Developing a Research Roadmap for Smart Fire Fighting

EXAMPLES OF "SMART FIRE FIGHTING" SCENARIOS

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The following are examples of possible emergency/safety scenarios typically encountered by emergency responders. These are intended to provide examples for the application of cyber-physical systems (CPS) to enable the "smart" fire fighter of the future. These examples are hypothetical but are based on previous real events with similar characteristics.

<table>
<tr><th colspan="3">1) WUI (with evacuation of retirement community)
based on Waldo Canyon Fire, June 2012 in CO (with 2 civilian fatalities and 346 buildings destroyed) and Yarnell Hill Fire, June 2013 in AZ (with 19 FF LODDs and 129 buildings destroyed)</th></tr>
<tr><th>Essential Details</th><th>Additional Challenges</th><th>Possible Emergency-Responder / CPS Enhancements</th></tr>
<tr><td rowspan="2">● Rapidly growing wildfire at WUI
● Semi-arid mountainous terrain
● Shifting winds and dry weather
● Retirement community threatened</td><td rowspan="2">● Limited available resources
● HotShots trained to wildland FF
● Urban crew trained to structural FF
● Crews from unfamiliar jurisdictions
● Rapidly evolving situation
● Complex weather patterns
● Evacuation route not clear
● Complex incident command
● Mass Casualty Event w/ FF LODDs
● High profile media event</td><td><u>Near-Term</u>
Ⓜ Locator sensors on FFs
Ⓜ Initial UAV deployed sensors

Ξ Real-time fire status updates
Ξ Real-time weather data
Ξ Real-time terrain data
Ξ Real-time use of traffic data

⇔ FF location/situational awareness
⇔ FF display using google glasses
⇔ Same info available for IC and FFs</td></tr>
<tr><td><u>Longer-Term</u>
Ⓜ Advanced sensors on FFs
Ⓜ Deployment of sensors on all equip
Ⓜ Multiple UAV deployed sensors
Ⓜ Use of building data
Ⓜ Use of community utility data

Ξ Reliable predictions of fire spread
Ξ Physiological monitoring of FFs
Ξ Optimization of evacuation routing

⇔ Enhanced incident command
⇔ Augmented reality for FFs</td></tr>
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1 Batterymarch Park, Quincy, MA 02169-7471
Telephone: +1.617.984.7281 Fax: +1.617.984.7010
Email: Foundation@NFPA.org www.NFPA.org/Foundation

2) Residential Structure Fire (wind driven fire) based on Marsh Overlook Structure Fire, April 2007 in Prince William County VA (with 1 FF LODD) and Houston Residential Fire, April 2009 in Houston TX (with 2 FF LODDs) and Pittsburgh House Fire, February 1995 in Pittsburgh PA (with 3 FF LODD)		
Essential Details	**Additional Challenges**	**Possible Emergency-Responder / CPS Enhancements**
● Large modern single family home ● Heavy synthetic fuel load ● Open interior wood-frame building ● Located on hillside: 1 to 3 stories ● Fire starts externally from grill ● Fire spreads rapidly with high wind ● Well staffed urban FD	● Fire at early morning hours ● Cars in driveway ● Location of occupants unknown ● Heavy fire on arrival ● Rapid spread of fire to interior ● Initial search crews trapped ● RIT implemented	**Near-Term** Ⓜ Coordination of existing FF sensors Ⓜ Coordination of dispatch data Ⓜ Initial use of building utility data ⌘ Real-time fire status updates ⌘ Real-time weather data ⌘ Real-time use of water supply data ⌘ Real-time use of traffic data ⌘ Real-time use of terrain data ⇔ FF location/situational awareness ⇔ FF display using google glasses ⇔ Same info available for IC and FFs
		Longer-Term Ⓜ Advanced sensors on FFs Ⓜ Deployment of sensors on all equip Ⓜ Multiple UAV deployed sensors Ⓜ Use of building data Ⓜ Use of community utility data ⌘ Reliable predictions of fire spread ⌘ Physiological monitoring of FFs ⌘ Advanced use of building data ⌘ Advanced use of public utility data ⇔ Enhanced incident command ⇔ Augmented reality for FFs ⇔ Coordination of FF location ⇔ Advanced use of medical data ⇔ Advanced info for IC and FFs

