Arizona Basic Search and Rescue

4^{th} Edition

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Preface

This manual is an introduction to the basics of searching for missing persons in wilderness environments. It is aimed at members of the public, primarily in Arizona, who are interested in becoming Search and Rescue (SAR) volunteers and also at SAR personnel who are new or inexperienced in searches. This is an introduction only—there is much more to wilderness searches than is presented here.

Outline of the Manual

The contents of this manual is based in part on the suggestions in the ASTM International[1] document F2209—10, "Standard Guide for Training of Level I Land Search Team Member", published in June 2010.

To quote from that guide:

1. "*Level one (1) is the basic or entrance level.*"
2. "*This guide establishes the minimum training standard for Level I land search team members as it relates to their general, field, and search specific knowledge and skills.*"
3. "*A Level I land search team member searches on the surface of the land only. This guide does not provide the minimum training requirements for searching in partially or fully collapsed structures, in or on water, in confined spaces, or underground (such as caves, mines, and tunnels.)*"
4. "*A Level I land search team member is required to have only an overview level of knowledge of rescue as it pertains to "search and rescue". No knots, rope, litter, or other rescue skills are required of a Level I land search team member.*"
5. "*Further training may be required before a Level I land search team member can actually participate on a particular kind of search team, depending on AHJ*[2] *regulations or policies.*"

This work is also based in part on the previous Basic SAR Academy manual and course materials, as well as the Arizona-specific manual used to train AZ SAR Coordinators,"Inland Search Management For AZ SAR Coordinators".

Style

When writing this manual, a conscious decision was made to exclude all occurrences of "he/she", and use the generic "they" in its place. Thus a sentence like "He/she sets the Incident Objectives" is replaced with the sentence "They set the Incident Objectives". Sometimes this leads to slightly awkward phrasing, but not enough to warrant the use of "he/she".

This manual was typeset using MiKTEX, a free Windows package available from `http://miktex.org/`.

Please email any corrections or suggestions to David Lovelock at dsl@math.arizona.edu.

[1] Formerly known as the American Society for Testing and Materials.
[2] AHJ stands for the Authority Having Jurisdiction.

Photo Credits

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CHAPTER 1

Arizona Requirements, Policies, and Procedures

Section 1.1

How Search and Rescue is Organized in Arizona

In the United States of America the Air Force has overall responsibility for Inland Search and Rescue and the Coast Guard covers the navigable water ways. This responsibility then trickles down to the individual states and local authorities.

Since 1971, Arizona Revised Statutes 11-441a-e mandates that the Sheriff shall conduct or coordinate Search and Rescue (SAR) operations. There are 15 counties in the state of Arizona, and in each county the Sheriff delegates that responsibility to SAR Coordinators, who are fulltime law-enforcement or other authorized personnel. There are approximately 40 active SAR Coordinators in Arizona. The statute allows the sheriff to request assistance from any person or agency in the execution of their duties and to organize volunteers. They may assist another county's Sheriff upon request.

The law states the Sheriff "shall conduct" but it does not say that other agencies (Fire Departments and Police Departments) cannot conduct. What agencies do within their jurisdictions is not of great concern or debate but ultimately the Sheriff is responsible.

The State of Arizona, by revised statutes and federal agreement, supports SAR within the State through the Arizona Department of Emergency and Military Affairs (AZDEMA). It provides a State Coordinator and organizes the assistance of other State and Federal agencies. AZDEMA also provides for reimbursement of eligible mission expenses like fuel for DPS Air Rescue and Workman's Compensation coverage for the Sheriff's SAR volunteers. On SAR missions volunteers are covered by Workman's Compensation from portal to portal without significant travel deviation. On training missions volunteers are only covered on scene during the actual exercise.

There is a state-wide organization, the Arizona Search and Rescue Coordinators Association (ASARCA). It organizes quarterly meetings in different parts of the state so all AZ SAR Coordinators from the 15 counties can meet to discuss common issues including searches that went well, and those that did not. They organize a 5-day course designed to train new coordinators on how to manage inland searches.

ASARCA arranged for the creation of this Basic SAR Academy manual. They also organize an AZ SAR conference for volunteers held every 2 years.

While the various SAR groups throughout Arizona differ in many ways—ranging from what they are called, how they are organized, how they are managed, how they are funded, what they call their officers, etc.—they are all governed by a common set of Arizona requirements, policies, and procedures.

Section 1.2
Arizona Requirements of Volunteers

There are basic minimum requirements for an individual to participate in a SAR incident in Arizona. To be deployed the individual must at least

- Be affiliated with a recognized government entity, for example, a Sheriff's Office, the Civil Air Patrol (CAP), or the Arizona Department of Emergency and Military Affairs (AZDEMA).
- Pass a basic background check.
- Complete a 2-day "Introduction to Arizona Search and Rescue" course, or equivalent, conducted by members of the Arizona Search and Rescue Coordinators Association.
- Complete an OSHA course on Bloodborne Pathogens and Body Substance Isolation Procedures, and renew it annually.
- Be equipped to stay in the field for 24 hours without support.

Some agencies require considerably more than these basic minimum requirements. These might include a longer, more in-depth basic course, maintaining a current Basic First Aid and CPR card, attending team meetings, and responding to a minimum number of SAR incidents and training events.

> *Some agencies require considerably more than these basic minimum requirements.*

Section 1.3
Arizona Policies and Procedures

Once an individual is field-qualified, they must be familiar with, and must follow, certain common policies and procedures.

- **Callout to an Incident**
  Typically an appeal for assistance comes through a 911 call from a reporting party. The call is dispatched to a first responder, such as a Patrol Unit in the area. The first responder gathers information and decides whether to involve additional resources. The SAR coordinator is notified and makes the determination as to which resources are needed. This decision is usually based on the terrain, the resource type, (mounted, ground teams, helicopter, etc.) and expertise (technical rescue, tracker, swiftwater rescue, etc.). This is called a scene size-up.

  The SAR Coordinator contacts the leader of the resource, gives a basic description of subjects to be searched for, and any response directives such as expected arrival times, meeting locations, routes to be taken, and equipment needed.

  Typically the resource is advised whether the mission is a
  - Search—to seek out and locate live people known or thought to be in a distressed situation that are unable to reach a place of safety on their own.
  - Rescue—to render aid to people whose life or health is threatened by circumstances beyond their control and return them to a place of safety.
  - Recovery—to relocate a deceased person from the site of their demise to an appropriate location.
- **Incident Command System (ICS)**.
  The ICS is discussed in detail in Chapter 12 on page 156. In Arizona it is mandated by the governor that ICS be used by all state agencies to manage all-hazard incidents, which includes SAR incidents.

  The ICS provides consistent and efficient guidelines for the management of a search, so that

1. The roles and functions of the **Incident Management Team** are clearly defined and coordinated ensuring that search management is a team effort. See Figure 1.1.
2. **Sound Management Principles** are specified and used permitting leaders to maintain control of the incident. Everyone is accountable. One person has one boss.
3. **Common Terminology and Plain language** are used allowing people to communicate effectively. No radio codes are used.
   - Incident Commander (IC). The boss.
   - Incident Command Post (ICP), where the IC oversees the incident.
   - Staging Areas, where resources wait for assignments.
   - Base, where primary logistics functions are coordinated and administered.
   - Camps, where resources get food, sanitation, sleep, ...
   - Resource Status: Assigned, Available, Out of Service.
4. All actions taken on behalf of the lost subject are goal-directed rather than resulting from isolated decisions: that is, they are driven by operational objectives, thereby contributing to an overall **Incident Action Plan** for finding the subject.
5. All decisions, clues, and activities are **Documented**. ICS provides a comprehensive set of forms for keeping a written record of the incident.

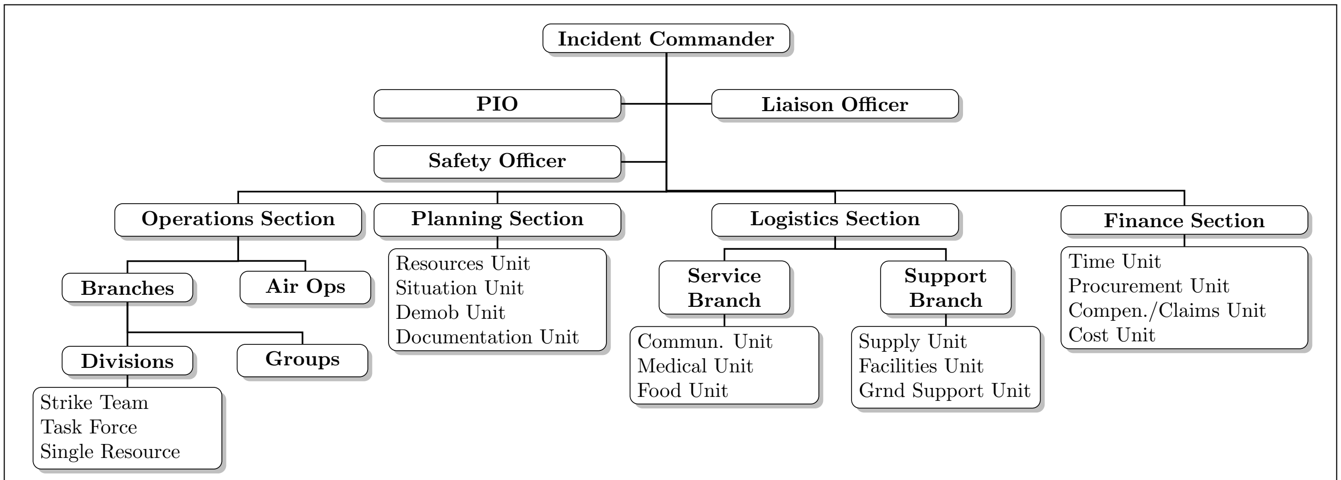


Figure 1.1. ICS Structure

- **Checking in at an Incident**

  All personnel must check in and check out. They must do this in person and they must never sign out another searcher for them. No exceptions. Look for the Logistics section or the check-in roster on the hood of the SAR Coordinator's vehicle and sign-in legibly. See Figure 1.2 on the next page. Park and unload equipment in the designated areas.

  > *Never sign out another searcher for them. No exceptions.*

- **Team Mission Briefing**

  Before teams leave the Incident Command Post or staging areas they are briefed on assignments and tactics to be used to accomplish the objectives established by the Incident Commander. See Figure 1.3 on the next page. They are also advised where to go to be debriefed when they have completed their assignment. The checking of packs, the evaluation of equipment, and all questions and concerns must be addressed before deployment.

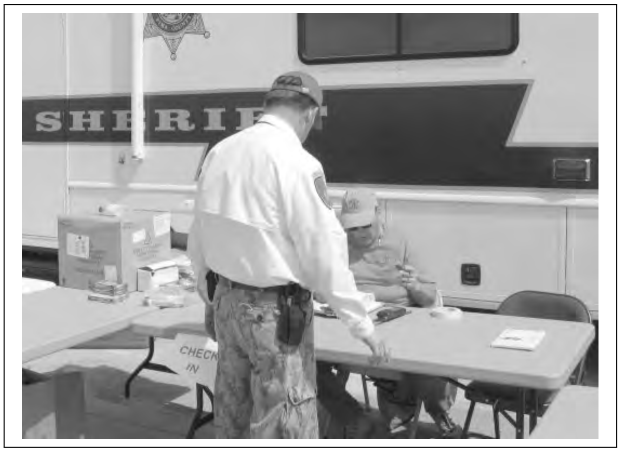
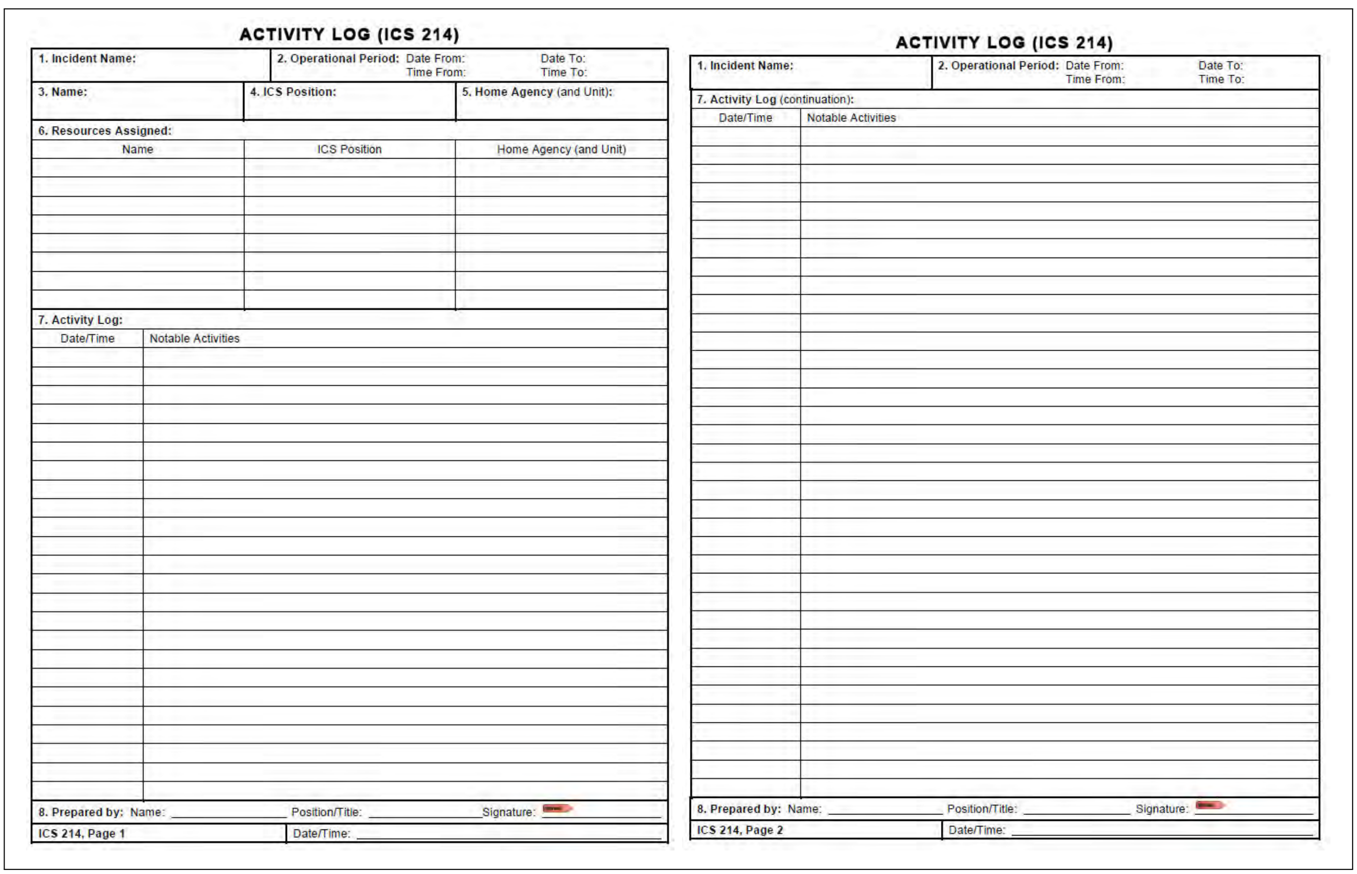


Figure 1.2. Checking In

Figure 1.3. Search Briefing

The Activity Log, ICS 214 form, see Figure 1.4, is a critical document to be completed by team members. These logs provide basic incident activity documentation, and a reference for any after-action review. Instructions for completing an ICS 214 are shown in Figure 1.5 on the next page. The team leader is usually responsible for this document and for making sure that it is archived with the other SAR documents for that incident.



ACTIVITY LOG (ICS 214)

1. Incident Name:
2. Operational Period: Date From: Date To: Time From: Time To:
3. Name:
4. ICS Position:
5. Home Agency (and Unit):
6. Resources Assigned:

Name	ICS Position	Home Agency (and Unit)

7. Activity Log:

Date/Time	Notable Activities

8. Prepared by: Name: Position/Title: Signature:
ICS 214, Page 1 Date/Time:

ACTIVITY LOG (ICS 214)

1. Incident Name:
2. Operational Period: Date From: Date To: Time From: Time To:
7. Activity Log (continuation):

Date/Time	Notable Activities

8. Prepared by: Name: Position/Title: Signature:
ICS 214, Page 2 Date/Time:

Figure 1.4. ICS 214

Block Number	Block Title	Instructions
1	**Incident Name**	Enter the name assigned to the incident.
2	**Operational Period** • Date and Time From • Date and Time To	Enter the start date (month/day/year) and time (using the 24-hour clock) and end date and time for the operational period to which the form applies.
3	**Name**	Enter the title of the organizational unit or resource designator (e.g., Facilities Unit, Safety Officer, Strike Team).
4	**ICS Position**	Enter the name and ICS position of the individual in charge of the Unit.
5	**Home Agency** (and Unit)	Enter the home agency of the individual completing the ICS 214. Enter a unit designator if utilized by the jurisdiction or discipline.
6	**Resources Assigned**	Enter the following information for resources assigned:
	• Name	Use this section to enter the resource's name. For all individuals, use at least the first initial and last name. Cell phone number for the individual can be added as an option.
	• ICS Position	Use this section to enter the resource's ICS position (e.g., Finance Section Chief).
	• Home Agency (and Unit)	Use this section to enter the resource's home agency and/or unit (e.g., Des Moines Public Works Department, Water Management Unit).
7	**Activity Log** • Date/Time • Notable Activities	• Enter the time (24-hour clock) and briefly describe individual notable activities. Note the date as well if the operational period covers more than one day. • Activities described may include notable occurrences or events such as task assignments, task completions, injuries, difficulties encountered, etc. • This block can also be used to track personal work habits by adding columns such as "Action Required," "Delegated To," "Status," etc.
8	**Prepared by** • Name • Position/Title • Signature • Date/Time	Enter the name, ICS position/title, and signature of the person preparing the form. Enter date (month/day/year) and time prepared (24-hour clock).

Figure 1.5. ICS 214 Instructions

- **Team Mission Debriefing**

  Team members must not check out from the incident without first being debriefed and their information documented on a designated debriefing form. Team members must be prepared to either download information from their GPS units or to transpose information from activity logs and maps onto the master map at the Incident Command Post that describes in detail the areas covered and not covered. This information is crucial in determining whether an area should continue to be searched, or if additional (or different) resources should be applied to it.

  During debriefing, team leaders are expected to hand in completed ICS 214 forms and to answer the following questions.

  1. Who was involved in the task?
  2. What was their assignment?
  3. What time did they begin?
  4. What did they accomplish?
  5. How likely were they to have seen the missing person? The efficiency with which a team searches its assigned segment is called its POD, probability of detection, which is discussed on page 53.
  6. What time did they finish?
  7. Any difficulties or areas they could not search adequately?

8. Any clues found?
   a) Where?
   b) What?
   c) What did they do?
   d) Where is it now?
9. Any hazards observed in the area and their location?
10. Any communications problems?
11. Any comments? For example, what would the team suggest if this task was done again: type of resource, how to search.

- **Demobilization and Departing the Incident**
  Specific directions for desired demobilization should be discussed and documented on large incidents but even on smaller incidents instructions may be given by the Incident Commander or designee on proper procedures to be followed. The length of time in the field is always a factor of concern during demobilization and instructions may be given and areas set aside for teams to rest before release. Before leaving the incident all ICS 214 forms must be handed in.

  > *Before leaving the incident all ICS 214 forms must be handed in.*

- **Member Interface with Media and Family**
  The State of Arizona has 15 counties and each Sheriff has policies in place with instructions on how to deal with the media. These vary from county to county. Team members should be briefed at the beginning of each mission by the Incident Commander on the procedure to be followed.

  Mission specifics, efforts, goals, and objectives, should not be discussed or divulged to anyone without prior authorization. Team members should always avoid voicing personal opinions publicly before discussing those issues or thoughts with the Incident Commander or designee.

  > *Mission specifics, efforts, goals, and objectives, should not be discussed or divulged to anyone without prior authorization.*

  Media should be directed to the Public Information Officer (PIO) or the Incident Commander. See Figure 1.6 on the next page. Cameras and news crews may be encountered in the field and a professional demeanor must be followed. Taking pride in the tasks accomplished and enjoyment of the assigned activity are accepted virtues, but laughing and unexplained gestures can be interpreted differently from a distance or on video. Be aware of who is around at all times.

  Team members shall be briefed on the presence and identification of family members at the incident and questions presented to team members by family should be referred to the Incident Commander or the designated liaison.

  Professionalism must be adhered to at all times. It is impossible to anticipate when a family member or a friend or the media may appear on scene.

  > *It is impossible to anticipate when a family member or a friend or the media may appear on scene.*

- **Social Media**
  The increasing popularity of social media such as Facebook, Twitter, MySpace, and others as well as blog and comment sites on media outlets has implications for public safety agencies. Traditionally

Figure 1.6. Dealing with the media

information about an incident was released to the public by an agency's public information staff. That still is the preferred method but with many paid and volunteer personnel having social media accounts some information about an incident is getting out to the public via these modes.

It is very important for all SAR personnel to realize that they are viewed as a representative of the agency for which they volunteer and are generally not authorized to release information on behalf of the agency. As a result it is critical that SAR personnel be aware of what information they choose to share on social media or blog sites. Information that is not released in the agency's official media release probably should not be shared in a social media post. If a search is ongoing there is generally an investigation ongoing as well. Releasing information that is not approved by the Incident Commander and released outside of the public information office may hamper the investigation. Some information is protected by law and posting photographs that can identify the subject of a SAR operation, especially if the subject was ill or injured, may violate the law and expose the individual and agency to legal action.

Often when reading a media report about a SAR incident someone involved in the incident may notice errors or omissions that present the operation in a negative light. It may be tempting to log into the comment section attached to the story on-line and post information that may correct or clarify the situation but that really is the job of the PIO and not the individual SAR member. Often the PIO will have a relationship with the reporter and can make contact to correct the record.

SAR personnel must remain professional and be a good representative of their agency and the profession. Refraining from posting comments or photos that could disparage the image of search and rescue or an agency is critical in that regard.

All personnel should familiarize themselves with their individual agency's policies about the use of social media and release of information to the media.

- **Legal Issues**
  - **Safety and Driving**

    Safety is the number one concern that should be on every SAR team member's mind. A volunteer cannot help if they do not get there! As a general rule **SAR Volunteers are not authorized to violate any State criminal or traffic laws in response to a search and rescue mission**. Passing the SAR Coordinator en route to the same incident is not acceptable driving behavior. Nowhere in State law is there a provision for traveling 5 or 10 mph over the posted speed limit. The Posted Speed is the limit and any variance can be costly. Make the right decision and do not gamble. There are times when a volunteer searcher is told to hurry their response but at no time are they granted permission to break any State law or knowingly violate individual department policy or procedure. Response should be efficient, effective, responsible, prompt, and safe.

> *Response should be efficient, effective, responsible, prompt, and safe.*

- **Finding Deceased Persons**
  On occasion searchers find a lost/missing person too late and they are deceased. It is crucial to remember in those cases that bringing closure to an incident is very critical to the well-being of family members. Death is always difficult to deal with but the unknown factors dealing with a loved one that has not been located is much more difficult. Searchers can also be affected.
- **Crime Scenes**
  Any time a subject is located and they are injured or deceased, or the predicament they were rescued from or found in suspicious circumstances, precautions should be taken. Searchers should always disturb as little as possible. Do not move anything unless it has to be moved for safety or mission success. All incidents are considered crime scenes until determined otherwise. The Incident Commander should be notified immediately and then the team must wait for specific directions before continuing. Treat every incident as a crime scene and every search team member should be briefed on the basic rules of evidence, chain of custody, and crime scene preservation.
- **Confidentiality**
  Subject, victim, witness, or patient confidentiality are covered by HIPAA[1] and shall always be adhered to. Personal details are not released to anyone without proper authorization. The condition of the subject, or however they are referred to, shall not be discussed with the media, public, or family members, without the proper requests being made. Everyone deserves a certain amount of privacy and the laws in the United States of America and the State of Arizona protect that privilege.
- **Entering Private Property**
  During a SAR incident entering private property is usually not an issue when property owners are aware of the task at hand, namely, looking for a lost person. There are exceptions and in those cases search parties must adhere to the wishes or demands of the owner. If it is determined that piece of property is crucial to the success of the mission, like tracks discovered or attractions/hazards, teams report this to the Incident Commander and other measures may be taken, such as written requests or search warrants drawn up and approved by a Judge having jurisdiction.
- **Illegal Activities**
  Many times during the course of their duties, SAR professionals encounter illegal or suspicious activities. Each situation presents its own hazard. Illegal marijuana growing operations are known to be occupied by armed individuals and/or booby trapped. Chemicals from clandestine meth labs are often dumped in remote areas. They are known to contain dangerous chemicals that are hazardous if inhaled or explosive if handled inappropriately. Some remote areas are often transited by individuals illegally entering the country or smuggling illegal drugs. These individuals are commonly known to be armed. SAR professionals may also encounter persons acting suspiciously or deceptively about their activities. Caution should be exercised and personal safety is of the utmost importance. Any suspicious or suspected activity must be immediately reported to the Incident Commander and handled following team policies and procedures.

[1] The Health Insurance Portability and Accountability Act of 1996.

Section 1.4

Continuing Education

The remaining chapters of this manual contain additional information that all field-qualified searchers should be familiar with. However, there is much more to SAR than is contained in these pages. It is critical that SAR team members remain up-to-date by continuing their SAR education and training. The website `WWW.SARAZ.ORG` contains lots of SAR information, including details of upcoming training and SAR conferences (such as the State SAR conference), copies of talks people gave at these conferences, and other SAR-oriented documents. Individual agencies offer their own training. It is the searchers' responsibility to avail themselves of these opportunities. Do so!

CHAPTER 2

Introduction to Searches

What is the difference between a Search and a Rescue? A rescue is a known problem at a known location. A search is an unknown problem at an unknown location. However, a search sometimes transitions into a rescue. Because a search is an unknown problem it is always an emergency and generally requires some type of immediate response.

This manual deals primarily with searches in wilderness environments. Managing a search is much more complicated than most people realize. Doing this properly requires training, knowledge, resources, and experience.

In the state of Arizona the Sheriffs of each of the 15 counties are responsible for SAR. In each county the Sheriff passes that responsibility onto SAR Coordinators, who are fulltime law enforcement or other authorized personnel.

The Arizona Department of Emergency and Military Affairs (AZDEMA) by direction of the Governor's Office supports SAR operations in the State. AZDEMA provides reimbursement of eligible mission expenses like fuel for DPS Air Rescue (a helicopter) and Workman's Compensation coverage for the Sheriff's SAR volunteers.

This chapter introduces new or inexperienced SAR personnel to five important questions that underpin all searches. These questions are

- **Who** do we search for?
- **What** types of searches are there?
- **What** do we search with?
- **How** do we plan for a search?
- **When** do we search?

Section 2.1
Who Do We Search For?

Who do we search for? Missing subjects—these are people (or objects) that are not where they are supposed to be. Most SAR incidents involve searching for people.[1] Occasionally an incident involves searching for an object, such as an airplane or evidence. Knowing the category of a missing subject often dictates the search tactics used, so subjects are divided into the following categories.

- **The Lost**
  - They usually self report by cell phone.
  - They are lost because they missed the trail or tried to take a short cut.

[1] In SAR, we do not call a missing person a "victim".

- They want to be found.
- Trained volunteers are used on these searches.

- **The Overdue**
  - They are usually reported missing by family or friends.
  - Most leave an itinerary or the reporting party gives a starting point for the search.
  - They want to be found.
  - Trained volunteers are used on these searches.
- **The Endangered**
  - Memory impaired.
  - Children—either lost or abducted.
  - Subjects who are unable to care for themselves.
  - They may not know or understand that they are the subject of a search.
  - Trained volunteers are used on these searches.
- **The Suicidal**
  - Despondents.
  - They may not want to be found.
  - There needs to be a good risk assessment before deploying trained volunteers to search for a suicidal subject.
- **Aircraft**
  - If they do not make their flight-plan destination, then a search is started immediately.[2]
  - If an electronic locating device (for example, an ELT or Emergency Locator Transmitter) hit is received, then a response is initiated immediately.
  - This always involves a large search area.
  - Aircraft are particularly difficult to locate because the size of the search object is unknown. It could range from an aircraft fuselage fully intact to a small burn site containing a completely destroyed aircraft. Also white aircraft are difficult to detect in snow.
  - Trained volunteers are used on these searches.

A missing subject may be thought of as in one of four states during the search.

- **Mobile and responsive.** Mobile means that the subject can move around, although they may not be moving at the present time. Responsive means that the subject has the ability and the willingness to signal the searchers in some way (voice, whistle, waving arms, mirror, etc.). An example of this is a healthy person who has merely lost the trail.
- **Mobile and unresponsive.** Unresponsive means that the subject cannot or will not signal the searchers in any way. An example of this is a healthy child who has been taught not to talk to strangers.
- **Immobile and responsive.** Immobile means that the subject cannot move around. They are stationary (standing still, not moving). An example of this is a person who has broken an ankle, but is conscious and able to communicate.
- **Immobile and unresponsive.** An example of this is a person who is in a coma or deceased.

The subject may be in one of these states permanently or temporarily. Permanently could be if the subject is in a coma or is deceased. Temporarily could be if the subject is sitting down or is asleep one moment and awake the next. However, in SAR, the temporary situations are discounted, and the search strategy is based on the predominant state the subject is most likely to be in (bearing in mind that, as the search progresses a subject may transition from "Mobile and responsive" to "Immobile and unresponsive".)

[2] However, there can still be a significant delay in a search being initiated. Part of this depends on whether the aircraft had a flight plan on file or not. And if a flight plan was on file, it depends on whether it was using VFR (Visual Flight Rules) or IFR (Instrument Flight Rules).

A subject could be intentionally unresponsive, that is evasive, or unintentionally unresponsive. Examples of intentionally unresponsive subjects are

- A child who does not to talk to strangers.
- A despondent who wants to get away from people and does not want to be found.
- A criminal who is fleeing.

An example of an unintentionally unresponsive subject is someone who is unaware that they are the subject of a search, such as a dementia patient.

Knowing whether a subject is mobile or immobile, and responsive or unresponsive, impacts the tactics used during the search.

For example, if, on the one hand, it is believed that the subject is mobile, then rapidly placing resources at strategic locations to confine the subject is a high priority because it restricts the size of the subsequent search area. If, on the other hand, it is believed that the subject is immobile, then that priority is lower, and now the mission of these resources is to talk to passers-by to see whether they have important information.

In the same way, if a subject is mobile, then laying down "traps" that capture evidence of the subject passing is an excellent tactic, which is not sensible if the subject is immobile.

If the subject is responsive, then shouting, lighting flares, etc., is good practice, whereas that is not the case if the subject is unresponsive. An unresponsive subject requires more searchers closer together.

How Do Disoriented Subjects Try To Reorient Themselves?

Sometimes lost and disoriented subjects appear to behave in bizarre and illogical ways, so it is useful to know how subjects try to reorient themselves. Ken Hill, see Reference [Hill 2], has identified nine techniques that lost subjects might use, and generally they "*will use at least one of these methods, some of which are considerably more effective than others, and most lost people will try more than one.*" What follows is a brief summary of these methods. For more details see Reference [Hill 2].

1. **Random Traveling** is where the subject moves in a random fashion with no apparent reason.
2. **Route Traveling** is where the subject decides to follow an unfamiliar trail, path, drainage, or other travel aid.
3. **Direction Traveling** is where the subject decides to follow a specific direction cross country, often ignoring trails and paths leading in the "wrong" direction.
4. **Route Sampling** is where the subject uses an intersection of trails as a "base", proceeding to travel some distance down each trail.
5. **Direction Sampling** is similar to route sampling, except that the subject does not have an intersection of trails as a "base", but instead selects some identifiable landmark as the "base".
6. **View Enhancing** is where the subject decides to gain height in order to view landmarks in the distance.
7. **Backtracking** is where the subject reverses direction and tries to backtrack on the route initially followed.
8. **Using Folk Wisdom** refers to an attempt by the subject to reorient themselves by using any of the numerous adages on how to find their way to safety.
9. **Staying Put** is where the subject follows the advice "stay where you are".

Section 2.2

What Types of Searches Are There?

Generally, there are two types of searches.

1. **Route and Location Searches**. These are searches where routes[3] and specific locations are the primary focus of the search resources.
   A Route and Location Search search is usually characterized by the following.
   - There are no identified search segments. Routes and locations are searched, rather than areas.
   - The subject has been missing for a short time.
   - Only a few local resources are used (ridge runners, trail runners, etc.) and only a few agencies are involved (one sheriff's department, SAR volunteers, etc.)
   - The subject may be moving or stationary (mobile or immobile).
   - The subject may be responsive or unresponsive.
   - There is a quick resolution—one way or the other.
   - The press might get involved, but usually not on the front page.

   A Route and Location Search is usually the first type of search used during the initial response phase of a search. Such searches are called **Hasty Searches**. The purpose of the hasty search is to cover the most obvious places a subject might be in the least time possible. The term "Hasty" is used to stress the urgency and immediacy of the search—it indicates that the search is being conducted in a thoughtful, skilled, and professional manner.

   > *The term "Hasty" is used to stress the urgency of the search—it indicates that the search is being conducted in a thoughtful, skilled, and professional manner.*

   About 85% of such searches are over within the first 12 hours.[4] About 97% of all searches fall into the Route and Location Searches category, and they are over within 24 hours.

   Generally, the remaining 12% (97%−85% = 12%) of Route and Location searches, which are over between 12 and 24 hours, go into another operational period, and are called **Extended Searches**. If after 24-hours the subject is not found, but there is evidence that the subject is mobile, then the extended search continues where routes and locations are still the primary focus of the search. However, if there is no evidence that the subject is mobile, then Route and Location Searches generally transition into Area Searches.
2. **Area Searches**. These are searches where segments (areas) are searched, rather than routes and locations. These searches are preceded by a consensus, where it is assumed that, if the subject is in the search area, then the subject is immobile. Only about 3% of searches reach this stage, but those that do are memorable and instructive!

   An Area Search is usually characterized by the following.
   - It covers many operational periods.
   - Multiple resources, not all local, are used (ground teams, canine, helicopters, fixed-wing aircraft, horses, 4WD, ATV, climbers, infrared, etc.).
   - Multiple agencies are involved (Sheriff/Police/Highway Patrol, National Park Service, Forest Service, FBI, military, SAR volunteers).
   - There are many search segments. The emphasis is on searching areas rather than searching routes and locations.
   - Search Theory is used.
   - The subject is assumed to be immobile (stationary).
   - There is lots of press coverage, both good and bad, with some on the front page.

[3] The term "route" used in this context includes all forms of travel aids, such as pathways, roads, game trails, railroad tracks, ridges, valleys, dry washes, drainages, streams, shorelines, clearcuts, power lines, vegetation lines, or any area that provides a sense of direction and a path of little resistance.

[4] This time is measured from when the initial report is made until the time the last searcher arrives home, so the actual search is considerably shorter than this.

- There is pressure, anxiety, and criticism.
- Lots of untrained volunteers, second-guessers, and "experts" come out of the woodwork.

