in origin. This review takes us from the days of optical or visual telegraphy, through the early development of mobile and radio communications, and up to the current sophisticated technologies. We pay particular attention to the use of amateur radio operators in times of emergency, and relate their activities to those of the most effective military communications. The germane assumption made in this discussion is that any emergency or disaster communications would necessarily be involved in response and resolution of medical aspects of those emergencies.

## Introduction

It is a virtually immutable universal law that when communications are needed the most desperately and urgently, the difficulty of effecting the desired communication increases exponentially. Examples in our immediate experience include the South Asia tsunami, Hurricanes Katrina and Rita in the USA, the South Asian earthquake in Pakistan, India, and Afghanistan, and the mudslides in Guatemala.

The history of disaster communications before computers or the Internet (or outside the realm of the Internet) provides us with a long-standing testament to this sad fact. The English word 'disaster' comes from a Greek prefix and root word meaning 'bad star'. This harks back to the notion that calamitous things happen under the influence of bad star alignment. No matter the level of faith one puts in the alignment of stars as affecting events on earth, the history of the effort to communicate over distances is inextricably rooted in the motivation to avoid, or at least mitigate, the effects of various disasters. The modern ability to chat casually or to be entertained by communication technology is but an offshoot of the development of that technology which first permitted priority communication about more urgent matters.

Acknowledging some of the earlier aspects of disaster or emergency communications can be interesting and engaging, and it can enable us to understand the fundamental need to communicate about emergent events. Although much of this review is oriented to history in the USA, there were parallel activities occurring in all countries in which the new technology of radio existed. Hopefully, my geocentrism in this review in an international medium can be understood and pardoned in light of that fact.

## The history and evolution of communication

Considerably predating the discovery of radio waves, many peoples had developed means of telegraphy within the broadest sense of the word. The word 'telegraph' has as its origin the union of another two Greek words that essentially mean 'long-distance writing'. Smoke signals, torch signaling, heliographs (flashing mirrors), and signal flags are but a few of those primitive means of communicating over distance.

The late 18th century saw a near simultaneous addition of a number of very important 'firsts' in the annals of communication. The applications were generally military and were developed in conjunction with the French Revolution and the Napoleonic Wars. What happened was the development of the first optical telegraph system. By the mid-1800s this system covered some 5000 km and involved more than 550 stations [1]. The system involved a variation in the theme most of us could relate to as the railroad semaphore system, the naval semaphore system, or the 'wig-wag' system we envision as being used by scouts.

ARRL = American Radio Relay League.

A significant advance over the tried and true system of messengers, this optical or visual telegraphy system achieved the goal of allowing information to be transmitted more rapidly than the fastest form of transportation. The significance of this ability must not be underestimated. This system also represents the first recorded use of error control (resending lost characters), flow control (send faster or slower), and message priority. These three essential concepts have remained a vital part of all disaster or emergency communications since that time. At close to the same time, encoded shutter systems of visual telegraphy were being developed in both England and Sweden.

In the USA, Samuel FB Morse had proved in 1835 that signals could be transmitted by wire using pulses of electrical current to deflect an electromagnet. Within a year the original device was modified to emboss a strip of paper with dots and dashes. Although this was demonstrated in public in 1838, it was not until 5 years later that Congress (which had been reflecting public apathy – another whole complete essay in the history of disaster communications!) funded the construction of an experimental telegraph line from Washington (DC) to Baltimore (MA) [2].

The original use of 'Morse' code involved the embossing of the code characters onto a paper tape. In the USA, however, the operation developed into sending by key and receiving by ear. A trained operator could send or receive 40–50 words/min. Automated transmission, developed in 1914, could handle more than twice that rate. This specific development in the process would prove to be a mainstay of communications during disasters and emergencies for decades, and formed the backbone of the earliest emergency communications. Telegraph by wire expanded its horizons for several decades into modern times.

