



The International Forum to Advance First Responder Innovation

Capability Gap 1 “Deep Dive” Analysis Synopsis

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**International Forum to Advance
FIRST RESPONDER INNOVATION**

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Introduction

This analysis activity intends to characterize markets and identify technology solutions relevant to the International Forum to Advance First Responder Innovation's (Forum) Common Global Capability Gaps List, to garner interest from researchers in industry and academia to develop affordable, innovative technology solutions addressing the various capability gaps for first responders. This publication represents a summary of analysis activity for **Capability Gap 1—The Ability to Know the Location of Responders and Their Proximity to Risks and Hazards in Real Time**. It is anticipated that the remaining capability gaps will be analyzed and published in a similar fashion.

Forum Background

Established in 2014, the Forum is an organization of government leaders from across the globe, focused on enhancing and expanding the development of affordable, innovative technology for first responders worldwide.

In order to respond more safely, efficiently and effectively to everyday and catastrophic emergencies, first responders around the globe need technologically advanced tools and equipment that are affordable. However, there is no centralized mechanism for responders to identify and discuss shared needs and requirements. In addition, overall purchasing of tools and equipment is fragmented into smaller quantities, which provides little incentive for industry to commercialize innovative technologies. Therefore, the lack of consolidated requirements for first responders, along with fragmented purchasing, results in an inadequate amount of affordable new technology being available. This leads to an insufficient amount of research and development (R&D) being conducted in the first responder market.

The Forum addresses this challenge 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 R&D initiatives and solutions.
3. Characterizing global first responder markets, to inform and guide industry and academia about market opportunities and to incentivize them to develop and produce innovative technology solutions to capability gaps.
4. Providing information about relevant and available first responder technologies to the first responder community, while not endorsing any specific technology, product or manufacturer.

Forum Membership

The Forum is currently composed of members from 13 different countries and the European Commission (EC), including Australia, Canada, Finland, Germany, Israel, Japan, the Netherlands, New Zealand, Singapore, Spain, Sweden, the United Kingdom and the United States. France and Mexico's participation in the Forum is pending.



Common Global Capability Gaps List Background

In 2016, the Forum agreed to a Common Global Capability Gaps list, presented below:

- | | |
|-------------------------|--|
| Capability Gap 1 | The ability to know the location of responders and their proximity to risks and hazards in real time |
| Capability Gap 2 | The ability to detect, monitor and analyze passive and active threats and hazards at incident scenes in real time |
| Capability Gap 3 | The ability to rapidly identify hazardous agents and contaminants |
| Capability Gap 4 | The ability to incorporate information from multiple and nontraditional sources (e.g. crowdsourcing and social media) into incident command operations |

To arrive at this initial set of gaps, Forum participants conducted analyses of first responder capability gaps in their countries. Some of the Forum participants used the methodology presented in the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) Project Responder 4 (PR4) report, as a guide in their gap analyses. PR4 is the fourth in a series of studies that started in 2003 to focus on identifying capability needs, shortfalls and priorities for catastrophic incident response. The methodology is based upon discussions with federal, state and local first responders as well as technical subject matter experts.

After submission of gaps from Forum participants, a comparative analysis of all submitted gaps was conducted. The analysis found a significant level of overlap among the various countries' gaps, which resulted in the proposal and adoption of the Forum's Common Global Capability Gaps List. This publication represents a general characterization of the global industries and market trends, specifically regarding potential solutions to Capability Gap 1. The purpose for analyzing and presenting this data is to identify potential areas of R&D where there may be opportunity for industry and academia to market an innovative solution. It is anticipated that the remaining three gaps will be analyzed in a similar fashion and published according to the timeline presented below:

Capability Gaps 2 and 3 | **Mid 2017**

Capability Gap 4 | **Late 2017**

Capability Gap 1

The definition of Capability Gap 1 is **the ability to know the location of responders and their proximity to risks and hazards in real time**. This capability gap involves the development of responder geolocation in all environments and subsequent software or devices enabled to display the precise location of responders (i.e. x, y and z coordinates) on an intuitive user interface.

As Forum participants examined gaps within their countries, first responders consistently stated there is a need to precisely identify the location of responders in real time. Incident commanders and team leaders expressed a need for a tool that displays the location of responders and their proximity to potential threats. The ability to geolocate responders in all environments, coupled with simultaneous awareness of incident risks and hazards, could potentially improve the safety, efficiency and effectiveness of first responders.

This analysis uses the Response Technology Objectives (RTOs) identified in PR4 as a starting point for further defining and segmenting Capability Gap 1. RTOs identify broad technology solutions designed to improve the capabilities of the first responder community. Capability Gap 1 consists of five corresponding RTOs, presented below:

Capability Gap 1
Response Technology Objectives (RTO)
RTO: Indoor (Above and Below Ground) Responder Geolocation
RTO: Infrastructure Standards for Technology Integration
RTO: Rapid Building Characterization, Generation and Display
RTO: Outdoor Responder Geolocation
RTO: Maritime (Above and Below Water) Geolocation

**Further definitions of these RTOs are provided in the Glossary.*

When examining the identified RTOs, this analysis activity found that a general market trend toward hybrid (indoor and outdoor) geolocation solutions appears to be emerging. Due to this trend, and in an effort to develop a more comprehensive analysis of relevant market opportunities, this analysis includes **Hybrid (Indoor and Outdoor) Responder Geolocation** as an additional market segment.

Methodology

The following section provides a brief overview of the processes used to obtain and assess the findings presented in this synopsis.

Objective

The key objective of this analysis activity is to characterize the markets relevant to Capability Gap 1, to garner interest from researchers in industry and academia to develop affordable, innovative technology addressing the gap for responders. In other words, it is intended that this information will serve to inform and guide research and development efforts, supporting the overall goals of the Forum.

Research Methods

Data presented in this report was gathered primarily using secondary research methodologies. Research consisted of gathering publicly available information from various sources including market reports and company Web sites, among others. This analysis chose secondary research methodologies because information gathered using primary research would likely have been proprietary in nature and therefore not suitable for publishing. With that in mind, data presented in this report should not be considered exhaustive. Furthermore, regarding potential solutions, this analysis relies upon information that is publicly available from manufacturers' Web sites, but it does not validate the claims made thereon.

Market Definition and Segmentation

This analysis uses the Responder Technology Objectives (RTOs) developed by PR4 as a starting point for further defining and segmenting Capability Gap 1. More specifically, relevant market segments for each RTO were identified through secondary research, with one or two primary markets being identified for each one.

Market Quantification

All relevant markets are quantified utilizing overall revenue figures for the forecast period 2015-2020. The Compound Annual Growth Rates (CAGRs) within each segment are used to measure growth within the forecast period and to extrapolate data when necessary. As the first responder segments of these relevant markets are currently underdeveloped, overarching market figures are presented. The data for the primary markets is used in the aggregated findings presented in the body of this report.

Market Phase and Factors

Market phase is determined using factors in the Industry Life Cycle model. The adapted market phase definitions are as follows:

Nascent	New market need with dominant solutions not yet determined, growth begins increasing toward end of cycle
Growth	Dominant solutions begin to emerge, high growth rates
Mature	Typically fewer firms than growth phase, as dominant solutions continue to capture the majority of market share and market consolidation occurs, lower growth rates that are typically on par with the general economy
Decline	Further market consolidation, rapidly declining growth rates

Market factors are assessed by examining barriers to entry and market opportunities, as determined through secondary research.

Competitive Landscape

This analysis also examines the competitive landscape within each market, accounting for the total number of firms, along with the number of responder-specific solutions. Total number of firms was estimated using the number of key players given within publicly available market reports for each segment, while responder-specific solutions were identified using a more tailored search. This search included examining the key players listed by the publicly available market reports and conducting targeted keyword searches for solutions from companies not mentioned in these reports.

Dominant Solutions

Dominant solutions are determined by examining market share breakdown. Solutions capturing the majority of the market share are considered to be dominant.

Presentation

This synopsis begins by presenting a *Market Overview* that summarizes the overall market and provides the market quantification data for each segment. It then presents the key findings for each market segment in the *Market Highlights* section, with a one-page summary for each segment. Finally, the *Technology Landscape* section breaks down the total number of firms participating in the market by segment and highlights responder-specific solutions available or in development.

Synopsis Overview

In order to meet its objectives of defining and publishing a global set of capability gaps and informing and guiding industry, the Forum has been conducting an on-going global capability gaps analysis. The key objective of this analysis activity is to characterize the markets relevant to Capability Gap 1, to garner interest from researchers in academia and industry to develop affordable, innovative technology addressing the gap for responders. This synopsis represents a summary of this activity to date.



Capability Gap 1

The ability to know the location of responders and their proximity to risks and hazards in real time

Market Definitions and Segmentation

This analysis activity begins by defining and segmenting the relevant markets for each Response Technology Objective (RTO) within Capability Gap 1, which includes the identification of primary markets for each RTO, presented below:

Primary Market Summary:

Response Technology Objectives (RTOs)

RTO: Indoor (Above and Below Ground) Responder Geolocation	Indoor Location Market
RTO: Infrastructure Standards for Technology	Building Information Modeling (BIM) Market
RTO: Rapid Building Characterization, Generation and Display	3D Mapping and 3D Modeling Market
RTO: Outdoor Responder Geolocation	Global Navigation Satellite System (GNSS) Market
RTO: Maritime (Above and Below Water) Geolocation	GNSS Market [Maritime] and SONAR Systems and Technology Market

*Further definitions of these RTOs are provided in the Glossary.

