Lesson 6
REFERENCE MATERIAL
Search and Location Techniques

Physical Search

Physical Void Search

By the time CSSR resources arrive at most incidents a basic physical search is done by neighbours, passers-by or first responders.

The physical void search method of locating potential victims may be used by the CSSR team during the initial stages of the rescue operation and at other times as deemed necessary by the team leader.

To be effective the physical void search must be organized and conducted in a logical and systematic manner to reduce duplication of effort and to locate as many victims as possible in the shortest amount of time while visually assessing all accessible void spaces.

Advantages of physical void search:

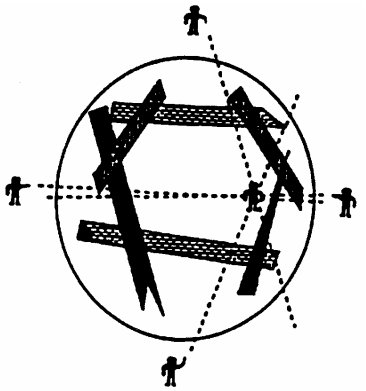
- Does not require specialized personnel, canine, or sophisticated electronic equipment.
- Most people can be quickly trained to support the physical void search – utilizes the natural sight and hearing capabilities of the personnel conducting the search while working in teams of at least two members.

Disadvantages of physical void search:

- Limited access to all void spaces in the building.
- Required proximity to damaged structures may be dangerous to search personnel.

Hailing Search Method

Since the ability to locate victims by actually seeing them during a void space search is limited, the **hailing search method** is also used during the physical search.



This method can be used by CSSR members working in teams of two during the physical void search or by several CSSR team members in a coordinated fashion as an array of listeners deployed in an encircling or grid pattern around the collapse site.

The area is quieted and a bullhorn or other hailing method is used to provide direction to potentially trapped victims. CSSR team members listen and attempt to pin-point the location of any noises being made in response to the directions.

Hailing directions given to potential victims:

- This method has a higher success rate when potential victims are told to yell and knock on something solid between 3 and 5 times at the same time.

- The collapse pattern, building materials and a multitude of other variables can cause voices to be heard clearer than knocking and sometimes knocking can be heard clearer than voices.

Advantages of the hailing search method:

- Same as above. Personnel can inform the victim of expected response and obtain information from the victim.

- This can be modified/used with listening devices.

Disadvantages hailing search method:

- Will not locate unconscious, physically weak or very young victims unable to follow directions.

- Sound of yelling/knocking may be too weak for audible detection by task force members.

Where to Start a Physical Void Search

- Search likely survival places first
  - Type of occupancy (office, school, home, etc.)
  - Time of day when the collapse occurred.
  - Talk with co-workers, relatives, neighbours, or survivors.
  - If possible, obtain a map of the site or facility.
  - Consider potential exit pathways and current position of the collapsed building.

- Victims are sometimes entrapped in hallways leading to an exit while trying to escape when the building collapsed.

- Depending on how far the building shifted during collapse, some victims have been located in rooms under floors six to eight feet to the side of similar rooms remaining above.

- Known location of entrapped victim(s)
  - The search team should take the safest and most direct route to that location to verify the location of the victim(s).
  - After locating the victim(s) the search team may take any one of the following actions based on their current assignment and stage of the rescue operation.
  - The victim(s) may be rescued by the search team if the rescue can be easily accomplished.
  - The search team requests appropriate resources to extricate severely entrapped victims.
  - The search team notifies the CSSR team about the location of the victim(s) and then continue to conduct a search of the entire building.

- Unknown location of potential victim(s)
  - The team will need to systematically search all the rooms and accessible void spaces of the entire building.

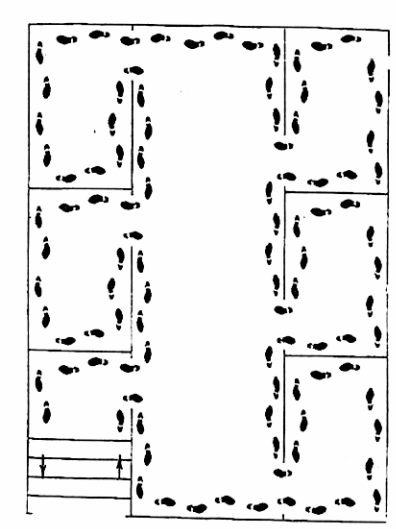
  - Entry options into the structure should include:

- If possible, use existing openings. Breaching (cutting) access holes through the roof or floors is quicker and safer than making holes in walls.