Italian inventor Guglielmo Marconi sent his first radio signals in 1895, and by 1899 he had sent a wireless signal across the English Channel. In 1901 he telegraphed a signal across the Atlantic, from England to Newfoundland. Marconi's telegraphy used spark gap technology and a very broad part of the radio spectrum [3]. Marconi and his wireless company quickly grew to transoceanic proportions and had a significant business enterprise going, part of which involved ship-to-ship and ship-to-shore communications. Elaborate and costly Marconi stations were set up on ships, including the Titanic.

Several milestones in disaster communications history and heroism came out of the Titanic disaster, but there also came a US Senate investigation into the practices of Marconi's company. Furthermore, specifically related to the sinking of the Titanic, some important principles of disaster communication were formulated. Several ships were responding to help the Titanic but, during a crucial time, one that was closer than the others did not receive signals from the Titanic because the vessel's lone radio operator was off duty. The earlier arrival of the closer ship could have saved many more lives. Out of that experience came the Radio Act of 1912. It required that at least two radio operators be on board all vessels carrying more than 50 passengers, and that at least one of the operators be on duty in the Marconi room at all times while the vessel was underway. This began formal management, including legislation, of disaster communications. This was also a landmark occasion in that investigations were held to find out what could have been done better, and both the public and the government began looking with a critical eye at the unregulated and unfettered development and use of communications technology.

Concurrently with code telegraphy in that latter part of the 19th century, Alexander Graham Bell was developing his concept for 'harmonic telegraphy' when he discovered he could hear a sound over a wire in 1875. Telephonic communication along wires developed for a number of years, but the first transatlantic cable, from Newfoundland to England, did not open until 1956. The marriage of this 'harmonic telegraphy' and traditional Morse code telegraphy, a foundation of modern disaster communications, was to take place shortly after the turn of the century.

Even in the earliest days of voice telecommunications, there was an awareness of the need for means to establish communications in case of emergency or disaster. The founders of the modern communications giant Ericcson contributed to progress with the first mobile telephone application in the earliest years of the 20th century [4]. They developed a portable phone handset and crank that could be hooked to the bare phone wires of the time. The connection was made by a pair of metal hooks that were placed over the wires by means of an extension wand. Once contact with the wires was made, the magneto in the handbox was cranked, making a signal, which hopefully would be answered by someone on the line. It was actually used to report a train robbery and contributed to the bandits' arrest at around 1907.

The 1920s saw the development of radio telephony, or voice communications using radio waves in safety and military communications. It was to be 1929 before public radio telephone service on the high seas was to be inaugurated. During the earlier part of these years, the concept of amateur radio was developing in all countries that had the technology. Indeed, other than the Marconi company, most of all work in radio communications was done by varying combinations of hobbyists, scientists, and tinkerers.

A portion of the radio spectrum was allotted for amateur use at that time; because this portion was only useful over relatively short distances, the need for systematic relay of messages became evident. In 1919 a dedicated amateur radio operator named Hiram Percy Maxim originated what is

now known as the American Radio Relay League (ARRL). The purpose was to set up a voluntary network of associated radio amateurs to facilitate the long-range relay of what came to be known as 'radiograms'. Development of similar networks to foster long-distance passage of radiograms was roughly parallel outside the USA.

The essentials of reliability and accuracy in relaying such messages became extremely important, and concurrent systems for military, commercial, and public service relay of information were established using very specific and standardized message formats. Most of the military and commercial services were staffed by amateur radio operators. The National Traffic System was born from this process, and became, in conjunction with the ARRL, the way radio messages were passed nationwide for commercial, health and welfare, and disaster information [5]. The basic format for National Traffic System messages or radiograms has not changed since the early days, even for voice messages. There is an active movement underway to redesign that format into one that is more suitable to the technologies and techniques that are used today to transmit and receive disaster communications.

