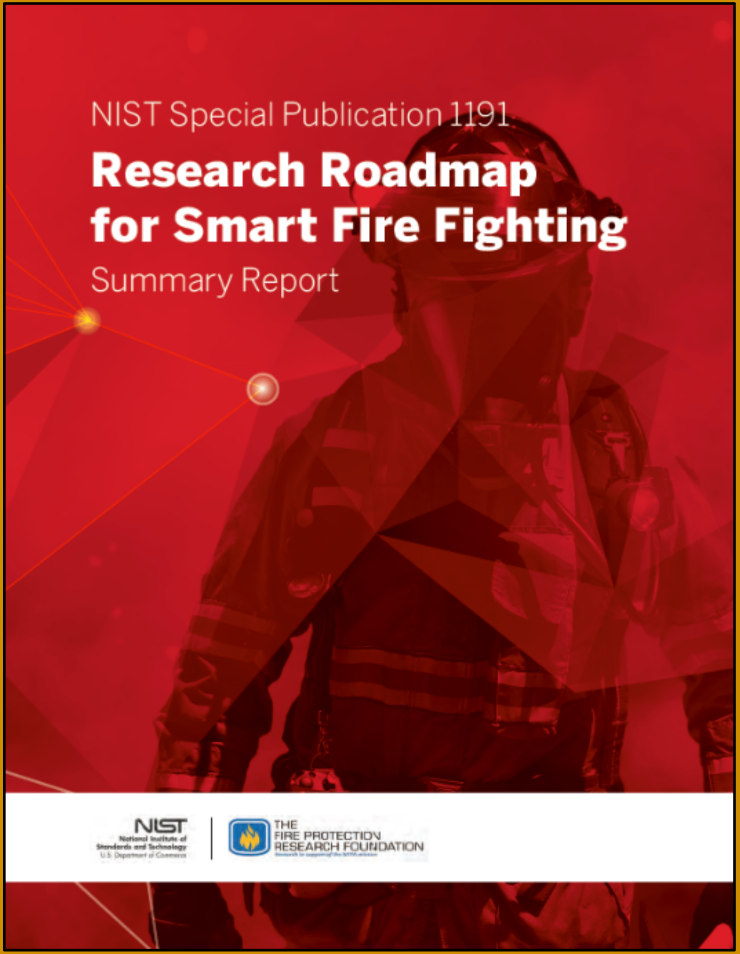
NIST

International Workshop on the Use of Robotic Technologies at Nuclear Facilities

Smart Fire Fighting Using Robotics

Gaithersburg, Maryland

4 February 2016 | Casey Grant



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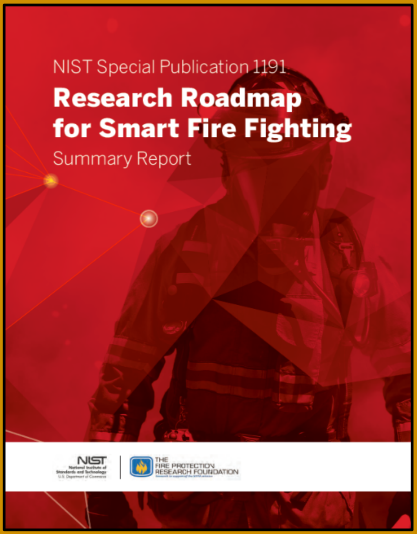
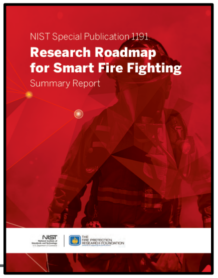


Smart Fire Fighting Using Robotics

AGENDA

- **1) Review of Smart Fire Fighting Basics**
- **2) Realizing the Vision: “CPS Smart FF” Scenarios**
- **3) The Research Roadmap for Smart FF**
- **4) Overview of Robotics**
- **5) Next Steps and Future Directions**

1) Review of Smart Fire Fighting Basics



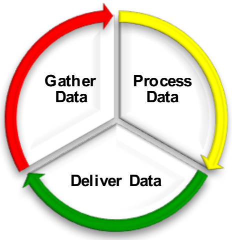
Key Concepts

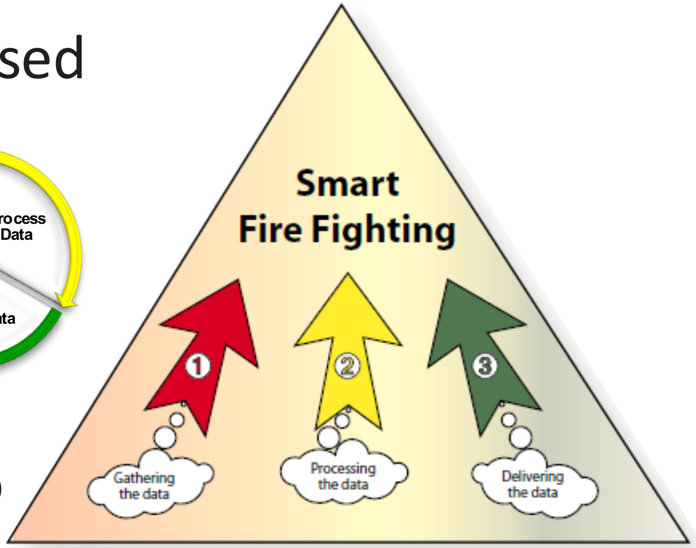
SMART : Specific, Measurable, Attainable, Relevant and Timely

CPS : *Cyber Physical Systems*

- World of Cyber Physical Systems composed of three basic areas:

1) Gathering of **Data** (Communication)
2) Processing of **Data** (Computation)
3) Use of **Data** (Targeted Decision Making)

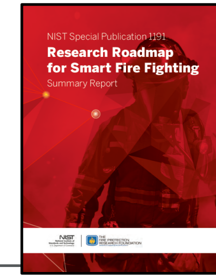




Focus Here: "CPS- Smart"

- Not to be confused with other efforts to introduce scientific approaches

1) Review of Smart Fire Fighting Basics



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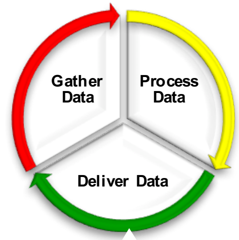
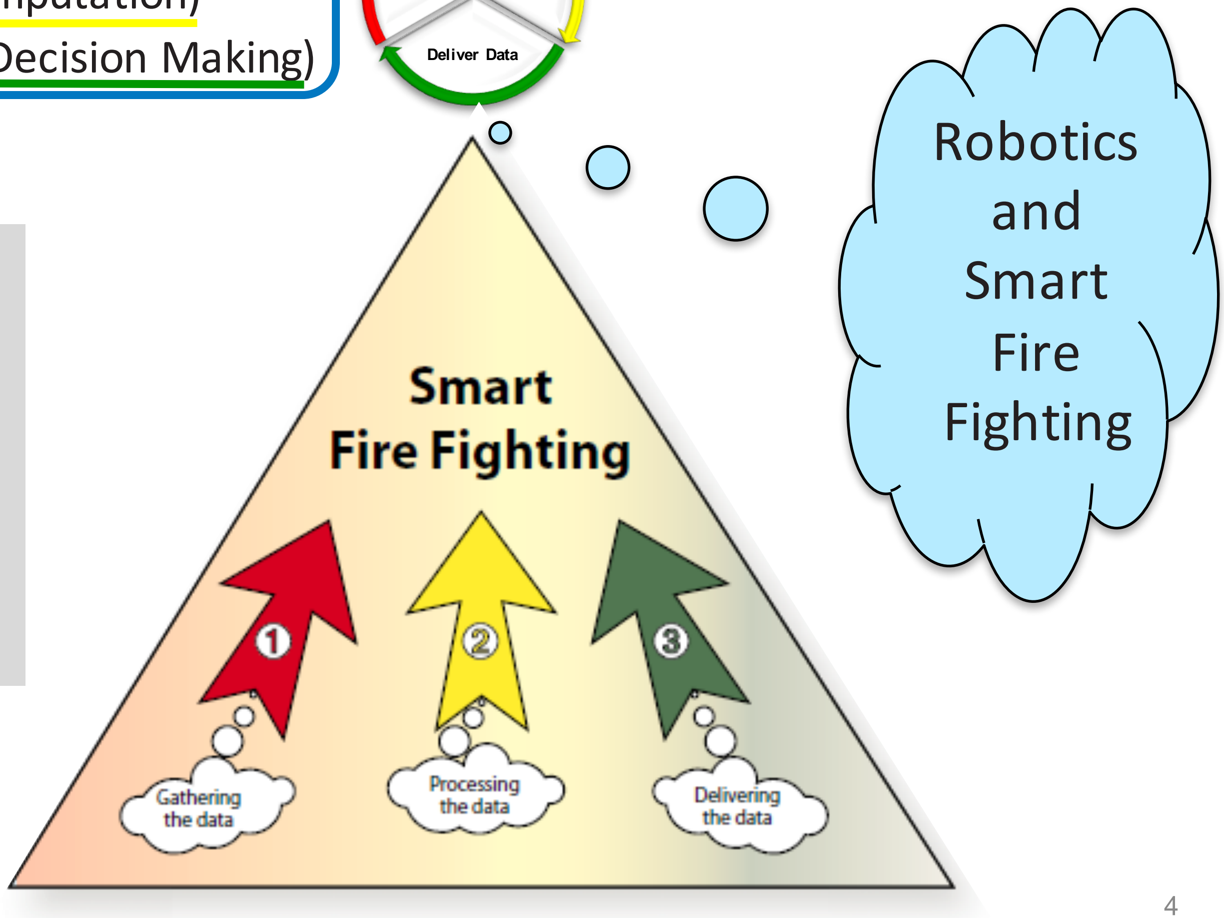
3) Use of **Data** (Targeted Decision Making)



