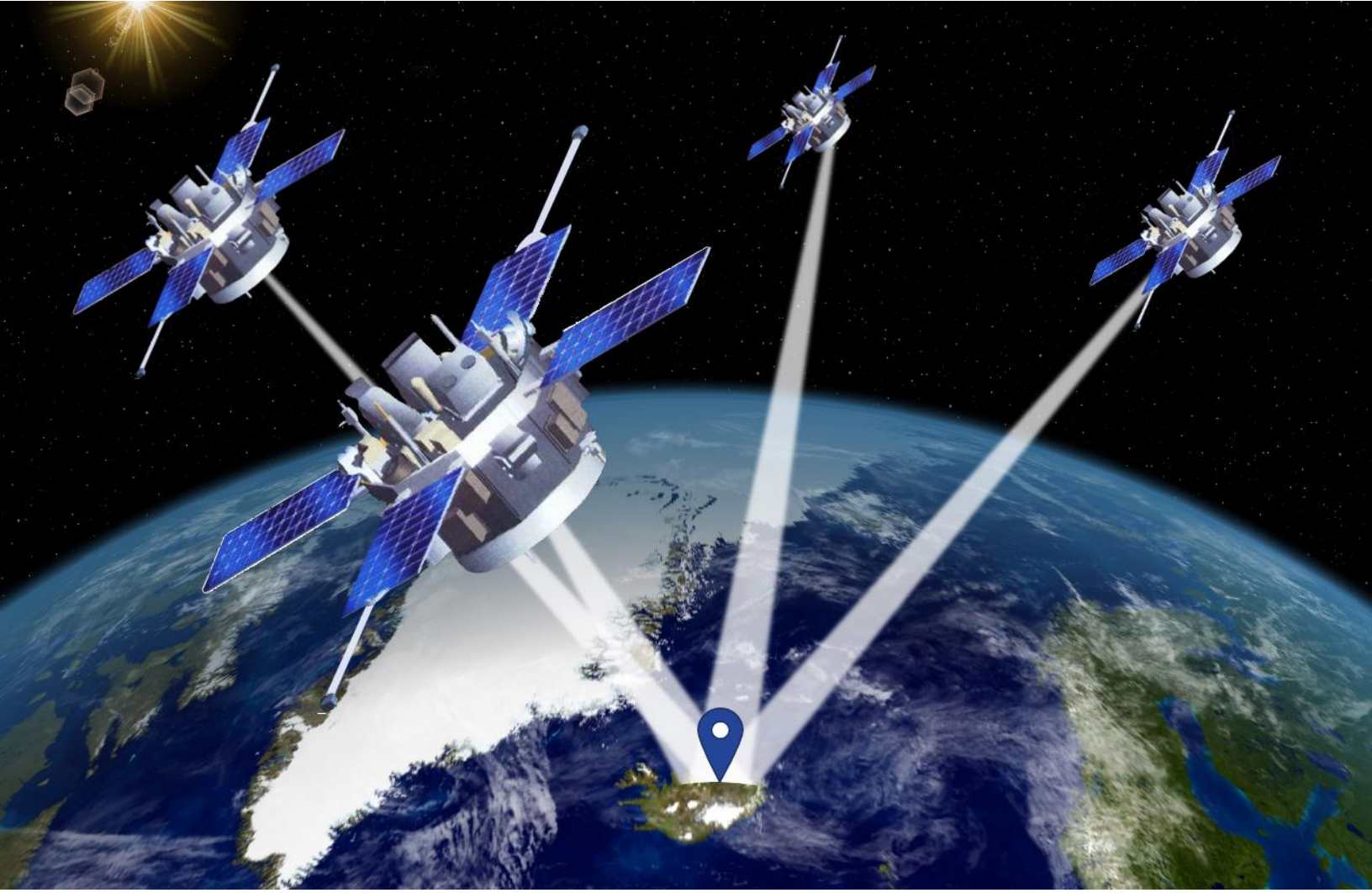

System Assessment and Validation for Emergency Responders (SAVER)

GPS Blue Force Tracking Systems Application Note

April 2014

Homeland Security
Science and Technology

U.S. Department of Homeland Security
SAVER
System Assessment and Validation for Emergency Responders

Prepared by Space and Naval Warfare Systems Center Atlantic

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FOREWORD

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders making procurement decisions. Located within the Science and Technology Directorate (S&T) of DHS, the SAVER Program conducts objective assessments and validations on commercially available equipment and systems, and develops knowledge products that provide relevant equipment information to the emergency responder community. The SAVER Program mission includes:

- Conducting impartial, practitioner-relevant, operationally oriented assessments and validations of emergency response equipment; and
- Providing information, in the form of knowledge products, that enables decision-makers and responders to better select, procure, use, and maintain emergency response equipment.

SAVER Program knowledge products provide information on equipment that falls under the categories listed in the DHS Authorized Equipment List (AEL), focusing primarily on two main questions for the responder community: "What equipment is available?" and "How does it perform?" These knowledge products are shared nationally with the responder community, providing a life- and cost-saving asset to DHS, as well as to Federal, state, and local responders.

The SAVER Program is supported by a network of Technical Agents who perform assessment and validation activities. As a SAVER Program Technical Agent, the Space and Naval Warfare Systems Center (SPAWARSYSCEN) Atlantic has been tasked to provide expertise and analysis on key subject areas, including communications, sensors, security, weapon detection, and surveillance, among others. In support of this tasking, SPAWARSYSCEN Atlantic developed this report to provide emergency responders with information on current GPS tracking systems, which fall under AEL reference number 04AP-02-OAPT Personnel Location Systems: Operations Area Personnel Tracking and Accountability, as well as AEL reference number 04AP-02-DGPS Device: Global Positioning System.

