# Personnel Accountability System Technology Assessment

United States Fire Administration
Federal Emergency Management Agency

This publication was produced under contract EME-96-CO-0587 for the U.S. Fire Administration, Federal Emergency Management Agency by IOCAD Engineering Services, Inc. Any information, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of the Federal Emergency Management Agency, the U.S. Fire Administration or IOCAD Engineering Services, Inc.

# TABLE OF CONTENTS

# CHAPTER I – INTRODUCTION

In recent years the fire service has focused considerable and increasing attention on the issue of personnel accountability. Although many fire and rescue agencies are now acknowledging the necessity of having a way to track and account for their personnel, it is difficult and confusing for some to choose the system and equipment best for them because of the variety of options available.

Essentially, personnel accountability is an effort to improve the safety of emergency responders by keeping track of their locations and assignments when operating at the scene of an incident. Accountability can be maintained in many different ways. However, irrespective of the type of personnel accountability system (PAS) implemented, the goals are generally similar.

A properly implemented PAS will help to ensure that the incident command staff knows the exact number and identity of personnel working at an incident, their approximate locations, and whether they are in distress. In some form or another, regardless of size or nature, personnel accountability is a part of every incident to which fire and rescue personnel may respond. Failure to maintain personnel accountability can, and does, have tragic results. In the event that an emergency responder is injured or otherwise incapacitated on the scene of an emergency, a properly functioning PAS should assist rescuers to locate the personnel in trouble and get them to safety quickly.

## *Structure of This Manual*

The intent of this manual is to provide an introduction to and explanation of the range of technologies that are designed for or that may be applicable to personnel accountability systems. The manual is presented as follows:

- Chapter II provides examples of personnel accountability systems used in various departments throughout the United States. Examples have been chosen from departments of different sizes and structures in an attempt to show the great variety of personnel accountability systems used in the field by actual fire and emergency medical services agencies.
- Chapter III describes basic, manual personnel accountability technologies and how they can be employed in a PAS.
- Chapter IV describes automated personnel accountability technologies and their uses in a PAS.
- Chapter V describes the application of radio frequency technologies to personnel accountability.
- Chapter VI describes Personal Alert Safety Systems (PASS) devices and their use in a PAS.
- Chapter VII describes technologies developed in other fields, such as the military, that may have uses in a PAS.
- Chapter VIII describes other technologies that can be used to increase visibility, safety, and accountability on the scenes of emergencies.
- Chapter IX describes some of the different communications systems available for use in emergency service agencies and their application in the PAS setting.

- Chapter X discusses some of the technological solutions to accountability problems specific to operations in and around water.
- Appendix A is a reprint of the joint IAFF/IAFC guidance on the OSHA “2-in/2-out” policy.
- Appendix B is a compilation of Standard Operating Procedures (SOPs) for PAS from fire departments.

### *Some Qualifying Comments*

This manual seeks to detail the various technologies that are available (and in development) that a fire, rescue or EMS department could use to implement and operate a PAS. The manual is not intended as a definitive guide to establishing a PAS program in a department. Not all of the technologies described in this manual have been developed specifically for use in a PAS. Some are being used in other fields, such as law enforcement or the military, and others are still in the research and development stage. Nonetheless, discussion of these transferable and pending technologies may provide readers with ideas as to how to improve an existing PAS or implement a new one.

Further, the estimated costs and cost ranges identified in the manual for various devices, equipment and systems does not include any costs for personnel or training. Some of the systems require that an officer at an emergency incident be assigned as the Personnel Accountability Officer; the costs associated with this additional person are not included in the manual. Similarly, nearly all equipment and systems mentioned in this manual require that personnel receive training in order to make the equipment/system effective; the costs associated with this training are not included in the manual.

Finally, although this manual is an assessment of present and future PAS technologies, it must be recognized that no technology alone can ensure the safety and accountability of emergency responders. Rather personnel accountability technology must be employed as a part of an overall system designed and dedicated to ensuring the safety of all personnel operating at the scene of emergency incidents. No PAS can outperform a firefighter that does not want to be a part of it. Firefighters must be educated about the benefits of a PAS so that they understand and participate in it. PAS systems must be easy to operate and become a part of everyday operations. Saving the PAS for a large scale incident means firefighters will be unfamiliar with its use when the fight is on.

# CHAPTER II – PERSONNEL ACCOUNTABILITY SYSTEMS THROUGHOUT THE UNITED STATES

Personnel accountability systems vary from state to state and, in some places, from department to department. The system used depends on a variety of factors – the size of the department, number of personnel, call volume, etc. Regardless, **it is important to note that SOPs can only work when they are understood and followed – merely implementing them as policy is not enough**. Personnel must be trained in how to use the particular PAS chosen by a department. The following examples and the SOPs contained in Appendix B are meant to be guides for emergency response agencies in the implementation of a PAS. They are in no way an entirely comprehensive list – there are many other implementation options available that are not listed here.

## *Large Departments*

Larger departments across the country are using a variety of PAS in their daily operations. Some are experimenting with more technologically advanced accountability systems. Newer technologies, such as bar-coding and RFID tags, which will be discussed later in this manual, may be found in larger departments with high call volumes.

<u>Chicago Fire Department, Chicago, Illinois</u>

The Chicago Fire Department is an urban department with 100 stations and close to 5,000 uniformed personnel. Included in its PAS is the mandatory use of Personal Alert Safety System (PASS) devices – a policy in effect since December 1995. That policy is included in Appendix B. Firefighters are required to be equipped with a working PASS device and must activate the devices on the scenes of emergencies. Also, the CFD is working with NASA to develop new technologies in personnel location and tracking using hydrogen/carbon monoxide imaging. This technology has great potential for use in locating downed firefighters and mass casualty situations, but it is not in a prototype stage at present. Research and development of this technology is continuing, and should it ever become operational might be of real use to the fire service.

<u>Seattle Fire Department, Seattle, Washington</u>

The Seattle Fire Department, located in the Pacific Northwest, is composed of approximately 1,000 personnel and 34 stations. The Seattle Fire Department uses a "passport" system, consisting of two personal identification tags per person. One of these tags is placed on the company passport, a small board that accommodates a tag for each crew member. When an incident occurs, the passport is left with a designated individual as the company enters a hazardous area and is retrieved as the company exits. A similar system exists at the Command Post in order to aid Incident Commanders in maintaining an overall perspective of the personnel on scene and their assignments. In addition, each firefighter is supplied with a portable radio equipped with an emergency button, which can be activated when in distress.

### *Small Departments*

Many smaller volunteer fire departments use manual personnel accountability systems to track their personnel at the scene of working incidents. Each firefighter is assigned a tag/clip that attaches/clips onto a central collection ring. These rings are then collected and brought to the incident command post. The incident commander is then able to ascertain who is assigned to a piece of apparatus and what their assignments are. Also common are passport-type systems, similar to that in use by the Seattle FD. These systems have the potential to become problematic during incidents with mutual aid response from other departments or jurisdictions. Still other departments may use a different PAS or none at all, making it difficult to maintain accountability for all personnel at an incident.

In some cases, smaller departments, both career and volunteer, have experimented with more technologically advanced PAS systems. Small departments, in many instances, are more agile and flexible to accommodate changes and to implement new programs, and may have the financial and other resources to make more sophisticated PAS a reality within their agencies.

Canandaigua Fire Department, New York

The Canandaigua Fire Department is a combination career/volunteer department in upper New York State. They run approximately 1,500 calls per year. Nametags are issued to each firefighter and are attached to their turnout coats. At the scene of a working incident, each firefighter clips his/her tag to the collection ring of the first-arriving apparatus. When taking an SCBA, each responder takes the ring assigned to that particular SCBA and attaches it to his/her personal ring. At the end of an incident each firefighter collects his/her nametag from the ring and reattaches it to his/her turnout coat. Officers are responsible for knowing who is under their command and when/where responders enter a structure. They are also responsible for informing the incident command staff of this information. Individual firefighters are responsible for keeping their officers informed as to their exact assignments and locations each time they enter a structure. Further, each team entering a structure is given a designation, an assignment, and a portable radio.

Versailles Fire-Rescue, Versailles, Kentucky

Located eight miles west of Lexington, this department is composed of 35 paid-on-call members and one full-time chief. They run approximately 300 calls per year. Each firefighter and officer has a 2” by 4” laminated ID tag that hangs from the back of his/her helmet at the station. Each tag contains the owner’s photo, name, unit number, rank, station, apparatus assignment, blood type, allergies, medications, and emergency contacts. On fire calls, personnel attach their tags to a central collection ring in the apparatus, which is collected by the officer and brought to the incident command post or collected by the safety officer. The incident commander has a dry-erase board where he/she can track the personnel and apparatus operating on the scene of an incident. *(Note: Dry-erase boards must be shielded from rain or precipitation to protect recorded information.)*

# CHAPTER III – MANUAL PAS TECHNOLOGIES

Manual accountability systems involve the use of paper, tracking boards, or other devices, and are operated by one or more persons. They tend to be uncomplicated and not very dependent on technology. They require effective communication and adherence to accountability and communications procedures. As with any Personnel Accountability System (PAS), manual accountability systems can be inaccurate if personnel enter and exit the scene at non-designated locations. Further, manual accountability systems have no way of tracking personnel once they are beyond the entry/egress checkpoints and have entered the scene, or if they use the PAS inappropriately or incorrectly.

Manual systems are technologically unsophisticated, and their simplicity often makes them the easiest to implement and most effective of the various PAS options. They tend to be low maintenance, easy to use, portable, durable, and effective.

These systems require that each person wear a tag or other device that identifies him/her as well as the unit to which he/she is assigned. These devices can be transferred to a PAS officer, and usually are kept near the entrance to a structure or scene, or with the apparatus to which a person is assigned.

Manual accountability systems show who is on-scene or inside a structure, and possibly even where, broadly speaking, that person is located. For example, a manual PAS may show that someone is inside a certain building, attending to or operating a piece of equipment, at the command center, or in the rest/rehabilitation sector.

More sophisticated versions include portable electronic devices that can monitor how long teams have been on a scene, how long their self-contained breathing apparatus (SCBAs) have been active, and other pertinent information. These types of devices depend on two-way communications between teams and the control center.

## Radio Rollcall

Although not a "device," a radio rollcall is an effective way of tracking personnel. It requires that each person, or each small group of people, has a radio. It further requires the PAS officer to have a radio capable of communicating with units in the field, and that he/she can monitor more than one transmission at a time should an emergency occur. Finally, field personnel must be attentive to their radios so they know when a radio rollcall is occurring.

A simple rollcall can be executed, in which the PAS officer questions each person or group operating at the scene. In return, each person or group answers with its location, status, condition, and any other information required or relevant to the situation. Radios can be equipped with an emergency tone that takes priority over other broadcasts and transmits on more than one frequency. The radio itself also may make an audible alarm, which might make it more likely that a firefighter in distress will be located.

**Training –** In order for a radio rollcall system to work, all personnel must be familiar with proper and effective radio procedures and how the equipment functions. Strict communication discipline is essential with a radio rollcall system.

**Costs –** Radio rollcall systems can be expensive because each person or unit must have a portable radio. For departments that have purchased a sufficient number of radios already, the cost of implementing a radio rollcall accountability system is minimal.

**Future Trends –** Some departments likely will shift away from radio rollcall systems as the price of new PAS technologies drop below the cost of providing the additional needed radios. This should not be construed as a decrease in the importance of individual radios for tactical operations and firefighter communications.

### *Clipboard and Paper*

This manual PAS technology entails someone standing by the entrance/exit of a scene and physically recording who enters/exits that particular area or scene, and how long each person stayed. Use of a clipboard and paper PAS requires good communication between the various PAS stations and the PAS officer.

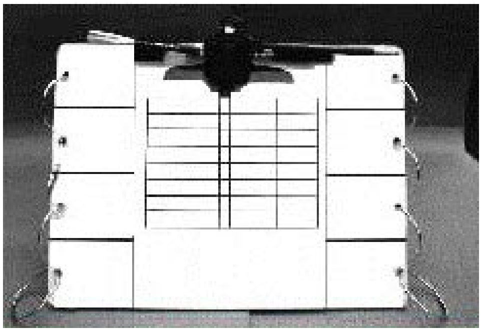
One drawback to this type of system is that its use in inclement weather is problematic. Normal paper doesn't hold up well when wet, and pens and pencils do not write well on wet surfaces. A potential solution is to use a china marker (or other wax-based marker) in place of a pen and treated paper or a plastic board instead of regular paper.

**Training –** Minimal training is required for this system. Emergency personnel must be well disciplined to ensure they check in and out at a given PAS station. Confusion can occur when there are multiple PAS stations.

**Costs –** This is by far the least expensive means of implementing a PAS. The necessary items are probably already on hand, but if not, they can be obtained for under $25 for most departments.

**Future Trends –** Some departments have shifted away from clipboard and paper systems because of the problems inherent in coordinating the information from multiple PAS stations.

### *White Board*

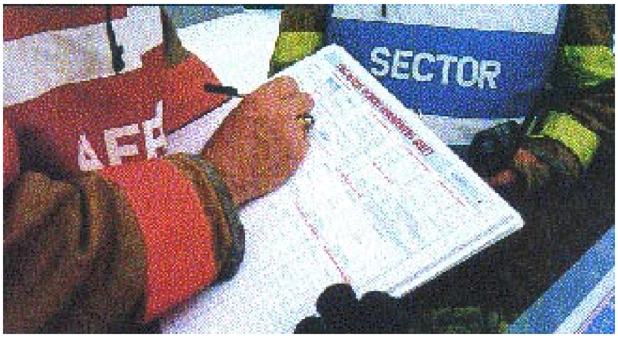


A white board (i.e., board and a dry-erase marker) functions very much like a clipboard and paper PAS; however, some of the properties of white boards make them better suited to PAS usage than clipboard and paper. Typically, these systems involve drawing a map of the scene indicating the locations of apparatus and sectors (such as command and rehabilitation), as well as personnel assignments. Some boards use small icons that are taped or otherwise attached to locate resources. Some boards may be magnetic, allowing icons for units and people to be moved and reassigned easily when necessary.

As with the standard clipboard and paper system, a drawback to using a white board is that its use in inclement weather can be problematic since information written with a white board marker will run if it gets wet. A potential solution is to use a china marker (or other wax-based marker) in place of a white board marker and a solvent to erase the markings. This may require testing the combination of the white board marker, grease pen, and solvent to ensure that they write and erase adequately.

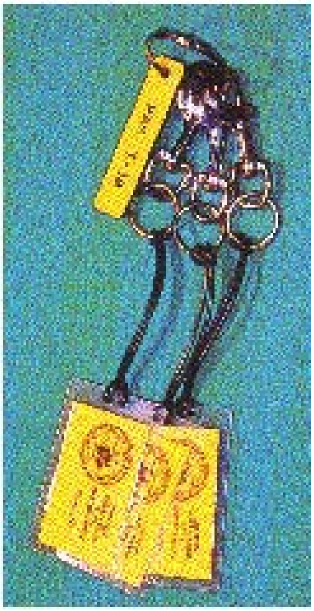
As with other manual accountability systems, a white board PAS requires good communications to report where personnel are accurately and in a timely fashion.

**Training –** Some proficiency in the Incident Command System (ICS) may be helpful, but otherwise, no other significant training is needed.




**Costs –** While white board systems cost more than clipboard and paper, they are, nonetheless, quite inexpensive. Magnetic white boards and icons can add to the cost of a basic system. Expenditures would likely be under $100 for a typical department.

**Future Trends –** Similar to those of clipboard and paper.



### *Ring-Based*

A ring-based PAS uses a ring that can be attached to a hook or other device, and has a means of identifying the bearer (i.e., it contains the individual's name and unit assignment or department/station). It is carried by a responder and handed over to the PAS officer at a PAS station. Upon exiting the hazardous area, the individual will receive his/her ring from the PAS officer. Some departments use a duplicate set of rings for each piece of apparatus. Upon descending from the apparatus, each member of the crew hands his/her ring to the apparatus operator or places the ring in/on a designated collection point.[1]

**Training –** Minimal training is required to ensure that all responders know how the system operates, and what they have to do with their PAS rings.

**Costs –** A complete ring-based PAS for 150 responders and 12 pieces of apparatus can be obtained for about $750.


**Future Trends –** This is a low-tech, highly regarded technique for performing personnel accountability. For departments unable to purchase high-technology PAS solutions, ring-based systems are a good solution. Because they represent a simple and moderately priced answer to PAS needs, their use likely will continue in the future.

### *Hook-and-Pile*

Hook-and-pile (commonly referred to as VelcroÔ ) systems are very similar to ring-based ones. The primary difference is in the mechanism used to attach the responder information. A hook-and-pile system involves two pieces of fabric–one with small "hooks" and the other with small "piles" or loops. When pressed together, the two pieces of fabric attach securely but can be pulled apart relatively easily. The fabric with the hooks is attached to the underside of an identifying device. Some systems use helmet shields as the identifiers while others use name patches from a uniform or turnout coat.