Note: Terminology is evolving, for example…

- Aerial Robotics
- UAVs (Unmanned Aerial Vehicles)
- UASs (Unmanned Aerial Systems)
- Drones



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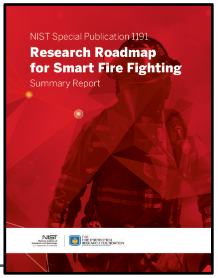
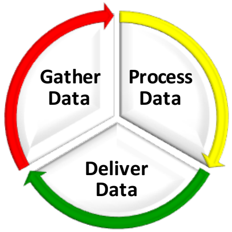
1) Review of Smart Fire Fighting Basics

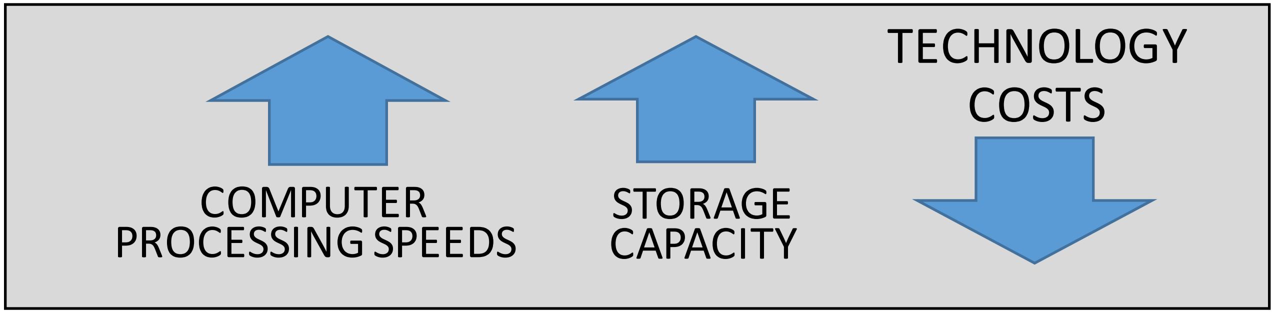


CPS: Cyber Physical Systems



Today's World --- Increasingly Sensor Rich

- Consider quote on use of data by Eric Schmidt, Google CEO 2010, at Googles' 2010 Atmosphere Convention, leading to much discussion, such as…
- "23 Exabytes of information was recorded & replicated in 2002. We now (2011) record and transfer that much information every 7 days" **- RJMetrics, The Data Point**



One Exabyte = 1 x 10^{18} Bytes

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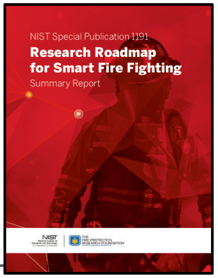
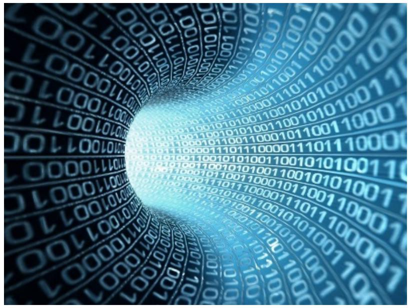
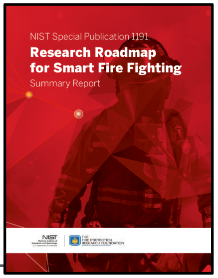


What is "Big Data"?

- Big data is not a new thing….the U.S. Bureau of Labor Statistics has been in effect since 1884.
- Big data is about the size of the problem, and distilling key insights from different forms of data.
- Key Characteristics:
  - Volume: Amount (e.g., Petabytes, Exabytes, Zettabytes, Yottabytes, etc.)
  - Variety: Type of content (e.g., numeric, GIS, text, voice, surveys, etc.)
  - Velocity: Speed at which data is generated/processed (e.g., real-time)
  - Veracity: Data quality and reliability



1) Review of Smart Fire Fighting Basics



WHAT DATA IS OF INTEREST TO EMERGENCY RESPONDERS?

EVERYTHING!

FOR EMERGENCY RESPONDERS, ALL DATA HAS VALUE. VIRTUALLY NOTHING IS EXCLUDED!

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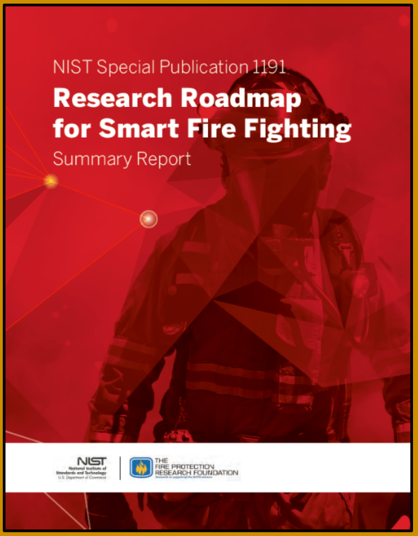

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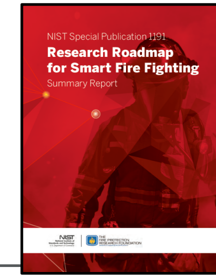
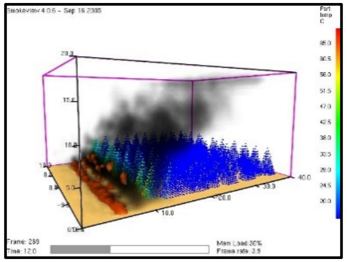
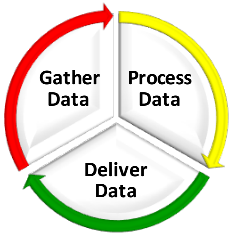
2) Realizing the Vision: "CPS Smart Fire Fighting Scenarios"