Visit the SAVER website on First Responder.gov (http://www.firstresponder.gov/SAVER) for more information on the SAVER Program or to view additional reports on GPS tracking systems or other technologies.

POINTS OF CONTACT

SAVER Program
U.S. Department of Homeland Security
Science and Technology Directorate
FRG Stop 0203
245 Murray Lane
Washington, DC 20528-0215

E-mail: saver@hq.dhs.gov
Website: http://www.firstresponder.gov/SAVER

Space and Naval Warfare Systems Center Atlantic
Advanced Technology and Assessments Branch
P.O. Box 190022
North Charleston, SC 29419-9022

E-mail: ssc_lant_saver_program.fcm@navy.mil

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1. INTRODUCTION

The Global Positioning System (GPS) is a constellation of more than 30 satellites orbiting the earth. These satellites broadcast radio signals that can be used to calculate and track the location information of people, vehicles and other assets equipped with GPS receivers. A specific application of this technology is blue force tracking, a term coined by the U.S. military that refers to monitoring the location of friendly forces' personnel and resources in a particular area of operation. GPS blue force tracking also includes civilian emergency responders, such as firefighters, law enforcement, and emergency medical services (EMS) technicians. Blue force tracking systems use GPS in combination with other technologies to increase the safety of emergency responder personnel and offer dynamic situational awareness.

Many emergency responder agencies have mutual aid agreements in place that significantly expand their potential areas of responsibility. GPS blue force tracking systems can help identify fellow members of multidisciplinary and multijurisdictional teams operating together and lessen the risk of friendly fire accidents. Real-time location information can also aid in finding injured personnel and provide a common operating picture (COP) to help determine the best use of assets. Large-scale incidents, such as the Boston Marathon bombing in April 2013 and recurring wildfire disasters in the United States, pose complex challenges for coordinating the efforts of multiple agencies and responders across large areas.

The following sections present information on GPS blue force tracking systems and their operational uses to assist emergency responders. This report is based on information gathered from October 2013 to January 2014 from Internet searches, industry publications, and interviews with subject matter experts.

2. GPS BLUE FORCE TRACKING SYSTEMS TECHNOLOGY OVERVIEW

GPS blue force tracking systems use a variety of technologies to track personnel and assets in real time or at specified intervals. The minimum primary components include a GPS tracking unit carried by or attached to individual personnel and assets, and a software package that typically includes a mapping application.

The tracking unit consists of a GPS receiver that calculates location information and a communications module that transmits the information. The software package collects and displays current personnel and asset location information in a graphical user interface (GUI) accessible to incident commanders and, in many cases, individual personnel. Increasingly, GPS blue force tracking systems incorporate a combination of GPS and other wireless communications capabilities and devices. The following sections describe these components of a blue force tracking system.

Additionally, there are two technologies which enhance these systems: specialized sensors and mesh nodes. Specialized sensors monitor personnel safety. Mesh nodes are an emerging wireless technology intended to provide tracking communications in areas with traditionally poor signal conditions (e.g., multi-story structures, underground).

2.1 GPS Tracking Unit

GPS tracking units (Figure 2-1) are often categorized according to how they log and retrieve location information, and are referred to as passive or active. Both passive and active tracking units contain a GPS receiver to determine the device's current location. However, passive tracking units log and store the data on the device for later download to a computer, whereas active tracking units can calculate and broadcast location information in real time. Active tracking units transmit their current location information to a central location, such as a database server, using a built-in communications module. Active tracking units provide a real-time COP during an event or incident, but passive tracking units are typically less expensive since they do not include a communications module suitable for real-time location reporting. Therefore, GPS blue force tracking systems may incorporate both types of units, depending on the need to capture particular personnel and asset movement in real time.

Figure 2-1. GPS Tracking Units

Images Courtesy of Chirange Technologies

GPS tracking units may be:

- **Dedicated GPS devices:** Standalone/autonomous devices whose primary function is GPS tracking and/or navigation; and
- **GPS-enabled mobile devices:** Devices such as smartphones, tablets, laptops, radios, and cameras that include GPS functionality.

The chosen form of a tracking unit depends on agency mission requirements. A GUI may or may not be a feature of the tracking unit. The following are types of tracking units available:

- Bracelets and wristwatches;
- Handheld and pocketable devices;
- Tablets;
- Mobile or permanently-mounted devices in vehicles (discussed in detail in the Automatic Vehicle Locating Systems [AVLS] SAVER publications, available on the SAVER website [http://www.firstresponder.gov/SAVER]);
- Laptop computers;
- Portable satellite terminals; and
- Collars, harnesses, and chip implants for law enforcement animals (e.g., K-9s).

GPS-enabled smartphones and tablets, as well as some newer models of dedicated GPS devices, are examples of tracking units that display maps and location information. These units provide increased situational awareness.

2.1.1 GPS Receivers

GPS receivers determine the location of the GPS tracking unit by utilizing high-frequency, low-power radio signals to obtain orbital and time stamp information from at least four GPS satellites in line-of-sight. The receiver then uses this information to determine its position on the earth's surface to within 20 meters or less, depending on receiver hardware and environmental conditions. In most cases, the receiver translates location information into longitude, latitude, and elevation. However, some receivers use the Universal Transverse Mercator (UTM) instead. UTM is a system of global, grid-based maps that transform the earth's three-dimensional (3-D) surface into a flat two-dimensional (2-D) surface using a mathematical formula.