When a firefighter goes through a PAS station, the helmet shield or name patch is removed and attached to a pile-covered status board. When the responder exits the hazardous area, the helmet shield or name patch is removed from the status board and reattached to the responder's helmet or turnout coat.

This is a low-tech, highly regarded solution for personnel accountability. For departments unable to purchase high-technology PAS solutions, hook-and-pile systems are a reliable option.

**Training –** Minimal training is required. Proper training will ensure that all responders know how the system operates and what they have to do with their identifiers.

**Costs –** This system is usually purchased as an option on helmets and generally adds between $15 and $20 to the price of the helmet.

**Future Trends –** Because hook-and-pile systems represent a simple and moderately priced answer to PAS needs their use likely will continue or grow in the future.

### *Card-Punch Technology*

Card-punch technology, similar to time-keeping systems used in private industry, is used by the Federal government on many large wildland fires. Cards indicating crew names operating at an incident are stored in a slotted carrier, which is maintained at the Command Post (CP). As crews arrive they turn in their cards to a PAS officer and collect them as they leave.

Accountability on major wildland fires differs widely from that on most municipal fire/rescue incidents. The wildland system tracks the assignment of crews, made up of twenty or more people, rather than individuals. Crew leaders and their subordinates are responsible for the individuals they oversee. As a result, it is extremely difficult to locate an individual firefighter without knowing that firefighter's crew assignment. Further, IC's may not know the location of all of the crews under their command, as there may be thousands of people involved in the incident. This combination of factors makes individual accountability on wildland fires extremely difficult and requires cooperation from every level – from the IC to each of the firefighters on the fireline. The same cooperation is required at the municipal level.

Fire and rescue departments at the municipal level could still use a card-punch type of system to account for personnel. Cards could be issued to crews or to individuals. Cards issued to individuals could contain information such as fire department identification number, training level, pertinent medical history, emergency contact information, etc. As responders enter the scene, they would turn in their cards to the PAS officer, who then could maintain the cards in a way that could track an individual's current location and assignment.

Departments that choose to use this system will have to adapt it so that changes can be made as an individual's or crew's emergency incident status changes. Departments also may wish to consider laminating the cards to allow for prolonged use.

**Training –** Training for this system consists mostly of basic accountability procedures. The designated accountability officer would require slightly more training to allow for the effective use of the system.

**Costs –** Costs for a card-punch accountability system should be minimal. A small- to mid-sized department of 100 personnel should be able to implement this system for between $300 and $500.

**Future Trends –** As with other manual accountability systems, the future of card-punch technology most likely will not hold significant change. Card-punch technology may, however, merge with other technologies to improve its information storage capacity. Card punches of the future may include bar codes or even radio frequency transmission capability. Most likely, however, the card-punch system of the future will be very similar to the systems used at present.

## *Endnotes*

[1] In one department studied, responders place their rings over the apparatus' radio antenna. In another department, a central ring was placed in the front seat of the apparatus, between the driver and officer's seats, and each rescuer attached his/her tag to the ring. The key is having one central location on each piece of apparatus where the tags are to be hung.

## *CHAPTER IV – ELECTRONIC ASSISTED PAS TECHNOLOGIES*

Electronic-assisted accountability systems combine elements of manual accountability systems with electronic technology to aid the Command Staff in tracking personnel at an incident. Some electronic technologies are rather basic, while other technologies can perform a wide range of personnel status and location tracking functions. Several of the following technologies are in use already by fire departments, while others are not, but all of them offer the potential to assist with accountability measures in the future.

In all cases, an underlying premise of any electronic-assisted accountability system is that it aids, **but does not eliminate the need for**, a strict accountability policy. Fire departments must have accountability procedures that all personnel must follow, or even an advanced electronic system will not be able to monitor the status and location of personnel.

### *Bar-Code Technologies*


Basic bar-coding technology, commonly found in many retail checkout lanes, uses a series of differently shaped rectangular bar code units in varying sequences to store information which can be read by a laser scanning device. Laser scanners can be units that must physically touch a bar code, or point-and-shoot devices that can scan bar codes from up to a foot away. They emit a low-power laser beam that reflects off a bar code into a mirror stored in the unit, which transmits the results of the scan to a processing and display area. Computer software associated with a bar-coding system then rapidly interprets the subtle patterns and translates the information stored in the bars into an easily understood format, which then can be displayed on a monitor.

Technological innovations in bar coding technology have expanded the amount of information bar codes contain and the way they are read by scanners. First-generation bar codes, also known as one-dimensional bar codes, can only store information on the horizontal axis. The amount of information that one-dimensional bar codes can store is limited by having only one factor that changes – the thickness of each bar. Each individual bar in a one-dimensional bar-code sequence is a solid rectangle of a different thickness than each of the bars around it. Lasers scanning the coded information read the information from side to side, noting the changing thickness of the bars. Since each one-dimensional bar is a uniform shape, the thin laser can scan the length of the sequence at any given height, either by physically touching or scanning from a distance.

Two-dimensional bar codes, the next generation of bar codes, can store much more information than one-dimensional bar codes because they use both a horizontal and vertical component in the sequence. Two-dimensional bar codes do not have a uniform shape from top to bottom: the height of each bar changes along its vertical axis. A typical two-dimensional bar code appears to have a solid border enclosing a series of grainy lines. By incorporating a vertical component, two-dimensional bar codes can store up to 1,850 characters per bar code unit; roughly 100 times more information than one-dimensional bar codes. Because of the amount of data they can store, two-dimensional bar codes have been likened to portable databases. Two-dimensional bar codes require a special scanner that scans the entire bar code sequence, not just a cross-section, to process all the stored information.

### *Accountability Applications*

Bar coding is not a personnel accountability system in and of itself. Bar-code-based accountability systems do, however, offer fire departments a computer-assisted means to track personnel at emergency incidents. Current bar-code-based personnel accountability systems are designed to work within the ICS, and function similarly to certain manual systems; however they can process, store, and display a much greater amount of information.

Some bar code-based accountability systems outfit responders with several bar code tags that are worn on various parts of the firefighter's protective equipment for safety reasons. This may seem redundant, but it is possible that one of the tags may be lost during duty. These tags store varying degrees of information, depending on whether they are part of a one or two-dimensional system. The information contained in the bar codes is customized by each agency to suit its particular needs. For example, a fire department using a two-dimensional system might include a responder's name, training level, pertinent medical history, and emergency contact information. Some departments also issue laminated photo identification cards with bar codes for use in non-emergency situations.

The bar codes themselves also can build redundancy into the coding sequences, as some systems can read and interpret the information with only 50 percent of the bar code intact. This means that even if a bar code is dirty or partially destroyed, it is still possible to access all of the data stored in that bar code.

Some commercially available bar-code-based personnel accountability software can track personnel who have been logged into the system, their training levels, how long they have been on site, and their SCBA status. Security safeguards can restrict the types of information that scanners can decipher. For example, access to a firefighter's selected medical information could be restricted to include only authorized scanners.

### *Personnel Accountability Using a Bar-Code System*


When responders arrive at an incident, they must report to the system scanner location, which usually operates at the Command Post or Staging sector, and have their individual tags scanned into the system. When the resource is deployed, the PAS officer links the resource with an assignment by scanning the appropriate assignment bar code created to represent common ICS terms and typical emergency control activities. This eliminates the need to write out or type this information. Often this is done using a preset bar code sheet. Another option is to place bar codes on magnets that can be arranged on a white board or another suitable display device.

Bar-code systems also require some kind of printer to create bar code sheets and tags. Since some mutual-aid companies may not have bar-coded PAS tags, spare “assignable” tags should be created and kept at the CP or with the PAS officer so that personnel from assisting departments can be included in the accountability system. In addition, some manufacturers recommend keeping a manual tag board to serve as a backup to the computer system.

An individual’s status can be updated as the incident progresses either by re-scanning the PAS tag and the assignment code prior to reassignment or simply by using the computer to change the individual’s assignment and location. Since most tracking software notes the time associated with each data entry, the system can track total time elapsed on many activities, including the total time a responder has been using an SCBA or has been recuperating in the rest/rehabilitation area.

The system can be programmed to sound an alarm if a responder is in danger of running low on air or has been operating on the scene for too long without visiting the rest/rehabilitation sector. The ability of some systems to be programmed to sound alarms for low air and other safety-related issues is an important asset to the IC.

Using bar-code technology as a component in a well-disciplined personnel accountability system offers certain benefits. Bar-code systems increase efficiency by reducing the need to rely totally on accountability tags, display boards, and manually moving unit markers, or symbols around a CP. Although these manual systems should be used as a backup, the bar-code system serves as the primary personnel tracking system. Depending on the software package used, IC’s are able to print out reports of the entered information much more quickly than if the information had to be compiled manually. Generating computer reports saves time and eliminates some of the errors associated with doing the same job by hand. Bar-code-based PASs typically do not have a limit on the number of personnel or assets they can track.

There are, however, certain limitations associated with bar-code systems. Most importantly, bar coding itself does not automatically track personnel at emergency incidents – it merely facilitates data entry for tracking systems. To function effectively, personnel trained in proper accountability procedures must use bar-code-based PASs in a disciplined manner. Finally, some bar-code systems require that firefighters be scanned in at one central location prior to receiving their assignment. While this may be an important aspect of personnel accountability, in some circumstances it might limit emergency operations.

**Training –** Overall, learning to operate bar-code-based systems is not difficult. With minimal training, a department with previous PAS experience could implement a bar-code system rapidly. For agencies without previous accountability experience, a bar-code-based PAS would be easy to learn; however, such departments would benefit from having basic accountability training prior to implementation.

**Cost –** Bar-code systems cost more than homemade or commercially available manual accountability systems. Basic bar-code systems can be obtained for less than $5,000, while more expensive systems sell for under $10,000.

**Future Trends –** Future bar-code-based accountability systems will address some of the limitations mentioned above by introducing advanced systems that merge bar-code scanning technology together with radio-frequency technology. Prototype systems just now entering the market have multiple bar-code scanners that operate similarly to existing systems, but have the ability to communicate with each other via radio. This radio-linked network will ensure that changes made at one location are displayed automatically throughout the entire network. This will create the ability to establish multiple accountability sectors while maintaining the integrity of the overall accountability database. This should allow greater flexibility and increased accountability, since individuals will have more opportunities to be scanned into the system.

Technology developments in data compression techniques are expanding the amount of data stored in bar codes, with some recent compression innovations claiming the ability to compress up to 29,000 characters of information. Based on current trends and fire service needs, bar-code-based PAS of the future most likely will be smaller and able to contain more data.

### *Radar Technology*

Radar technology that can detect a person breathing on the other side of a door or wall has been in existence since 1989. It is a modification of ground-penetrating radar. Using Ultra Wide

Band (UWB) and UWB impulse technology, the radar can "see" people breathing by measuring changes in a person's cross section. The technology is similar to the tomography technology used in Computerized Axial Tomography (CAT) scans. (The technology is also able to detect weakening structural components of a building, indicating where a potential collapse is likely to occur.) Technology available today is ten times as sensitive as what was available in 1989. This increased sensitivity makes it likely that today's radar is sensitive enough to even detect a person's heartbeat. At this time this technology has not yet been implemented, however, a ten-fold increase in sensitivity should not be required to differentiate between heartbeats and respirations.

The component size of the radar varies. While the transmitter and receiver used for searching large structures is the size of a stereo speaker, the transmitter and receiver for searching individual floor levels is about the size of a business card. Both are programmed to conduct a wide search or focus on a specific area. Also, both use a search pattern that divides areas into cubes, six inches on each side. Using pulse technology, and searching in six-inch cubes, a large area can be searched in as little as ten seconds.

A limitation of the technology is that it cannot penetrate solid metal areas. A structure that is surrounded by a metallic cage would be impenetrable to radar. However, if there are openings within the metal framework–windows, doors, nonmetal areas – the beams can be aimed into these openings. Reinforced concrete construction ("rebar") is penetrable.

**Costs –** Depending on the manufacturer, model, and option chosen, departments should expect to spend several thousand dollars.

**Training –** Moderate training would be required to operate the device. Personnel might also require specialized training in search and rescue techniques.

**Future Trends –** This technology, in conjunction with an advanced software package that could plot data received on a simple screen or grid, would have numerous applications to the fire service. It would allow a rapid search of a structure by a minimum number of personnel exposed to minimal danger, and could display the locations of any victims found. It could track firefighters' movements through structures, allowing the IC to locate personnel at all times. Also, Urban Search and Rescue (US&R) teams might be able to locate victims beneath the rubble either by their heartbeats or breathing patterns.

### *Trapped Miner Locating System*

The U.S. Bureau of Mines has developed the Trapped Miner Locating System (TMLS), a technology that uses a series of "geophones" to listen for tapping noises to locate trapped miners following a mine accident. A large unit located on the ground above the mine can sense noises resonating from as far as 1,500 feet below the surface.

### *Accountability Applications*

This technology is not designed for personnel accountability; however, it is likely that uses for it could be found within a PAS. For example, this device could assist IC's with accountability in below-grade operations. However, the TMLS does have its drawbacks. The system is extremely large and must be mounted on a tractor-trailer. Also, as with any listening device, the search area must be silent for the technology to work – an unlikely occurrence on most search and rescue incidents.

**Costs –** The TMLS technology is not yet available commercially, and it would be extremely costly to develop into a commercial application.

**Training –** Emergency response personnel need to be trained how to operate and apply the TMLS. The length of training required is unclear at this point.

**Future Trends –** Based on the reasons listed previously, the system appears impractical for fire and rescue use at the present time; however, if some of the system's drawbacks were to be corrected, it is possible that TMLS technology could be adapted for emergency services use.

# CHAPTER V – RADIO FREQUENCY TECHNOLOGIES

Several accountability programs use radio-frequency technology to track emergency responder location and status at an incident. Current radio systems can assist accountability systems but cannot automatically track personnel. Recent radio frequency innovations offer the potential to improve accountability and to automate certain aspects of personnel location and status monitoring.

## *Radio-Transmission-Based Accountability Systems*

Radio-transmission-based accountability systems require incident command personnel to monitor radio transmissions to update a department's manual accountability system. A PAS officer listens to the radio for various crew assignments and locations and then updates whatever manual system (white board, magnetic board, etc.) the department uses. Radio-transmission-based systems assume that the CP will be able to monitor and hear all radio transmissions at an incident.

The basic components of this type of system are portable radios and some form of manual accountability system. If a department chooses to track personnel at the crew level, then each crew operating at an incident must have a portable radio. Departments might even consider issuing portables to individual rescuers. However, the system does require that all individuals have easy access to a portable radio. One benefit of this type of system is that departments are free to choose among various manual accountability systems.

Radio-transmission-based PASs need not rely only on manual tracking components. One manufacturer offers a computer system that the PAS officer can use to update crew locations and activities quickly. The system is programmed to track various department apparatus crews and their potential fireground assignments. It is not designed to track individual firefighters. To use it, a PAS officer listens to radio transmissions and uses the computer to select, for example, "Engine 10 performing a primary search on the first floor." The computer system tracks the amount of time a crew has been performing a particular function and also has a countdown clock to monitor SCBA airtime. If a crew exceeds the allotted SCBA time, an alarm will sound. This option helps the IC to see which crews are in need of relief. The computer system can be expanded to meet a department's needs.

### *Accountability Applications*

Radio-transmission-based accountability systems are not automatic systems. They require that someone monitor **all** radio traffic and update resource statuses accordingly.

Although radio-transmission systems can be effective accountability systems, they do have several disadvantages. A department that relies on this system is forced to monitor radio transmissions closely. This requires that departments have reliable radio equipment and effective radio communications procedures, both of which can increase radio efficiency and allow ICs to quickly identify calls for help. If some radio transmissions are not heard, then the system will not work properly. Accountability officers also must update their manual or computer-assisted accountability systems continuously in order to reflect the most current locations and assignments of crews on the fireground.

**Training –** Radio-transmission-based accountability systems do not require extensive training. Many fire departments are familiar with the use of portable radios and radio transmission technology. Departments with pre-existing manual accountability systems frequently can incorporate aspects of radio-transmission-based accountability systems into their existing systems. Fire or rescue departments unfamiliar with accountability procedures would require accountability training. Departments that do not use established radio procedures would most likely have to develop and learn more formal radio communications procedures.

**Cost –** Radio-transmission-based systems vary in cost. The primary cost involved in this type of PAS is the purchase of the radio communication equipment. Departments with existing radio equipment would not necessarily be required to update their units, as long as their systems remain reliable. The costs of a radio-transmission-based accountability system also depend on the method chosen. If a department opts to use a computer to track the information transmitted, it can expect to pay between $1,000 and $2,500 to acquire the hardware and software needed. Overall, however, these types of electronic-assisted accountability systems are generally an inexpensive way to account for personnel. Since many departments already have portable radios, adapting an existing manual system to a radio-based protocol could offer increased accountability benefits at relatively little cost.