- Access from the top of the structure is sometimes safer than entering from the sides.

Basic Search Patterns

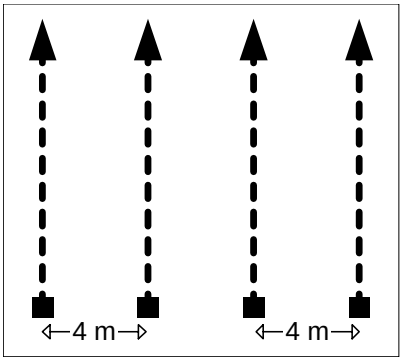
- Basic search pattern for multiple rooms — **go right, stay right.**



  - After entering the structure turn to the right, stay in contact with the right wall, either visually or physically, until the entire accessible area has been searched and search team returns to their starting point.

  - If the search team needs to exit and can't remember the direction they entered, simply turn around and stay in contact with the same wall, either visually or physically, keeping it on the left.

- Basic search pattern for large open areas (auditoriums, cafeterias, offices with multiple partitions, etc.) — **line search:**



  - Spread search team members straight across the open area.

  - Slowly walk through the entire open area to the other side.

  - Team members on the ends of the line, search perimeter rooms using the go-right, stay-right method.

Other Physical Void Search Considerations

- Radio Communications

  - Radio communication procedures should be established prior to the search beginning.

  - The search team should contact the search team manager by radio and update the status of each room or area searched if this does not cause too much radio traffic.

  - Search team manager can update a site map, if available, and keep track of the search team's progress and exact location within the building.

- Documentation
  - Each search team should develop and update a site map during the physical search of a building.
  - Identify location of known or potential victims.
  - Identify location of hazards (structural, Haz-Mat other).
  - Useful to develop accurate incident action plans and direct other resources inside the building.

Search Markings

- A separate and distinct marking system is necessary to conspicuously denote information relating to victim and hazard locations in the areas searched.
- The search marking system is designed to be used in conjunction with the Structure/Hazards Evaluation marking system.
- Search markings must be easy to make, easy to read and easy to understand.
- To be easily seen the search mark must be large and of a contrasting color to be background surface.
  - Orange spray paint seems to be the most easily seen colour on most backgrounds.
  - Line marking or "downward" spray cans apply the best paint marks on both vertical and horizontal surfaces.
  - Lumber chalk or lumber crayons should be used to mark additional information inside the search mark because they are easier to write with than spray paint.

Refer to the INSARAG Marking System, Lesson 4.

Search Capabilities

Use of Fibre Optics

(This section for reference only — not included in the CSSR course.)

Fibre optic viewing equipment provides another, and more recent capability for the search tool box.

The flexibility and the small diameter of the fibre optics bundles makes the **Flexible Fibrescopes** very appealing in extremely tight spaces. The technology has been advanced primarily for medical applications where fibre optics systems are used to view the operation and walls of the heart, veins, intestines etc. The picture resolution is limited by the number of fibres in the bundle. Light can be brought in and the picture will return through the same bundle. Eyepieces, camera, light sources, articulation are all available. Most fibrescopes have four-way articulation of the tip. Diameters range from 2.4 mm to 13 mm. Long high resolution fibre bundles can become very expensive.

- This equipment, especially when used with conjunction with concrete hammer drills, is quite effective at pinpointing the exact location of victims. However, it may also be used for general void searches within collapsed buildings. Prior experience has shown success, when rescue personnel have drilled an array or series of holes (e.g., in a floor space) and an operator subsequently follows with the fibre optic device to make quick assessments through it.

- This equipment is simple to us once personnel are fully trained in its operation. The most difficult aspect to master is the determination of which direction one is viewing when the instrument is inserted into a drill hole or void opening. This requires consistent training. The equipment can also be considered as part of the rescue element's responsibility due to its ease of operation, and used when culling/breaching near a victim.