In this type of search, the primary search tactic used is some form of a grid search,[5] in the widest sense. This would include a helicopter using a creeping line search, a ground team using critical separation, or a handler using an air scent dog. Hasty tactics might also be used in Area Searches. For example, if a search team discovers tracks then a tracking team might follow those to allow the search team to complete its assignment.

> *There are two types of searches: Route and Location Searches and Area Searches.*

A search that goes beyond the Initial Response is also called a **Multi-Operational Period Search**. Depending on the status of the search, a Multi-Operational Period Search could either remain as a Route and Location Search or transition to an Area Search.

There is another type of search, called a **Bogus Search**.[6] This occurs when, unknown to the searchers, the subject is not missing at all, or if the subject is missing, has left the search area and is now safe, at home, at the movies, in a tavern, ...

Initial Response and Operational Periods

The beginning period of a search is called the Initial Response. How long it lasts depends on the incident. During that period, the IC decides when the first full operational period starts and ends. This is called Operational Period 1. It is typically 12 hours long. The next OP, Operational Period 2, starts when OP 1 ends, and so on. See Figure 2.1.

Initial Response	Operational Period 1	Operational Period 2	···

Figure 2.1. Initial Response and Operational Periods

Section 2.3
What Resources Do We Search With?

Resources are the people and equipment used to help locate the lost subject.

The people come in various categories: paid or unpaid, trained or untrained. When authorized to do so, paid resources are guaranteed to respond to an incident. Because of prior and job-related commitments, unpaid resources (trained volunteers) cannot guarantee to respond.

Depending on the tactics employed, the following resources may be used.

- Ground Searchers.
- Canines.
- Horses.
- Aircraft.
- Ground Vehicles.
- Specialized Units.

[5] Grid searchers form a line, with trained team members at a specified distance apart, and progress through the assigned area together.

[6] This is the current terminology. Previously it was given another name, also starting with the letter 'B', which suggested that it was an illegitimate search. That terminology is still prevalent.

Ground Searchers

Ground searchers come in various categories, but they all refer to a resource that searches on foot. See Figure 2.2.

Figure 2.2. Ground searchers

- **Human Trackers—Sign Cutters.** These highly-trained resources follow the route of the subject step-by-step from the place the subject was last known to be, by identifying tracks and signs left by the subject. They can also be used to reduce the search area by binary searching.[7]
  - **Usage**. Usually they are among the first responders requested for a hasty search. Also, if tracks are discovered during an Area Search, then they are used while the regular searchers continue searching their segment.
  - **Advantages**. They can give the subject's direction of travel, follow the subject's path, locate clues, and reduce the size of the search area.
  - **Limitations**. Time consuming. Skill levels vary. Less effective if not used immediately or if clues have been destroyed by other resources or the environment. Difficult to have available and their skills require frequent updating.
  - **Sources**. Trained volunteer units, National Park Service, U.S. Customs and Border Protection, law-enforcement tracking units.
- **Hasty Teams.** These trained resources are clue-conscious and very mobile searchers. They are independent and can work without supervision.
  - **Usage**. Usually used during a hasty search.
  - **Advantages**. They can search the high probability routes and locations quickly. They can also locate clues.
  - **Limitations**. May miss or destroy clues in their haste.
  - **Sources**. Trained volunteer units.
- **Grid Search Teams** (AKA Line Searchers or Sweep Searchers). These generally search areas by forming a line, with trained team members at a specified distance apart, and progressing through the assigned area together.
  - **Usage**. Usually used during an Area Search.
  - **Advantages**. They can search areas thoroughly, depending on the spacing between searchers. They can also locate clues.
  - **Limitations**. Time consuming. Low efficiency. Require a lot of man-power. May destroy clues, if not detected.
  - **Sources**. Trained volunteer units.

[7] A Binary Search is a strategy that involves sending sign cutters in a direction that is perpendicular to the subject's assumed direction of travel, in an effort to reduce the size of the search area.

- **Untrained Volunteers** (AKA Spontaneous Searchers). These are untrained personnel who offer to help with the search effort. See Figure 2.3. There is no consensus in the SAR community as to whether their offer should be accepted or declined. That decision is made by the Incident Commander. Expect pressure from the family and the community if these volunteers are not used, especially if there are insufficient trained resources available. There have been situations where untrained volunteers were used who then worked against the agency, even trying to convince the family that a terrible job is being done.
  - **Usage**. Whether to use them or not is determined on a case-by-case basis. Only used in the field if they are trained and supervised. Could be used in non-search capacities.
    - It requires some tact to explain to untrained volunteers why they cannot be used on a search.
    - If they are told to go away they may search on their own. Those days where control of a situation can be achieved with road blocks and crime scene tape are over. With social networks today, search groups of hundreds of people can be organized by amateurs in a very short time.
    - Possibly get them involved, suggesting feasible assignments, but stress that the agency is not responsible for their actions or safety and they must not interfere with the official search.
    - Discouragement is the best method but experience in recent years suggests this may not work. Encourage them to join regulated groups and get trained to participate in the next operation.
    - If agency, family, and public pressure force the Incident Commander to use untrained volunteers that show up to help, train them quickly, put them with experienced trained searchers, and provide a means of communication. Give them assignments—do not let them go off on their own.
  - **Limitations**. Untrained. Unprepared for environment. Unfamiliar with command structure. Require constant supervision. May be available only for a short time. Background checks required, especially in the case of a missing child. Unknown health or physical conditions. Not covered under Workman's Compensation. If used, the agency in charge of the search may be legally liable for their actions and welfare.

Figure 2.3. Briefing untrained volunteers

Figure 2.4. Dog team

Canines—K9

A canine unit consists of a dog and its handler, and sometimes an additional person to manage communications, navigation, and note-taking. Generally canines used in searches fall into two categories, Trailing Dogs (also called Tracking or Ground Scent Dogs) and Air Scent Dogs. See[8] Figure 2.4 on the previous page.

- **Trailing Dogs.** These dogs are typified by the Bloodhound, although other breeds are said to be as effective. Like human trackers, trailing dogs follow the route of the subject from the place the subject was last known to be, by identifying scent left by the subject on the ground and nearby vegetation. Typically trailing dogs require a scent article belonging to the subject, which has been protected from contamination. Ideally this should be clothing the subject has recently worn, or bedding recently slept in. Such an article should be placed, without touching it, into a Ziploc© type bag. Some handlers prefer to collect these articles themselves, although that is not always practical.
  - **Usage**. Usually they are among the first responders requested for a hasty search.
  - **Advantages**. They can give the subject's direction of travel, follow the subject's path, locate clues, work day or night, and work independently of other resources searching the same region.
  - **Limitations**. Require a scent article. Skill levels vary widely. Effectiveness adversely affected by the weather (high temperatures, low humidity, any wind). In Area Searches they are unable to search segments.
  - **Sources**. Trained volunteer units, U.S. Customs and Border Protection, law-enforcement dog units (but not "piranhas on a leash").
- **Air Scent Dogs.** These dogs typically work off-lead. They detect scent from a human as it is carried by air drifting from the source to the dog. The dog searches and samples the air currents by ranging/quartering back and forth through the area that is assigned to the team. Usually they are unable to discriminate between the subject's scent and that of any other human.
  - **Usage**. Can be used in any type of search.
  - **Advantages**. They can search large areas effectively and quickly, during the day or at night. No scent article is required. They can be assigned segments to search. If the search segment has been "aired" of previous search teams' scents, air scent dogs can still search that segment effectively. They can search areas that are more difficult for ground searchers to search. They can reduce the size of the search area by determining areas where no human scent exists.
  - **Limitations**. Skill levels vary widely. Less effective if not used immediately. Effectiveness adversely affected by the weather (high temperatures, low humidity, low wind, clear sky) and possible contamination by other humans within the dog's range of detection.
  - **Sources**. Trained volunteer units, U.S. Customs and Border Protection, law-enforcement dog units (but not "piranhas on a leash").

  Other types of dog teams that might be used in a more general search environment are Cadaver/Human Remains Detection (HRD) dogs (searching for the scent of human decomposition), Evidence dogs (searching for weapons, drugs, or explosives), Disaster dogs, Avalanche dogs, and Water-search dogs.

Horses—Posse—Mounted

These are trained searchers mounted on horses or mules. See Figure 2.5 on the next page.

- **Usage**. Can be used in any type of search.
- **Advantages**. They can travel faster than ground teams, and carry more equipment. The rider, being higher than a ground searcher, has a different perspective and an elevated view. A horse may

[8] Photo courtesy of Vi Brown, Southwest Rescue Dogs, Inc, Tucson, AZ.

Figure 2.5. Horse team

alert its rider to the presence of the lost subject. If the subject is found and needs transporting out of the field, a horse may do that more easily than ground searchers.

- **Limitations**. Require considerable logistical support (trailers, corral, food). Being higher off the ground, clues such as footprints may be missed. The horse's hooves can destroy clues, such as footprints. Less effective in areas of thick vegetation or terrain where the horse has difficulty holding its footing.
- **Sources**. Trained volunteer units, law-enforcement posses or auxiliary units.

Aircraft

Aircraft are divided into three categories, helicopters, fixed-wing, and unmanned.

- **Helicopters.** Helicopters come in many shapes and sizes, each with their own capabilities. Generally the smaller the helicopter the better it is for searching, and the larger the helicopter the better it is for transporting payloads.
  - **Usage**. Can be used in any type of search. They can be used as a search platform. They can also be used for transporting searchers/gear into the search area, or for extracting an injured subject from the search area. If used for transporting resources they might land to offload searchers, or the searchers may have to rappel out of the helicopter. See Figure 2.6 on the next page. They can be used by the command staff to overfly and evaluate the search area.
  - **Advantages**. They can search large areas quickly. Their noise can alert the lost subject that a search is in progress. Some helicopter crews can fly at night, and are particularly effective using night vision goggles, especially if the subject has been instructed to use their cell phone's LCD screen to point at the helicopter. Spotting campfires, signal fires, or any other light source with night vision goggles is very effective. Some have Direction Finding equipment on board and can be a good asset in locating ELTs[9] and PLBs[10] providing the weather is favorable. Can use the PA system to call the subject. Can be a platform for FLIR.[11] See Figure 2.7 on the next page. Can usually land near the Incident Command Post.

[9] Emergency Locator Transmitter is a transmitter installed on most aircraft that emits a signal which can be picked up by satellites or other aircraft to determine the location of a downed aircraft An ELT is activated by the impact of a crash.

[10] Personal Locator Beacon is the personal version of an ELT that is designed to be carried by a person on foot. It is manually activated.

[11] Quoting from Reference [FLIR], "*Forward looking infrared (FLIR) is an imaging technology that senses infrared radiation. Since FLIRs use detection of thermal energy to create the 'picture' assembled for the video output, they can be*

- **Limitations**. Ineffective in searching forested areas. Some do not fly at night. Weather and altitude may prevent them flying or severely limit loads. Not always available because they are in use elsewhere, or are down for maintenance, or refueling. Expensive to use. Require safety training for searchers. Usually require helispots near the Incident Command Post.
- **Sources**. U.S. Customs and Border Protection, law-enforcement, military, and EMS agencies.

Figure 2.6. Rappeling from a helicopter

Figure 2.7. FLIR image

- **Fixed-Wing Aircraft.** In searches, these are usually small, single engine aircraft.
  - **Usage**. Can be used in any type of search for searching large open areas or for locating large search subjects, such as vehicles or planes. They can also be used by the command staff to overfly and evaluate the search area.
  - **Advantages**. Can be a platform for FLIR. Can search large areas quickly. Can be used for radio communication relays.
  - **Limitations**. Ineffective in confined or wooded areas. Weather may prevent them flying. Usually cannot land near the Incident Command Post.
  - **Sources**. U.S. Customs and Border Protection, law-enforcement, Civil Air Patrol (CAP).[12]
- **Unmanned Aerial Vehicle.** An unmanned aircraft is called a UAV (Unmanned Aerial Vehicle). The UAVs used for SAR may have[13] "*a sophisticated all-weather sensor capable of providing photographic-like images through clouds, rain or fog, and in daytime or nighttime conditions; all in real-time*". See Figure 2.8 on the next page, taken from Reference [UAV2].
  - **Usage**. Can be used in any type of search.
  - **Advantages**. Can see great details from high altitudes. Can remain airborne for up to 24 hours.

used to help pilots and drivers steer their vehicles at night, and in fog, or detect warm objects against a cold background when it is completely dark (such as a cloudy, moonless night)."

[12] CAP resources are accessed through AZDEMA.

[13] Quoted from Reference [UAV1].

Figure 2.8. Unmanned aerial vehicle

- **Limitations**. Availability. Cannot land to help subject. Limited by weather and wind.
- **Sources**. Military, U.S. Customs and Border Protection.

Ground Vehicles

Vehicles come in various forms, ranging from mountain bikes and 4WDs to ATVs, snowmobiles, and snow cats. They can be used for transportation and searching. In addition to searching, they are used for containment and as magnets, using their horns and lights to attract attention.

Specialized Units

These include Divers, Climbers, Mine Rescue Units, and Cavers. Sometimes outside agencies with special skills, such as searching a landfill or a trash dump, are needed. See Figure 2.9.

Figure 2.9. Searching a trash dump

Organizing Resources on a Search

Under the Incident Command System, ICS (see Chapter 12 on page 156), there are three ways to temporarily organize resources: as single resources, as strike teams, or as task forces.[14]

- **Single Resources**. As the name implies, a single resource is an individual piece of equipment, or group of individuals, with an identified supervisor. Examples of a single resource are: a helicopter with pilot, an air scent dog with handler, a UAV with "pilot", an ATV with driver, or a hasty search team with leader.
- **Strike Teams**. A strike team consists of resources of the same kind. Examples of a strike team are: an 8-man team created from four 2-man hasty teams to search a segment, or two horses and their riders.
- **Task Forces**. A task force consists of resources of different kinds deployed under a single leader with common communications. An example of a task force is an air-scent dog and handler together with an additional person to handle communications.

Working With Other Jurisdictions

SAR Coordinators never have enough resources. This is particularly true during searches that last many days. A county starts to exhaust local resources, and so requests resources from other counties. That request is made from one county SAR Coordinator to another, who then passes it on to their resources.

Particularly important when working with other jurisdictions is the use of ICS. It ensures that common language is used. See "Common Terminology and Plain language" on page 10.

A measure of a unit's reputation in Arizona is by the quantity and quality of the resources that respond to another jurisdictions' request. Multi-jurisdictional, multi-operational period searches do not occur very often. When they do, jump at the chance.

> *Multi-jurisdictional, multi-operational period searches do not occur very often. When they do, jump at the chance.*

Section 2.4

How Do We Plan For a Search?

The question is "How do we plan for a search?" The answer is simple, "Create a preplan". But, it takes effort to write a good preplan.

> *It takes effort to write a good preplan.*

According to Tim Setnicka,[15] a "*preplan is an operational guide that, if designed and implemented correctly, will help introduce order to the chaos and furor accompanying the initial notification for help . . . The preplan is a combination of search technique, management guidelines, and policies integrated for use in resolving field SAR situations.*"

The preplan need neither be long nor complicated, but it must be realistic, down-to-earth, clear, and up-to-date. It should be written so the new kid on the block can initiate a search as effectively

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[14] More precise definitions of these items are given in Chapter 12 on page 156.

[15] See Reference [Setnicka, page 51]

as the "local expert". It should help ensure that the initial search response is swift and apt. In fact, "preplanning" is usually planning for the hasty search phase of the incident, and during that phase, plans need to be made for the next Operational Period, and so on, which is the purpose of the Incident Action Plan.

The preplan should be a group effort, involving representatives and input from all resources. It should be a checklist that is reviewed annually or even more frequently. In fact, creating a preplan is sometimes more informative than the end result.

> *The preplan should be reviewed annually or even more frequently.*

Although a preplan depends on the specific agencies and groups involved, some questions to be answered in the preplan are:

1. What is the objective/purpose of the preplan?
2. Which agency is responsible for the management of the search?
3. Who should be advised of the incident?
4. Which forms, papers, procedures, manuals, etc., should be available for reference purposes, to ensure that the initial response runs smoothly?
5. What is the environment like, including hazards, past incidents, weather, maps?
6. How is the urgency of the search determined, and what type of response is justified for that urgency?
7. Which resources are typically available, including qualifications, response times, contact information?
8. What equipment is typically available, including response times, contact information?
9. Who is responsible for the initial callout of these resources and equipment?
10. Who is in charge of investigations, completing the Lost Person Questionnaire?
11. Who is in charge of keeping track of clues?
12. What are the communication options?
13. What documents should be completed during the initial response and by whom?
14. How are the arrival, briefing, tracking, and debriefing of the search resources managed?
15. How is the care and feeding of the search resources managed?
16. How are the family, media, stake-holders, handled?
17. What are the plans if a resource is injured?
18. What are the options if the subject is found: healthy, injured, deceased?
19. What are the guidelines for suspending a search if the subject is not found?
20. What are the demobilization plans?

Section 2.5
When Do We Search?

When do we search? Day and night. However, for night searches, it is the duty of the Incident Commander to balance the search urgency against the safety of the searchers.

The tactics used for night searches may differ from day searches. For example, if the search is in unfamiliar or dangerous territory, or the weather is bad, then the emphasis at night might be on passive search tactics such as placing resources at safe locations to confine the subject, thereby restricting the size of the subsequent search area. These resources can shout the subject's name to attract their attention. They can also interview non-SAR personnel in the search area who might have valuable information about the subject.

Advantages of Night Searching

- Some resources search well at night, for example, canines, resources using night vision goggles, FLIR, and thermal-imaging devices.
- Because it is quieter at night than during the day, human voices and sounds carry farther. This increases the effectiveness of any search tactics involving sound.
- Light signals from the subject are more easily detected by searchers.
- The subject is usually immobile at night. There are two advantages to this. Subjects are more likely to hear searcher sounds, and searchers on trails can overtake them.
- Searchers have the ability to control the angle of light from flashlights to best illuminate tracks and cast shadows.

Disadvantages of Night Searching

- Even with a full moon, visibility is not as good as in daylight.
- There is an increased risk to searchers. Aside from a hazard like the terrain, deer and other prey move at night, which attracts predators such as mountain lions and bears.
- A missing person could be injured while attempting to move towards searchers.
- Clues can be missed or destroyed.

CHAPTER 3

Behind the Scenes of a Route and Location Search

Most searches are over within 24 hours, see Figure 3.1,[1] which "*includes investigation, driving time, and time after the subject is found needed for search resources to return from the field and drive home.*" The graph shows the percentage of searches ended as a function of time. So, according to this graph, 85% of these searches were over within 12 hours, and 97% within 24 hours.

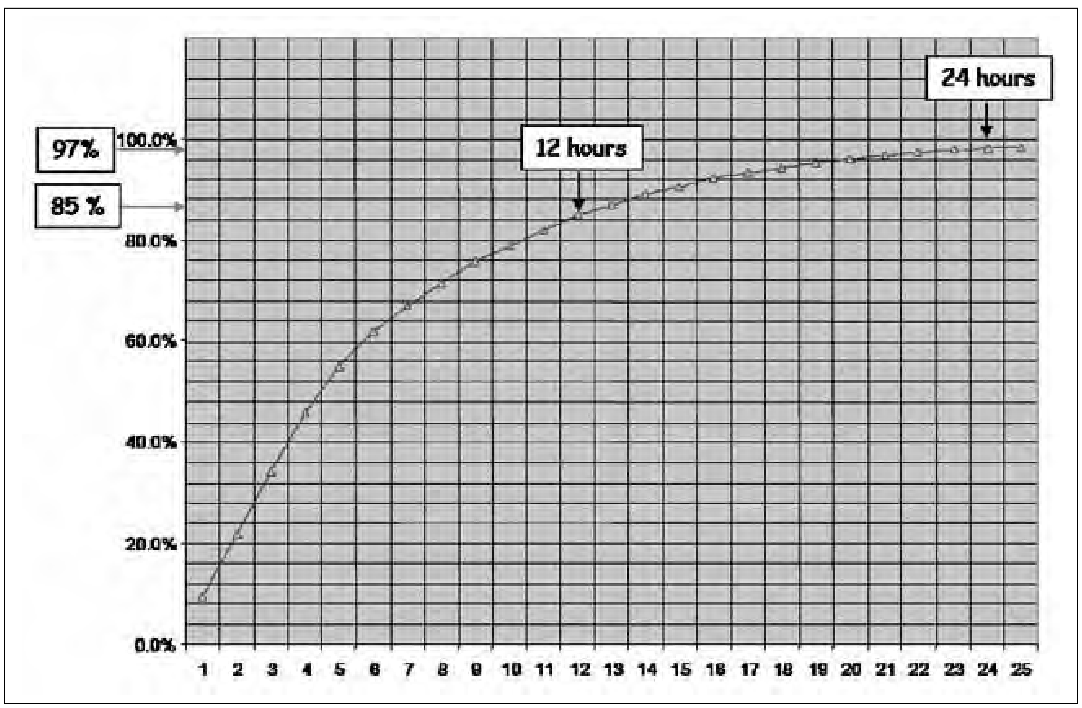

Figure 3.1. Length of search

In any search and rescue incident the initial actions set the stage for the rest of the incident. Although about 97% of all SAR incidents are resolved in the first 24 hours, good quality initial actions are extremely important to optimize the outcome. Actions taken during the first few hours often dictate the outcome of the incident. Search is an unknown emergency at an unknown location.

[1] This graph was obtained from Reference [SAR], which summarizes the results of 3000 searches in the United Kingdom, Oregon, New Mexico, Alberta, British Columbia, and North Cascades NP. Used with permission.

Actions taken during the first few hours often dictate the outcome of the incident.

Before resources are called out for the Initial Response phase of a search for a missing subject, the Incident Commander is responsible for various actions that dictate the response and tone of the search. It is important that searchers realize what is going on behind the scenes. This familiarity reduces the frustration of not being given an assignment immediately.

Some of these actions include:

1. Receiving the missing person report.
2. Starting to document everything.
3. Starting an investigation that continues until the end of the incident.
4. Interviewing the reporting party.
5. Starting a Lost Person Questionnaire (LPQ).
6. Deciding on the search urgency. This dictates whether the search is a “Go” or a “No go”.
7. If a “No go”, then continue the investigation but do not deploy other resources.
8. If a “Go”, then identify the place where the subject was last seen or known to be, the Initial Planning Point (IPP).
9. Creating and posting a Missing Person Flyer.
10. Deciding on possible scenarios that suggest what the missing subject did after leaving the IPP. This uses Lost Person Behavior data (LPB), which is historical data that shows how the subject behaved when lost, how far they were found from the IPP (as the crow flies), and so on.
11. Defining a rough search boundary.
12. Identifying containment and attractions. The purpose of Containment is to keep the lost subject within a specific area, and, if that fails, to know whether they have left the area. It assumes that the subject is Mobile. The purpose of Attraction is to catch the attention of the lost subject causing them to either respond or walk out on their own. This is done by searchers producing some form of visible or audible signal. It assumes that the subject is Responsive.
13. Using the preplan, identify the resources required initially.
14. Identifying the staging area and the requested time of arrival of the resources.
15. Creating a call-out message to request resources.
16. Calling out the resources.

After the resources are called out, the Incident Commander continues by

17. Making sure that the resources log in.
18. Briefing the resources, specifically being clue-conscious.
19. Confining the search area.
20. Initiating the Hasty Search during the Initial Response.
21. Documenting everything.
22. Tracking the resources.
23. Planning for the next Operational Period.
24. Debriefing the resources.
25. If, after 24 hours, there is no evidence that the subject is moving, consider transitioning to an Area Search.

After the subject is found and treated, or not found and the search is suspended, the Incident Commander

26. Makes sure everyone is out of the field.

27. Makes sure everyone is rested before they check out and drive home.
28. Conducts an After Action Review (AAR), which is a critique of the incident.

This process is now discussed in more detail.

Investigation and Interviewing

Once the initial report is received the investigation begins and continues until the incident is concluded. Investigation can easily be overlooked in favor of field operations, but to do so is a serious mistake.

Good investigation allows the Incident Commander to allocate field resources in the best and most efficient ways. It is critical to develop a fairly accurate picture of what is occurring or has occurred—and that is accomplished through a thorough investigation. A report of a missing or overdue person can be just that, but it could be the result of a criminal act or an intentional disappearance. The initial investigation determines whether only law enforcement resources are used or whether volunteer SAR resources are also employed. Investigation is critical to the success of a SAR operation. It must not be overlooked.

> *Investigation is critical to the success of a SAR operation. It must not be overlooked.*

Lost Person Questionnaire (LPQ)

The dispatch center is the most common source of the initial missing person report and the dispatchers generally gather basic information about the nature of the call and details of the reporting party. A SAR Coordinator or law enforcement officer should then follow up with the reporting party to complete a lost person questionnaire, LPQ.[2] The LPQ serves as a guide for collecting important search data including

- The subject's name and description.
- The subject's experience level.
- Any potential complications.
- The last known position/place last seen.
- A trip itinerary.
- Any known equipment carried.
- Other valuable information.

Search Urgency Rating Chart

As the information is gathered a Search Urgency is determined by the Incident Commander using the Search Urgency Rating Chart shown in Table B on page 176. Every incident requires an immediate response, but response does not necessarily mean deploying resources into the search area. The Search Urgency rating is used to help decide on the level of response to the incident. On the one hand it might indicate that an urgent situation exists necessitating one type of response, while on the other hand it might indicate that the situation is less urgent but requires additional investigation.

> *Every incident requires an immediate response, but response does not necessarily mean deploying resources into the search area.*

[2] There are many acronyms used in SAR. They are collected together in Appendix D on page 180.

Missing Person Flyer

The information collected on the LPQ is used to create a Missing Person Flyer, such as the ones in Figure 3.2. This flyer is distributed by the Incident Commander to the media and by the searchers to the public in order to maximize awareness of the incident. Many valuable tips are received as a result of media attention and the posting of missing person flyers.

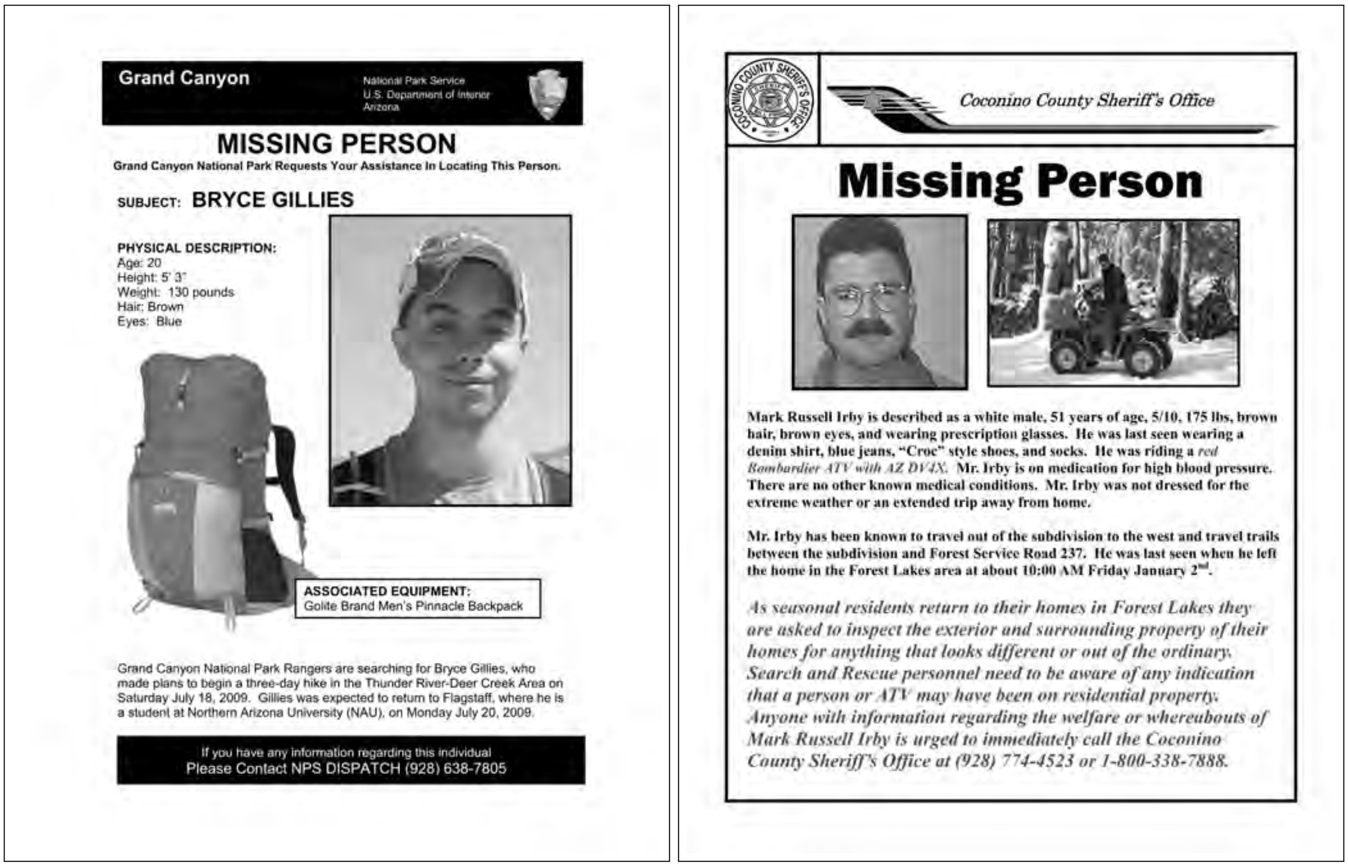

Figure 3.2. Missing person flyers

Place Last Seen, Last Known Position, Initial Planning Point

The place where the subject was last seen or known to be is either the Place Last Seen (PLS) or the Last Known Position (LKP).

The **PLS**, Place Last Seen, is the location where the missing subject was actually seen by another person. The **LKP**, Last Known Position, is the last known location of the missing subject determined by physical evidence such as a vehicle, a discarded object, or a footprint. Initially one of these is the hub of the search, and is called the **IPP**, Initial Planning Point, being the first LKP or PLS that is relevant. As the search progresses, the PLS and LKP can change, whereas the IPP does not. The IPP is important, not only because it is the hub of the search, but also because it is the point from which all statistical data is measured, such as that shown in Tables A.3 to A.4 on pages 172–173.

Many valuable clues can be discovered at LKP's and PLS's, which may be related to a criminal event. Preventing the contamination of the LKP's and PLS's is very important so that clues can be properly documented and investigated. They can be crucial to the search and to the prosecution of any crime. Many times there is foot track or scent evidence that can be used by search resources to determine a direction of travel.

Scenario Analysis

Once the investigative part of the incident is underway, the Incident Commander tries to make an educated guess as to what might have happened to the missing subject by creating different scenarios. This helps to focus on

- Where to search.
- How to search.
- What containment and attraction techniques are needed.

When creating scenarios and establishing containment, the Lost Person Behavior, LPB, category should be considered. Typically lost subjects are divided into different categories, such as

- Children (1 to 3 years)
- Children (4 to 6 years)
- Children (7 to 12 years)
- Youths (13 to 15 years)
- Climbers
- Despondents
- Elderly
- Hikers
- Hunters
- Miscellaneous
- Fishermen
- Skiers
- Walkaways

Then within each category there is data that can be very useful, such as how the subject behaved when lost, how far they were found from the IPP (as the crow flies), and so on.

There are many sources of Lost Person Behavior data, one of which is found in Table A.1 on page 165. It is important to remember that the subject of this search is not yet part of the LPB data set. This subject's behavior may deviate markedly from other members of the subject's group.

It is important to remember that the subject of this search is not yet part of the LPB data set. This subject's behavior may deviate markedly from other members of the subject's group.

The State of Arizona is developing LPB information specific to this state from the information collected on the AZDEMA SARFORCE database. It is very important to future search missions that the information collected in the field is accurate and complete so that the best Arizona LPB profiles are developed. The latest Arizona LPB distance traveled data is shown in Table A.3 on page 172. For example, this table shows the distance that 75% of lost children between 1 and 3 years old, were found from the IPP, as the crow flies—1.03 miles—an extremely useful piece of information.

A good approach to understanding what might have happened to the missing subject is to create a Scenario—a plausible story—that suggests what they did after leaving the IPP. Scenarios should

1. Fit with known facts, in particular what is contained in the LPQ and the investigative report.
2. Be a real possibility.
3. Be in general agreement with Lost Person Behavior characteristics.
4. Take into account the terrain.
5. Suggest where the missing person might have gone and how they got there.

Scenarios constitute an important part of the initial action process and need to be documented.

Containment

Once the IPP has been determined, the investigation is continuing, possible scenarios have been discussed and evaluated, then the initial search area must be confined. Containment serves to detect and limit the search subject's movements because a small geographic area is easier to search than a large one. Containment can be physical or virtual. Physical containment includes the use of

- Trail blocks.
- Road patrols.
- Track traps, etc.

Virtual containment includes

- Leaving voice mail messages, text messages, email messages, and notes on cars or residences.
- Checking with transportation companies.
- Checking with hospitals or jails, etc.

If appropriate, containment can be combined with attraction to catch the subject's attention..

Call Out

Once the incident has been reported and the initial investigation indicates the need for a SAR response, the next issues facing the Incident Commander is requesting resources for containment, attraction, and searching, and then deploying them. For most operations in Arizona this call out entails notifying local search and rescue teams, which are primarily composed of dedicated volunteers. There are a variety of call-out systems in place from the phone tree, to pagers, to cell phone based notification systems utilizing text messaging, and to email messaging. Whichever call-out system is used it must be understood by those needing to make the notification. The call-out message should include information about

- The nature of the incident.
- The staging area location.
- The preferred time of arrival.
- Any special equipment or expertise needed.
- The subject information and description, if available.

It is often sensible to have the resources arrive at staggered times to avoid chaotic congestion at check-in and the staging area, although this may be more crucial during the initial response than on a multi-operational period incident.

When resources are en route to the staging area, it is important that they can be contacted in case the incident ends before they arrive, so they can be canceled.

In some cases the travel time to an incident may be lengthy. In this case, it is prudent for the searchers to respond to the staging area and then rest before they are deployed into the field.

Prior to deploying personnel in the field from the staging area it is important to assess the personnel and their equipment to ensure that they can complete the task assigned. Deploying poorly equipped searchers can degrade the overall mission and create a safety problem.

Briefing

Briefing takes place in a relatively quiet location mostly free of distractions, out of sight and earshot of media and family.

As with any SAR operation, the hasty teams are given a quality briefing that includes maps of the area so that they maintain their situational awareness and are able to analyze terrain for searching. A discussion of the items in the Search Urgency Rating Chart[3] (age, medical condition, number of subjects, subject experience profile, weather profile, equipment profile, and terrain/hazards profile) with the hasty teams provides them with important information about the mission. A safety message, including terrain, animal hazards, and possible illegal activities in the area, is also part of the briefing.

[3] See Table B on page 176.

Briefing When Subject Has Dementia

Typically there is no need to brief resources on how to approach and converse with a lost subject who has just been found. However, if the subject suffers from dementia, then, additional briefing is required. The following suggestions were made by Teepa Snow at the 2009 Arizona SAR Conference in Heber, AZ.