**Future Trends –** As more departments acquire portable radios, the likelihood of using this type of system will increase.

### *Radio-Frequency Identification Accountability Systems*

Radio-frequency identification (RFID) technology, already used for many security entry control systems, uses radio-transmitting “interrogators” to send out radio waves to preprogrammed receiver computer chips which “respond” to the radio query with another radio signal. Interrogators and receivers only recognize specific frequencies. If the frequency is not correct, the receiver or interrogator will not recognize it. The signals transmitted by receivers can be programmed to include information such as name, rank, training level, etc.

RFID interrogators and receivers have become smaller over the past several years. Currently, RFID receivers are available as small portable devices, many the size of a credit card. As the size of the receiver decreases, however, it must be placed closer to the interrogator in order for the receiver’s response signal to reach the interrogator. The small size of receivers makes it necessary to have it fairly close (less than one foot) to the interrogator in order for the receiver’s radio signal to reach the interrogator. Current fixed-facility interrogators can be the size of shoeboxes or smaller.

Portable interrogators also have decreased in size and typically are stereo speaker-size or smaller.

As with other radio technology, RFID systems are prone to interference from such things as building construction, electrical sources, and other radio systems. Typical urban construction, including some modern homes, which uses a large amount of radio-interfering materials can limit the performance of RFID technology.

To combat potential radio interference and to ensure that the interrogator and receiver receive each other's signals, it can be necessary for departments to set up multiple interrogator units at large or complex incidents. By setting up several units at the corners of a building (in order to triangulate the radio signals and optimize the coverage area) departments can ensure that RFID systems will overcome interference. Large, multistory buildings may require that an interrogator be mounted on an elevating boom. For most buildings, the boom would potentially have to raise the interrogator only several stories and not the full height of the building. If the building were especially tall, another potential solution would be to equip crews with portable interrogators that could be deployed on each floor on which a crew is operating. Then, the signals and information from the various floors could be relayed manually or using repeater technology to the CP.

In addition to interrogator and receiver components, an RFID-based PAS will require a computer processor with interpretation software and a display device to show the status of emergency scene personnel. This display typically will be a liquid crystal display or a computer monitor.

RFID technology can be found in many applications and sectors of the economy and is being tested for use in the fire service. Although technology capable of performing the functions described above exists, it has not – with the possible exception of electronic transmitting PASS devices – been widely applied to fit emergency service personnel accountability needs. The following describes several cutting edge RFID accountability technologies that could be available commercially in the near future.

### *Accountability Applications*

RFID transmitters can improve emergency incident accountability by allowing for some automatic information gathering. RFID systems can be programmed to survey the scene periodically and display the results. RFID systems will be able to display some responder information and location. RFID systems currently are not able to display tasking assignments. For this reason, IC's must use supplemental methods to ensure that they can track each individual rescuer, their location, and current scene assignment.

### *RFID PASS Devices*

RFID PASS devices, or electronic transmitting PASS devices, are commercially available. See Electronic-Transmitting PASS Devices on page 44 for more details.

### *Helmet- or SCBA-Mounted RFID Tags*

One new RFID accountability system under development envisions mounting a matchbox-sized RFID tag on a firefighter's helmet or SCBA. Fire departments would use stereo-sized interrogator units that could be either vehicle-mounted or portable units positioned outside the building.

Since the RFID tags are matchbox-sized, developers did not think it practical to mount the units on turnout gear. The tags might easily be knocked off of turnout gear or damaged on the scene of an emergency. Developers feel that by mounting the tags to SCBA's and/or the underside of helmets, they might be more protected from damage and unintentional removal.

Helmet-mounted RFID tags can be programmed to transmit personnel information, including name, rank, training, or other department-specific information. SCBA-mounted RFID tags will most likely transmit information reflecting the SCBA's location on a given piece of apparatus. For example, if Firefighter Smith's riding assignment were as the officer for Engine 8, then he would be tracked on the fireground as "Engine 8's officer," rather than as "Firefighter Smith." This technology can be programmed to transmit individual information as the helmet-mounted tags do; however, if a department desired to track individual-specific information using SCBA-mounted RFID tags, they would have to reprogram the RFID tag each time a new person was assigned to the SCBA.

One drawback to an SCBA- or helmet-mounted RFID system is that the PAS will depend on emergency personnel always wearing their protective equipment. Although this should be commonplace, sometimes PAS protocols are not followed, which can compromise individual's safety and diminish the effectiveness of the PAS.

For this reason, it may be better to place the RFID tag on a piece of equipment that is more likely to be worn on all incidents (i.e., the helmet). For example, a fire department which issues SCBA-mounted RFID tags may not be able to track its personnel at a mass casualty incident, such as a passenger train derailment, since many personnel will not necessarily be wearing an SCBA. Similarly, rescue departments would be forced to select a piece of equipment worn on all incidents, and on which they could mount the RFID tags, to ensure that their RFID PAS can track personnel locations.

**Training –** Training to use RFID PAS technology will not likely be extensive. Individual firefighters would need only basic instructions on how the system will work and routine maintenance and care instructions for the RFID tags. Accountability officers will need some basic instruction on

RFID technology and minimal training how to operate the system and manipulate the computer software and display monitors. Overall, this technology will require minimal training of personnel.

**Cost –** Costs for RFID PAS will vary depending on the size of the system. RFID tags can be expected to cost several hundred dollars each (less if greater numbers of them are ordered). Interrogators will be more expensive, with models costing up to $5,000. Elevating booms, multiple interrogators, etc., will raise the price of an RFID PAS. Departments should be able to purchase a system to track 50 people for less than $10,000. These prices are all projections at this time since this technology is not yet commercially available for accountability applications.

**Future Trends –** Assuming the technology becomes commercially available, RFID PAS has the potential to be very useful in the fire service. Also, as the technology advances, more PAS applications may be discovered.

### *RFID Tags Sewn into Turnout Gear*

Recently, researchers have been able to develop a thin, flexible RFID receiver that can be sewn into the weave of a fabric. With this new capability, RFID tags can be sewn into turnout gear, station uniforms, or other fabrics.

Fabric-based RFID technology will promote accountability by allowing a flexible, non-bulky alternative to other RFID devices. Since all personnel operating at an incident will be wearing clothing of some form, accountability officers can expect that they will be able to track all individuals operating on scene. Fabric-based systems can allow for RFID tags to be sewn into uniforms as well as PPE, allowing system redundancy for added safety measures. The more places in which tags are sewn, the greater the likelihood of tracking personnel.

One problem currently being addressed deals with the small size of the tags, since small size can limit effective transmission range. Research is under way to ensure that the fabric-based RFID transmission signals are able to reach interrogator units, even if other layers of clothing or objects, such as an SCBA, covers the tag.

**Costs –** Fabric-based RFID technology is under development, and is not yet commercially available. Developers are unsure of the final equipment costs, but they hope to have their technology available at prices similar to other RFID devices.

**Training –** Training for this technology likely would be similar to training for helmet- or SCBA-mounted RFID technology.

**Future Trends –** Since much of the RFID technology is just now on the verge of becoming more common in the fields of the emergency services, it is difficult to say what the future will hold. RFID technology promises a number of accountability benefits for a moderate price. As the technology is developed further, one can expect that the size of the units will decrease, the signal strength and information amount will increase, and the price will fall.

### *RF Motion Sensors*

Another promising technology sends RF signals through nonmetallic objects to scan for movement on the other side of the object. A briefcase-size locator with directional or omni-directional antennae is used to “see” eight to ten feet beyond a cement wall. When motion is sensed, an audible signal sounds. This technology employs RF scanning and requires responders to wear mini data chips. When the chip is scanned, it sends information back to the interrogator.

The material through which the signals must pass and the signal transmission strength determine how much motion must be present for it to be detected by the unit. Easily penetrable materials combined with a strong signal should allow the unit to detect smaller movements, such as breathing. With thick materials and lower signal strengths, however, the unit may be capable only of detecting very large movements, such as walking.

#### *Accountability Applications*

This technology is not a constant monitor, but can be used to assist accountability systems by allowing command personnel to scan areas rapidly for movement in the event that personnel become missing. For example, if a crew was thought to be operating in one particular area of a building, the unit could be used to scan that area for movement. If personnel are incapacitated or trapped, however, this unit might not be able to identify their location as they will not be moving.

**Training –** Training to use the unit would not be extensive. However, it would involve understanding basic concepts of radar physics, unit operations, as well as care and maintenance.

**Cost –** Were the system commercially available, a unit would range in cost from $2,500 to $5,000.

**Future Trends –** This system is not yet commercially available. It has much promise for enhancing personnel safety in a PAS setting once it becomes available.

### GPS-Based Accountability Systems

The Global Positioning System (GPS) is a space-age navigational system developed in the 1970s. Since then, its network of satellites has been controlled and maintained by the U. S. Department of Defense (DoD). GPS was originally intended for military use, but from the outset the U.S. government realized that the system could meet numerous vital civilian needs as well.

The GPS system uses a network of 24 satellites in precisely controlled orbits. By locking on to the signals these satellites send, any GPS receiver can, with great precision, triangulate its precise latitudinal/longitudinal coordinates. This satellite network operates 24 hours a day, in all weather conditions, and can be used worldwide for precise navigation on land, water, or in the air.

By measuring the travel time of the signals transmitted by these satellites multiplied by the speed of light, a GPS receiver on earth can determine its precise distance from each satellite being tracked. By locking onto the signals from three satellites, a GPS receiver can calculate current latitude/longitude (a two-dimensional reading). If a fourth satellite is available, a GPS receiver also can calculate altitude (a three-dimensional reading).

There are two main types of GPS receivers: multiplexing receivers and parallel channel receivers. These terms refer to how a receiver receives and processes information from the satellites. Keep in mind how GPS works: a receiver must lock onto and measure the signals of at least three different satellites in order to navigate. This is called triangulation.

#### *Multiplexing Receivers*

Multiplexing receivers use a shortcut to achieve triangulation. They establish contact with a satellite only long enough to sample its data, and then they hunt for another satellite to sample and acquire data, and then a third and possibly a fourth. All told, this process takes several seconds at a minimum. In order to provide a one-second update, most multiplexing receivers obtain an update from a couple of satellites and make a best guess at the position update.

Multiplexing receivers are the least expensive types of GPS receivers because they cost the least to build. Unfortunately, these savings result in less accurate positioning responses to changes in direction and speed. With only one channel to receive, the information must be pieced together and then averaged. Because of all this switching, multiplexing receivers tend to have more problems finding and keeping contact with satellites in areas covered by foliage and where parts of the sky are blocked by mountains, hills, trees, cliffs, slopes, or even tall city buildings.

### *Parallel Channel Receivers*

Parallel channel receivers maintain a constant simultaneous lock on several satellites at once, eliminating the switching inaccuracies of multiplexing receivers. A parallel channel receiver holds all the navigational information needed for the most reliable, up-to-date, and accurate information possible.

Several GPS units use at least a five-parallel-channel receiver. This means that there are five channels reserved for satellite communication. Three of the channels lock on to satellites to triangulate position. Another channel locks on to a fourth satellite–computing altitude as well as longitude/ latitude. These four channels continuously and simultaneously track the four satellites in the best geometrical positions relative to the user.

The fifth channel tracks all other visible satellites, giving the receiver the ability to switch instantly to an alternative satellite in the event that any of the four primary satellites becomes obstructed. This tracking channel also constantly seeks the best possible satellite geometry to use for the greatest positioning accuracy. These four channels, coupled with the fifth tracking channel, ensure reliable, continuous, and uninterrupted navigation, even in adverse conditions like valleys or dense woods.

Because GPS was designed as a military navigational system, the DoD created two transmission codes: the "P" code (Precision Code) for military use and the "C/A" code (Civilian Access code) for civilian use. The highest accuracy levels were to be reserved for the military to prevent hostile enemy attacks against the United States using our own navigational system. However, once in operation, the civilian code proved to be more accurate than the DoD had intended. Consequently, the military developed a system for randomly degrading the accuracy of the signals being transmitted to civilian GPS receivers. This intentional degradation in accuracy, controlled by the DoD, is called "Selective Availability" or "S/A."

S/A is a random error, intentionally created by the military. It can be low or high, and can vary in degree at any given moment. It should be emphasized that all brands of civilian GPS receivers are affected equally by S/A; no manufacturer has an advantage. The government has stated that with S/A turned on, civilian GPS accuracy levels consistently will be 100 meters or less, 95 percent of the time. The other 5 percent of the time, the accuracy will be 300 meters or less. With S/A off, civilian GPS accuracy levels increase to 15 meters or less. However, even with S/A on, the majority of the time, most GPS users typically experience accuracy between 20 and 50 meters.

Although there's a strong possibility that S/A will be turned off completely in the future, differential GPS (DGPS) has been developed to improve GPS accuracy to within a few meters. Originally initiated by the U.S. Coast Guard (USCG), DGPS adds a land-based reference receiver located at an accurately surveyed site. Since this nonmoving DGPS reference station knows where the satellites are located in space at any given moment as well as its own exact location, the station can compute theoretical distance and signal travel times between itself and each satellite. When those theoretical measurements are compared to actual satellite transmissions, any differences represent the error in the satellite's signal caused by S/A. All the DGPS reference station has to do is transmit the error factors to your DGPS receiver, which gives the information to the GPS receiver so it can use the data to correct its own measurements.

Currently, there are two basic sources of corrective DGPS signals: (1) USCG land-based beacon transmitters broadcast the data to the public without charge, but are primarily located in coastal areas; and (2) commercial FM radio subcarrier transmitters that broadcast in both coastal and inland areas, but are limited to paying subscribers. In order to receive the DGPS correction data from the Coast Guard beacon transmitters, the mobile GPS unit requires a separate beacon receiver. To receive FM subcarrier DGPS signals from local subscriber radio stations, the GPS unit requires a separate FM receiver, normally the size of a pager. Naturally, a GPS unit must have the capability both to receive and to process DGPS data. Obviously, if the government turns S/A off, the need for DGPS will be diminished greatly.

GPS receivers display the latitude and longitude of the unit, and some can be attached to a computer to display location using a computer-generated map. In addition to displaying coordinate information, some GPS units can lead rescuers to a specified location. The units can store multiple points, including the starting point of the mission. At any given point during the search, rescuers can recall any stored location, and the unit will direct them back to it.

### *Accountability Applications*

There are many current and future PAS applications for this technology, most of which involve operations taking place over large areas of land or water. Searching a very large area presents difficult challenges to rescuers. A basic compass can indicate direction of travel, but using it to calculate distance traveled and the size of the area covered by a search is difficult and time consuming. However, new global positioning technology makes searching large areas easier, faster, and more exact.

Emergency personnel equipped with GPS locators could report their specific locations to the IC during a rollcall or at any given time. Current technology innovations are linking GPS systems with radio frequency transmitters to allow the units to transmit data automatically to a receiver on a preprogrammed basis. The central receiver, usually a portable computer, then displays the data in a desired format that allows an IC to assess the location of rescue personnel continually. Some units also are being equipped with a panic key that could transmit a distress signal and location coordinates back to the central receiver.

Some GPS manufacturers have discussed the possibility of merging GPS functions into a PASS device that could measure certain factors, including motion, ambient temperature, and perhaps even selected vital signs. This automatic function would facilitate tracking both the location and status of all personnel, and significantly assist the IC in accounting for emergency personnel.

The U.S. Marine Corps (USMC), which frequently sends personnel from Camp Pendleton, California, to large wildland fires, uses GPS technology to track its personnel. The military is experimenting with GPS transmitters that will allow their commanders to track personnel automatically as they move about the fire. Officials from several State and Federal wildland fire agencies are working to develop similar systems.

**Training –** The training required to operate a GPS/PAS would not be extensive. Personnel would require a minimal background in GPS technology and some training in the basic care and maintenance of GPS units. Accountability officers would require some more advanced training to ensure they understand the limitations of the technology.

**Cost –** The primary cost of using GPS technology is that of acquiring the GPS receivers. Current hand-held GPS units are available for under $1,000, depending on the features selected. Combining GPS tracking units with radio transmitting capabilities will increase the price slightly. The computer processor associated with radio transmitting GPS units most likely will be available for the price of a laptop computer.

