Homeland Defense & Security
Information Analysis Center

2018 State of the Art Report:

Department of Defense Considerations for Disaster Response

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HDIAC Overview

What is the Homeland Defense & Security Information Analysis Center (HDIAC)?

One of three Department of Defense Information Analysis Centers

Responsible for acquiring, analyzing, and disseminating relevant scientific and technical information, in each of its eight focus areas, in support of the DoD and U.S. government R&D activities

HDIAC's Mission

Our mission is to be the go-to R&D/S&T and RDT&E leader within the homeland defense and security (HDS) community, by providing timely and relevant information, superior technical solutions, and quality products to the DoD and HDS Communities of Interest/Communities of Practice.

State of the Art Reports

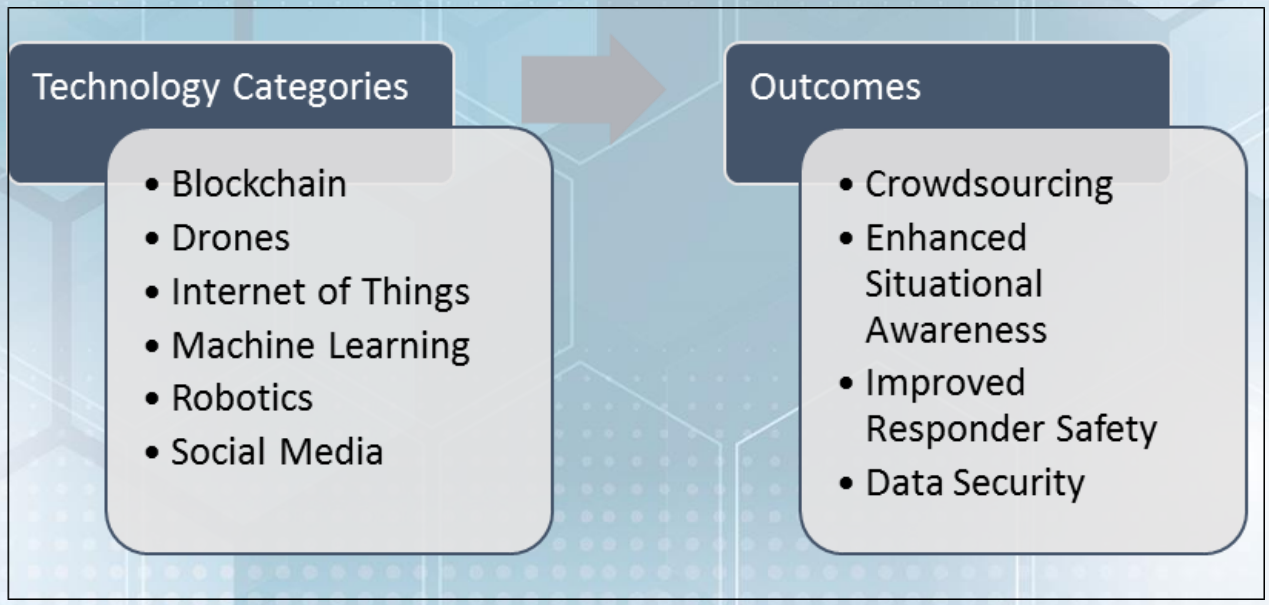
- **The Homeland Defense & Security Information Analysis Center (HDIAC) develops annual State of the Art Reports (SOARs) on scientific and technical topics that are highly relevant to the Department of Defense (DoD).**
- **Methodology: we paired original research conducted at the HDIAC Basic Center of Operations (BCO) with expert elicitation from outside Subject Matter Experts (SMEs) to choose individual chapter topics**
- **Authors include researchers from private industry, academia, national laboratories, and independent consultants**

Why Disaster Response?

- 2017 was an unprecedented year for disasters
- The most recent *National Security Strategy* (2017) highlights disaster response as critical to homeland defense
- Since 2011, DoD has provided assistance for several significant disasters
- The concept and practice of disaster response aligns with at least five of HDIAC's focus areas

Themes in the Report

This report highlights six areas of technology likely to have an outsized effect on the current state and future practice of disaster response.



Outline / Areas Covered

This report addresses six areas in which scientific and technical (S&T) research and development (R&D) are most likely to intersect with improving disaster response practices relevant to DoD and defending the homeland

- **Communications management**
  - Risk and crisis communications
  - Social media technologies
- **Data management**
- **Responder protection**
- **Search and rescue (SAR) technologies**
- **Supply chain management**
- **Radiation emergencies**

Risk and Crisis Communication – Theories

"The goal of risk and crisis communication is to keep the public informed about the status of an event may adversely affect the public."