1. Approach within visual range from the front, and stop 6 feet from the subject. Approaching from the back can produce anxiety.
2. Look friendly and make a "Hi!" sign with the hand.
3. Offer the hand making eye contact.
4. Approach from the front—moving slowly. Allow time for the subject to take in that someone is approaching.
5. Call the person by name and introduce self.
6. Keep shoulders and face out of their personal space.
7. Use a supportive stance—stand to the side to communicate. Standing right in front of the subject may feel confrontational.
8. Crouch down if they are seated or lying down. This helps them feel less threatened.
9. Wait for their response before continuing.
10. Make positive statements like
    - "Let's try . . . ".
    - "Do this . . . ".
    - "Could you please help me . . . ".
11. Keep your voice calm, low, and slow.
12. Keep it short and simple.
13. Give simple choices—"this or that".
14. Use objects—show them—don't just say it!
15. Break task/movement down—one step at a time.
16. Ask to 'try' or to 'help'.
17. Use empathetic statements like
    - "You look busy."
    - "It looks like you are tired."
    - "It sounds like you are upset."

    and wait for their response.

It is important that search personnel document their activities and be prepared to debrief once the assignment is complete. This can include completing an ICS 214 Activity Log (see Figure 1.4 on page 11), keeping a GPS on to develop a track log for download, or making notations and shading on the map so that accurate information about what has been searched and how well it has been searched can be verified.

Clues/Signs

Although there may be only one subject of a search, that subject is constantly generating clues. Documenting, investigating, and authenticating the clues is a critical task.

The absence of clues in the area of a search is also a clue in itself. A distinct absence of clues may indicate the need to reevaluate the initial information and the location of the search for the missing person.

The absence of clues in the area of a search is also a clue.

Searchers, especially hasty teams, should be clue aware so that important clues in the field are not overlooked. While in most cases search incidents are not related to criminal activity that does occur. The clues found during a search that are important to the search can also be evidence in a criminal investigation.

Sign is an indicator of a subject moving through an area, but is not attributable to a specific person.

Clues come in a variety of forms:

- Physical.
- Electronic.
- Witness reports.
- Investigative information.

Physical clues include known foot tracks (see Figure 3.3), a blood trail, an abandoned vehicle, a campsite, items of dropped clothing (see Figure 3.4), a candy wrapper, and a note.

Figure 3.3. A foot track located on a search for a missing 2-year-old

Figure 3.4. Clothing dropped by the subject of a search in cold weather

Electronic clues include cell phone data, email, web site visits, other computer forensic information, satellite emergency notification devices (SEND) information, other emergency beacons, and permit information.

Witness reports are also very important clues and should be evaluated by a trained interviewer.

Investigative information can also be considered clues and include use-permit information from a land management agency, financial information, criminal history, law enforcement database information, and medical history.

The briefing should include a reminder to employ **all** senses during a search: smell, sight, sound, and touch, in order to follow and/or detect the sign left by the missing person. Specific instructions should be given on how to treat clues. For example, probe found feces with a stick to get clues pertaining to the diet; check fly activity around the feces to indicate its age—a few flies may indicate it is fresh;

check the color of found urine—a dark color is a possible indication that the missing person is becoming dehydrated. Some of the factors that influence the clue-awareness of a searcher are inexperience, inattention, preconceived ideas or beliefs about the missing person, lack of sleep, fatigue, ego, fear, stress, mental and physical state, and not actively looking.

Once a clue is discovered by a searcher a decision must be made as to how to handle the clue. At a minimum the location, preferably GPS derived, should be relayed to the incident command so that it can be placed on a map. The location should also be flagged with the date, time, type of clue, and the name of the team that found it written on the flagging tape (see Figure 3.5). The team should also photograph the clue. Because of the increased popularity of cell phones with integrated cameras, it is possible for the team to photograph the clue and send that photo to the incident command. Depending on the nature of the clue the team may be asked to collect the clue and bring it in, or they may be asked to leave it in place for an investigator to examine and/or collect the clue. Some clues may have value for the collection of biological (DNA) or fingerprint evidence and so need to be handled with care to preserve that material.

Figure 3.5. Foot tracks protected at the scene of a search for a missing 2-year-old

Searchers are likely to find many clues during a search. Some of those clues can be ruled out quickly. For example, a search subject who has been missing for 12 hours may be known to drink a particular brand of soda. If a team finds a soda can of that variety, but it is sun-faded and filled with dirt, then it is unlikely that the can is related to the subject. Other clues may be fresh and not have specific identifying information. Those clues require more work to authenticate.

Some clues have specific information that allows relatively easy authentication such as a prescription bottle in the subject's name, a receipt containing credit card numbers, or a trail register signed by the subject. Some clues, such as foot tracks, quickly degrade with time and weather. Those types of clues need to be protected from further decay so that they can be processed and properly documented. If a team or individual is in doubt about a clue it should be reported so that the incident managers can make the decision.

Keep in mind that if a search clue becomes a piece of evidence in a criminal investigation then the person who found it may be called to testify in court. Good documentation of the circumstances surrounding locating the clue is essential. In the field a searcher should make notes on the ICS 214 Activity Log and that Activity Log should be turned in to the Incident Management Team for inclusion in the incident file.

> *If a search clue becomes a piece of evidence in a criminal investigation then the person who found it may be called to testify in court.*

Clues, once reported, are generally documented individually on a Clue Report form and then entered collectively on a Clue Log form by the Incident Management Team.

Try to avoid contaminating the clue location by having too many personnel look at the clue.

Hasty Search

After the IPP has been established, containment is in place, and the investigation is ongoing, the hasty search portion of a Route and Location Search is started. LPB must also be considered at this point. During the hasty search the routes and locations of high probability, arising from the most likely scenarios, are searched. These areas generally include

- Roads and trails.
- Utility corridors.
- Other travel aids.
- Areas of known hazard.
- Areas of attraction (likely spots) for the subject.
- Locations where subjects are historically found.

Ideally hasty search teams

- Consist of 2 or 3 trained search personnel.
- Have an identified team leader.
- Have a knowledge of the search area.
- Are clue-aware searchers that are capable and prepared for the assignment.
- Have maps so that they can be spatially aware of the area and can relate the location of any clues found to the type of surrounding terrain.
- Are self-sufficient for 24 hours.
- Have appropriate communications systems to receive and relay information between the team and the Incident Commander.
- Have a member with EMS training.

The appropriate tactics are selected, and the teams are briefed, based on the search information available at that time. Search tactics vary depending on the category of subject that is being sought and whether that subject is believed to be responsive, unresponsive, or evasive. An adult may react to their name being called whereas a child might be scared of strangers and so not react. Developmentally disabled and dementia patients may react in unpredictable ways to searchers so the investigator should be consulted to determine the best tactic to be used in this search.

Typically the hasty and extended search phase lasts from 12 to 24 hours, or until it is believed that the subject is no longer mobile, in which case the search transitions to an Area Search. Even after that point hasty tactics may still be employed, such as using a tracking team if a set of tracks is located during an area search.

The actions of the hasty search teams must be well documented.

During the initial response phase of a search, the Incident Commander plans for the next Operational Period. This is done carefully and thoughtfully because searches that continue beyond this phase can escalate rapidly out of control. The plan not only details the additional field resources required, but it also specifies which of the Incident Management Team positions are to be filled. The Incident Action Plan, IAP, is designed specifically for this purpose.

Debriefing

Just as important as telling the searchers what they need to do with a briefing, is knowing what they have done. The process of gleaning the information from the searchers after their assignment has been completed is called debriefing. During the debriefing process many critical items are learned such as the area covered and how well it was covered, the hazards in the area, the communications difficulties, and suggestions for future efforts in that area.

During the debriefing process many critical items are learned.

Debriefing is a task that is carried out by an experienced searcher or incident management team member, so that the critical information is collected. It takes place in a relatively quiet location mostly free of distractions, out of sight and earshot of media and family. The debriefer sits down with the team leader and discusses the assignment that was just completed. This debriefing is documented and any relevant materials collected from the team leader such as the team's map with all notations, and any ICS 214 Activity Logs. If the team was using GPS in a tracking capacity, then the track log is downloaded. If possible witnesses were interviewed during their assignment then this is reviewed. If clues were located during the search then those are discussed and if collected they are turned in during the debriefing. If relevant photographs were taken then those are also shared with the debriefer.

Incident Conclusion

At some point the incident is concluded. This may be due to

- **The subject being located**.
  Once the subject is located the work of the search and rescue team is not necessarily over.
  If the subject is found alive an evacuation plan must be formulated and executed. Ideally a rudimentary evacuation plan has been established during the initial planning process including knowing where the evacuation equipment is and which personnel are available to support the evacuation. Some subjects are able to walk out under their own power after receiving support from the SAR team. Other subjects need medical care and assistance to be removed from their situation. See Figure 3.6 on the next page.
  Unfortunately some subjects are located deceased. In this case the SAR team should protect the scene and defer to the agency with jurisdiction to determine the next course of action. Finding the subject deceased dramatically reduces the urgency of the incident, so the operation can slow down.
  The team that located the subject should report their location, an assessment of the subject's condition, and the most appropriate evacuation method. A careful examination of maps of the area should be made to determine the best evacuation route.
  Care should be taken to make a risk assessment of the evacuation plan. While the use of a helicopter may speed things up and make the work much easier, the additional risk may not be justified. Conversely, if there are relatively few personnel to do a litter-carry in rugged terrain then it may be worth the risk of using a helicopter to minimize the exposure of the rescuers and the patient to potentially dangerous situations. The coordinates of the found subject need to be documented.
- **Subject not being located**. On occasion the subject of the search is not located by the search efforts. This presents a set of difficult decisions for the Incident Commander and the Agency Administrator.[4]

[4] The Agency Administrator is the chief executive officer (or designee) of the agency or jurisdiction that has responsibility for the incident. The designee might be the person to whom the IC reports. Usually the Agency Administrator is not on scene. In Arizona, the Agency Administrator of an incident that occurs in a county is the Sheriff of that county. If the incident occurs on NPS land then the Agency Administrator is the superintendent of that park.

Figure 3.6. Subject located alive—evacuated by litter

A search cannot be continued indefinitely. At some point the following could occur.

- The conditions make searching unsafe for the SAR personnel.
- The available resources are exhausted.
- The chances of survival are significantly diminished.[5]
- Higher priority missions develop.
- Investigations indicate that the subject is not in the search area.
- The *ROW* (the probability that the subject is out of the search area, discussed on page 50) indicates that suspension is warranted.

The Incident Commander must gather the relevant data about the operation and make a recommendation to the Agency Administrator that the search be suspended. Suspension does not necessarily mean closed.

While a search is underway the conditions may deteriorate to the point that it is no longer safe to search. At that point the search may be suspended until conditions improve. While active searching may be suspended it is worth considering whether it is safe to maintain containment and attraction points in the event that the subject is mobile and trying to reach a point of safety.

Limited Continuous Mode

The concept of Limited Continuous Mode is the state of the incident where there is no active searching but if clues are discovered they are investigated and, if warranted, active searching is resumed. In Limited Continuous Mode the agency keeps the information about the case available to those working or recreating in the area.

When transitioning from active searching to Limited Continuous Mode it is important to involve the family, stake-holders, and any other pertinent external influence in the decision. If the family has been kept informed of the status of the search through regular briefings and meetings with the Incident Management Team as well as being consulted for their input into the operation, then it may be easier to obtain their concurrence that the incident should be suspended.

Political and media pressures also need to be addressed in the decision to suspend a search. Providing accurate information about the status of the search effort, the environmental conditions, and the factors that played into the decision to suspend, may alleviate some of that pressure. Briefing the family and other external influences about what happens next is important.

[5] Some survivability data can be found in Section A.3 on page 174.

After Action Review

Following every search and rescue incident an After Action Review, AAR, should be conducted. An AAR is a tool designed to evaluate an incident in order to improve performance by supporting strengths and correcting weaknesses.

On small scale incidents the AAR may be informal and conducted around the hood of a vehicle or at the Incident Command Post, see Figure 3.7, while on larger and more complex incidents a more formal setting may be appropriate a short time after the incident is concluded.

Figure 3.7. Informal AAR

The goal of each type of review is the same. Important aspects of the AAR are determining

- What worked well.
- What did not work well.
- What should be done the next time.

The AAR is not the place to point fingers or place blame, rather it should be a point of learning so that improvements can be made and successful tactics are remembered.

On a small-scale incident the content of the After Action Review may not be documented but on large or more complex incidents it should be thoroughly documented, together with sharing the lessons learned from the search with others.

The basis of search management is lessons learned from past searches. Much of the success in the profession of search and rescue comes from learning from each other. Sharing the lessons learned and the near misses helps everyone.

The basis of search management is lessons learned from past searches.

Demobilization

After a search team's assignment is completed or the incident is concluded, the searchers are eager to head home. Unfortunately it is often the trip home after a mission that results in searchers being injured or killed in traffic accidents. The Incident Management Team should formulate a demobilization plan that allows the search resources time to rest before leaving. Many volunteers are opposed to being forced to stay and rest, but the demobilization plan is designed for their safety. The demobilization plan should also contain a reminder to cancel resources en route.

Acronyms

There are many acronyms used in SAR, and they are collected together in Appendix D on page 180. The ones used most frequently during the initial response phase of a search are

- AAR—After Action Review.
- IAP—Incident Action Plan.
- ICS—Incident Command System.
- IPP—Initial Planning Point.
- LKP—Last Known Position.
- LPB—Lost Person Behavior.
- LPQ—Lost Person Questionnaire.
- PLS—Place Last Seen.

CHAPTER 4

Behind the Scenes of an Area Search

Most searches are over within 24 hours. However, if after 24 hours there is no evidence that the subject is moving, it is time to consider taking actions to transition from a Route and Location Search to an Area Search. This transition is a critical time in the search and if not handled carefully can cause the Incident Management Team to fall behind the curve in terms of good search management.

> *The transition from a Route and Location Search to an Area Search is a critical time in the search.*

The actions taken by the Incident Management Team assume that the subject is immobile and include the following, which are first summarized and then developed in depth.

1. **Establish the Search Area**. Everything outside the search area is identified as the Rest of the World (ROW). The search area is likely to be too large for a single resource to search in one operational period. The search area then needs to be divided into smaller units, called **segments**, that can be searched in one operational period (about 6 to 8 hours of active searching) by a search team.
2. **Segment the Search Area**. Segmentation can be very difficult and is truly an art. When segmenting the search area it is critical to have
   - Good map reading skills to interpret the topographic information.
   - An understanding of the vegetation in the area.
   - The ability to estimate the area of the segment.
3. **Conduct an Initial Consensus**. The purpose of the consensus is to identify the "hot" segments, and is usually done by three to five experienced SAR people. This requires that every individual involved in the process assign a probability that the subject is in each segment and in the ROW without consulting with each other. This is done after all the known information about the situation is briefed to the personnel involved in the consensus. The consensus allows the Incident Commander to calculate the high probability areas which then allows them to effectively assign resources to the segments.
4. **Assign Resources to Search Segments**. Based on the current situation assign resources to the hottest segments.
5. **Debrief Resources**. Debrief the resources to see how well their segments were searched.
6. **Update Segments**. Decide which segments are now hot, taking into account the previous item and whether any clues have surfaced. If a segment is searched without success then the chance that the subject is in that segment decreases, and the chance that the subject is in another segment, or in the ROW, increases.

7. **Reassign Resources**. Return to item 4, namely assign resources to the hottest segments. This circular process continues until either the subject is found, or the search is suspended.

These actions are now discussed in more detail.

Section 4.1
Establishing the Search Area

One of the first actions in the transition to an Area Search is establishing the search area. This is a critical action and, like other components of search planning, should not be done alone. The establishment of the search area sets the stage for the rest of the transition actions.

If a suitable Incident Command Post for an extended operation has not yet been selected it must be done at this point because much map and paper work needs to be completed during the transition. It is more comfortable and efficient to have a suitable space for this than it is to continue working off the hood of a truck, as suggested by Figure 4.1.

Figure 4.1. Establishing the Search Area

At this stage it is assumed that during the Route and Location Search a PLS or LKP was determined and identified as the IPP.

When establishing the search area it is critical that quality maps of the region are available. Generally 1:24,000 scale topographic maps are used for this process, which are either in paper format or on a computer mapping or GIS program. Other specialty maps may also be helpful in interpreting the area especially if those maps have been in the possession of the search subject. Increasingly aerial photographs and internet based programs, such as GOOGLE Earth™ and Microsoft® Bing, are used to supplement topographic maps during this process. If paper maps are being used it is also helpful to have clear mylar or acetate for overlays and a variety of permanent and dry-erase markers available. The map that is selected for use in defining the search area will need to be reproduced for the IAP that will be distributed to search resources once the search area has been identified and segmented. Key locations should be marked on the map such as the IPP, Incident Command Post, together with other incident facilities and important reference points.

There are four common methods of establishing the search area,[1] assuming the location of the IPP is known.

1. **Theoretical**. Based on the time elapsed, how far could the subject have traveled?
2. **Statistical**. What have others in the missing subject's category done?
3. **Subjective**. What are the natural or manmade features that could limit the movement of the subject?
4. **Deductive Reasoning**. What does the Incident Management Team believe happened?

Each of these methods determines a region that is plotted on the map. The area common to all four regions determines the boundary of the search area.

Once the four methods for establishing the search area have been employed the initial search area must be drawn on the map. The area outside of the search area is known as the Rest of the World (ROW). With the search area determined the incident management team can move ahead with segmenting the area into searchable units that are suitable for SAR resources to search during an operational period, and then conducting the Consensus to develop the initial hot segments.

Section 4.2
Segmentation

Segmentation is the process of slicing the search area into manageable regions called Segments. Segmentation is performed for various reasons.

- To ensure that no part of the search area is ignored.
- To effectively manage the deployment of resources.
- To help set tactics that can be accomplished during an operational period.
- To track resources' tasks for the duration of the search.
- To have a means of quantifying the search effort in an understandable way (using POD and $CPOD$ discussed later in this chapter).

Segmentation looks easy, but it is not. It takes practice, patience, and thought.

Segmentation looks easy, but it is not.

Segmentation is a two-step process.

1. First, identify all regions that are not to be searched, that is, the ROW. Start with the area whose outer boundaries have just been established. Within that area exclude regions such as places where the subject could not have reached (because they are out of range, because the subject could not get there due to the terrain or vegetation, etc.) and those regions that are not searchable by live subjects (such us under the surface of a lake), unless those regions are specifically identified as being of interest. The region that remains is the Search Area—it often looks like Swiss cheese, with holes in it.
2. Second, divide this remaining region, the search area, into clearly-identified, non-overlapping, segments that cover the entire search area, using the principles discussed later in this chapter. Whereas establishing the search area is based on factors that affect the subject, segmenting the search area is based on factors that affect the searchers.

[1] See Reference [Setnicka, page 85].

In relatively flat, sparsely-vegetated terrain, it is common for the final search area to look like a distorted checker board, with no gaps in it, which is how most people imagine a segmented search area. In mountainous terrain, some segments might look like pieces of ribbon, being trails with strips of land on either side bordered by the ROW, leaving the search area pocked with disconnected regions that are in the ROW. So typically, a search area does not look like a distorted checker board—it has gaps in it.

A typical search area does not look like a distorted checker board—it has gaps in it.

The Incident Commander should be prepared to answer questions from the family and stake-holders concerning the fact that there are gaps in the search area.

Ideally segmentation should be performed by a segmentation team rather than an individual, preferably the same team that performs the consensus. Some members of the segmentation team must have a very good understanding of map reading in order to know which features make good segment boundaries and which features do not.[2] Members with a personal knowledge of the area are invaluable.

When identifying segments, the segmentation team must consider the following points.

- **The Size of the Segment.** This is important because the size of the segment must be searchable by a typical resource in one Operational Period. This includes being briefed, transported to the segment, finishing their assignment, transported from the segment, and being debriefed. See Figure 4.2.

Figure 4.2. It takes time to get resources into the field

The size of the segment is dictated by the resource being used, the terrain, and the vegetation. A rule of thumb is to make the size searchable by a typical search team in about 6 hours. If the segment is to be searched by ground resources (air scent dogs, grid searchers, etc.) then a segment size of about 0.25 square miles is often quoted as being an appropriate size. The dimensions of various rectangles with area 0.25 square miles are shown in Table 4.1.

Table 4.1. Dimensions of Rectangles with Area 0.25 square miles

Length (miles)	0.5	1	2	3	4	5
Width (yards)	880	440	220	147	110	88

[2] An introduction to map reading can be found in Chapter 9 on page 104.

On a 1:24,000 topo map, a little more than 1.25 inches represents 0.5 miles while the width of a dollar bill represents about 1 mile. However, the area estimated on a map is almost always smaller than the area on the ground, unless the terrain is flat and horizontal.[3]

Making search segments too large is a common mistake.

- Doing so causes searchers to rush to complete their assignments resulting in poor coverage and missed clues.
- Searchers who do not rush, search only part of their segment, resulting in the segment having to be split, and the un-searched segment re-searched during a later Operational Period.
- Not completing their assignments because the segment is too large causes poor morale.

> *Making search segments too large is a common mistake.*

- **Uniform Terrain and Vegetation.** The terrain and vegetation within the search segment should be relatively uniform. A resource cannot use consistent tactics, nor estimate a single *POD* (a measure of the efficiency of the resource, discussed later in this chapter) for a segment, if the terrain or vegetation vary considerably.
- **Segment Boundaries.**
  - Segment boundaries have to be identifiable by resources in the field. Ridge lines, rivers, cliffs, canyon bottoms, fences, power lines, railroad tracks, roads, dry washes, etc., make good boundaries because they are easily identifiable in the field. Good boundaries are essential to ensure that search teams assigned to different segments neither leave gaps nor overlap in their coverage.
  - Flagging may be used for segmenting long washes or canyons where the sides of the segment are clearly defined by the terrain but the bottom needs to be broken into shorter lengths. Once flagging is in place, it should remain there for the remainder of the search. Ribbon-like segments that follow very long trails could be segmented in this way.
  - Using GPS or UTM grid lines is strongly discouraged, but if they are used it must be with extreme caution to avoid gaps in coverage and overlaps with adjacent segments. Sometimes there is no choice but to use grid lines as segment boundaries by flagging them. For example, flat featureless terrains need to be flagged so that teams can identify their segments. See Figure 4.3 on the next page.
  - If the subject's dwelling is to be searched, then it would be natural to include this as its own segment.
  - When drawing boundaries, it is not good practice to have resources crossing streams, highways, chasms, and other natural barriers. This endangers the resources and distracts them from their assignments.
- **Individual Segments.** Regions such as trails, lakes, rivers, dry washes, should be treated as individual segments. This helps to ensure complete coverage for the whole trail within the search area or complete coverage for the lake, not just the shoreline. However, many trails may have been searched during the hasty search phase, or may be used as transportation corridors, so treating them as a separate segment may be unnecessary. They are automatically searched.
- **2-Dimensional Map.** The map that is being used to segment is 2-dimensional, whereas the search area is 3-dimensional. This means that segments drawn on maps represent the surface of the search area, not underneath the surface. For example, a lake or a snowfield may be a segment, but, unless specifically stated otherwise, the segment is the surface of the lake or snowfield, and includes nothing below the surface.
- **Shape.** A uniformly-shaped segment is desirable, but not always possible.

[3] An overlay tool that helps estimate areas can be downloaded from `http://maptools.com/pdf/AreaEsts/BigArea.pdf`. When printing this file, ensure that the printer does not resize the image.

Figure 4.3. Segment boundary flagged

- **ROW.** Fast flowing rivers are always in the ROW, because the subject, if in it, would be mobile.
- **Rethink.** If a segment cannot be searched by "boots on the ground" then it is unlikely that the subject is there, and so thought should be given to moving this segment to the ROW.
- **Identify Segments.** All segments must be identified with a unique number, and the ROW must be clearly marked.

Section 4.3
Consensus

After the search area has been identified and segmented, the third and final step before embarking on an Area Search, is to decide which segments are "hottest", that is, have the highest priority.

Ideally this is done by a small team of three to five experts with local knowledge and expertise. Before making any decisions, the consensus team is appraised of all the facts in an extensive briefing where different possible scenarios are thoroughly discussed.

Then, each expert independently and subjectively estimates the probability that the subject is in each of the segments and the probability that the subject is outside the search area, that is, in the ROW, Rest of the World.

For example, if there are only two segments and three experts in the consensus team,[4] then Jesse, Aaron, and David, might make the subjective estimates shown in Table 4.2.[5]

Table 4.2. Jesse, Aaron, and David's Estimates

Segment	Jesse	Aaron	David
ROW	10%	10%	10%
1	55%	45%	50%
2	35%	45%	40%
Total	100%	100%	100%

[4] Having only two segments in the search area is unrealistic, but it is used here to fix ideas and to make the arithmetic transparent.

[5] Probabilities are decimal numbers between 0 and 1, but they are frequently converted to percentages in every-day life. For example, 0.5 = 50% and 0.01 = 1%. To convert a number from decimal to percentage, multiply the number by 100. To convert from percentage to decimal, divide the number by 100.

According to this table, Jesse thinks there is a 10% chance the subject is out of the search area, a 55% chance the subject is in Segment 1, and a 35% chance in Segment 2. If someone says that Aaron thinks that there is an equal chance of the subject being in Segments 1 and 2, are they correct?[6]

Notice that all three columns total 100%, which is essential because the subject is either in or out of the search area.

The Initial Consensus is obtained by averaging each of Jesse, Aaron, and David's estimates, as shown in Table 4.3.

Table 4.3. Calculate Initial Consensus

Segment	Jesse	Aaron	David	Consensus
ROW	10%	10%	10%	$(10\% + 10\% + 10\%)/3 = 10\%$
1	55%	45%	50%	$(55\% + 45\% + 50\%)/3 = 50\%$
2	35%	45%	40%	$(35\% + 45\% + 40\%)/3 = 40\%$
Total	100%	100%	100%	100%

The Initial Consensus is shown in Table 4.4.

Table 4.4. Initial Consensus

Segment	Consensus
ROW	10%
1	50%
2	40%
Total	100%

This shows that the consensus team believes that there is a 10% chance the subject is out of the search area, a 50% chance the subject is in Segment 1, and a 40% chance in Segment 2. Which is the "hottest" segment?[7]

This represents the best guess about where the subject might be found, based on the experience and subjective "hunches" of the consensus team.

These numbers represent the probability of the subject being out of the search, and the probability of the subject being in a particular segment. They are called **Probability of Areas** and are denoted by POA. Thus, the initial POA's are $POA(1) = 50\%$, $POA(2) = 40\%$, and $POA(ROW) = 10\%$. We usually abbreviate $POA(ROW)$ by ROW, so $ROW = 10\%$.

Although this process seems straight-forward, a number of hidden assumptions are being made.

Assumptions

Before taking a consensus the experts must realize that this process involves the following five assumptions.

1. The search area is well defined and segmented into reasonably-sized segments.
2. There is a positive probability that the subject is in any one of the segments.
3. There is a positive probability that the subject is not in the search area.
4. All search segments are very familiar to the consensus team members and contain **no unknown features**.
5. If the subject is in the search area, then **the subject is immobile**.

There are a number of consequences of these assumptions.

- Experts must not assign a POA of 0% or 100% to any of the segments or to the ROW.

[6] Yes, because Aaron has assigned the same probability of 45% to both Segments 1 and 2.
[7] Segment 1, because $50\% > 40\% > 10\%$.

- Unless specifically included in the original search area when the consensus is taken, regions such as beneath soil, beneath snow, or beneath water, are not in the search area, but are in the ROW. Thus, the search area is more 2-dimensional than 3-dimensional.
- If an item, such as a cave, mine-shaft, or dwelling, is discovered in a search segment that was unknown to the consensus team members at the time of the initial consensus, then that item is in the ROW. Had the experts known of this item at that time, then that item would have been given its own segment and its own initial probability. To include this item in the search area at this stage, the search area must be expanded.[8]
- Any regions searched that were initially in the ROW, must be included by expanding the search area. For example, an investigator searches the subject's home, which was not included in the initial search area, without finding the subject. The search area must be expanded to include the home.
- The assumption that "If the subject is in the search area, then the subject is not moving" carries with it an important corollary, namely, "If the subject is moving then the subject is not in the search area, but in the ROW". Thus, rivers that flow fast enough to transport the subject are not in the search area but in the ROW. A similar comment applies to the abduction of a child being transported in a vehicle.
- The assumption that "If the subject is in the search area, then the subject is not moving" carries with it another important consequence, namely, **if it is believed that the subject is moving in the search area, then the experts should not be doing a consensus.**

If it is believed that the subject is moving in the search area, then the experts should not be doing a consensus.

Comments

1. All consensus team members should submit their estimates in writing.
2. Software has been specifically designed to calculate the initial POA's from the consensus members' estimates.
3. A consensus is performed only once per incident.

A consensus is performed only once per incident.

Section 4.4

Assign Resources to Search Segments

In contrast to the Hasty Search where Routes and Locations are searched, the Area Search focuses on searching segments. Segments are distinct pieces of the search area that have defined boundaries and should have been crafted so that they can be searched by a team in one operational period (about 6 hours of active searching). The purpose of developing segments in the search area is to achieve accountability and to quantify the amount of search effort expended.

Resources identified to search a particular segment are selected by the terrain type or other conditions present in the segment. For example, relatively flat or rolling terrain may be suitable for mounted SAR teams to search while rugged canyon country may require mountain rescue type teams. It is important to match the terrain and conditions in the segment with the appropriate resource so that the search objectives are met.

[8] Expanding the search area is discussed later in this chapter.

Search teams that are assigned to search a segment should have a designated team leader who receives a briefing from the Incident Management Team about the assignment. The leader should then brief the rest of the team and assign any subordinate tasks such as communication and primary navigation. The leader is charged with the overall responsibility for the team including making sure that the team conducts the segment search in the way requested by the Incident Management Team and ensuring that the region searched is documented on the map or GPS and reporting any clues found to the Incident Command Post. If the search of the segment is not completed it is imperative that the team leader be able to show what was searched and identify the reasons that the entire segment could not be searched during the operational period. Following the completion of the assignment the team leader must report to the Plans Section so that a debriefing can be conducted. It is helpful if the team leader completes an ICS 214 Unit Log documenting important occurrences during the assignment.

One of the important pieces of information coming out of the debriefing is how well the segment has been searched, in other words, if the subject is in the segment the resource was assigned to search, what was the probability of finding the subject. This probability is called the **Probability of Detection** and is denoted by POD. The higher the POD the better the segment has been searched. POD is discussed in more detail later in this chapter, but a POD greater than 60% is unlikely.

Once an Area Search is undertaken it is assumed that the subject of the search is no longer mobile. The subject may be responsive or unresponsive. As a result the search of a segment is more systematic. Resources use Area Search tactics rather than Hasty tactics to conduct the systematic search. Examples of Area Search tactics include

- Ground Sweep Search—Critical Spacing is employed.
  - Visual Sweep or Sound Sweep may be employed.
- Aerial Sweep Search.
- Hyperspectral Camera Analysis.
- High Resolution Camera Analysis.

Ground Sweep Search

The Ground Sweep Search is a line search where searchers on a team are spaced an equal distance apart along a line according to a Critical Separation determination (described on page 55) and the team makes parallel sweeps through a segment to cover the entire segment. This type of search is also called a Grid Search. See Figures 4.4 to 4.5 on the next page. A typical grid search team should consist of a team leader and no more than seven team members. On occasion, several grid search teams may be assigned to work together to search a segment. In that situation the team leaders should coordinate their actions to complete the assignment. The closer together the searchers are spaced the higher the theoretical POD. However, tight spacing of the searchers may not be the most efficient use of the SAR resources available.

> *A typical grid search team should consist of a team leader and no more than seven team members.*

While conducting the sweep the team may employ only a visual sweep or a sound sweep. The Visual Sweep involves searching the segment while relying primarily on visual observation of the segment. This technique is used if the subject is immobile and unresponsive. The Sound Sweep technique involves searching the segment using both audio and visual observations. One method for conducting a Sound Sweep search is to have the team searching the segment stop every couple of minutes to yell or blow whistles simultaneously and then **wait** from 30 seconds up to a minute listening for a response.[9] If no

[9] Be aware that not everyone's hearing is perfect.

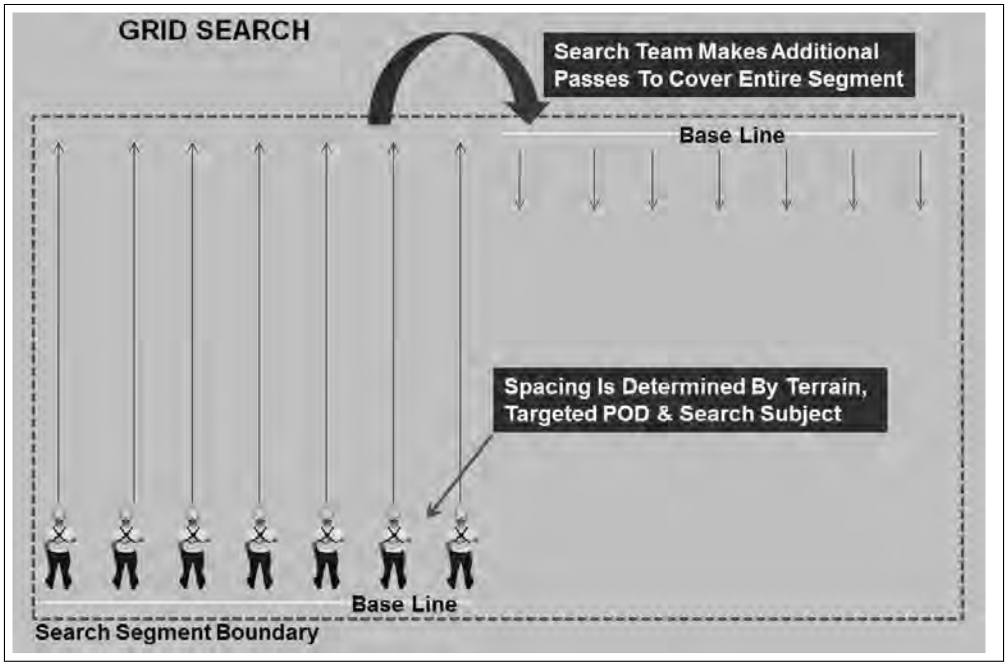

Figure 4.4. Grid Search—In Theory

Figure 4.5. Grid Search—In Practice

response is heard the team continues to move through the segment. This technique is effective if the subject of the search is responsive. The search team should be constantly looking for clues, including audio-, visual-, and scent-related, during the sweep. If a clue is located the entire team should stop while the clue is investigated, documented, and reported to the Incident Command Post. Once the disposition of the clue is determined the team then continues the sweep. A team may make several sweeps to cover the search segment entirely.

The goal of a Ground Sweep Search is to achieve the highest *POD* possible given the conditions. The goal is not to cover the segment as fast as possible.

The Ground Sweep Search is best conducted by experienced and trained SAR personnel. However, if non-trained SAR personnel such as other law enforcement or military personnel are available and properly equipped then they can be given some basic training on the technique and then used in a Ground Sweep Search under the supervision of a SAR team leader.