**Future Trends –** GPS technology is evolving rapidly, and recent innovations offer insights into future capabilities. First-generation GPS technology frequently was hampered by physical obstructions such as trees and most forms of electronic interference. The earliest GPS technologies did not work at all inside structures. Accuracy with early units was problematic at best. Recent technological breakthroughs suggest that it is possible to create a GPS unit that can work inside a structure. Scientists have even reported some success with using GPS to determine elevation in multistory buildings. This, combined with GPS's ever-increasing accuracy range, indicates that the GPS of the future not only will be more accurate, but also will be able to function in a wide variety of situations in which it presently cannot. Moreover, GPS units have come down in cost considerably since they were first introduced for nonmilitary use. If this trend continues, future GPS units will become much more affordable – perhaps to the extent that equipping individual emergency responders would not be cost-prohibitive.

# CHAPTER VI – PERSONAL ALERT SAFETY SYSTEM DEVICES

## *Characteristics of PASS Devices Compliant with NFPA 1982*

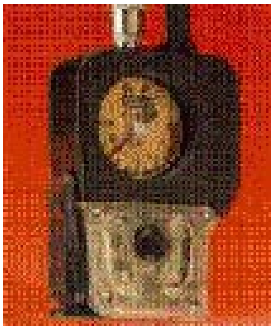

In 1980 the National Fire Protection Association's (NFPA) Technical Committee on Protective Equipment for Fire Fighters responded to requests from the fire service to develop requirements for a device that would signal for aid in the event that a firefighter became incapacitated on the scene of an emergency. These requirements, last revised in 1999, are known as the *Standard on Personal Alert Safety Systems for Firefighters*—NFPA 1982. The standard specifies operating and testing criteria for PASS devices. These devices must be able to function in hazardous environments and are required to be intrinsically safe. They have three modes of operation: off, manual, and automatic. To prevent accidentally deactivating the device, two manual actions must be required to switch the unit from automatic to off. PASS devices have three tones. The first is an operational signal to inform the operator that the device is functioning properly. Another is a pre-alert signal that goes off ten seconds before the alert signal and can be disabled by the firefighter's moving. Finally, there is the alert signal which goes off either manually or when the device has not sensed motion in 30 seconds. (Some PASS devices may have four tones, with the fourth being a tone indicating a low battery.) Further, PASS devices are rigorously tested and must be able to function after exposure to extreme temperatures, immersion, and other extreme environments. PASS devices have become an essential element of a firefighter's protective envelope and are now standard issue in the fire service.

Although NFPA 1500, *Standard on Fire Department Occupational Safety and Health Programs*, requires that each rescuer involved in rescue, firefighting, or other hazardous duties be provided with and use a PASS device, personnel do not always activate their PASS devices at the scenes of emergencies. In some firefighter fatality investigations it has been discovered that firefighters killed during fire suppression operations failed to turn on their PASS devices. This phenomenon can be attributed to many reasons, however, regardless of the reasons, this presents a serious dilemma for ICs as PASS devices are an essential component in most accountability systems. When they are not activated, a potential safety hazard is created for everyone involved in the incident.

Manufacturers have begun to address the problem of PASS devices not being turned on by developing automatically activating PASS devices as well as developing devices that provide more information. The SCBA-integrated PASS, the electronic-transmitting PASS, temperature-sensitive PASS devices, and other technology initiatives are all designed to increase PASS reliability.

### *SCBA-Integrated PASS*

SCBA-integrated PASS devices are designed to allow for the automatic activation of the PASS device when the SCBA is turned on. Sensing mechanisms detect when the air pressure in an SCBA's cylinder is opened, and automatically activate the PASS device. Excluding the automatic activation feature, both types of integrated PASS devices function like traditional PASS units. Unlike traditional PASS units, however, SCBA- integrated PASS units undergo a severe vibration test in place of a drop test to meet NFPA 1982.



All integrated PASS units offer a panic button that can be pressed in a single motion to place the PASS unit in alarm mode. Integrated PASS devices will continue to operate even if the SCBA runs out of air. Each PASS device emits a pre-alarm warning indicating the PASS will go into full alarm mode if the user does not move shortly. If a false alarm does occur, depressing a button or switch will reset the integrated PASS device. Most integrated PASS devices include a visual indicator of the PASS device's status, enabling firefighters to see the status of their unit easily. When the PASS device activates, the visual indicator can assist rescuers in locating downed firefighters. Several integrated PASS devices incorporate temperature-sensing and electronic-transmitting features. Many SCBA manufacturers offer conversion kits that allow the conversion of existing SCBAs to PASS-integrated SCBAs.

### *Partially and Fully Integrated Units*

PASS-integrated SCBAs are available either as fully integrated units or as partially integrated units. A number of partially integrated PASS devices are designed to operate both as an automatic PASS device activated as the SCBA is turned on, and as a detachable stand-alone PASS unit. Partially integrated PASS units generally are mounted in a special bracket that is connected to the SCBA. When the bottle is turned on, the flow of air causes a mechanical device in the bracket to activate the PASS device. If the user needs to use the PASS without the SCBA, the device can be removed from the bracket and clipped to clothing.

Fully integrated PASS devices and partially integrated PASS devices present unique advantages and disadvantages. Integrated PASS devices generally cost between two to four times as much as traditional nonintegrated PASS devices. Fully integrated PASS devices do not offer the versatility of partially integrated devices or traditional units and will function only in conjunction with an SCBA (i.e., they cannot be detached). Although they may cost more, and in some situations have more limitations than traditional devices, integrated PASS alarms offer the invaluable assurance that firefighters will be operating with their PASS devices turned on.

### *Temperature-Sensitive PASS Devices*

Some newer model PASS devices are offered with temperature sensors in addition to motion detectors. Temperature-sensitive PASS devices are designed to sound an alarm after being exposed to dangerous temperature levels. Dangerous temperature levels are defined as a function of both temperature and time. If a firefighter enters an extremely hot area, the device will alarm quickly–usually within seconds. If a firefighter enters a moderately hot area and the temperature does not change, the device will alarm – usually within several minutes. For example, one temperature sensitive device is designed to alarm in 1½ minutes at 450°F (232°C) and in twelve minutes at 212°F (100°C). The alarm tones for excess temperature and non-motion are different, allowing firefighters to readily distinguish between the two.

### *Electronic-Transmitting PASS Devices*

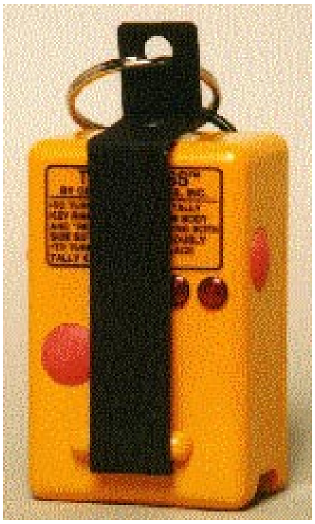
Electronic-transmitting PASS devices are designed to transmit a radio signal from the PASS device to a receiver in close proximity (see discussion of RFID technology). The basic components of this system consist of an individual PASS device and a portable receiver. An electronic transmitting PASS is roughly the same size and weight as a non-transmitting PASS. The only visible difference is a small flexible antenna extending from the PASS device itself. The receiver, which weighs between five and ten pounds, is a battery-powered (with an A/C port) combination microprocessor and liquid crystal display screen, usually housed in a weatherproof, impact-resistant protective case.

Once electronic PASS devices are turned on, they are motion-sensitive. Some also include temperature-sensing capabilities. If the PASS device alarms, it sounds an audible alarm while simultaneously transmitting an alarm notice to the receiver. Some electronic PASS units also emit visual signals during alarm mode. Once it is notified of a PASS in alarm mode, the receiver will sound an audible alarm, display a visual warning, and place the field containing the activated PASS in a prominent location. The receiver will stay in alarm mode until the IC resets it. Only the firefighter wearing the PASS device can reset the unit if there is an erroneous alarm.

Another feature of electronic PASS devices is that they transmit their on/off status and personnel information every ten seconds, regardless of whether or not the PASS has been activated. These transmissions can include information specific to the individual such as name, rank, department identification number, blood type, etc., if a department assigns PASS devices to each member. If PASS units are assigned to a location on a particular apparatus, then they can include the apparatus information such as “Engine 18’s officer” or “Truck 10’s tiller.” As mentioned earlier, electronic PASS units must be activated in order to detect motion and transmit distress signals.

Since electronic PASS units continuously emit PASS on/off and personnel information, once a firefighter comes into range, the receiver will display the firefighter’s identity and whether his/her PASS is on or off. In this way, the IC can see all personnel who are operating on the scene, as well as which specific individuals have not turned on their PASS devices. If the firefighter whom the unit is tracking goes out of range or leaves the scene, the receiver notifies the IC. If the firefighter is authorized to leave, then the unit is simply reset. If the IC did not authorize the firefighter to leave, then efforts to establish the firefighter’s status can be made. This feature is particularly useful at operations taking place over a large area.

Electronic PASS devices’ lightweight design prevents them from housing large transmitters and reduces the effective range from which they can operate. In urban settings, range may be limited to a single structure or floor depending on the amount of electrical interference and building materials used. Rural areas’ more open spaces offer a larger range, usually up to one mile. To overcome this limitation, manufacturers produce portable repeating units that can rebroadcast data to the CP. By linking several repeaters, or by placing them at corners of a structure, emergency personnel can decrease the amount of data transmission interference they encounter.



### *Key-Activated PASS Devices*

Key-activated PASS devices are activated by removing a key or pin housed in the top of the PASS unit. This key usually contains some information such as a firefighter’s name or the PASS devices’ apparatus assignment, such as “Engine 5’s officer.” The key then can be turned over to the accountability sector and placed on a location board. As firefighters enter the incident command structure, they remove their accountability tags from the PASS devices, which activates the PASS device, and turn the tags over to the PAS officer. If an audible alarm occurs, the wearer can reset the alarm, but the only way to turn the device off is to replace the key. Linking PASS activation directly with personnel accountability can ensure that firefighters operate with activated PASS devices at an emergency scene. Key-activated PASS devices are commonly used by fire crews in Great Britain.

*Accountability Applications*

PASS devices are essential elements of any accountability system because they provide a means of constantly monitoring the status of emergency personnel operating at an incident. PASS devices can alert fellow responders to problems and can help rescue/intervention teams locate personnel who are in trouble. Although current technology is improving and becoming more sensitive and able to test for more hazardous situations, PASS devices are still only a **component** of a functioning accountability system–they should not be used as the entire PAS.

**Training –** Sophisticated PASS technology cannot substitute for effective and disciplined accountability procedures. A combination of regular accountability drilling incorporating PASS devices, devices that do not generate as many false alarms, and technology that activates automatically some or all PASS functions will serve to increase PASS reliability. Overall, though, the most important first step for many departments is to train rescuers to activate and use their current PASS devices properly.

**Cost –** Depending on the manufacturer, individual PASS devices can range from $150, for basic, motion-only devices, to $180 or more for advanced devices that can sense temperature, motion and/or are key-activated. Electronic transmitting systems can cost upwards of $11,000 for the PASS devices and the monitoring system. Integrated PASS systems are usually purchased through the manufacturers in conjunction with an SCBA. These systems, including a facepiece, cylinder, etc., can cost several thousand dollars, depending on the options/materials chosen. Purchased alone, kits for adding an integrated PASS element to an SCBA cost approximately $500. As PASS technology advances, these prices are likely to decrease.

**Future Trends –** Ideally, ICs should rely on emergency responders to activate their PASS devices on every call, every time. However, PASS devices are not always manually activated. This indicates that in the future PASS devices will probably become more automatic and less user-controlled. Current electronic transmitting PASS devices offer a glimpse into the future of the potential operations of automatic PASS technology. The PASS devices of the future are likely to be smaller, lighter, and able to sense and test for factors other than motion and extreme temperature. PASS devices of the future are likely to have increased transmission range and may help pinpoint a responder's exact location. In fact, military electronic status monitoring technology may offer a glimpse of the future capabilities of emergency responder status monitoring technology.

# *CHAPTER VII – ELECTRONIC STATUS MONITORS*

Most of these items were designed for military use, but it has been found that they may have significant fire/EMS applicability as well. These devices can either be carried or worn. They provide continuous information on the physical condition and status of the wearer. Sensors include devices that can fit on a wrist, attach to various body parts, or even be worn as a vest. (In the case of the vest, this monitoring capability has been combined with some sort of protective function as well, such as protection against fragments, bullets, and other projectiles common in military situations.) The sensors in these devices are connected remotely by radio, satellite, or other means, to a monitoring facility, which may be a headquarters or simply one person with a computer.

Models that integrate real-time movement, position, and status data are being developed for the military. These systems also may integrate audio and visual transmitters worn by those out in the field, and provide images and sounds to whoever is monitoring and receiving the data. In some cases, a transparent "heads-up display" is integrated into the wearer's visor, providing information about the whole scene. This information can be tailored to individual needs by the control center. Due to its military applications, it is unlikely that this sort of equipment will be made available to emergency response units until well into the future.

In general, electronic status monitors are simply devices that transmit data about the person wearing the monitor back to a command and control center. Most of these devices are able to measure pulse, blood pressure, and respiration. More advanced models are able to measure perfusion and oxygen saturation levels.

At present, these instruments are relevant to personnel accountability in a way that may not be considered mainstream. While these devices cannot, at present, indicate the location of an individual, they do still have a valuable role, and are important to a PAS. Used in an appropriate system, they can establish who is in a structure or on a scene. They can also be used to determine who is in trouble or in imminent danger of becoming so. Should a person be need help, these devices could alert an IC and allow a search and rescue effort to be implemented.

In the future, it is hoped and expected that advances in positioning technology, such as GPS or radar, will be combined with these devices to provide a more complete picture of the location and status of any individual or group. Future models also are expected to be able to sense when an injury occurs or a wound is inflicted.

## *Sensor Vest*

This is essentially an elastic vest embedded with sensors and processors that both collect and disseminate information about the wearer. These vests are designed to detect torso penetration as well as areas of major bleeding. They also may be able to detect wounds and their location. The sensor vest monitors the wearer's heart rate, blood pressure, and respiration rate. The capacity for these devices to monitor such items as blood oxygenation, blood loss (through changes in body weight), dehydration, EKG, motion, and position is also being developed.

**Training –** Significant training or usage issues are not foreseen for this type of system. Using the vest in a PAS may require someone who is technically proficient to operate the monitoring station and interpret the data. For the most part, however, this technology operates on a stand-alone basis and should not interfere with what the wearer is doing. Good communication still will be required for optimum performance.

**Cost –** The costs of such systems probably will be prohibitive to fire and EMS agencies for the foreseeable future. Should a civilian application warrant commercial production, the costs could be expected to drop significantly. This, of course, would take place after the technology for such devices becomes more refined.

**Future Trends –** Future versions of this vest may integrate more sensing capability, such as EKG's, with an increased ability to provide location data. The vests also may provide a protective element and allow greater communication opportunities.

### *Noninvasive Medical Sensors (Personal Status Monitors)*

Noninvasive medical sensors are basically a type of sonar used on the human body for medical purposes. These types of devices are used to monitor respiration, circulation, blood pressure, and Central Nervous System (CNS) function. Sensors can be worn on the body in several locations, as they are the size of a silver dollar and can fit into grooves such as those around the carotid arteries. Once in place, the sensors monitor pulse, perfusion, and blood pressure. They relay their data to a transmitter worn on the belt, which then sends the data back to the monitoring station.

**Training –** The training for using these devices is not significant. These devices are easy to use and wear. All that is required is an ability to adequately and promptly interpret the data being sent, as well as the ability to maintain communication between those wearing the sensors, those monitoring them, and those in overall command of the operation.

**Cost –** Such devices may be prohibitively expensive until a reasonable commercial application necessitates that they be priced competitively.

**Future Trends –** In the future, this type of technology will be able to provide a more complete picture of an individual's status, but it is unlikely that they will be able to provide positional information.

### *Silicone Rubber Optical Fibers*

Another type of monitoring system, silicone rubber optical fibers, is composed of elastic materials that attach around the torso. They are sensitive to expansion and contraction, allowing them to monitor respirations. Presumably they also can detect heart rate, skin temperature, and other vital signs. This type of system is especially desirable in areas where alternate monitoring is not possible due to electromagnetic interference, etc.

**Training –** No significant training or usage issues appear. These systems require basic capabilities for monitoring purposes.

**Costs –** As these devices are not yet commercially available, it is impossible to predict potential cost.

**Future Trends –** Silicone rubber optical fibers will provide an increased ability to collect information about vital signs and other physiological factors. This will enhance other technologies that have potential PAS application.

### *Foot Force Sensors*

Foot force sensor systems use a special insole to detect foot pressure. The sensors can be calibrated individually to transmit data. The system is limited in its ability to provide essential physiological data, but it can monitor movement. This system acts as a motion sensor that could be used to track the movement of emergency responders.

**Training –** No significant training or usage issues appear. This system would require basic monitoring capabilities.

**Costs –** These devices are not yet commercially available therefore an accurate prediction of cost is not possible at this time.

**Future Trends –** At this point this technology is still in the developmental stage. If it can be made commercially available, it might be very useful in the fire service.

