Recovering Communications Operability and Interoperability After Large Incidents

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Public safety has made great strides in achieving interoperability since the events of 9/11. The focus on interoperability also highlighted the need to maintain operability during large incidents such as earthquakes and storms like Katrina. The traditional approach has been to build stronger infrastructure and backups to ride out the incident. However, it is also clear that the awesome power of nature cannot be completely overcome. The best efforts of humans could still fail in a major event. No tower is completely impervious to storm winds, and sometimes debris flies into generator cooling radiators and shuts down a system. Even a more contained event such as the quake in Haiti can reach havoc and leave the populace stranded without administration to provide help.

When communications infrastructure is unavailable or disrupted in a large area, first responders often turn to satellite communications (satcom). Some responders are well versed in the use of satcom. Firefighters fighting wild land fires, for example, may use satcom terminals for data, situation awareness and incident management. However, when a major disaster such as Katrina, which spanned several states, strikes, the disruption in its path is not easily repaired. Moreover, those affected may not be conversant with the use of satcom technology if it is not in regular used or exercised regularly. The communications needs may also be so great that a few satcom terminals flown in may only be able to provide localized communications. The yeoman services provided by satcom with voice and data were critical to the early stages of recovery from Katrina. Still, their limited capacity to handle heavy traffic over large areas (spatial capacity), results in critical needs not being met. Even commercial terrestrial services which survive may not be designed to operate over extended periods of time after power failure.

To avoid breaking out unfamiliar equipment in a time of crisis, satcom needs to become an integral part of every EOC and EMA location. Satcom could provide alternate live paths for command communications with state and federal administrative centers, including the governor's office and FEMA. First responders on the field need to make satcom part of any exercises. This is the only way to keep this equipment working and ensure that first responders are trained to use them.

Most importantly, the inability of first responders to use their regular land mobile radio (LMR) handsets and mobiles means that law and order, as well as all forms of disaster response and rescue are compromised. The citizenry is left to survive on its own. When command, control, and communications (C3) are disrupted, the resulting loss of situation awareness may sometimes result in inadequate response from federal or state government and possibly overly optimistic statements from state and national leadership!

The normal terrestrial communications we are all familiar with will be referred to as the **Terrestrial Layer (TL)** in this paper. The satcom element will be referred to as the **Space Layer (SL)**. The approach suggested in this paper is to also formalize the use of an **Airborne Layer (AL)** into the emergency communications mix and propose an integrated strategy, while also looking at powering needs.

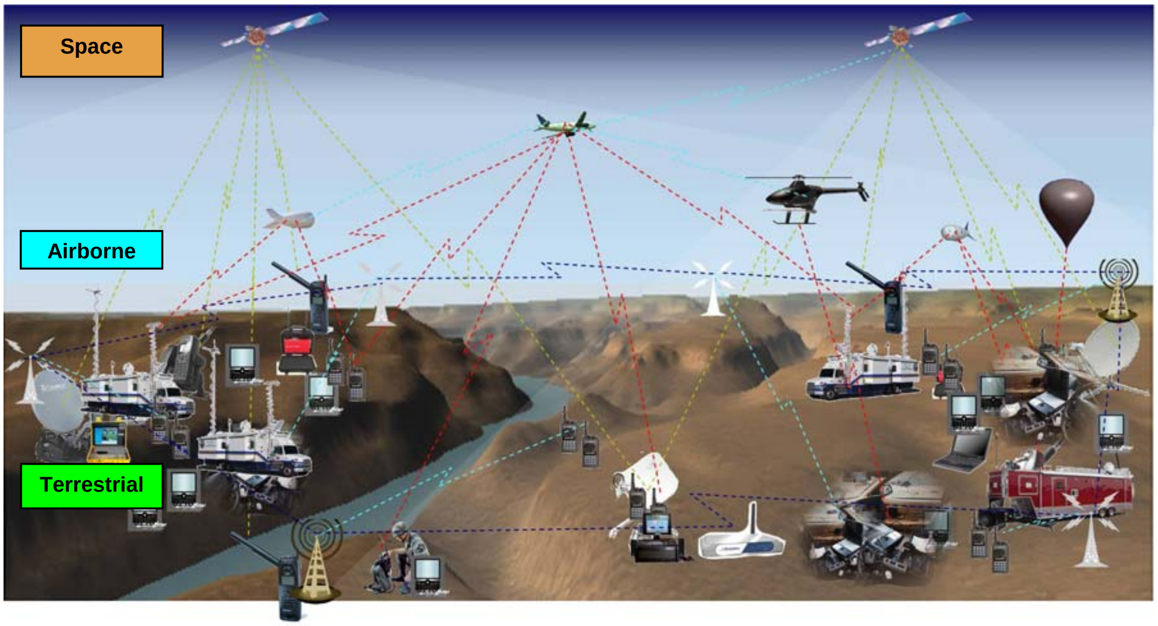

Figure 1: The Three Layers of Recovery Communications

The Space Layer: This is often the first phase of the recovery. However, it usually requires specialized Terrestrial Layer terminals. The regular terminals most used by first responders are rendered inoperable due to infrastructure damage. In the second phase, the SL will work with the AL to relay higher capacity communications.