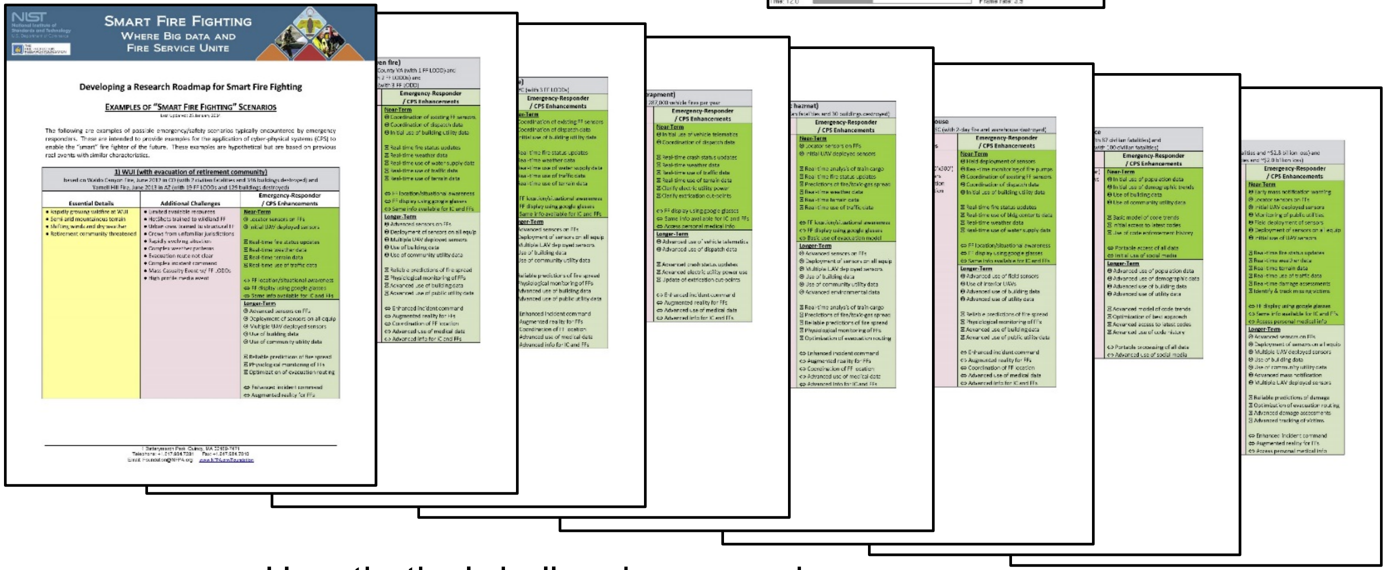


Ten Basic Fire Fighting Scenarios for CPS Application

1) WUI
2) Residential Fire
3) Hi-Rise Fire
4) Vehicle Extrication
5) Train Derailment (HazMat)
6) Hi-Challenge Warehouse
7) Illegal Nightclub
8) Tornado
9) EMS (Mass Casualty Event)
10) Elevator Rescue







- Hypothetical challenging scenarios
- Intent to inspire and promote insight
- Loosely based on real events

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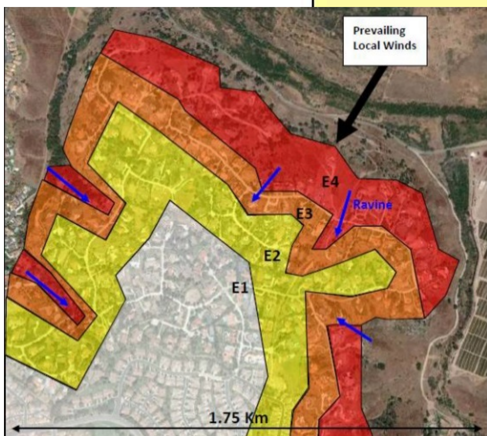
1) WUI (with evacuation of retirement community)

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)

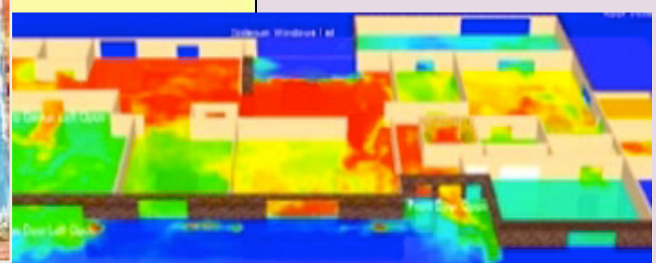
Essential Details	Additional Challenges	Emergency-Responder / CPS Enhancements
• Rapidly growing wildfire at WUI • Semi-arid mountainous terrain • Shifting winds and dry weather • Retirement community threatened	• Limited available resources • HotShots trained to wildland FF • Urban crew trained to structural 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	**Near-Term** Θ Locator sensors on FFs Θ 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
		Longer-Term Θ Advanced sensors on FFs Θ Deployment of sensors on all equip Θ Multiple UAV deployed sensors Θ Use of building data Θ 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



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)

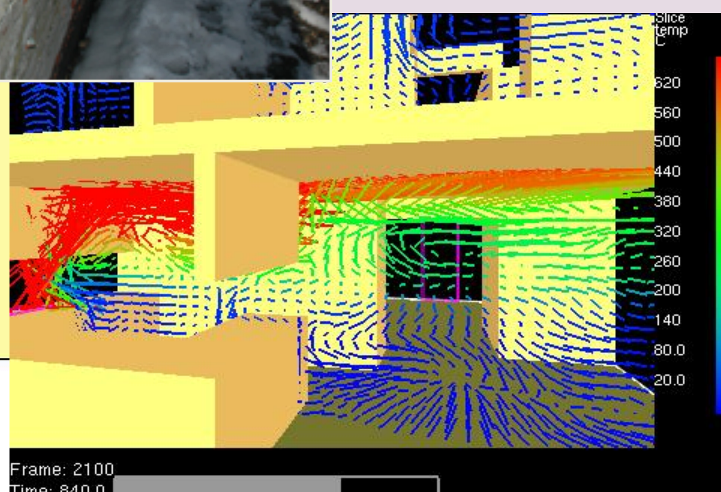
Essential Details	Additional Challenges	Emergency-Responder / CPS Enhancements
• Large modern single family home	• Fire at early morning hours	**Near-Term**
• Heavy synthetic fuel load	• Cars in driveway	Θ Coordination of existing FF sensors
• Open interior wood-frame building	• Location of occupants unknown	Θ Coordination of dispatch data
• Located on hillside: 1 to 3 stories	• Heavy fire on arrival	Θ Initial use of building utility data
• Fire starts externally from grill	• Rapid spread of fire to interior	Ξ Real-time fire status updates
• Fire spreads rapidly with high wind	• Initial search crews trapped	Ξ Real-time weather data
• Well staffed urban FD	• RIT implemented	Ξ Real-time use of water supply data
		Ξ Real-time use of traffic data
		Ξ Real-time use of terrain data
		⇔ FF location/situational awareness
		⇔ FF display using google glasses
		⇔ Same info available for IC and FFs
		Longer-Term
		Θ Advanced sensors on FFs
		Θ Deployment of sensors on all equip
		Θ Multiple UAV deployed sensors
		Θ Use of building data
		Θ Use of community utility data
		Ξ Reliable predictions of fire spread
		Ξ Physiological monitoring of FFs
		Ξ Advanced use of building data
		Ξ 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)

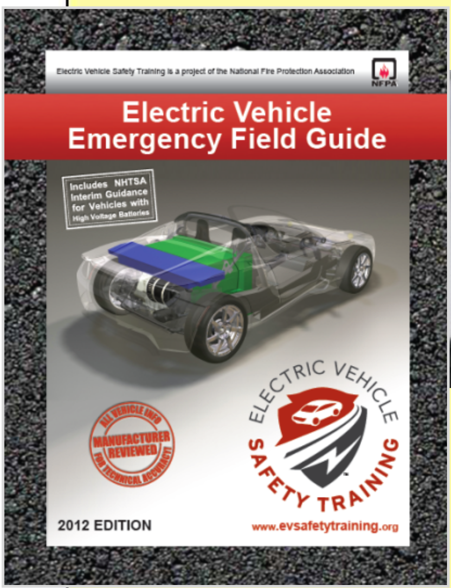
Essential Details	Additional Challenges	Emergency-Responder / CPS Enhancements
● 15 story brick apartment ● Building approximately 40 years old ● Unit on 12th floor fully involved ● High wind conditions ● Fire on up-wind side of building ● FD well-staffed metro department	● Most occupants are elderly ● Occupants trapped in rooms ● During FF windows break ● Fire rapidly intensities ● Wheelchair occupants on fire floor ● Wheelchair occupants elsewhere	**Near-Term** Θ Coordination of existing FF sensors Θ Coordination of dispatch data Θ Initial use of building utility data Ξ Real-time fire status updates Ξ Real-time weather data Ξ Real-time use of water supply data Ξ Real-time use of traffic data Ξ Real-time use of terrain data ⇔ FF location/situational awareness ⇔ FF display using google glasses ⇔ Same info available for IC and FFs
		Longer-Term Θ Advanced sensors on FFs Θ Deployment of sensors on all equip Θ Multiple UAV deployed sensors Θ Use of building data Θ Use of community utility data Ξ Reliable predictions of fire spread Ξ Physiological monitoring of FFs Ξ Advanced use of building data Ξ 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

