

# Presentation by Nelson Bryner – National Institute of Standards and Technology

**NIST High-Rise Building and Complex Incident  
Emergency Responder Communications Workshop**



## Distributed Multi-Nodal Voice / Data Communication Systems



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## Overview



- **Introduction**
  - Communication
    - who, what, where, under which conditions
  - Radio systems – why not?
- **Distributed Multi-Nodal  
Voice/Data Communication -**
  - **Wireless Sensors**
    - **Building**
    - **Fire fighter**
  - **Networks**
    - **Fixed**
    - **Ad-Hoc**
- **Summary**



## Communication – Who & What?



- Who is “communicating” in building?
  - First responders
    - Fire fighters
    - Law enforcement
  - Incident commander
  - Rapid Intervention Teams
  - Rehab Team
- What is the information needed for?
  - Tactical
    - Fire ground – suppression and venting
    - Searching for victims/suspects
    - Rapid intervention teams (RIT)
  - Staging of additional resources



## Communication – Who & What?



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    - Rapid intervention teams (RIT)
  - Staging of additional resources
- **Locating/tracking first responders**
- **Fire conditions – fire spread**
- **Bio-metrics – heat stress**



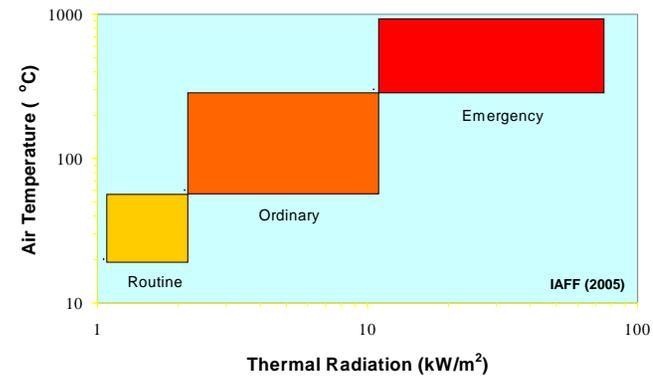
## Where or what building type ?



- Type I or Fire-Resistive (NFPA)
  - High rise office, shopping centers, or residential units
  - Reinforced concrete, structural steel (protected)
- Type II or Noncombustible
  - Office buildings, warehouses, auto repair shops
  - Metal frame with metal walls, metal frame with masonry walls, masonry walls with metal roof
- Type III or Ordinary
  - Office buildings, retail stores, mixed occupancy, apartment buildings
  - Noncombustible bearing walls and combustible roofs
  - Most buildings are of this type
- Type IV or Heavy Timber
  - Exterior noncombustible or limited combustible, masonry
  - Interior structural members, walls, columns, floors and roofs are large timbers
  - Common in the New England area
- Type V or Wood Frame
  - Single family dwelling, restaurants, retail stores
  - Log, post & beam, balloon, platform, and plank & beam
  - Structural members are wood and exterior walls are combustible



## Under what conditions ?



## Under what conditions ?



Thermal Class	Maximum Time (min)	Maximum Temperature (°C)/(°F)	Maximum Flux (kW/m <sup>2</sup> )
I	25	100/212	1
II	15	160/320	2
III	5	260/500	10
IV	<1	>260/500	>10



## Radio Communication – Why not?



### •Radio Frequency Based Systems

- VHF – 30 MHz to 300 MHz
- UHF – 300 MHz to 3 GHz
- UWB – 2.4 GHz – 5.4 GHz

### •Simplex – point to point

### •Duplex -

### •Signal Attenuation–

- Construction materials absorb
  - Varying degrees
- Metals or metal containing materials block transmission
  - Siding or roofs
  - Solar radiation coatings
  - Aluminum foil on insulation



## Communication Technology



- **Wide range of technologies**
  - Acoustic/sound
  - Radio frequency
  - Infrared signal
- **Source of Technologies**
  - Military
  - Security and surveillance industry
  - NASA
  - Mining Industry