Market Quantification

Each market, both primary and secondary, is quantified utilizing overall revenue figures, and growth is measured using Compound Annual Growth Rate (CAGR). This analysis found that the identified primary markets accounted for approximately **\$109.5 billion in revenue in 2015**.

Competitive Landscape

This analysis activity found that there are over 400 global firms, including innovators, working within these markets. However, the number of responder-specific solutions identified is comparably low. This presents an opportunity for those firms already developing solutions in the broader market, as in some cases they may be able to make slight adaptations to existing solutions, or those in development, to meet first responder needs. By engaging with responders, particularly on a global level through the Forum, firms can begin to further assess how close they are to providing meaningful solutions for responders.

Dominant Solutions, Market Factors and Market Phase

Expectedly, this analysis activity found that the existence of dominant solutions, the influencing market factors and the market phase varies greatly by market. These aspects of each market are summarized further within the *Market Highlights* section of this synopsis.

Summary

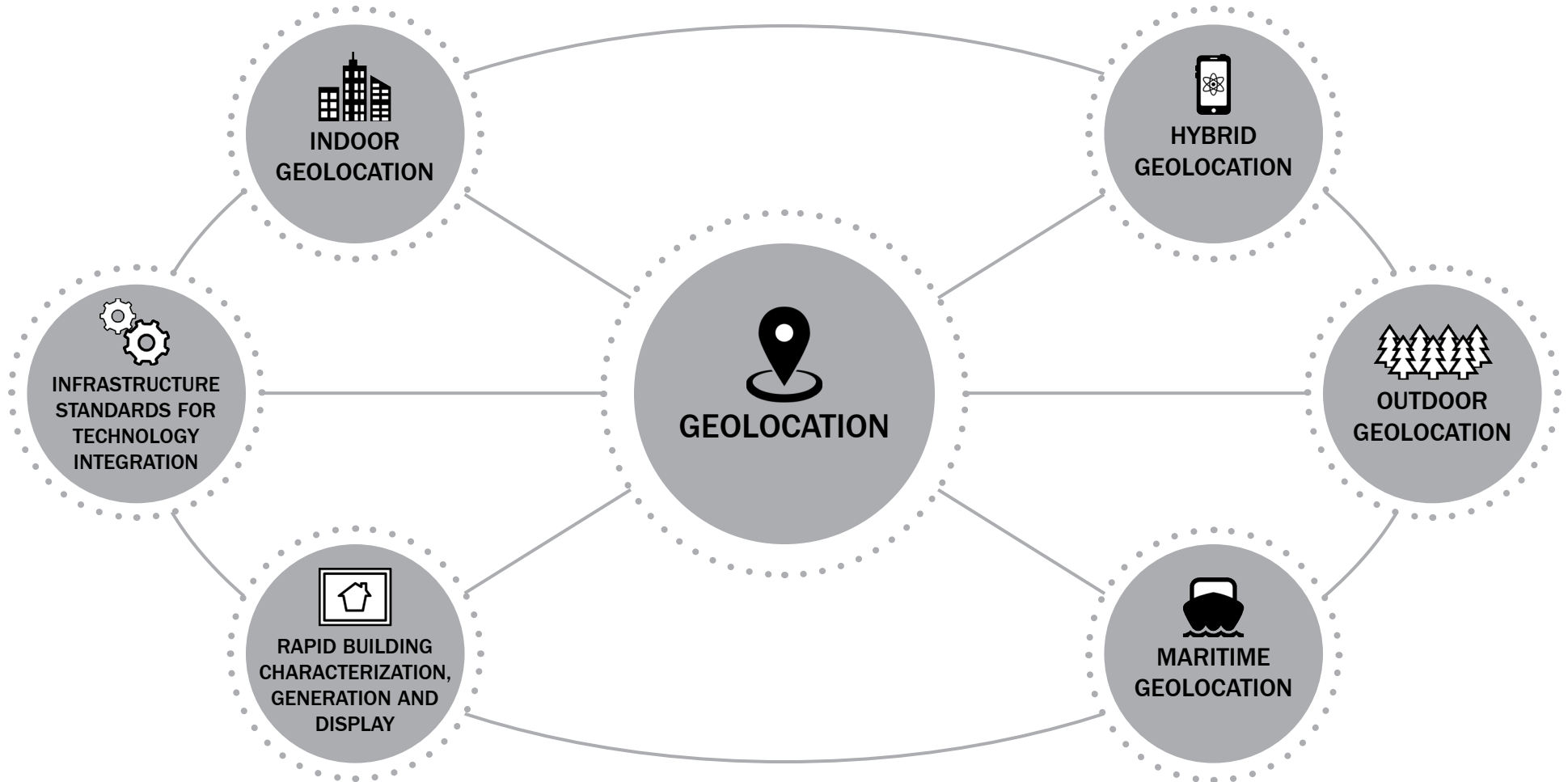
It appears that there is a large overall market opportunity within the primary markets that are relevant to Capability Gap 1. However, the number of first responder-specific solutions is low when compared with the total number of firms working on and providing solutions in the broader market. Therefore, in general, there is a potentially large opportunity for firms to adapt their solutions for responder needs. The factors impacting the ability to capture these opportunities varies by market, as detailed further within this synopsis.

Market Overview

Market Definition

Geolocation can be described as **the geographical position of an object, usually defined by latitude, longitude and altitude coordinates or area-specific designations (such as a street address) in all environments (i.e. indoors, outdoors and maritime).** The following figure presents the breakdown of the geolocation market, as identified in this analysis:

Market Segmentation

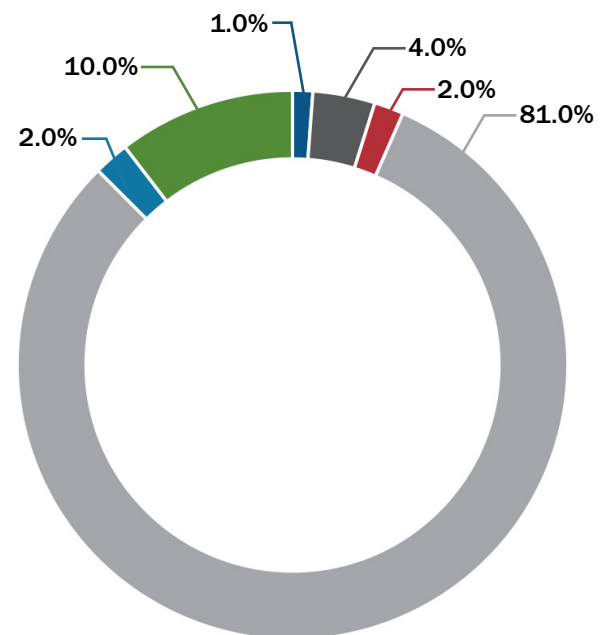
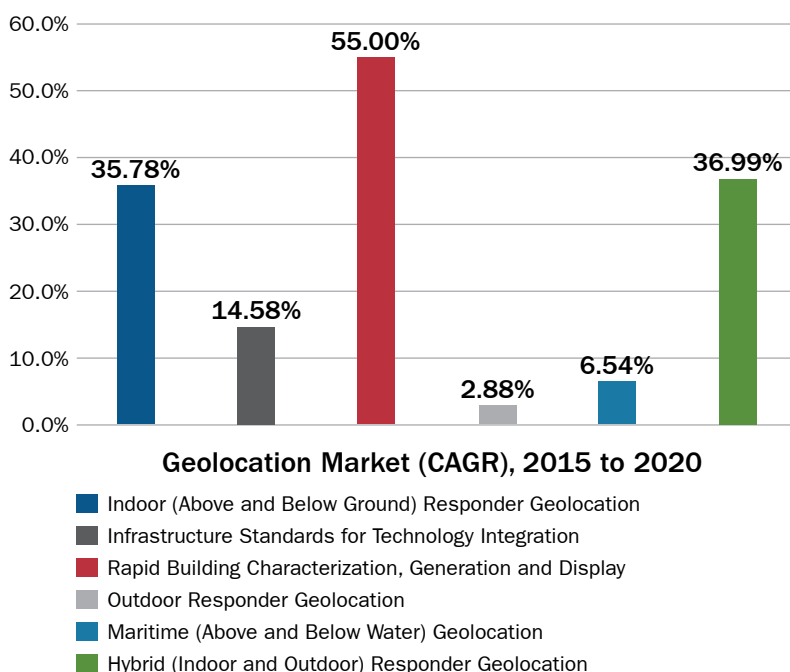


Capability Gap 1 - The Ability to Know the Location of Responders and Their Proximity to Risks and Hazards in Real Time

The ability to know the location of responders and their proximity to risks and hazards in real time involves the development of responder geolocation in all environments and subsequent software or devices enabled to display the precise location of responders (i.e. x, y and z coordinates) on an intuitive user interface. Further, the establishment of operational standards or requirements is likely to aid the development of responder safety, efficiency and effectiveness.

A myriad of geolocation solutions currently exist within the market. However, there appears to be a limited number of technologies suitable for first responder use. It is therefore acknowledged that the identified market figures and growth rates are likely to be more reflective of the broader geolocation market, rather than the responder-specific geolocation market.