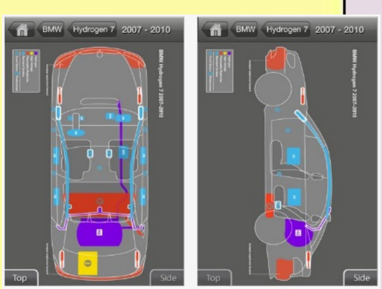


4) Vehicle Crash (ICEV and EV with entrapment)

based on NFPA statistics of U.S., with 17 vehicle fire per hour and 287,000 vehicle fires per year

Essential Details	Additional Challenges	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	**Near-Term** Θ Initial use of vehicle telematics Θ Coordination of dispatch data Ξ Real-time crash status updates Ξ Real-time weather data Ξ Real-time use of traffic data Ξ Real-time use of terrain data Ξ Clarify electric utility power Ξ Clarify extrication cut-points ⇔ FF display using google glasses ⇔ Same info available for IC and FFs ⇔ Access personal medical info
		Longer-Term Θ Advanced use of vehicle telematics Θ Advanced use of dispatch data Ξ Advanced crash status updates Ξ Advanced electric utility power use Ξ 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)

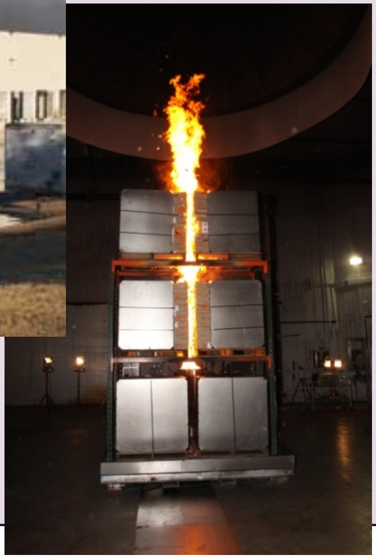
based on Lac-Mégantic Train Derailment, June 2012 in Quebec (with 47 civilian fatalities and 30 buildings destroyed)

Essential Details	Additional Challenges	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>** Θ Locator sensors on FFs Θ Initial UAV deployed sensors Ξ Real-time analysis of train cargo Ξ Real-time fire status updates Ξ Predictions of fire/toxic-gas spread 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 ⇔ Basic use of evacuation model
		<u>Longer-Term</u> Θ Advanced sensors on FFs Θ Deployment of sensors on all equip Θ Multiple UAV deployed sensors Θ Use of building data Θ Use of community utility data Θ Advanced environmental data Ξ Real-time analysis of train cargo Ξ Predictions of fire/toxic-gas spread Ξ Reliable predictions of fire spread Ξ Physiological monitoring of FFs Ξ 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	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	**<u>Near-Term</u>** Θ Field deployment of sensors Θ Real-time monitoring of fire pumps Θ Coordination of existing FF sensors Θ Coordination of dispatch data Θ Initial use of building utility data Ξ Real-time fire status updates Ξ Real-time use of bldg contents data Ξ Real-time weather data Ξ Real-time use of water supply data ⇔ FF location/situational awareness ⇔ FF display using google glasses ⇔ Same info available for IC and FFs
		<u>Longer-Term</u> Θ Advanced use of field sensors Θ Use of interior UAVs Θ Advanced use of building data Θ Advanced use of utility data Ξ Reliable predictions of fire spread Ξ Physiological monitoring of FFs Ξ Advanced use of building data Ξ 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	Emergency-Responder / CPS Enhancements
• Large influx of refugee population	• Refugees ignore authority (via fear)	**Near-Term**
• Closed illegal dance clubs 3 times	• Not understanding of building laws	Θ Initial use of population data
• Each time illegally opens elsewhere	• Lack of appreciation for safety	Θ Initial use of demographic trends
• Different people involved	• Mass Casualty Event	Θ Use of building data
• Inner neighborhood in major city	• High profile media event	Θ Use of community utility data
		Ξ Basic model of code trends
		Ξ Initial access to latest codes
		Ξ Use of code enforcement history
		⇔ Portable access of all data
		⇔ Initial use of social media
		Longer-Term
		Θ Advanced use of population data
		Θ Advanced use of demographic data
		Θ Advanced use of building data
		Θ Advanced use of utility data
		Ξ Advanced model of code trends
		Ξ Optimization of best approach
		Ξ Advanced access to latest codes
		Ξ Advanced use of code history
		⇔ 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	Emergency-Responder / CPS Enhancements
● F-4 Tornado strikes mid-sized city	● Hits residential area	**Near-Term**
● Occurs at 3 am	● Directly hits hospital	Θ Early mass notification warning
● Well staffed FD	● Little warning	Θ Locator sensors on FFs
	● Damage significant	Θ Initial UAV deployed sensors
	● Mass Casualty Event	Θ Monitoring of public utilities
	● High profile media event	Θ Field deployment of sensors
		Θ Deployment of sensors on all equip
		Θ Initial use of UAV sensors
		Ξ Real-time fire status updates
		Ξ Real-time weather data
		Ξ Real-time terrain data
		Ξ Real-time use of traffic data
		Ξ Real-time damage assessments
		Ξ Identify & track missing victims
		⇔ FF display using google glasses
		⇔ Same info available for IC and FFs
		⇔ Access personal medical info
		Longer-Term
		Θ Advanced sensors on FFs
		Θ Deployment of sensors on all equip
		Θ Multiple UAV deployed sensors
		Θ Use of building data
		Θ Use of community utility data
		Θ Advanced mass notification
		Θ Multiple UAV deployed sensors
		Ξ Reliable predictions of damage
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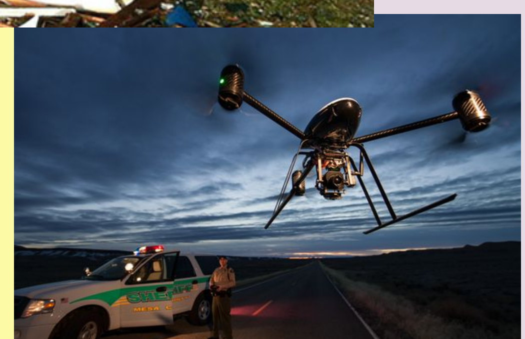
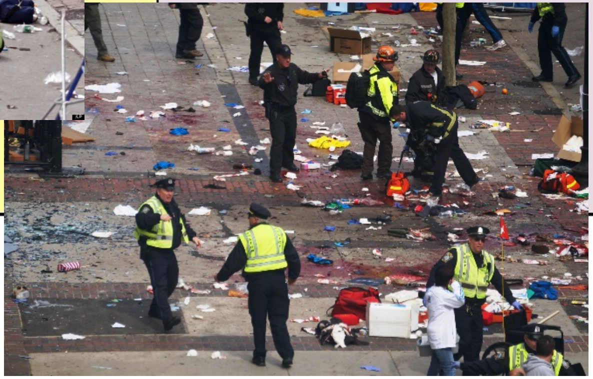


9) Terrorist Bombing (Large Scale EMS Event) based on Boston Marathon Bombing, April 2013 in Boston (with 3 civilian fatalities, 260+ injuries)		
Essential Details	**Additional Challenges**	**Possible Emergency-Responder / CPS Enhancements**
● Two separate IED (improvised explosive device) events in 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** Θ Early mass notification warning Θ Coordination of dispatch data Θ Coordination with security Θ Coordination of data for triage Ξ Processing of triage victims Ξ Coordination of resources Ξ Real-time use of traffic data Ξ Real-time use of crowd data Ξ Identification of investigative data ⇔ Portable access of all data ⇔ Initial use of social media
		Longer-Term Θ Advanced sensors on FFs Θ Deployment of sensors on all equip Θ Advanced use of dispatch data Ξ Advanced use of dispatch data Ξ Optimization of best approach Ξ Advanced processing of victims Ξ 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>** Θ Deployment of sensors on all equip Θ Advanced incident tracking Θ Use of building data Θ Use of community utility data Ξ Real time power outage updates Ξ Coordination of resources ⇔ Portable access of all data ⇔ Initial use of social media
		<u>Longer-Term</u> Θ Advanced sensors on FFs Θ Deployment of sensors on all equip Θ Advanced use of dispatch data Θ Advanced use of building data Θ Advanced use of utility data Ξ Advanced use of dispatch data Ξ Optimization of best approach Ξ Advanced use of building data Ξ Advanced use of public utility data ⇔ Portable processing of all data ⇔ Advanced use of social media