The foundation of risk communication is centered on four theories

Risk Communication Summary [1]		
Theory	Effect	Solution
Risk perception	Frustration and outrage	Recognize and respond to risk communication factors
Mental noise	Blocks communication	Use clear, concise messages and active listening
Negative dominance	Distorts communication	Develop positive messages
Trust determination	Enhances or detracts from the message	Show that you care

1. Covello, V. T., & Milligan, P. A. (2002). Risk communication—principles, tools, & techniques. United States Nuclear Regulatory Commission Center for Risk Communication.

Risk and Crisis Communication – Execution

Goals in Risk and Crisis Communication

- Planning and Development
- Developing Trust and Credibility
- Minimizing Communication Issues during a Crisis

Risk Communication Lifecycle

DoD's strategic communication process involves:

(a) Disseminating timely, accurate, and coordinated information

(b) Delivering DoD messages

(c) Ensuring stakeholder involvement

Social Media Technologies – Overview

"Social media are forms of electronic communication (such as websites for social networking and microblogging) through which users create online communities to share information and other content."

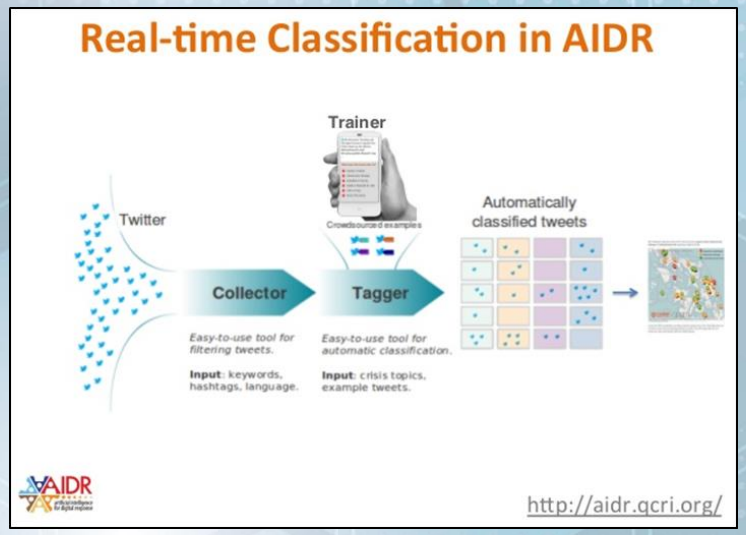
The Evolution of Social Media and Disaster Response

- 2005 – Hurricane Katrina (little to no role)
- 2007 – Virginia Tech mass shooting (played an important role)
- 2012 – Hurricane Sandy (breakthrough)

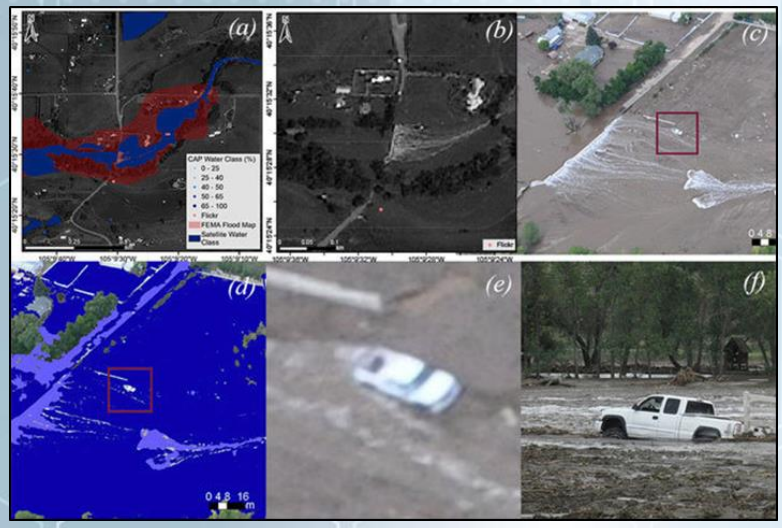
Major challenge – countering/preventing false information

Social Media Technologies – Emerging Trends

Emerging trends involving artificial intelligence, internet of things, and blockchain



AIDR Real-Time Classification Process[1]



Identifying flooded areas with remote sensing and data from Twitter and Flickr[2]

1. Artificial Intelligence for Disaster Response (n.d.). Retrieved from http://aidr.qcri.org/
2. Cervone, G., Sava, E., Huang, Q., Schnebele, E., Harrison, J., & Waters, N. (2016) Using Twitter for tasking remote-sensing data collection and damage assessment: 2013 Boulder flood case study. *International Journal of Remote Sensing, 37*(1), 100–124. doi:10.1080/01431161.2015.1117684