Outdoor responder geolocation appears to be the most mature market. However, the emergence of hybrid (indoor and outdoor) responder geolocation solutions, such as Location-Based Services, may provide the best means of capturing geolocation needs within a single, seamless solution for the first responder community.



Geolocation Market, 2015

- Indoor (Above and Below Ground) Responder Geolocation
- Infrastructure Standards for Technology Integration
- Rapid Building Characterization, Generation and Display
- Outdoor Responder Geolocation
- Maritime (Above and Below Water) Geolocation
- Hybrid (Indoor and Outdoor) Responder Geolocation

As of 2015, the outdoor responder geolocation market captures the greatest market share at 81.0 percent, followed by hybrid (indoor and outdoor) responder geolocation at 10.0 percent. Rapid building characterization, generation and display, which will perpetuate the indoor (above and below ground) responder geolocation market is expected to grow at the highest CAGR of 55.00 percent during the forecast period of 2015 to 2020.

Other markets with significant growth rates include hybrid (indoor and outdoor) responder geolocation at 36.99 percent and indoor (above and below ground) responder geolocation at 35.78 percent.

Market Figures


The following tables present the estimated revenue figures for the various sub-markets identified for each segment within the geolocation market. The figures in the colored rows represent the primary markets used to quantify each segment in this analysis activity.

Disclaimer

All figures have been rounded to the nearest hundred thousand. The market forecast period examined is 2015 to 2020. When a market value was not available, it was estimated using the corresponding CAGR given over the forecast period 2015 to 2020 to represent growth or decline.

For consistency, data that fell outside of the forecast period 2015 to 2020 has been extrapolated, as denoted by an asterisk (*). A more detailed explanation of how the extrapolated figures were estimated can be found in the Appendix at the end of this analysis activity.


Indoor (Above and Below Ground) Responder Geolocation

	Revenue by Year (in \$100,000)						CAGR
	2015	2016	2017	2018	2019	2020	
Acoustic Wave Sensor	\$387.1	\$484.1	\$605.3	\$756.9	\$946.5	\$1,200.0	25.39%
Indoor Location*	\$1,300.0	\$1,700.0	\$2,400.0	\$3,200.0	\$4,400.0	\$6,000.0	35.78%
Inertial Navigation System (INS)	\$4,600.0	\$5,300.0	\$6,000.0	\$6,800.0	\$7,800.0	\$8,900.0	14.11%
Infrared Detector	\$253.0	\$278.0	\$305.5	\$335.6	\$368.8	\$405.2	9.88%
Light Detection and Ranging (LiDAR)*	\$1,200.0	\$1,400.0	\$1,600.0	\$1,800.0	\$2,100.0	\$2,400.0	14.87%
Machine Vision	\$8,100.0	\$8,800.0	\$9,600.0	\$10,500.0	\$11,500.0	\$12,500.0	9.06%
Magnetic Field Sensors*	\$1,900.0	\$2,100.0	\$2,200.0	\$2,400.0	\$2,700.0	\$2,900.0	8.83%
Radio Frequency Identification (RFID)*	\$10,900.0	\$12,600.0	\$14,500.0	\$16,600.0	\$19,100.0	\$22,000.0	15.08%

Infrastructure Standards for Technology Integration

	Revenue by Year (in \$100,000)						CAGR
	2015	2016	2017	2018	2019	2020	
Anti-Jamming Market for Global Positioning System (GPS) Technology	\$2,900.0	\$3,100.0	\$3,300.0	\$3,600.0	\$3,900.0	\$4,200.0	7.69%
Building Information Modeling (BIM)	\$4,000.0	\$4,600.0	\$5,200.0	\$6,000.0	\$6,900.0	\$7,900.0	14.58%
Free Space Optics (FSO)	\$116.7	\$117.1	\$268.9	\$408.1	\$619.4	\$940.2	51.79%
Global Wi-Fi	\$14,800.0	\$17,400.0	\$20,500.0	\$24,200.0	\$28,500.0	\$33,600.0	17.82%
Outdoor Wi-Fi	\$21,900.0	\$26,100.0	\$31,200.0	\$37,200.0	\$44,400.0	\$52,900.0	19.29%
In-Building Wireless Solutions, Services and Networks	\$4,800.0	\$6,200.0	\$7,900.0	\$10,200.0	\$13,000.0	\$16,700.0	28.32%
Public Safety In-Building Wireless Distributed Antenna System (DAS)	\$267.2	\$404.2	\$541.2	\$724.7	\$970.5	\$1,300.0	37.21%
Visible Light Communications (LiFi)	\$327.8	\$628.6	\$1,200.0	\$2,300.0	\$4,400.0	\$8,500.0	91.76%
Wireless Broadband in Public Safety	\$16,500.0	\$17,600.0	\$18,800.0	\$20,100.0	\$21,400.0	\$22,900.0	6.78%

Rapid Building Characterization, Generation and Display

	Revenue by Year (in \$100,000)						CAGR
	2015	2016	2017	2018	2019	2020	
Augmented Reality (AR)	\$3,100.0	\$5,500.0	\$9,900.0	\$17,700.0	\$31,700.0	\$56,800.0	78.89%
Head-Up Display (HUD)*	\$2,000.0	\$2,700.0	\$3,600.0	\$4,900.0	\$6,700.0	\$9,000.0	35.10%
Three-dimensional (3D) Mapping and 3D Modeling	\$1,900.0	\$2,900.0	\$4,600.0	\$7,100.0	\$11,000.0	\$17,000.0	55.00%

Outdoor Responder Geolocation

	Revenue by Year (in \$100,000)						CAGR
	2015	2016	2017	2018	2019	2020	
Global Navigation Satellite System (GNSS)	\$88,600.0	\$86,400.0	\$90,700.0	\$94,500.0	\$98,800.0	\$102,100.0	2.88%
Global Positioning System (GPS) Receiver(s) for Mid/High Level Real-Time Kinematics (RTK)*	\$1,300.0	\$1,500.0	\$1,800.0	\$2,200.0	\$2,600.0	\$3,100.0	18.98%

Maritime (Above and Below Water) Geolocation

	Revenue by Year (in \$100,000)						CAGR
	2015	2016	2017	2018	2019	2020	
Automatic Identification System (AIS)*	\$182.1	\$189.9	\$198.2	\$206.8	\$215.7	\$225.1	4.33%
Cables and Connectors for Satellite and Submarine Industries*	\$24,000.0	\$27,000.0	\$30,500.0	\$34,300.0	\$38,700.0	\$43,600.0	12.68%
Global Navigation Satellite System (GNSS) [Maritime]	\$66.3	\$59.4	\$64.8	\$72.4	\$83.2	\$88.6	5.97%
Hydrographic Survey Equipment*	\$2,600.0	\$2,800.0	\$2,900.0	\$3,100.0	\$3,300.0	\$3,400.0	5.51%
Sonobuoy(s)	\$226.1	\$241.9	\$258.7	\$276.7	\$296.0	\$316.6	6.97%
Sound Navigation and Ranging (SONAR) Systems and Technology	\$2,200.0	\$2,400.0	\$2,600.0	\$2,700.0	\$2,900.0	\$3,100.0	7.10%

Hybrid (Indoor and Outdoor) Responder Geolocation

	Revenue by Year (in \$100,000)						CAGR
	2015	2016	2017	2018	2019	2020	
Emergency Beacon Transmitter(s)	\$133.3	\$140.8	\$148.8	\$157.2	\$166.0	\$175.4	5.64%
Geographic Information System (GIS)*	\$8,500.0	\$9,500.0	\$10,600.0	\$11,800.0	\$13,100.0	\$14,600.0	11.43%
Location-Based Services (LBS)	\$11,400.0	\$15,600.0	\$21,300.0	\$29,300.0	\$40,100.0	\$55,000.0	36.99%
Mobile Mapping	\$10,300.0	\$12,400.0	\$15,000.0	\$18,200.0	\$22,000.0	\$26,600.0	20.90%

Market Highlights



Indoor (Above and Below Ground) Responder Geolocation

The identification of one or more responders' precise location within any type of commercial or residential building, structure or enclosed setting underground (e.g. basements, caves, subway systems, and tunnels). Further, according to a proposed standard (18305) from the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC), indoor responder geolocation may be defined as any environment where there is no line of sight to the sky. This proposed standard would therefore include responders working within or under rubble piles.

PRIMARY MARKET
Indoor Location

Current Capability:

Responders utilize hand-held radios (i.e. 700/800 MHz, VHF, UHF) to verbally communicate coordinates to command and other responders at an incident scene. Real-time geolocation can be obtained using GPS. However, these systems are costly and therefore not deployed at the individual responder level. Further, GPS signals are not powerful enough to penetrate building walls or other building materials (e.g. steel and other metals), which limits geolocation capabilities for indoor (above and below ground) environments.

Market Quantification

Market Size (2015): **\$1.3 billion**

Compound Annual Growth Rate
(2015-2020): **35.78%**

Competitive Landscape

Number of Firms: **96**

Number of Responder-Specific
Solutions: **6**

Dominant Solution

None, to date

The *Indoor Location Market* is used to quantify this segment

Defined: Indoor location technologies modernize smartphones by incorporating GPS and other position technologies with style mapping; enabling accurate mapping and navigation for indoor environments without any complex infrastructure.