### *Heart/Lung Sound Project*

The heart/lung sound project is an acoustic detection and classification system that is being developed by the military to detect heart and lung abnormalities. This system will allow onsite supervisors and medics to make diagnostic decisions based on physiological function. The advancement of computing, signal processing, and acoustic sensing technologies has made it possible to collect and analyze short-duration signals on inexpensive and portable off-the-shelf equipment. This system is being developed using a portable laptop as the computing platform. The initial system will have the following attributes:

- two acoustic, one EKG, and two reference channels. The acoustic channels will have a bandwidth from 20 Hz to 2 kHz with a variable prewhiting filter to emphasize different detection of selected signal component;
- background noise subtraction for detection of quiet sounds in noisy environments;
- EKG for time-referencing cardiac events and detection of arrhythmias;
- multiple time/frequency analysis and display screens; and
- automatic detection of selected signals.

**Training –** Anyone receiving this information would have to be trained in the interpretation of cardiac rhythms and methods to correct arrhythmias (abnormal heartbeats).

**Costs –** This technology is not yet available and cost information is not known at this time.

**Future Trends –** Assuming the military makes this technology commercially available, it has the potential to become a valuable diagnostic/monitoring device in the fire service.

### *Hands-off Arrhythmia Monitor*

The hands-off arrhythmia monitor is a small, noninvasive sensor that can detect arrhythmia (abnormal heartbeats) in the wearer. The device could up-link to a distress transmitter that will notify monitoring personnel of the occurrence of a dangerous arrhythmia. The sensors also could transmit data to a control center or hospital.

**Training –** Anyone receiving this information would have to be trained in cardiac rhythm interpretation, and possibly in arrhythmia intervention techniques.

**Costs –** This technology is not yet commercially available and cost information is not known at this time.

**Future Trends –** Perhaps in the future this type of instrument will be able to provide other information about a wearer’s status, or even have the capability to deliver anti-arrhythmic electrical shocks.

### *Secure Laser Communication*

A key element to electronic status monitoring for any PAS system is real-time data transfer. The military currently employs a secure laser communication system that is able to relay digital and acoustic data at high speeds digitally, in real time, over distances of up to five miles. This system could be useful in situations where activities were being conducted over a large area, and could, in combination with monitoring devices, be used to relay personnel status back to a command center. Alternatively, this type of system could be used to relay data about injured personnel to a physician or hospital from the scene, and allow a preliminary evaluation to be made. Instructions then could be given on initial care and requirements.

**Training –** This system would require some training as to proper usage, although it is unclear how much training would be needed for nonmilitary applications.

**Cost –** Because these units are so expensive, their day-to-day use in a PAS is not anticipated for some time to come.

**Future Trends –** Future applications of this type of technology might provide personnel with individual communications equipment that would replace radios (and the associated problems of range and overlap of transmission).

# *CHAPTER VIII – ACCOUNTABILITY AIDS/SAFETY AIDS*

Personnel accountability aids, both visual and audible, might enhance existing personnel accountability systems by increasing scene safety, preventing firefighters from becoming lost or disoriented, assisting firefighters with finding the way out of hazardous areas, and promoting scene visibility. Some structures or wildland areas are extremely confusing to navigate even in non-fire conditions, while other seemingly routine areas can cause even veteran firefighters to become disoriented. Although current technology cannot replace a firefighter's good judgment, there are numerous innovations designed to prevent firefighters from becoming lost inside structures as well as to increase overall scene safety.

## *Sound-Based Exit Device*

The sound-based exit device is a self-contained, weatherproof, audible transmitter designed to be placed at an entry/egress location. The device automatically emits a distinctive penetrating sound and strobe light every ten seconds, enabling lost or disoriented firefighters to the direction of an exit more quickly in low visibility environments. The audible signal has an effective range of 100 feet in most structures, although this can vary depending on the type of construction materials involved. The device also offers an emergency transmitter function that sounds a distinctive emergency tone if activated by a firefighter in distress. ICs also may use the device to transmit an emergency evacuation signal.

Sound-based exit devices, which augment an existing personnel accountability system, would be most useful on structural emergency incidents. An exit device could also be used in wildland or maritime operations. However, some sound-based devices are not intrinsically safe and are not recommended for use in potentially explosive environments.

**Training –** Minimal training would be required to integrate these units into fire suppression activities. Firefighters would have to be trained as to the best locations to place the devices and be made aware of its various alert tones.

**Cost –** Individual units cost approximately $1,200 each.

**Future Trends –** In the future, intrinsically safe models may appear on the market, increasing the types of situation where this device could be used. Used in conjunction with a PAS, this device could be very useful in the fire service.

### *Visual Safety Aids*

A number of existing technologies enhance visual recognition of personnel or provide visual safety cues. These technologies could be employed as part of an overall PAS.

### *Thermal Imaging Technology*

By sensing the heat patterns of infrared radiation signatures, thermal imaging technology has the capacity to locate and monitor emergency personnel operating in smoke, fog, night, and other low-visibility conditions.

Thermal imaging devices, which are especially sensitive to body heat, use infrared technology to sense very small differences in heat levels. Typical thermal imaging devices are able to discern differences of as little as 0.1 °F between an object and its background, and can display this thermal contrast on a monitor. Thermal imaging devices cannot see through most structures, since infrared radiation cannot be detected through concrete, rock, brick, wood, drywall, or other materials that block heat patterns.

The typical black and white image monitor varies in brightness depending upon an object's temperature and generally produces a silhouette-style image of a person, but will show neither detailed features nor colors. Most thermal imaging cameras available for the fire service use either a pyro-electric vidicon (PEV) unit or a focal plan array chip (FPAC). Many handheld thermal imaging devices contain PEV technology, which has a tendency to "white out" or flood the entire display screen with light when the unit is pointed directly at a high-energy heat source. FPAC technology displays a "virtual reality" image that does not white out when pointed at a high-energy heat source. While this technology is initially more expensive than PEV, it tends to have lower maintenance costs over time.

#### *Personnel Accountability Applications*

Numerous fire departments around the country are using thermal imaging devices as to assist Incident Commanders in tracking emergency personnel, locating trapped victims, or doing size-ups at incidents where heat signatures are not blocked by surrounding objects.

Thermal imaging devices may provide a number of tangible benefits for personnel accountability at low-visibility wildland and other open-area emergency operations, as there would be few heat-signature-blocking structures to limit the device's effectiveness. Even though thermal devices cannot identify specific individuals on a regular basis, it could be used to track the movement of crews on wildland fires as well as the movement of the fire itself. Thermal imaging devices could also be useful in maritime operations since thermal devices are capable of scanning the surface of open bodies of water; some can even scan several feet under the surface. Incidents covering large areas, such as a major wildfire operation, however, would require powerful thermal devices capable of scanning large areas.

Thermal cameras can track firefighters on some structure fires, depending on the construction of the building, but most usually are unable to track personnel once they enter a building. Thermal cameras are probably more useful in that they permit intervention teams to locate comrades in need of assistance rapidly. With a properly functioning accountability system, an IC could know the identity and location of a firefighter in distress, and could direct a rescue team to that location. Thermal devices could enhance the safety and efficiency of rescue/intervention teams significantly.

Thermal cameras offer other safety and efficiency improvements, outside of direct personnel accountability applications, which in turn promote the general themes of safety and accountability on the fireground. One fire department has a standard operating procedure (SOP) of using a thermal imaging camera, mounted to a telescoping antenna atop their command vehicles, to quickly scan a building or an area for hazards. Thermal cameras can show the differences in air temperature inside a structure, enabling firefighters to locate the seat of a fire rapidly, show fire spread in a building, predict flashover, and sometimes can show downed wires or other hazards in smoke-covered areas.

### *Personal Thermal Imaging Cameras*

Personal thermal imaging cameras range from helmet-mounted systems to small, handheld, camcorder-like devices. Helmet-mounted systems consist of a camera lens, attached to the side of a helmet, a video display area, anchored to the front of the helmet, and a power pack, worn on the belt. They provide a thermally enhanced image and allow firefighters the use of both hands, but are permanently attached to the helmet. Handheld units are designed for one-handed operation. Firefighters simply lift the camera to eye-level and look into the video display area. These units offer the advantage of being easily passed from one firefighter to another, without having to remove pieces of protective equipment.

Both types of personal cameras are designed ruggedly, for limited use in, and exposure to, areas near fire or water. They usually can be used for several hours before their batteries are exhausted. Some units must be turned off hourly to cool down, since their airtight design does not allow for easy cooling of internal components.

**Training –** Use of this technology requires moderate training. Firefighters must become familiar with the equipment and must be able to interpret the images they see though the camera's lens. Often, manufacturers will offer assistance to fire departments in training personnel to operate their products. Sometimes, a training session is included in the overall cost of the system.

**Costs –** Personal thermal imaging cameras cost around $16,000 for basic models and $25,000 for more expensive units, which offer increased range and image clarity.

**Future Trends –** More and more fire departments are attempting to procure these devices because of their primary application in interior fire suppression—search-and-rescue. Although the units are expensive, it is hoped that advances in thermal imaging technology eventually will lead to cost reductions that will enable more departments to acquire and use these devices. As departments become familiar with the devices, their use in a PAS is likely to become more commonplace.

Thermal imaging cameras of the future will be smaller, lighter, and more powerful. Experimental work has been performed to build a firefighting helmet that incorporates thermal imaging technology, an SCBA facemask, and an internal communications system. The growing popularity of thermal imaging cameras for use in a wide variety of roles will serve to stimulate the development of improved models.

### *Forward-Looking Infrared Radar*

Forward-looking infrared radar (FLIR) units used by law enforcement and some search and rescue teams to scan for people over large areas, are very powerful and expensive thermal imaging devices that mount to vehicles and aircraft. Depending on the lens, FLIR units can have a range measured in miles, so they are ideal for vehicles capable of covering large amounts of territory rapidly. For example, some helicopter-mounted FLIR units have a range of ten miles. Sophisticated new tracking technology allows FLIR units to lock-on and automatically track a thermal signature as long as it stays in range of the camera.

**Training –** Significant training issues are not foreseen for this technology.

**Cost –** Helicopter- and vehicle-mounted FLIR units are more expensive than handheld models, usually costing over $100,000.

**Future Trends –** Because these units are so expensive, their day-to-day use within a PAS is not anticipated for some time to come.

### *Reflective Hose*

Reflective (luminescent) directional hose incorporates reflective lettering and a directional arrow into the weave of each section of hose. The lettering and arrow can be seen in smoky conditions using a handlight or any other direct light source. The arrows and lettering point toward the female coupling (i.e., in the direction of the exterior of the structure). Firefighters need only to shine a light, instead of fumbling along a hose section in search of a coupling, to rapidly identify the direction of building exits or the location of the engine. This type of hose could enhance personnel accountability since it could allow lost firefighters to find their way back to safety more quickly.

Caution must be used with this approach. If the reflective hose alone is used to find an exit, a firefighter may pass other exits unknowingly or, worse, be drawn close to the fire if the hose is looped. Another concern is if this hose is somehow attached to a double female connection, this may lead a firefighter away from an exit.

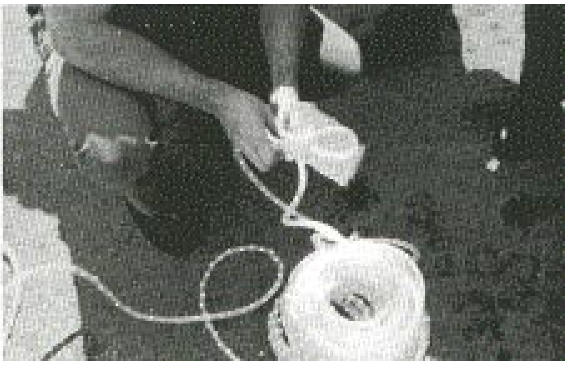
**Training –** Very little additional training would be required. Firefighters already know how to operate a hose line; the addition of reflective material should not significantly change that process.

**Cost –** Reflective hose is more expensive than standard hose. For 1 ¾-inch attack line, standard hose costs approximately $90 per section while reflective hose costs approximately $272 per section.

**Future Trends –** The use of hose in the fire service is not a trend likely to end any time soon. Improvements in the hose itself, such as reflectivity, which could help save lives, are likely to continue to be improved upon. As the technology advances, hose may become lighter and less expensive.

### *Reflective and Lighted Rope*

Reflective rope, which qualifies as a lifeline since it is built with the same strength as kernmantle rope, contains filaments that reflect light when illuminated by a light source. Lighted rope, which does **not** qualify as a lifeline, resembles a hollow plastic tube containing hundreds of small lights. These lights will remain lit if one burns out, and are intrinsically safe and waterproof. Lighted rope, which may be most useful as a tagline, is slightly stiffer than normal kernmantle rope, but it is flexible enough to use to tie some knots. Both types of ropes can be useful in a PAS by making potential safety hazards, like the ropes themselves, more visible on the fireground.



**Training –** Very little additional training would be required. Firefighters are already well aware of the importance of ropes and knots in the fire service. The addition of reflective material is not likely to significantly impact fire departments' SOPs.

**Cost –** Reflective rope generally costs approximately 20 percent more than standard fire service rope.

**Future Trends –** The use of ropes and knots in the fire service is likely to continue and improvements that make this technology more useful in the field are likely to be embraced.

### *Reflective Clothing*

Reflective clothing, available as vests, gloves, and caps, uses bright colors in conjunction with elements that reflect light, some at a strength of 500 candlepower and visible up to ½ mile away, to allow emergency personnel to be seen as they move about at emergency incidents. Bunker gear reflective material can fade over time or become soiled and ineffective. Reflective clothing, worn in addition to or in place of bunker gear reflective material, can assist Incident Commanders in monitoring the locations of personnel, and allow firefighters to be seen both during the day and at night. Fire departments should make sure that any reflective clothing that might be used during fire suppression activities meets the appropriate standards for such use.

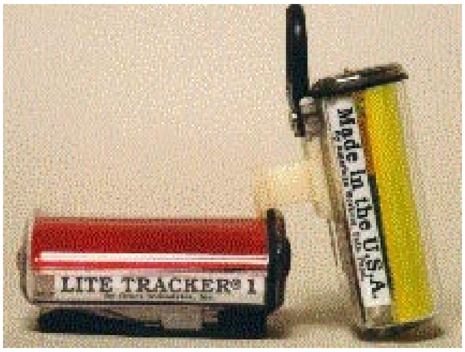
Reflective clothing can be useful in a PAS by visually identifying personnel at the scene of an emergency as well as key incident command personnel, helping to alleviate on-scene confusion. In addition to clothing, some manufacturers produce free-standing reflective sector flags which are placed at the various sector locations, rest/rehabilitation, Staging, the CP, etc., to clearly identify the location. Such sector identification is an aid to a PAS because PAS officers (as well as personnel operating at an emergency incident) can better identify specific operational areas.

**Training –** Very minimal training would be involved. Personnel would simply have to wear the reflective items.

**Cost –** Varies depending on the manufacturer and the types of items desired. Vests can range in cost from $7-$30, while gloves are approximately $15.

**Future Trends –** Reflective clothing may become more readily reflective and brighter in the future.

### *Light Indicators*




Light indicators are small, light-emitting devices that clip to clothing, helmets, or SCBA, allowing personnel working in low-visibility conditions to be seen more easily by fellow crew members. Visual indicating devices typically emit either a steady or pulsing light that helps personnel maintain crew integrity and command personnel to monitor responders' movements at an emergency incident.

Light indicators come in a wide variety of forms. Available in many stores, chemically activated glowsticks are inexpensive and weatherproof, but are not recommended for exposure to the extreme temperatures encountered in many fire operations. They must be discarded after use. Another option is reusable, battery-powered strobe flashing indicators, which are small, lightweight devices that clip to an SCBA or turnout gear, and are able to withstand the temperatures and abuse associated with fire/EMS operations.

Greater visibility increases the ability to coordinate activities and provides another tool to assist in locating downed personnel. Many firefighters use personal flashlights clipped to helmets as a simple light indicator. Visual indicators also increase visibility for personnel not directly engaged in firefighting activities, thus raising the overall safety level of the operation. Visual indicators are already common in underwater emergency operations.

**Training –** Minimal training is necessary. A firefighter simply has to activate the device and clip it onto a piece of equipment.

**Cost –** Individual units range in cost from $30-$45.

**Future Trends –** These devices are likely to become lighter, brighter, and less expensive.

# CHAPTER IX – COMMUNICATIONS

Clear, concise communications, which are mutually understood by the message transmitter and receiver, are an essential component of any effective PAS. A wide variety of communication systems are available to keep emergency personnel informed and connected to the ICS and PAS in which they operate.

