



# The International Forum to Advance First Responder Innovation

Statement of Objectives (SOO) for Technologies Related to:  
“The ability to monitor the physiological signs of emergency responders”

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International Forum to Advance  
**FIRST RESPONDER INNOVATION**



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**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 monitor the physiological signs of emergency 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.<sup>1</sup> 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:

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<sup>1</sup> 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
<b>The ability to monitor the physiological signs of emergency responders</b>
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 monitor the physiological signs of emergency responders”**

The demands of emergency response can lead to physical and mental performance degradation, endangering individuals or teams of responders. Monitoring physiological (and cognitive) indicators may allow responders, medical personnel, and command to identify changes in health and performance.

Responders cannot operate at peak levels if physiological factors are outside of normal parameters. Responders want to be able to monitor physiological signs to identify when personnel are experiencing or are developing symptoms related to a medical issue or emergency. The ability to monitor responders’ vital signs would enable commanders to direct personnel to rehabilitation or medical stations before measurements reach critical levels.



Cognitive performance is affected by factors such as cardiovascular strain, psychological stress, thermal stress, and dehydration.<sup>2</sup> This is important because effective mental processing through attention, perception, memory, etc., is critical for assessing and responding to unfolding emergency events.<sup>3</sup> The ability to monitor cognitive performance can help to identify when responders are no longer able to complete their task or mission safely or effectively.

This capability exists in fields outside of public safety. From remote monitoring of astronauts in space to measurement of an athlete's vital signs, many of the requirements listed in the sections below are technologically feasible today. Despite expanding use of physiological sensors in other industries, responders do not currently monitor physiological signs in the field. This is primarily because commercial systems are not built to withstand the demands of the response environment. Yet, according to the National Fire Protection Association (NFPA), "overexertion/stress/medical" causes are the leading source of firefighter fatalities (53 percent).<sup>4</sup> While the percentage of law enforcement and emergency medical technician and paramedic deaths tied to medical causes is lower, responders in both disciplines regularly experience high levels of physical, physiological, and cognitive stress.<sup>5</sup>

### General Description of Operational Capability

Responders and their respective agencies would like a solution that monitors, analyzes, and alerts based on physiological, cognitive, and behavioral signs and indicators. Components may be attached to the body, personal protective equipment (PPE), or embedded in responder garments. The system should be able to compare measurements against the normal parameters for each responder (as appropriate). Some responders, for example, have a lower normal range for blood pressure or pulse. Data, analysis, and corresponding guidance should be transmitted in real time, as appropriate, to responders, on-scene supervisors, command staff, safety officers, and/or medical personnel. An alert should be generated when measurements are outside of the responder- or indicator-specific ranges or levels. Different alerts should be generated for the responder, medical staff, and command to avoid alarm overload. Physiological sensors should be integrated with other threat and hazard sensors to provide a comprehensive picture of responder health and safety. In addition, false negatives and positives can have a significant impact; these should be minimized to the lowest possible levels.

### Existing First Responder Capabilities

Current capabilities to monitor physiological signs include:

- Annual physicals;
- On-scene rehabilitation and wellness checks;

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<sup>2</sup> *Remote Physiological Health and Status Monitoring of First Responders: Promises, Practicalities, and Prospects*, Sanquist, TF, (Seattle: Pacific Northwest National Laboratory), February 2015, 5.

<https://nwrtpc.pnnl.gov/PDFs/RemotePhysiologicalHealthandStatusMonitoringofFirstRespondersR13.pdf>

<sup>3</sup> Ibid, 5.

<sup>4</sup> "Firefighter deaths by nature and cause of injury," NFPA, last updated: June 2018,

<https://www.nfpa.org/News-and-Research/Data-research-and-tools/Emergency-Responders/Firefighter-fatalities-in-the-United-States/Firefighter-deaths-by-cause-and-nature-of-injury>

<sup>5</sup> *Project Responder 5*, (Washington: Department of Homeland Security,) August 2017, 63-64.

[https://www.dhs.gov/sites/default/files/publications/Project-Responder-5-Report\\_170814-508.pdf](https://www.dhs.gov/sites/default/files/publications/Project-Responder-5-Report_170814-508.pdf)

- Distress signal units (e.g., Personal Alert Safety System (PASS), Automatic Distress Signal Unit (ADSU)); and
- Body-worn physiological/sport monitors (personal use) (e.g., Garmin, Fitbit).

## Operational Environment

The following list provides examples of operational environments that *may* be encountered by first responders on a daily basis. Tools and systems developed to address this capability gap should be able to be used during routine operations.

- 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;
- Thermal radiation<sup>6</sup>;
- Direct flame contact or exposure;
- Excessively noisy and smoky conditions in outdoor, indoor and/or subterranean areas;
- Lack of line-of-sight vision between commanders and deployed personnel; and
- Underwater and maritime environments.