3) Hi-Rise Apartment Fire (wind driven fire) based on Vandelia Ave 10-Story Apartment Fire, December 1998 in NYC (with 3 FF LODDs)		
Essential Details	**Additional Challenges**	**Possible Emergency-Responder / CPS Enhancements**
● 15 story brick apartment ● Building approximately 40 years old ● Unit on 12th floor fully involved ● High wind conditions ● Fire on up-wind side of building ● FD well-staffed metro department	● Most occupants are elderly ● Occupants trapped in rooms ● During FF windows break ● Fire rapidly intensities ● Wheelchair occupants on fire floor ● Wheelchair occupants elsewhere	**Near-Term** Ⓜ Coordination of existing FF sensors Ⓜ Coordination of dispatch data Ⓜ Initial use of building utility data ⌘ Real-time fire status updates ⌘ Real-time weather data ⌘ Real-time use of water supply data ⌘ Real-time use of traffic data ⌘ Real-time use of terrain data ⇔ FF location/situational awareness ⇔ FF display using google glasses ⇔ Same info available for IC and FFs
		Longer-Term Ⓜ Advanced sensors on FFs Ⓜ Deployment of sensors on all equip Ⓜ Multiple UAV deployed sensors Ⓜ Use of building data Ⓜ Use of community utility data ⌘ Reliable predictions of fire spread ⌘ Physiological monitoring of FFs ⌘ Advanced use of building data ⌘ Advanced use of public utility data ⇔ Enhanced incident command ⇔ Augmented reality for FFs ⇔ Coordination of FF location ⇔ Advanced use of medical data ⇔ Advanced info for IC and FFs

4) Vehicle Crash (ICEV and EV with entrapment) based on NFPA statistics of U.S., with 17 vehicle fire per hour and 287,000 vehicle fires per year		
Essential Details	**Additional Challenges**	**Possible Emergency-Responder / CPS Enhancements**
● Two car MVA with electric pole ● Open two-lane roadway ● Daytime rainy weather ● Rush hour ● Mid-sized suburban FD	● One vehicle is an ICE ● One is EV with entrapment ● ICE vehicle smoking, fire threat ● Wires down in vicinity	**<u>Near-Term</u>** Ⓜ Initial use of vehicle telematics Ⓜ Coordination of dispatch data ⌘ Real-time crash status updates ⌘ Real-time weather data ⌘ Real-time use of traffic data ⌘ Real-time use of terrain data ⌘ Clarify electric utility power ⌘ Clarify extrication cut-points ⇔ FF display using google glasses ⇔ Same info available for IC and FFs ⇔ Access personal medical info **<u>Longer-Term</u>** Ⓜ Advanced use of vehicle telematics Ⓜ Advanced use of dispatch data ⌘ Advanced crash status updates ⌘ Advanced electric utility power use ⌘ Update of extrication cut-points ⇔ Enhanced incident command ⇔ Augmented reality for FFs ⇔ Advanced use of medical data ⇔ Advanced info for IC and FFs

5) Train Derailment (with fire and toxic hazmat) based on Lac-Mégantic Train Derailment, June 2012 in Quebec (with 47 civilian fatalities and 30 buildings destroyed)		
Essential Details	**Additional Challenges**	**Possible Emergency-Responder / CPS Enhancements**
● Freight train derailment w/ hazmat ● Three petroleum cars on fire ● Another car releasing toxic gas ● Type of gas (green) unknown ● In center of small rural town	● Immediate evacuation required ● Train crew location unknown ● Occupants nearby not known ● Volunteer FD w/ limited resources ● Mass Casualty Event ● High profile media event	**<u>Near-Term</u>** Ⓜ Locator sensors on FFs Ⓜ Initial UAV deployed sensors ⌘ Real-time analysis of train cargo ⌘ Real-time fire status updates ⌘ Predictions of fire/toxic-gas spread ⌘ Real-time weather data ⌘ Real-time terrain data ⌘ Real-time use of traffic data ⇔ FF location/situational awareness ⇔ FF display using google glasses ⇔ Basic use of evacuation model
		<u>Longer-Term</u> Ⓜ Advanced sensors on FFs Ⓜ Deployment of sensors on all equip Ⓜ Multiple UAV deployed sensors Ⓜ Use of building data Ⓜ Use of community utility data Ⓜ Advanced environmental data ⌘ Real-time analysis of train cargo ⌘ Predictions of fire/toxic-gas spread ⌘ Reliable predictions of fire spread ⌘ Physiological monitoring of FFs ⌘ Optimization of evacuation routing ⇔ Enhanced incident command ⇔ Augmented reality for FFs ⇔ Coordination of FF location ⇔ Advanced use of medical data ⇔ Advanced info for IC and FFs