It is helpful if the personnel on the ends of the Ground Sweep Team flag their path as they make sweeps so that the team can remain oriented when they make another sweep. A GPS is also helpful if the track log is turned on so that the personnel on the ends can ensure that the team is making a subsequent sweep immediately adjacent to the completed sweep.

Critical Separation

One of the important questions that arises during a Segment Search is how far apart to space the searchers. There are different ways to determine the spacing but Critical Separation is the most practical method for use during search operations so it is the only one that is discussed here.

The Critical Separation (CS) method was developed by Dave Perkins and Pete Roberts, see Reference [Perkins 1]. This is a relatively fast way to determine searcher spacing that generates a *POD* of about 50%, and should be conducted in a representative piece of terrain that is similar in topography and vegetation to the segment to be searched.

To determine the spacing an object similar to the object being searched for is placed on the ground in the representative piece of terrain and the members of the search team move away from the object in different directions keeping it just barely in sight. The distance from the object to each searcher is then measured and all the distances are averaged. This average distance represents 0.5 CS since the searcher would be scanning an area equal to the distance to the object both to the left and right of the searcher. One CS is equivalent to twice the distance from the searcher to the object.[10]

> *One CS is equivalent to twice the distance from the searcher to the object.*

Searchers assigned to a segment space themselves at 1 CS apart and then make sweeps through the segment attempting to keep the original spacing. To boost the chances of finding the search subject Perkins and Roberts introduced the idea of Purposeful Wandering to the Ground Sweep Search that uses Critical Separation. Purposeful Wandering allows the searchers on a segment search that are spaced according to Critical Spacing to deviate from their straight line track to look at objects that attract their attention or may conceal the subject such as bushes, rocks, and trees, **before returning to the place where they left their centerline**. In general the Critical Separation should be maintained as the sweep progresses through the segment.

Often when a Segment Search is conducted searcher spacing of 1 CS is requested but other distances are possible.

Aerial Sweep Search

Aircraft may be used to conduct segment searches in addition to or in lieu of ground searchers. The tactics used by air resources are different for a segment search as compared to a Hasty Search. The aircraft conducts a systematic pattern of passes over the search segment in order to search the complete segment. It is important that the aircraft crew members be able to determine the segment boundaries. Aerial Sweep Searches are most successful in locating responsive subjects that are able to signal the aircraft in some fashion.

High Resolution Camera Analysis

There has been some success in flying over a search segment and photographing it with high resolution cameras. Once on the ground the photos are studied and may be examined by reversing the image (making it appear as a negative) to look for anomalies or objects that stand out. If an object of interest is identified a resource is sent to the area to investigate the object.

[10] The distance from the searcher to the object is called Critical Spacing.

Searching Segments Conclusion

Segments may be searched several times by the same or different resources to increase the $CPOD$. If possible, avoid searching a segment multiple times using the same team because they may subconsciously feel that they had searched it adequately before and then have a reduced effectiveness based on those feelings. If the same team is used to search a segment that they have previously searched it may be helpful to have the team approach the segment from a different angle and to reinforce with them that they did a good job searching the first time but the segment is still a high probability area that needs to be searched again. Searching a segment more than once is not necessarily a commentary about the inadequacy of the previous search effort.

Section 4.5

Debrief Resources

Debriefing SAR resources following an Area Search assignment is a critical step in good search management. Time and thought went into developing the Area Search assignment so evaluating the results of that assignment must be a priority for the Incident Management Team. There can be a tendency for teams to want to leave the incident after their task is complete but the assignment is not finished until the debrief is conducted.

> *The assignment is not finished until the debrief is conducted.*

Probability of Detection—POD

As pointed out earlier, the POD is the probability of a resource detecting the subject in a segment, assuming the subject is in that segment. It is a measure of the efficiency of the resource searching the segment. Thus, $POD(1) = 60\%$ means that the resource had a 60% probability of finding the subject, if the subject is in Segment 1. It also means that there is a $100\% - 60\% = 40\%$ probability of the resource not finding the subject, if the subject is in Segment 1.

When a resource finishes its assignment—and assuming the subject has not been found—part of the debriefing process is to estimate a POD for the segment searched. The POD should be reported for the object of the search, whether it be a person, an evidence search, or a clandestine grave. Even though clues are important, they are usually not the object of the search, so reporting a POD for a clue, when searching for a subject, is irrelevant.

> *The POD should be reported for the object of the search. Reporting a POD for a clue, when searching for a subject, is irrelevant.*

In addition, the reported POD must be for the segment as it was at the time of the consensus. For example, if there was no snow on the ground at the time of the consensus, but by the time a team searches that segment a foot of snow has fallen, then the team must estimate a POD for the original segment, that is, for one foot below the current surface of the segment.

> *The POD must be for the segment as it was at the time of the consensus.*

The *POD* is affected by many different factors, including

- The terrain in the segment. The *POD* for a flat segment is likely to be higher than for an uneven, crevice-pocked, or hilly segment.
- The weather. The *POD* during good weather conditions is likely to be higher than during poor weather conditions.
- The vegetation. The *POD* for sparse vegetation is likely to be higher than for dense vegetation. The vegetation in the same segment can differ enormously depending on the season. See Figure 4.6 on the next page,[11] which shows the same view taken in fall, winter, spring, and summer (clockwise).
- The detectability of the subject. Large subjects dressed in bright colors are more likely to be detected than small subjects in colors that blend in with the background, such as camouflage.[12]
- The lighting conditions. Sometimes bright, sunny conditions are a disadvantage, because the subject may be in the shadows and difficult to detect, compared to a cloudy day when there are no shadows. See Figure 4.7 and Figure 4.8 on the next page.
- The capability of the resource. Experienced, fresh resources are likely to be more efficient than inexperienced, tired resources.
- The segment/team size. A small team in a large segment is likely to be less efficient than a large team in a small segment.

While there are general guidelines for estimating *POD*'s, there is no one formula that can be used. However, it is always best to err on the side of caution by using lower *POD* estimates rather than higher ones. Over-estimating *POD*'s means that the *ROW* grows artificially, contributing to the search being suspended prematurely.

Over-estimating POD's means that the ROW grows artificially, contributing to the search being suspended prematurely.

Debriefing Resources

The team should be allowed to rest between the completion of their field assignment and the debrief if they want one. They may need to get refreshments before the interview is conducted. Often only the team leader is interviewed. The debriefer should collect any maps with notations on them, the team's ICS 214 Unit Log, and if the team was using a GPS or multiple GPS's in tracking mode the track logs should be downloaded to confirm the area searched.

It is important to determine whether or not the entire assigned segment was searched. If the segment was not completed a *POD* provided by the team is only valid for the region actually searched and not the entire segment.

All data collected during the debriefing is used by the Incident Management Team to develop future search assignments. Both the debriefer and the team leader need to realize the importance of the debriefing process and take it seriously.

Debriefing Resources Checklist

1. Who was involved in the debriefing?
2. What was their assignment?
3. What time did they begin?

[11] Photos courtesy of Rick Toman.

[12] There is evidence that color-blind individuals have an advantage over those with normal color vision when detecting subjects dressed in camouflage. See Reference [Morgan].

Figure 4.6. Vegetation change with season—same view taken in fall, winter, spring, and summer (clockwise)

4. What did they accomplish?
5. Was the assignment/segment completed?

Figure 4.7. Cloudy Day—Where is the subject?

Figure 4.8. Sunny Day—Where is the subject?

6. What is the Probability of Detection for the resource on the assignment?
7. What time did they finish?
8. Any difficulties or areas they could not search adequately?
9. Any clues found?
   a) Where?
   b) What?
   c) What did they do?
   d) Where is it now?
10. Any hazards observed in the area.
11. Any communications problems.
12. Comments. For example, what would the team suggest for future actions in the segment.

Section 4.6

Update Segments

If a segment is searched without success then the chance that the subject is in that segment decreases, and the chance that the subject is in another segment, or in the ROW, increases. In other words, if Segment 1 is searched without success then $POA(1)$ decreases, and all the other POA's increase, including the ROW. How much they change depends on the efficiency of the resource searching Segment 1, that is, on $POD(1)$.

To demonstrate this, the Initial Consensus shown in Table 4.4 on page 51 is repeated in Table 4.5.

Table 4.5. Initial POA's

Event	$POA(1)$	$POA(2)$	ROW	Total
Initial Consensus	50%	40%	10%	100%

If Segment 1 is unsuccessfully searched with a POD of 60%, then the updated POA's are shown in Table 4.6.[13]

Table 4.6. Updated POA's After One Search

Event	$POA(1)$	$POA(2)$	ROW	Total
Initial Consensus	50.00%	40.00%	10.00%	100.00%
Searched Segment 1 ($POD = 60\%$)	28.57%	57.14%	14.29%	100.00%

Notice that, in agreement with intuition, $POA(1)$ has dropped from 50.00% to 28.57%, $POA(2)$ has risen from 40.00% to 57.14%, while ROW has increased from 10.00% to 14.29%.

If Segment 2 is searched with $POD(2) = 30\%$ during the same Operational Period as Segment 1, then Table 4.7, shows the current state of the search, where Segment 2 is the hottest segment, with a POA of 48.28%.

Table 4.7. Updated POA's After Two Searches

Event	$POA(1)$	$POA(2)$	ROW	Total
Initial Consensus	50.00%	40.00%	10.00%	100.00%
Searched Segment 1 ($POD = 60\%$)	28.57%	57.14%	14.29%	100.00%
Searched Segment 2 ($POD = 30\%$)	34.48%	48.28%	17.24%	100.00%

Imagine the search continues into a second Operational Period, when Segment 2 is searched by a resource with POD of 60%, $POD(2) = 60\%$, and Segment 1 is searched by a resource with POD of

[13] Doing these calculations by hand is a slow, tedious, and error-prone process. Using software designed specifically for this is strongly advised.

40%, $POD(1) = 40\%$. If both searches end unsuccessfully, then Table 4.8 shows the current state of the search.

Table 4.8. Updated *POA*'s After Two OP's

Event	$POA(1)$	$POA(2)$	ROW	Total	OP
Initial Consensus	50.00%	40.00%	10.00%	100.00%	
Searched Segment 1 ($POD = 60\%$)	28.57%	57.14%	14.29%	100.00%	1
Searched Segment 2 ($POD = 30\%$)	34.48%	48.28%	17.24%	100.00%	1
Searched Segment 2 ($POD = 60\%$)	48.54%	27.18%	24.27%	100.00%	2
Searched Segment 1 ($POD = 40\%$)	36.14%	33.73%	30.12%	100.00%	2

Notice that each time a segment is searched without success, the *ROW* increases, as it always must, because it is not searched.

At this stage in the search, Segment 1 has been searched by two resources, one with a 60% *POD*, and the other with a 40% POD. Knowing how well Segment 1 has been searched after successive unsuccessful searches is valuable information. This number is called the **Cumulative Probability of Detection**, denoted by *CPOD*.

Unfortunately it is incorrect to just add the *POD*'s and assert that Segment 1 has been searched with a *CPOD* of $60\% + 40\% = 100\%$. This would mean that there is no chance that the resources missed the subject. The correct answer is 76%. In the same way, the *CPOD* of Segment 2 is not $60\% + 30\% = 90\%$, but is 72%.

So, after two Operational Periods, the status of the search is shown in Table 4.9.

Table 4.9. Search Status After Two OP's

Segment	Current POA	$CPOD$
ROW	30.12%	0%
1	36.14%	76%
2	33.73%	72%

ROW—Rest of the World

As pointed out earlier, the *ROW* is the probability that the subject is out of the search area taking into account all searches that have taken place within the search area.[14] The concept of *ROW*, introduced by John Bownds of the University of Arizona in the 1970s, is very important to SAR incidents because it can be used as a barometer of the search in two different ways.

1. If the *ROW* exceeds 50% there is more chance that the subject is out of the search area than in. It may be time to expand the search area.
2. When the *ROW* gets very high, it may be time to expand the search area or to suspend the search.

[14] This means that the probability of the subject being inside the search area at this stage is $100 - ROW\%$.

CHAPTER 5

Safety and Hazards

What is Safety? Safety is preventing mishaps and unintentional injuries. Safety is a state of mind. Do not trust to luck. Most mishaps and injuries are caused by factors that can be controlled. Search team members should not pretend they are immune. They are inviting trouble if they think "It can't happen to me". Searchers should expect the unexpected. The more mishaps that can be foreseen, the easier it is to guard against them. Do not gamble with anyone's safety. Use common sense. It is up to the searcher to take control of the risks.

The role of SAR personnel is often misunderstood. The highest priority of SAR personnel is not the health and well-being of the subject. The highest priority is the health and well-being of self, then the team, and finally the subject. When these priorities are scrambled, the possibility of a rescuer becoming a victim increases, turning an asset into a liability. If a searcher becomes injured, then it takes time and vital resources away from the original objective of the incident.

> *The highest priority is the health and well-being of self, then the team, and finally the subject.*

The number one responsibility of a SAR team member is to be adequately prepared. This requires both physical and mental conditioning, together with carrying the proper equipment and knowing how and when to use it. The more prepared the SAR team member, the more use they are to the Incident Commander, their team members, and the subject.

Before any search or training SAR team members must make an honest assessment of themselves. Are they physically and mentally up to the task assigned to them? Do they have the proper equipment to perform the task required safely, effectively, and efficiently? If they are not prepared for the task they must let the incident staff or their team leader know so that the problem can be addressed and they can be assigned to a task they are more suited for.

Section 5.1
Personal Hazards

Human Error

Human performance in critical situations involves effective decision making and completing error-free tasks. During SAR operations, emotions can run high and adrenalin flow can create an environment ripe for human error. Human error is repeatedly cited in accidents and incidents across a wide variety of disciplines.

Gordon Dupont, a Canadian aviation accident investigator, has complied the "Dirty Dozen of Human Errors" based upon his experiences.[1] These factors can set anyone up to make an error no matter what the task or occupation.

1. **Lack Of Communication**—A failure to exchange information.
2. **Complacency**—Loss of awareness and the development of overconfidence.
3. **Lack Of Knowledge**—Lack of experience or training in the task.
4. **Distraction**—Anything that takes your mind off the job.
5. **Lack Of Teamwork**—Without teamwork, we are only a group of individuals involved in a similar task.
6. **Fatigue**—Considered to be the number one contributor to human error.
7. **Lack Of Resources**—Insufficient or not fully operational equipment and manpower to safely perform a task.
8. **Pressure**—External as well as self imposed psychological pressure.
9. **Lack Of Assertiveness**—Failing to speak up when things do not seem right.
10. **Stress**—Overwhelmed by stress leads to human error.
11. **Lack Of Awareness**—A lack of alertness and vigilance in observing. Failing to ask the "what if?" question.
12. **Norms**—The "normal" accepted way things actually are done in an organization, regardless of whether their practices are valid and safe.

These common errors are points that should be reviewed during an operational briefing.

Fatigue

Combating fatigue during a SAR incident requires vigilance. Incident Management Team members must make an effort to monitor and manage personnel fatigue. Personnel who are fatigued are prone to making poor decisions.

Factors increasing fatigue[2]

- Sleep loss (7–8 hours of sleep is optimal).
- Disrupted sleep from alcohol, medications, caffeine.
- Disruption of circadian rhythm—working between 10 p.m. and 6 a.m.
- Long and multiple work shifts.
- Low activity and repetitive tasks as well as high intensity workload.
- Decision-makers are more prone than those doing hard physical work.
- Environment (altitude, heat stress, carbon monoxide exposure, etc.).
- Dehydration.
- Age or poor fitness level.

Signs and symptoms of fatigue

- Poor decision making.
- Slowed reaction time.
- Difficulty communicating.
- Forgetfulness.
- Fixation.
- Lethargy.
- Bad mood.

[1] See Reference [Dupont].
[2] See Reference [USDA].

Fatigue has been equated to being intoxicated. In some studies a 19-hour work day equates to the mental performance of someone with a 0.08 blood alcohol concentration, which is legally impaired in most states.

Rest periods, including naps of about 30 minutes, and good nutrition are important to combat fatigue.

The natural circadian rhythm is also a factor in fatigue. Humans naturally have low points in the circadian rhythm in the early afternoon (1500–1700 hours) and in the early morning (0300–0500 hours).

Case Study—People Just Aren't At Their Peak At 4 a.m.

Before the March 28, 1979, Three-Mile Island Nuclear Generating Station Accident near Harrisburg, Pennsylvania began, the reactor was operating at full power, and there did not appear to be any cause for concern. But unbeknown to the operators, a valve that was supposed to be open had been left closed by a maintenance worker who was no longer on shift. And it was four o'clock in the morning, the lowest point in the human circadian cycle.[3] No matter how well-intentioned they are, how attentive they try to be, how much coffee they have had, people are not at their best at 4 a.m.—not even people whose job it is to control a nuclear power plant.[4]

People are not at their best at 4 a.m.

During wildland firefighting activities the U.S. Forest Service and the Department of Interior adhere to a 2-to-1 work-rest ratio (for every two hours of work or travel, one hour of sleep is provided). This translates into a work shift of 16 hours in a given 24 hour period. Additionally drivers are limited to 10 hours of behind the wheel driving. A driver is permitted to drive only if they have had at least 8 consecutive hours off duty before beginning a shift. However, if this is not possible during critical response situations, fatigue mitigation measures must be documented.

SAR Incident Management Team members should be thinking about and planning for demobilization and relief almost as soon as the incident starts. Prior to releasing personnel from an incident consideration should be given to fatigue issues and responder safety. A rest period may be needed after a responder leaves the field and before they are allowed to drive home from the incident.

Case Study—Death of an Incident Commander, Virginia

Five-year-old boy Victor Shoemaker was reported missing and lost after wandering away from kids he was playing with in the mountains of Hampshire Country near the town of Kirby, WV. At 8 o'clock on the morning of May 3, 1994, 24-year-old Lisa Hannon had just been relieved as Incident Commander by fellow Appalachian Search and Rescue Conference (VA) members. Lisa had worked tirelessly through the night to organize the massive search operation that would eventually involve over 1,000 personnel. She had not slept in 23 hours. Twenty minutes after sliding in behind the wheel of her truck, Lisa fell asleep while driving and struck a tree on U.S. Route 50 at full speed, killing her instantly. Lisa's death was the first line-of-duty death for the State of Virginia Search & Rescue Program.[5]

Dehydration

Typically the human body can survive without water for 3 days. In the hot Arizona desert this time can be drastically reduced. About 75% of the body's weight is water. The body is constantly losing

[3] The human circadian cycle is about 24 hours.
[4] See Reference [Vicente, page 127].
[5] See Reference [Dixon].

water through three normal functions: breathing, sweating, and eliminating waste through urination and bowel movements.

A 150 lb person loses 65 ounces (over 8 cups) of fluids in a normal day. The same 150 lb person may lose more than a gallon of water hiking in the desert in one day. Dehydration occurs when water is not replaced as fast as it leaves the body. Alcohol, soda, and tobacco greatly increase the risk of dehydration. A SAR emergency responder may be called on a mission at any time. It is important to remain hydrated before a search or training mission occurs, by routinely drinking plenty of water. Also ensure to replace lost electrolytes through the use of sports drinks. Thirst is the body's signal that it needs hydration. When a searcher feels thirsty they should drink water or a sports drink and eat regularly.

During a hike or SAR mission drink water frequently. Hydration bladders are highly recommended in order to constantly drink while on the move, see Figure 5.1. Without a hydration bladder drink at least every 30 minutes. Waiting until thirsty means the body is already dehydrated. Over-hydration may lead to a complication known as Exercise-associated Hyponatremia. (`https://www.eurekalert.org/pub_releases/2015-06/luhs-as062915.php`). Each searcher should have one gallon of water per day in their packs while in dry desert conditions.

Figure 5.1. A hydration bladder

Beginning stages of dehydration are characterized by thirst and decreased or no urination. Urine is dark yellow instead of clear.[6] As water loss continues other symptoms are present such as dry mouth, dry eyes, no sweating, muscle cramps, nausea and vomiting, heart palpitations, dizziness, and weakness. As dehydration becomes more severe the body tries to compensate for the lack of fluids by increasing the heart rate and vasoconstriction to maintain blood pressure and flow to vital organs. Confusion and weakness occur as the brain receives less blood and ultimately coma, organ failure, and death follow. Many outdoor accidents and deaths happen because the body is not at peak performance due to dehydration.

Clothing

As a general rule dress in light weight and light colored cotton in hot temperatures and dark colored wool, fleece, or other synthetic material in cold temperatures.

[6] Various dehydration urine color charts are available from the web.

> *As a general rule dress in light weight and light colored cotton in hot temperatures and dark colored wool, fleece or other synthetic material in cold temperatures.*

Footwear

Footwear is the most important gear the SAR team member possesses. It consists of two components, socks and boots.

Starting with the socks follow the three Ws rule of wicking, warmth, and wet.

The first layer should be a thin high tech moisture-wicking fabric. Each foot can produce nearly a cup of sweat in one day of heavy activity. It is important to wick that moisture away to avoid blisters and body heat loss. The sock liner also allows any friction to rub between the socks instead of on the skin helping to prevent hot spots and blisters. Even in the summer the sock liner keeps the feet cool and comfortable.

The warmth layer should be a heavier wool or synthetic sock. Make sure the sock fits the foot. One-size-fits-all or socks that are too large cause wrinkles and bunching, which leads to blisters. This layer also creates a padding layer to keep the feet comfortable after miles of hiking. Even in the summer use a summer weight wool or synthetic sock. Avoid cotton on the feet at all times of the year.

> *Avoid cotton on the feet at all times of the year.*

The wet layer is the boots themselves. Comfort and proper fit are very important when choosing a boot. For SAR use, pick a medium- or heavy-weight boot with a high ankle to give the ankle proper support. The boot should have a metal shank in the sole to give support on rocky terrain and keep the foot from rocking when carrying heavy loads. Make sure the boot has good traction with a lugged sole.

When trying on boots make sure to wear both the insulation layer and the hiking sock to have the proper thickness to ensure comfort. Choose a store that has a knowledgeable sales person. Good outfitters have a rock ramp to test the comfort of the boots when walking up and down hills. Make sure the boot remains comfortably snug without slipping while walking on the ramp. Also tap the toe cap against the wall or the ramp—the toes should not feel the impact. Make sure the boot is wide enough for the foot. Women may be able to move to a man's boot to find a wider size but men may have to special order.

For winter and snow conditions make sure the boot is waterproof and breathable. For summer desert conditions opt for a lighter fabric or mesh-sided boot to allow more air flow but do not wear this type of boot during wet conditions.

Also consider buying leather or waterproof gaiters. The gaiters help keep snow and mud from seeping into the top of the boots and go a long way to keeping the feet dry and comfortable. Gaiters also help keep debris and cactus thorns from entering the boots. In wet or snow conditions, if gaiters are not available, wrap black trash bags around the ankles and secure the top and bottom with duct tape.

Cold Weather Clothing

In cold temperatures always dress in layers. Strive to maintain a comfortable slightly cool, not chilled temperature just before any activity. If a person does not, then their body heats up as their activity increases and they begin to sweat causing their clothing to become wet and to lose some of its insulating properties, which ultimately makes them cold. Remove or add layers of clothing to maintain the slightly cool feeling as the temperature and activities alter their heat level.

Layers provide air spaces between clothing which allow for insulation. Warmth generated from clothing is proportional to the thickness of dead air space a garment provides. Additionally synthetic materials such as fleece and polypropylene are actually small tubes of plastic thread. The thread is hollow allowing for that insulating dead air space. Furthermore, wool and the synthetic materials wick moisture away while still retaining the air pockets that provide warmth. However, cotton and down absorb moisture into the air spaces and are slow to dry providing no insulating properties when wet. The SAR team member should completely avoid wearing any cotton or down including under garments during the winter months. The most common winter clothing mistake is wearing blue jeans which are cotton and absorb lots of moisture and can quickly drop the core temperature.

The most common winter clothing mistake is wearing blue jeans which are cotton and absorb lots of moisture and can quickly drop the core temperature.

The Three Ws of Layering. Wicking, Warmth, and Wind/Wet

The Wicking base layer, the layer closest to the skin, should be made of a material such as wool or synthetic that allows moisture (sweat) to be wicked away from the skin. Cotton and similar materials absorb moisture and are slow to dry keeping moisture next to the skin which can cause chilling and, even worse, hypothermia. A good wicking base layer garment helps draw moisture away from the skin and move it out to the next layer. This helps a person to stay cool in hot summer days as well as warm and dry on cold winter nights.

The Warmth layer is the Insulation Layer and should again be wool or synthetic. Thickness equals warmth. Good examples are wool or fleece pants, sweaters, socks, beanie hats, and scarves. Wool retains 80% of its insulating factor when it is soaking wet. Wool can also absorb 30% of its weight in water and still feel dry.

The Wind/Wet Outer Layer performs two jobs. The first is to allow moisture wicked away from the skin by the previous layers to escape into the environment, and the second is to protect the insulation layer from the elements such as wind and rain. The outer layer should be a waterproof and breathable Gore-Tex® type of garment. A plastic rain coat should be avoided because it does not allow moisture to escape causing the inner layers to remain wet and lose their insulation qualities.

Another consideration in cold weather clothing is to make sure that extremities are covered. As the core temperature cools, the body's heat concentrates on keeping the vital organs and core warm and sacrifices the extremities such as hands, feet, ears, and nose, causing the risk of frost nip or frost bite.

Warm Weather Clothing

While horrible for cold conditions, cotton is ideal for hot conditions. Wear light weight and light-colored breathable cotton clothing during the hot desert conditions. Long sleeves and long pants help protect the skin from the sun and from desert plants. A wide brimmed hat is essential for summer months to help keep the sun off the face and neck. Radiation of heat from the head is one of the main ways the body loses heat. Make sure the summer hat is vented to allow heat to escape.

Wetting a handkerchief to tie around the neck not only protects the skin from sun exposure but provides evaporative cooling as the handkerchief dries. Keep wetting the handkerchief as it dries to continue the cooling effect during the hot daylight hours.

As a final level of protection make sure to apply sunscreen to all exposed skin. Repeat the application every few hours to ensure protection.

Injuries

There are many areas involving the environment that pose potential injuries to the SAR volunteer. Consider the ground composition. Is it loose, rocky, steep, wet, . . . , that increase the chances of a fall, or twisting ankles and knees? Constant evaluation of conditions reduces the chance of injury.

The common types of volunteer injuries are

- **Back Injuries**. These are very serious and have the potential to greatly impact the volunteer's life. Serious injury can disable a person permanently. Back injuries are the number one job-related injury. Fatigued muscles are more susceptible to injury. Lighter backpacks reduce fatigue and this potential.

  > *Back injuries are the number one job-related injury.*

  Remember the proper techniques when lifting anything heavy or awkward.
  - Assess the situation and plan the lift.
  - Wear nonskid shoes and ensure firm footing.
  - Make sure you have a good grip on the item or person being lifted—this is not a good time for hand lotion.
  - Feet shoulder width apart, one foot ahead of the other.
  - Bend the knees, tighten the stomach, and keep the back straight.
  - Lift smoothly to avoid twisting the body.
  - Lift with the legs, keeping the back straight.
  - If possible, push rather than pull. Pushing gives more power, better balance, and less muscle strain. Pulling gives less power, poor balance and traction, and is hard on the back muscles.
  - Never lift heavy objects alone, whether it be a piece of equipment, debris, or a litter. Have plenty of manpower to accomplish the task and reduce the potential for this type of injury.
  - Practice deep breaths and drink plenty of water. Continuous breathing while lifting keeps muscles oxygenated. Muscles are made up primarily of water, so stay hydrated.

  Water related rescues have a serious potential for back injuries due to the force of the water. Following the proper techniques in this environment greatly reduces this possibility.
- **Shoulder Injuries**. These are experienced primarily in swiftwater rescue incidents. The force of the water can easily overpower the strongest person. Attempting to overpower this force causes injuries that results in serious loss of time from work, medical costs, and permanent damage. Following the proper techniques in this environment greatly reduces this possibility.
- **Knee Injuries**. These injuries are serious and costly. They are prevalent in swiftwater rescues, but can occur from falls or loss of footing. Footwear should be appropriate for the conditions underfoot. Mounted personnel should especially be concerned if they dismount and are required to walk the mount down a steep hill.

  Proper footwear, with soles made for gripping with lugs and rubber type composition, helps in securing steps on steep, rocky, or loose gravel. Using handholds whenever possible helps.
- **Ankle Injuries**. These are the most vulnerable part of the body to suffer injuries. This is due to the rough terrain and hazardous conditions that is encountered on searches and rescues. Proper footwear with ankle support and remaining vigilant is required.

Remember when team members are injured it removes them and others from the initial task, and creates hardship in their personal lives. Serious injuries and accidents have the potential to permanently disable and even cause death. SAR team members must be mentally and physically prepared, and must never exceed their capabilities.

> *SAR team members must be mentally and physically prepared, and must never exceed their capabilities.*

Bloodborne Pathogens

The purpose of this section is to introduce the SAR team member to Bloodborne Pathogens.[7] It is **not** a thorough treatment of this subject. Each agency (County) should provide formal training to its employees and volunteers approved by OSHA and in compliance with their standards.

What are Bloodborne Pathogens? Bloodborne pathogens are microorganisms such as viruses or bacteria that are carried in blood and can cause disease in people. There are many different bloodborne pathogens including malaria, syphilis, and brucellosis, but the pathogens of primary concern to SAR personnel are the human immunodeficiency virus (HIV), the hepatitis B virus (HBV), and the hepatitis C virus (HCV).

The **Human Immunodeficiency Virus** (HIV) causes AIDS, acquired immune deficiency syndrome. Once a person has been infected with HIV, it may be many years before AIDS actually develops. HIV attacks the body's immune system, weakening it so that it cannot fight other deadly diseases. AIDS is a fatal disease, and while treatment for it is improving, there is no known cure.

The **Hepatitis B Virus** (HBV) attacks the liver. While there are several different types of Hepatitis, Hepatitis B is transmitted primarily through "blood to blood" contact. Hepatitis B initially causes inflammation of the liver, but it can lead to more serious conditions such as cirrhosis and liver cancer.

There is no "cure" or specific treatment for HBV, but many people who contract the disease will develop antibodies which help them get over the infection and protect them from getting it again. It is important to note, however, that there are different kinds of hepatitis, so infection with HBV will not stop someone from getting another kind.

The **Hepatitis C Virus** (HCV) is another liver infection that can be acute and, in some cases, chronic. It can also lead to cirrhosis of the liver or liver cancer.

Anyone can be exposed to Bloodborne Pathogens, if they have direct contact with another's blood or body fluids, such as plasma; semen; vaginal secretions; fluids in the uterus of a pregnant woman; fluids surrounding the brain, heart, spine and joints; and fluids in the chest and abdomen.

People infected with pathogens may look and feel healthy. They may not know that they are infected, but they can infect others if their blood or body fluids enter another person through needle sticks; cuts, scrapes, or other breaks in the skin; splashes in the mouth, nose, or eyes; oral, vaginal, or anal sex; and sharing needles. Pregnant women can pass them on to their babies. .

Universal Precautions[8]

Universal precautions is a method of infection control in which all human blood and certain human body fluids are treated as if known to be infectious for HIV, HBV, and other bloodborne pathogens. Universal precautions are to be observed in all situations where there is a potential for contact with blood or other potentially infectious material. Under circumstances in which differentiating between body fluid types is difficult or impossible, all body fluids are to be considered potentially infectious.

> *Universal precautions is a method of infection control in which all human blood and certain human body fluids are treated as if known to be infectious for HIV, HBV, and other bloodborne pathogens.*

[7] A pathogen is a microbe or microorganism such as a virus, bacterium, prion, or fungus that causes disease in its animal or plant host.

[8] Parts of this section are based on materials from the OSHA website.

Many workers must follow Universal Precautions by law. The workers most susceptible to bloodborne pathogens are emergency response workers, medical workers, lab workers, and in occupations that are "hands on", such as barbers, laundry workers, funeral workers, cosmetologists, and dentists.

Personal protective equipment (PPE) consists of gloves, face shields, masks, eye protection, gowns, aprons, and similar items. Employers also must ensure that appropriate personal protective equipment is used and used correctly. Employers also must ensure that PPE is properly cleaned, laundered, repaired, replaced, or disposed of as needed, at no cost to the employee. The employer also must ensure that employees observe the following precautions for handling and using personal protective equipment:

- Remove garments penetrated by blood or other infectious materials immediately, or as soon as feasible.
- Before leaving the work area contaminated protective equipment shall be placed in appropriately designated areas or containers for storing, washing, decontaminating or discarding.
- Wear appropriate gloves when there is a potential for hand contact with blood, other potentially infectious materials, mucous membranes, non-intact skin; when performing vascular access procedures; and when handling or touching contaminated items or surfaces. Replace gloves if torn, punctured, contaminated, or if their ability to function as a barrier is compromised.
- Disposable (single use) gloves, such as surgical or examination gloves, shall be replaced as soon as practical when contaminated or as soon as feasible if they are torn, punctured, or when their ability to function as a barrier is compromised. They shall not be washed or decontaminated for re-use.
- Utility gloves may be decontaminated for re-use if the integrity of the glove is not compromised. However, they must be discarded if they are cracked, peeling, torn, punctured, or exhibit other signs of deterioration, or when their ability to function as a barrier is compromised.

Wear appropriate face and eye protection such as goggles, glasses with solid side shields or chin-length face shields when splashes, sprays, spatters, or droplets of infectious materials pose a hazard to the eyes, nose, or mouth. These should be available on all emergency vehicles. Masks in combination with eye protection devices-such as goggles or glasses with solid side shields or chin-length face shields-shall be worn whenever splashes, spray, spatter, or droplets of blood or other potentially infectious materials may be generated and eye, nose, or mouth contamination can be reasonably anticipated. These should be used in accordance with the level of exposure encountered. An extra change of work clothing should be available. Medical records must be kept confidential and maintained for at least the duration of employment plus 30 years. The bloodborne pathogens standard also requires employers to maintain and to keep accurate training records for 3 years and to include the following:

- Training dates,
- Content or a summary of the training,
- Names and qualifications of trainer(s), and
- Names and job titles of trainees.

Protection from and treatment of Bloodborne pathogens.

- Use required equipment and labels: special waste containers, bio-hazard labels, special equipment such as gloves and eye protection.
- Follow required work practices.
  - Cover cuts, scrapes and rashes.
  - Handle sharp objects carefully.
  - Minimize splashing of blood and body fluids.
  - Do **not** keep food and beverages in areas of infectious materials.
  - Do **not** eat, drink, or smoke in areas where Bloodborne Pathogens may be present.
- Use required PPE.
  - Gloves. Wash hands before and after. Examine gloves before and after for tears or damage.

  - Mask, eye protection, and gown. Protect against splashing that may occur.
  - Resuscitation Mask. Use when providing rescue breathing.
  - Proper Disposal. Remove contaminated PPE and other contaminated clothing. Dispose of properly.
- Wash the exposed area immediately.
- Report the incident promptly according to workplace policy.
- Seek medical help, treatment, and counseling. If necessary, ask about getting confidential medical evaluation, testing, counseling, and treatment.
- Ask about
  - Immediate drug treatment to help prevent infection with HIV.
  - Hepatitis B immune globulin (HBIG) and vaccine series for vaccination against HBV.
  - Antiviral therapy, if chronic HCV infection develops.