Communications technology can transmit a signal via radio frequency waves or through a hardwired cable. Radio signals can be blocked by walls and metal, and are limited by distance and can be interfered with by other physical/electrical barriers. It is estimated that radio communication systems are approximately 95 percent reliable at the most. Hardwired communications equipment may be close to 100 percent reliable, but might not be as versatile since communication signals must travel through a physical wire.

## *Radio Frequency Systems*

Conventional radio frequency (RF) systems are widespread throughout all aspects of the emergency services sector. RF technologies convert a voice message into a specific radio wave frequency, measured in megahertz (MHz), and transmit those waves to allow other radio units to operate on the same frequency. These units then convert the radio waves back into a voice message.

RF systems, standard for fire department handheld and mobile communication units, transmit messages in the 25 MHz to 800 MHz radio frequency range. A general rule associated with radio waves is that lower frequency waves will travel a greater distance than higher frequency waves, but lower frequency waves will not be as able to penetrate barriers as higher frequency waves. For example, a 40 MHz signal from a standard mobile radio can travel 50 miles or more without a signal repeater, whereas an 800 MHz signal would have difficulty traveling the same distance, even under ideal conditions. An 800 MHz signal, however, can transmit through a concrete enclosed room that would block a 40 MHz signal.

Many RF communications systems rely on repeating stations to increase a network's range. Repeaters simply take an incoming signal and relay it to the radio network, sometimes at an increased strength. Repeating stations located at strategic points in an emergency response area increase the range of any one particular radio by decreasing the total distance that a radio signal must travel.

## *Trunked Radio Systems*

RF technology, already widely used throughout the emergency response service, offers advantages for a wide variety of emergency incidents, since it can transmit over a large area and, depending on the frequency, through a number of obstacles. RF technology does, however, have certain limitations. Obstructions such as concrete, metal, tunnels, static interference, similar high-powered frequencies, and atmospheric disturbances like electrical storms can interfere with radio signal transmissions. RF signals are not able to pass below the surface of water and are blocked frequently in many confined space emergencies. Technologies that address some of these problems are available such as portable repeaters or the use of a hardwired communications system.

Trunked radio systems allocate twenty or more channels to a particular radio frequency. Trunked radio systems do not require one frequency for every one channel; instead, the system picks an open frequency when the user transmits over a channel. Trunked systems work on the concept that even though there are a multitude of channels available to users, it is extremely unlikely that more than a few of them are in use simultaneously at any given moment.

The heart of a trunked system is a computer that assigns users an open frequency. This computer selection process is invisible to the user. The multiple channel capability of a trunked radio system offers many advantages at small- and large- scale rescue or fire incidents. Typically, there are many high priority operations occurring simultaneously at an emergency incident. Coordination of the operation can be very difficult if only one or two channels are available to rescuers. The new trunked technology could offer multiple channels. For instance, each sector of an incident command could use a separate channel, while the commanders could utilize another channel for communications and coordination among themselves. Commanders, however, would have to monitor ongoing operations on the separate channels to ensure that they are coordinated.

A trunked system is designed to allow communications among multiple agencies, allowing fire, police, public works, and other agencies to communicate with one another, facilitating communications during a disaster. The technology also allows other jurisdictions to use the same radio system so that no patching of frequencies is necessary. One limitation with the trunked system is that if the signal does not reach the central trunked system receiver, the transmission will not reach other radios that are connected to the system.

### *Hardwired Communications Systems*

Hardwired systems are considered to be the most reliable media of communications available because a wire or cable directly connects users. Some systems use a console to interconnect several users. This allows for duplex communications, where two or more of the rescuers can talk simultaneously and everyone is able to hear them (similar to a conference call). These systems generally use headsets, sometimes with throat microphones, attached to a wire that runs to a central console. The headsets and microphones are very compact. The transmit button can be placed either in a rescuer’s palm, or the system can be voice activated. These features facilitate movement within a confined space or inside a protective suit.

Hardwired systems can be used effectively at incidents where RF signals cannot penetrate, such as confined spaces. Since a wire carries the signal, it is virtually ensured that a rescuer can be heard at any time. Many rescuers find the greatest advantage of these systems to be the psychological reassurance of knowing that they always will be able to communicate, especially when they are out of visual contact with non-entry personnel.

Some hardwired units have emergency buttons that can be activated if a rescuer needs assistance. Some are intrinsically safe, making them useful at incidents where the atmosphere is flammable or explosive, such as silos, sewers, vats, storage tanks, or ship hulls. The main power supply for intrinsically safe units remains outside the explosive environment, the wire is fully shielded, and it conducts only a few milli-volts. Newer hardwired systems are insulated from outside electrical signals that can create interference or static.

Divers also can use hardwired communications systems. Underwater communications are particularly important in dark or dirty water, where visibility is restricted. This technology allows divers to communicate and coordinate their efforts. It also allows divers to communicate with rescue personnel on the surface. These systems also give psychological reassurance to divers.

The major limitation with any hardwired system is the length of the wire. Depending on the system, the wire generally is limited to between 500 and 1,500 feet. For longer distances, a repeater may be necessary to boost the signal. Most hardwired systems are also limited to four or five users, unlike RF systems that can accommodate thousands. Sometimes, two hardwired systems can be connected at the control console to double the number of users. Users of hardwired systems must deal with dragging wire, which may become snagged or tangled.

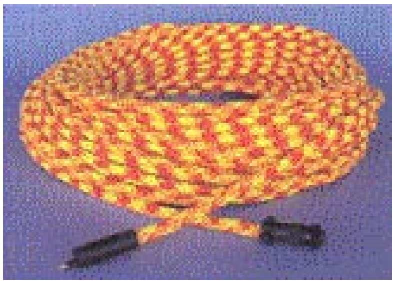
**Training –** Many departments are already familiar with the use of radio communications. However, they may not be used to the tether of a wire and the safety hazards it creates. Further, they may need to be trained how to lay down the wires and connect them properly.

**Cost –** Multi-user hardwired systems range from $5,000 to $10,000.

**Future Trends –** As long as wireless communications continue to face interference from a host of electrical and physical barriers, hardwired communications should provide a reliable option to ensure that messages are sent and received in emergency situations.

### *Communications Wire/Rope*

Many rescue incidents require a safety line (tag line) to be attached to rescuers at all times. Rescuers involved in confined space entry, diving, rappelling, or swiftwater entry often must use safety lines. Sometimes rescuers also need to take a hardwired communications line and/or an air hose, Self-Activated Breathing Apparatus (SABA), in with them for air supply. The three separate lines may present a hazard to rescuers if they become tangled, twisted, or caught.



Communications wire/rope is technology that combines two of these lines into one in order to reduce the risk of tangling. It is usually made as a kernmantle, with the wire running through the inside of the kern (the rope's inside core). The encased wire does not compromise the strength of the rope, allowing it to serve as a safety line. Each end of the wire/rope has a locking coaxial-type connection so that it can be attached to a radio, headset, or other communications console.

Most communications wire/rope has a breaking strength of around 5,000 pounds; military-grade wire/rope is rated as high as 9,000 pounds. The rope is made from synthetic fibers and is waterproof. Since the wire runs through the center of the rope, it is intrinsically safe for rescue operations in flammable environments. However, under high stress, the wire portion of the rope could be damaged due to the greater elasticity of the rope surrounding it. Communications wire/rope is available in various widths and lengths.

**Training –** Rescuers would have to be aware of the dangers of their lines getting tangled and other dangers inherent in working in confined spaces.

**Cost –** Communications rope generally costs approximately $3 per foot, if it is encased in kernmantle rope.

**Future Trends –** Since wireless radios often cannot be used during confined space rescues, this could be a reliable way to ensure communication. Hardwired systems may become less expensive and more reliable in the future.

### *Wireless Underwater Radios*

Hardwired communications systems were mentioned previously as a method for communicating underwater. New technology developments make wireless communications possible today. Wireless underwater communications systems transmit signals via ultrasonic waves. Some ultrasonic systems can transmit signals up to five miles, allowing divers to communicate at greater distances than is possible with hardwired underwater communications systems; lower powered systems can transmit up to 5,000 feet. There is virtually no limit to the number of divers that can receive the signal, another advantage over hardwired systems.

The ultrasonic signals cannot travel outside of water (the 33KHz signal does not propagate through the air and is limited to line-of-sight transmission). Personnel on the surface must lower a transducer (antenna) into the water to receive and transmit signals. Some systems also require the divers to drag a transducer.

In order to talk underwater, divers must wear full facemasks. Besides offering communications capabilities, full facemasks also protect the diver from hazardous chemicals or organisms in the water. More expensive communications systems use a full facemask with an earphone containing a bone microphone, which picks up vocal sounds, carried through a bone (often the skull or jawbone). In some models, a part of the microphone assembly itself if made of bone.

**Training –** Anyone using this technology would have to be familiar with underwater rescue and the equipment involved in such a task. Beyond that, a rescuer would have to become familiar with the specific system he/she is using and understand its limitations.

**Cost –** A three-unit wireless system costs approximately $3,000.

**Future Trends –** These units may become more powerful, more reliable, and less expensive as the technology is developed.

### *Water-Resistant Communications Equipment*

The use of portable radio equipment to maintain communications and personnel accountability is a growing trend in all types of water rescue. Any time rescuers are operating around a river or other wet area vital PAS communications equipment is exposed to water. Dive support personnel, water rescuers, boat operators, and other rescuers use radios that could be damaged by the water (see Accountability for Water Rescue Operations section). For these reasons, water-resistant communications equipment plays an important role in water-rescue accountability systems.

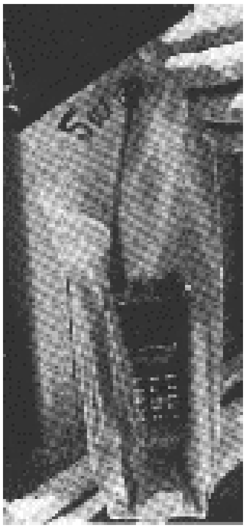
### *Waterproof Radios*

Most major manufacturers of portable two-way radios produce models that are waterproof or water-resistant. These radios enable rescuers in the water to maintain radio contact with each other and with personnel on the shore.

**Training** – Only minimal training beyond care and maintenance of waterproof radios will be necessary, as most emergency response personnel already will be familiar with the operation of portable communications equipment.

**Cost** – Radio manufacturers often charge a considerable premium (as much as $3,000 per radio) for waterproof models. A more affordable alternative is to use existing USCG-approved marine band portable radios, which often can be purchased for under $200 each. These radios use FCC-approved public frequencies and are not limited to use by fire/rescue personnel.

**Future Trends** – As this technology is developed, it likely to become less expensive and therefore more readily available to the fire service.



### *Waterproof Radio Bags*

Watertight bags that hold portable radios can be attached to the rescuer's chest or waist to carry the portable radio. Waterproof headsets with the microphones or throat mikes with palm push-to-talk buttons are ideal for a rescuer who needs to communicate with others over loud noises, but who cannot use his/her hands to activate a radio.

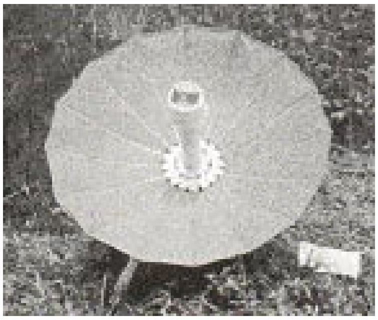
Several companies produce rubber or plastic bags designed to protect radio equipment from immersion in water and to allow the radios to be operated within the bags. This is an inexpensive means to protect radios from accidental submersion in water, or for situations in a water-rescue incident where a radio is used only rarely. These bags are useful for shore support operations of dive or swiftwater incidents, or occasional uses in the water.

**Training –** Training beyond care and maintenance of waterproof radio bags is not necessary, as most emergency response personnel already will be familiar with the operation of portable communications equipment. Personnel also might need to be trained how to test the bags to ensure a solid water barrier is intact.

**Cost –** Waterproof radio bags range from $20 to $40 apiece, depending on the model and manufacturer chosen.

**Future Trends –** This technology will continue to be useful as long as waterproof radios are prohibitively expensive. Waterproof bags may become more watertight and less expensive.

### *Cellular and Satellite Technology*



Following major disasters, telephone systems may be totally disabled or severely limited. Communication cables may be down, incoming and outgoing calls may jam circuits, and switching stations may be destroyed. Communications towers of all types may be down. Many rescue teams have begun to use alternative telephone systems, such as cellular and/or satellite phones, to work around potential telephone problems. Another application of cellular technology to PAS is its use as a means to track personnel at the scenes of emergency incidents.

#### *Communications*

When hardwired systems are out of service, cellular phones are one alternative. This assumes that the cellular receiving sites are not destroyed. However, with the increasing number of cellular phones in use by the public, cells also may become jammed and prevent the rescuer's calls from getting through. Cellular transmission may not get through if the user is in an area where signals cannot reach a receiving cell.

Another communication option is to bypass the local telephone or cellular system entirely by using a satellite telephone. Satellite telephones can bypass the jammed circuitry of a disaster scene. These expensive units (the size of a suitcase) are particularly useful for rescuers in remote areas where neither hardwired phones nor cellular receiving sites are available, and might be particularly useful on large wildland incidents where radio communications are not feasible due to the long range the radio waves would have to travel.

**Training –** While many people are familiar with the use of cellular phones, minimal training might be required to familiarize rescuers with the setup and positioning of a satellite phone.

**Cost –** Cellular phones are commercially available, and rates vary according to the region, the service providers, and whether government service plans are available. Satellite telephones can cost more than $10,000.

**Future Trends –** Cellular and satellite phones are becoming more and more common in all segments of society. This technology is likely to become less expensive and more reliable in the coming years.

### *Personnel Location*

New cellular technology is also being developed in response to new FCC regulations mandating enhanced cellular 911. By the year 2001 locating technology must be in place that will locate a cellular caller within 125 meters. Such technology also has great potential in a PAS, as it may be possible to locate signals much more accurately – within 15 feet. Using this increased accuracy, "Automatic Personnel Locators" are able to track personnel wearing the pager-sized device. Incident commanders would be able to track the positions and assignments of personnel on the scene of an emergency incident.

**Training** – Significant training is not foreseen for this technology. Incident commanders would require training in the use of the tracking software available for use with this equipment.

**Cost** – This technology is not yet commercially available, however, it is being developed with the intention for its use in public safety. Accordingly, its cost will probably not be prohibitive.

**Future trends** – This is an emerging technology with great potential for use in a PAS. As it is refined and developed its use will become more commonplace.

### ***Portable Repeaters***

Rescues deep within a confined space can create communications problems for several reasons. First, portable radio signals often cannot reach outside the space. Second, a hardwired system may not be able to extend far enough into the space to reach the victim.

Some rescuers are testing the viability of portable signal repeater technology borrowed from the military and mining industry. These units simply boost the signal from the portable radio so that it can reach personnel outside of the confined area. Individual repeaters can be placed within the space as rescuers enter. Depending on the number of bends and other barriers, the repeaters may be placed closer or farther away from one another. Portable repeater systems can be used for entry into caves, ship hulls, sewer lines, and tunnels.

A portable repeater could be useful to ensure that voice and data transmissions for a PAS are received when operations take place over large distances or in areas where standard radio transmissions are hampered by construction, remoteness, or topography. Portable repeaters are useful in hurricane- and tornado- stricken areas as destructive winds usually destroy radio repeater systems. Portable repeaters, the size of a suitcase, can be set up throughout a damaged area to reestablish communications temporarily. Fire departments could mount a repeater on an extended platform ladder, which would act as a temporary communications tower.

**Training –** Personnel would need to know how to set up and monitor the device.

**Cost –** Units range from $1,800-$2,500, depending on the model and the manufacturer.

**Future Trends –** Units are likely to become smaller, less expensive, easier to use, and more powerful as the technology is advanced.

### *Real-Time Video Transmitter*

Damage assessments following a disaster are handled many different ways. Usually rescue teams send assessment teams out on foot or by vehicle to assess an area. They also watch news video taken by helicopters or use military photographs from airplanes and satellites to assess damage. A new technology used currently by the military allows real-time video transmission from a remote camera to a receiving video monitor.

The system is composed of two briefcase-sized instruments: a transmitter and a receiver. The transmitter unit takes a video from a standard or FLIR camera and transmits it using microwave technology to a receiving unit, which has a portable video monitor. Real-time video transmission is used most often to send video from a helicopter to a ground assessment point. The unit can transmit sharp video pictures for eight or more miles, depending on the wattage of the transmitter. However, its transmission distance decreases when used at lower altitudes (below 1,000 feet) and on the ground. This system

has many applications for the remote monitoring of personnel in the context of a PAS. For example, on large wildland fires it could allow IC's to monitor the exact locations and actions of crews under their command.

**Training –** Personnel would have to be trained to set up and monitor the device as well as how to transmit and receive images.