Data Management – Foundation

Five primary types of data most commonly applied in disaster response activities

- **Traditional sensors**
  Application of semantic tools and technologies to create a semi-autonomous data processing framework
- **Data exhaust**
  Identify useful data sources from data exhaust proactively and address the challenges to obtain the information before an incident or event occurs
- **Online or social media activity**
  Natural Language Processing
- **Crowdsourcing**
  Increased processing demand and evaluating public participation
- **Public/government data**
  Familiarity with available datasets and how to process and query them

Data Management – Mitigating Overload

Machine Learning

- Twitter Dashboard for Disaster Response
- Low Resource Languages for Emergent Incidents (LORELEI) program
- California Polytechnic State University, San Luis Obispo – Earthquake structural damage

Crowd Computing

- Disappearance in 2014 of Malaysia Airlines Flight 370
- 2010 Haiti earthquake

Visual Analytics/Neo-geography

- Light Detection and Ranging (LiDAR)
- Incident & Crisis Management System (ICMS)
- COBRA™ Crisis Incident Mangement System (CIMS) solution
- XchangeCore

Responder Protection – Protective Clothing

Category	Current	Challenges	Future
Firefighting	• Modern turnout gear – three protective layers Gloves, footwear, helmets	• Balancing Thermal Protection and Heat Stress • Minimizing Firefighter Exposure to Products of Combustion	• New Materials to Increase Thermal Performance While Maintaining Breathability • Ensemble Designs to Minimize Exposure to Products of Combustion • Ensemble Cleaning • Ensemble Durability for Increased Laundering • Ensemble Issuance
Special Operations	• Rugged single-layer flame-resistant textile products • Foot protection normally consists of neoprene water booties, sneakers, a nonslip boot, or swim fins	• Lack of selection for gear designed specifically for SAR missions • Garment convertibility	• Garment convertibility
Hazardous Materials/CBRN Threats	• NFPA 1991 (2016 ed.) • NFPA 1992 (2018 ed.) • NFPA 1992 (2012 ed.) • NFPA 1994 (2012 ed.) • NFPA 1994 (2018 ed.)	• Current Level A/NFPA 1991 Products are Design-limited • Limited Visibility • Operational Utility of Gloves • Current Level A/NFPA 1991 Products are Over-Protective • Service Life Issues • Storage Life Issues	• Form-fitting Gloves • Balancing Protection with Comfort • Non-Encapsulating Vapor-Protective Ensemble Designs

Responder Protection – Heat Stress Management

Current products

- Pre-cooling: cooling vests, arm immersion, water-perfused suits, heliox, and ice slushy
- Operational cooling: ice phase change, non-ice phase change, liquid cooled, water immersion, evaporative, or hybrid systems
- Physiological Status Monitoring: most common products used are from Hidalgo and Zephyr

Challenges

- Inconsistent technical data
- Technologies focus on cooling skin

Future Directions

- Product Standard Development
- Non-Invasive Measures of Core Temperature
- Effects of Chronic Heat Exposure
- Heat Stress and Toxicology
- Hydration Status Monitoring
- Heat Stress Calculators and Estimating Work-Rest Cycles
- Physiological Monitoring and Work-Rest Cycles

Responder Protection – Respiratory Protection

Current Products

- Avon Protection Systems Deltair (300027, 300028, 300029, and 300030)
- Draeger Safety UK PSSS5000/PSS7000 Series and PSS7000H series
- Honeywell Safety Products (Sperian Respiratory) Titan
- Interspiro, Inc. Spiromatic S8
- MSA Safety FireHawk M7 XT Air Mask and G1 SCBA
- Scott Health & Safety, Inc. Air Pak 2013 CBRN, Air Pak X3 CBRN, and NxG7 CBRN

Challenges

- Breathing Rates
- Mask Interoperability
- Fire-Hardened Designs

Future Directions

- Combination Unit Respirators
- Manual and Automated Switching Mechanisms
- Low-Profile SCBA Cylinder Design

Search and Rescue Technology – Currently Available

Communications

- DARPA Spectrum Collaboration Challenge
- AT&T's First Responder Network Authority (FirstNet)
- Mesh networks