Market Factors

BARRIERS

- Lack of oversight, standardization and testing
- Cost of development and implementation to the individual responder level
- Ability to leverage existing infrastructure

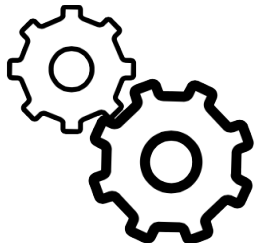
Market Phase

NASCENT

OPPORTUNITIES

- Establishment of legal authority for oversight, standardization and testing
- Solutions that address accuracy, mobility, speed and cost
- The evolution of "Smart Buildings" and the Internet of Things (IoT)

Market Highlights



Infrastructure Standards for Technology Integration

The standard requirement of technology integration in infrastructure, especially regard to indoor environments (for example, commercial or residential buildings). The RTO does not necessarily implicate specific technological solutions currently available or in development within the market, rather the RTO is primarily focused on the particular government requirements and legislation related to its efforts. Notably, the success and failure of emergency operations is dictated not by training or ability, but rather by the equipment at a response team's disposal.

PRIMARY MARKET
Building Information
Modeling (BIM)

Current Capability:

It appears there is no current standard for infrastructure mapping of new or existing buildings. Further, it appears there is no current standard for requiring building construction to include technology, such as radio frequency identification [RFID] tags, that would facilitate the use of responder locating devices inside structures.

Market Quantification

Market Size (2015): **\$4.0 billion**

Compound Annual Growth Rate
(2015-2020): **14.58%**

Competitive Landscape

Number of Firms: **93**

Number of Responder-Specific
Solutions: **None identified**

Dominant Solution

None, to date

The Building Information Modeling (BIM)
Market is used to quantify this segment

Defined: An intelligent 3D model-based process that equips architecture, engineering and construction professionals with the insight and tools to more efficiently plan, design, construct and manage buildings and infrastructure.

Market Factors

BARRIERS

Lack of oversight, standardization and testing
Cost of development and implementation
Potential resistance from construction industry due to added costs

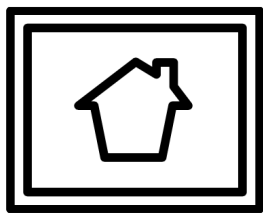
Market Phase

NASCENT

OPPORTUNITIES

Establishment of legal authority for oversight, standardization and testing
Database of digitized blueprints and/or maps
Light infrastructure (e.g. time-of-flight beacons and anchor sensors) and LTE networks

Market Highlights



Rapid Building Characterization, Generation and Display

The ability to rapidly characterize, generate and display a three-dimensional (3D) visualization of a building to provide enhanced situational awareness to responders at incident scenes; aiding the development of indoor (above and below ground) responder geolocation. Notably, the success and failure of emergency operations is dictated not by training or ability, but rather by the equipment at a response team's disposal.

PRIMARY MARKET
3D Mapping and
3D Modeling

Current Capability:

Responders often use open-source imagery to gain insight about target buildings. However, these images are typically limited to external visualizations of a building and do not provide indoor mapping capability. In addition, digitized blueprints are likely to enhance situational awareness for responders at an incident scene. However, these resources do not appear readily available in most jurisdictions nor have they been collected or integrated into a usable format that is accessible to responders.

Market Quantification

Market Size (2015): **\$4.0 billion**

Compound Annual Growth Rate
(2015-2020): **55.0%**

Competitive Landscape

Number of Firms: **32**

Number of Responder-Specific
Solutions: **1**

Dominant Solution

**3D Mapping and
3D Modeling**

Defined: 3D mapping is a technology that creates 3D views of objects on a computer screen. 3D mapping and modeling solutions enable a user to view and develop 3D model images without using special viewing equipment.

Market Factors

BARRIERS

- Lack of oversight, standardization and testing
- Cost of development and implementation
- Security and privacy concerns

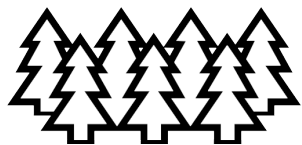
Market Phase
GROWTH

OPPORTUNITIES

- Establishment of legal authority for oversight, standardization and testing
- Integration into software programs for real-time analytics
- 3D digitized blueprints and/or maps on a user-friendly interface

Figures for Competitive Landscape are not all encompassing; it is likely that additional firms and solutions exist.

Market Highlights



Outdoor Responder Geolocation

The identification of one or more responders' precise location outside of any type of commercial or residential building, structure or enclosed setting underground (for example, basements, caves, subway systems, tunnels).

PRIMARY MARKET
Global Navigation
Satellite System (GNSS)

Current Capability:

Responders utilize hand-held radios (i.e. 700/800 MHz, VHF, UHF) to verbally communicate coordinates to dispatch and other responders at an incident scene. Real-time geolocation can be achieved using Global Navigation Satellite System (GNSS) units. However, these units are costly and often fixed to an apparatus (e.g., fire truck or police cruiser) rather than an individual responder.

Market Quantification

Market Size (2015): **\$88.6 billion**

Compound Annual Growth Rate
(2015-2020): **2.88%**

Competitive Landscape

Number of Firms: **76**

Number of Responder-Specific
Solutions: **4**

Dominant Solution

**Global Navigation
Satellite System (GNSS)**

Defined: The infrastructure that allows users with a compatible device to determine their position, velocity and local time by processing signals from satellites in space.

Market Factors

BARRIERS

Cost of development and implementation to the individual responder level

Signal interference and GNSS-denied environments

Energy consumption and durability of devices in responder operating environments

Market Phase

MATURE

OPPORTUNITIES

Cost effective solutions that can be deployed at the responder level

Integration of additional components to boost signal strength and overall reliability and effectiveness

Interoperability

Market Highlights

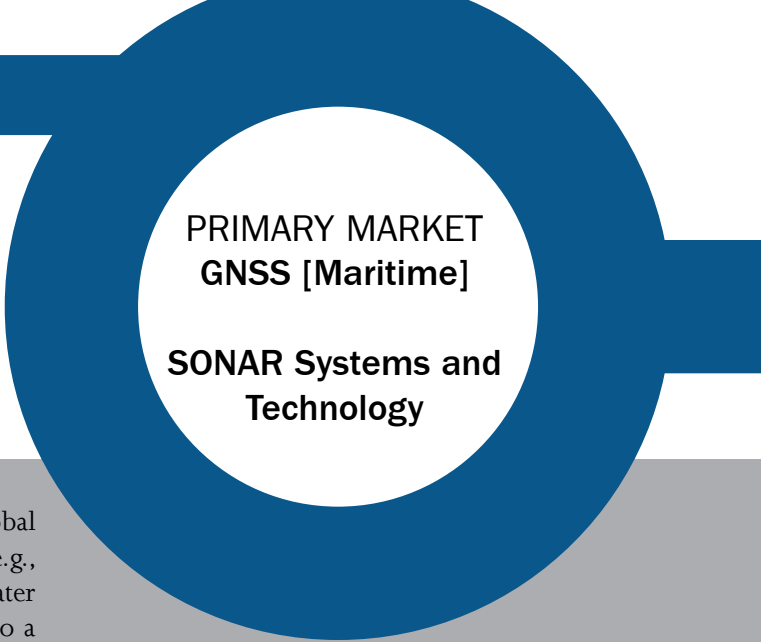


Maritime (Above and Below Water) Geolocation

The identification of one or more responders’ precise location either above or below a body of water’s surface. Maritime environments include fresh and salt bodies of water, as well as the airspace above these environments.

Current Capability:

Real-time geolocation in the maritime environment (above the water’s surface) can be achieved using Global Navigation Satellite System (GNSS) units. However, these units are costly and often fixed to an apparatus (e.g., rescue vessel) rather than an individual responder. Most agencies do not have the capability to conduct underwater geolocation of responders—sophisticated dive teams may utilize fiber-optic umbilical cord cables tethered to a diver for location, underwater communication and safety purposes.



Market Quantification

Market Size (2015): **\$2.3 billion**

Compound Annual Growth Rate
(2015-2020): **6.83%**

Competitive Landscape

Number of Firms: **61**

Number of Responder-Specific
Solutions: **2**

Dominant Solution

Global Navigation Satellite System (GNSS)
[Above Water]

Defined: See *Outdoor Responder Geolocation* for GNSS definition.

SONAR Systems and Technology
[Below Water]

Sound Navigation and Ranging (SONAR) is a system for the detection of objects under water and for measuring the water’s depth by emitting sound pulses and detecting or measuring their return after being reflected.

Market Factors

BARRIERS

- Strict standards, operational requirements and regulation
- Cost of development and implementation to the individual responder level
- Energy consumption and durability of devices in responder operating environments

Market Phase

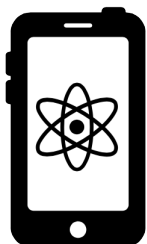
MATURE + GROWTH

OPPORTUNITIES

- Solutions for responder geolocation below the water’s surface
- Personal location devices; solutions not attached to apparatus or vessel
- Interoperability

Figures for Competitive Landscape are not all encompassing; it is likely that additional firms and solutions exist.