In 1940, before US involvement in World War II, the ARRL had developed an Emergency Corps that trained and drilled, even on frequencies not open for casual amateur use. Five hundred amateur operators manned listening and direction finding stations [6]. In June 1942, at the request of the ARRL, the War Emergency Radio Service was created. Air raid protection and notification was its primary purpose. By 1945 and 1946 amateurs were back on the air on all bands but one that had been restricted during wartime. In 1948 the Military Affiliate Radio System was established, which integrated amateur operators (hams) and military operators on specific common frequencies worldwide. Requirements for participation in Military Affiliate Radio System included (and does to this day) certain minimum training and continuing active participation in practice nets and drills.

As the Cold War got into fill swing (1952), the Radio Amateur Civil Emergency Services were formed in conjunction with the federal Civil Defense effort. Development of this and similar groups in the USA and wordwide continued during the 1960s and 1970s, while federal and local authorities were realizing the need for disaster and emergency communications that involved all aspects of civil life. Mindful of their own history, amateur radio operators were in the forefront of reminding the authorities that communications and preparedness for all types of emergencies were beneficial. It would be doing the population a great disservice to act as if military or nuclear disasters were the only kind of disaster worthy of thoughtful planning and preparation. In the USA, 1972 saw what had been called Civil Defense change its name to the Federal Emergency Management Agency (FEMA).

During this time the world of technology had been evolving at a much higher rate than the level of sophistication of civil emergency planning. Transistors and integrated circuits had come into existence. Ham radio operators were developing ways to use the most advanced communications technologies known to man, on frequencies ranging from the lowest to microwaves. The divergence of the rate of development of technology and the development of thoughtful emergency preparedness is a significant aspect of this overall study that we dare not ignore or underestimate.

## The modern era of telecommunications

The advent of cellular phones, microwave relays, and fiber optic cables has allowed a wondrous set of advances in complex telecommunications. Many of these techniques are still bound to the backbone of wire at some level. Therein lays the great potential for disruption in natural or man-made disasters. Emergency services telecommunications, including public safety radio systems, have exhibited tremendous growth and improvement in capabilities. Trunking radio systems and other methods that allow for very sophisticated organizations are still breakable, as has amply been shown in the recent natural disasters.

Current capabilities of amateur radio include much more than the Morse code telegraphy or even the clear and intelligible voice technologies of today. There are digital technologies that include data packets, even e-mail via radio, and satellite technology. Indeed, the two entities that have the most unbreakable, most long range, most dependable emergency communications in the world are the military and the amateur radio communities. As is covered by Leitl in this issue, computer linkage via the Internet has permitted interlinking of radios and computers; the bridging of these modes of communication has enhanced the dependability of worldwide disaster communication.

To dovetail this presentation into one that includes computers and the Internet (which was developed initially as a link for the military/defense infrastructure), I shall mention the significant potential that exists for bridging the last miles of hardwire connection when that infrastructure is interrupted by disaster. Movement toward realizing that bridge will significantly improve the abilities of emergency and disaster communication in the future. Two of those rapidly emerging technologies are 'Winlink' [7] and 'Echolink' [8]. Both of these methods have been used in the disasters I have mentioned, and have added significantly to the effectiveness of communications following those events.

## Conclusion

This has been an extremely truncated history of disaster communications outside the world of computers and Internet. There is a huge body of information, to some portions of which I undoubtedly owe apologies for lack of mention.

In all the history of disaster and emergency communications, from the bleak beginnings to the 21st century, we can see how the combination of great potential with lack of planning and preparedness has caused fiasco after fiasco. Technology will be of little benefit without the foresight to use it wisely. This history is also replete with examples of how old practices die hard. It is the hope of this writer that the reviews included in this collective work will enable us as citizens of the globe to begin to find ways to adjust our planning for disasters and emergencies. An essential part of that planning includes the deployment and effective use of the best means of communications that we may have at our disposal, surmounting both political and habitual objections to that process. We all know George Santayana's maxim about history, so I shall not repeat it here. Now we have the opportunity to live into it.

## Competing interests

The author(s) declare that they have no competing interests.

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