Crowdsourcing

- Facebook's Crisis Response and Safety Check
- Crisis Mappers Net
- Ushahidi

Unmanned Aerial and Ground Systems

- Oshkosh Defense's TerraMax
- QinetiQ North America and Milrem Robotics' Titan

Search and Rescue Technology – Emerging Tech

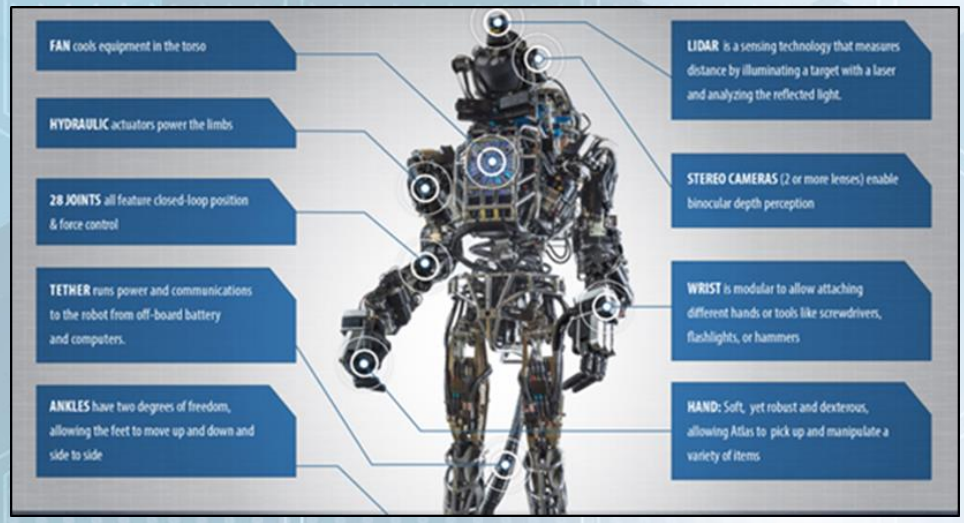
Artificial Intelligence and Machine Learning

Virtual Reality/Augmented Reality

Wearable Technology

Robotics

- RoboCup Federation Rescue Robot League
- 2015 DARPA Robotics Challenge
- DARPA SHort-Range Independent Microrobotic Platforms (SHRIMP)



Overview of functions of the Atlas disaster response robot[1]

1. Defense Advanced Research Projects Agency. (2013, December 19). DRC Trials 2013 countdown: Anatomy of a disaster-response robot. Retrieved from https://www.darpa.mil/news-events/2013-12-19

Supply Chain Management (Logistics) – Basics

Supply Chain Management (SCM) in disaster response is different from routine SCM, for three reasons:

- Uncertainty of the system
- Supply good types
- Structure of the system

Three essential challenges in SCM

- Facility location problem - finding the best facility locations to satisfy a goal
- Goods transportation problem - best transportation plan to transfer disaster response materiel (goods) from supply nodes to demand nodes with a detailed vehicle routing and scheduling plan
- Inventory management problem - refers to inventory replenishment needs over the entire planning horizon

Primary methodologies in SCM

- Mathematical programming
- Simulation
- Probability theory and statistics
- Fuzzy programming
- Social science

Supply Chain Management – Future Research

Four key perspectives

- Emerging technologies and methodologies
- Future disaster relief issues that might concern government organizations
- Upcoming challenges in future responses
- Cooperation and communication of agencies

Radiation / Nuclear Emergencies – Intro

"Rad/Nuc responses, DoD has the following assets available within its CBRN Response Enterprise"

- Command and Control CBRN Response Elements
- Defense CBRN Response Force
- National Guard Teams
- Medical Radio-Biology Advisory Teams
- CBRN Military Advisory Teams

- **A nuclear (Nuc) emergency involves only those events that begin with a nuclear weapon detonation**
- **A radiological (Rad) emergency includes all incidents with radioactive material that do not begin with a nuclear detonation**

Radiation / Nuclear Emergencies – Response

Emergency Response

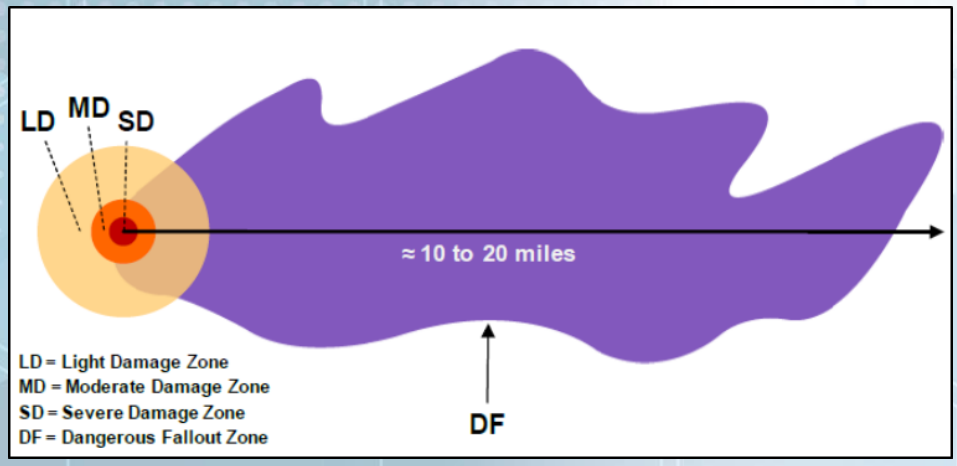
- Zoned response
- Responder Protection
- Emergency Responder Health Monitoring and Surveillance System
- Planning Guide for Protecting Responders following a Nuclear Detonation
- Planning Guidance for Response to a Nuclear Detonation