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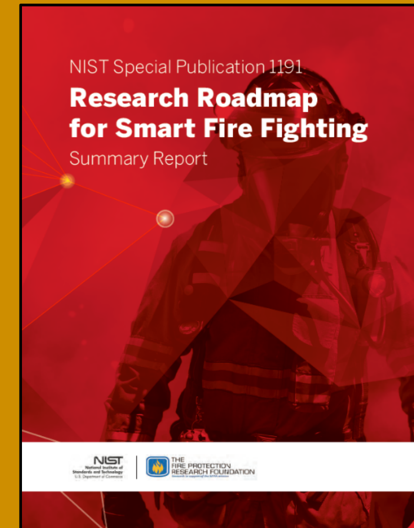

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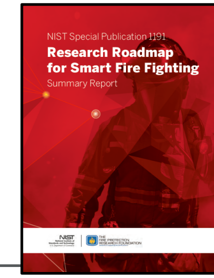

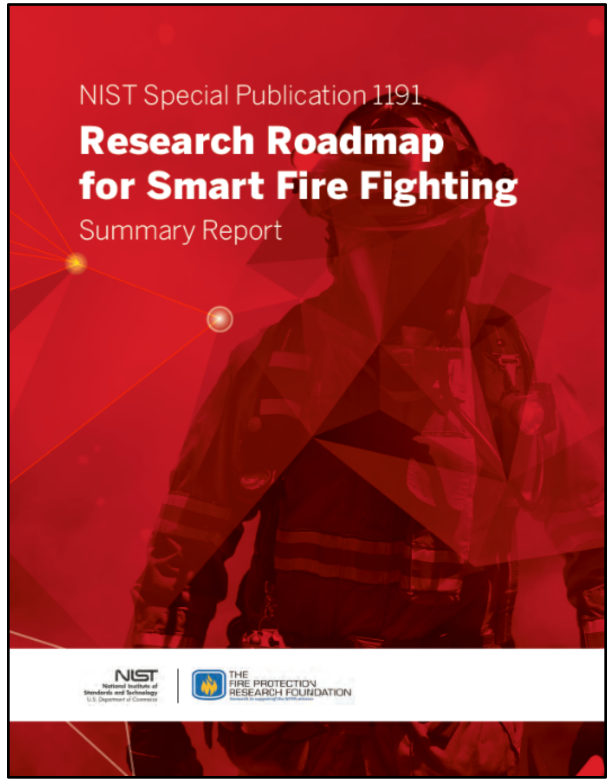

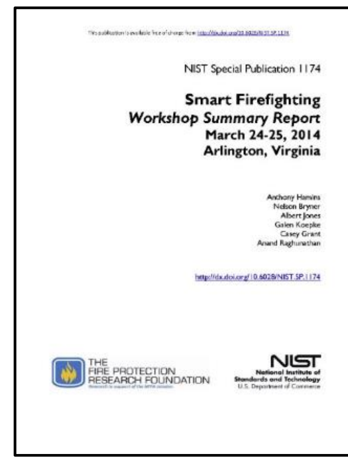

Project Report available on the Foundation website

www.nfpa.org/SmartFireFighting

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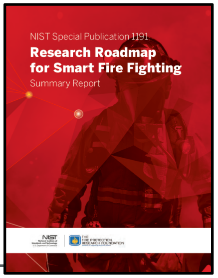
3) The Research Roadmap for Smart FF



Project Scope:

- All Activities Handled by the Fire Service
- All Fire Service Tasks
  - i.e., Consistent with NFPA Pro-Qual Standards
- All Types of Events
  - Structural, Wildland, Special Ops, etc.
- All Stages of Events
  - Pre-Event, During Event, Post-Event, etc.

Project funded by
National Institute of Standards and Technology
NIST

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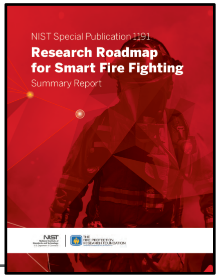
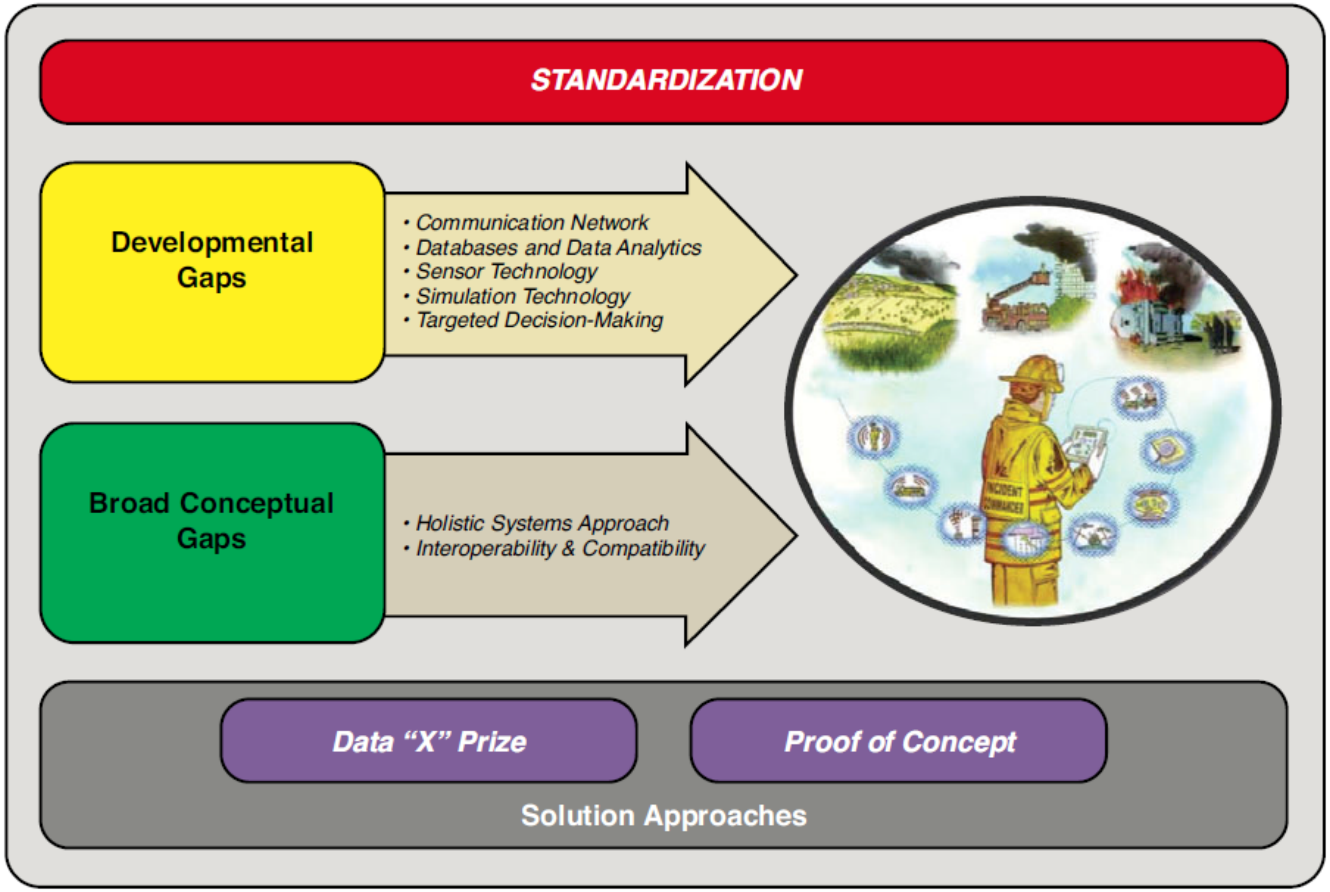
3) The Research Roadmap for Smart FF



