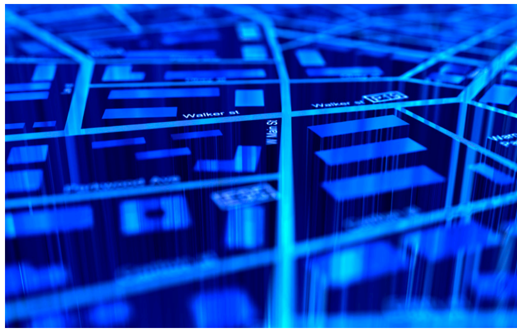

The International Forum to Advance First Responder Innovation

Statement of Objectives (SOO) for Technologies Related to: “The ability to conduct on-scene operations remotely without endangering responders”

October 2019

International Forum to Advance
FIRST RESPONDER INNOVATION

Homeland Security

Science and Technology

Sponsorship:

Effort sponsored in whole or in part by the Department of Homeland Security (DHS) Science and Technology Directorate (S&T) and the Air Force Research Laboratory (AFRL), under Memorandum of Understanding/Partnership Intermediary Agreement No. FA8650-09-3-9400. The U.S. government is authorized to reproduce and distribute reprints for governmental purposes notwithstanding any copyright notation thereon.

International Forum to Advance
FIRST RESPONDER INNOVATION

Endorsement:

This document has been checked for accuracy by the International Forum to Advance First Responder Innovation (IFAFRI) and accords with its aim to inform and guide industry and provide unbiased information on first responder technologies.

International Forum to Advance
FIRST RESPONDER INNOVATION

Statement of Objectives (SOO) for Technologies Related to: **"The ability to conduct on-scene operations remotely without endangering responders"**

Background

The International Forum to Advance First Responder Innovation (IFAFRI) is an organization of international government leaders from 13 countries and the European Commission, focused on enhancing and expanding the development of new technology for first responders worldwide.[1] IFAFRI does this by:

1. Working with the global first responder community to define a list of common, high priority capability gaps;
2. Providing a platform for international collaboration on innovative research and development (R&D) initiatives and solutions;
3. Characterizing global first responder markets to inform and guide industry and academia to develop and produce innovative technology solutions at affordable prices; and
4. Providing information about relevant and available first responder technologies to the first responder community.

To arrive at a set of *Common Global Capability Gaps*, IFAFRI members conducted analyses of first responder capability gaps in their respective countries. IFAFRI then assessed those gaps to identify those that were common across multiple member nations. The gaps with the highest commonality amongst member nations were presented to all IFAFRI members for consensus. IFAFRI has reached consensus on ten first responder capability gaps:

[1] For the purpose of this document, the term "first responder" refers to those individuals who, in the early stages of an incident, are responsible for the protection and preservation of life, property, evidence and the environment, including fire service, law enforcement and emergency medical services.

The ability to know the location of responders and their proximity to risks and hazards in real time
The ability to detect, monitor, and analyze passive and active threats and hazards at incident scenes in real time
The ability to rapidly identify hazardous agents and contaminants
The ability to incorporate information from multiple and nontraditional sources into incident command operations
The ability to maintain interoperable communications with responders in any environmental conditions
The ability to obtain critical information remotely about the extent, perimeter, or interior of the incident
The ability to conduct on-scene operations remotely without endangering responders
The ability to monitor the physiological signs of emergency responders
The ability to create actionable intelligence based on data and information from multiple sources
The ability to provide appropriate and advanced personal protective equipment (i.e., garments, gear, and breathing apparatus)

To arrive at this set of *Common Global Capability Gaps*, IFAFRI members conducted analyses of first responder capability gaps in their respective countries. IFAFRI then assessed those gaps to identify those that were common across multiple member nations. The gaps with the highest commonality amongst member nations were presented to all IFAFRI members for consensus.