In medical emergencies a SAR team member may come into contact with unhygienic substances and blood borne pathogens. Always practice body substance isolation (BSI) when coming into contact with any type of body fluids. Always use latex gloves when touching or handling a subject or clue. The latex gloves not only protects from any body substance infections but it also protects an injured subject from infection. It is also important to use latex gloves when handling clues to prevent contamination of a potential scent article that could be used by K-9 teams. If the situation warrants it, then also consider wearing eye protection and a face mask when coming into contact with an injured or deceased subject.

After coming into contact with any substance or clue it is a good idea to have a small bottle of hand sanitizer. When using hand sanitizer make sure to continue to rub it into your skin until it is dry.

Any exposure to potentially infectious materials entered through the eye, mouth, nasal passage, wound or lesion of the skin, or penetration of the skin should be immediately reported to the Incident Command. Emergency personal are assessed and treated as per local work compensation SOP's.

During the course of a search task the team member may also come into contact with various hazardous substances such as dumped chemicals, drugs, narcotics, and other hazardous substances. When confronted with such situations remain at a safe distance and use the radio to inform the incident commander of the hazard.

Water Hazards

Performing rescue operations on and around water requires special considerations and training. If faced with a water hazard, then radio base and let the incident commander decide how to proceed.

Much of Arizona is subject to quick flash floods. A rain storm in the mountains can manifest itself in a sudden and unpredicted flash flood down slope in the desert areas many miles away. Always be watchful for approaching flood water when in desert washes. Rushing flood water can quickly erode away the banks of a previously defined river. Stay at least 10 feet away from the edge of a running river in case the force of the rushing water breaks off large chunks of the bank.

Similar to swiftwater rescues, vertical and semi-technical rescues require special equipment and training. Always stay at least 10 feet away from edges and cliffs. Watch the ground for cracks and fissures that indicate a portion of the cliff face may be near to giving way. The SAR team member's extra weight may be just enough to make it break away. During the mission debriefing identify any edges that the team was unable to search so the incident staff can decide whether to return with specialized resources.

Helicopter Operations

A SAR professional may be deployed and/or extracted by helicopter during the course of their duties. Safety around a helicopter is everyone's responsibility. If a searcher sees anything that looks unsafe, immediately say something to someone.

Personnel being transported in a helicopter should always wear a safety helmet, safety glasses or goggles, and hearing protection. All gear should be put away and securely strapped down in a pack. Any loose items may blow in the rotor wash causing injury or damage. Long tracking sticks should be left behind and not carried aboard the helicopter. A collapsible tracking stick, which can be stowed in a pack, is a better option.

When working around helicopters the pilot or his designated crew is in charge. Watch the pilot or designated crew for instructions. Do not approach or exit the helicopter until directed by the crew to do so. Always wear a seat belt when in the aircraft. If the nose or front of the helicopter is 12 o'clock, always approach from the 10 o'clock or 2 o'clock position. See Figure 5.2 downloaded from `http://www.coromandelhelicopters.co.nz/aboutus.html`.

Figure 5.2. Helicopter safety zones

NEVER approach the rear of the helicopter, avoid the tail rotor. When approaching and exiting a helicopter, pay attention to the slope of the terrain. The blades of some helicopters can flex to within a couple feet of the ground. Do not travel up any incline because this brings the searcher closer to the moving blades and increases the chance of being struck. Always keep the head down and bend at the waist when approaching and exiting the helicopter.

Landing Zones

Landing zone size varies by size of helicopter, however, 100′ by 100′ open area is a good rule of thumb. When setting up a landing zone, identify any overhead obstructions or general hazards such as antenna's, power lines, trees, large rocks, etc. Estimate the wind speed and general direction it is coming from. Provide the pilot with this information prior to landing. If assigned to a landing zone, make sure all equipment and personnel/bystanders are secure. Do not allow any persons or vehicles to approach the aircraft unless directed by the pilot or crew. Smoking is never allowed in or around an aircraft.

Critical Incident Stress Management

During the course of a SAR incident a team member may become involved in a particularly stressful situation or event such as the death or severe injury of a subject or even another rescue worker. Such incidents can have lasting effects on the mental state. It is important to express feelings about such events so that stress and depression does not build up inside. After any such incident the unit may hold a Critical Incident Stress Debriefing (CISD) where those involved in the event get together and talk about it. If a CISD session is warranted speak to the incident commander or safety officer.

Section 5.2
Local Hazards

Poison Ivy, Oak, Sumac

Poison Ivy and its relative plants grow abundantly in the Juniper belt in Arizona, between 3000 and 8000 feet elevation. Some people are more susceptible than others to the rash resulting from contact with the plant. Most people experience only a localized itchy rash. Some however have a severe allergic reaction to contact with the plant and should be wary of coming close to it. The plant is usually shrub-like but may climb on other shrubs and small trees forming a vine. The plant has three lusterless oak-like leaves. See Figure 5.3. The plant produces clusters of white and shinny berry-like fruit. The stem often has a reddish color.

Regardless, whether allergic to the plant or not it is best to stay away from any contact with any part of the plant. If someone does come into contact with the plant wash the plant's oil off with heavy soap as soon as possible. Washing with just water only spreads the oil around the skin.

Figure 5.3. Poison Ivy leaves—Photo © Stilfehler

Snakes

Arizona is home to over 13 different species of rattlesnakes. Less than 1% of bites in Arizona result in death but a bite is still a serious medical emergency and should be treated as such. Only about a third of all rattlesnake bites inject venom. When venom is injected the symptoms present immediately.

The best advice when encountering a snake is to leave it alone. Be aware that rattlesnakes sometimes travel in pairs, so look behind before jumping back. Fifty to seventy percent of all snake bites in Arizona were provoked by the person trying to kill, capture, or harass the snake.[9] Figure 5.4 was taken during a SAR mission in Arizona.

Figure 5.4. Rattlesnakes sometimes travel in pairs

Watch where putting hands and feet. Never put the hand where the eyes do not go first. Climbers reaching up onto a ledge are some of the most common snake bite victims. Use a tracking stick to move brush and look under things instead of using hands.

In case of a bite get to a hospital to receive anti-venom as soon as possible. If in the wilderness when bitten keep the bite location low, below the level of the heart. Wash the area with warm water and soap. Remove any constricting clothing and jewelry from the extremity. The area may swell and constricting items may cause tissue death.

DO NOT

- Use a tourniquet.
- Cut and suck. Drug store snake bite kits with the suction plunger do not work. Cutting into the wound may cause infections and tissue loss.

Arizona also has coral snakes that carry a more potent venom than the rattlesnake. See Figure 5.5 on the next page. Sightings are extremely rare and bites are even rarer due to the coral snakes reclusive behavior. Only about 15 to 20 bites are reported each year. When confronted by humans the coral snake almost always flees and only bite as a last resort. Coral snakes have short teeth-like fangs that cannot penetrate most clothing.

Gila Monsters

The Gila Monster is the only venomous lizard native to the U.S. See Figure 5.6 on the next page. The venom of the Gila Monster is a neurotoxin similar to the coral snake. However there have been no reported human deaths since 1939. The Gila Monster is sluggish and slow moving. The venom is secreted like saliva and drips down the teeth into the wound. When bitting the Gila Monster hangs on tenaciously and it is often very difficult to remove.

Signs and symptoms of a bite include:

[9] What is the last thing most people say just before being bitten by a rattlesnake? "*Here, hold my beer and watch this.*"

Figure 5.5. Coral snake—Photo © Tom Brennan

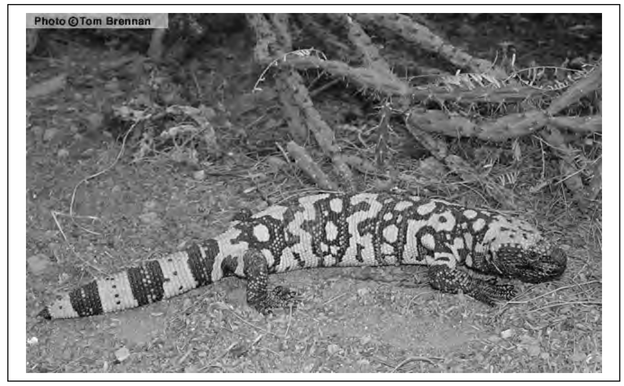

Figure 5.6. Gila Monster—Photo © Tom Brennan

- Pain.
- Edema—swelling caused by fluid in the body's tissues.
- Weakness.
- Rapid drop in blood pressure.
- Partial paralysis of the limbs.

In the event of a bite the subject should be transported to a hospital immediately.

Spiders

The Black Widow spider is fairly common in Arizona. It is characterized by a shinny black body, thin legs and a crimson red marking on its abdomen in the shape of an hourglass. See Figure 5.7 on the next page. The black widow spider bite is the most dangerous in the U.S. People under 16 or over 60, and people with chronic illness, are at higher risk of complications due to a Black Widow bite.

Signs and symptoms of the Black Widow bite include

- Pinprick sensation at the bite site becoming a dull ache within 30 minutes.
- Severe muscle spasms, usually in the shoulders, back, chest and abdomen.
- Abdominal rigidity and pain.
- Nausea.
- Vomiting.
- Fainting.
- Dizziness.
- Chest pain.
- Difficulty breathing.

Fortunately Black Widow bites are extremely rare. Most bites do not puncture the skin. The Black widow is nocturnal and prefers secluded dark areas. They typically only bite to protect their egg sacks.

Victims of a Black Widow bite should be transported to a hospital as soon as possible.

Contrary to common belief the Brown Recluse is not found in Arizona. However, a relative, the Arizona brown spider is.

Scorpions

Ninety percent of all scorpion stings occur on the hands. See Figure 5.8 on the next page. There are three different species of scorpions in the U.S., only one of them has reported fatalities from a sting. In the past 20 years there have been no reported fatalities from scorpion stings. Signs and Symptoms of a sting:

- Severe pain and swelling at the sting sight.
- Numbness.
- Frothing at the mouth.
- Difficulty breathing.
- Muscle spasms.
- Seizures.

Figure 5.7. Black Widow—Photo © Chepyle

Figure 5.8. Arizona Bark Scorpion

- Shock.
- In rare cases death.

In the event of a sting clean the sting area with warm water and soap. Apply an ice pack to the sting area for 10 minutes. Call poison control center or transport to a hospital as soon as possible.

Africanized Honey Bees—AKA Killer Bees

Africanized bees are often referred to as killer bees due to their behavior of viciously attacking people or animals who stray into their territory. The bee hive does not have to be disturbed to provoke an attack. Simple noises or vibrations may set off an attack. Africanized bees were first reported in Arizona in 1993. The sting of an Africanized bee is no more dangerous than the common garden honey bee. They are more dangerous because they are more easily provoked into a swarm and attack in greater numbers. The Africanized bees also pursue their victims over greater distances and may continue to attack up to a quarter of a mile away from the hive. Since they where first reported in Arizona there have been 5 human deaths and several animal deaths from bee attacks. The American Medical Association states that it requires 7 bee stings per pound to become fatal.

In case of a bee attack quickly get into a house, car, tent or other enclosure to get away from the bees. If unable to get inside, then run away in a straight line and preferably into the wind. Most people can outrun the bees within a few blocks. Protect the face to prevent stings to the eyes, nose, and in the mouth. Bees attack where carbon dioxide is expelled from breathing and facial stings are much more dangerous than stings to the body. Pull the shirt over the head if no other protection is available. Do not swat at the bees or jump into water—the bees wait at the surface.

A video of the attempted rescue of an injured hiker by a Phoenix fire fighter who is then attacked by killer bees can be seen at `http://tinyurl.com/7ex2y2x`.

Anaphylactic Shock

Some people are highly allergic to stings and bites and may experience Anaphylactic Shock as a result. Anaphylactic Shock is a life threatening condition.

Signs and symptoms of Anaphylactic Shock:

- Hives.
- Flushing.
- Airway obstruction.
- Faintness.
- Dizziness.
- Generalized itching.
- Swelling including eyelids, lips, and tongue.
- Difficulty swallowing.

- Difficulty breathing.
- Abdominal cramping.
- Confusion and disorientation.
- Loss of consciousness.
- Seizures.
- May result in death.

If a subject is experiencing Anaphylactic Shock they require medical treatment immediately. Transport to a hospital as soon as possible. Many people who know they are allergic to stings and bites carry an Epinephrine Auto-Injector, also referred to as an "EpiPen". Administer Epinephrine with permission of medical direction as soon as possible. The biggest danger of Anaphylactic Shock is occlusion of the airway. Attempt to maintain the airway while transporting to medical personnel.

Mountain Lions (Cougars)

In Arizona, mountain lions are absent only from the areas heavily impacted by human development. In general, the distribution of mountain lions in Arizona corresponds to the distribution of its major prey species, deer.

Attacks on humans are rare, as cougar prey recognition is a learned behavior and they do not generally recognize humans as prey. As with many predators, a cougar may attack if cornered, if a fleeing human stimulates their instinct to chase, or if a person "plays dead". Standing still however may cause the cougar to consider a person easy prey.[10] Exaggerating the threat to the animal through intense eye contact, loud but calm shouting, and any other action to appear larger and more menacing, may make the animal retreat. Fighting back with sticks and rocks, or even bare hands, is often effective in persuading an attacking cougar to disengage.[11] Figure 5.9 was taken in a recreational area in Arizona—the scene of many SAR missions.

Figure 5.9. Mountain lion

Black Bears

In Arizona, the black bear is found in most woodland habitats, including pinyon-juniper, oak woodland, coniferous forest, and chaparral.

According to the Arizona Game and Fish Department (`http://www.azgfd.gov/w_c/urban_bear.shtml`) black bears should always be considered unpredictable and potentially dangerous. A black bear

[10] See `http://www.scientificamerican.com/article.cfm?id=should-you-run-or-freeze-when-you-see-a-mountain-lion`.
[11] See `http://www.env.gov.bc.ca/wld/documents/cougsf.htm`.

will usually detect people and leave the area before being noticed, unless the bear has been conditioned to people and their food.

To discourage a black bear, immediately:

- Alter your route to avoid a bear in the distance.
- Make yourself as large and imposing as possible if the bear continues to approach. Stand upright and wave your arms, jacket or other items. Make loud noises, such as yelling, whistles, and banging pots and pans.
- Do not run and never play dead.
- Give the bear a chance to leave the area.
- If the bear does not leave, stay calm, continue facing it, and slowly back away.

On the rare occasion that a black bear becomes aggressive, fight back with everything in your power—fists, sticks, rocks and E.P.A. registered bear-pepper spray.

Figure 5.10 was taken during a SAR mission in Arizona.

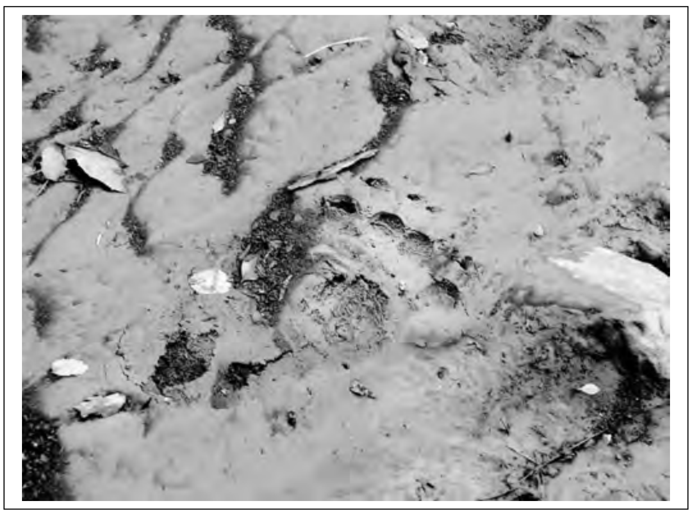

Figure 5.10. Bear tracks

Section 5.3

Environment Related Hazards

Arizona is a unique area that can provide the extremes of weather in temperature at both ends of the scale. The Sonoran desert can reach dry temperatures into the 120°s while high alpine regions of the White Mountains and Flagstaff can drop well below freezing. Weather can range from blistering sun and dust storms to torrential rain and blizzards. The SAR practitioner needs to be prepared to tackle the worst that Arizona creates at a moment's notice.

Cold Related Problems

Be aware that extreme cold weather conditions can create or increase the danger of weather-related injuries, illnesses, and accidents. Ice may make normally sure surfaces slippery and dangerous. Piled up snow may suddenly collapse or avalanche. Winter storms can reduce visibility to near zero.

Cold related emergencies come in two basic categories. The first is generalized cold such as hypothermia which is an overall reduction in body temperature. The second is a local cold injury or damage to body tissue in local parts of the body, usually the extremities.

The following factors predispose people to cold related injuries.

- Exposure to a cold environment.
- Wet clothing.
- Age (either very young or elderly).
- Pre-existing medical conditions. Especially conditions that limit blood flow.
- Use of drugs, alcohol, or poisons.
- Dehydration.
- Trauma.
- High altitudes.
- Loss of blood.

Early or superficial cold injuries usually involve the extremities such as the ears, nose, chin, toes, and fingers. As the body's temperature decreases the body sacrifices warmth in the extremities to protect the core and vital organs.

The subject is usually unaware of the injury occurring. As exposure times increase and the body temperature drops the subject loses feeling and sensation in the affected areas. The skin remains soft but cold to the touch. As the affected area is re-warmed the subject usually reports a tingling sensation as the area thaws.

Late or deep cold injury involves both the skin and the underlying tissues. The skin becomes white and waxy and feels frozen and firm to the touch. Swelling and blisters filled with clear fluid may be present. As the area is thawed it may become blotchy or mottled with colors ranging from white to purple and grayish blue. Deep cold injuries can result in permanent tissue loss.

Hypothermia is when the body's temperature falls below its normal 98.6°F. This drop in temperature can be caused by an increase in the body's heat loss from Radiation, Convection, Conduction, Evaporation, or Respiration. The body can also lose heat from a decrease in the body's heat production. Hypothermia is the most severe of cold related injuries. The mortality rate for generalized hypothermia is 87%. Death can occur within two hours of the onset of the first signs and symptoms.

Hypothermia can have sudden onset such as becoming exposed to extreme wet and cold conditions, like falling through ice, or it can have a slow and gradual onset such as prolonged exposure to cold temperatures, wind, and wetness. Many hypothermia cases occur in the spring and fall when the day time temperatures are comfortable. Subjects may get caught by falling temperatures as the sun goes down or may become wet from sweat or rain causing body temperature to drop even on comfortably warm days.

Hypothermia has five recognized stages as the core temperature drops.

Stage 1. Shivering: Body temperature 95°F to 98°F. The body begins to shiver in an attempt to generate heat. Shivering continues in Stage 2 but does not continue if the body temperature falls below 90°F. Skin is cold and pale. Subject is alert but shivering. The subject may have poor muscle coordination, rapid breathing and rapid heart rate.

Stage 2. Apathy and decreased muscle function: Body Temperature 90°F to 95°F. Fine motor functions are first affected and, as the core temperature continues to drop, gross motor functions are also affected. Skin is cold and waxy. Face is puffy and pink. Subjects are often confused. Muscles become rigid and heart rate begins to slow.

Stage 3. Decreased level of Responsiveness: Body temperature 86°F to 90°F. The Subject commonly has a glassy stare and the extremities begin to freeze as the body sacrifices them to keep the core warm. Pupils dilate. Reflexes are diminished or non-existent. Muscles continue to become rigid and breathing and heart rate significantly decreases. The subject may fall into a stupor or coma during Stage 3.

Stage 4. Decreased vital signs: Body temperature 82°F to 86°F. Subject falls into a coma state. Pupils are fixed and dilated. Muscles are flaccid. Respiration is slow. Heat rate may be slow or rapid but irregular. Subject may go into cardiac arrest.

Stage 5. Death: Body temperature 68°F to 82°F. Subject is unresponsive. Vital signs may be barely detectable with a weak and irregular pulse. Stage 5 ends in cardiac arrest.

General Signs and Symptoms of Hypothermia

- Decreased mental status.
  - Memory loss, amnesia.
  - Moody.
  - Impaired judgment.
  - Dizziness.
  - Impaired speech.
  - Drowsiness progressing to unconsciousness.
- Decreased motor functions.
  - Muscle stiffness and rigidity.
  - Exhaustion.
  - Loss of feeling.
  - Loss of fine and then gross motor function.
  - Shivering at first.
- Changes in Vital signs.
  - Rapid breathing at first slowing later to shallow and eventually no breathing.
  - Pulse rate may become rapid and later slow and irregular and eventually stop.
  - Skin may be flushed red or pink in early stages then become pale, gray, and waxy.
  - Skin becomes cool then cold and hard to the touch.
  - Pupils are slow to respond and later dilated and fixed.

Emergency care for the hypothermic subject

It is important to immediately stop any further heat loss. If possible remove the subject from the cold environment. Immediately remove any wet clothing and dry the subject off.

Handle the subject with care. Many deaths from hypothermia result from cardiac arrest. Rough handling in the late stages of hypothermia can trigger a cardiac arrest.

Active rewarming is a technique used only when the subject is in the early stages of hypothermia and remains alert and responding. Active rewarming is aggressively applying heat to the body by wrapping in warm blankets and placing a heat source such as heat packs or hot water bottles in the groin, armpits, and on the chest. Active rewarming can also be accomplished by getting into a vehicle and turning up the heat. As a general rule the body should not be rewarmed faster than 1°F per hour.

If the subject is unresponsive, then passive rewarming should be used. As before, take measures to prevent further heat loss by removing them from the cold environment and removing any wet clothing. Wrap the subject in warm blankets and let the body naturally heat itself back up.

With cold-related injuries never rub or massage the tissue. Frozen tissue acts like small knifes that cut and damage the surrounding tissue as it is rubbed or massaged.

Paradoxical undressing under hypothermia

Between 20% and 50% of deaths from hypothermia involve paradoxical undressing of some kind, where the subject begins discarding their clothing, which, in turn, increases the rate of heat loss.[12] Quoting from the Wilderness Medicine Newsletter:[13] *"we do not know of any cases where a hypothermia victim that underwent paradoxical undressing survived"*.[14]

"The supposition as to the cause of paradoxical undressing is that the primary defense against the cold and hypothermia is vasoconstriction of the peripheral circulation.[15] *This shunts the blood into the warm core and the skin now becomes a more effective layer of insulation. The problem is that vasoconstriction of the smooth muscles in the vasculature requires glucose and energy consumption. Vasodilation,*[16] *on the other hand, is a passive process that simply requires the smooth muscles that make up the blood*

[12] See `http://www.newscientist.com/article/mg19426002.600-the-word-paradoxical-undressing.html`.

[13] See `http://wildernessmedicinenewsletter.wordpress.com/2007/02/07/hypothermia-paradoxical-undressing/`

[14] In fact there is at least one case. Cochise County SAR located and successfully saved one such person.

[15] Vasoconstriction is the narrowing (constriction) of blood vessels by small muscles in their walls. When blood vessels constrict, the flow of blood is restricted or slowed.

[16] Vasodilation is the increase in the internal diameter of blood vessels that is caused by relaxation of smooth muscle within the wall of the vessels, thus causing an increase in blood flow.

vessels to relax. Over time, the vasoconstricted vessels begin to run out of energy (glucose) because of the poor circulation, and they fatigue and relax, thus vasodilating. This now allows the warm core-blood to re-perfuse the skin, causing a sensation of warmth. This results in the hypothermia victim feeling warm, so, they now begin to shed layers, thus the paradoxical undressing. Between the peripheral vasodilation and the loss of layers of protective clothing, their core temperature now begins to plummet and this hastens death from hypothermia."

Heat Related Problems

On the flip side of cold injuries, heat can also cause life-threatening emergencies. Heat exposure can range from mild discomfort and sunburn to heat stroke and death.

The following factors predispose people to heat related injuries.

- Climate.
  - Hot temperatures reduce the body's ability to lose heat via radiation.
  - High humidity reduces the body's ability to lose heat via evaporation.
- Strenuous activity and exercise.
- Age (either very young or elderly).
- Past medical history.
  - Heart disease.
  - Kidney disease.
  - Dementia.
  - Thyroid disorders.
  - Skin disorders.
  - Dehydration.
  - Obesity.
  - Infections and reduced immune system ability.
  - Fatigue.
  - Diabetes.
  - Malnutrition.
  - Alcoholism.
  - Mental retardation.
- Use of drugs, alcohol, or poisons.

Hyperthermia (as opposed to hyp**o**thermia) is the increase in the body's core temperature above 98.6°F. Hyperthermia is most often caused by dehydration and overexertion in hot environments. There are three stages of Hyperthermia: Heat Cramps, Heat Exhaustion, and Heat Stroke.

Stage 1. Heat Cramps. Muscle pain or spasms that occur during heavy exercise in hot weather.

Stage 2. Heat Exhaustion. The body's temperature is greater than 101°F. Can be the precursor to heat stroke. Symptoms include heavy sweating, rapid breathing and a fast but weak pulse. Heat Exhaustion may also include nausea, vomiting, fatigue, weakness, headache, muscle cramps, and dizziness.

Stage 3. Heat Stroke. The body's temperature is greater than 105°F. The body is typically worn out from trying to cool itself down. Symptoms include confusion, inability to continue sweating, dry skin, rapid and strong pulse and dizziness. Heat Stroke may also include difficulty breathing, strange behavior, hallucinations, confusion, agitation, disorientation, seizure, and eventually coma.

General signs and symptoms of Hyperthermia:

- Muscle cramps.
- Fatigue and exhaustion.
- Dizziness.
- Heart beat rapid and strong at first but becomes weak and irregular with progression.
- Breathing is deep and rapid at first but becomes shallow and weak with progression.
- Headache.
- Seizures.
- Skin may be normal to cool in temperature, pale in color and moist or it may be hot to the touch in severe cases.
- Nausea and vomiting.
- Confusion and altered mental status.
- Unconsciousness and death.

Emergency Care

For beginning stages when the skin is moist and pale with normal to cool skin temperature provide the following care. Move the patient to a cool location such as a car with air conditioning or simply into the shade. Remove excess clothing and loosen clothing to allow air flow over the skin. Apply a cool wet cloth to the neck, or under the armpits. Fan the subject if there is no wind. If the subject is fully responsive and is not vomiting, then give them cool water. Allow them to slowly drink a half a glass every 15 minutes.

If the subject is unresponsive or has an altered mental status or is vomiting do **NOT** give them fluids.

A subject with more severe hyperthermia with hot skin is in a dire medial emergency. Cooling the subject is the highest priority. Move the patient to a cool location such as a car with air conditioning or simply into the shade. Remove as much of the subject's clothing as possible. Immediately begin to cool the subject by using multiple techniques.

- Pour cool water over the subject's body.
- Place cold packs in the subject's groin, side of neck, armpits, and behind the knees.
- Wrap a wet sheet or cloth around the subject.
- Aggressively fan the subject.
- Keep the skin wet to promote cooling through evaporation.

Note: If the cooling produces shivering slow down the cooling efforts as shivering produces heat.

As with all medical emergencies get the subject to the nearest hospital or medical care as quickly as possible.

Case Study—Death of Ultrarunner, Death Valley, California

Marathon speed hiker Michael Popov gained world renown in 2007 when he completed the 222-mile John Muir Trail without receiving outside assistance, in 4 days, 5 hours, 25 minutes, a record at the time. Popov (34) died August 7, 2012 of heatstroke in Death Valley, California, during a solo training run started at 2 pm. Popov was attempting to run across Badwater Basin, a distance of approximately 6.25 miles. No marked route exists between the two locations. Popov began his run with four 16-ounce bottles of ice water. Popov misjudged his route, lengthening his time in the 123° heat. He reached the other side, 6 miles south of his intended destination, and at 4:30 he was found lying on the side of the asphalt. He was conscious but delirious and combative. His condition worsened. When paramedics arrived, they were unable to revive him.[17]

Lightning[18]

Arizona is world renowned for its spectacular lightning displays. The National Lightning Detection Network (based in Tucson, Arizona) monitors all lightning strikes that occur over the continental United States. The average number of strikes in Arizona between 1996 and 2005 was over 600,000 per year.

Lightning can occur with storms at any time of the year in Arizona, but the summer monsoon season (July through September) is when the state experiences most of its thunderstorm activity. See Figure 5.11 on the next page.[19]

[17] `http://www.outsideonline.com/outdoor-adventure/running/trail-running/Michael-Popovs-Last-Run.html?page=all` accessed September 18, 2012.
[18] This section is based on References [Crimmins] and [NOAA].
[19] This image was downloaded from `http://www.scenicreflections.com/media/380558/ARIZONA_DESERT_LIGHTNING_Wallpaper/`.

Figure 5.11. Lightning strikes in Arizona

Lightning is very dangerous. It is the number two weather-related killer in the United States killing an average of 73 people per year. Nine lightning related deaths were recorded in Arizona between 1997 and 2006. Lightning leaves many victims with permanent disabilities. While a small percentage of lightning-strike victims die, many survivors must learn to live with very serious lifelong pain and neurological disabilities.

It is possible to estimate how close the lightning is by counting the seconds from when the lightning flash is seen until the thunder boom is heard. It takes thunder about 5 seconds to travel one mile from the originating flash. Thus, a count of 5 before hearing the boom means that the lightning is approximately 1 mile away. (10 seconds = 2 miles, 15 seconds = 3 miles, ...). If thunder is heard inside 30 seconds, then lightning is very close and dangerous. Take shelter and wait out the storm.

If anyone is working outside and they hear thunder or see lightning they should seek shelter immediately. A house with wiring and plumbing offers the greatest protection against a lightning strike. Stay away from electrical appliances, corded telephones, and plumbing during the storm. If housing is not nearby, seek shelter in a vehicle with a metal roof. The metal body of the vehicle provides a path to conduct electricity away from the occupants in the case of a strike. Sheds, picnic shelters, tents or covered porches do not protect from lightning strikes.

When there is no shelter, avoid open areas. Do not be the tallest object in the area. Stay away from isolated tall trees, towers or utility poles. Lightning tends to strike the taller objects in an area. Stay away from metal conductors such as wires or fences. Metal does not attract lightning, but lightning can travel long distances through it. People in a group should spread out. While this actually increases the chance that someone might get struck, it tends to prevent multiple casualties, and increases the chances that someone could help if a person is struck.

What to do if someone is struck by lightning

- Lightning victims do not carry an electrical charge, are safe to touch, and need urgent medical attention. Cardiac arrest is the immediate cause of death for those who die. Some deaths can be prevented if the victim receives the proper first aid immediately.
- Call for help. Call 9-1-1 or an ambulance service.
- Give first aid. Do not delay CPR if the person is unresponsive or not breathing. Use an Automatic External Defibrillator if one is available. See Figure 5.12 on the next page.[20]
- If possible, move the subject to a safer place. Lightning can strike twice. Do not become a victim.

[20] Photo credit to Owain Davies.

Figure 5.12. Automated External Defibrillator (AED), open, charged and ready for use

Section 5.4
Altitude Related Hazards

Snow Blindness

Snow Blindness is a temporary eye damage caused by reflected sunlight off snow or other highly reflective surfaces. This typically occurs at high altitudes. It is important to wear sun glasses with UV protection to prevent Snow Blindness from occurring.

Signs and Symptoms of Snow Blindness include:

- Tearing.
- Eye pain.
- Eye redness.
- Headache.
- Swelling around the eyes.
- Halos in vision.
- Hazy vision.
- Temporary loss of vision.

Symptoms may not present until up to 12 hours after exposure to UV light. The subject should seek medical help for treatment of Snow Blindness.

Acute Mountain Sickness (AMS)

AMS or Altitude Sickness is caused by exposure to low oxygen levels at high altitudes. This commonly occurs above 8000 feet but can occur as low as 6500 feet elevation. Less than 10% of people are affected by AMS for short duration trips above 8000 feet. Symptoms present as flu-like and often are described as feeling like a hangover. Symptoms usually present themselves six to ten hours after ascent and generally subside in one to two days.

Signs and symptoms of Acute Mountain Sickness:

- Headache.
- Fatigue.
- Nausea and vomiting.
- Dizziness.
- Insomnia.
- Nose bleed.
- Shortness of breath.
- Swelling of the extremities.

High Altitude Pulmonary Edema (HAPE)

HAPE is a more severe case of altitude sickness and is presented with fluid in the lungs. HAPE can progress rapidly and is often fatal.

Signs and symptoms of High Altitude Pulmonary Edema:

- All AMS signs.
- Symptoms similar to Bronchitis.
- Persistent dry cough.
- Fever.
- Shortness of Breath.
- May result in Death.

High Altitude Cerebral Edema (HACE)

HACE is also a more severe form of altitude sickness and is presented with fluid in the brain. HACE is a life-threatening medical emergency which can lead to coma or death.

Signs and symptoms of High Altitude Cerebral Edema:

- Headache that does not respond to pain medications.
- Unsteady gait.
- Unconsciousness.
- Increased nausea.
- Retinal hemorrhaging.
- May Result in Death.

The risk of altitude sickness can be reduced or eliminated by ascending slowly and allowing the body time to acclimatize to the thinner air. Avoid strenuous activity such as hiking and searching in the first 24 hours at high altitudes. Dehydration can increase risk of altitude sickness so stay hydrated and avoid drugs, alcohol, and tobacco.

Rapid descent may alleviate symptoms of altitude sickness. Subjects should seek medical help as soon as the more severe HACE and HAPE symptoms present themselves or if the AMS symptoms last longer than two days.

CHAPTER 6

Risk Management

Section 6.1
Risk Assessment

Do you accurately understand the risks that rescuers are exposed to during a search operation?

Tragically, many accidents in search and rescue operations are the result of a failure to adequately identify and manage risk. This chapter will provide some tools to assess and manage risk during SAR operations. Applying these concepts may very well save a life.

Risk management is a process that should be ongoing. The key steps in the process are shown in Figure 6.1 starting with Situational Awareness.

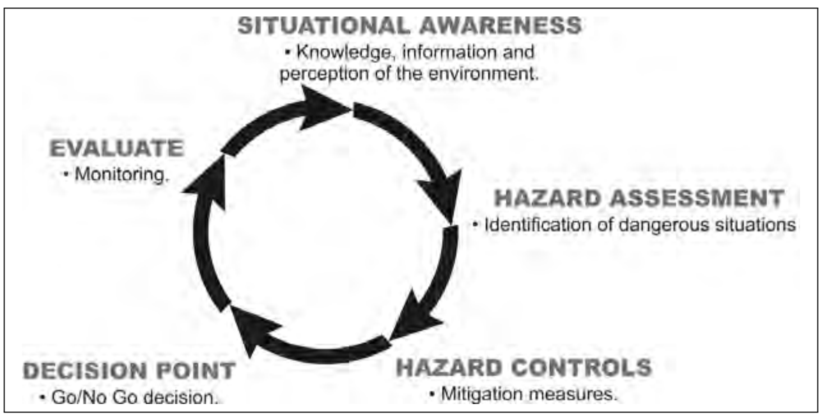

Figure 6.1. The Cyclic Process

Once a Risk Management Cycle is completed the cycle should start again to ensure that personnel are maintaining their situational awareness with updated information.