Research Priorities for CPS Smart Fire Fighting



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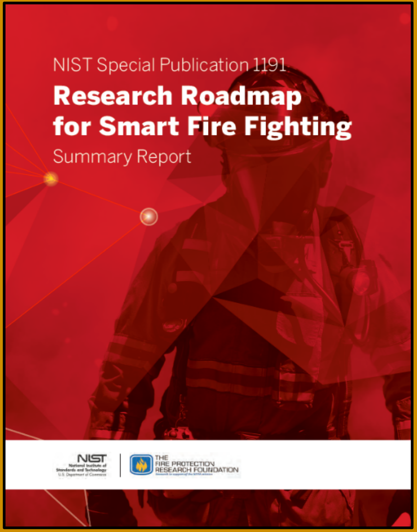

Smart Fire Fighting Using Robotics

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- 1) Review of Smart Fire Fighting Basics
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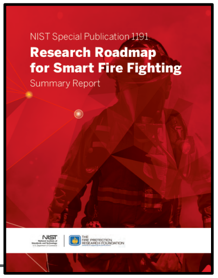
4) Overview of Robotics



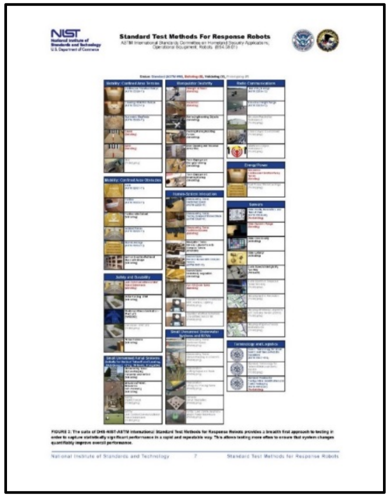

Standard Test Methods For Response Robots

Guide for Evaluating, Purchasing, and Training with Response Robots Using DHS-NIST-ASTM International Standard Test Methods

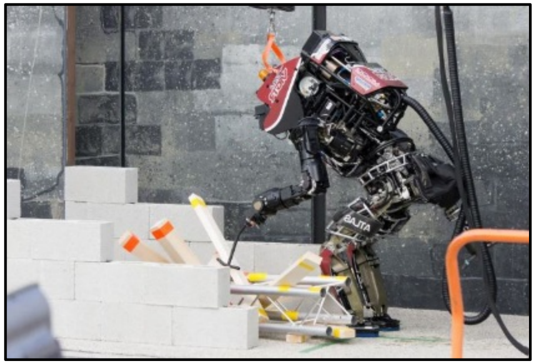
Office of Standards, Science and Technology Directorate, U.S. Department of Homeland Security

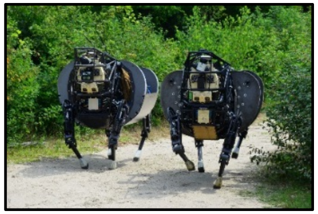
Intelligent Systems Division, Engineering Laboratory, National Institute of Standards and Technology

Adam Jacoff


Standard Test Methods For Response Robots


A robot struts its stuff at the recent DARPA Robotics Challenge.





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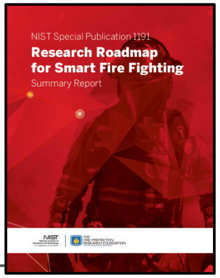
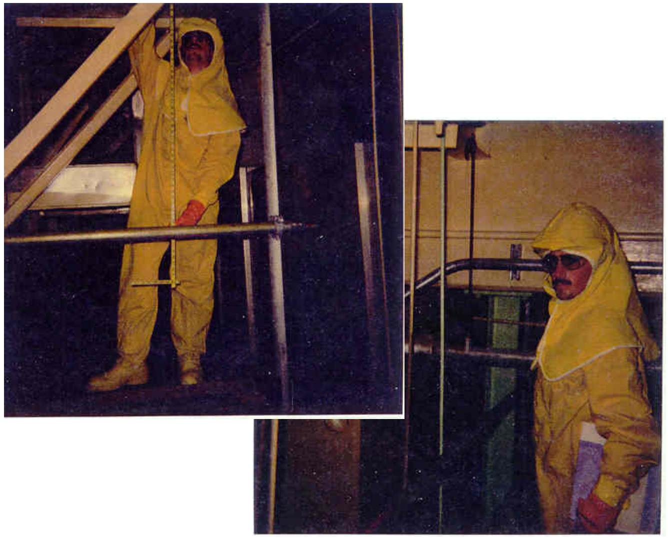
4) Overview of Robotics



Example of Robotics with Specific Focused Task

- *Doffing of PPE (Emergency Responder) and PCs (Nuclear)*
- *Example: Project by Northeastern University on "doffing" of contaminated gear*



INSPECTION OF FUKUSHIMA DAIICHI NUCLEAR POWER PLANT

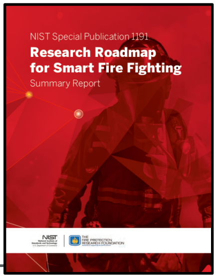
IMAGE CAPTURE FOLLOWING NEPAL EARTHQUAKE

INSPECTION OF FIRE GROUND TO ASSIST FIREFIGHTERS

WILDFIRE OBSERVATION

UNDERWATER SEARCH, RESCUE, + RECOVERY

4) Overview of Robotics



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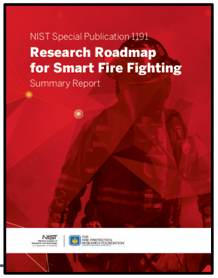
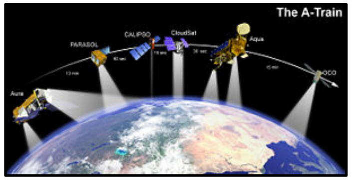
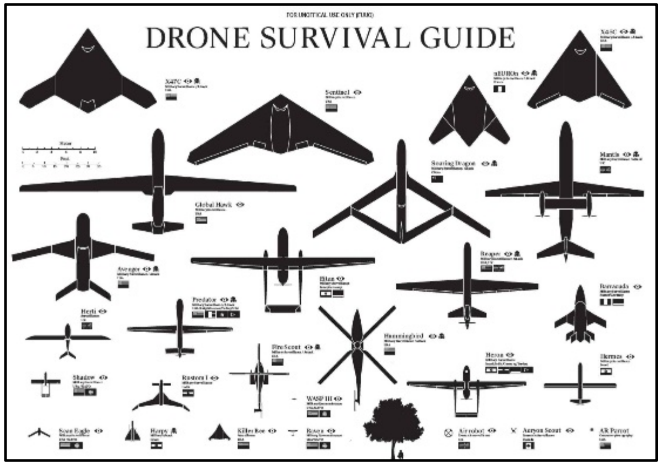
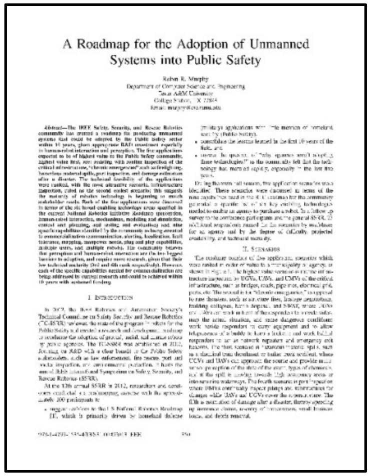
4) Overview of Robotics