Decision Making

- Radiological Operations Support Specialist
- FirstNet
- RadResponder

Future Directions

- DARPA SIGMA Program



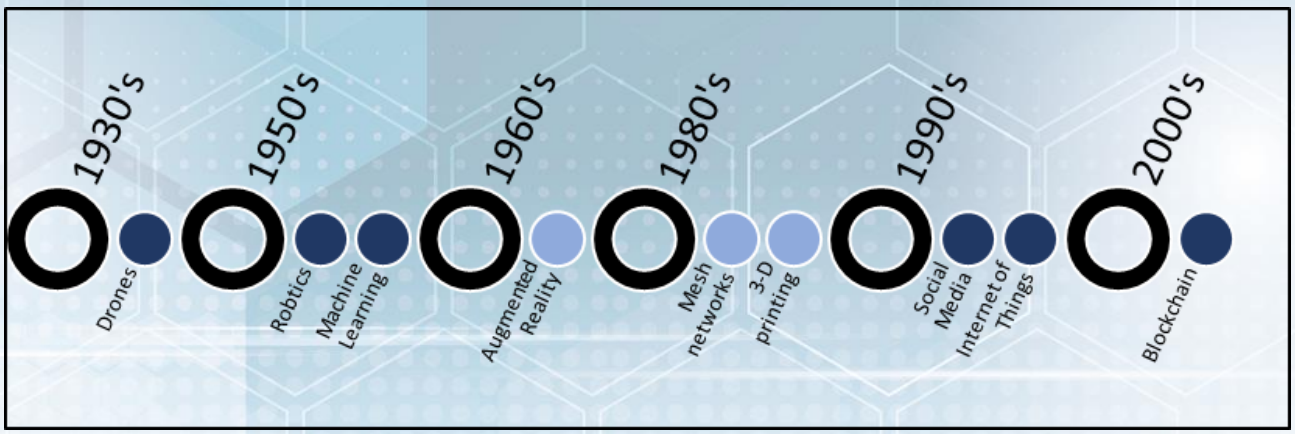
Damage and Fallout Zones[1]

1. National Security Council led Domestic Readiness Group. (2016). Health and Safety Planning Guide for Protecting Responders Following a Nuclear Detonation. Retrieved from https://www.dhs.gov/sites/default/files/publications/IND%20Health%20Safety%20Planners%20Guide%20Final.pdf. [Accessed 30 March 2018].

Looking Forward

Five technical trends in disaster response are likely to grow in importance over the next three to five years

- **Continued advancement of the technologies discussed in this report**
- **Implementation of "next wave" technology**
- **Technological convergence**
- **Overlap of functions**
- **Rising emphasis on the primacy of first responders**



HDIAC Services

Technical Inquiry Service

- HDIAC provides up to 4 free hours of information services:
  - Literature searches
  - Document/bibliography requests
  - Analysis within our eight focus areas – Alternative Energy, Biometrics, CBRN Defense, Critical Infrastructure Protection, Cultural Studies, Homeland Defense and Security, Medical, Weapons of Mass Destruction

Core Analysis Task (CAT)

- Challenging technical problems requiring more than 4 hours of research can be solved by initiating a CAT:
  - Pre-competed and pre-awarded
  - Work can begin on a project approximately two months after the statement of work has been approved
  - Cap of $500,000
  - Must be completed within 12 months

HDIAC Subject Matter Experts

HDIAC Subject Matter Expert (SME) Network

HDIAC SMEs are experts in their field(s), and, typically, have been published in technical journals and publications.

SMEs are involved in a variety of HDIAC activities

- Authoring HDIAC Journal articles
- Answering HDIAC Technical Inquiries
- Engaging in active discussions in the HDIAC community
- Assisting with HDIAC Core Analysis Tasks
- Presenting webinars

If you are interested in applying to become a SME, please visit HDIAC.org or email info@hdiac.org.

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