IFAFRI is publishing this Statement of Objectives (SOO) to provide a technical overview of the global first responder need and direct researchers who may be interested in pursuing development of a solution. IFAFRI will assist with facilitating interactions between first responders and organizations pursuing development toward this capability gap. This particular SOO is focused on:

"The ability to conduct on-scene operations remotely without endangering responders"

The missions that emergency responders perform can place them at risk of bodily harm. Many line of duty injuries and deaths occur because they must perform tasks in hazardous environments. Suppression of wildfires, neutralizing explosive devices, and responding to hazardous materials (HAZMAT) incidents are examples of tasks that can be particularly unsafe. The focus of this capability gap is to identify solutions that can execute emergency response tasks while responders remain at a safe distance. A current example is the use of explosive ordnance disposal (EOD) robots to examine and defuse explosive devices. The operator is able to direct the EOD robot from a safe distance via a controller. Should the device detonate, it is only the robot that is destroyed and the operator remains safe. Responders are interested in the development of tools or systems that will perform other tasks that can endanger responders.

This gap is distinct from another gap, “the ability to obtain critical information remotely about the extent, perimeter, or interior of the incident,” which focuses on the ability to obtain and maintain real-time, continuous surveillance of the incident scene. It is possible that similar platforms (e.g., unmanned vehicles) may be used to address both gaps, however, the focus of this Statement of Objectives document is on the execution of tasks. This capability gap calls attention to the need to expand current remotely-operated systems for additional hazardous response missions.

General Description of Operational Capability

There are multiple tasks that can be directed from a safe distance to improve the health and safety of emergency responders. Responders would like solutions that are able to do the following:

- Perform gross motor tasks (e.g., lifting, pushing, pulling);
- Perform missions in hazardous atmospheres;
- Perform missions in locations that are difficult for humans to reach; and
- Perform intricate tasks (e.g., drum opening).

Addressing this capability gap may involve multiple types of systems. If the potential solution is mobile, responders are interested in systems that they can control from a hand-held unit or a virtual reality headset. Components may include a fine-motor manipulator, capacity for heavy labor tasks, threat disruptors, or other payloads. Such solutions should be able to navigate multiple and varied environments. However, addressing this gap may also include fixed installations or sensor-activated systems. The growth of Internet of things (IoT) devices provides significant opportunity to address this gap.

Responders would like the ability to view the tasks being performed by the systems. Depending on task, autonomous execution or operator controlled execution may be appropriate. Example tasks that may be addressed with a remote system include search and rescue, hazardous materials (HAZMAT) operations, fire suppression, communications support, and tactical operations. Responders would prefer multi-purpose platforms when possible.

Existing First Responder Capabilities

Current capabilities to perform on-scene operations remotely include:

- Unmanned ground systems (UGS) (e.g., tactical robots)
- Unmanned marine systems (UMS) (e.g., water rescue)
- Unmanned aircraft systems (UAS)
- Fixed systems (e.g.. fire suppression, entry control)
- Automated fire suppression monitors

Some of the systems listed above have a significant price tag and may not be affordable to many agencies. The financial cost of a small ground-based reconnaissance robot exceeds $15,000 USD while an EOD robot can exceed $100,000 USD.

Operational Environment

The following list provides examples of operating conditions that *may* be encountered by first responders on a daily basis. It is not an all-inclusive list, but is intended to illustrate the diversity of conditions in which responders operate.

- Single and multi-level buildings;
- Structures of varied construction materials (e.g., steel, concrete, wood frame, masonry, synthetic materials);
- Collapsed or threatened buildings;
- Confined spaces;
- Subterranean and underground facilities;
- Wooded areas with dense vegetation;
- Rugged outdoor terrain;
- Areas with limited or no cellular and/or radio connectivity;
- Extreme high and low temperatures and humidity;
- Wet conditions (e.g., rain, flooding);
- Thermal radiation [2];
- Direct flame contact or exposure;
- Excessively noisy and smoky conditions in outdoor, indoor and/or subterranean areas;
- Vast expanse of incident scene (i.e., lack of line-of-sight between commanders and deployed personnel);
- Underwater and maritime environments;
- Chemical, biological, and radiological hazards (e.g., corrosives, infectious diseases); and
- Human threats (e.g., active shooter, knife attacker).

Target Objectives

1. Provide mission-appropriate capability to remotely carry out emergency response tasks to improve responder safety;
2. Operate in hazardous conditions; and
3. Operate in a beyond line-of-sight capability.