GPS receivers collect and store orbital information for all the GPS satellites in an almanac. The almanac is a general schedule of where every satellite should be at any given time. All GPS satellites broadcast this almanac information. Additionally, each satellite transmits its own ephemeris data (i.e., precise corrections for any deviations/errors specific to that individual satellite's predicted orbit). The receiver combines this data to more accurately determine location information.

Adverse signal conditions can slow or prevent the receiver from downloading the necessary almanac and ephemeris data. This process can take significant time and if the receiver loses the signal, it must start over. Assisted GPS and differential GPS, as explained below, are techniques that can aid in acquiring more accurate location information.

- **Assisted GPS (A-GPS):** A-GPS offers an alternative to downloading data from the satellites alone. A-GPS can lessen the time the receiver needs to determine its initial position, referred to as time-to-first-fix (TTFF), by obtaining fresh almanac and ephemeris data from wireless network resources instead. When GPS signals are weak or unavailable, A-GPS-equipped receivers can also calculate proximity to cellular towers or Wi-Fi® base stations with precisely known GPS coordinates to determine position. Smartphones typically include A-GPS capability.
- **Differential GPS (DGPS):** DGPS is a technique that improves positional accuracy. It helps correct errors from radio signals bouncing off of large objects, such as skyscrapers, or when signals weaken from passing through walls, tree cover, or variations in the atmosphere. A DGPS-equipped receiver uses fixed, ground-based reference stations to determine the effect of local environmental conditions on satellite signals. A fixed, ground-based station occupies a known position, and can therefore readily calculate its own receiver's current signal inaccuracy. The station then broadcasts to all DGPS-equipped receivers in the area, providing signal correction data. Within 10 seconds, the roving receiver can apply this position correction to its own location information and be accurate within 10 meters.
    - **Wide-Area Augmentation System (WAAS):** WAAS is a DGPS system originally developed to assist in aerial navigation. It consists of many ground reference stations positioned across the United States that monitor and correct errors in GPS signals. Two master stations, one on each coast, then collect all the reference station data and create a GPS correction message. This message is then uplinked to one of two fixed-orbit satellites, where it can then be broadcast to WAAS-enabled receivers. Accuracy is often within 3 meters.

2.1.2 Communications Modules

Once the GPS receiver determines the tracking unit's current location, a communications module within that tracking unit transmits this location information through a wireless communications service, such as Wi-Fi, broadband, cellular network, or satellite Internet, depending on the specific GPS product and service plan. Access to multiple transmission options helps ensure communications are not interrupted or lost in environments where a particular type of wireless service proves unreliable due to poor signal conditions.

Many systems leverage the strengths of both GPS and wireless communications technology to track personnel and assets. GPS is typically utilized for determining outdoor location information, and wireless for improved indoor tracking.

2.2 Tracking Software

Blue force tracking software often utilizes a robust geographic information system (GIS) mapping application to track movement of personnel and assets in real time or at specified intervals. This process is illustrated in Figure 2-2. Blue force tracking software collects and interprets dynamic location information from multiple tracking units and displays it in a graphical interface. In addition to the mapping application, software products are likely to include middleware invisible to the end user, but necessary for fulfilling important backbone and infrastructure requirements.

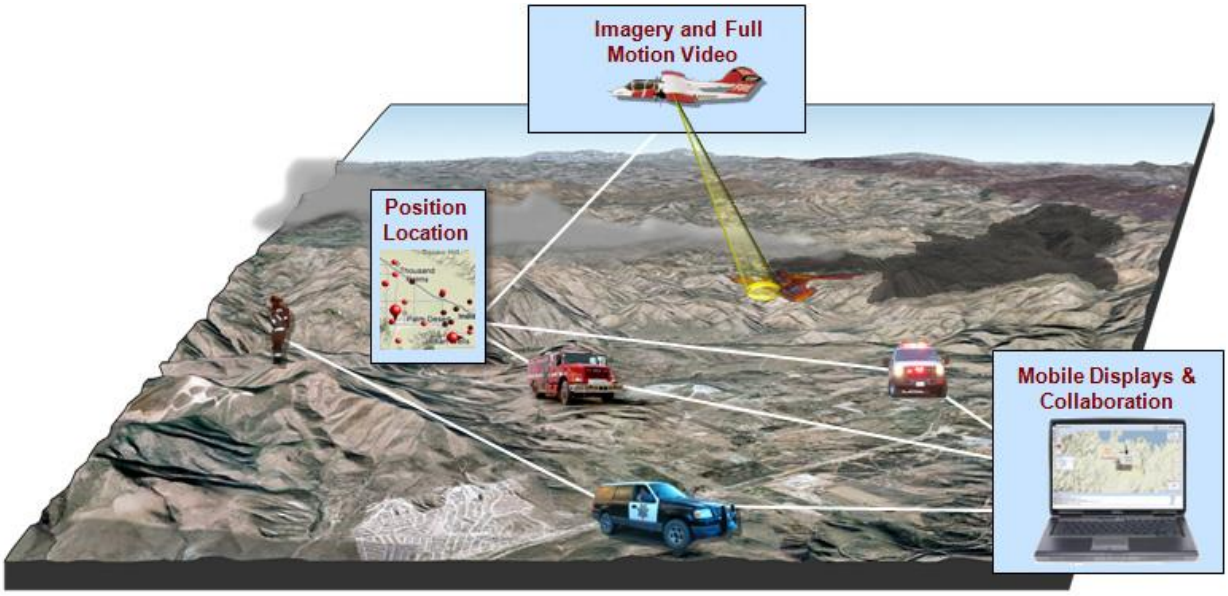

Figure 2-2. Blue Force Tracking Illustration

Photo Courtesy of Massachusetts Institute of Technology (MIT) Lincoln Laboratories