- Due to its actual visual indication of a victim, no redundant check is usually required. If the operator is required to move on for subsequent operations, the site should be marked with red tape to indicate a live victim. In addition, the specialist should sketch the general features of the structure/area being searched noting any significant information on the sketch for future reference.

- An available alternative to the Flexible Fibrescope is **Rigid Borescopes**. These devices have been in use for a long time. As the name implies they are mainly used to explore, through bored holes, mechanical devices such as aircraft engines, castings, and pipes. These devices consist of straight tubes with lenses, mirrors or prisms on the ends. Because no fibres limit the resolution, picture quality is very high, cost is moderate. Limited articulation is available. Brightness, colour and resolution are excellent especially when used with high-intensity light sources. Tactics are similar to fibre optic search.

Advantages of Fibre Optics

- Provides the general position and condition of the victim.

- Can be used to verify other search tactics prior to commencing rescue operations.

- Can be used to monitor victim during rescue operation.

Disadvantages of Fibre Optics

- Extended or inaccessible voids (observation holes) cannot be viewed due to the flexible nature of the fibre optic cable and the limited light source.

Search Cameras

(This section for reference only — not included in the CSSR course.)

Recently cameras have been mad available designed specifically for search and rescue applications. Tactics used will make use of available holes and openings to look inside voids, or holes can be drilled to allow camera access. This item is a very important tool for close in search that has been added to the tool box.

Search Cam™ is a pole-mounted, 3.85 cm diameter camera specifically designed for urban search and rescue. The camera itself is remotely movable over a +/-90° angle. A black and white 15.4 cm CRT monitor displays a television-like picture in front of the operator. Typically a 5 cm hole is drilled into a void. The very light-sensitive CCD camera is placed into the hole. A built-in light source will illuminate the interior of the void. Turning the telescoping pole and using the articulation allows viewing in all directions. A microphone and speaker permit listening for sound and possibly communications with a victim. Depending on the distance to the objects to be viewed, the light source has to be adjusted carefully, so as not to wash out the picture. Unless there are obstructions that block the view,

this is a very useful tool, not only during the search but also during extrication, where it can guide cutting and avoid hurting the victim.

SnakeEye™ is a low-cost ($2000) device featuring a 2.75 cm diameter CCD-type camera, mounted on a lightweight, rigid pole. While the SnakeEye has a built-in LED light source, it may need additional light. The display is a small (11 cm), flat, high-resolution (960 x 234 pixels) rotatable color TFT-LCD. The camera head is mounted on a swivel joint that allows 90-degree vertical articulation, or the camera head may be removed from the wand, mounted on another device, or suspended by its cable. The camera head is waterproof and therefore may be submerged to the length of the cable (100 ft max.). The display, connected only to the opposite end of the cable, is rugged and portable.

- Other cameras: Rescue teams may also have access to other cameras from local resources. A chimney inspection camera can be helpful in exploring shafts, pipes, or other voids, and cameras used in sewer or water pipe inspection may also be useful. These may all be available locally.

Advantages of cameras

- Easily understood
- Possibility to record picture
- Remote viewing

Disadvantages of cameras

- Size, cost, power requirement
- Has only straight line of sight

Infrared/Thermal Imaging

(This section for reference only — not included in the CSSR course.)

A unique way of seeing through smoke and dust is infrared. An infrared imaging system was used successfully in the very smoky environment of the World Trade Center incident. These cameras are fairly expensive.

Some models are helmet mounted with a small TV display right in front of the eyes of the operator. Infrared vision also allows one to find hot spots inside of walls and sources of fire in very smokey environments

Resolution is poorer than on a typical black and white TV picture, but they are useful when maneuvering around in unfamiliar surroundings.

Advantages of Infrared Imaging

Equipment is sometimes readily available with some responding local organizations. Can be used to survey large, open, dark areas.

Disadvantages of Infrared Imaging

Unit cannot detect heat differential through solid media. Sources of heat other than persons buried under debris are also indicated which creates confusion in a search application.

Electronic Listening Devices

(This section for reference only — not included in the CSSR course.)