Figure 2: The Space Layer in the First Phase of the Recovery

Airborne Layer: The AL can be considered in three stages. Stage one consists of fixed wing aircraft which, at 20,000 to 40,000 feet, can initially fly above the storm and its aftermath in a station keeping pattern. They can carry equipment that communicates both with satellites and with ground satcom terminals which are either in place or brought in by aid agencies. This allows them to aggregate the traffic and relay it with high bandwidth connections to the satellites, thus increasing spatial capacity. They are not power limited. These are sometimes called "surrogate satellites". Depending on the LMR technology, these craft may also be able to carry LMR base stations if they can operate despite the aircraft's high speed and attendant Doppler effects if it not directly overhead. They may even be able to perform airborne command post functions, much like military AWACS aircraft. However, these are specialized aircraft and will probably need to be federal (and perhaps state) assets. They are manned and will require refueling and frequent crew change and replacement.

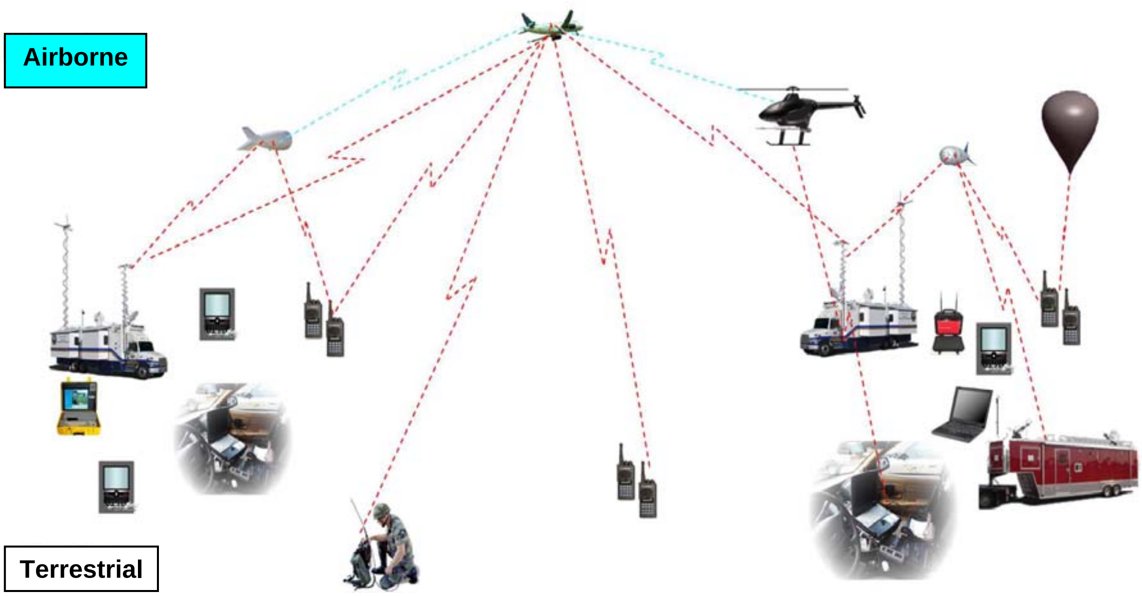

Figure 3: The Airborne Layer is used with Existing Terrestrial Terminals and the Space Layer

The second AL stage could consist of stationary, lower flying, rotating wing craft (helicopters) flying from 5000 to 20,000 ft. These can be regular craft that can be quickly outfitted with LMR base stations since there is no concern about piercing a pressure hull. The direct line of sight communications to these high platforms means their base stations can be low powered. They will allow the first responders on the ground to immediately use their traditional mobiles and handhelds. The stage two platforms could also carry mobile satellite equipment to relay the communications out via the SL to distant EMAs. Since they fly lower, their coverage is less and hence they will need more craft to cover a large area, increasing spatial capacity. Finally, they could be outfitted with mesh networking equipment to connect with other craft so that an extended network can be formed to support ground LMR communications. The initial stages of ground communications recovery will be underway.