It is not uncommon for blue force tracking systems to be incorporated into larger, more comprehensive software packages that offer an extended range of tools for overall incident command support. These systems may offer cross-platform solutions that function on more than one type of operating system, such as Microsoft Windows® and Apple® Mac OS X®, or more than one mobile operating system like Google Android™ and Apple® iOS. Cross-platform

products often leverage common standards-based software to promote use on different operating systems.

The kind of software package chosen may influence how readily an agency can expand the system to include additional end users and leverage third-party applications, such as mapping resources or sensor plugins that provide specialized information. Blue force tracking software may be deployed on in-house servers (i.e., client/server model), be web-based, or be downloaded as a mobile application.

- Web-based applications are programs hosted on an external server and accessed over a network connection, rather than residing in a computer or device's memory. Authorized personnel can log in using an ordinary web browser and Internet connection. This enables agencies to run a program or application on many connected computers at the same time.
- Native mobile apps are applications developed specifically for mobile devices like smartphones and tablets. They are installed through an app store like Google Play™ or Apple's App Store℠, and designed to fully utilize the mobile device's many features. Mobile apps can be accessed through icons on the device's home screen.

Blue force tracking software is often optimized for use with particular GPS tracking devices. However, the prevalence of software application programming interfaces (APIs) expands potential use with multiple types of tracking devices, whether dedicated GPS units or GPS-enabled devices. APIs provide instructions and standards for other developers to use in order to design or utilize products that complement the original applications and tools. APIs are software-to-software interfaces that can also allow for the incorporation of additional agency-specific databases and other resources.

2.3 Sensors

A variety of sensors are available to track specialized information, such as equipment supply levels, physical health (e.g., heart rate and respiration) of individual personnel, or position status—whether an individual is moving, lying down, or stationary. Some blue force tracking applications support plugin interfaces for integration of multiple sensor types. These sensors may be commercial off-the-shelf (COTS) or custom plugins.

Sensors are typically compact in nature for easy mobility. For example, physiological health sensors may be strapped to the body or integrated into a shirt. They are designed to interface with common equipment, such as tactical radios or smartphones that may also provide location information. Sensor data may be logged or transmitted through a network connection, such as Bluetooth®, which uses low-power radio communications to link network devices within approximately 30 feet of each other. Sensor data for multiple individuals and teams may be remotely monitored, shared in real time, and accessed through a mobile app or web-based application visual interface.

2.4 Mesh Nodes

Mesh nodes are an emerging technology that can help promote seamless communication and tracking capability underground, inside buildings, and in other locations with traditionally poor GPS signal conditions. As shown in Figure 2-3, mesh nodes are small radio transmitters that are part of a decentralized type of wireless network (called a mesh network). Each node acts like a wireless router with the ability to 1) capture and disseminate its own data and 2) serve as a relay for other nodes. Mesh networks can maintain strong signal strength by sending data on a series of short hops to whichever nodes provide the most efficient path to the final destination. If a node malfunctions, the network re-routes around it and uses other nodes (self-heals). A mesh network also self-configures, automatically incorporating new nodes enabled within its range. This allows a mesh network to be flexible and cover a potentially large area.

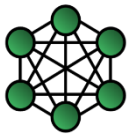

Figure 2-3. Mesh Network

Photo courtesy of Wikimedia Commons

Mesh nodes are viewed as an adaptable resource and can be fixed or mobile. Mobile mesh nodes can be added for ad hoc events or situations, as needed, and then removed for use elsewhere. Some cities have the ability to reserve the use of mesh networks for emergency responder agencies in case cellular networks become overtaxed or unavailable during emergencies.

Individual mobile mesh nodes may be fitted with GPS receivers to provide real-time location information. Additionally, each node may maintain a list of media access control (MAC) addresses, which provide an identifier for every device using its services. Combined with the known fixed or GPS-derived location of each node, an approximation can then be made to determine an end user's location. Mesh nodes can also be used to receive and transmit health and safety sensor data on personnel.

3. APPLICATIONS

GPS blue force tracking systems may increase the safety of emergency responder personnel by offering dynamic situational awareness at both the tactical and command level. Blue force tracking systems may be utilized by firefighters, law enforcement, and EMS technicians during incidents, disaster response, search and rescue, special events, or even daily operations.

3.1 Situational Awareness and Collaboration

Knowledge of the real-time location of essential personnel and assets can help emergency responders and their command elements develop a COP and make better informed decisions during an incident or large-scale event. Blue force tracking systems can provide tracking information on personnel, vehicles, and other assets.