## Target Objectives

1. Persistent measurement of responder physiological data to detect threats to responder (e.g., stroke, heart attack, rhabdomyolysis);
2. Assessment of data against responder-specific parameters;
3. Provision of operational and health-related guidance based on physiological data;
4. Integration of components into personal protective equipment (PPE) or garments.

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.

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<sup>6</sup> 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.

## Monitoring Requirements

Monitoring the physiological and cognitive signs and indicators of responders may significantly improve responder health and safety. Monitoring components should collect and assess measurement data to provide information that can be used to make decisions about physical and cognitive fitness for duty. Potential solutions should:

- Measure physiological signs (e.g., body temperature, heart rate, respiration rate);
- Assess signs of cognitive overload (e.g., perception of fatigue, reaction time, memory);
- Measure related incident-specific parameters (e.g., ambient temperature, atmospheric gas levels);
- Integrate with equipment data (e.g., self-contained breathing apparatus [SCBA] air tank levels, PASS/ADSU alarm status);
- Integrate with incident-specific threat and hazard data (e.g., sensor readings);
- Compare physiological data against individualized responder:
  - Measurements;
  - Patterns over time;
- Compare exposure data against responder-specific measurements;
- Produce outputs that can be used for triage;
- Include visualization of detailed data for medical staff and command;
- Integrate components into responder PPE or garments when feasible; and
- Include form factors for different operational needs.

## Alert Requirements

It is important for responders, medical personnel, and command to know when measurements and assessments are outside of specified ranges to identify when responders are no longer able to complete their task or mission safely or effectively. Potential solutions should:

- Generate automated alerts in multiple formats (e.g., audible, visible and tactile) when preset, responder-specific, or indicator-specific thresholds have been reached;
- Allow user (agency or responder) to configure alert rate and type;
- Generate user-appropriate alerts for responders, command, and other intended destinations (e.g., medical tent or center); and
- Allow minimal false positive alerts / false negative errors.

## Transmission Requirements

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

- Encrypt data prior to transmission;
- Transmit physiological and related data:
  - To intended destination;
  - In real time or when there is a sign-specific change (e.g., heart-rate increases at X% or exceeds responder parameters);
- Automate data routing, storage, and processing;

- 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; and
- Store physiological data for post-incident analysis in accordance with local policies.

### Power Source Requirements

Potential solutions should use a non-proprietary power source that provides sufficient power to support duration of monitoring. Potential solutions should:

- Provide endurance of no less than 12 hours (operational);
- Be powered using multiple sources including those on the incident scene;
- 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 physiological data with other response systems. Potential solutions should:

- Comply with exchange standards for data transmission;<sup>7</sup>
- Comply with medical privacy regulations and standards;<sup>8</sup>
- Integrate with:
  - Existing electronic incident command systems;
  - Existing incident documentation systems;
  - Responder geolocation systems;
  - Incident-specific hazard data from other responders (e.g., indication of pathogen exposure);
  - Electronic medical records; and
  - Existing platforms for visualization of data (e.g., smartphones, tablets, fitness wearables).

### 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;

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<sup>7</sup> Examples: National Information Exchange Model (NIEM) and OASIS Standards

<sup>8</sup> Examples: Health Insurance Portability and Accountability Act (HIPAA) and EU General Data Protection Regulation 2016-679



- Be designed to reduce the time to repair;
- Be designed to minimize skills needed for maintenance (e.g., calibration, cleaning);
- Perform automated periodic 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 a data access log.

## Robustness Requirements

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

- Operate at temperature ranges typical of international climate (e.g., -30 degrees C to 50 degrees C);<sup>9,10</sup>
- Operate at temperature ranges typical of response activities (e.g., -100 degrees C to 500 degrees C);<sup>11,12</sup>
- Be ruggedized;
- Resistant to effects of electromagnetic pulse (EMP);
- Function after immersion in water;<sup>13</sup>
- 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;<sup>14</sup>
- Match the laundry life of garment or textile if any components are integrated into garments or textiles;
- Have recyclable components;
- Be easy to decontaminate;<sup>15</sup>
- Be non-degradable due to wear or hazard;

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<sup>9</sup> Average minimum temperature in Sweden was used to provide a minimum figure for international climate, <https://www.weatheronline.co.uk/reports/climate/Sweden.htm>

<sup>10</sup> 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>

<sup>11</sup> *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](http://ws680.nist.gov/publication/get_pdf.cfm?pub_id=101375)

<sup>12</sup> 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.

<sup>13</sup> Refer to IP68 of IEC 60529: Degrees of Protection Provided by Enclosures, <https://webstore.iec.ch/publication/2452>

<sup>14</sup> Refer to IP68 of IEC 60529: Degrees of Protection Provided by Enclosures, <https://webstore.iec.ch/publication/2452>

<sup>15</sup> 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>

- Not cause injury to the user when worn;
- Not cause injury to the user if damaged;
- Comply with existing federal and/or international standards and guidelines; and
- Function underwater.

### **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;
- 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.