Cognitive and Engineering Aspects of Disaster Recovery Communications

SDR’11-WInnComm, Washington, D.C., December 2011

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December, 2011

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Problem Overview

Disaster Communications

- There will always be some incidents too large to be survived intact
  - Natural – earthquakes, hurricanes, tsunamis, floods, etc.
  - Man-made – dam break, nuclear, etc.
- Large incidents often take down communications infrastructure and/or links
  - Access networks destroyed (useless radio terminals)
  - Mobiles and portable terminals often left intact
- Most solutions concentrate on the terrestrial/tactical layer
  - Building more robust structures, towers, generator sites, etc.
  - Building redundant forms of terrestrial communications
  - However, SEE BULLET 1
- In some remote areas, communications may be needed where there was none before
  - For example, wilderness search and rescue
  - Probably not a large disaster, but still need innovative solutions

Goal and Strategy for Recovery (Satcom to Airborne)

- Goal: Recover communications after large incidents
  - Establish national/regional/local disaster management strategy
  - Re-establish front-line communications to enable local response
  - Facilitate integrated communications with local and visiting rescuers
  - Quickly serve a devastated population
- Key concept: Do the best possible for the greater good until conditions improve
  - Best effort to re-establish limited communications in affected area
    - Pre-plan and distribute information if there is time. Often not possible
  - Reactivate existing user terminals
  - Minimize possible inconvenience to unaffected parties for the greater good
    - Some shared pain, if unavoidable
  - Empower local decision making, especially in later stages of recovery
- Stages of deployments – bringing the relay down lower
  - Start with satellite communications (Satcom). This may need special terminals
  - Next, high-altitude flights, then high-altitude long-endurance (HALE) platforms
  - Helicopters, drones, heliostats, free-flying and tethered platforms in later stages

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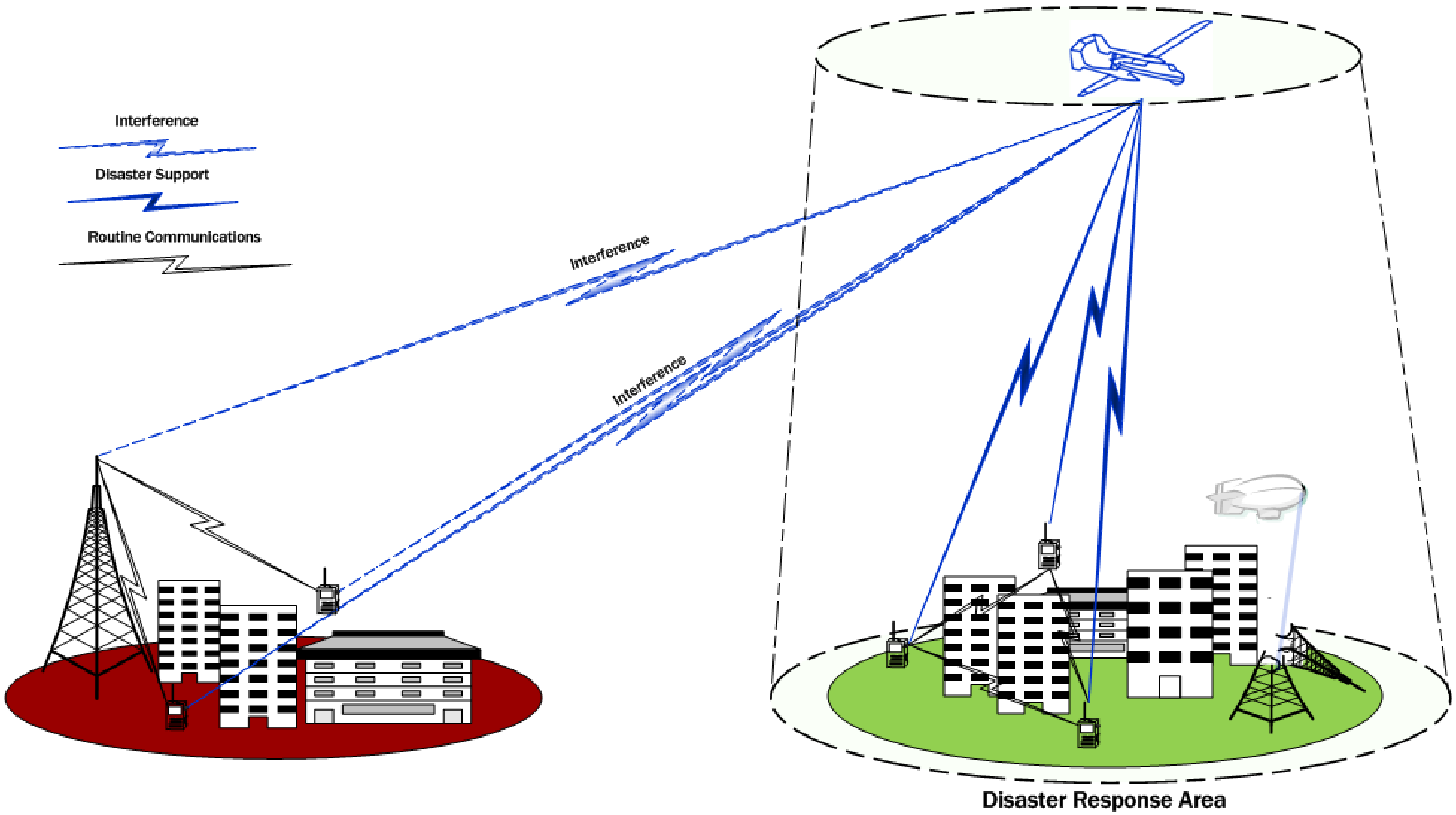
Coverage and Interference in an Aerial Deployment Scenario