Market Highlights



Hybrid (Indoor and Outdoor) Responder Geolocation

The identification of one or more responders' precise location within or outside of any type of commercial or residential building, structure or enclosed setting underground (for example, basements, caves, subway systems, tunnels). Hybrid responder geolocation solutions are operable in all environments. In order to function in all environments, these solutions often combine multiple technology capabilities.

PRIMARY MARKET
Location-Based
Services (LBS)

Current Capability:

It appears that most agencies do not have the capability for real-time automated geolocation of responders at an incident scene. Responders utilize hand-held radios (i.e. 700/800 MHz, VHF, UHF) to verbally communicate coordinates to command and other responders at an incident scene. Real-time geolocation can be obtained using Global Positioning Units (GPS). However, these systems are costly and are operationally-limited among indoor (above and below ground) environments.

Market Quantification

Market Size (2015): \$11.4 billion

Compound Annual Growth Rate (2015-2020): 36.99%

Competitive Landscape

Number of Firms: 42

Number of Responder-Specific Solutions: 4

Dominant Solution

Location-Based Services (LBS)

Defined: A broad range of applications, functions and services based on or enhanced by information about the physical location of a user, device or target of interest that provide added value to users.

Market Factors

BARRIERS

- Lack of oversight, standardization and testing
- General lack of awareness, education and training
- Energy consumption and durability of devices in responder operating environments
- Security and privacy concerns

Market Phase

GROWTH

OPPORTUNITIES

- Establishment of legal authority for oversight, standardization and testing
- Standardized testing among all environments
- Development of LBS and smartphone applications
- Interoperability, namely the Internet of Things (IoT)

Market Factors

Market Barriers

Market Opportunities

Indoor (Above and Below Ground) Responder Geolocation

- x Lack of oversight, standardization and testing
- x Cost of development and implementation to the individual responder level
- x Ability to leverage existing infrastructure

- ✓ Establishment of legal authority for oversight, standardization and testing
- ✓ Solutions that address accuracy, mobility, speed and cost
- ✓ The evolution of “Smart Buildings” and the Internet of Things (IoT)

Infrastructure Standards for Technology Integration

- x Lack of oversight, standardization and testing
- x Cost of development and implementation
- x Potential resistance from construction industry due to added costs

- ✓ Establishment of legal authority for oversight, standardization and testing
- ✓ Database of digitized blueprints and/or maps
- ✓ Light infrastructure (e.g. time-of-flight beacons and anchor sensors) and LTE networks

Rapid Building Characterization, Generation and Display

- x Lack of oversight, standardization and testing
- x Cost of development and implementation
- x Security and privacy concerns

- ✓ Establishment of legal authority for oversight, standardization and testing
- ✓ Integration into software programs for real-time analytics
- ✓ 3D digitized blueprints and/or maps on a user-friendly interface

Outdoor Responder Geolocation

- x Cost of development and implementation to the individual responder level
- x Signal interference and GNSS-denied environments
- x Energy consumption and durability of devices in responder operating environment

- ✓ Cost effective solutions that can be deployed at the responder level
- ✓ Integration of additional components to boost signal strength and overall reliability and effectiveness
- ✓ Interoperability

Maritime (Above and Below Water) Geolocation

- x Strict standards, operational requirements and regulation
- x Cost of development and implementation to the individual responder level
- x Energy consumption and durability of devices in responder operating environment

- ✓ Solutions for responder geolocation below the water's surface
- ✓ Personal location devices; solutions not attached to apparatus or vessel
- ✓ Interoperability

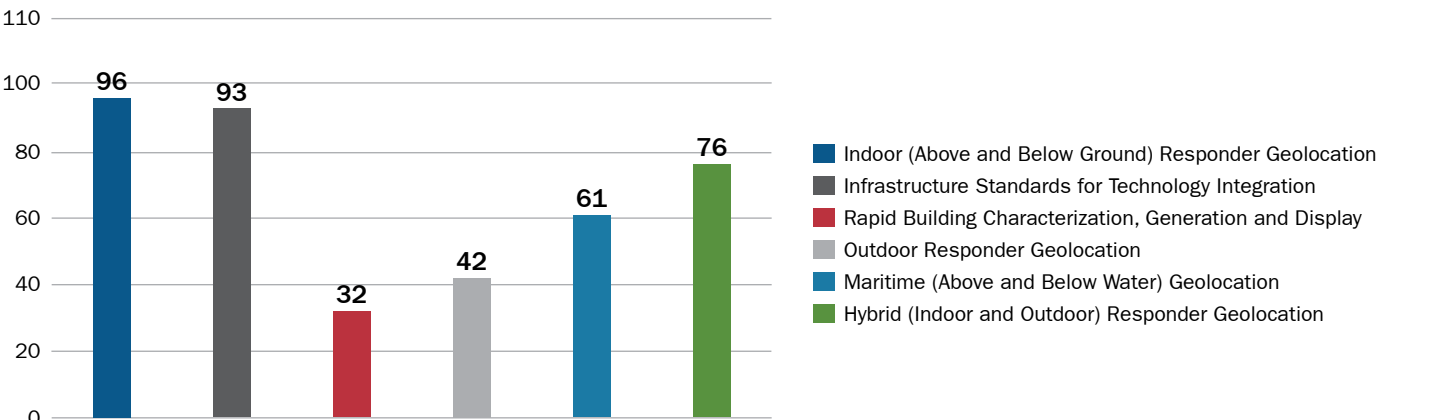
Hybrid (Indoor and Outdoor) Responder Geolocation

- x Lack of oversight, standardization and testing
- x General lack of awareness, education and training
- x Energy consumption and durability of devices in responder operating environment
- x Security and privacy concerns

- ✓ Establishment of legal authority for oversight, standardization and testing
- ✓ Standardized testing among all environments
- ✓ Development of LBS and smartphone applications
- ✓ Interoperability, namely the Internet of Things (IoT)

Competitive Landscape

A total of 400 global firms were recognized as key players and innovators within the submarkets of geolocation. Specifically, the breakdown of each submarket is as follows:



Geolocation Market: Key Players and Innovators, 2015

These figures are not all encompassing;
it is likely that additional firms exist within each market.

The following firms were identified as key players and innovators in at least 4 of the 6 market segments regarding geolocation solutions: Apple Inc. (U.S.), Cobham plc (UK), Furuno Electric Co. Ltd. (Japan), Google Inc. (U.S.), Here (Finland), NovAtel Inc. (Canada), Thales Group (France) and Trimble Navigation Limited (U.S.).

Based upon the data presented, there is a comparably low number of responder-specific solutions identified, given the number of firms operating in each segment. This presents an opportunity for those firms already developing solutions in the broader market, as in some cases they may be able to make slight adaptations to existing solutions to meet first responder needs. By engaging with responders, particularly on a global level through the Forum, firms can begin to further assess how close they are to providing meaningful solutions for responders. Furthermore, they can engage responders throughout their process to ensure that their developments will meet responder needs.

For questions or comments related to the information presented in this assessment, please contact the Forum at info@internationalresponderforum.org.

The following section presents potential first responder-specific solutions by segment as identified by this assessment. It is likely that there are additional potential solutions that exist and therefore, this section should not be considered exhaustive. The number of responder-specific solutions identified by segment is summarized below:

- Indoor (Above and Below Ground) Responder Geolocation—6
- Infrastructure Standards for Technology Integration—0
- Rapid Building Characterization, Generation and Display—1
- Outdoor Responder Geolocation—4
- Maritime (Above and Below Water) Geolocation—1
- Hybrid (Indoor and Outdoor) Responder Geolocation—4

The data presented in this section represents information that is publicly available from manufacturers' Web sites. This information is not further validated by this assessment.

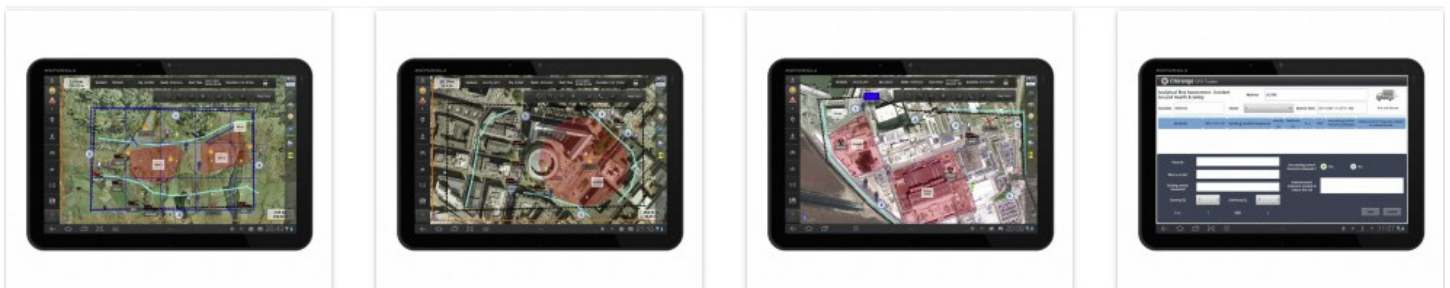
Indoor (Above and Below Ground) Responder Geolocation

Chirange Incident Commander

Chirange Technologies (Manchester, United Kingdom) designs and builds intelligence GPS and geo-location indoor tracking and incident management solutions. The company specifically targets solutions for tactical law enforcement and fire rescue services.