The following section provides responder-identified requirements for potential solutions. It is understood that not all requirements may be currently technically feasible. Responders would prefer incremental, continuous advancement of solutions instead of waiting for equipment that meets all of the requirements at the same time. As such, these requirements do not represent a minimum set of requirements that must be met before new tools, devices, platforms or systems can be released. Further, the potential missions that may be supported remotely are varied. As such, the requirements listed below are mission-dependent.

[2] Thermal radiation, one of three methods of heat transfer, causes increase in temperature from electromagnetic waves. Thermal radiation can cause flashover within a room, causing all contents to raise to their ignition temperature and engulf the room from floor to ceiling. Thermal radiation can also increase the temperature of firefighter garments, damaging the gear and causing potential harm to the responder.

Platform Requirements[3]

Systems that remotely perform emergency response tasks may include unmanned ground, maritime and aerial systems. Responders need these systems in a variety of sizes and configurations dependent on mission. It is not intended that one system is able to meet all of the following requirements. Potential solutions should:

- Carry mission-appropriate payloads (e.g., an arm with hose attachments):
    - Fine motor manipulator;
    - Gross motor tools;
    - Camera/surveillance systems (e.g., electro-optical, infrared, thermal imaging)
    - Threat, hazard, and biometric sensors;
    - Lighting;
    - Communications equipment (e.g., microphones, repeaters);
    - Medical transport and/or treatment equipment;
    - Tools for neutralizing threats/targets;
- Be able to transport associated equipment and supplies;
- Pose low risk for operators, responders, and civilians;
- Deploy within 20 minutes;
- Be able to be deployed and operated by 2 or less persons;
- Be able to move payload in excess of 150 kilograms (e.g., person, equipment);
- Be able to be controlled remotely;
- Be controlled intuitively (e.g., hand-held operator control unit, heads up display);
- Provide optional secondary monitors for viewing by others beyond controller;
- Be able to navigate around threats, hazards, and obstacles;
- Navigate without becoming a hazard to others (e.g., deconflicting air space) ;
- Be able to neutralize threats (e.g., water disruptor);
- Operate in covert or overt/highly visible mode;
- Be able to operate multiple systems in a networked configuration;
- Provide one- or two-way audio and/or video systems (dependent on mission);
- Provide 1-4 hour operational endurance (dependent on mission);
- Ground systems:
    - Be able to right itself after tip over;
    - Be able to climb stairs and obstacles;
    - Be able to manipulate surroundings (e.g., open/close doors)
    - Provide an operational range of at least two kilometers;
- Maritime systems: operate on the surface and/or underwater;
- Aerial systems: provide minimum and maximum altitude parameters;
- Allow remote release of payload;
- Be resistant to interference with functionality;
- Allow manual or autonomous navigation;

[3] For the purposes of this SOO, the term “platform” is being used as a general descriptor of the hardware and/or software components of a system used to conduct remote operations.

- Detect targets or threats;
- Locate targets or threats;
- Identify targets or threats;
- Prevent actions that will damage or destroy the system (e.g., driving off a cliff) without authorization;
- Be able to record audio, video, sensor data;
- Provide real time geographic information system (GIS) waypoints;
- Automatically return to base at low power;
- Use a common hub or interface for sensors and imagers; and
- Be able to carry interchangeable payloads.

Transmission Requirements

Potential solutions should provide real-time transmission of mission data to controllers, command, and other intended destinations. Potential solutions should:

- Function in a communications-degraded environment:
    - Securely cache data intended for recipients when connection to a communication network cannot be made;
    - Securely transmit cached data to recipients when connection to a communications network is restored without affecting live data streaming;
- Encrypt data prior to transmission;
- Store data for post-incident analysis; and
- Allow for remote deletion of incident data.

Power Source Requirements

Potential solutions should use a non-proprietary power source that provides sufficient power to support the mission (variable by platform). Potential solutions should:

- Be powered using multiple sources including those on the incident scene and/or at operator/alternate site locations;
- Incorporate interchangeable battery systems;
- Incorporate power systems that can be safely and compliantly carried on commercial aircraft;
- Be able to replenish power supply using non-proprietary technology;
- Utilize an easy-to-replenish power source; and
- Be compatible with renewable or sustainable energy sources.

