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

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  - 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?

<table>
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<th>Thermal Class</th>
<th>Maximum Time (min)</th>
<th>Maximum Temperature (°C)/(°F)</th>
<th>Maximum Flux (kW/m²)</th>
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<td>25</td>
<td>100/212</td>
<td>1</td>
</tr>
<tr>
<td>II</td>
<td>15</td>
<td>160/320</td>
<td>2</td>
</tr>
<tr>
<td>III</td>
<td>5</td>
<td>260/500</td>
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<td>IV</td>
<td>&lt;1</td>
<td>&gt;260/500</td>
<td>&gt;10</td>
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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

**Commercial market**
- Fire Service Equipment
  - Limited due to the market size/funding

### Acoustic / Sound Systems

- Transmitter/receiver system
  - Acoustic or sound waves
  - Not in range of human hearing
- Data communication
  - Not voice
  - Locates firefighter
- 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

**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

**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
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

Multi-hop Network – fixed path

Fire Team 1

Incident Command

Fire Team 2

Engine 3

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

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?

Nelson Bryner
301-975-6868
nelson.bryner@nist.gov

www.fire.gov
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