## Communication Technology



- **Wide range of technologies**
  - Acoustic/sound
  - Infrared signal
  - Radio frequency
- **Source of Technologies**
  - Military
  - Security and surveillance industry
  - NASA
  - Mining Industry
- **Commercial market**
  - Fire Service Equipment
    - Limited due to the market size/funding



## Communication Technology



- **Wide range of technologies**
  - Acoustic/sound
  - Infrared signal
  - Radio frequency



## Communication Technology



### Acoustic / Sound Systems

- **Transmitter/receiver system**
  - Acoustic or sound waves
  - Not in range of human hearing
- **Data communication**
  - Not voice
  - Locates fire fighter
- **Commercially available**
  - Summit Safety
- **Issues-**
  - Reflections –
    - Must compare strength of signal
    - Materials reflect differently
    - Multiple reflections
  - No tracking



## Communication Technology



- **Wide range of technologies**
  - Acoustic/sound
  - Infrared signal
  - Radio frequency



## Communication Technology



### Infrared / Laser Signal

- **Transmitter/receiver system**
  - Light signal
  - Not in range of human vision
- **Data communication**
  - Not voice, but could be digitized audio
  - Can be used to locate fire fighter
- **Commercially available**
  - Relume, Inc.
- **Issues-**
  - Reflections –
    - Materials reflect differently
    - Multiple reflections
  - No tracking



## Communication Technology



- **Wide range of technologies**
  - Acoustic/sound
  - Infrared signal
  - Radio frequency



## Communication Technology



### Distributed Multi-Nodal Voice / Data Systems

- Each sensor or package a “node”
- More than one node – “multi”
- Can transmit voice in real time
- Can transmit data in real time



### May or may not be in network arrangement



## Distributed Multi-Nodal Voice / Data Systems



- **Building Sensor Nodes**
  - System performance – heat, AC, etc.
    - Network
    - Equipment specific
  - RFID tags/readers
- **Fire Fighter Nodes**
  - Network
  - RFID tags/readers
  - Multi-hop
  - Ad hoc



## Wireless Building Sensors



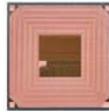
- **Building Sensors or Nodes**
  - In place to track building performance
    - Attached to specific equipment
    - Designed for months/years of service
  - Locate and track
    - Sample frequency
      - Buildings – samples / hours
      - Fire fighters – samples / second
- **Issues –**
  - Need complete building coverage
    - Not just equipment spaces
  - Require pre-wiring of building
  - Adaptive sampling?



## Wireless Fire Fighter Sensors cont'd



- **RF Identification Tags**
- **Reader and Tag uniquely identified**
- **RFID readers in building**
  - Each fire fighter is tagged
  - Walmart tracking merchandise in warehouse
  - Nursing homes – patients
- **RFID tabs in building**
  - Each fire fighter has reader
  - Readers more expensive



## Wireless Fire Fighter Sensors cont'd



### RFID Tags cont'd

- **Issues-**
- **Pre-wiring of readers/tags**
- **Signal**
  - Coverage
  - Penetration/attenuation
  - reflections

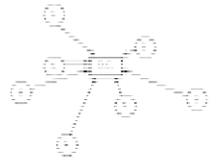


## Wireless Fire Fighter Sensors cont'd

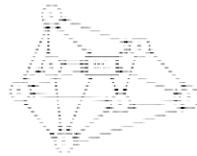


### Fire Fighter Sensor Networks

- Fixed
  - Pre configured
  - Data paths established
- Ad Hoc
  - Self healing or reforming
- RF systems
  - 802.15.4 ZigBee
  - Bluetooth



Star or Point-to-Point



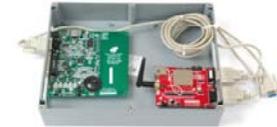
Mesh Network



## Wireless Fire Fighter Sensors cont'd



- Fixed networks
  - Multi-hop
  - Voice/data communication
    - Williams-Pyro (SBIR)
  - Not locating/tracking
    - Strength of signal
    - TOF



- Issues-
  - Limited ability to dynamically add new nodes/sensors
  - Short range
  - Node drop-out