Section 6.2
Situational Awareness

Situational Awareness is the ability to continuously analyze information coming in and constantly update your mental model of the situation. This is a critical skill for emergency responders. Many times responders get initial incident information from Dispatch and begin to formulate a plan to deal with the incident based on that information only to find a different situation when responders arrive on scene. It is crucial that responders are able to recognize that the conditions have changed from the initial impression and compensate for those changes.

A lack of situational awareness has been cited in many accidents as a contributing factor. Under stress it is sometimes hard to take in new information, analyze it, and update the mental image of the conditions. The following are some actions that prevent the loss of situational awareness.

- Actively question and evaluate the mission progress.
- Analyze the situation.
- Update and revise the image of the mission.
- Use assertive behaviors when necessary:
  - Make suggestions.
  - Provide relevant information without being asked.
  - Ask questions as necessary.
  - Confront ambiguities.
  - State opinion on decisions/procedures.
  - Refuse unreasonable requests. IT'S OKAY TO SAY NO!

Section 6.3

Communications

Communications are essential during a SAR mission. Personnel rely on both their communications equipment and their personal communications skills to convey important information. Without good communications the mission can rapidly degrade and responder safety can be jeopardized.

SAR personnel have the following communications responsibilities:[1]

1. Brief others as needed.
2. Debrief your actions.
3. Communicate hazards to others.
4. Acknowledge messages.
5. If you don't know, Ask. Clarify ambiguities before proceeding.

Radio/Phone Communications

Effective incident communications must be established before operations get underway. There are several issues that should be considered when establishing incident communications.

- Pre-plan communications in response areas especially areas that are known to cause communications difficulty.
- Brief incident personnel on established communications plans and protocols.
- Use adjacent agency radio frequencies to expand incident coverage.
- Use long range (high gain) portable radio antennas.
- Use ground-to-air radios.
- Use amateur radio to supplement agency radio communications ability (requires properly licensed personnel).
- Deploy human relays or portable repeaters.
- Use satellite phones.
- Use satellite tracking/messaging devices.

[1] See Reference [NIFC-IRPG, page ix].

Section 6.4

Personal Preparedness

It is a fact that some people do not belong in SAR operations. SAR personnel must be evaluated for fitness and readiness to respond to SAR incidents. Capabilities must be matched with appropriate tasks.

When evaluating personnel for assignment on a SAR mission the following items should be considered.

- Physical fitness.
- Mental fitness.
- Equipment and Clothing.

The Incident Commander must be ready to demobilize personnel who are not fit for the mission.

Section 6.5

Aviation Operations

Within the limits of safety, weather, and performance capability, the helicopter and fixed wing aircraft can be valuable resources in SAR operations. It is vital that these resources be applied appropriately. Discipline is required of rescuers to not let the urgency of the situation overwhelm their judgement. Flight operations must be conducted in accordance with applicable FAA Regulations and agency policy. The nature of search incidents requires a higher degree of vigilance of SAR personnel during responses to unimproved helispots.

Case Study—Navy Helicopter Crash, Granite Dome, California

A military helicopter crashed on July 8, 2001, during a search for 28-year-old Eric Tucker in the Emigrant Wilderness of the Stanislaus National Forrest. See Figure 6.2 on the next page. "Longhorn 1", an HH-1N Huey from Fallon NAS (NV), was in the process of transporting personnel and equipment to a radio relay site on Granite Dome. All six persons on board escaped with light to moderate injuries. There was a "loss of control" as the aircrew attempted to land on the 10,322 foot summit of Granite Dome.[2] The accident was a result of the aircraft being over its allowable gross weight for the altitude of the mission.

Twelve standard aviation questions that could save your life

1. Is this flight necessary?
2. Who is in charge?
3. Are all hazards identified and have you made them known?
4. Should you stop the operation or flight due to:
   - Communications?
   - Weather?
   - Turbulence?
   - Personnel?
   - Conflicting Priorities?
5. Is there a better way to do it?
6. Are you driven by an overwhelming sense of urgency?
7. Can you justify your actions?

[2] See Reference [Scharper].

Figure 6.2. Navy helicopter crash, Granite Dome, CA

8. Are there other aircraft in the area?
9. Do you have an escape route?
10. Are any rules being broken?
11. Are communications getting tense?
12. Are you deviating from the assigned operation or flight?

WHEN IN DOUBT—DON'T!

Case Study—State Police Helicopter Crash, Santa Fe, New Mexico

On June 9, 2009, a New Mexico State Police Agusta A109E crashed during the attempted rescue of an uninjured hiker near Santa Fe Baldy Peak 12,632 feet, which is northeast of Santa Fe, New Mexico. Instrument meteorological conditions prevailed when the helicopter impacted terrain, killing the 46-year-old pilot and female subject. The pilot and police spotter had landed after locating the search subject just before dark. Dispatchers had directed the helicopter crew to the missing hiker, as they spoke with her by cell phone. While the pilot hiked off from the landing zone to reach the subject, the weather deteriorated and began sleeting. The pilot returned carrying the hiker on his back. After becoming airborne, storm clouds closed in around the helicopter. Based on radio transmissions, the pilot reported "*we hit a mountain*", and continued to fly for at least one minute. The helicopter impacted terrain and rolled 800 feet down a steep talus slope. The deteriorating weather conditions were known in advance and the helicopter response lacked a formal mission briefing between all personnel involved. The incident commander had not dispatched and was not in operational control of the helicopter during the mission. The flight crew was not prepared with adequate survival equipment to remain at the landing zone overnight. A late season snowstorm hampered rescue efforts and the spotter, who was the sole survivor, was not located until the following day.[3]

[3] See Reference [Ledwidge, page 3].

During an escalating SAR operation, responders may be tempted by the urgency and mission tempo to take shortcuts with personal safety. A lack of "operational control" of aviation assets on a SAR incident can allow this dangerous condition to develop. It requires professional discipline to not allow turning rotors to let poor decision-making occur. Some common hazards associated with helicopter missions include crew fitness, distraction, mission focus, communication, weather, takeoff or landing weights, landing areas, other aircraft, wires and other obstructions.

Aviation user checklist[4]

- Pilot is qualified and current for aircraft type and mission?
- Aircraft approved for mission?
- "Flight Following" in place or Flight Plan filed?
- Personal Protective Equipment-available and worn by all passengers and pilot?
- Pilot briefed on mission objectives, flight parameters, known hazards, and aerial hazard map?
- Pilot has provided a briefing to passengers?

Flight Following

"Flight Following" is the task of maintaining contact with specified aircraft for the purpose of determining en route progress and/or flight termination. It involves positive control and position reporting of deployed aviation assets. This is a key component in aircraft mission safety and, regardless of whether it is performed by a dispatch facility or at a remote location in the field, it must be given a high priority.

Identification of Flight Following requirements.[5]

- When the flight is planned, Flight Following requirements should be clearly identified.
- Requirements should identify check-in procedures, including time and locations, dispatch office(s) or other flight following facilities involved, individuals responsible for Flight Following, frequencies to be used, and any special circumstances requiring check-ins (for example, to military facilities within Special Use Airspace).
- Check-ins must be documented and provide enough information so the aircraft can be easily located if it is overdue or missing.
- Identify that the Flight Following facility shall implement response procedures for overdue or missing aircraft.

The four M's of aviation risk assessment

- Method—Appropriate method for the task?
- Medium—Safe working environment for the aircraft?
- Man—Adequate trained personnel to manage the aircraft? Pilot carded?
- Machine—Aircraft carded? Task within performance limitations of the aircraft?

The concept of Crew Resource Management (CRM), where each member of the aviation operation assumes a pro-active and responsible role in the safety of the mission, needs to be promoted and adhered to. Team members must be encouraged to speak up and provide relevant information without being asked.

When employing Department of Interior and USDA-Forest Service carded aircraft, all personnel are required by national policy to wear personal protective equipment including flight helmet, Nomex®

[4] See Reference [NIFC-IRPG, page 51].
[5] See Reference [NIFC-IRPG, page 56].

clothing, leather boots and leather or Nomex® gloves. See Figure 6.3. The Interagency Helicopter Operations Guide (IHOG) is an excellent reference for employing federal land management agency helicopter assets as well as non-federal rotorcraft during SAR operations. The complete Guide is available on-line.[6]

Figure 6.3. Nomex® flight suit and gloves

The single most important management action that an incident commander can take when they have aviation assets assigned to an incident is to dedicate a properly trained individual to manage air operations. This dedicated oversight will be worth the effort and peace of mind.

Section 6.6

Vehicle Operations

Motor vehicles are operated on a near constant basis, providing recurring exposure to a hazard that can easily be normalized. According to NIOSH, "*roadway crashes are the leading cause of occupational fatalities in the U.S.*"[7]

Case Study—Outside Joshua Tree National Park, California

On Saturday July 17, 2004, two volunteer members of the San Gorgonio (CA) SAR Team died in a motor vehicle accident, while traveling to a search assignment at Joshua Tree National Park (CA). As five team members drove through the town of Morongo Valley at 5 a.m., a Ford Ranger pick-up truck heading west on State Highway 62, a four-lane highway, veered into oncoming traffic and struck the marked suburban carrying them. As a result of the collision, Mr. Scott Johnston, age 30, SAR Tech. II, team member for five years, was pronounced dead at the scene. Philip Calvert, age 58, SAR Tech. II, team member for 12 years, sustained major injuries and subsequently died of those injuries. Three additional SAR members were in the vehicle and they received minor to moderate injuries. The driver of the other vehicle was arrested for driving under the influence. The search subject, 17-year-old, Eric Sears was found deceased one week later.[8]

While this type of accident may not immediately appear preventable, it truly underscores the personal risk involved with an activity that is performed on a routine basis. Additionally any vehicle

[6] See Reference [NIFC-IHOG].
[7] See Reference [NIOSH].
[8] See References [Lehman] and [Ohlfs].

operation conducted in an emergency response (lights and siren) mode dramatically increases personal risk.

Case Study—Oceano Dunes State Vehicular Recreation Area, California

A SAR volunteer was killed on May 24, 2009 during an emergency response at Oceano Dunes State Vehicular Recreation Area in San Luis Obispo County. Christopher Meadows, 24, was part of a team responding to an accident at the state park south of Pismo Beach. The Honda ATV quad he was operating flipped due to the "*unsafe speed for descending a sand dune*" and landed on top of him after an almost sheer drop of about 30 feet. According to the California Highway Patrol, which investigated the accident, a 4-wheel-drive ambulance behind Meadows wasn't able to stop completely before hitting the downed ATV and Meadows. Meadows had been a SAR volunteer for one year and was employed as a full-time EMT with the ambulance company, whose vehicle struck him.[9]

To operate an emergency vehicle in the emergency response mode, a responder must have completed a formal Emergency Vehicle Operations Course (EVOC) or agency accepted equivalent. All emergency vehicle responses must be carried out in accordance with agency policy and applicable state laws.

Recurring incident safety briefings and tailgate training sessions are an effective means to promote safe vehicle operations.

Section 6.7

Incident Safety Analysis

During an extended search incident the safety officer prepares an incident safety analysis in conjunction with the operations section chief. This formal analysis reviews the planned tactical work assignments in the next operational period, lists the known safety hazards, and identifies the associated mitigation strategies being put in place to reduce the operational risk. The safety officer employs the ICS 215A Form (Incident Safety Analysis). Part of a completed ICS 215A Form is shown in Figure 6.4. The completed ICS 215A is reviewed during the planning meeting. The information from the

Incident Safety Analysis

WORK ASSIGNMENTS	HAZARDS				MITIGATIONS			
	Dehydration	Hazardous footing	Fatigue	ATV operations	Emphasize hydration and provide water resupply for personnel	Awareness of footing, safe route selection and good footwear.	Crew rest monitored. Adequate backup resources. Work breaks enforced.	Follow established agency ATV operations policy.
DIVISION A-Ground search assignments.	X	X	X		X	X	X	
DIVISION B-ATV patrols.	X		X	X	X		X	X

Figure 6.4. Completed ICS 215A Form

[9] See Reference [Wenner].

Incident Safety Analysis is then incorporated into the written incident action plan by the Safety Officer as a detailed safety message or a specific written plan for an assignment. Examples of a Search Incident Safety Message and a written Rock Fall Mitigation Plan—written by the NPS—are shown starting on the next page.

Additionally the Safety Officer has the authority to suspend or terminate operations immediately if operations are found to be dangerous to personnel. There is only one Safety Officer assigned to an incident. However they may have assistants, as necessary. In fact, on any mission or training, everyone is a safety officer and can stop any unsafe or questionable actions.

Top SAR-specific hazards and training opportunities

- Personal Protective Equipment (PPE).
- Critical Personal Communications.
- Emergency Vehicle Operations and Scene Safety.
- Patient Lift and Moving Techniques.
- Environmental Exposure.
- Body Substance Isolation Procedures.
- Tool and Equipment Safety.
- Fall Prevention and Protection.
- Personal Health and Fitness Testing.

FINALLY, BEFORE YOU HEAD OUT...

It is the subject's emergency—not yours! Be a professional and do not sacrifice personal safety. There are folks at home who want everyone to return. This is a job—no one needs to die doing it.

Search Incident Safety Message

Our Top Priority Is The Safety And Health Of All Incident Personnel In The Search Area. The safety and health of all personnel shall be accomplished by strict planning in the development of individual assignments. Do not complicate the ongoing incident response with an accident. If you identify a safety issue and can address the situation, then FIX IT! If you are unable to correct a problem, notify your Division/Group Supervisor immediately.

Personal Preparedness: Be rested. Be alert. Stay hydrated by drinking plenty of fluids. On field search assignments be prepared to stay overnight by having enough food, water and personal items with you.

- Be prepared for the known and unknown.
- Use sunscreen.
- Have rain gear ready.
- Wear proper clothing and personal protective equipment (PPE) for your assignment.

Weather: This is the monsoon season which is usually characterized with clear mornings and afternoon thunderstorms. Intense rain, flash flooding, and lightning is possible during this time of year. Be prepared with appropriate clothing.

- Remember while searching in drainages stay alert for potential flash flood.
- Again, protect yourself from the heat, and direct sunlight. Do this by wearing proper clothing, sunscreen, hat and of course drinking plenty of fluids.

Communication: Communication and coordination between all personal is essential. All incident personnel must have access to a radio to communicate through the chain of command. Keep radio transmissions concise and clear using plain text.

Vehicle Safety:

- Avoid distractions to driving and adhere to posted speed limits.
- Seatbelts in use by all occupants.
- Driver is rested or takes breaks as necessary.

Aviation:

- Ensure personnel receive safety briefings and are qualified for the required mission.
- Keep Air Operations involved in planning and updates that change focus of incident.
- Avoid aerial search assignments that involve flying into the sun.
- For over-water assignments, complete a water ditching briefing in advance.

River Operations:

- Search personnel will wear PFD and helmet when operating within ten feet of swiftwater.
- Ensure personnel are qualified for river rescue operations.
- Be alert to the location and activities and all personnel in your group.

Operational Mindset:

- "SPEAK UP" if you do not understand an assignment, feel you're not qualified for an assignment, or feel something is "just not right".
- **Maintain Your Situational Alertness At All Times.**

Rock Fall Mitigation Plan

Helmets to be worn at all times when in areas of rockfall or while in technical terrain.
MINIMIZE YOUR EXPOSURE.

- Take breaks in a safe location.
- Complete the task with the essential personnel required and depart the hazardous zone as quickly as possible.

Preplan your reaction to rockfall.

- Yell, *"rock!"*
- Don't look up.
- Protect your spine with your hand cupped to the back of your neck.
- Minimize you profile—hug the cliff or use available natural protection for cover and safety.

Rappel or ascend a cliff face by means of a clean route.

- Remove potential debris along rope path above cliff.
- Scout in advance with a critical eye.
- Mentally project and ask yourself, *"what potential rockfall exists at this location?"*
- Clear away loose debris near a cliff edge or rope pathway in advance.
- Try to position the rope to pass over a barren edge or slick-rock edge.
- Employ a natural high directional (for example, tree) close to the cliff edge, which will minimize critical rope contact.

Avoid having a rope pendulum along the cliff edge.

- Personnel that must remain "on belay" below a cliff may need to establish a separate fixed safety line, which permits them to traverse safely.

Avoid standing directly beneath someone who is rappeling or ascending.
Remain motionless while someone passes beneath you or is working below you.

Working on a slope

- Avoid placement or positioning of personnel directly below one another.
- Stage multiple personnel in a diagonal pattern if possible.
- If necessary to be in the fall line—work close together rather than far apart.

Traveling on/across slopes

- Step on uphill side of a rock.
- Lift your feet and place them deliberately when walking on talus.
- Rig your gear/pack to prevent dangling tripping hazards.

CHAPTER 7

Wilderness Survival

In 1719, Daniel Defoe created Robinson Crusoe and popularized the notion that living off the land on a deserted island is an admirable ambition. Recently though, television reality series such as Survivor rekindled that adventurous spirit in many.

The reality is, television is not reality. Surviving a crisis outdoors is neither glamorous nor fun. Ask anyone who has had to deal with it and made the hard choices of survival first hand—they do not want to repeat the ordeal. In a real survival situation, all that people think about is getting back to safety, as fast as possible.

A SAR team member may be asked to perform tasks in hostile environments such as the hot Sonoran desert summer or the high mountain Alpine winters. A task can easily turn into a survival situation so it is important for all SAR personnel to recognize when they are in a survival situation and the steps they can take to ensure their personal survival as well as their team's and, potentially, the subject's survival. Understanding the survival situation also helps place the SAR team member in the subject's shoes helping them to better understand what may have happened to the subject.

Basic Human Requirements to Survive

The basic physiological requirements for a human to survive are air, water, food, and shelter. It is commonly suggested that the average person can survive three minutes without air, three days without water, and three weeks without food. The human body can do extraordinary things in its struggle to survive but the SAR team member should keep in mind the 3–3–3 rule both when considering the possible survival of a search subject and of themselves and their team if placed in a potential survival situation.

> *It is commonly suggested that the average person can survive three minutes without air, three days without water, and three weeks without food.*

Depending on the time of year and the location the SAR team member finds themselves in, a shelter may be the most important—excluding air—of the four basic physiological requirements to sustain life. Whether in the Sonoran desert summer or the alpine forest winter, shelter is the first thing needed in a survival situation.

What is a shelter designed to do? Shelter is going to protect the team member's body from the number one outdoor killer, exposure. Exposure is a condition resulting from exposure to extreme weather and temperatures. A mild form of exposure is sunburn, while more severe cases end in Hypothermia (the fall of the body's core temperature), or Hyperthermia (the rise of the body's core temperature).

There are five ways the body exchanges heat with the environment.

1. **Radiation** is the transfer of heat from your body to the environment without physical contact. Most radiation heat loss happens through the head, which is why it is important to always wear some kind of head cover. Think of a body as a chimney. Heat radiates up the body and out of the head. At 40°F the body loses up to one half of the body's total heat production. If the feet are cold, then cover the top of the chimney by putting on a hat.
2. **Evaporation** is the loss of heat from the evaporation of water from the skin and lungs. This is how the body uses sweating as a natural way to cool our core temperatures down. In cold temperatures do everything to remain dry. In hot weather evaporative cooling is helped by wetting clothing or spraying water on the skin.
3. **Conduction** is the heat exchange from physical contact. For example, if someone sits on a cold rock their body gives heat to the rock until an equilibrium temperature is gained, warming the rock and cooling the body. To reduce conduction, place an insulating barrier such as a Therm-a-Rest® pad or a thick layer of grass or leaves, between them and the rock.
4. **Convection** is the heat exchange from wind and air moving around your skin. Thermal imagery studies have shown that the body maintains a thin protective layer of heat around itself. Convection is when wind and air remove this thin layer of protection and the body has to work to replace it.
5. **Respiration** is the heat exchange when the body inhales and exhales. The body always exhales air at 98.6°F then inhales it at the current temperature, causing the body to lose or gain heat. This effect is minimized by breathing through a scarf or handkerchief.

Shelter

When considering shelter the SAR team member should always keep in mind the various types of heat exchange and how the shelter may or may not protect the body from the elements.

Types of shelter

A SAR team member may need to seek or even make a temporary shelter in order to survive a harsh summer desert day or Alpine winter night. When seeking or making a shelter always keep in mind the five types of heat exchange Radiation, Evaporation, Conduction, Convection, and Respiration. Does the shelter protect them against each one?

- **Natural Shelter**. Nature often conveniently provides natural places of shelter such as a cave, rock outcropping, overhang, depression, tree or thicket. Be careful when using a cave, do not enter a cave farther than the exit can be seen because it is easy to become disoriented and lost in deep caves or mines. Also consider that other wild life may already live in the convenient shelter nature provided. Trees and thickets can provide partial protection from wind and rain and they tend to keep radiated heat during night.
- **Bivouac Shelter**. A bivouac is a simple shelter that is easy to set up. The main purpose of the bivouac is to protect the body from Conduction and Convection types of heat exchange. To protect from conduction create an insulating mattress as a barrier between the body and the ground. This can be accomplished with a Therm-a-Rest® pad or with natural materials. Use pine needles, leaves, grass, reeds and other soft plant materials to make a mat. Then to protect from Convection cover the body with black plastic trash bags, a reflective space blanket, or more similar natural materials you used to make the mattress. The positives of the bivouac is that they are quick and easy to set up. The negatives are that they are typically not water proof nor do they allow for much movement.
- **A-Frame Shelter**. An A-Frame shelter is a little more substantial and permanent than a bivouac shelter. There are many ways to make an A-Frame shelter. Use a space blanket or black trash bags taped together with duct tape to form a large tarp. Use a stick and a piece of parachute cord to

form a central beam and drape the blanket over the top forming a tent like structure. Use a Therm-a-Rest® pad or natural materials to form a mattress to protect the body from conduction. Using natural materials, make what is commonly referred to as a debris hut. See Figure 7.1. Use logs and sticks to form a frame and then use pieces of bark as shingles or grass, leaves and pine needles for a thatched roof. If the roof is thick enough, then it is usually waterproof and has good insulation.

- **A Lean-To**. A Lean-to is a more simple form of shelter. It is simply one side of a roof or wall to a structure open on the other. Typically a lean-to is used to get out of the sun or wind. It can be used as an effective winter shelter if a camp fire is placed in front of the lean-to so the heat is captured in the structure. See Figure 7.2.[1] The lean-to can be made by draping trash bags or an emergency blanket down at an angle between two uprights or trees. A more substantial lean-to can be made with a stick frame and thatched roof similar to the debris hut. Line the inside of the lean-to with a reflective space blanket to reflect the heat of the camp fire back. Make sure to anticipate the sun angle and wind direction before deciding on the direction the lean-to should face.

Figure 7.1. Debris hut

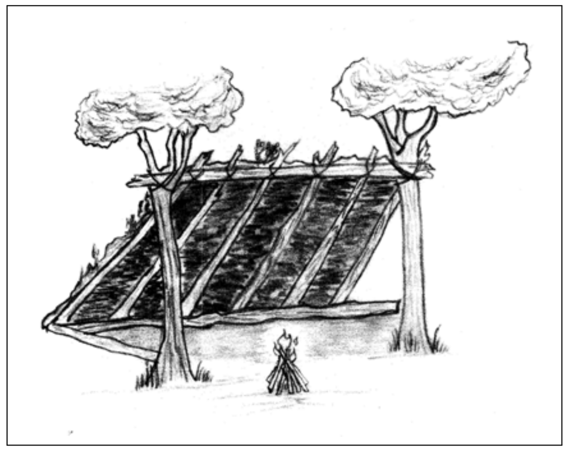

Figure 7.2. Lean-To shelter

Fire

After securing shelter a camp fire needs to be created. The camp fire does many things in a survival situation. It not only provides warmth but it also provides companionship, which has positive physiological effects and helps the survivalist remain calm and better able to reason a course of action. Fire can also be used cook food, boil water, and signal for help.

Every pack should have redundant equipment for creating fire. Consider including in the pack, a lighter, waterproof matches, ferrocerium and scraper,[2] steel wool, dry kindling, and a candle. It is easier to light a fire by using a lighter or matches to first light a long skinny candle and then use that candle to light the fire. A fire can be started with steel wool and a battery by using a 9-volt battery and contacting the wool between the positive and negative terminals. Keep some dry kindling in a dry container such as an old pill bottle. Cotton balls rubbed with Vaseline make great dry kindling when a fire is needed quickly.

Fire needs three things to burn: oxygen, fuel, and heat. Having trouble starting a fire? Consider this fire triangle and determine which of the three is missing. To ensure oxygen levels, build a fire using the

[1] Drawing courtesy of Amanda Peters-Foils.
[2] These are the so-called "flint-and-steel" fire-starters in emergency survival kits

tepee or log cabin method. See Figures 7.3 and 7.4.[3] Stack the kindling so that air can flow to the base of the fire.

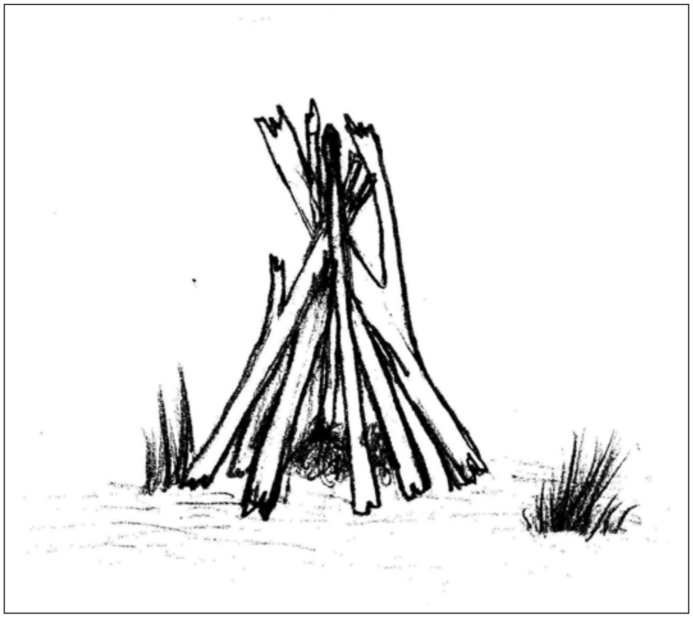

Figure 7.3. Tepee fire method

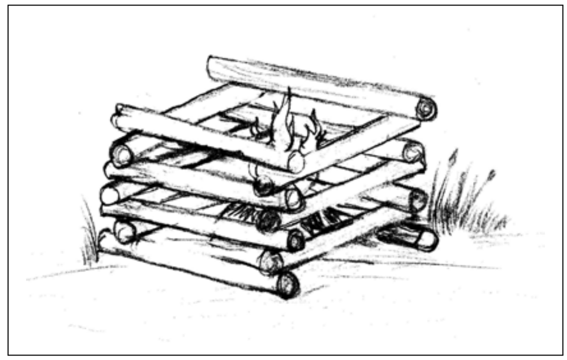

Figure 7.4. Log cabin fire method

Heat is a common problem when trying to start a fire. Make sure kindling and fuel are dry. Moisture in the fuel does not allow enough heat to generate to create combustion. Look for dry fuel under thick vegetation, under rocks, or hanging from trees and shrubs. There are many different types of fuel and kindling to consider. Each type of fuel has a different combustion level. Having trouble starting a fire? Then look for kindling with a lower combustion level. Find tiny hair-like grass, or roll plant material between the hands to break it down into small fibers. Pull the fibers apart into an airy birds nest before trying to light it. Once the birds nest is lit place it under a tepee or log cabin kindling. Start adding to the kindling small twigs, and consecutively add larger fuel as the fire grows. Soft woods such as pine burn fast and create few coals. Hard woods such as oak and ironwood burn slower and create long lasting coals.

There are two ways to signal with a fire. Adding some live green fuel to an already burning fire creates white smoke that can be seen from a long ways off on a clear day. Three fires in a triangle formation is a universal SOS symbol for any aircraft. However, it can be difficult to maintain or start three fires in time to signal a passing aircraft. If search teams are looking, then be assured they check any camp fire they locate.

As always when dealing with fire make sure to clear the area around the fire pit of any debris in a several foot radius. Line the ring with rocks to help prevent the fire from accidentally spreading and causing a forest fire. Have some water and or loose dirt near the fire in case it gets out of hand and needs to be put out quickly.

Water

Finding water in the desert

A 7.5 minute Topographic map denotes perennial and intermittent streams as well as water sources such as natural springs. On a SAR mission a team may be given a black and white copy of the area

[3] Drawings courtesy of Amanda Peters-Foils.

map. Use colored pencils to copy the water features from the main color map at base.

Even if marked on a map, in the Arizona summer water sources may not be present.

Look for lines of green vegetation such as cottonwood trees, fan palms, and willows. These plants require large amounts of water and if they are surviving, then water must be within reach. If water is not on the surface at these areas, then try digging at the base of large shade trees such as cottonwoods. Water may be just under the surface.

Dry washes may have water still flowing beneath the surface. Find a place where the wash is forced to turn because of an area of granite rock. Finding vegetation growing at the base of the rock is a good sign. Try digging a hole a few feet into the sand and dirt on the outside edge of the curve. Water is forced nearer the surface as it is forced around the curve. Leave the hole for 15 to 30 minutes. If water does not begin to fill the bottom of the hole after that, then try a different spot. After finding a hole that fills with water place a bundle of grass or reeds at the bottom to help filter out the larger pieces of sediment before collecting the water.

The base of large granite cliffs and rock formations may also have some water. As water flows down through the granite it may exit at the base of the rock or just under the surface.

Most cactus plants grow cactus fruit. All cactus fruit is edible, high in water content, fructose, and electrolytes. However, the spines or nubs must be removed before eating. Swallowing one nub irritates or swells the throat. Not a good thing to have happen in the field.

Water Purification

Even though water may be sparkling clean it may contain microorganisms which may cause various water born diseases. Typical water born diseases cause vomiting and diarrhea that accelerates fluid loss. However, most water born diseases have a gestation period of several days to a week, so in a survival situation, when faced with the choice between drinking from an unknown water source and risking water born diseases, it is best to drink the water to prevent dehydration.

There are ways to mitigate or even eliminate the risk of drinking from natural sources of water though. First filter the large chunks and sediment out of any water collected. Keeping a coffee filter in a pack works well for this purpose. A tightly bunched group of grass or reeds can also be used.

The surest way to make water safe to drink is to bring it to a rolling boil for at least 5 minutes. There are also numerous water purification systems available on the market. Most of these are 99% effective at eliminating the risks. Read the label of any system purchased. Systems and methods used include iodine tablets, bleach, charcoal water filters such as SweetWater®, and the latest method, the UV light pen that uses concentrated UV light to kill all microorganisms in the water. See Figure 7.5.

Figure 7.5. UV light pen

Food

In a survival situation remember that the body can typically go for 3 weeks without food. The body stores excess energy in fat and muscle tissue. Consuming food uses precious water in a survival situation so if water is a concern, then it is best not to eat.

A search and rescue practitioner is often expected to perform grueling tasks in some of the worst conditions and the body needs regular replenishment of energy to cells and muscles to help prevent exhaustion and fatigue. Because SAR members are expected to sustain themselves in the field for at least 24 hours they should always carry enough food for that period, and have extra food for another 24 hours in a base kit.

When selecting food for a SAR pack consider that the body needs foods high in energy. Also consider foods that can be left packed in a kit without spoiling ready to go in an emergency situation.

Dried foods such as jerky, dehydrated fruit and vegetables, granola bars, and energy bars are great sources of energy with the added benefits of being light weight and lasting a long time in a pack. The downside to dried food is that they use more water to digest. Also consider adding foods high in carbohydrates to help keep the energy level up. A peanut butter and jelly or honey sandwich is a great choice. Other good ideas are fruits such as oranges or apples, and vegetables such as carrot sticks and celery.

In case the assignment is a camp-in or if in the field overnight, add something that can make a more substantial meal. MREs (Meal, Ready to Eat), or dehydrated backpacking meals from companies such as Mountain House®, or Wise Company, Inc. are great choices.

Signaling

During the course of SAR duties a team member may need to signal an aircraft or another SAR team at some distance. Signals are audible, visual, and even smell. The purpose of a signal is to make the team member as large as possible to attract attention.

Visual signals should be made of a contrasting color to the environment. It also helps to incorporate movement into a signal. Flagging tape tied on a branch gives both contrast and movement but can be too small for aircraft to spot. Ground to air visual signals should be 20' to 30' long and contrast with the environment. The universal distress sign is three of anything. Three camp fires, three flairs, three flash lights, three whistle blasts, three gun fires, and so on. Burning rubber or plastic creates a thick black smoke. Burning green brush or wet wood creates a thick white smoke. Both can been seen and smelled at a long distance. Signal mirrors are an effective tool for signaling aircraft or other teams at a long distance. Hold the mirror in the right hand next to the eye and extend the left hand out in front with the thumb up. Use the thumb as the “front sight”.

CHAPTER 8

Personal Protective Equipment

It is incumbent on individual SAR personnel to be personally prepared for SAR missions. This includes having the appropriate personal protective equipment—PPE—to function safely and efficiently in the field.

Arizona has diverse landscapes and climate conditions making it nearly impossible to define a minimum gear list that covers all locations within the state. Each county or SAR Unit may have a specific list that meets the needs of that particular unit. When responding to another county for a mutual-aid request the requesting county may have some equipment requirements that they ask the responders to meet. This chapter aims to cover the basic categories of personal equipment that a SAR responder should address.

Basic Personal Protective Equipment

Staying safe on a SAR assignment is a top priority. Some basic recommended PPE includes appropriate headgear for the climate and environment, headlamp with spare batteries, leather gloves, safety glasses or goggles, and high visibility clothing. Other PPE may be necessary depending on the environment and assignment.

Clothing

Clothing is a critical component of personal preparedness. Appropriate clothing forms the first line of defense from the environment and may be the primary shelter material. The clothing used on SAR missions should be considered carefully. The clothing must allow for comfort and functionality. Different climates and conditions demand different clothing systems. In the winter or in wet conditions cotton clothing is unacceptable and is dangerous. In hot and dry summer conditions cotton may very well be a good material. In many cases the clothing may also be used to identify SAR responders to the public and other agencies and may need to be highly visible for safety.

Clothing should be thought of as a system that is modified throughout the task to protect the wearer. Here are some major components of a clothing system.

- Base Layer—wicking underwear of various weights depending on climate and activity.
- Insulation Layer. Serves to trap air around the body (fleece jacket, down vest, etc.).
- Outer Layer. Serves to keep the Insulation Layer and Base Layer dry and out of the wind. Items useful in the Outer Layer include water resistant and wind resistant jacket and pants.
- Extremity Protection:
    - Head Gear (hat, cap, balaclava).
    - Hand Protection (gloves, mittens).

- Foot Gear (socks, boots, gaiters).