Emergency responders may be required to respond to incidents in unfamiliar areas and as part of multidisciplinary and multijurisdictional teams where fellow field personnel are unknown to each other. Blue force tracking systems may aid in a number of ways. These flexible solutions may help field personnel rapidly build a communications network to share information and form cohesive teams. Some examples include:

- **Navigation:** Personnel may need to be directed to incident command post sites and important infrastructure locations.
- **Identification:** A visual notification on the presence and whereabouts of on-scene personnel can help prevent friendly fire accidents.
- **On-scene personnel tracking of disparate units:** On-scene field personnel may view detailed maps that provide agency-specific information on the location of fellow responders while an incident commander tracks the locations and status of multiagency personnel and assets from the command post.
- **On-scene updates**: Some systems allow field personnel to directly input data such as waypoints, which are latitude and longitude coordinates identifying specific important structures and locations.

The Boston Metropolitan Law Enforcement Council, a consortium of over 43 local area law enforcement agencies, used a blue force tracking system with both command and tactical level software components for 4th of July events. Fifty deployed teams, consisting of Special Weapons and Tactics (SWAT), K-9, Explosive Ordnance, and Marine units, used a blue force tracking mobile app on GPS-enabled Android and iOS smartphones to gain real-time, visual situational awareness of personnel positions. Mobile commanders used tablets to gain a higher level of tracking information, and command post elements were able to monitor operations on laptops. The system also included the deployment of a visual tracking tool that enabled ground personnel to use their devices to view real-time aerial video from a helicopter.

During Game 6 of the World Series in Boston, this same blue force tracking system was used to monitor law enforcement and K-9 unit locations in Fenway Park. Visual communication tools that included texting capability and a visual map display of location information were particularly useful in a venue where the noise of the crowd prevented effective voice radio communications.

Text messaging also offers a means to communicate silently when a situation warrants it. Additionally, in times of heavy communications traffic, text messaging can require fewer network resources.

3.1.1 GPS Position Location Information

The GPS component of blue force tracking systems can provide location information in a number of ways and for a multitude of purposes. A few examples are listed below and depicted in Figure 3-1.

- **Breadcrumb trail and location pinpoint:** GPS tracking units can provide detailed information on an individual's current position and exact path taken (breadcrumb trail), as well as direction, time, and distance travelled. Based on current speed or pace, units can also estimate arrival time at destination. Some systems allow for these data layers to be simplified for an incident commander, showing last known location only, last tracks (path) only, or all tracks, as needed.
- **Geo-tagged photos:** Photos can be time-stamped and tagged with the GPS coordinates (latitude/longitude and altitude) of the location where the photo was taken. Many digital cameras as well as smartphones and tablets have this capability.

- **Routing:** GPS location and navigation features promote more efficient use of assets by providing visual information on the closest vehicles and personnel to an incident, as well as the best routes to get there. GPS can be helpful in avoiding traffic or other obstructions, and difficult terrain. Many GPS devices allow users to flag certain addresses and label them, as well as set waypoints to mark important locations.
- **Evidence:** GPS tracking units log location information of personnel in real time or at set intervals, whether on the tracking unit itself, or at a central server location. Date, timestamp, and location information may be useful as evidence to later support criminal law enforcement cases.
- **Tracking off-leash K-9 units:** K-9s fitted with GPS tracking units in their harnesses may be used to sniff out drug contraband in large areas such as container shipyards. The GPS receiver pinpoints location of the off-leash dog.
- **Personnel/vehicle identification:** GPS tracking units installed in doorways and using a remote GPS identifier can allow authorized individuals to enter specific buildings without sounding an alarm. Also, GPS vehicle tracking can store vehicle location information and speeds as well as driver actions (e.g., braking, lights, siren).

Figure 3-1. Position Location Information

Images Courtesy of MIT Lincoln Laboratories and Scientific Research Corporation

An example of a blue force tracking system successfully used to monitor personnel locations occurred in September 2013. Mountain View Police Department in California used a blue force tracking application to track the movements of over 20 uniformed and plain-clothed law enforcement officers at a concert that drew over 40,000 people in a 2-day period. Those equipped with department-provided mobile phones were tracked from the command post on event grounds, providing situational awareness.

3.1.2 Indoor Position Location Information

Blue force tracking systems leverage the strengths of both GPS and wireless communications technology to track personnel and assets in a variety of environments. GPS is utilized for outdoor positioning—on foot or bike and in vehicles. Accurate indoor tracking of personnel is still considered an emerging technology, although wireless communications and specialized micro-sensors that detect changes in speed, direction, and elevation are increasingly being used to significant effect. Differentiating between floors of a multi-story building has posed the greatest challenge, but recent indoor position location attempts have been successful.

In 2012, the Worchester Fire Department in Massachusetts successfully tested the Department of Homeland Security (DHS)-funded Geospatial Location Accountability and Navigation System for Emergency Responders (GLANSER). The tracking unit transmits location information to software utilized in a command post and provides not only images of basic building interiors, but also firefighters' current location: to include floor level, specific room, and breadcrumb trail. This information is relayed using individual firefighter tracking units as locating devices as well as mesh nodes that help maintain wireless signal strength inside buildings. Issues such as the relatively large size of the tracking unit remain to be resolved before the product goes to market.

Additionally, DHS is working with business partners to perfect the use of 1-inch square, ½-inch thick, throwaway mesh nodes that are waterproof and heat-resistant up to 500° Fahrenheit to work in conjunction with GLANSER. This Wireless Intelligent Sensor Platform for Emergency Responders (WISPER) ejects disposable mesh nodes as a firefighter enters a building and when signal strength weakens to a designated degree. This mesh network is meant to enable remote monitoring and tracking of sensors on emergency responders.

3.2 Health and Safety Monitoring

Blue force tracking systems can aid in locating injured personnel. They can help mitigate physiological as well as environmental risks.