The Chirange Incident Commander is an Android tablet and smartphone based system that offers secure enterprise data sharing with real-time GPS tracking of personnel and assets for incident and operation commands.

Chirange offers a wide range of purchasing and billing options. However, information regarding price and specific deployment within the first responder community does not appear to be publicly available.



Chirange Incident Commander

Inertial Sensors Combination with GNSS Augmentation for Pedestrian Tracking (RESCUE)

DUNE (Rome, Italy) is a Small-Medium Enterprise currently operating in aerospace, industrial control and telecommunications industries. DUNE offers RESCUE, a pedestrian localization and tracking system that is operable in environments where GPS signals are unreliable or absent (i.e. buildings, underground areas, GPS-denied environments).

The system is composed of an Inertial Sensing Unit attached inside or outside a shoe heel, a Computing Unit processing raw data and a man-machine interface (MMI) shifting window (SW) used to acquire, integrate and display the path walked by the operators wearing the system. Further, RESCUE integrates additional information including GPS (when available) and compass to overlap inertial position data with existing maps and magnetic charing Sensing Unit.

In 2014, Dune released an enhanced version of the solution, ARIANA.

Information regarding price and specific deployment within the first responder community does not appear to be publicly available.



*DUNE
RESCUE Solution*

iTrack First Responder Tracking System

iTrack, LLC (Rochester, Michigan) provides autonomous navigation and tracking solutions. iTrack offers a customized version of iTrack's Local Positioning Tracking System for locating firefighters in unknown indoor environments. The system consists of a small strap-down foot-mounted module and a vest-worn network radio module. The system combines information from various absolute and relative sensors to determine the most accurate position and provide 2D and 3D tracking capabilities to incident and operation commands.

Information regarding price and specific deployment within the first responder community does not appear to be publicly available.



*iTrack, First Responder
Tracking System*

NextNav

NextNav, LLC (Sunnyvale, California) deploys urban and indoor positioning services across the U.S. Specifically, NextNav seeks to enhance urban and indoor positioning for public safety and commercial application.

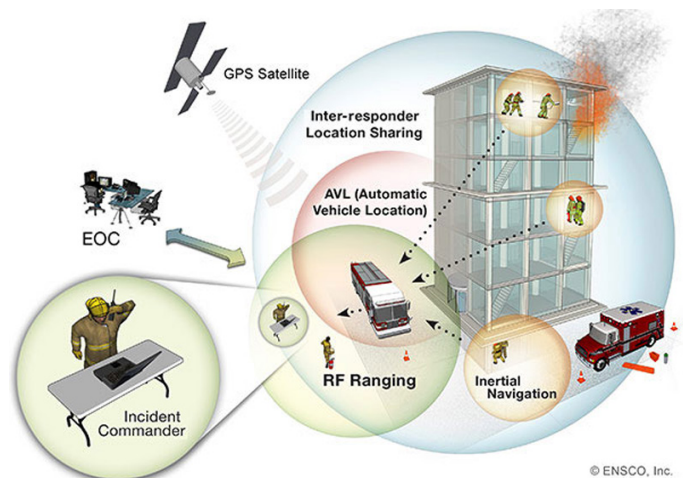
NextNav integrates terrestrial-based transmitters into buildings and urban areas where satellite-based GPS signals are denied. The NextNav network transmits timed signals and information regarding the placement of the transmitters over a secured channel. In addition, the solution computes height information using differential barometric pressure measurements, similar to an aircraft altimeter. NexNav is available on any mobile devices with GPS capabilities.

Information regarding price and specific deployment within the first responder community does not appear to be publicly available.

Personnel Navigation, Locating & Tracking

ENSCO, Inc. (Falls Church, Virginia) offers custom pedestrian navigation solutions that feature robust, real-time positioning, tracking and locating where GPS service is degraded or unavailable. ENSCO claims its solutions can be integrated with other navigation or positioning systems, vision-based sensors, foot-to-foot radio frequency ranging and other orthogonal technologies designed to increase positional accuracy over longer periods without GPS.

Information regarding price and specific deployment within the first responder community does not appear to be publicly available.



ENSCO, Inc. Personnel Navigation, Locating & Tracking

PENS - Personal Navigation System

Israel Aerospace Industries Ltd. (IAI) is the largest government owned defense and aerospace company in Israel. IAI claims to be a global leader in the development and production of systems for the defense and commercial markets, providing unique solutions for space, air, land, sea and cyber spectrums.

PENS - Personal Navigation System is a mobile multi-sensor inertial navigation system, composed of two units: (1) Navigation and Computation Unit and (2) Sensors Unit. PENS provides each user with personal navigation, positioning, pointing and orientation data in various terrain, including urban and indoor areas.

PENS is designed for infantry soldiers, special forces, rescue forces and fire brigades. Information regarding price and specific deployment within the first responder community does not appear to be publicly available.



PENS
Personal Navigation System

Rapid Building Characterization, Generation and Display

OrbiFire™

The Digit Group, Inc. (Memphis, Tennessee) offers “Smart Cities” solutions that provide increased security and safety, efficient energy use and an enhanced urban experience. TDG’s solutions have been implemented in China, Europe, India, the Middle East, Southeast Asia and the U.S. Specifically, TDG offers the Orbi® platform, described as a real-time 3D gaming engine used to develop Smart City applications, such as OrbiFire™.

OrbiFire™ compiles various sources of authenticated data from municipalities to develop an on-demand, real-time 3D environment to display critical information regarding an incident scene to fire service personnel before, during and after an event takes place. OrbiFire™ features include “Check-In/Check-Out” geo-fencing that informs incident commanders of the who, what and where of each firefighter. In addition, OrbiFire™ can provide an augmented reality 3D view of the interior of a building, which is displayed into a firefighter’s compatible, iVisor Helmet. TDG retains a collection of 3D modeled, real-time environments from over 70 cities around the world for immediate use.



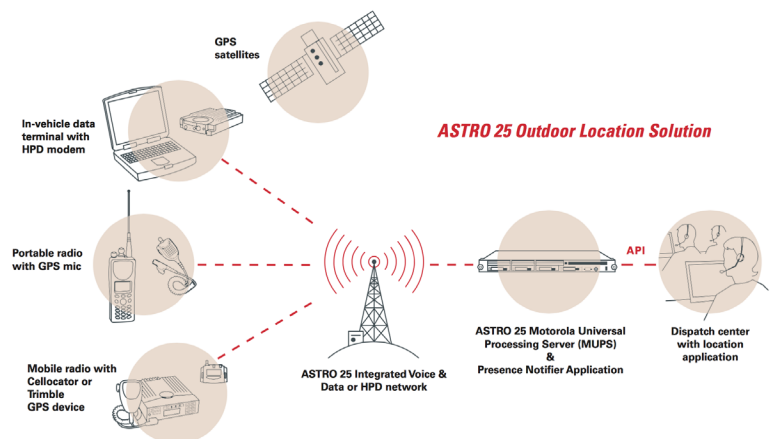
Screenshot of OrbiFire™ demo [video](#)

Information regarding price and specific deployment within the first responder community does not appear to be publicly available.

Outdoor Responder Geolocation

ASTRO 25 Outdoor Location Solution

Motorola, Inc. (Schaumburg, Illinois) claims to be a global leader in mission-critical communications products, services and solutions. Specifically, Motorola offers the ASTRO 25 Outdoor Location Solution, a suite of products used for tracking the location of people and assets via a Motorola-provided GPS device, connected to an ASTRO 25 radio. The solution provides operators with the ability to accurately locate and track outdoor personnel and assets on-demand and in real-time. The solution’s Dispatch Mapping feature enables GPS coordinates to be sent over the air to the Motorola Universal Processing Server (MUPS) and integrated into a mapping application via the Application Programming Interface (API).



Information regarding price and specific deployment within the first responder community does not appear to be publicly available.

Echo Responder™

Echo Response Technologies, LLC (New York, New York) develops mobile applications and tactical tools for emergency first responders. Echo Responder™ is described as a robust solution for any size or type of emergency response agency. The mobile application provides tactical intelligence such as dispatch instructions, location of responders and apparatuses, incident scene footage and responder-to-responder messaging.

Echo Responder™ is available for purchase at the user (\$2.00 per month), department (\$75.00 per month) and country level.

Information regarding specific deployment within the first responder community does not appear to be publicly available.



Echo Responder™

Spark Nano 5.0 GPS Tracker

BrickHouse Security (New York, New York) is a global supplier of security and surveillance solutions. BrickHouse Security claims to provide solutions and consulting services to more than 400 of the Fortune 500 companies and more than 2,500 local and national government agencies, including the New York Police Department (NYPD), the Los Angeles County Sheriffs Department and the Federal Bureau of Investigation (FBI).

The Spark Nano 5.0 GPS Tracker is a motion-activated, weather-resistant, personal GPS tracker, that provides real time location viewing via a computer, tablet or smartphone. Its battery is rechargeable and can run up to two weeks or more under normal use (approximately 1 hour a day). Spark Nano 5.0 GPS Tracker retails for approximately \$129.99 per device, with an added service plan of \$29.99 per month. Discount tracking rates are available for multiple unit purchases.

Information regarding specific deployment within the first responder community does not appear to be publicly available.