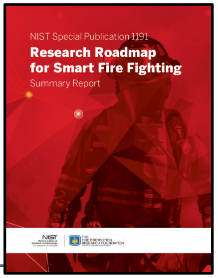


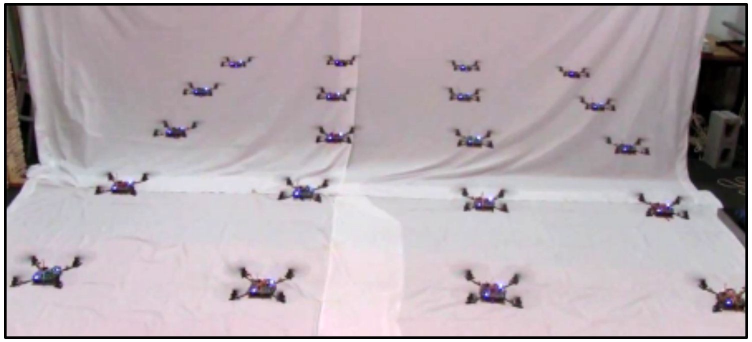


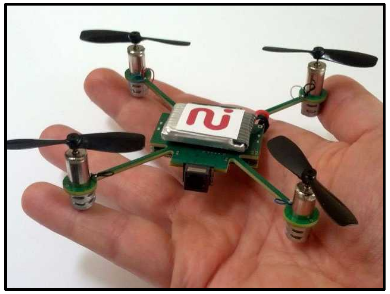


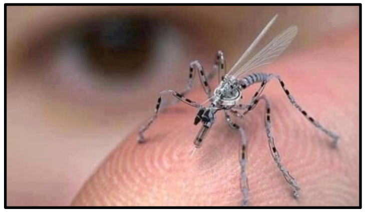

A Roadmap for the Adoption of Unmanned Systems into Public Safety

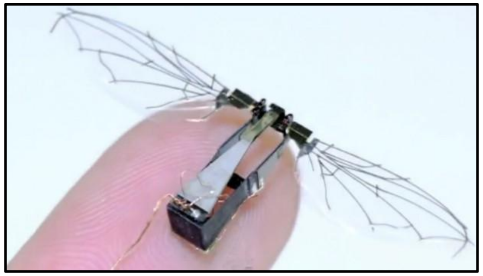
4) Overview of Robotics











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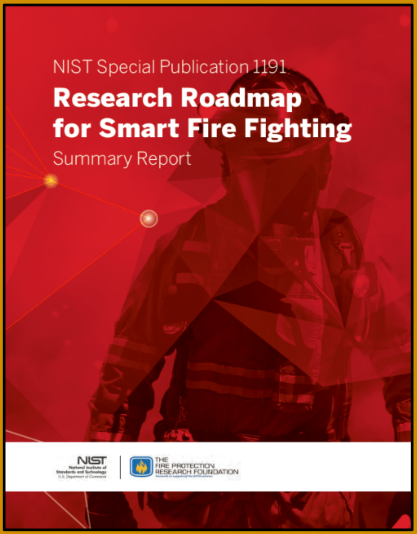

Smart Fire Fighting Using Robotics

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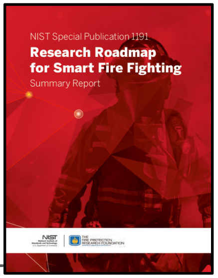
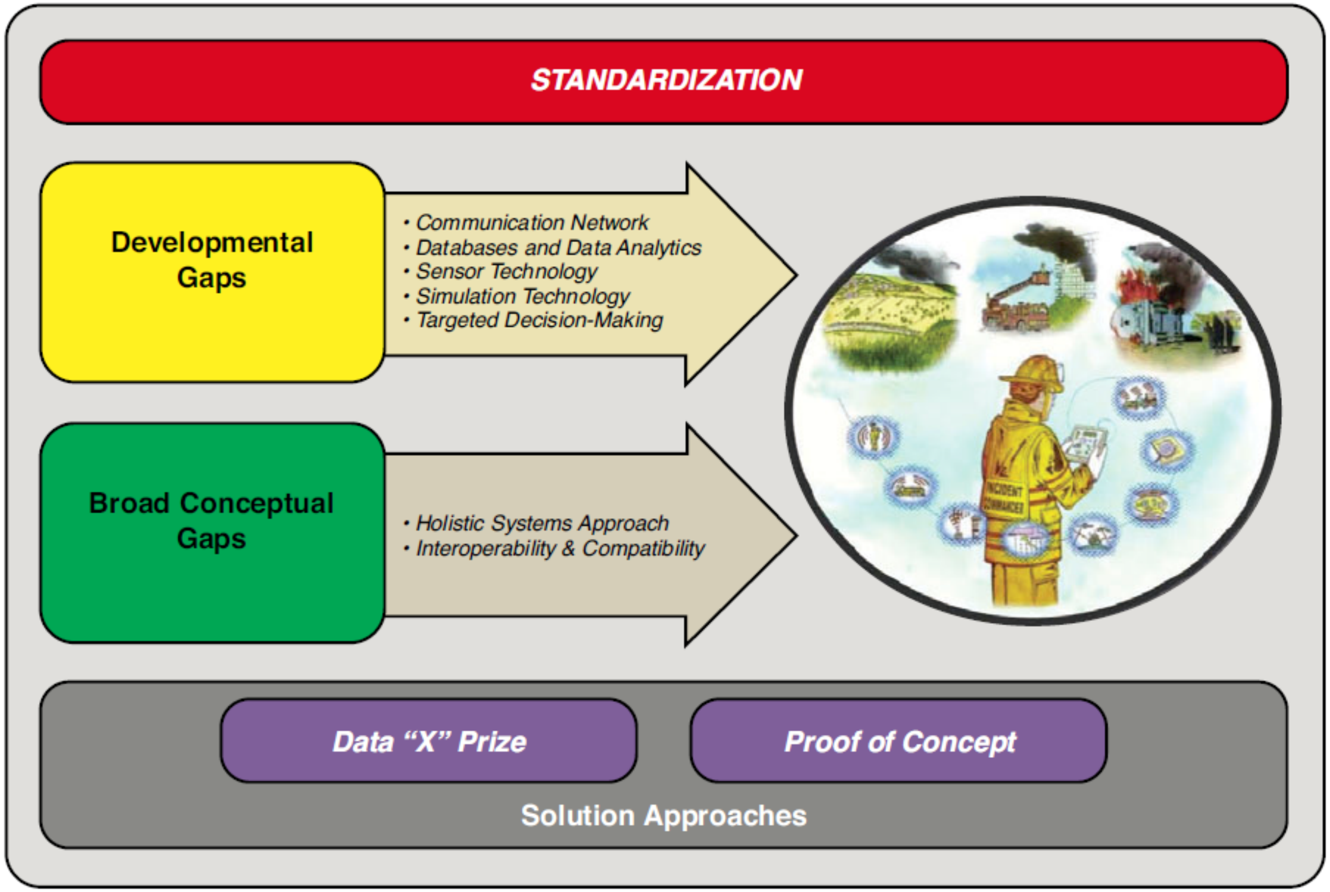


[Research Priorities for CPS Smart Fire Fighting]



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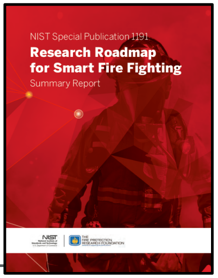
5) Next Steps and Future Direction



- ***Example of Research Priorities for Mobile Sensors***
  - ***Robotics***

Area	Research Priorities	Barriers	Impacts of Success
Portable equipment	1. Define data needs from portable equipment to enhance incident command (driven from incident command – not equipment) 2. Develop and test communication protocol for high-priority equipment	1. Incident command needs	1. More robust incident command decisions based on more and better data
Land-based vehicles	1. Driver health monitoring 2. Crash avoidance 3. Sensors, communication and control between 'end of hose' and pump control and related functions	1. Data communications and cost 2. Cost	1. Fewer deaths and injuries on firefighters and other emergency responders in route to incidents 2. Same as 1. 3. More immediate response of water needs at the nozzle – better pump control
Air and water craft			
Unmanned vehicles	1. Autonomous / swarming UAVs 2. Resilient sensor platforms for harsh environments 3. Robust mobile communications technology	1. FAA – autonomous navigation – environmental resilience – monitoring, command and control systems – cost 2. Cost	1. Fewer fire ground deaths and injuries
Robotics	1. Autonomous / swarming robots 2. Walking, grasping, human-like robots 3. Resilient sensor platforms for harsh environments 4. Robust mobile communications technology	1. Autonomous navigation – environmental resilience – monitoring, command and control systems – cost 2. Fine motor controls – cost 3. Cost	1. Fewer fire ground deaths and injuries
Remote data communications	1. Developing reliable and interoperable radio links for data exchanges		1. High reliability and high availability of Smart fire fighting distributed Cyber Physical System.
Application architectures	1. Developing Sensor services ontologies 2. Developing middleware to support ecosystem of apps developers	1. Industry alignment 2. Bootstrapping	1. Supplier diversity and innovative and feature rich applications that enable Smart fire fighting