6) Hi-Challenge Warehouse based on Food Product Warehouse, December 2007 in Hemingway SC (with 2-day fire and warehouse destroyed)		
Essential Details	**Additional Challenges**	**Possible Emergency-Responder / CPS Enhancements**
● Industrial warehouse fire ● Storage of general housewares ● Automatic retrieval system ● On-site industrial fire brigade ● Back-up by large metro FD	● Very high ceilings (125 ft) ● Very narrow aisles (5 ft) ● Large building footprint (100'x500') ● Full in-rack & ceiling sprinklers ● Fire at high level in back section ● Unable to pinpoint fire location	**Near-Term** Ⓜ Field deployment of sensors Ⓜ Real-time monitoring of fire pumps Ⓜ Coordination of existing FF sensors Ⓜ Coordination of dispatch data Ⓜ Initial use of building utility data ⌘ Real-time fire status updates ⌘ Real-time use of bldg contents data ⌘ Real-time weather data ⌘ Real-time use of water supply data ⇔ FF location/situational awareness ⇔ FF display using google glasses ⇔ Same info available for IC and FFs
		Longer-Term Ⓜ Advanced use of field sensors Ⓜ Use of interior UAVs Ⓜ Advanced use of building data Ⓜ Advanced use of utility data ⌘ Reliable predictions of fire spread ⌘ Physiological monitoring of FFs ⌘ Advanced use of building data ⌘ Advanced use of public utility data ⇔ Enhanced incident command ⇔ Augmented reality for FFs ⇔ Coordination of FF location ⇔ Advanced use of medical data ⇔ Advanced info for IC and FFs

7) Night Club Code Compliance based on Happyland Social Club Fire, March 1990 in NYC (with 87 civilian fatalities) and Station Nightclub Fire, February 2003 in West Warwick RI (with 100 civilian fatalities)		
Essential Details	**Additional Challenges**	**Possible Emergency-Responder / CPS Enhancements**
● Large influx of refugee population ● Closed illegal dance clubs 3 times ● Each time illegally opens elsewhere ● Different people involved ● Inner neighborhood in major city	● Refugees ignore authority (via fear) ● Not understanding of building laws ● Lack of appreciation for safety ● Mass Casualty Event ● High profile media event	<u>Near-Term</u> Θ Initial use of population data Θ Initial use of demographic trends Θ Use of building data Θ Use of community utility data Ξ Basic model of code trends Ξ Initial access to latest codes Ξ Use of code enforcement history Ξ Initial use of investigative data ⇔ Portable access of all data ⇔ Initial use of social media **<u>Longer-Term</u>** Ⓗ Advanced use of population data Ⓗ Advanced use of demographic data Ⓗ Advanced use of building data Ⓗ Advanced use of utility data Ⱶ Advanced model of code trends Ⱶ Optimization of best approach Ⱶ Advanced access to latest codes Ⱶ Advanced use of code history Ξ Advanced use of investigative data ⇔ Portable processing of all data ⇔ Advanced use of social media