The advent of state-of-the-art electronic listening devices has added a new dimension to the search function. The latest electronic devices can extend the range of the search, (in case where the victim's scent may not reach the surface and therefore be inaccessible to canine) by detecting sounds from the victim. The task force staffing provides for two technical search specialists, who will usually use the electronic acoustic/seismic listening devices as their primary tool. These specialists may also assist with fibre optic equipment, thermal imaging (if available on site) or other sophisticated equipment as necessary.

Both of the technical search specialists would usually be deployed early in the mission. After an initial period of operation, one of the two specialists must be rotated into rest cycles for extended operations. Electronic search operations are usually more site-specific and longer in duration than canine search operations. Other task force personnel (preferably rescue personnel) should assist the Technical Search Specialist and also act in the overhead function to ensure overall safety. In addition, the specialist should sketch the general features of the structure/area being searched noting any significant information for future reference.

The general application if the acoustic/seismic device involves the deployment of an array of two or more pick-up probes around the perimeter of a building or void area. A bullhorn or other hailing device should be used to attempt to give direction to any conscious victim trapped within the structure. The victims should be directed to make a repetitive sound (e.g., "knock five times repeatedly"). The general area should be made as quiet as possible during this operation. the repetitive series will provide the operator with an identifiable sound to detect. If detected, the different probes are assessed separately to determine which gives the strongest indication and should theoretically be closest to the source of the sound/victim. If necessary, the array of probes may then be redistributed (around the area of the original probe giving the strongest indication) to more precisely identify the victim's 1ocation.

The distance between probes or sensors will depend on the material of which the structure or rubble pile is made, and in what sections of material the structure-borne sound is expected to travel. Also of influence will be the presence of interfering signals, which may lead to a further reduction in sensor spacing. In any case, the sensor spacing should not exceed 25 feet (8 meters). Typically, a 15' (5 meter) spacing will cover the area well, even under more difficult circumstances.

For detection, and as part of a hasty search, a single operator using one sensor may suffice. But for safety reasons, the search team should always consist of at least 2 people.

Pinpointing the location of a victim using only one sensor will be difficult, because the signal amplitude and clarity would have to be remembered from sensor location to sensor location. Being able to compare several sensors, and to switch from sensor to sensor quickly, will allow the operator to identify the sensor with the largest and/or clearest signal. As a rule, if a signal is detected, it is advised to leave that sensor in its position and reposition the other sensors around it for more accurate determination of

the location. The more sensors available, the larger is the area which can be searched and the quicker a victim location can be pin-pointed.

Comparison of signals is only meaningful if the sensors are matched in sensitivity and are of the same type and construction, covering the same frequency range. This may not be the case with all listening devices. Some use two types of sensors: one for high and one for low (seismic) waves.

If two sensors are available and a signal is heard, the louder sensor again should be left in place. When the second sensor is moved step by step in a circular fashion around the first sensor, a direction toward the signal source may be obtained, when the movable sensor shows maximum signal.

However, it should be kept in mind that the majority of collapsed sites will be made out of different materials: steel, concrete, brick, and wood may be found on one site, with each material having a different sound transmission capability. There will be breaks and fractures, large and small pieces, and overall inhomogeneous materials. It will be more important to access the larger structural parts and to try to place the sensor on similar materials rather than work with theoretical search patterns and assume equal sound distribution and attenuation. The "stereo effect" is effective if homogenous materials are present. Eventually some type of modified grid search should be used to verify that no section of the site is overlooked.

In the same manner as in searching with dogs, the second technical search specialist (or other CSSR team member fully skilled in acoustic/seismic devices) should be used to confirm the initial find (certain brands of devices employ two separate headphones for this purpose). Should the second operator provide an indication of a find at the same location, this position should be marked with orange survey tape. This information would then be passed on to the task force leadership and the technical search would continue.

Advantages of Electronic Search

- Able to cover large search areas and sometimes triangulate on victim position.
- Capable of picking up faint noises and vibrations.
- Can be used in conjunction with other search devices to verify find.

Disadvantages of Electronic Search

- Unconscious person cannot be detected.
- Ambient site noise is intrusive.
- Victim must create a recognizable sound pattern.
- Range is limited (acoustic, 7.5 metres, seismic, 23 metres).

Canine Search

(This section for reference only — not included in the CSSR course.)