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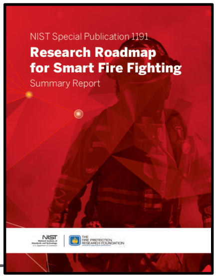
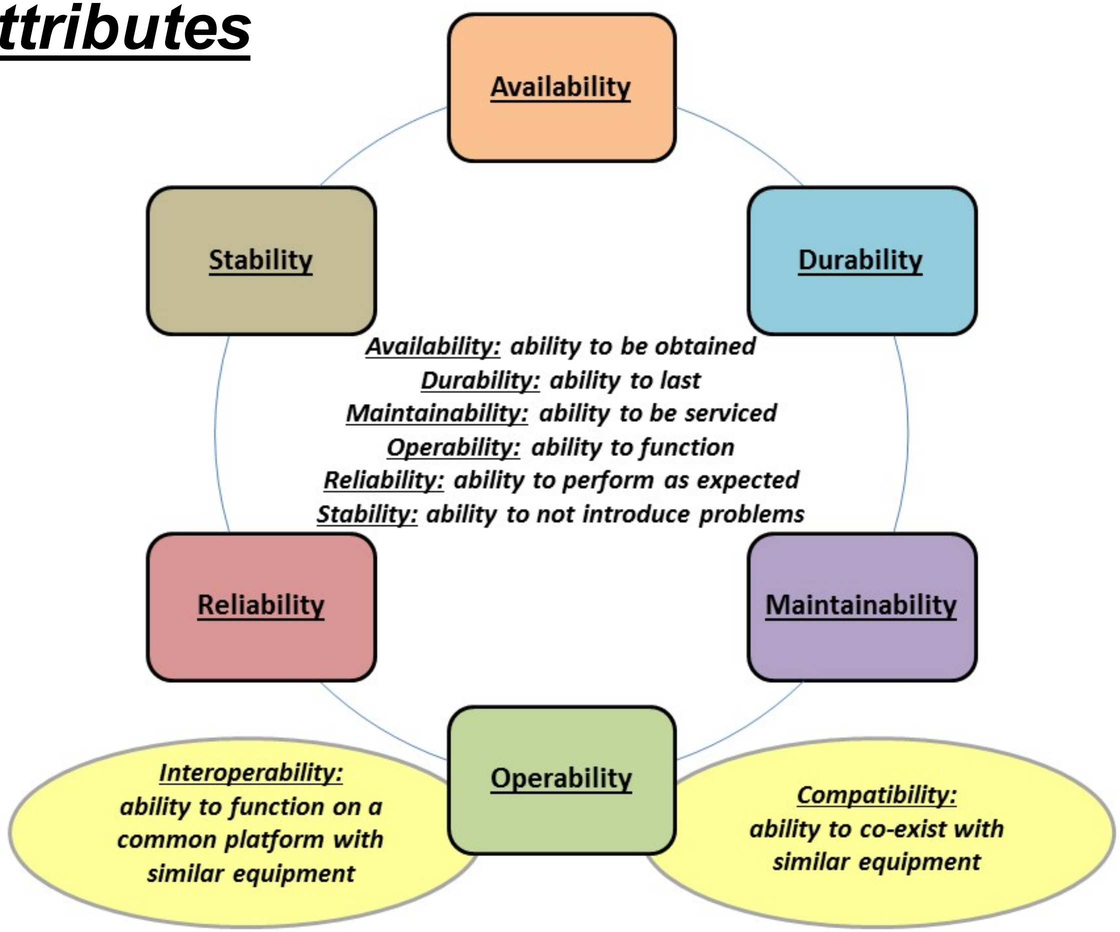
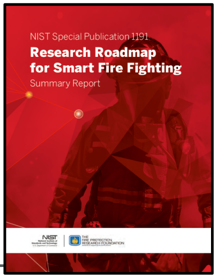
5) Next Steps and Future Direction



- ***Example of Performance Requirements***
  - ***Component Attributes***



5) Next Steps and Future Direction

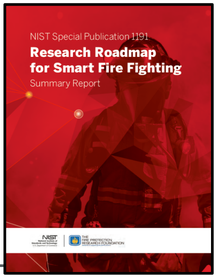


Related Activities and Outreach

- *Example of Related NFPA Standards Activity:*
  - NFPA 801: *Standard for Fire Protection for Facilities Handling Radioactive Materials*
  - NFPA 805: *Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants*
  - NFPA 950: *Standard for Data Development & Exchange for the Fire Service*

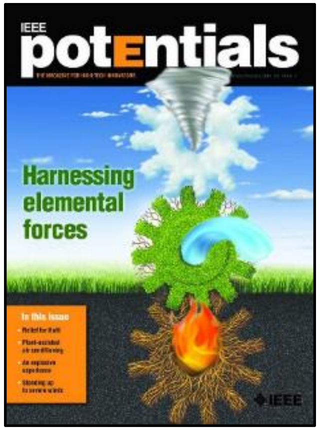
- *Example of Other Related Standards Activity: ISO 37120*
  - ISO 37120: Sustainable Development of Communities (Chap 10)
- *Example of Related other Activity: Smart America*
  - A White House Presidential Innovation Fellow project, bringing together research in CPS by combining test-beds, projects and activities.
- *Example of Related other Activity: Global Cities Team Challenge*
  - A NIST effort to involving collaborative project teams addressing innovative applications of IoT technologies in a smart city environment.
- *Example: "Smart Home Summit" (hosted by FPRF)*
  - 20-21 October 2015; Palo Alto, CA
- *Example: "Smart Enforcement Workshop" (hosted by FPRF)*
  - 19 November 2015; Tempe,

5) Next Steps and Future Direction

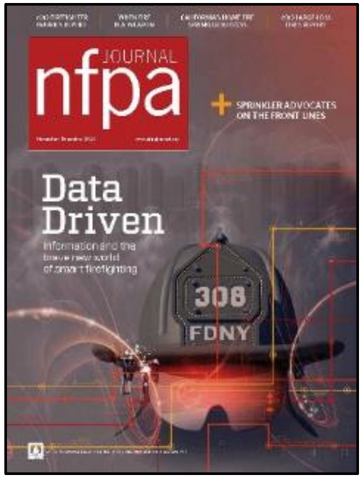


Examples of targeted outreach relating to CPS-Smart Fire Fighting

(demonstrating the broad diversity of the involved constituents)

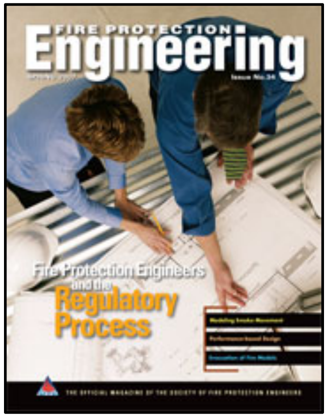


IEEE Membership



NFPA Membership

NFPA Membership



SFPE Membership

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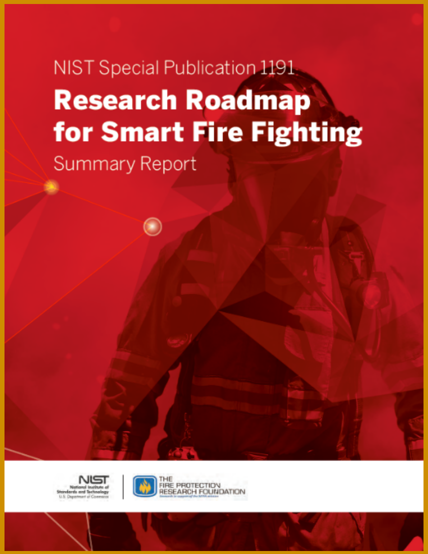

<u>Contact Information:</u>

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Phone: 01-617-984-7284   Email: cgrant@nfpa.org

FPRF Website: www.nfpa.org/Foundation

Smart FF Website: www.nfpa.org/SmartFireFighting