## Multi-hop Network – fixed path



Fire Team 1



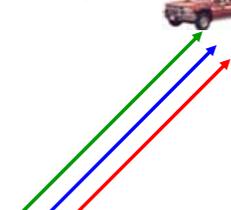
Fire Team 2



Engine 3



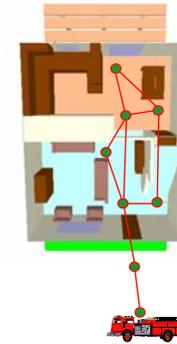
Incident Command



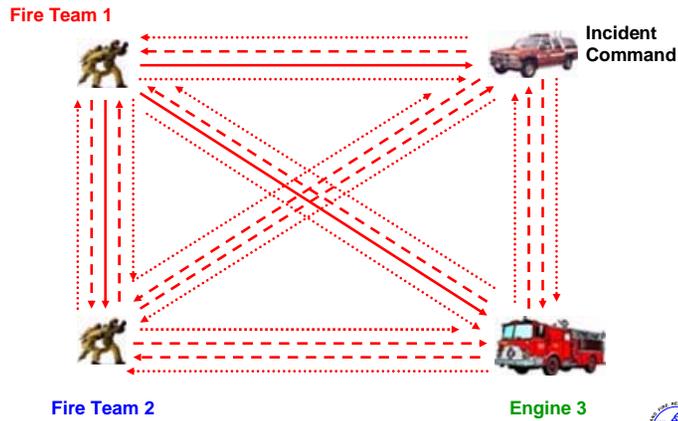
## Wireless Fire Fighter Sensors cont'd



- Ad Hoc Networks
  - Self-forming/re-forming
  - Data communication
    - Locating and tracking
      - GPS
    - Physiology sensors and dosimeters
    - Siemens (USAF)
- Dynamically add sensors/nodes
  - Data paths established on the fly
  - Repetitive pinging to locate nearby nodes
- Issues-
  - Short range
  - Path determination
    - Ping, ping, ping, ping, ping, ping
  - Data, but not voice



## Ad Hoc Network – Two Pings



## Distributed Multi-Nodal Voice/Data Summary



- **Building Sensors**
  - Interior of Structure
  - Commercial systems for indoor use
  - Pre-wired for limited coverage
- **Fire Fighter Nodes**
  - Interior and exterior of structures
  - Downed fire fighter
- **Currently no commercially available system**
  - Voice, data and video
  - Inside and outside
  - Locate and track
  - Fire responders
  - Occupants



## Communication Technology Future Work



- **Assist in development of new technology**
  - Technical expertise
  - Internal research funds
  - Grants
- **Evaluate current systems**
  - Laboratory-scale tests
  - Full-scale fire exposure tests
  - Collaborate with Fire Service
- **Standards & testing protocols**
  - Representative building types
  - Representative exposure conditions



## Communication Technology



- **Questions?**

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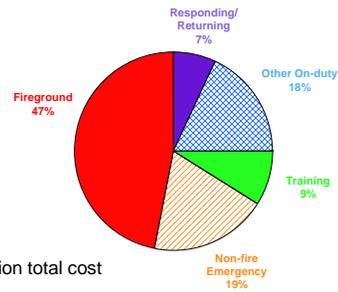
[www.fire.gov](http://www.fire.gov)  
[www.bfrl.nist.gov](http://www.bfrl.nist.gov)



## Why Invest in Distributed Multi-Nodal Voice/Data Technology ?



- **Firefighter Fatalities –**
  - 117 in 2004 (USFA)
- **Total Injuries –**
  - 80,800 in 2004 (NFPA)
  - Fireground – 37,976 injuries



- Magnitude of U.S. Annual Losses ~ \$128 billion total cost
- Tracking fire fighters allow
  - Better tactical decisions
    - Faster suppression
    - Decreased property losses



## Communication Technology



- **Roles of NIST**
  - **Fundamental Science**
    - Measurement or metrology
    - Signal penetration
    - Sensor design
    - Combustion Science
  - **Building performance**
  - **Fire Environment**
  - **Performance Standards and Testing Protocols**
    - Signal quality
    - Sensor interfaces/performance
    - Thermal exposure testing
    - Network design
  - **Develop new technology where expertise exists**