A well trained canine search team can search large areas in a relatively short amount of time. The team consists of a canine search specialist and a search dog. The dogs use their keen sense of smell to detect victims buried under the debris.

Many different breeds of dogs are used in disaster work. The dogs should be medium-sized, agile, responsive to the handler's directions, generally friendly, and extremely willing to please. The dogs used for high-level CSSR disaster work should be nationally certified at the advanced level. If demand exceeds availability, then the dogs used should at least be certified at the minimally deployable basic level.

The handler should be certified in advanced first aid and CPR. This person should be required to have taken a rescue systems course, and hazardous materials awareness, as well as having a good knowledge of Incident Command Systems and critical incident stress debriefing methodology.

The search dog will indicate finding the scent of a buried human victim by focused barking at the strongest scent source. The canine may dig at the scent source and try to penetrate to the victim. The primary function of the canine is to detect those victims that are alive. However, most canines will give subtle indications of the dead, and whenever possible, these areas will be noted for future recovery.

Canine Operations

The search team manager, technical search specialist, and the canine search specialists (handlers) will survey the site and decide the best search strategy for the operation. They will factor in the time of day, the temperature, size of area to be searched, and the type of collapse. The site will usually be divided into small search sectors. The search team manager should sketch the general features of the structure/rubble area, labelling each search sector, and noting all significant information (land marks, etc) on the sketch for future reference.

Search Tactics

The search specialist from a safe zone will deploy canine #1 to free search the sector. If no alerts or areas of interest are indicated the handler will then direct the canine in a fine grid like search of the sector. While canine #1 is searching, canine #2 is nearby and resting. However, team two handler and possibly the Team Manager will be observing (spotting) canine #1 search. Each will watch from a different vantage point. These spotters provide the handler with very important information on how well the area has been covered, areas that need to be researched, and any subtle alerts on possible dead bodies, etc.

If canine #1 detects human scent and alerts, the handler will praise and reward the canine as they leave the area. The area must be noted on the map and no flagging will be placed at this time. Canine #2 will be deployed into the general area of the alert. If the alert is confirmed by canine #2 it will be flagged and the search team manager will inform the task force leader of a find.

If there are no finds the canine teams will switch places after approximately 20-30 minutes of searching. Canine #2 will re-search the same sector. If possible, the handler will direct canine #2 to fine grid the sector in a different direction than canine #1 worked, such as north to south or east to west.

When a search sector has been completely searched by both canines, the next sector will be started, and so on until the entire site has been searched. The canine team should continue to search around rescue operations that may be in progress, providing this doesn't endanger the rescuers.

Scent

Scent channels around the solid slabs, large chunks of concrete, and canines will indicate where scent is emerging, not necessarily exactly where the victim is located. Scent tends to raise /flow relatively evenly through more broken rubble and lighter types of structures such as light frame, URM rubble with wood floor planes, and badly broken reinforced concrete and pre-cast concrete buildings. Therefore, the canines will tend to indicate a more precise location of the scent source/victim in these lighter, more broken structures.

Continued researching of any structure, as it is penetrated by cutting and removal, is important in order to better locate the initial victim and provide information regarding additional victims. This is especially true for concrete structures with solid slabs, since the scent may be travelling back and forth across many solid layers/floor surfaces, and a true direction for victim location may not be indicated until the layers/floor level on which the victim rests is reached.

Best canine working conditions:

- Dawn and dusk when scent is rising
- Cool weather, light winds (up to 20 mph)
- Stable rubble that doesn't slide as canine traverses
- Light rain.

Difficult working conditions

- Hot weather above 32° C
- Middle of day when temperatures are above 27° C.
- Strong winds/no winds.
- Snow makes surfaces more slippery/hides surface
- Safe footing unknown
- Firefighting foam and other chemicals.

Advantages of canine search

- Can search large areas in short period of time
- Can traverse or gain access to voids and other
- Opportunity sources
- Can work in unsafe areas.
- Can detect unconscious victims

Disadvantages of canine search

- Short work period of 20-30 minutes, rest for 20-30 minutes
- Need two canines to search same area to check/confirm
- Performance may vary according to handler and canine capabilities
- Scarce resource

Combining Search Tools

Whenever possible, dogs and electronic search should be employed together. Canines can and have successfully worked with electronic detection that senses structure borne sound/vibration.