SPOT Trace® and SPOT Gen3®

SPOT, LLC (Milpitas, California) offers a diverse product line of satellite technology devices for all types of outdoor enthusiasts and other users, such as first responders. SPOT, LLC solutions are also operable in maritime environments.

SPOT Trace® utilizes 100 percent satellite technology to track valuable asset(s) in near real-time. Location information regarding the asset(s) is displayed on a mobile device or computer interface. SPOT Trace® retails for approximately \$119.95 per device.

SPOT Gen3® utilizes 100 percent satellite technology to track a user's location in near real-time and provide pre-programmed communication capabilities. Information regarding the user's location is displayed on a mobile device or computer interface. SPOT Gen3® retails for approximately \$169.95 per device with an added service plan fee of \$149.99.

Information regarding specific deployment within the first responder community does not appear to be publicly available.



SPOT Personal Locator Beacons

Maritime (Above and Below Water) Geolocation

Navimate™

Shb Instruments Inc. (Northridge, California) manufactures high technology electronics, such as magnetic measurement instruments. Navimate™ is a product of Shb Instruments Inc. The technology was invented to provide underwater navigation to recreational and professional divers. The product functions through use of a small unit that is most commonly hung from a dive boat or buoy (the GPS gateway). The GPS gateway has a floating radio antenna to determine its exact location and communicates with the wrist units (attached to the users) via its underwater transducer portion using acoustic signals. As a result of this communication, the wrist units know their range and bearing from the GPS gateway, as well as the exact position of the gateway. Additional Navimate™ features include the following:



Navimate™

- > Display of exact latitude and longitude coordinates
- > Display of detailed maps of underwater terrain (where available)
- > A computer interface allows a user to save marked points of interest and download new maps
- > Display of other Navimate™ users and their exact positions
- > Ability to communicate with other Navimate™ users (i.e. air pressure information, SOS call)

Information regarding price and specific deployment within the first responder community does not appear to be publicly available.

Hybrid (Indoor and Outdoor) Responder Geolocation

Altus Blue Force

Polaris Wireless (Mountain View, California) is a wireless location technology provider. The company offers location capabilities on all air interfaces and devices, as a standalone solution or in hybrid mode.

Polaris Wireless offers the Altus Blue Force, a user-friendly, smart device based mobile solution that provides real-time location of all “opted in” field personnel with their safety as the prime focus. Knowing where public safety personnel are located at all times and facilitating non-voice communications efforts in the field can be achieved with Altus Blue Force. Altus Blue Force offers the following features:



Altus Blue Force Location Map

- > Works in all environments, from woodland areas to deep indoors, and across all popular iOS and Android mobile devices
- > Easily deployed in the cloud with Software as a Service (SaaS) model
- > Fully supports all security requirements
- > Designed with open APIs for integration of external data sources
- > Offers cost effective, flexible pay-as-you-go options

Additional key benefits include the following:

Constant High Accuracy Location Awareness – users can receive continuous real-time location updates of “opted in” team members, this includes coordinates of ground locations and floor level when operating inside of a building. Users are also able to view periodic updates and associated timestamps on a map for easy orientation.

Map Annotations and Visual Communications – users are able to exchange visual information such as photos, visuals, etc. and can annotate a team map with geo-fences and icons representing critical areas.

The “Z” (elevation) Value – users are able to obtain floor level information about their team members through an advanced weather independent, elevation calculation engine. With this, users can plan backups, evacuation and pursuit of a suspect or victim within minutes as opposed to hours.

Team Management and Emergency Mode – users can self-define cross functional teams and roles and update them on an as needed basis. In addition, it enables users to locate team members at a very high frequency and within seconds.

Multi-Team, Multi-Agency and Multi-Device Collaboration – users are able to communicate with multiple teams simultaneously with secure messaging and alerts. In addition, users are able to coordinate rapid and accurate multi-agency incident response planning.

Information regarding price and specific deployment within the first responder community does not appear to be publicly available.

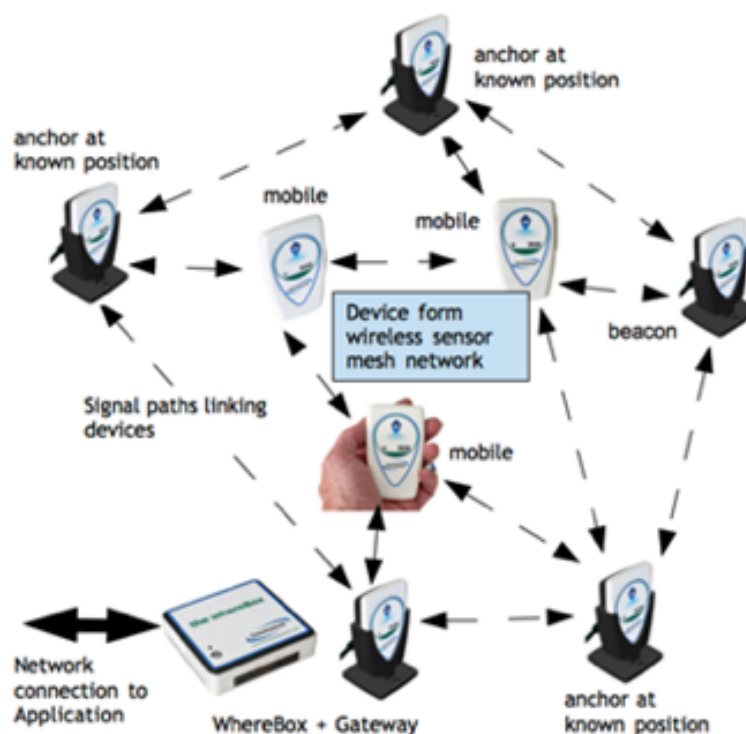
Omnisense S500

Omnisense Ltd. (Cambridge, United Kingdom) develops and exploits proprietary IPR in advanced real-time locating systems (RTLS). The company's patented 'Cluster' technology offers highly accurate real time tracking without the costs, inconvenience and disruption needed to install a fixed infrastructure. Omnisense solutions can be utilized in various market sectors including emergency services (i.e. firefighters, fire responders, police, prisons, incident management, event management and security). For emergency services, the Omnisense S500 solution claims to provide the following benefits:

- > Continual awareness of location where GPS cannot be relied upon
- > Enhanced command, control and safety
- > Support for rapid deployment of personnel in hazardous environments attending incidents, safe recovery of personnel and objects
- > Situational Awareness – accurately identifying and locating assets and individuals
- > Improved monitoring, analysis and debriefing of training events
- > Detection and monitoring of activity intensity and behavioral patterns
- > An auditable record of the history of behavioral and positioning information
- > A tool for improved post-incident analysis and debriefing

The S500 solution claims to be optimized for position, motion and behavior tracking in local areas, indoors and outdoors for groups or teams of objects. The solution is a full 3D system and the Nodes include motion sensors that allow it to deliver information about the attitude (heading, pitch and roll) of the sensor. It also includes smart algorithms to interpret the position and behavior in a contextual way (e.g. zone occupancy, neighbor associations or fall alert).

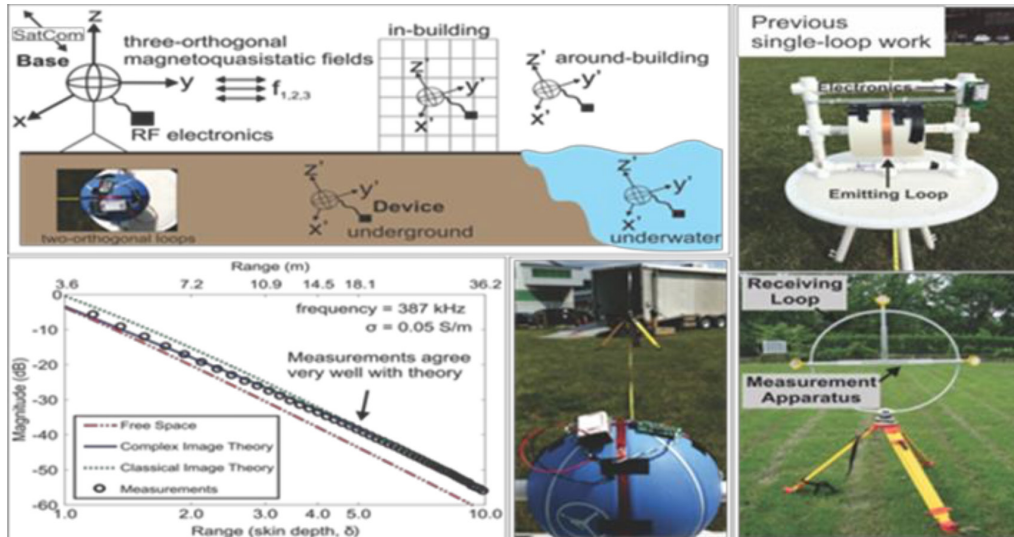
Information regarding price and specific deployment within the first responder community does not appear to be publicly available.



Omnisense S500 System

Precision Outdoor and Indoor Navigation and Tracking for Emergency Responders (POINTER)

POINTER is a precision positioning sensor system that locates first responders via low-frequency magnetic fields that can transmit signals through materials such as wood, concrete, brick and rebar. The solution is currently under development by the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) and the National Aeronautics and Space Administration Jet Propulsion Laboratory (NASA JPL).