In the third AL stage, as the weather calms further or when there is time to bring in new assets, other craft such as unmanned heliostats and slow-flying solar powered airplanes that can operate for weeks at a time can take over, further increasing capacity. Even free flying low cost balloons with repeaters, which can be replaced with others as they drift out of range, have been proposed. Finally, these can be supplemented or replaced by tethered balloons, carrying lightweight base stations flying at 500 ft or less and powered through the tether. We now have an operational LMR system. Most importantly, first responders are able to use their regular mobiles and handsets which they use day-to-day (though perhaps in conventional, analog mode). They can be dispatched from active fixed or mobile dispatch centers.

Power for the Recovery: A less glamorous aspect of this strategy is the need to keep first responders' terminals powered and operating. The restoration of the infrastructure outlined above is useless if the users' terminals are dead and there is no ground power to recharge them. One option is to look for decentralized powering solutions such as solar panels and propane fuel cells in addition to any available generator power, though the latter may be needed to run the base stations. For example, it is estimated that a 1.2 sq. meter solar panel can provide about 180 watts to power six handset chargers. This should be enough to serve a small first responder post. Smaller, portable units could be placed in first responders' homes so that personnel are available for duty even if their work location has been damaged or destroyed or they are unable to reach it.

This approach buys time until the regular communications and power infrastructure is repaired. C3 is restored quickly in an orderly fashion. Situational awareness is maintained. Necessary aid can begin flowing in as roads are repaired. Law and order and rescue units are able to function.

Action Plan: What is needed to implement this approach? *The AL* needs airborne assets with satellite relay capability that can work with multiple satellite types and ground terminals. These need to be stationed around the country for quick deployment by an agency such as FEMA. Next, lightweight portable equipment that can be quickly installed and taken up with helicopters are needed, both for satcom and LMR. These may be kept in regional centers from which helicopters can be dispatched. Low cost, lighter-than-air craft can also be placed in regions to facilitate rapid deployment in sufficient numbers. Finally, local agencies may keep tethered balloons as emergency backups for towers. However, since transportation infrastructure may be sufficiently restored by the time these are deployed, they may be trucked in. They could also be brought into the area in advance of a major storm. Additionally, some federal agencies, such as DoD installations and the National Guard may already have such equipment, which could be used to relay civilian communications in an emergency with appropriate portable base stations, provided the necessary SOPs and MOUs are executed.

The Space Layer could also use a small number of specialized National Emergency Communications Satellites (NECS) as national assets. These are justifiable in the same manner as GPS or weather satellites are national resources and could cost much less.

They could be made available for use without charge by the Federal Government. Another approach is to leverage commercial satellites which are redirected to support emergency use in a public private partnership. The satcom industry could cooperate with first responders to minimize tariffs while ensuring that they have a steady stream of revenue supporting normal traffic between EOCs and the state, for example. This is particularly important since operational funding to pay for satcom as part of day-to-day activities is difficult to find.

Even in a relatively well contained disaster area such as Haiti after the recent earthquake, the above approaches could have provided several benefits. Satcom and airborne assets could have relayed communications to the surrounding cities which were unaffected.

While many of the pieces of this approach may be already present, various communications links proposed above may need to be standardized. Software and middleware are needed to connect dissimilar systems together in the SL, AL, and some elements of the TL. The Software Defined Radio Forum's satcom special interest group (Satcom SIG) has started to look at some of the hardware and software issues necessary to build such hybrid architectures. Organizations such as APCO, the federal government, and industry need to provide leadership.

Another important area to consider is to designate frequencies which could be used in airborne LMR nodes in disasters in the various bands, and also the licensing of airborne satcom relays. These could be used if there is a declaration of disaster and the infrastructure is down. Regulatory mechanisms for using existing ground frequencies with damaged infrastructure and mutual aid channels in low power airborne nodes may also need to be explored. Clearly, there would be no time for specific FCC or NTIA applications and studies!

Finally, these approaches may not be very useful if first responders are not trained to work with the multiple recovery layers before ground infrastructure is restored. SOPs and MOUs are critical. The concepts of operation (CONOPS) need to be developed and all parties need to know the playbook so that relief is provided quickly.

In summary, the present ad-hoc approaches to communications recovery after large incidents need to be improved. This paper views disaster recovery as a layered process to provide an orderly restoration of communications after large incidents, and identifies some of the missing pieces needed to make this happen.

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