Compatibility Requirements

Potential solutions should integrate mission data with other response systems. Potential solutions should:

- Comply with exchange standards for data transmission;[4]
- Comply with appropriate regulations and guidelines;[5]
- Integrate with:
    - Responder geolocation systems;
    - Responder physiological monitoring systems; and
    - Existing digital street and terrain maps, blueprints and floorplans.

Maintenance Requirements

Potential solutions should be easy to operate, calibrate and maintain throughout the service life. Potential solutions should:

- Self-initialize in less than one minute;
- Be modular to allow for upgrade and replacement of components;
- Maintain backwards compatibility after upgrade;
- Be rated for a service life of no less than five years;
- Be designed to reduce the time to repair;
- Be designed to minimize skills needed for maintenance (e.g., calibration, cleaning);
- Perform automated malware detection and cybersecurity screening of software and firmware components;
- Allow for remote maintenance;
- Allow for remote upgrades;
- Provide live notification of a fault;
- Maintain a fault log; and
- Maintain an activity log.

Robustness Requirements

Potential solutions should operate within multiple environments (e.g., smoke, humidity, temperature extremes, precipitation). Potential solutions should:

- Aerial systems:
    - Be able to maintain an operationally-appropriate altitudes;
    - Be able to fly in 50 kilometers per hour (km/h) crosswinds;
- Be able to operate in hazardous (e.g., chemical, radiological) environments;

---

[4] Example: National Information Exchange Model (NIEM)

[5] Examples: United States Federal Aviation Administration (FAA) Small Unmanned Aircraft Rule 107 and Civil Aviation Authority (CAA), European Aviation Safety Agency (EASA)

- Operate at temperature ranges typical of international climate (e.g., -30 degrees C to 50 degrees C);[6,7]
- Operate at temperature ranges typical of response activities (e.g., -100 degrees C to 500 degrees C);[8,9]
- Be ruggedized;
- Resistant to effects of electromagnetic pulse (EMP);
- Function after immersion in water;[10]
- Function at humidity of 100%;
- Function properly after exposure for five minutes at a maximum thermal radiation threshold of 500 degrees C;
- Resist air pollutants, dust, smoke, ash and sand;[11]
- Match the laundry life of garment or textile if any components are integrated into garments or textiles;
- Have recyclable components;
- Be easy to decontaminate;[12]
- Be non-degradable due to wear or hazard;
- Not cause injury to the user if damaged; and
- Comply with existing federal and/or international standards and guidelines.

Cost Requirements

Potential solutions should be designed to minimize price of system, consumables, training, and maintenance. Potential solutions should be priced to be affordable to all response agencies and should be designed for daily use.

Additional Considerations

As in other research and development endeavors, additional considerations should be evaluated by organizations wishing to pursue innovation toward this gap:

- Detailed test and evaluation strategy for the viability of system(s);
- Transition strategy to guide the prototype(s) into commercialization;

---

[6] Average minimum temperature in Sweden was used to provide a minimum figure for international climate, https://www.weatheronline.co.uk/reports/climate/Sweden.htm

[7] Historic summer temperature in Phoenix, Arizona, was used to provide a maximum figure for international climate, http://www.12news.com/article/weather/heat/hottest-day-ever-122-and-other-cool-phoenix-is-really-hot-facts/448964915

[8] *NIST Technical Note 1474: Thermal Environment for Electronic Equipment Used by First Responders*, p. 7 http://ws680.nist.gov/publication/get_pdf.cfm?pub_id=101375

[9] First responder participants of the SOO Validation Meeting (January 23-25, 2018, in Stockholm, Sweden) stated that operations may involve temperatures of -100 degrees C to 500 degrees C.

[10] Refer to IP68 of IEC 60529: Degrees of Protection Provided by Enclosures, https://webstore.iec.ch/publication/2452

[11] Refer to IP68 of IEC 60529: Degrees of Protection Provided by Enclosures, https://webstore.iec.ch/publication/2452

[12] Refer to NFPA 1841: Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting, https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1851

- Specifications to guide the development of viable commercial system(s);
- Standards, guidelines, other legal requirements; and
- Stakeholder oversight/interaction, to ensure that the developed system meets the requirements identified by the first responder community.