In the Mexico City 1985 quake, relatively crude seismic sensors were used in the quiet of late night to determine if live/conscious victims were present in pancaked, waffle slab structures. Canine teams were then deployed within the cavities of the building to pinpoint the location of victims, leading to the successful rescue.

With the more sensitive electronic detection currently available, a more efficient interaction between canine and seismic sensors should be initiated.

For large, multi-story, pancaked concrete slab structures the electronic detectors could initially indicate, if conscious victims respond, even on which floor level they are trapped. Canine could then be more efficiently directed to search a specific floor area, even through relatively thin, unsafe voids.

During hot daytime hours, the electronic devices could be deployed to locate numerous areas where victims are located. These areas would then be searched at dusk by canine teams to confirm and pinpoint location.

In buildings with unconscious victims or poor vibration transmission, characteristic of (badly broken structures of wood, brick, and even pre-cast concrete), the initial search by canines may be the most effective.

By contrast, in a large concrete and/or steel structures, electronic detection should be the most effective initial search tool. When both of these search tools are available, they should be used to check/verify the finds of the other.

Site Search Priority

Depending upon the situation, it may not be necessary to deploy a full search and recon team. Once a viable specific work area (i.e., group of buildings, single building o separate section within a building) has been determined or assigned, the various search tactics should be determined. In many instances, the canine search can provide the most rapid assessment of a work site area. One search canine team can cover a significant area in short amount of time. This capability might be used first to sweep an area for a general assessment of indications for victims. The redundant check by the other canine should be used to ensure the greatest degree of credibility.

The electronic search capability may be used effectively, prior to, in conjunction with the ongoing canine search, or afterward. The electronic search by it's nature will usually be slower and more time consuming. The specific selection of an electronic search site could result from the prior indications of the canine search teams or be based upon the types of construction/occupancies affected, as noted earlier. Once again, a redundant check by a second operator should be made after an initial find is identified and should also be marked if necessary.

Prior to the location of any viable trapped victims, the task force rescue personnel present a significant search resource. They should be used to assist the canine and technical search personnel with safety assessments at collapse sites, gaining access to difficult areas, deploying equipment, etc. They also should conduct physical search operations, either separately, or in conjunction with the canine/electronic search operations. Individual void inspections or combined listening operations can be conducted, as necessary. These operations would be coordinated by the Rescue Team Manager in conjunction with the Rescue Squad Officers.

Once a reliable indication of the general location of a victim(s) is made, the use of the fibre optic viewing equipment (in conjunction with the concrete hammer/drills, if necessary) may prove useful in precisely determining the exact location and orientation of the victim(s). These tools may also prove to be the most effective method of performing a general sweep of a collapse area adjacent to an open, accessible area (such as an intact basement or floor above a collapsed area). An array of inspections holes can be drilled and fibre optic viewers can be inserted to make a general determination of the collapsed area.

Summary

- When the CSSR team arrives at an area severely affected by an earthquake, they could possibly be faced with hundreds of persons trapped beneath the rubble. Some may be alive, others dead, and many simple rescues may have already been accomplished by the community.
- The combined use of physical, canine and electronic search tactics will enable the task force to better establish priorities and focus emphasis on the most important rescue activities.
- The CSSR team will be assigned the most difficult rescue situations. Depending on the complexity of the search and rescue activity, a great amount of time may be spent on each live extrication. The search function must locate viable victims before committing rescue resources to any prolonged operation.
- Time should not be wasted in unproductive missions (such as removing bodies or finding trapped animals) while other live victims might still be saved.
- Accordingly, it is essential that all members of the CSSR team understand the advantages and disadvantages of each search tool. The interdependence of the search and rescue function requires mutual respect and confidence, which can be best maintained by understanding that each has significant capability, and limitations.
- CSSR team supervisors must ensure the close interaction of the structure specialists with the search and rescue personnel during search operations. The structure/hazards assessment should include information regarding existing openings, probable victim location, in addition to evaluation of structure stability and hazard identification.
- Recurring assessments should be performed throughout the operations, since aftershocks and debris/structure removal can expose new hazards and new search opportunities.