3.2.1 Personnel Biotelemetry

Cardiovascular trauma, such as heart attacks and strokes, remain a top cause of line-of-duty deaths (LODDs) in emergency responders. A primary, national objective of the U.S. Fire Administration is to greatly reduce LODDs within the decade. In response, some blue force tracking systems incorporate life safety sensors that track real-time biotelemetry data, such as heart rate, body temperature, and pulse oximetry (i.e., oxygen saturation in the blood), and relay this vital information back to incident commanders or safety officers. Recently developed products use a physiological sensor strapped around the chest or integrated into a shirt, so as not to impede the wearer's duty performance. An example of this type of device is the Physiological Health Assessment System for Emergency Responders (PHASER), developed by DHS and industry partners.

Additionally, deaths from heat stroke in law enforcement dogs are being mitigated by embedding sensors that monitor their internal body temperature. The K-9 unit of the Plymouth County Sheriff's Department in Massachusetts has utilized K-9 temperature monitoring sensors for their dogs, whose primary functions are to patrol local correctional facilities and perimeters and assist in locating fugitives and missing persons.

Also, blue force tracking systems may include sensors that track whether individual personnel are stationary, moving, or lying down. If lying down, man-down alerts/notifications can be sent to command personnel, while the tracking unit provides location information for rescue and recovery.

3.2.2 Alerts/Notifications

In addition to delivering biotelemetry data, blue force tracking systems may be used to notify commanders of personnel at risk for equipment malfunction or depletion (e.g., a firefighter's air pack supply falling below a certain level). Depending on the system, emergency alerts may be activated automatically when certain thresholds are reached, at the push of a button by the affected individual (i.e., SOS function), or remotely using a ping function.

Commanders may also be notified of breaches to pre-set parameters, such as a geo-fence drawn around an incident area and buffer zone with potential Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) risk. A geo-fence is a virtual perimeter for a real-world geographic area. If the restricted perimeter is breached by field personnel or others carrying GPS-enabled devices, automated alerts may be triggered. Typical notification mechanisms may include an audible alarm, phone vibration, e-mail, or text message.

4. OPERATIONAL CONSIDERATIONS

A variety of factors, discussed below, should be considered prior to purchasing a GPS blue force tracking system or its individual components.

4.1 System Compatibility

Determining how the tracking system and components are expected to enhance, integrate, or replace an agency's existing technology infrastructure and equipment should be a primary concern.

- Some blue force tracking systems are part of larger, more comprehensive software packages that offer an extended range of tools for overall incident command support. Special consideration should be given to interoperability with computer aided dispatch (CAD) tools.
- Many tracking systems now offer multi-platform software that supports the use of a variety of third-party applications and different types of tracking devices. However, the application programming interfaces necessary to make them functional may vary in complexity and expense.
- Agencies should be wary of extra features on devices that prevent efficient usage and actually inhibit performance of duty.
- Alternate data transmission methods may be necessary depending on the geographical environment where personnel will operate, whether rural or urban settings.
- New applications may require modifying standard operating procedures.

4.2 Component Functionality and Integration

Although GPS blue force tracking systems offer an increasing mix-and-match of devices and technologies, some primary functional considerations are discussed below.

4.2.1 GPS Tracking Unit Accuracy and Function

Some considerations for choosing a GPS tracking unit are time-to-first-fix (TTFF), location accuracy, and power consumption.

As explained in Section 2.1.1, TTFF measures how long it takes a GPS receiver to lock or fix with the satellites to acquire signals and determine its position. The TTFF is affected by the start type as discussed below.

- **Factory start:** The receiver has neither current almanac nor ephemeris data, and can take approximately 12.5 to 15 minutes to download all the necessary data;
- **Cold start:** The receiver has retained the general almanac data that remains current for several months, but has no ephemeris data. The receiver may have been switched off for at least 8 to 12 hours, or transported a long distance since last used. TTFF may take 29 seconds to 1.5 minutes;
- **Warm start:** The receiver has valid almanac as well as some ephemeris data. The receiver may have been switched off for a few hours. Typical TTFF may take 6 seconds to over a minute; and
- **Hot start:** The receiver has retained almost a full set of ephemeris data and has been switched off for less than 30 minutes. TTFF may take less than a few seconds.

The number of channels a receiver can monitor simultaneously in order to acquire the necessary signals will typically range from 12 to 20, but some receivers may include over 50. Also, dual frequency (L1 and L2) receivers can provide more options for improved TTFF and resistance to jamming.

Effective GPS tracking relies on geo-location accuracy. Some GPS receivers may provide position accuracy within a distance of a few meters. However, poor weather conditions and local environmental factors can greatly inhibit position accuracy. Therefore, it is essential to understand the capabilities available in a GPS receiver to overcome and correct for errors. GPS receivers with the ability to utilize A-GPS and DGPS may be important resources.

Tracking unit power consumption is discussed below in Section 4.2.3. Additional considerations may include:

- A tracking unit with specific, streamlined functionality versus one that accomplishes multiple tasks. The ability to toggle between viewing texts and GIS maps and taking phone calls in the field may be a factor;
- The work environment and how rugged and water resistant a tracking unit will need to be;
- A dedicated GPS unit versus a GPS-enabled device such as a smartphone with mobile apps; and
- The inclusion of an SOS feature that can be activated on the tracking unit.