Food and Water

SAR personnel must carry adequate food and water to sustain them during their assignment. It is a rule of thumb to carry food and water for 24 hours of unsupported activity in the field. The food must be palatable for the individual and should be high energy foods that do not easily spoil. There are a wide variety of foods acceptable for this purpose such as trail mix, Meals Ready to Eat, and jerky. Water requirements vary depending on the environment. If it is a hot and dry environment more water needs to be carried. If it is a cool and wet environment potentially less water needs to be carried as water could be replenished from sources found in the field if properly treated with purification chemicals, a filter, or boiling the water. Water containers should also be chosen carefully. Hydration bladders are popular but can be problematic in very cold conditions as the straw can freeze. The containers must be durable enough to not break under the stresses of a SAR mission.

Communications

The ability to send and receive information from the field is key component of a successful mission as well as a safety issue. SAR personnel should have a radio and spare batteries (consider a clamshell battery pack that can use AA size batteries), a cell phone, a whistle, and a signal mirror. Technology can fail at the most inopportune times so the whistle and signal mirror are important emergency communication back-ups. Additional communication equipment like a satellite emergency notification device or satellite phone may be options as well.

Tools and Equipment

SAR personnel need to carry many tools of the trade including a note pad and pencil, extra light source, batteries, fire starting kit, a knife or multi-tool, flagging tape, and duct tape. These items are important for survival, equipment repair, documenting activity, and marking routes and clues.

Shelter

Spending the night out in the field is always a possibility and having to make a shelter to get out of hazardous weather for a short period of time is more likely. A SAR pack should always contain some shelter building material such as a tarp, heavy duty space blanket, large heavy duty leaf bag, a 3/4 length closed cell foam pad, and parachute cord. A bivy sack might also be appropriate.

Medical

Part of search and rescue is caring for the subject of the search. Searchers are also likely to need to take care of themselves and their teammates. A medical kit that contains a small first aid kit, examination gloves, and personal medications should be part of the SAR pack. However, searchers should carry only those items they know how to use.

Navigation

Navigation may be the backbone of search and rescue operations. SAR personnel must be able to know where they are, where they need to go, and interpret the terrain around them to be efficient and safe in the field. Navigation equipment that should be carried includes a topographic map of the search area, an orienteering base plate compass, map tool for plotting and measuring coordinates, and a GPS.

Personal Items

SAR personnel need to be able to take care of their personal needs so that they can focus on their tasks. Personal items include toilet paper, sunscreen, sunglasses, spare glasses or contacts, and oral hygiene items.

Travel

Travel over off trail terrain and in a variety of environments may require special equipment. Depending on the environment trekking poles, in-step crampons, snowshoes, avalanche beacon and probe, and an avalanche shovel may be needed.

Climbing

If any technical climbing must be conducted as part of the assignment the proper equipment must be carried. This equipment may include a sit harness, chest harness, carabiners, belay device, and an ascending device.

Additional Items

If the assignment lasts 24 hours or longer in the field the following items should be considered.

- Sleeping Bag.
- Sleeping Pad.
- Small Tent.
- Extra Clothing.
- Additional Food and Water.
- Backpacking Stove and Fuel.
- Cooking Gear.
- Toiletries.

As always consult with your Unit or Agency for specific equipment requirements.

CHAPTER 9

Map, Compass, and Land Navigation

The backbone to effective search and rescue operations is a good foundation in backcountry navigation. SAR personnel must know where they are, where they need to go, and how to get there efficiently. Along the way clues, hazards, or other items may be discovered and the coordinates of those locations need to be collected and transmitted to others. There are a variety of technologies available to aid in backcountry navigation. A good SAR member does not rely on one technology alone but utilizes a variety of technology and techniques to navigate.

SAR members have a special responsibility to understand and use navigation effectively because SAR personnel use those skills to save lives.

In this chapter maps, compasses, Global Positioning Systems (GPS), and land navigation are discussed.

Section 9.1
Maps

If there is a choice between having a map, a compass, or a GPS as the only source of navigation information, choose the map. Good navigators often only occasionally use the compass and GPS but frequently look at the map. Maps come in different varieties and each has advantages and disadvantages. The bottom line is: never leave the Incident Command Post for an assignment in the field without a paper map of the area. GPS maps are a good tool, but if the GPS or mapping software fails, or if batteries fail, a paper map is essential as a backup, and often easier to read for a larger comprehensive view than a map on a small GPS screen.

> *Never leave the Incident Command Post for an assignment in the field without a paper map of the area.*

Map Scales

Maps come in a variety of scales and are generally referred to as small-scale maps or large-scale maps. A small-scale map provides a large overview and covers many square miles. A large-scale map provides a more detailed view of an area and encompasses a smaller area. This seems counterintuitive but think about looking at a house on each of these types of maps. On a small-scale map the house appears very small and also shows neighboring houses, whereas on a large-scale map the house would appear larger and more detail can be seen.

An example of a small-scale map is a U.S. Forest Service Forest Map, see Figure 9.1. It covers a large area with less detail. Compare that to a U.S. Geological Survey topographic map which covers a small area in much more detail. The USGS topographic map would be a large-scale map, see Figure 9.2 on the next page.

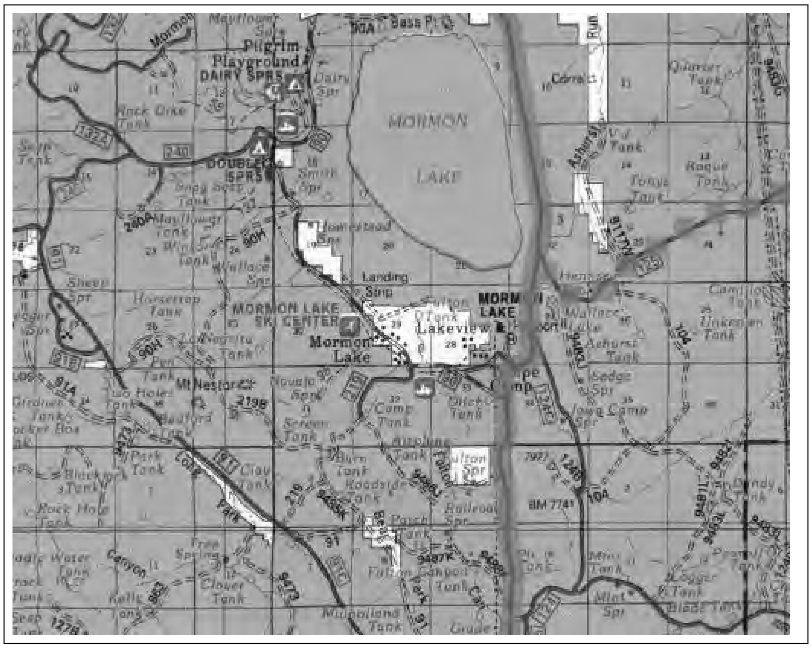

Figure 9.1. A USFS Forest Map is an example of a small scale map

There are other scales related to maps that are important. See Figure 9.3 on the next page.

1. The first is the **representative fraction**. This is usually found in the map information block. The representative fraction is the ratio of map distance to ground distance in similar units. A common topographic map scale is 1:24000. That means that one inch on the map equals 24,000 inches (2000 ft) on the ground. This information is critical to know when using various map measurement tools. Map measurement tools are generally designed for a particular representative fraction. Make sure that the tool used on a map is designed for the scale of that map or there will be measuring and plotting errors.
2. The second scale is the **graphic scale**. This scale compares map distance to ground distance in different units of measure. For example, on a typical forest service map one inch on the map equals two miles on the ground. The graphic scale may be found in the map information block or among other information in the map margin.

Map Datums

There are several different map datums in use in the United States and it is important to know the map datums for maps and make sure that the datum of the GPS units in use on the incident match the map datum used on the incident.

Simply stated the map datum is a mathematical model of the size and shape of the earth. Not all map datums agree. Suppose one cartographer believed that the earth was a cube and devised a mathematical model based on that notion while another cartographer believed that the earth was a sphere and devised a mathematical model based on that notion. A particular point on the earth would have significantly different descriptions on each of those models. While that is an extreme example it

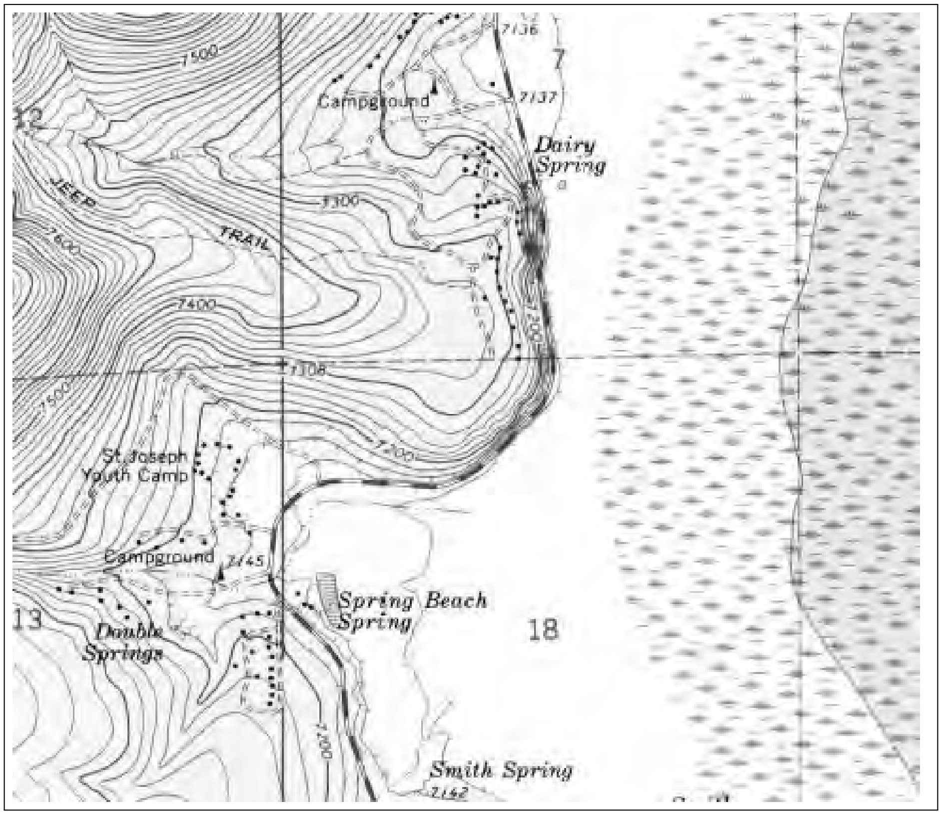

Figure 9.2. A USGS Topographic Map is an example of a large scale map

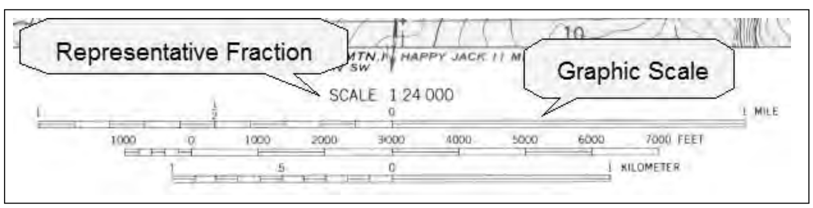

Figure 9.3. Representative Fraction and Graphic Scale

does help to understand the issue. The same location on the Earth's surface in the same coordinate system has different coordinates under different datums.

The most common map datums in use in the United States are NAD27, NAD83, and WGS84. Most older paper topographic maps and U.S. Forest Service maps used the NAD27 datum. However, newer versions of those maps are now produced using the NAD83 datum. Aeronautical charts have been using the WGS84 datum for some time. For SAR use, NAD83 and WGS84 are functionally equivalent.

For SAR use, NAD83 and WGS84 are functionally equivalent.

Traditionally the ground user who was using paper topographic maps would have been using NAD27 while aircraft were using WGS84. That certainly has created errors in transferring information about locations of objects during SAR missions. With the rising popularity of computer-based mapping programs such as MyTopo Terrain Navigator, National Geographic Topo!, and others, incident personnel can print maps in whatever datum they choose. This allows incident staff to match the datum to accommodate most of the users. For example, if SAR aviation and ground resources were going to be used on the same incident it would make sense for the ground searchers to receive topographic maps printed in NAD83 or WGS84 to be compatible with the aviation assets because they would be also using aeronautical charts and most likely would have their GPS set to one of those datums. Note that when looking at the datum list in a GPS there are several different NAD27 datums listed. The NAD27 CONUS datum should be used in Arizona and other portions of the continental United States.

A datum shift—where a coordinate is given in one datum and then plotted on a map that is in a different datum—can cause significant errors especially in canyon or mountainous terrain. Generally the errors are on the order of 0.05 to 0.15 miles in Arizona if a location was given in one of the common datums (NAD27 or NAD83) and plotted or entered into a GPS in the other datum. While those distances do not seem too great in rugged terrain it may have significant consequences (see Figure 9.4).

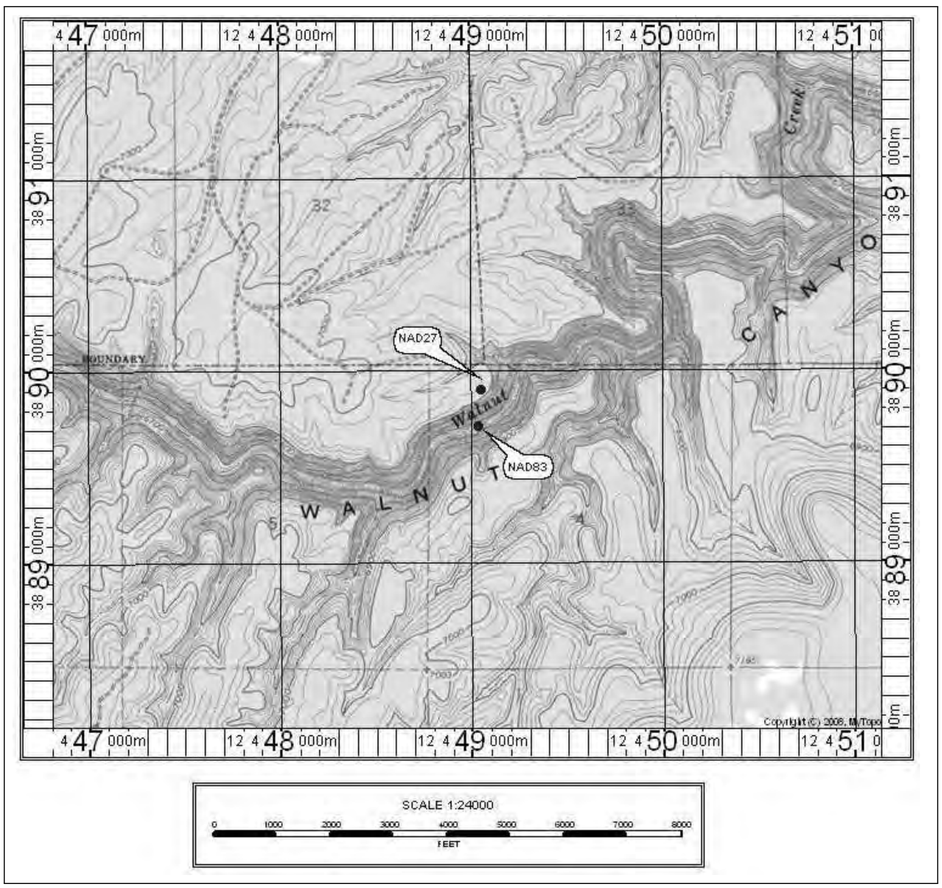

Figure 9.4. A datum shift in UTM between NAD27 (top) and NAD83 (bottom)

Map Accuracy

Maps are an accurate representation of the area at the time the map was made. As time passes features on the map may change. The most common change is development. Manmade features on maps change more rapidly than the maps can be updated. Wild fires can also cause changes to vegetation cover from the time the map was produced to the present. Because maps are made by humans they are not free from other errors such as naming errors or other notations. Finally, the declination information on the map changes with time. The declination information listed on the map may not be accurate depending on the when the map was published. The older the map publication date the more the declination information is in error. On many USGS topographic maps that have been updated using aerial photography the updated features appear in purple.

General Map Types

There are two general map types encountered in SAR, Planimetric and Topographic. Planimetric maps do not represent the shape of the land. These maps may show spot elevations and indicate the general area of canyons, rivers, or mountains with symbols or labels. An example of a planimetric map is the Forest Service map or common road maps. Topographic maps do represent the shape of the land with the use of contour lines. An example of a topographic map is the USGS topographic map, discussed in detail in Section 9.3 on page 122.

The planimetric Forest Service map is good for an overview of the area, road names and numbers, land ownership information, and other recreational information. The topographic map is good for a detailed view of the area and is more useful for backcountry navigation as those maps have land shape information, and more coordinate systems (UTM, Lat/Long, and Township and Range).

Quality maps of all types have a legend that describes the meanings of various colors, lines, and labels on the map. Map information blocks and margins contain information such as the representative fraction, graphic scale, and datum information.

In SAR, a planimetric map is used to get a large overview of the area and determine what roads to use to get to the general search area. The more detailed topographic map is then used by searchers on foot who need the terrain information to conduct ground operations. It is not uncommon to use both types of maps at the same time on an incident.

Interpreting Contour Lines on a Topographic Map

Understanding and interpreting contour lines on a topo map are essential skills for all involved in a search. This section contains a brief overview of these topics.[1]

Contour lines are a means of trying to characterize a three-dimensional object (the surface of the earth) when projected onto a two-dimensional piece of paper (a topo map).

A contour line (AKA a contour) is a line on a map that connects points of equal elevation above sea level (or some other fixed reference). So someone who follows a contour line neither loses nor gains altitude, and eventually arrives back at their starting point.

The direction perpendicular to a contour line at any point is the direction of steepest or shallowest slope of the terrain at that point.

A common way of demonstrating contour lines is by means of an egg slicer, which slices hard-boiled eggs into slices of equal thickness. See Figure 9.5 on the next page. Imagine a hard-boiled egg placed on a countertop in an upright position sitting on one end, and then sliced horizontally, without separating the slices. Viewed from above, the edge of each individual cut is the same height above the counter and so is a contour line. In fact, stepping from the top down, a sequence of contours that are circles emerges, gradually increasing in size, until halfway. Typically a contour would have a number associated with it, indicating its elevation above the countertop. So to rebuild the egg from the contours, circles are drawn at the associated elevation creating a wire grid skeleton, which is completed by adding skin, thereby approximating the original egg's surface. Notice that contour lines representing different elevations cannot touch, otherwise the point of contact would have two different elevations.

Now imagine a hill sliced horizontally with a giant egg slicer. The edges of the individual cuts are the contours. Although they are no longer circles, the contours are closed loops that are deformed circles. In the same way as for the egg, if a sequence of contours are deformed circles that increase in size as the elevation decreases, then the contours represent a hill.[2] The top of the hill is contained in the smallest contour.

[1] For general information on Basic Land Navigation see Reference [PMS].
[2] A mountain is a large hill.

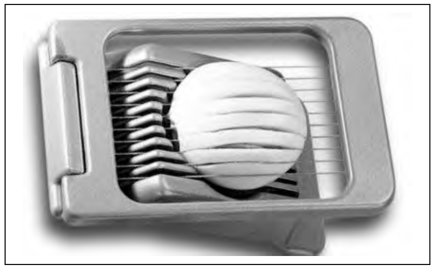

Figure 9.5. Egg slicer

If a sequence of contours are deformed circles that increase in size as the elevation decreases, then the contours represent a hill. The top of the hill is contained in the smallest contour.

Refer to Figure 9.6, which is a portion of a topo map. Look at the left-hand figure and the top of the hill contained within the contour cut by the number 3. This is identified by the letter A in the right-hand figure. On the top of this hill is a Benchmark (the small $\times$ symbol).[3] In this case the benchmark is 3818 feet above sea-level. (The units, namely feet, are identified by the map's legend, which is not shown on this portion of the map.)

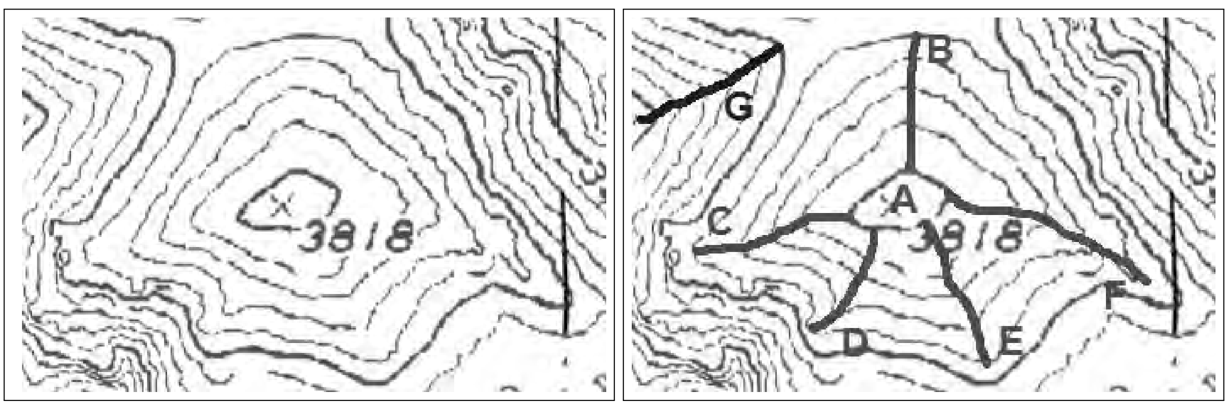

Figure 9.6. Contour Lines of a hill

Now compare a person heading due south-west from the benchmark to one heading due north, each crossing 5 contours, so they both end up at the same elevation. The one heading south-west covers less ground than the one heading north, for the same drop in elevation. This means that the terrain to the south-west is steeper than the terrain to the north. This is characterized by the closeness of the contours. The closer the contour lines the steeper the terrain. The wider the contours the flatter the terrain. No contours indicates flat terrain. Contours that are extremely close together represent steep cliffs.

The closer the contour lines the steeper the terrain. The wider the contours the flatter the terrain. No contours indicates flat terrain. Contours that are extremely close together represent steep cliffs.

[3] Benchmarks are usually metal disks set into concrete or rock in the ground. They are placed by national surveying or mapping organizations, such as the United States Geological Survey, and indicate the elevation at the benchmark.

Notice that, if both people look back, they see the same thing, namely a hill. This is true for anyone looking towards the benchmark. They each see a hill, although they may not see the summit.

Widely spaced contours at the top of a hill indicate a flat hilltop, whereas closely spaced contours at the top of a hill indicate a pointed hilltop. So the top of the hill containing the benchmark is relatively flat.

> *Widely spaced contours at the top of a hill indicate a flat hilltop. Closely spaced contours at the top of a hill indicate a pointed hilltop.*

Unlike the egg, the contours on this hill are not circles but more like diamonds, with the corners pointing in different directions. Concentrate on those parts of the contours that point north, and imagine a person standing on one of the contours at its northern corner. The terrain to the immediate left and right of the person is lower than the person's elevation, because the elevation of the region between contours is between the elevation of the two contours bounding it, and the person is standing on the higher elevation contour. Thus, if the person follows the direction of the corners from one contour to the next always heading perpendicular to the contour at that point, the person follows a ridge, and the ridge line can be estimated by joining the corners of these successive contours. This is shown in the right-hand figure with the letter B. These corners can be approximated in shape by a $\cup$ that points downhill.

Notice that there are four other ridges emanating from the summit of the hill. Counting counter-clockwise they are

1. A ridge slightly south of west of the summit. This is shown in the right-hand figure with the letter C.
2. A ridge slightly west of south of the summit. This is shown in the right-hand figure with the letter D.
3. A ridge slightly east of south of the summit. This is shown in the right-hand figure with the letter E.
4. A ridge slightly south of east of the summit. This is shown in the right-hand figure with the letter F.

The first three are very similar to the original ridge heading north, but the fourth one is characterized by a pattern of $\vee$s pointing downhill rather than $\cup$s. This means that the falloff from this ridge is much steeper than the other ridges, so it is much sharper.

> *Contour lines that appear in a pattern shaped like a $\cup$ or a $\vee$ pointing in a **downhill** direction indicate a ridge. A $\cup$ shape indicates a gentle ridge, a $\vee$ shape a sharp ridge.*

There are more $\cup$ and $\vee$ shapes in Figure 9.6 on the preceding page.

1. Between the two ridges heading southwest (ridges C and D) is a series of contours shaped like a $\cup$, but these are pointing uphill, not downhill, so they do not represent a ridge.
2. There are a series of $\vee$ shaped contours coming in from the west near the top of the figure, heading north-east, identified by G in the right-hand figure. These too are pointing uphill, not down.

In contrast to ridges, someone standing on a contour line at one of these $\cup$ or $\vee$ shapes are at a lower elevation than the terrain immediately to their left and right. This is characteristic of a valley or gully. The $\cup$s indicate a wide gully or rounded valley. In the case of the gulley identified in Item 1, it is a steep but wide gulley. Wide gulleys are often called gentle gulleys. The gully identified by the letter G is a sharp, steep valley or gully.

Contour lines that appear in a pattern shaped like a ∪ or a ∨ pointing in an ***uphill*** *direction indicate a valley or gully. A ∪ shape indicates a gentle valley or gully, a ∨ shape a steep valley or gully.*

Valleys and gullies are natural places for water to flow. Water follows steepest slopes, so it flows perpendicular to the contours.

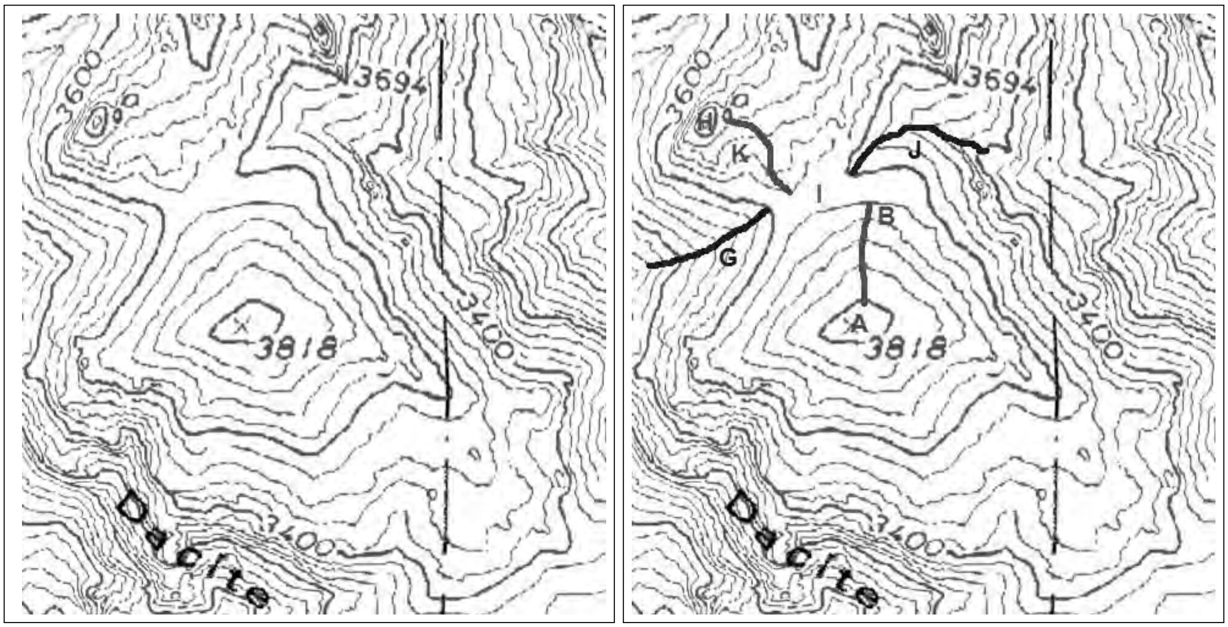

Figure 9.7. A wider view near the hill

Figure 9.7 shows a wider view of Figure 9.6 on page 109. On a typical colored topo map, the contour lines are colored brown. Usually the contours are separated by equal elevations. Some contours are darker than others, and are called Contour Index Lines. This does not make them more important, but is an aid to identifying the elevation of contours. The darker contour that starts near the top left-hand side has the numbers 3600 through it. This means that contour is 3600 feet above sea level. Following it around shows that it exits at the middle top portion of the map just after the numbers 3694. (In fact, it eventually rejoins the original contour.) The number 3600 is called a contour index.

Notice at the lower end of the 3600 foot contour, that this is the sixth contour from the benchmark. Immediately south of this is another darker contour at elevation 3400 feet. So there is a 200 foot elevation change between successive dark contours. What about the lighter contours? Well there are 4 lighter contours between adjacent dark contours, which means there are 5 segments that must contribute 200 feet, each one being 200/5 = 40 feet different in elevation. They would represent elevations of 3440, 3480, 3520, and 3560 feet. This difference is called the contour interval, and it can also be found on the map's legend.

The contour interval is the change in elevation between successive contour lines.

Looking at the top of the hill shows another dark contour, which must be 200 feet higher than 3600 feet, namely at 3800 feet. This is consistent with the benchmark of 3818 feet. Presumably the figures 3800 are not on this contour because it would add confusion to the map.

Notice to the south of the numbers 3400 near the bottom of the map, that there is another dark contour, which must be 200 feet lower than 3400 feet, namely 3200 feet. In this part of the map the contour lines are very close together, indicating a steep cliff.

There is a second hill just below the number 3600 in the top left part of the map, identified by the letter H in the right-hand figure. This hill is higher than the benchmark hill A because it not only has a dark contour, but also a lighter one inside it, so this hill is at least 3820 feet in elevation. The contour lines near the top are close together, so the top is more pointed than the benchmark hill. To its west is a very steep cliff.

Imagine walking north down the ridge B from the benchmark hill A. After 5 contours there is a large open area with elevation between 3560 and 3600 feet, denoted by the letter I in the right-hand figure. In the south westerly direction is the gulley identified earlier by the letter G. In the north easterly direction there is another gulley denoted by the letter J, so following either of these decreases the elevation. However, ahead is the hill H and walking up the ridge K increases elevation. Thus, this large open area I is indicative of a saddle. How is a saddle easily identified from contour lines? Look at the 3600 contour line again. It is the contour that contains the saddle, and the saddle occurs where the 3600 contour line pinches in on itself, looking like an hour-glass. In fact there is an elevation that, if a contour line were drawn through it, would look like a figure 8. So, in theory, contour lines can touch, but they represent the same elevation.[4]

> *A saddle occurs between two hills where a contour line has an hour-glass shape.*

Note that two hills need not be separated by a saddle—they could be separated by a gulley. Also, depending on their location, a person may see only one hill (for example, if they were south-east of the benchmark hill) or both hills (for example, if they were west of the benchmark hill).

Caution needs to be exercised when extrapolating the nature of the terrain between contour lines. In the case where contours represent elevations every 40 feet, it could happen that between any two contours there is a steep cliff 39 feet high, which circles the entire hill, and the topo map would not show it.

A final type of contour that may appear on a topo map is a line representing a closed depression, such as a crater at the top of a volcano. These contours have small tic marks perpendicular to the contour line, with the tic marks pointing downhill.[5]

> *Depressions are represented by closed contour lines that have tick marks pointing downhill.*

In Figure 9.8 on the next page there are two craters, although it may be difficult to see the tic marks on the left-hand one.

[4] Sometimes, on a topo map, contour lines that represent different elevations appear to touch. This indicates a steep, near vertical, cliff face.

[5] These tic marks are called hachures.

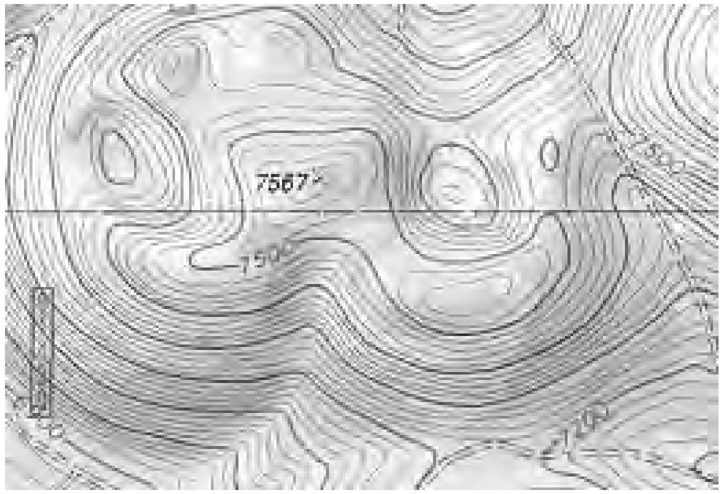

Figure 9.8. Two craters

Summary—See Figure 9.9 on the next page

- If a sequence of contours are deformed circles that increase in size as the elevation decreases, then the contours represent a hill. The top of the hill is contained in the smallest contour. Contours that are extremely close together represent steep cliffs.
- The closer the contour lines the steeper the terrain. The wider the contours the flatter the terrain. No contours indicates flat terrain.
- Widely spaced contours at the top of a hill indicate a flat hilltop. Closely spaced contours at the top of a hill indicate a pointed hilltop.
- Contour lines that appear in a pattern shaped like a $\cup$ or a $\vee$ pointing in a **downhill** direction indicate a ridge. A $\cup$ shape indicates a gentle ridge, a $\vee$ shape a sharp ridge.
- Contour lines that appear in a pattern shaped like a $\cup$ or a $\vee$ pointing in an **uphill** direction indicate a valley or gully. A $\cup$ shape indicates a gentle valley or gully, a $\vee$ shape a steep valley or gully.
- A saddle occurs between two hills where a contour line has an hour-glass shape.
- Depressions are represented by closed contour lines that have tic marks pointing downhill.

Section 9.2
Coordinate Systems

There are several different coordinate systems that are commonly used by SAR personnel. The most common are Lat/Long (Latitude/Longitude), UTM (Universal Transverse Mercator), USNG (U.S. National Grid) and Public Land Survey System (Township and Range).