Drawing by Preston Hathaway

Engineering Considerations on Aerial Deployment for Public Safety Voice

- Define "coverage" as a delivered audio quality (DAQ) of 3.0 to a portable on the street
  - Compromise in a disaster
  - Reduces transmitter power in aerial platform to mitigate interference
- Stay as low as possible (1,000 – 5,000 feet) to keep the interference radius down while providing reasonable coverage radius
- As you go higher, toward 50,000 feet, the proportionate path loss to the desired cell increases significantly, reducing coverage increase for a fixed transmitter power
- As you go very low, the effect of the ground increases and again limits or decreases coverage
- As you go higher, the interference radius increases much faster than the covered cell radius
- To limit interference and increase spatial reuse of frequency
  - Limit aerial platform antenna beamwidth and shape it to direct the power to the desired coverage area, to increase coverage and reduce interference
  - Limit aerial platform power. This, together with the limited beamwidth, increases frequency reuse
- Using P25 instead of analog will increase the coverage radius for a given interference radius
  - Due to lower margin (CPC) needed for a given performance
- Multiple relays linked to extend coverage are needed as capacity requirements increase

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Role of Cognitive Technologies

- Goal: Free the users from complexity and adapt to conditions on site
  - Users' primary focus is to provide disaster assistance
- Self-configuring user terminals, airborne relays and links to satellite communications (Satcom)
  - User terminals which will self-configure to best satellite system or relay
  - Select both space system, communications technology, and link parameters
- Self-configuring airborne relay platforms
  - Preparatory database analysis of what systems were in place prior to disaster
  - Sniff and identify what systems are still in place after disaster
  - Self-configure to minimize interference to surviving systems while providing maximum coverage to support damaged systems
    - Antenna beam patterns, frequencies, waveforms, power levels,
  - Possibly extend coverage of operational systems or provide replacement coverage
  - Reduced capability set will be most likely
- Self-configuring relay-to-relay links
  - Detect proximity of other relays and automatically select link parameters to extend coverage
  - Provide onboard switching to relay back down, send to other relays, or to Satcom
- Key requirement: Provide an auditable trail of actions taken, for regulatory purposes

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Issues to Resolve

- How do you define "coverage" from an aerial platform in a disaster?
  - Is DAQ 3.0 to a portable on the street OK as a design parameter?
  - This minimizes resulting interference as well
- How do you define "interference" to a surviving system in a disaster when using an aerial platform, especially in an unaffected area?
  - Should they tolerate "some" interference for the greater good of their affected brethren?
  - How much is "acceptable" interference before it affects responder safety in the healthy system?
- How should a surviving system in a disaster area be used to help facilitate possibly lower-quality coverage that can be provided to more people via aerial platforms?
- How do these considerations change for commercial cellular systems?
- Should flight profiles (heights, speeds, etc.) and powers be pre-defined by the FAA and FCC?
  - Standard designs to avoid guesswork in a disaster and optimize results?
- Could frequencies licensed to systems that have been destroyed be "lofted"?
  - Could national assets be used to intelligently "sniff" the scene before aerial platforms are deployed?
- Under what conditions and what protocols should these actions be invoked?
  - CONOPS are crucial for all players to work together and understand what happens and when
- Answers needed from the FCC, FAA, FEMA, public safety, industry, et al.

FAA = Federal Aviation Administration; FCC = Federal Communications Commission; CONOPS = concept of operations; FEMA = Federal Emergency Management Agency

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Other Work and Summary

- The Europeans are working on disaster recovery
  - Software defined radios under the EULER program
  - Cities using helicopters as aerial platforms for communications, for example
  - More work in progress
- The WInnForum (Wirelessinnovation.org) SATCOM SIG (Special Interest Group) and Public Safety SIG are working jointly on defining a hybrid architecture for disaster recovery
  - Using satellites, airborne platforms, etc., in a staged approach
  - Work on an architecture document is in progress in outline stage
  - Understanding what can be done today with existing technology and what more is needed
  - Examining concepts such as the use of cognitive radios for intelligent deployment
  - A Disaster Recovery Communications workshop is being planned for March 2012
- Input from Public Safety is vital
- Space and aerial platforms have a crucial role to play in large disasters
- Further work needs to be done to make this a national, state, and local strategy

WInnForum = Wireless Innovation Forum   SATCOM = satellite communications

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Thank You

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Reference:

Daniel M. Devasirvatham: "Recovering Communications After Large Disasters", Wireless Innovation Forum SDR'11-WInnComm Europe Proceedings, pp 61-65, June 2011. Also APCO Public Safety Communications magazine, pp 26-28, May 2011.

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