4.2.2 Data Transmission Options

To help ensure communications are not interrupted or lost in inhospitable environments, a communications module that offers alternative transmission methods and mobility across multiple networks should play a significant role in choosing a tracking unit. Agencies should identify tracking units that support wireless services already used by the agency or those most appropriate to fulfill the mission under local environmental conditions. Some examples are cellular 3G/4G/LTE networks, Wi-Fi, WiMAX™, satellite Internet service, and, in some cases, mesh and ad hoc mobile networks. Most active tracking units require a monthly data service plan.

How GPS devices communicate with other tracking equipment will also be a consideration. For example, some new models of dedicated GPS tracking units support communications with a smartphone through a Bluetooth connection to access and send information beyond basic GPS coordinates. Another example is a portable two-way radio with cellular voice and data capability connected to a GPS remote speaker microphone. The variety of interconnectivity options is expanding significantly.

Some blue force tracking systems have also developed portable tactical communications packages for situations where reach-back to Wi-Fi and cellular networks at an incident site are unavailable. These tactical communications packages may include a portable satellite terminal as well as a Wi-Fi hotspot router that offers Internet access over a wireless local area network (WLAN).

4.2.3 Transmission Intervals and Power Requirements

GPS blue force tracking systems may incorporate both active and passive tracking units, depending on the need to capture particular personnel and asset movement in real time. The intervals at which active tracking units transmit this information are typically customizable. Transmission intervals can be set as frequently as every 3 seconds; however, intervals of 1 to 10 minutes are more common. If only a snapshot view of movements is needed, extended timeframes such as 4 hours may be sufficient. In addition to set time intervals, tracking units may be designated to update when certain parameters have been met, such as certain distances traveled, changes in heading, or auxiliary equipment turned on or off. Units can also be queried remotely or updated manually by individual field personnel. Set intervals may help prevent tying up valuable network bandwidth with unnecessary reports and preserve the battery life of the tracking unit.

Particularly for satellite communications, sending and receiving significant amounts of data can be a drain on power. However, a dedicated GPS tracking unit may run for 15 to 20 hours on a replaceable lithium battery, whereas a GPS-enabled smartphone may be able to run a mapping application for no longer than 5 to 7 hours before needing to recharge. Transmission intervals can heavily impact battery life. The battery type, and whether both AC and DC power connectors/adaptors are included, may be differentiating factors.

4.2.4 Hosting Locations and Mapping Services

Blue force tracking system software may be hosted on a secure cloud, which requires an annual or monthly subscription, or on an agency's own servers. The choice depends on in-house technical skill levels, infrastructure, and network security.

Active GPS tracking units typically transmit location information to a central location server and have little internal memory available. Agencies should determine how the tracking unit prevents data loss in the event that communications are interrupted.

Blue force tracking units and application packages differ in the quality and variety of GIS maps and services included. Considerations include:

- Usefulness and detail of maps;
- Availability and format of additional maps;
- Update terms, whether free with purchase or by subscription;
- Frequency of updates and the method to receive them;
- Ability to independently input data, such as waypoints;
- Inclusion of municipal traffic reports and route construction zones or closures, and update intervals (i.e., from every 30 seconds to 15 minutes);
- Capability to upload to Google Earth™ for 2-D or 3-D display; and
- Map access when offline (i.e., streaming or downloaded).

Standalone GPS units often must be plugged into a computer to receive updates to maps, although some newer models have built-in wireless communication capability to receive updates.

4.2.5 Information Exchange Formats

Blue force tracking systems may include software configured to send and receive information in a multitude of formats at the incident command level, but desired communications at the tactical level may prove the deciding factor in which type of tracking unit to purchase. GPS tracking units vary in their ability to send and receive some types of information, such as audio communications, Short Message Service (SMS)/text messages, e-mail, text-to-speech processing, and voice to text. They also vary in their ability to display video, data, and imagery.

4.2.6 User Interfaces

Blue force tracking systems used at the incident command level may offer a highly adaptable user interface, such as dashboard-type views that stream data in a variety of formats and layers of complexity. Additionally, for those GPS tracking units at the tactical level that include a visual interface, there are some general considerations:

- **User friendliness:** Simple access, ease of data entry, and sharing capability may be factors, in addition to well-designed control schemes and button placement. Acceptable limitations, such as the ability to use while wearing bulky gloves, should be considered;
- **View and Perspective:** Typical screen sizes range from 3.5 inches to 7 inches for handheld devices, and screens may include color graphics. When viewing large graphic files, the user may only be able to view a fraction of the map on a small viewing screen, making maps difficult to manipulate and understand. GPS-enabled tablets provide larger viewing screens typically over 9 inches. Resolution and screen view in sunlight are additional considerations;

- **Standardized Interface:** Software may make use of standard GUI tools, such as sliders, switches and buttons, finger tap navigation controls, pinch, zoom, drag, drop, and swipe;
- **Customizable:** Software may allow for viewing additional map layers and also for users to access functions easily. However, experienced users may be able to utilize rich command language and keyboard shortcuts; and
- **Interactive Interface:** Some software includes drawing tools and supports dynamic input or updates to operational graphics by end users.

4.2.7 Secure Information Exchange

Blue force tracking systems and components provide various levels of secure communications. The layers of security processing will depend on individual agency requirements. The use of virtual private networks (VPNs) is common. VPNs utilize public networks, yet enable data sharing as if personnel are directly connected to an agency's private network. In particular, mobile VPNs may be used to provide securely encrypted data sessions (i.e., VPN tunnels) to emergency responders traveling and roaming across various networks while conducting on-scene emergency operations. Security measures typically include data encryption, authentication for personnel remote access, and authorized functionality. Smart cards may be used to provide individual personnel identification sign-in for access to web-based applications and programs. The Cryptographic Module Validation Program (CMVP) of the National Institute of Standards and Technology provides an extensive list of encryption modules, including VPNs and smart cards that meet the U.S. Government standards. This CMVP list is available at http://csrc.nist.gov/groups/STM/cmvp/validation.html.