8) Tornado based on Joplin Tornado, May 2011 in Joplin MO (with 158 civilian fatalities and ~$2.8 billion loss) and Moore Tornado, May 2013 in Moore OK (with 25 civilian fatalities and ~$2.0 billion loss)		
Essential Details	**Additional Challenges**	**Possible Emergency-Responder / CPS Enhancements**
● F-4 Tornado strikes mid-sized city ● Occurs at 3 am ● Well staffed FD	● Hits residential area ● Directly hits hospital ● Little warning ● Damage significant ● Mass Casualty Event ● High profile media event	**<u>Near-Term</u>** Ⓜ Early mass notification warning Ⓜ Locator sensors on FFs Ⓜ Initial UAV deployed sensors Ⓜ Monitoring of public utilities Ⓜ Field deployment of sensors Ⓜ Deployment of sensors on all equip Ⓜ Initial use of UAV sensors ⌘ Real-time fire status updates ⌘ Real-time weather data ⌘ Real-time terrain data ⌘ Real-time use of traffic data ⌘ Real-time damage assessments ⌘ Identify & track missing victims ⇔ FF display using google glasses ⇔ Same info available for IC and FFs ⇔ Access personal medical info
		<u>Longer-Term</u> Ⓜ Advanced sensors on FFs Ⓜ Deployment of sensors on all equip Ⓜ Multiple UAV deployed sensors Ⓜ Use of building data Ⓜ Use of community utility data Ⓜ Advanced mass notification Ⓜ Multiple UAV deployed sensors ⌘ Reliable predictions of damage ⌘ Optimization of evacuation routing ⌘ Advanced damage assessments ⌘ Advanced tracking of victims ⇔ Enhanced incident command ⇔ Augmented reality for FFs ⇔ Access personal medical info

9) Terrorist Bombing (Large Scale EMS Event) based on Boston Marathon Bombing, April 2013 in Boston (with 3 civilian fatalities, 260+ injuries)		
Essential Details	**Additional Challenges**	**Possible Emergency-Responder / CPS Enhancements**
● Two separate IED (improvised explosive device) events in crowds, within ¼ mile (½ km) and 2 minutes ● Large exterior crowds (tens of thousands) ● Crowd relatively widespread along road race course (with crowd control and traffic implications)	● Mass casualty events, with multiple fatalities and hundreds of injuries ● Event is immediately both a rescue scene and crime scene ● Crowd control ● High profile media event with live news coverage ● Crowd immediately aware of terrorism based on multiple delayed explosions and media coverage	**Near-Term** Ⓜ Early mass notification warning Ⓜ Coordination of dispatch data Ⓜ Coordination with security Ⓜ Coordination of data for triage ⌘ Processing of triage victims ⌘ Coordination of resources ⌘ Real-time use of traffic data ⌘ Real-time use of crowd data ⌘ Identification of investigative data ⇔ Portable access of all data ⇔ Initial use of social media
		Longer-Term Ⓜ Advanced sensors on FFs Ⓜ Deployment of sensors on all equip Ⓜ Advanced use of dispatch data ⌘ Advanced use of dispatch data ⌘ Optimization of best approach ⌘ Advanced processing of victims ⌘ Advanced use of investigative data ⇔ Portable processing of all data ⇔ Advanced use of social media ⇔ Advanced investigative data use

10) Elevator Rescue (Metro City Power Failure) based on sub-station fire causing widespread city center power failure, 2012 in Boston (with hundreds of elevator rescue calls)		
Essential Details	**Additional Challenges**	**Possible Emergency-Responder / CPS Enhancements**
● Multiple alarm fire in electrical sub-station ● Extended 12 hour power failure in center affecting hundreds of tall buildings equipped with elevators ● Hundreds trapped in stuck elevators requiring rescue ● Event occurs in early evening after dark with cold winter outside temperatures	● Fighting electrical transformer fire challenging but straight-forward ● Bigger problem is power outage and widespread elevator rescue ● Numerous individual requests for assistance in short time frame ● High profile media event	**<u>Near-Term</u>** Ⓜ Deployment of sensors on all equip Ⓜ Advanced incident tracking Ⓜ Use of building data Ⓜ Use of community utility data ⌘ Real time power outage updates ⌘ Coordination of resources ⇔ Portable access of all data ⇔ Initial use of social media
		<u>Longer-Term</u> Ⓜ Advanced sensors on FFs Ⓜ Deployment of sensors on all equip Ⓜ Advanced use of dispatch data Ⓜ Advanced use of building data Ⓜ Advanced use of utility data ⌘ Advanced use of dispatch data ⌘ Optimization of best approach ⌘ Advanced use of building data ⌘ Advanced use of public utility data ⇔ Portable processing of all data ⇔ Advanced use of social media