**Cost –** The system costs approximately $40,000.

**Future Trends –** For now, the cost of this technology prohibits it from becoming widely used in the fire service. However, if it were to become more affordable and more widely available, it might have many uses in the fire service.

# *CHAPTER X – ACCOUNTABILITY FOR WATER RESCUE OPERATIONS*

Water rescue operations present special challenges for emergency response personnel accountability. This section details some of the special considerations and technologies that have been adapted for use in ensuring the safety and accountability of personnel operating in, beneath, or around water.

## *Surf Rescue*

Thousands of surf rescues are performed on beaches and lakes in the United States every year. Lifeguard services that conduct surf rescue generally account for their personnel through visual and audible signals. Visual signals include the use of semaphore signaling with flags to relay information from guard to guard. Audible signals are relayed with whistles. Most lifeguard services have adopted the use of portable radios or hardwired phone systems over the last decade as their primary means of communicating. Lifeguards usually are assigned along beachfronts within sight of other lifeguards. When they perform a rescue, other lifeguards rotate towards the incident to render further assistance and back up the lifeguards making the rescue.

Some areas have lifeguards on bikes or all-terrain vehicles who patrol the beach and provide this additional assistance. Some busy beach lifeguard services have boats or helicopters that can perform rescues or back up lifeguards in the water. Some large lifeguard services use a "tower zero" concept, where a centralized lifeguard tower (tower zero) acts as a command center for other lifeguard towers on the beach. This tower directs guards to respond to rescues, rotates other guards to assist or back up guards, fills in gaps in coverage, and directs other resources that may be necessary to assist. Accountability therefore is maintained through visual observation of operations by other guards and regular communications.

### *Technology for Surf Rescue Accountability*

Little technology is used to account for lifeguards in the water. Personnel accountability usually takes the form of a voice or visual roll call following a rescue. However, some services employ GPS for their rescue boats, or use enhanced imaging systems such as night vision devices or infrared cameras to conduct searches for victims in the water.

## *Dive Rescue and Recovery*

Departments that provide dive rescue and recovery teams maintain personnel accountability through "tenders" for dive operations. Each diver is assigned a topside tender to assist with entry and exit from the water and to maintain communications with divers during operations. A designated dive safety officer (who checks the divers and their systems) and a dive commander (who oversees the entire operation) also aid in maintaining personnel accountability.

Aspects of dive operations are similar to confined space rescues. A typical dive operation will consist of a rescue diver, a backup emergency diver (to provide assistance or rescue for the first diver), and a "90-percent" diver (a third diver who is 90-percent suited-up and prepared to back up the emergency diver if he/she enters the water).

### *Technology for Dive Rescue and Recovery Operations Accountability*

Rescue and recovery diving employs a variety of sophisticated equipment. Specific accountability technologies used include many types of communications gear, including hardwired and wireless communications equipment (discussed earlier in the Communications chapter, page 62).

Traditional rescue diving often includes tethering divers to ropes where they can use line signals to communicate with the surface by tugging on the rope. Hand signals or boards to write messages underwater also are used. Some divers use strobe lights or luminescent markers such as cyalume light sticks to mark themselves or their lines.

Some dive teams also use high-tech equipment before inserting divers into the water. This includes underwater cameras and towed sonar arrays that can help locate victims or objects underwater and enable divers to engage directly in recovery operations without conducting long underwater searches. Despite these procedures, diving remains a high-risk operation and it must be conducted by rescuers with appropriate rescue diving training.

## ***Swiftwater Rescue Accountability***

Flash floods and moving water claim the lives of several hundred people each year. Increasingly, fire departments and EMS agencies are responding to incidents where people have become trapped in flooded creeks, roadways, or drainage spillways. These are dangerous events that claim the lives of would-be rescuers every year. In 1995, three firefighters died while attempting rescues in swiftwater.

Accountability for personnel at these rescues is maintained with the use of standard incident management and PAS practices. Personnel work in teams with backup safety personnel standing by, and are tracked by visual or radio contact. Standard practices often include having a designated downstream safety team in case a victim or rescuer is swept away. If personnel are available, an upstream safety team also is assigned to warn of hazards such as logs or other large debris that could be floating downstream towards rescuers and victims.

All personnel should be able to communicate via radios, and many teams use whistle signals to sound alerts or warnings. Helicopters or boats often are used, either as backup or as primary rescue methods, depending upon the scenario faced by rescuers. Any PAS employed should ensure that the crews of these units are included. As with any emergency incident, a disciplined incident command structure is the best method to account for the safety of all personnel. Each part of the rescue team must understand its assignment and role in the rescue operation.

Recently, some of the FEMA-sponsored US&R Teams have added local flood rescue response capabilities. They maintain accountability for their personnel through strong ICS, using backup units, and assigning appropriate personnel portable radios. Some individual fire departments also use their fireground accountability systems to track personnel at these types of incidents.

### *Technology for Swiftwater Rescue Operations Accountability*

Some technologies have been adapted to account for personnel during swiftwater rescue operations. Many departments use color-coded lifejackets. Swiftwater team members or members with specialized training wear lifejackets of a certain color, first responders wear another color, and civilians (or victims) yet another color. This helps personnel visually track members operating at the scene and allows them to differentiate quickly between a rescue swimmer who might be operating in the water and a civilian or support person who has slipped accidentally into the water and may need rescue.

Waterproof radios or radio bags (see Communications chapter) often are used to allow rescuers to maintain radio contact with other personnel. GPS tracking is being used more often to direct helicopters, boats, and land search teams to rescue locations. PAS during nighttime operations is aided greatly by technologies such as night vision, thermal imaging, or FLIR camera systems (see Visual Safety Aids). Additionally, color-coded light sticks often are used to track rescuers and boats.

# APPENDIX A – IAFF/IAFC GUIDANCE ON THE OSHA 2-IN/2-OUT POLICY

This is a reprint of a document published by the IAFF/IAFC regarding OSHA's revision of the 2-in/2-out policy.

**United States Department of Labor**
**Occupational Safety and Health Administration**
**Fire Fighters' Two-In/Two-Out Regulation**

The federal Occupational Safety and Health Administration (OSHA) recently issued a revised standard regarding respiratory protection. Among other changes, the regulation now requires that interior structural fire fighting procedures provide for at least two fire fighters inside the structure. Two fire fighters inside the structure must have direct visual or voice contact between each other and direct, voice or radio contact with fire fighters outside the structure. This section has been dubbed the fire fighters' "two-in/two-out" regulation. The International Association of Fire Fighters and the International Association of Fire Chiefs are providing the following questions and answers to assist you in understanding the section of the regulation related to interior structural fire fighting.

*1. What is the federal OSHA Respiratory Protection Standard?*

In 1971, federal OSHA adopted a respiratory protection standard requiring employers to establish and maintain a respiratory protection program for their respirator-wearing employees. The revised standard strengthens some requirements and eliminates duplicative requirements in other OSHA health standards.

The standard specifically addresses the use of respirators in immediately dangerous to life or health (IDLH) atmospheres, including interior structural fire fighting. OSHA defines structures that are involved in fire beyond the incipient stage as IDLH atmospheres. In these atmospheres, OSHA requires that personnel use self-contained breathing apparatus (SCBA), that a minimum of two fire fighters work as a team inside the structure, and that a minimum of two fire fighters be on standby outside the structure to provide assistance or perform rescue.

*2. Why is this standard important to fire fighters?*

This standard, with its two-in/two-out provision, may be one of the most important safety advances for fire fighters in this decade. Too many fire fighters have died because of insufficient accountability and poor communications. The standard addresses both and leaves no doubt that two-in/two-out requirements must be followed for fire fighter safety and compliance with the law.

*3. Which fire fighters are covered by these regulations?*

The federal OSHA standard applies to all private sector workers engaged in fire fighting activities through industrial fire brigades, private incorporated fire companies (including the "employees" of incorporated volunteer companies and private fire departments contracting to public jurisdictions) and federal fire fighters. In 23 states and 2 territories, the state, not the federal government, has responsibility for enforcing worker health and safety regulations. These "state plan" states have earned the approval of federal OSHA to implement their own enforcement programs. These states must establish and maintain occupational safety and health programs for all public employees that are as effective as the programs for private sector employees. In addition, state safety and health regulations must be at least as stringent as federal OSHA regulations. Federal OSHA has no direct enforcement authority over state and local governments in states that do not have state OSHA plans.

All professional career fire fighters, whether state, county, or municipal, in any of the states or territories where an OSHA state plan agreement is in effect, have the protection of all federal OSHA health and safety standards, including the new respirator standard and its requirements for fire fighting operations. The following states have OSHA-approved plans and must enforce the two-in/two-out provision for all fire departments.

| | | | |
|---|---|---|---|
| Alaska | Kentucky | North Carolina | Virginia |
| Arizona | Maryland | Oregon | Virgin Islands |
| California | Michigan | Puerto Rico | Washington |
| Connecticut | Minnesota | South Carolina | Wyoming |
| Hawaii | Nevada | Tennessee | |
| Indiana | New Mexico | Utah | |
| Iowa | New York | Vermont | |

A number of other states have adopted, by reference, federal OSHA regulations for public employee fire fighters. These states include Florida, Illinois and Oklahoma. In these states, the regulations carry the force of state law.

Additionally, a number of states have adopted NFPA standards, including NFPA 1500, Standard for Fire Department Occupational Safety and Health Program. The 1997 edition of NFPA 1 500 now includes requirements corresponding to OSHA's respiratory protection regulation. Since the NFPA is a private consensus standards organization, its recommendations are preempted by OSHA regulations that are more stringent. In other words, the OSHA regulations are the minimum requirement where they are legally applicable. There is nothing in federal regulations that "deem compliance" with any consensus standards, including NFPA standards, if the consensus standards are less stringent.

It is unfortunate that all U.S. and Canadian fire fighters are not covered by the OSHA respiratory protection standard. However, we must consider the two-in/two-out requirements to be the minimum acceptable standard for safe fire ground operations for all fire fighters when self-contained breathing apparatus is used.

*4. When are two-in/two-out procedures required for fire fighters?*

OSHA states that "once fire fighters begin the interior attack on an internal or structural fire, the atmosphere is assumed to be IDLH and paragraph 29 CFR 1910.134(g)(4) [two-in/two-out] applies." OSHA defines interior structural fire fighting "as the physical activity of fire suppression, rescue or both inside of buildings or enclosed structures which are involved in a fire situation beyond the incipient stage." OSHA further defines an incipient stage fire in 29 CFR 1910.1 55(c)(26) as a "fire which is in the initial or beginning stage and which can be controlled or extinguished by portable fire extinguishers, Class II standpipe or small hose systems without the need for protective clothing or breathing apparatus." Any structural fire beyond incipient stage is considered to be an IDLH atmosphere by OSHA.

*5. What respiratory protection is required for interior structural fire fighting?*

OSHA requires that all fire fighters engaged in interior structural fire fighting must wear SCBAs. SCBAs must be NIOSH-certified, positive pressure, with a minimum duration of 30 minutes. [29 CFR 1910.156(f)(1)(ii)] and [29 CFR 1910.134(g)(4)(iii)]

*6. Are all fire fighters performing interior structural fire fighting operations required to operate in a buddy system with two or more personnel?*

Yes. OSHA clearly requires that all workers engaged in interior structural fire fighting operations beyond the incipient stage use SCBA and work in teams of two or more. [29 CFR 1910.1 34(g)(4)(i)]

*7. Are fire fighters in the interior of the structure required to be in direct contact with one another?*

Yes. Fire fighters operating in the interior of the structure must operate in a buddy system and maintain voice or visual contact with one another at all times. This assists in assuring accountability within the team. [29 CFR 1910.134(g)(4)(i)]

*8. Can radios or other means of electronic contact be substituted for visual or voice contact, allowing fire fighters in an interior structural fire to separate from their "buddy" or "buddies"?*

No. Due to the potential of mechanical failure or reception failure of electronic communication devices, radio contact is not acceptable to replace visual or voice contact between the members of the "buddy system" team. Also, the individual needing rescue may not be physically able to operate an electronic device to alert other members of the interior team that assistance is needed.

Radios can and should be used for communications on the fire ground, including communications between the interior fire fighter team(s) and exterior fire fighters. They cannot, however, be the sole tool for accounting for one's partner in the interior of a structural fire. (29 CFR 1910.134(g)(4)(i)] [29 CFR 1910.134(g)(3)(ii)]

9. *Are fire fighters required to be present outside the structural fire prior to a team entering and during the team's work in the hazard area?*

Yes. OSHA requires at least one team of two or more properly equipped and trained fire fighters be present outside the structure before any team(s) of fire fighters enter the structural fire. This requirement is intended to assure that the team outside the structure has the training, clothing and equipment to protect themselves and, if necessary, safely and effectively rescue fire fighters inside the structure. For high-rise operations, the team(s) would be staged below the IDLH atmosphere. [29 CFR 1910.134(g)(3)(iii)]

10. *Do these regulations mean that, at a minimum, four individuals are required, that is, two individuals working as a team in the interior of the structural fire and two individuals outside the structure for assistance or rescues?*

Yes. OSHA requires that a minimum of two individuals, operating as a team in direct voice or visual contact, conduct interior fire fighting operations utilizing SCBA. In addition, a minimum of two individuals who are properly equipped and trained must be positioned outside the IDLH atmosphere, account for the interior team(s) and remain capable of rapid rescue of the interior team. The outside personnel must at all times account for and be available to assist or rescue members of the interior team. [29 CFR 1910.1 34(g)(4)]

11. *Does OSHA permit the two individuals outside the hazard area to be engaged in other activities, such as incident command or fire apparatus operation (for example, pump or aerial operators)?*

OSHA requires that one of the two outside person's function is to account for and, if necessary, initiate a fire fighter rescue. Aside from this individual dedicated to tracking interior personnel, the other designated person(s) is permitted to take on other roles, such as incident commander in charge of the emergency incident, safety officer or equipment operator. However, the other designated outside person(s) cannot be assigned tasks that are critical to the safety and health of any other employee working at the incident.

Any task that the outside fire fighter(s) performs while in standby rescue status must not interfere with the responsibility to account for those individuals in the hazard area. Any task, evolution, duty, or function being performed by the standby individual(s) must be such that the work can be abandoned, without placing any employee at additional risk, if rescue or other assistance is needed. [29 CFR 1910.134(g)(4)(Note 1)]

*12. If a rescue operation is necessary, must the buddy system be maintained while entering the interior structural fire?*

Yes. Any entry into an internal or structural fire beyond the incipient stage, regardless of the reason, must be made in teams of two or more individuals. (29 CFR 1910.1 34(g)(4)(i)]

*13. Do the regulations require two individuals outside for each team of individuals operating in the interior of a structural fire?*

The regulations do not require a separate “two-out” team for each team operating in the structure. However, if the incident escalates, if accountability cannot be properly maintained from a single exposure, or if rapid rescue becomes infeasible, additional outside crews must be added. For example, if the involved structure is large enough to require entry at different locations or levels, additional “two-out” teams would be required. [29 CFR 1910.134(g)(4)]

*14. If four fire fighters are on scene of an interior structural fire, is it permissible to enter the structure with a team of two?*

OSHA’s respiratory protection standard is not about counting heads. Rather, it dictates functions of fire fighters prior to an interior attack. The entry team must consist of at least two individuals. qf the two fire fighters outside, one must perform accountability functions and be immediately available for fire fighter rescue. As explained above, the other may perform other tasks, as long as those tasks do not interfere with the accountability functions and can be abandoned to perform fire fighter rescue. Depending on the operating procedures of the fire department, more than four individuals may be required. [29 CFR 1910.1 34(g)(4)(i)]

*15. Does OSHA recognize any exceptions to this regulation?*

OSHA regulations recognize deviations to regulations in an emergency operation where immediate action is necessary to save a life. For fire department employers, initial attack operations must be organized to ensure that adequate personnel are at the emergency scene prior to any interior attack at a structural fire. If initial attack personnel find a known life hazard situation where immediate action could prevent the loss of life, deviation from the two-in/two-out standard may be permitted, as an exception to the fire department’s organizational plan.

However, such deviations from the regulations must be exceptions and not defacto standard practices. In fact, OSHA may still issue “de minimis” citations for such deviations from the standard, meaning that the citation will not require monetary penalties or corrective action. The exception is for a known life rescue only, not for standard search and rescue activities. When the exception becomes the practice, OSHA citations are authorized. [29 CFR 1910.1 34(g)(4)(Note 2)]

*16. Does OSHA require employer notification prior to any rescue by outside personnel?*

Yes. OSHA requires the fire department or fire department designee (i.e. incident commander) be notified prior to any rescue of fire fighters operating in an IDLH atmosphere. The fire department would have to provide any additional assistance appropriate to the emergency, including the notification of on-scene personnel and incoming units. Additionally, any such actions taken in accordance with the "exception" provision should be thoroughly investigated by the fire department with a written report submitted to the Fire Chief. [29 CFR 1910.1 34(g)(3)(iv)]

*17. How do the regulations affect fire fighters entering a hazardous environment that is not an interior structural fire?*

Fire fighters must adhere to the two-in/two-out regulations for other emergency response operations in any IDLH, potential IDLH, or unknown atmosphere. OSHA permits one standby person only in those IDLH environments in fixed workplaces, not fire emergency situations. Such sites, in normal operating conditions, contain only hazards that are known, well characterized, and well controlled. [29 CFR 1910.120(q)(3)(vi)]

*18. When is the new regulation effective?*

The revised OSHA respiratory protection standard was released by the Department of Labor and published in the Federal Register on january 8, 1 998. It is effective on April 8, 1998. "State Plan" states have six months from the release date to implement and enforce the new regulations.