4.2.8 Scalability and Interoperability

Blue force tracking systems can be useful for incidents and events of any size. Yet large-scale emergencies, in particular, may require the tracking of a significant number of personnel and resources that include multidisciplinary and multijurisdictional teams with different tracking and communications equipment. To promote compatibility, blue force tracking components that function on more than one operating system, as well as utilize COTS products and common standards-based software, may be preferred.

Software designed web applications and mobile apps can allow access to users without extensive technical assistance, and be available for use on common devices such as smartphones and tablets. Some blue force tracking software developers state that their systems can support thousands of subscribed end users.

The prevalence of APIs has greatly expanded the potential interoperability of software applications and tools in conjunction with different tracking devices, such as dedicated, handheld GPS units, GPS-enabled devices, and specialized sensors.

The Next-Generation Incident Command System (NICS) is an example of a non-proprietary, open standards, web-based command and control platform that includes a significant and free blue force tracking capability. Sponsored by DHS, Science and Technology Directorate, NICS was developed by the Massachusetts Institute of Technology Lincoln Laboratory in partnership with members of the California First Responder Community for the purpose of increasing

situational awareness in emergencies. The NICS platform is available at http://public.nics.ll.mit.edu/nicshelp/videolibrary.php. NICS has been used in over 250 operational incidents since 2010, including the 2013 Boston Marathon bombing. The Massachusetts National Guard leveraged NICS at the bombings to track and coordinate units during the response.

4.3 Cost and Training

The operational considerations listed above can be used to help select components and systems best suited to an agency's needs. The cost of blue force tracking systems may vary widely depending on many factors that include:

- Tracking unit components;
- Chosen communication networks and service packages;
- Tracking software and necessary APIs;
- Number of software licenses included for users; and
- Types of sensors that may need to be incorporated.

Blue force tracking system software, particularly those that are larger, more comprehensive incident command software packages, will likely be more expensive and require more training to cover the extended range of features. Some software may be free, such as the NICS platform described above or individual mobile apps developed for discipline-specific uses.

The level of technical support available and training needed to learn the software should be determined prior to selecting a platform or application. Also, a significant percentage of errors in location information accuracy derive from a lack of end user knowledge on how to most effectively use GPS tracking units. Organizations such as the National Wildfire Coordinating Group who have extensive experience in the use of GPS conduct 16 to 24 hour GPS courses. These GPS courses are available at http://gis.nwcg.gov/training_gps.html.

5. GPS BLUE FORCE TRACKING SOFTWARE

Table 5-1 lists a number of available blue force tracking software solutions that incorporate a combination of GPS and wireless communications capabilities. This list is representative of software options, rather than being comprehensive. In addition, agencies have a multitude of choices regarding mobile apps that are discipline-specific. This information is based on Internet research and has not been verified with vendors.

Table 5-1. Blue Force Tracking Software

Product	Vendor/Developer	Website
Altus	Polaris Wireless	http://www.polariswireless.com/altus
Blueforce Tactical V 1.2 and Command Center V 1.0	Blue Force Development Corporation	http://blueforcedev.com
Incident Command Tablet Application with GPS Tracking	Chirange Technologies	http://www.chirange.com
CommandTRACKER GPS	Salient Federal Solutions	http://www.salientfed.com/commandtracker-gps
DragonForce	Drakontas LLC	http://www.drakontas.com
GpsGate Server	GpsGate	http://gpsgate.com/blogComment/low_cost_police_tracking_solution
Incident Commander Pro Version 7	SAR Technology Inc.	http://sartechnology.ca/sartechnology/ST_ICPro7GISFeatures.htm
Next-Generation Incident Command System (NICS)	Department of Homeland Security and Massachusetts Institute of Technology	http://public.nics.ll.mit.edu/nicshelp
Raytheon Advanced Tactical System (RATS™)	Raytheon	http://www.raytheon.com/capabilities/products/rats
SARApp™	Metron Inc. and Defense Advanced Research Projects Agency (DARPA)	http://sarapp.com

6. SUMMARY

GPS blue force tracking systems monitor the location of emergency responders and can help ensure their safety. Real-time location information can lead to finding injured personnel faster, and specialized sensors can forewarn of potential health risks or equipment malfunction. If there is a potential CBRNE event, a geo-fence alert may be triggered that warns personnel not to enter the area or proceed any further.

To see the incident area on a GUI along with the current locations of responders from different agencies provides a valuable COP to commanders as well as on-scene personnel. Situational awareness can promote more effective collaboration and better use of resources.

Agencies have many options when selecting components of a blue force tracking system, including GPS tracking units that may be GPS-enabled or dedicated devices, as well as compatible software applications for use with computers and mobile devices. Advances in wireless communications, such as decentralized mesh networks, also allow for increased mobility and greater tracking continuity. The mesh nodes that make up mesh networks are an emerging means of seamless communications inside multi-story buildings and other areas with poor signal conditions.

Agencies considering the purchase of blue force tracking systems or components should carefully evaluate each product's overall capabilities and limitations in relation to their agency's operational needs.