# Interference and Coexistence in Recovery Communications After Large Incidents

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# 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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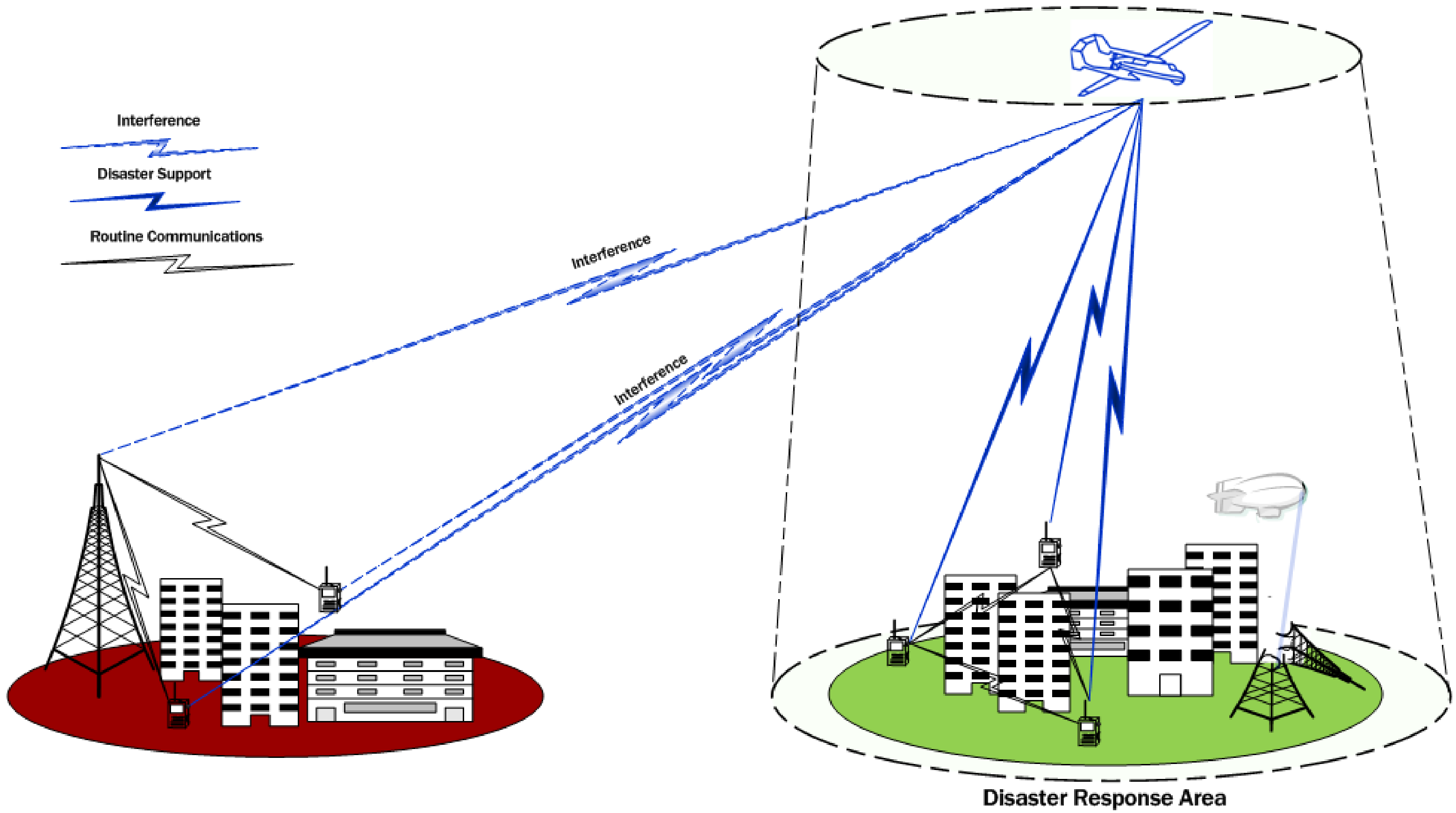
# Coverage and Interference in an Aerial Deployment Scenario




Drawing by Preston Hathaway

# What Communications Needs to be Recovered?

- **Traditional thinking: Narrowband Public Safety Land Mobile Radio (LMR)**
  - Provide airborne relays to replace lost ground LMR base stations
- **New development: Broadband for Public Safety, mainly LTE**
  - Radically different link budget and network needs compared to LMR
- **Additional Consideration: Population needs to communicate**
  - Initial response is to seek more information, overloading emergency services
    - 9-1-1 Overload in DC after earthquake
  - Another action is to inform relatives etc.
  - Uses 2G, 3G and 4G/LTE networks
  - Similar link budget and network needs as Public Safety LTE
- **Population actions overload cellular mobile communications**
  - Could come crashing back down as everyone's phones try to sign back in
- **A Better initial medium is Broadcast Radio restoration**
  - FM radios often found in cell phones.
  - Most people have access to a broadcast radio receiver



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# Airborne Restoration Strategies

- **LMR Base Stations and Broadcast transmitter: similar powers, hence similar coverage**
- **1) LMR restoration enables public safety to function**
- **2) Broadcast Transmitters to send information to public**
  - Calm rumors and quell mass panic
  - Give instructions on what to do next
  - Give estimates on when relief might arrive
- **LMR and Broadcast relays can be part of initial high altitude platforms**
- **Cellular/LTE and PS Broadband LTE need lower relay altitudes**
  - Lower power of handsets reduces range (i.e., height) significantly
  - Relays need to be at approximately 1/3 the height compared to LMR
    - Based on uplink budgets
    - More dense, lower altitude relays
- **Hence more suitable in later phases of the restoration**
- **3) Enable CMAS/ Cellular Emergency information broadcast to further disseminate info**
- **4) Enable Cellular Data first with rate throttling, then Cellular Voice last if possible**



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# Engineering Considerations on Aerial Deployment

- **As you go higher, the interference radius increases much faster than the covered cell radius**
  - Distance to the ground nearby is proportional to height, ‘h’
  - Path loss rises as h**2
  - Distance to the horizon goes up as SQRT(h)
  - Path loss rises as h
  - Distance to an interfered cell, several radius’s away is in between
- **Hence, As you go higher, the proportionate path loss to the desired cell increases significantly, reducing coverage increase for a fixed transmitter power**
- **The path loss the a cell with which it could interfere rises more slowly**
- **Permissible interference power level is 10s of dBs lower than power required for coverage**

- **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**

- **It should be possible to calculate optimum relay heights for various technologies**
  - But real world considerations will dominate (flight rules, number of relays etc)



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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
  - User terminals which will self-configure to satellite system or relay
  - Select space system or relays based on 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

# Other Work and Summary

- The Europeans are working on disaster recovery
  - Equipment available for using aerial platforms for communications, for example
  - Airborne to satcom relays are available
  - Exercises held to see how this would work
  - More work in progress
- The WInnForum (http://Wirelessinnovation.org) SATCOM SIG (Special Interest Group) is working on defining a hybrid architecture for disaster recovery
  - Using satellites, airborne platforms, etc., in a staged approach
  - Work on an architecture document is nearing completion
  - 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
  - Disaster Recovery Communications workshop was held in March 2012 in San Diego
- 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 EU-wide, national, state, and local strategy

WInnForum = Wireless Innovation Forum    SATCOM = satellite communications

# 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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