Until the April 8 effective date, earlier requirements for two-in/two-out are in effect. The formal interpretation and compliance memo issued by James W. Stanley, Deputy Assistant Secretary of Labor, on May 1, 1 995 and the compliance memo issued by Assistant Secretary of Labor Joe Dear on July 30, 1 996 establish that OSHA interprets the earlier 1971 regulation as requiring two-in/two-out. (29 CFR 1910.134(n)(1)]

*19. How does a fire department demonstrate compliance with the regulations?*

Fire departments must develop and implement standard operating procedures addressing fire ground operations and the two-in/two-out procedures to demonstrate compliance. Fire department training programs must ensure that fire fighters understand and implement appropriate two-in/two-out procedures. [29 CFR 1910.134(c)]

*20. What can be done if the fire department does not comply?*

Federal OSHA and approved state plan states must"…assure so far as possible every working man and woman in the Nation safe and healthful working conditions." To ensure such protection, federal OSHA and states with approved state plans are authorized to enforce safety and health standards. These agencies must investigate complaints and conduct inspections to make sure that specific standards are met and that the workplace is generally free from recognized hazards likely to cause death or serious physical harm.

Federal OSHA and state occupational safety and health agencies must investigate written complaints signed by current employees or their representatives regarding hazards that threaten serious physical harm to workers. By law, federal and state OSHA agencies do not reveal the name of the person filing the complaint, if he or she so requests. Complaints regarding imminent danger are investigated even if they are unsigned or anonymous. For all other complaints (from other than a current employee, or unsigned, or anonymous), the agency may send a letter to the employer describing the complaint and requesting a response. It is important that an OSHA (either federal or state) complaint be in writing.

When an OSHA inspector arrives, he or she displays official credentials and asks to see the employer. The inspector explains the nature of the visit, the scope of the inspection and applicable standards. A copy of any employee complaint (edited, if requested, to conceal the employee's identity) is available to the employer. An employer representative may accompany the inspector during the inspection. An authorized representative of the employees, if any, also has the right to participate in the inspection. The inspector may review records, collect information and view work sites. The inspector may also interview employees in private for additional information. Federal law prohibits discrimination in any form by employers against workers because of anything that workers say or show the inspector during the inspection or for any other OSHA protected safety-related activity.

Investigations of imminent danger situations have top priority. An imminent danger is a hazard that could cause death or serious physical harm immediately, or before the danger can be eliminated through normal enforcement procedures. Because of the hazardous and unpredictable nature of the fire ground, a fire department's failure to comply with the two-in/ two-out requirements creates an imminent danger and the agency receiving a related complaint must provide an immediate response. If inspectors find imminent danger conditions, they will ask for immediate voluntary correction of the hazard by the employer or removal of endangered employees from the area. If an employer fails to do so, federal OSHA can go to federal district court to force the employer to comply. State occupational safety and health agencies rely on state courts for similar authority.

Federal and state OSHA agencies are required by law to issue citations for violations of safety and health standards. The agencies are not permitted to issue warnings. Citations include a description of the violation, the proposed penalty (if any), and the date by which the hazard must be corrected. Citations must be posted in the workplace to inform employees about the violation and the corrective action. [29 CFR 1903.3(a)]

It is important for labor and management to know that this regulation can also be used as evidence of industry standards and feasibility in arbitration and grievance hearings on fire fighter safety, as well as in other civil or criminal legal proceedings involving injury or death where the cause can be attributed to employer failure to implement two-in/two-out procedures. Regardless of OSHA's enforcement authority, this federal regulation links fire ground operations with fire fighter safety.

*21. What can be done if a fire fighter does not comply with fire department operating procedures for two-in/two-out?*

Fire departments must amend any existing policies and operational procedures to address the two-in/two-out regulations and develop clear protocols and reporting procedures for deviations from these fire department policies and procedures. Any individual violating this safety regulation should face appropriate departmental action.

*22. How can I obtain additional information regarding the OSHA respirator standard and the two-in/two-out provision?*

Affiliates of the International Association of Fire Fighters may contact:

International Association of Fire Fighters
Department of Occupational Health and Safety
1750 New York Avenue, NW
Washington, DC 20006
202-737-8484
202-737-8418 (FAX)

Members of the International Association of Fire Chiefs may contact:

International Association of Fire Chiefs
4025 Fair Ridge Drive
Fairfax, VA 22033-2868
703-273-0911
703-273-9363 (FAX)

# *APPENDIX B – EXAMPLES OF PERSONNEL ACCOUNTABILITY SYSTEMS THROUGHOUT THE UNITED STATES*

The following are examples of personnel accountability Standard Operating Procedures (SOPs) from fire/rescue departments throughout the United States.

GENERAL ORDER 95-009

December 1, 1995

**SUBJECT: MANDATORY USE OF PERSONAL ALERT SAFETY SYSTEMS**

**(PASS ALARMS)**

**I. PURPOSE**

This order:

A. establishes the Chicago Fire Department's policy and procedures regarding the mandatory use of Personal Alert Safety Systems (PASS Alarms).

B. defines department and member responsibilities in the maintenance, repair and replacement of pass alarms.

C. becomes effective December 16, 1995.

**I. POLICY**

A. In the event a member or members become disabled or trapped at an incident, the use of the pass alarm shall enable the member or members who are so equipped, to be located more readily.

B. It is mandatory that all personnel – with the exception of engineers – engaged in suppression activities, responding to a fire (confirmed or unconfirmed), hazardous materials incident, and all other incidents of an unknown nature, wear and activate their pass alarm device upon arrival at the scene of the incident.

C. The pass alarm will be affixed to the department issued utility belt, or to the pass alarm device holder if the member's turnout coat is so equipped.

**I. PROCEDURE**

A. All members equipped with pass alarms shall wear and activate their devices on the fire ground or emergency scene. Possible exceptions would be at ambulance assist incidents or T.O.C. inspections, etc, where pass alarm would be worn by the member but no activated.

B. The wearing and use of the pass alarm device is required on the fire ground, with the exception of those chief officers and other personnel operating at the command post, staging area or similar areas.

C. A pass alarm device that is damaged (unserviceable) not due to a member's negligence, shall be replaced at the department's expense. If negligence is determined the member shall replace the pass alarm, as per department policy, and may also result in appropriate discipline.

## I. TESTING OF PASS ALARM DEVICES

A. Immediately, upon completion of testing their sefl contained breathing apparatus each morning, all chiefs, company officers and firefighters shall test their pass alarm device that has been turned over to them by their relief.

B. The results of the pass alarm device shall be reported to the company officer, who shall record the results in the company journal. The information in the journal shall consist of the pass alarm unit identification number alongside the name of the member using the unit.

C. Pass alarms shall be retested after each use during the duty day.

D. Chief officers assigned to non-platoon duty shall test their pass alarms at least once each week and after each use.

E. Any need for a replacement battery, defects, or requests for service shall be immediately reported through channels to district headquarters by the company officer. District chiefs/deputy district chiefs shall be responsible for contacting Breathing Apparatus Service, and for issuing a spare pass alarm unit until the problem has been resolved.

F. The results of all testing, replacement of batteries, or exchange of units shall be logged on the individual record card for that pass alarm device, indicating who performed the activity and the name of the officer who supervised such activity.

## I. RESPONSIBILITIES

A. Chief officers and company officers shall enter the receipt of all pass alarm devices into their company inventory records.

B. Chief officers and company officers shall have the joint responsibility to ensure all personnel are in compliance with this order.

# Canandaigua Fire Department S.O.P.

## Accountability

# A-014

Date: 4-1-91

**I. PURPOSE**

A. It is necessary to be able to account for all personnel that may be assigned to or working at the scene of an emergency. Occasionally, our members respond on a fire apparatus as does the mutual aid personnel. Generally, our personnel will respond to the scene in their private automobile and participate in the emergency operation. We must ensure that all personnel, regardless of the method of transportation, will be accounted for in case of a change in strategies such as changing from an offensive position to a defensive position, a building collapse, or other circumstance that would require an accounting for all personnel at the scene.

**II. METHOD**

A. A name tag shall be issued to every active firefighter. This tay will be attached to the outside of the firefighter's turnout coat. Note that they were made purposefully large to aid as a reminder to use them.

B. On arrival at the scene of every incident all firefighters will clip their accountability tags on the collection ring of the first arriving apparatus.

C. When putting on an airpack, the firefighter will take the airpack tag off the breathing apparatus and clip it on their own accountability tag ring, even if it is already on the collection ring.

D. Upon returning to the apparatus just prior to returning to service, you should retrieve your name tag from the apparatus collection ring.

E. Leave the airpack tag on your personal ring until the breathing apparatus is put back in service.

## III. OFFICERS

A. Firefighters should be working under your direction in teams of two or more. Firefighters entering the structure should be doing so in order to accomplish a tactical objective. If not needed inside, they should be held together in readiness until the incident commander assigns your team/crew an assignment. Once you and/or your team/crew enters the structure, someone should be aware that you are entering, the approximate area where you are going, the general time when you are entering, and the number of personnel going inside. It may be the incident commander, safety officer, pump operator, or other person that you inform. The intent is if conditions should deteriorate, someone would know your approximate location and the number of persons we are looking for.

B. The incident commander should advise mutual aid officers and firefighters of the procedure and establish a means of accounting for them.

## IV. FIREFIGHTERS

A. It is imperative that you inform someone prior to entering the structure so that in the event of a deterioration of conditions, someonw will be aware of your position and be looking for you. A system of communication must be maintained so that the firefighters may be notified or that firefighters may inform persons outside of problems. The tag system is intended to identify the number and names of persons who may be in need or assistance and for your safety. Please help make it work.

## V. COMMUNICATIONS

A. Each team/crew entering a structure should have a portable radio, be given a tactival objective and assigned a team/crew identification, i.e. Interior 1, Search 1, etc.

# PERSONAL ACCOUNTABILITY SYSTEM (P.A.S.)

In February of 1996, Versailles Fire-Rescue implemented an accountability system to keep up with personnel at fire scenes. Each firefighter and officer has a 2” by 4” laminated ID tag which hangs from the back of their helmet at the station. Each tag contains the following information (but not necessarily in this order):

- Photo-Name-Unit Number
- Rank-Station-Apparatus Assignment
- Blood Type-Allergies-Medications
- Emergency Contacts

## STANDARD OPERATING PROCEDURE

1. I.D. tags shall be attached to the firefighter helmet attachment ring.

2. Upon fire runs, all firefighters will remove I.D. tags and give to the officer of the apparatus or the individual in the officer seat before reaching the scene.

3. The officer will make sure that he or she has all the I.D. tags of his or her personnel and attach them to the P.A.S. ring hanging inside the apparatus.

4. Each apparatus P.A.S ring will have the apparatus number on it.

5. If at the scene an incident command post is established, the officer of each apparatus will remove the ring and take it to the I.C. for assignments.

6. If upon arrival at the scene, an I.C. post is not already extablished, the officer will leave the P.A.S ring in the apparatus and if needed it will be retrieved by the safety officer.

7. At the completion of the incident, the officer of each apparatus will make sure the P.A.S ring is in the apparatus, and if not, he or she will retrieve it from the I.C. post and reinstall it before leaving the scene.

8. Upon return to the station, each firefighter will re-attach the I.D. tag to their helmet ring.

# PERSONNEL ACCOUNTABILITY SYSTEM
# MARION COUNTY FIRE RESCUE

## 1. PURPOSE

To establish a procedure to account for personnel at the scene of an emergency incident.

## 2. RESPONSIBILITY

It shall be the responsibility of every member of the MCFR to have thorough knowledge of this Standard Operating Guideline and to follow its guidelines so that the appropriate steps are taken to ensure personnel accountability at all times during an emergency incident.

## 3. POLICY

The personnel accountability system gives the incident commanders a fast, effective and efficient means to account for all fire rescue members at any point during an operation. In order to ensure the effectiveness of this system and the subsequent safety of all personnel, accountability procedures will be strictly adhered to at all times.

## 4. PROCEDURES

A. Personnel Accountability Card (PAC)

Every member of the MCFR will be issued a PAC that will be printed with their name, appropriate information and be color coded by rank.

WHITE – Battalion Chief and above

RED – Lieutenants, Captains and Station Captains

BLUE – Firefighter/Paramedics and EMTs

YELLOW – Combat Qualified Firefighters

ORANGE – Support Members

GREEN – Unit Identification Tags

1. Each member shall keep his/her PAC with their bunker gear when not on duty or when not assigned to a unit. The PAC will be attached to the front of the bunker coat so that it is easily visible.

2. Replacements are available through the Training and Safety Division.

A. Collector Ring

Each emergency vehicle, except automobiles, shall be equipped with a PAC collector ring.

1. The collector ring shall consist of a large ring with a unit identification tag attached.

2. The collector ring shall be maintained in the cab of each unit in such a manner that it is readily accessible and removable.

B. Information Gathering Components

1. Each first due apparatus shall be equipped with two grease pencis and a supply of towels.

2. Battalion Chiefs shall have in their vehicle an expanded accountability board. These boards will be used to assemble information about the incident upon their arrival at the scene.

**5. IMPLEMENTATION**

A. Upon being dispatched to a call, the firefighters will attach their PAC o the collector ring on the responding unit. Stations with only one unit may place their PACs on the ring at the start of the duty tour.

B. Upon arrival at the scene, the first due unit shall announce that they are assuming command and announce the command post location in accordance with the MCFR SOGs. If the situation warrants, the first due unit may pass command to the next in unit.

C. If possible, the unit that assumes command will use their grease pencil to write unit assignments on a window of their unit. All collector rings will be brought to this unit upon being assigned a task.

D. Upon arrival, the responding chief officer will proceed to the command post to review the information and take command.

E. Upon transfer of command the chief officer shall retrieve all collector rings and attach them to his/her expanded accountability board. At this time the chief officer shall announce that he/she has assumed command and the new location of the command post.

F. It shall be the responsibility of the Incident Commander to maintain the collector rings under the proper sector throughout the entire operation. The exception will be when a crew is sent to rehab; at this time the crew will take their tags with them and the IC shall note this in his/her records.

G. It shall be the company officer's responsibility to account for all of his/her firefighters whenever finished with an assigned task and prior to leaving the scene.

H. It shall be the responsibility of the individual member to ensure that his/her PAC be reattached to their gear upon return to quarters.

I. It shall be the responsibility of the driver to ensure that the collector ring, as well as the grease pencil, be returned to the unit upon being released from the scene.

**6. PROCEDURE FOR LOCATING A MISSING FIREFIGHTER OR CREW**

A. General protocol

1. Roll call of crews will be taken directly after every benchmark:

- Completion of primary search
- Fire out
- Completion of secondary search

- Completion of overhaul
- When changing from offensive to defensive operations

B. Action to be taken upon a supervisors knowledge of missing crew.

1. When a supervisor presumes a firefighter or company may be missing or trapped, the supervisor shall initiate rescue efforts as soon as possible at the last known location. This information will be transmitted to the IC and he/she shall initiate a roll call of the emergency incident to confirm the status of the missing personnel.

2. Whenever possible the roll call procedure should follow this example:

“Command to dispatch and all sectors, an inidentified MAYDAY distress call has been transmitted.” Command to all sectors, “conduct a roll call of your units.”

“Command to fire sector, report”… “Fire to command, all accounted for.” “Command to roof sector, report”… “Roof to command, all accounted for.” “Command to side 3, report”… “Side 3 to command, all accounted for.” “Command to dispatch, all accounted for.”

7. Roll Calls: All roll calls at the company level should be done by face to face communications so that the radio can be kept clear. Also, while roll call is taking place all crews will be securing their assignments and preparing for possible search and rescue orders. If a search is necessary, the IC will formulate the plan with the area supervisor at the last known location. This face to face roll call will take place at any of the previously mentioned benchmarks.

8. Evaluation Signal: The standard evacuation signal will be three long blasts on an air horn. At the same time, the communications center will send a “warble tone” over the fire ground channel for five seconds, then announce: “Attention all personnel operation at the incident on ________, EVACUATE THE BUILDING IMMEDIATELY!” They will repeat this again on all channels.