POINTER utilizes radio frequency emissions to track and locate first responders in all environments

POINTER is composed of a system of electrically-small magnetic field loops that generate a magnetoquasistatic energy field. The magnetoquasistatic energy field is capable of penetrating most materials without significant energy loss. In addition, responders are required to wear a small transmitter to send signals to a receiver located at a base-station or command unit. POINTER's specific capabilities include:

- Administration of 3D location and motion tracking
- Operational indoors and outdoors, above and below ground and underwater
- Enables precise positioning for numerous response applications including long-range in-building positioning, air-to-underground position for individuals inside mines or bunkers and heavily-cluttered electromagnetic environments where line-of-sight may be compromised



POINTER field trial, Spring 2016

Recent testing concluded the technology is reliable with a margin of error of less than three feet. The next anticipated phase of testing will determine the system's 3D tracking capability and identification of the location and elevation (i.e. what floor a responder is located). A commercialized system is expected in 2017.

TRX NEON®

TRX Systems, Inc. (Greenbelt, Maryland) delivers location software and solutions. TRX initially entered the market to safeguard public safety personnel when operating indoors or in GPS-denied environments.

The TRX NEON® solution implements sensor fusion and mapping to deliver accurate 2D and 3D navigation maps inside buildings, outdoors in urban canyons and underground, without relying upon pre-installed or networked infrastructure. Tracker enables users to be located and tracked both indoors and outdoors using a combination of technologies including sensor fusion, Wi-Fi, Bluetooth and GPS. TRX NEON® is available as a “turnkey service” for personnel tracking and signal mapping, as well as a location service API for third party applications.

NEON® Personnel Tracking Developer’s Kit, which includes the NEON Command Software, NEON® Location Service and API, NEON® Personnel Tracker UI, four multi-purpose NEON® Tracking/Anchor Units, six months software license and access to NEON® Cloud Service, retails at \$3,499.00 per kit. NEON® Signal Mapper Developer’s Kit, which includes the Command Software, Location Service, Signal Mapper UI, four Tracking Units and six months of NEON cloud-based logging services, retails at \$2,999.00 per kit.

The TRX NEON products and services use technology covered by the following patents: USPTO 8,688,375, USPTO 8,706,414, USPTO 8,712,686, USPTO 8,965,688, USPTO 9,008,962, USPTO 9,046,373, USPTO 8,930,163, USPTO 8,751,151, USPTO 9,146,113, USPTO 8,990,014, USPTO 9,322,648, USPTO 9,297,658, Australia PTO 2007348326, Australia PTO 2012203438, Singapore PTO 148346, Singapore PTO 158730, EPO (France, Germany, Great Britain), EP2179600, Australia 2013300136.

Information regarding specific deployment within the first responder community does not appear to be publicly available.



TRX NEON® Personnel Tracker

Market Figure Disclaimers

RTO: Indoor (Above and Below Ground) Responder Geolocation

Indoor Location - the Indoor Location market forecast period is 2014 to 2019 with market figures available for 2014 and 2019. The CAGR of 35.78 percent was used to estimate the revenue values for 2015 to 2020. The figure for 2020 was extrapolated outside of the market forecast period of 2014 to 2019.

Light Detection and Ranging (LiDAR) - The LiDAR market forecast period is 2016 to 2022 with market figures available for 2016 and 2022. The CAGR of 14.87 percent was used to estimate the revenue values for 2015 to 2020. The figure for 2015 was extrapolated outside of the market forecast period of 2016 to 2022.

Magnetic Field Sensors - the Magnetic Field Sensors market forecast period is 2013 to 2020 with market figures available for 2013 and 2020. The CAGR of 8.83 percent was used to estimate the revenue values for 2015 to 2019.

Radiofrequency Identification (RFID) - the RFID market forecast period is 2014 to 2020 with market figures available for 2014 and 2020. The CAGR of 15.08 percent was used to estimate the revenue values for 2015 to 2019.

RTO: Infrastructure Standards for Technology Integration

Anti-Jamming Market for Global Positioning System (GPS) Technology - the Anti-Jamming Market for Global Positioning System (GPS) Technology market forecast period is 2016 to 2022 with a market figure available for 2022. The CAGR of 7.69 percent was used to estimate the revenue values for 2015 to 2020. The figure for 2015 was extrapolated outside of the forecast period of 2016 to 2022.

Building Information Modeling (BIM) - the BIM market forecast period is 2015 to 2020 with a market figure available for 2020. The CAGR of 14.58 percent was used to estimate the revenue values for 2015 to 2019.

Outdoor Wi-Fi - the Outdoor Wi-Fi market forecast period is from 2013 to 2018 with market figures available for 2013 and 2018. The CAGR of 19.29 percent was used to estimate the revenue values for 2015 to 2020. The figures for 2019 to 2020 were extrapolated outside of the forecast period of 2013 to 2018.

Public Safety In-Building Wireless Distributed Antenna System (DAS) - the DAS market forecast period is 2016 to 2021 with market figures available for 2016 and 2021. The CAGR of 37.21 percent was used to estimate the revenue values for 2015 to 2020. The figure for 2015 was extrapolated outside of the forecast period of 2016 to 2021.

RTO: Rapid Building Characterization, Generation and Display

Head Up Display (HUD) - the HUD market forecast period is 2015 to 2020 with a market figure available for 2020. The CAGR of 35.10 percent was used to estimate the revenue for 2015 to 2019.

RTO: Outdoor Responder Geolocation

Global Positioning System (GPS) Receiver Market for Mid/High Level Real-Time Kinematics (RTK) - the GPS receiver market for RTK forecast is for 2015 to 2020 with a market figure available for 2020. The CAGR of 18.98 percent was used to estimate the revenue values for 2015 to 2019.

RTO: Maritime (Above and Below Water) Geolocation

Automatic Identification System (AIS) - the AIS market forecast period is 2014 to 2020 with market figures available for 2014 and 2020. The CAGR of 4.33 percent was used to estimate the revenue values for 2015 to 2019.

Cables and Connectors Market for Satellite and Submarine Industries - the cables and connectors market for satellite and submarine industries forecast period is 2013 to 2020 with market figures available for 2013 and 2020. The CAGR of 12.68 percent was used to estimate the revenue values for 2015 to 2019.

Hydrographic Survey Equipment - the hydrographic survey equipment market forecast period is 2016 to 2021 with market figures available for 2016 and 2021. The CAGR of 5.51 percent was used to estimate the revenue values for 2015 to 2020. The figure for 2015 was extrapolated outside of the forecast period of 2016 to 2021.

Hybrid (Indoor and Outdoor) Responder Geolocation

Geographic Information System (GIS) - the GIS market forecast period is 2014 to 2020 with market figures available for 2014 and 2020. The CAGR of 11.43 percent was used to estimate the revenue values for 2015 to 2019.

Glossary

Compound Annual Growth Rate (CAGR)

The average annual growth rate when compounding is taken into account; its formula is as follows:

$$CAGR = (FV/PV)^{(1/n)} - 1$$
, where FV is the future or ending value, PV is the present or starting value and n is the number of years between PV and FV.

First Responder

A person among those responsible for going immediately to the scene of an accident or emergency to provide assistance. The first responder market is to include law enforcement, fire services and emergency medical services.

Hybrid (Indoor and Outdoor) Responder Geolocation

The identification of one or more responders' precise location within or outside of any type of commercial or residential building, structure or enclosed setting underground (for example, basements, caves, subway systems, tunnels). Hybrid responder geolocation solutions are operable in all environments. In order to function in all environments, these solutions often combine multiple technology capabilities.

Project Responder 4 (PR4)

The fourth in a series of studies that commenced in 2003 to focus on identifying capability needs, shortfalls and priorities for catastrophic incident response in the United States. Findings, including a set of enduring and emerging capability needs, technology objectives and state of science and technology to meet capability needs, are based on discussions with federal, state and local first responders as well as technical subject matter experts (SMEs).

Response Technology Objective (RTO)

A term used within Project Responder 4 (PR4) to translate a capability statement into an actionable, technology-centric objective.

**RTO: Indoor (Above and Below Ground)
Responder Geolocation**

The identification of one or more responders' precise location within any type of commercial or residential building, structure or enclosed setting underground (for example, basements, caves, subway systems, tunnels). Further, according to a proposed standard (18305) from the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC), indoor responder geolocation may be defined as any environment where there is no line of sight to the sky. This proposed standard would therefore include responders working within or under rubble piles.

**RTO: Infrastructure Standards for Technology
Integration**

The standard requirement of technology integration in infrastructure, especially in regards to indoor environments (for example, commercial or residential buildings).

**RTO: Maritime (Above and Below Water)
Responder Geolocation**

The identification of one or more responders' precise location either above or below a body of water's surface.

RTO: Outdoor Responder Geolocation

The identification of one or more responders' precise location outside of any type of commercial or residential building, structure or enclosed setting underground (for example, basements, caves, subway systems, tunnels).

**RTO: Rapidly Building Characterization,
Generation and Display**

The ability to rapidly characterize, generate and display a three-dimensional (3D) visualization of a building to provide enhanced situational awareness to responders at incident scenes; aiding the development of indoor (above and below ground) responder geolocation.

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RTO: Indoor (Above and Below Ground) Responder Geolocation

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RTO: Maritime (Above and Below Water) Geolocation

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RTO: Rapid Building Characterization, Generation and Display

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