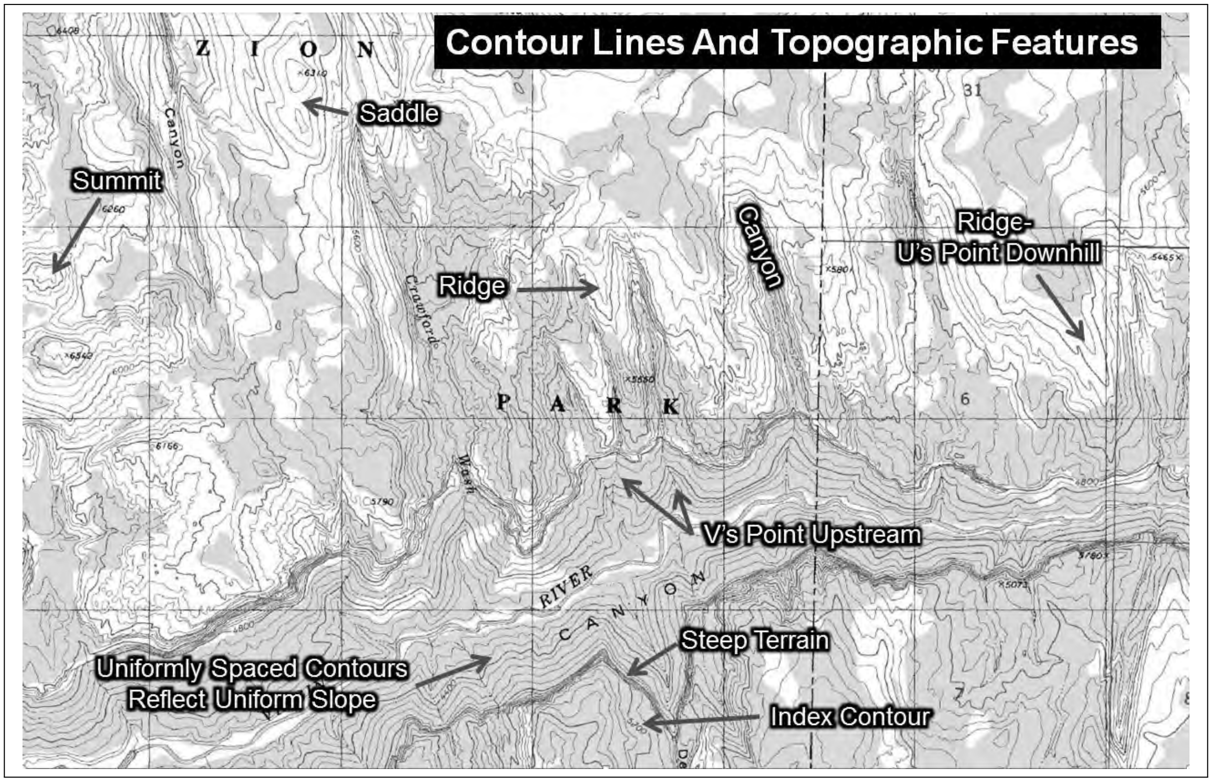

Figure 9.9. Summary

Latitude and Longitude

Latitude and Longitude, Lat/Long, is an angular coordinate system used for three dimensional objects. On a map, latitude lines are horizontal and run east and west, while longitude lines are vertical and run north and south.

Latitude lines are parallel horizontal lines. Degrees latitude are counted from 0° at the equator to 90° north at the North Pole and 90° south at the South Pole. One way to remember that latitude lines are horizontal is to think of them as the rungs of a ladder ("ladder-tude").

Longitude lines are not parallel but are widest at the equator and closest at the poles. Zero degrees longitude (0°—called the Prime Meridian) is located at Greenwich, England. The degrees continue 180° east and 180° west where they meet and essentially form the International Date Line, which is opposite the Prime Meridian. See Figures 9.10 and 9.11 on the next page.[6]

The circumference of the earth at the equator is about 25,000 miles. Dividing this by 360° makes lines of Latitude separated by 1° approximately 69 miles apart. This also holds true for lines of Longitude at the equator but as the lines get closer to the poles they get closer together. For example, at 34° N or S Longitude lines are approximately 57 miles apart,[7] while at 45° N or S Longitude lines are approximately 49 miles apart.[8]

Each of the 360° around the Earth are further divided into 60 minutes, denoted by ′, so 60′ = 1°. Each minute is further divided into 60 seconds, denoted by ″, so 60″ = 1′. Depending on different formats minutes and seconds can further be divided into decimals of tenths, hundredths, and thousandths to allow the system greater and greater accuracy of pinpointing a specific location on the globe.

[6] Downloaded from `http://ibis.colostate.edu/WebContent/WS/CitSci/Tutorials_Wisconsin/Tutorial2_Static.html`.
[7] 34° N passes through the middle of Arizona.
[8] For the mathematically inclined, the approximate distance, d, in miles between lines of longitude that are 1° apart is given by the formula $d = 22\pi \cos(\text{latitude})$.

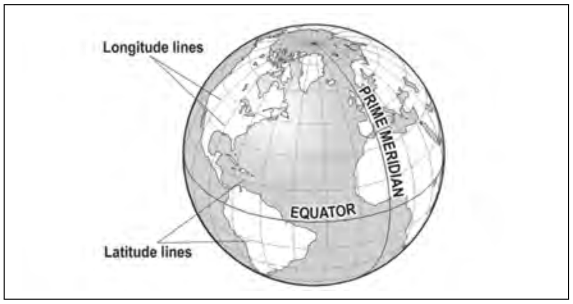

Figure 9.10. Latitude and longitude on the earth

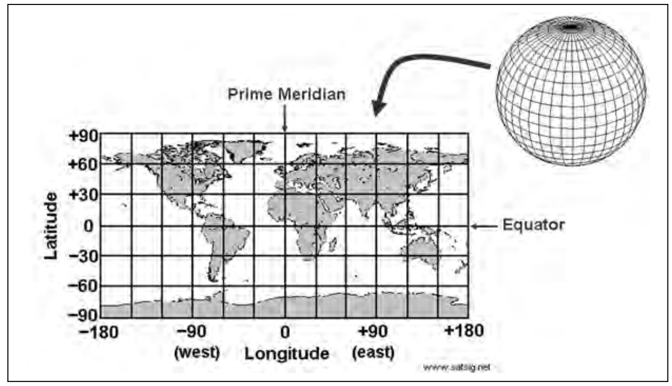

Figure 9.11. Latitude and longitude on a map

Arizona's latitudes lie between N 31° 20′ and N 37°, and its longitudes lie between W 109° 3′ and W 114° 50′.

Latitudes lines that are separated by 1° are about 69 miles apart. In view of the fact that $1° = 60'$, then one minute represents about $69/60 = 1.15$ miles, and one second represents about $69/3600 = 100$ feet. In Arizona, longitude lines that are separated by 1° are about 57 miles apart, in which case one minute represents about $57/60 = 0.95$ miles and one second about $57/3600 = 84$ feet.

For latitude,

$$1° = 69 \ miles$$
$$1' = 1.15 \ miles$$
$$1'' = 100 \ feet.$$

For longitude in Arizona,

$$1° = 57 \ miles$$
$$1' = 0.95 \ miles$$
$$1'' = 84 \ feet.$$

Common topographic maps are scaled by 1 to 260,000 (one inch on the map is equal to 260,000 inches on the ground) frequently referred to as a "*two degree sheet*". They cover about 1° of Latitude by 2° of Longitude. This map scale is best for giving an overview and are useful for activities where coverage of a large area is more important than detail. They show large areas on a single map sheet, but details are limited to major features, such as boundaries, parks, airports, major roads, railroads, and streams. To obtain more details, two degree sheet can be subdivided into four smaller quadrangles called "*one degree sheets*" covering about 0.5° of Latitude by 1° of Longitude. Each one degree sheet is broken down into eight 15 minute quadrangles measuring 15′ of Latitude by 15′ of Longitude. Finally, each 15 minute quadrangle is broken down into four 7.5′ quadrangles, also know as a USGS 1:24,000 scale map. See Figure 9.12 on the next page. The USGS 7.5′ Quadrangle is often what the SAR professional uses, where one inch on the map is equal to 24,000 inches (or 2000 ft) on the ground.

There are three different formats for expressing a location in Latitude and Longitude that can cause some confusion and location errors if one format is forced into another format that may be more familiar to the person receiving the coordinates (see Figure 9.13 on page 117).

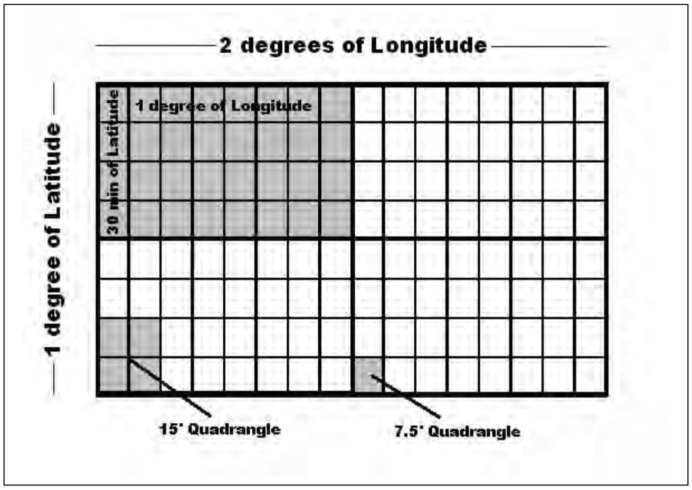

Figure 9.12. Subdividing a two degree sheet.

- Degrees Minutes Seconds—(hddd mm ss.s), which stands for hemisphere, degrees, minutes, seconds and decimal seconds.
- Degrees Decimal Minutes—(hddd mm.mmm), which stands for hemisphere, degrees, minutes, decimal minutes.
- Decimal Degrees—(hddd.ddddd), which stands for hemisphere, decimal degrees.

The letters in parentheses in this list are generally how those formats are listed in many GPS coordinate or position format menus.

Hemisphere is either North, South, East, or West and must be correctly designated; degrees are between 0 and 360; and minutes and seconds are between 0 and 60. Each location has two coordinates associated with it, latitude and longitude. The first coordinate (the latitude) has the hemisphere of either North or South, and the second coordinate (the longitude) has the hemisphere of either East or West. For example, the coordinates of Tucson International Airport in each of these coordinate systems are

- Degrees Minutes Seconds. Latitude: N 32° 7' 15.73", Longitude: W 110° 56' 14.52".
- Degrees Decimal Minutes. Latitude: N 32° 7.2622', Longitude: W 110° 56.2420'.
- Decimal Degrees. Latitude: N 32.12104°, Longitude: W 110.93737°.

Case Study—Maryland State Police Trooper 2 Accident

Coordinate forcing was a significant problem in an emergency response in the Maryland State Police Trooper 2 accident on September 27, 2008.[9] In this incident the Trooper 2 helicopter crashed on approaching Andrews Air Force Base with the crew and an auto-accident patient on board. The aircraft was equipped with position tracking equipment and the Maryland State Police dispatch center (SYSCOM) was able to monitor the location. Once it was noted that the aircraft was missing the last known coordinates were determined and SYSCOM relayed the location to Prince George's County Communications Center by reading the coordinate as "three eight five two one seven, north was seven six five two two six." The SYSCOM personnel did not indicate the format of these coordinates. Prince George's County dispatchers plotted the coordinates in the format that they were most used to, which was degrees decimal (hddd.ddddd), giving N 38.5217°, and W 76.5226°. Prince George's County sent emergency crews to that location, which was 30 miles southeast of the actual accident site. The coordinates relayed by SYSCOM were in fact in degrees minutes seconds (hddd mm ss.s) format, namely, N 38° 52' 17", and W 76° 52' 26". If the

[9] See Reference [NTSB 1].

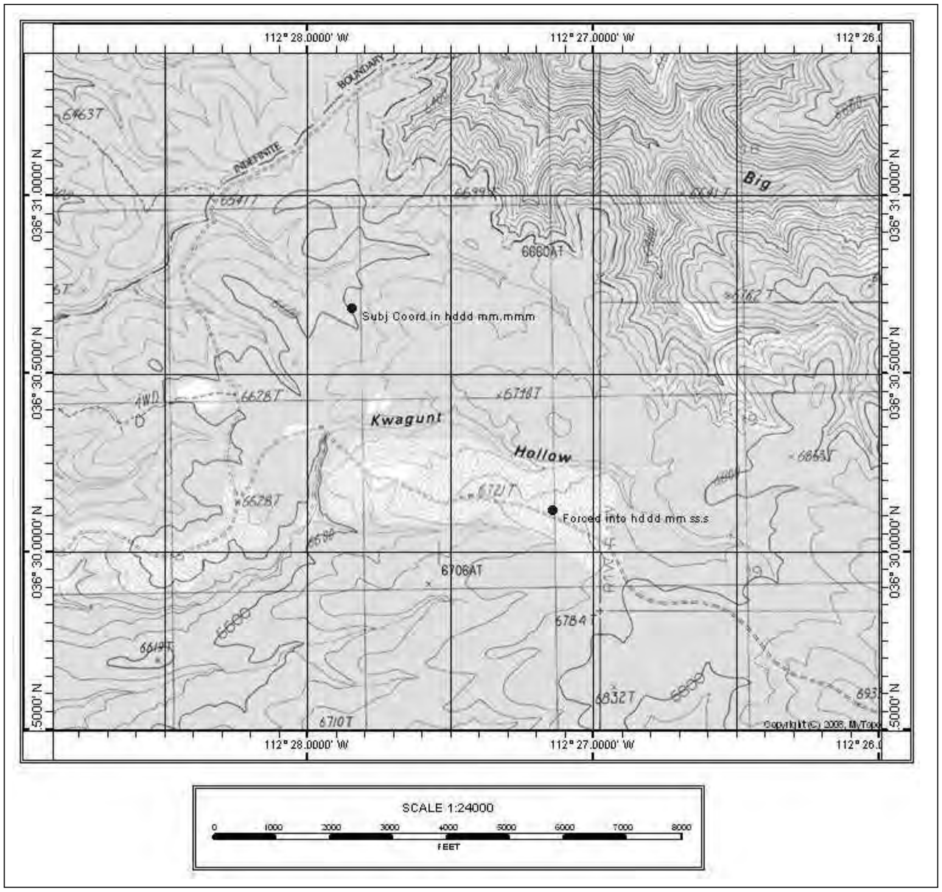

Figure 9.13. Location error when one Lat/Long format is forced into a different Lat/Long format

SYSCOM personnel had identified the coordinate format or if the Prince George's County dispatcher had asked what the format was, then the confusion about the location would not have occurred and emergency crews could have located the accident much more quickly. Furthermore, the Maryland State Police personnel that responded to the incident, excluding the SYSCOM personnel, were unfamiliar with latitude and longitude coordinates, which contributed to the difficulty in locating the accident site.

Coordinate format confusion is a serious problem and can be easily mitigated by reading the coordinates correctly, for example N 38° 52' 17", and W 76° 52' 26" should be read as "*North Thirty Eight Degrees Fifty Two Minutes Seventeen Seconds and West Seventy Six Degrees Fifty Two Minutes Twenty Six Seconds*". Reading the coordinate in this way allows the receiver to determine the format, thereby eliminating any misunderstandings. Increasingly, the notation for the hemisphere (North, South, East, and West) in Latitude/Longitude coordinates is using positive numbers for the Northern and Eastern hemispheres and negative (−) numbers for the Southern and Western hemispheres.

Universal Transverse Mercator

Universal Transverse Mercator, UTM, is a rectangular grid coordinate system designed for a flat 2-dimensional object such as a paper map. UTM divides the globe into 60 longitudinal zones that are 6° wide and are numbered from 1 to 60, and divides the globe into 20 latitude bands that are 8° wide and are labeled with letters *C* to *X*.[10] Figure 9.14 on the next page shows the UTM coordinates of the

[10] The letters *I* and *O* are not used to avoid confusion with the numbers 1 and 0. There is a separate system for the polar areas called Universal Polar Stereographic, UPS.

United States.[11]

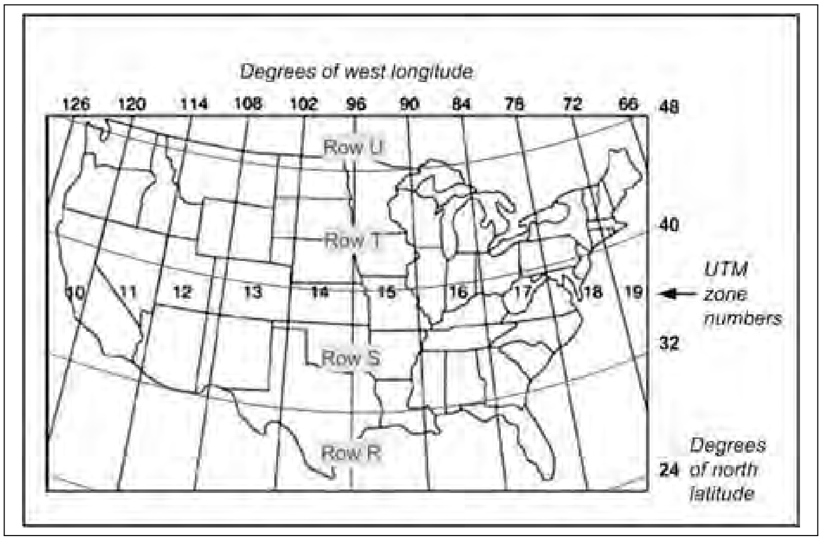

Figure 9.14. UTM coordinates of the United States

The UTM system uses meters as its measurement unit. There are three components to a UTM coordinate: the Zone, the Easting, and the Northing. The Zone refers to the longitudinal zone number and the latitudinal band letter. The Northing is the number of meters north of the equator (for areas in the northern hemisphere). The Easting number is based off of the central meridian of the UTM Zone which is given the value of 500,000 to avoid negative numbers. The Zonal boundary will not be 0 meters but the Easting value always increases moving to the east. Arizona is fortunate to lie mostly within Zone 12 but there is a small sliver of Arizona along the western part of the state that is in Zone 11. If someone travels, for example, on I-40 headed west, as they enter the Kingman area near Andy Devine Boulevard they could watch their GPS change from Zone 12 to Zone 11. When they neared the Zonal Boundary between Zone 12 and Zone 11 the value of the Easting in Zone 12 would be approximately 0226932 meters and as they crossed into Zone 11 the Easting value would be 0773069. Just as the Zonal boundary Easting value at the west end of the Zone will never be 0 the Easting value at the east end of the Zone will never exceed 999,999 meters.

The important point in using UTM is to remember that the coordinate is always read to the right and then up (easting then northing). It is helpful to remember the *ZEN* (Zone Easting Northing) of UTM when reading the coordinate. It is a good habit to always include the Zone and Latitudinal Band designator (that is, 12S) when giving a UTM coordinate especially if working near the western part of Arizona.

A typical UTM coordinate is *12S 0456908 3845897* and is read as "*Zone Twelve S, Easting Zero Four Five Six Nine Zero Eight and Northing Three Eight Four Five Eight Nine Seven*".

Because UTM is a rectangular coordinate system and it is more uniformly marked on most topographic maps (every 1000 meters on a typical USGS 7.5 minute quad) it is easy to use in the field and is becoming more popular with recreational users including SAR. Even without a map tool it is fairly easy to estimate the coordinates for a particular location. In addition the potential for error with UTM coordinates may be reduced since there is basically one format and not three different formats like there are with Lat/Long.

[11] Downloaded from `http://usmanqayyum.blogspot.com/2011_01_01_archive.html`.

U.S. National Grid

U.S. National Grid USNG, is a fairly new grid coordinate system that has been designed for use by public safety, commerce, and the general public. This grid system is an alpha-numeric point reference system that is overlaid on a UTM numerical grid system. The stated purpose of USNG is to provide an interoperable coordinate system for use by civilian and military authorities during emergency or disaster response. USNG and Military Grid Reference System, MGRS, are functionally equivalent when using NAD83 or WGS84 map datums.

Similar to UTM, the coordinates in USNG are read to the right then up. The principal difference between UTM and USNG is that USNG uses a 100,000 meter Grid Zone Designator, GZD, which replaces the first two digits in the UTM Easting and Northing coordinate strings. For example the location in UTM "*12S 0453609 Easting 3892176 Northing*" would be expressed in USNG as "*12SVD5360992176*". The "04" and "38" in the Easting and Northing respectively have been replaced by a single GZD "VD", see Figure 9.15.

USNG has different levels of resolution. A location can be described in USNG in 1 meter, 10 meter, 100 meter, or 1000 meter resolution. Using the example coordinate "12SVD5360992176", the 1 meter resolution is "12SVD5360992176", the 10 meter resolution is "12SVD53609217", the 100 meter resolution is "12SVD536921", and the 1000 meter resolution is "12SVD5392". The resolution can be determined by counting the number of digits after the GZD.

More information about USNG can be found at `https://usngcenter.org/`.

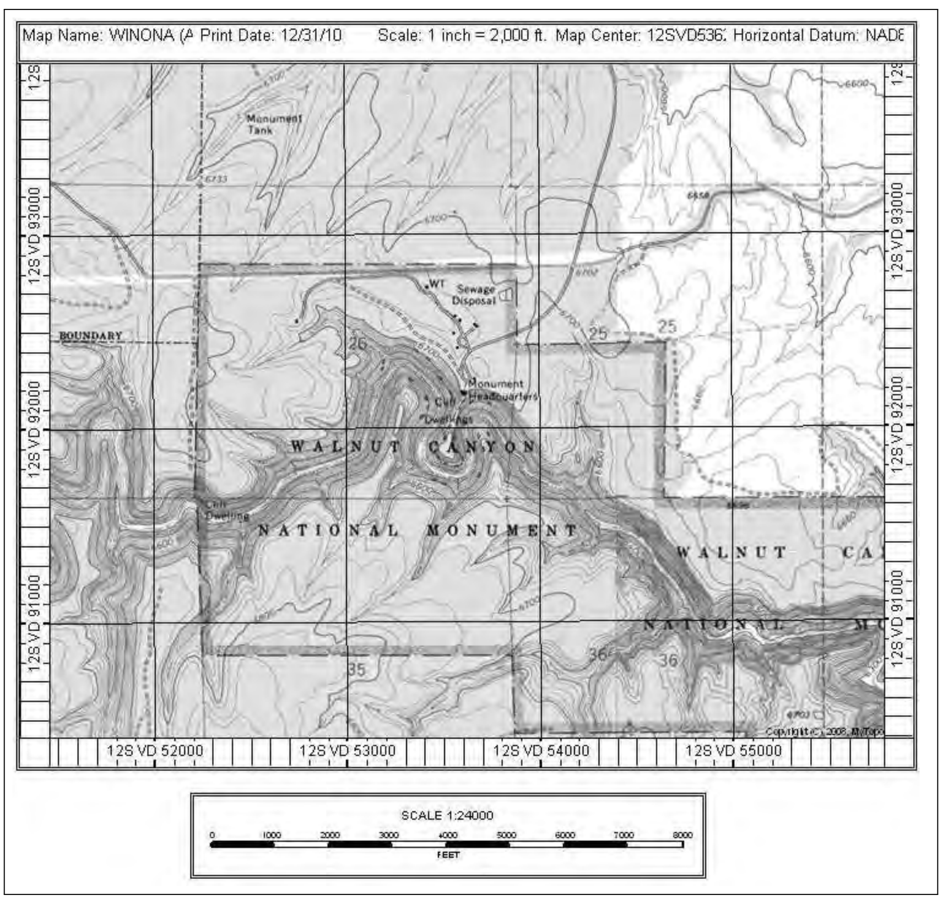

Figure 9.15. Example of a topographic map with USNG coordinate system

Global Area Reference System

Global Area Reference System, GARS, is a standardized area reference system based on Latitude and Longitude for use by military and civilian SAR. GARS divides the globe into 30 by 30 minute cells which are designated with a five character coordinate, for example 013BH. The first three digits indicate a 30 minute wide longitudinal band and the last two characters indicate a 30 minute wide latitudinal band. Each cell is subdivided into 15 minute quadrants which are numbered west to east starting at the northwest. So a particular cell would have a coordinate such as 013BH4. A 15 minute quadrant is then subdivided into 9 five minute by 5 minute keys which are also numbered from west to east starting with the northwesternmost key. The coordinate for a particular key would look like 013BH47.

More information about GARS can be found at `https://www.gocivilairpatrol.com/media/cms/Pathfinder_Articlenovdec06GARS_4CDC9DF09FFFA.pdf`.

Public Land Survey System

The *Public Land Survey System*, also known as *Township and Range*, is another coordinate system sometimes used in search and rescue and by land management agencies and is found on topographic maps and U.S. Forest Service maps. This system was designed primarily as a land survey system to divide land and is mostly used in the Western United States. While it is an area location system and not a point location coordinate system like Lat and Long or UTM it can be useful as it is the only coordinate system that can be found marked on the ground. Public Land Survey System markers are often found at section corners and are usually a brass cap with the Township, Range, and the four Sections that intersect at that location. Due to cattle ranching in the west section lines often correlate with fences to designate cattle grazing allotments. A particular Township and Range has 36 sections, numbered according to Figure 9.16. On a topographic map Sections are bordered by red lines and are approximately one-square mile in area (see Figure 9.17 on the next page). Sometimes a fence runs along a section line. On some maps this is indicated by a red dashed line. Be cautious as there are fences that do not run along section lines and there are many section lines that do not have fences at all. A red dashed section line on a map may also indicate that the location of that line is approximate.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Figure 9.16. Section numbering within a township

A Township and Range coordinate looks like T26N R6E Sec 24. That coordinate would be read as "*Township Twenty Six North Range Six East Section 24*". The section can be broken down into smaller parts by dividing it in to half or quarter sections, for example the Southwest 1/4 of the Southeast 1/4 of the northwest 1/4 of Section 24.

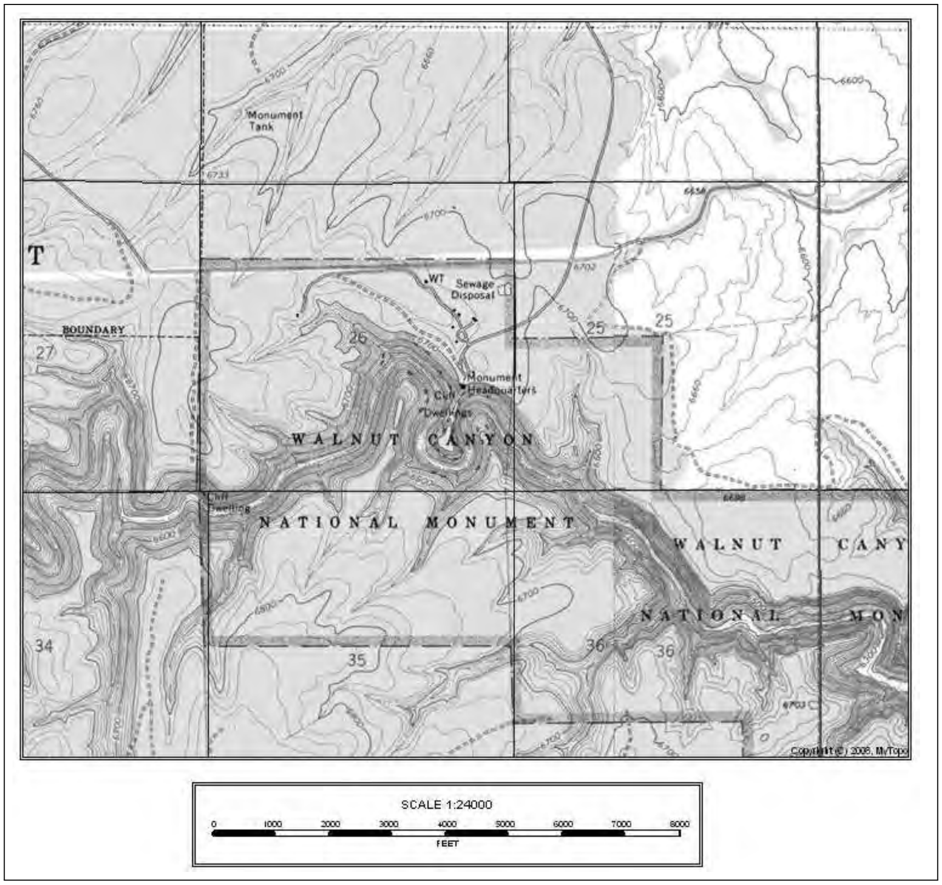

Figure 9.17. Example of Topographic Map with Township and Range. Sections are the squares with a number in the center

Who Uses What Coordinate System?

While each SAR unit can use the coordinate system of its choice, it is important to know what the National SAR Committee has designated the coordinate system to use in their Catastrophic Incident SAR addendum to the National SAR Plan. See Table 9.1, where all Lat/Long coordinates are in degrees decimal minutes (hddd mm.mmm).

Table 9.1. National SAR Committee Designated Coordinate System

Responders	Primary	Secondary	Tertiary
Land SAR	USNG	Lat/Long	
Aeronautical SAR	Lat/Long	USNG	GARS
Air Space Deconfliction	Lat/Long		
Land/Aeronautical SAR Interface	USNG	Lat/Long	
Incident Command—Land SAR Coordination	USNG	Lat/Long	
Incident Command—Air SAR Coordination	Lat/Long	USNG	
Area Organization and Accountability	GARS	USNG	Lat/Long

Section 9.3

Reading A 7.5' Topographic Map

Often searchers are given a photocopy of a section of a 7.5' USGS topographic map when deployed on a mission.[12] The 7.5' map has the greatest detail of the terrain and is essential for successful SAR operations. It is therefor important to understand the information a 7.5' topographic map provides and how to read it.

In view of the fact that a change in latitude of 1' corresponds to 1.15 miles, and a similar change in longitude in Arizona corresponds to 0.95 miles (see page 115) then in Arizona the USGS 7.5' topo map covers about $7.5 \times 1.15 = 8.6$ miles vertically, and about $7.5 \times 0.95 = 7.1$ miles horizontally.

Around the outside of the 7.5' map there is a wealth of important information. Start with the top right corner of the map, see Figure 9.18.[13] This section is called the Title section. The name of the map is printed at ① , "Horse Mesa Dam Quadrangle" which is in Arizona. The names of the adjoining 8 quadrangles can sometimes be found printed in the four corners and along each edge. This is absent in this map, but would at ② . The map series in this case is 7.5 minute, see ③ . This means that the map covers an area of 7.5 minutes of Longitude by 7.5 minutes of Latitude.

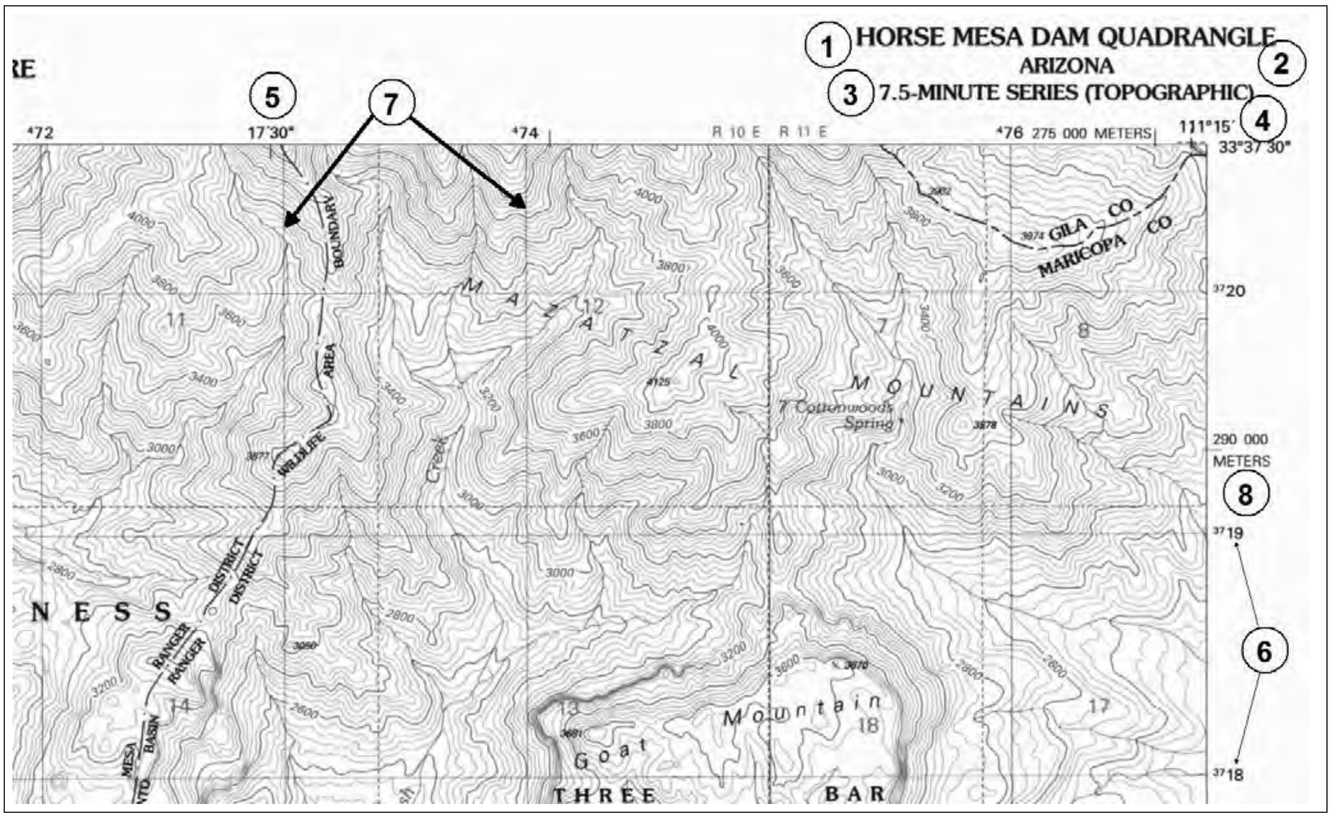

Figure 9.18. Top right of a topo map

The numbers running around the edge of the map represent three grid systems that can be used to pinpoint an exact location. These three systems are Latitude and Longitude, Universal Transverse Mercator (UTM), and the State Plane system.

The Latitude and Longitude position is given at each corner of the map, ④ , and is given in the Degrees Minutes Seconds format. The top right-hand corner of this map shows the latitude as 33° 37'

[12] Free digital copies of any 7.5 USGS Topographic Map can be downloaded from the U.S. Geological Survey store, `http://store.usgs.gov/`, by selecting "Map Locater & Download".

[13] Numbers in circles are not usually on a topo map. They have been added here to identify various parts of the map.

30″ and the longitude as 111° 15′. This position is read "*North Thirty Three degrees Thirty Seven minutes Thirty seconds and West One Hundred Eleven degrees Fifteen minutes*". The other three corners of the full map have similar coordinates. Clockwise they read 33° 30′, 111° 15′; 33° 30′, 111° 22′ 30″; and 33° 37′ 30″, 111° 22′ 30″. There is 7′ 30″ difference between each of these coordinates, hence a 7.5 minute series. Along each edge there are more Latitude and Longitude markers, ⑤ , one every 2′ 30″. These positions usually give only the minutes and seconds omitting the degrees—adding 2′ 30″ to 111° 15′ gives 111° 17′ 30″, which is written as 17′ 30″.

The set of smaller numbers around the entire edge of the map are the UTM grid coordinates, ⑥ . The distance between successive grid hash mark represents one kilometer. On some maps the UTM grid is printed throughout the map, ⑦ , which is useful for finding a position and estimating distances. The numbers in meters, or sometimes in feet, ⑧ , represent the State Plane system.

Many USGS maps also show the Township and Range System. The township and range lines are marked in red on either side of the line. For example a range marker may read R 10 E R 11 E. This means that the portion on the left of the range line is in range 10 E and the portion on the right of the range line is in R 11 E. Range lines are vertical and are marked along the top and bottom edges of the map whereas Township lines are horizontal and are marked on the right and left edges of the map. Within each township there are 36 sections, see Figure 9.16 on page 120. These sections are usually marked with red gridlines, ⑨ , as shown in Figure 9.19 on the next page. Each section is one square mile and is usually marked with its section number in the middle of each grid also printed in red, ⑩ —in this case 17, 18, 19, and 20.

Many of the USGS maps have a legend in the lower right-hand corner. The complete legend contains an extensive list of symbols used which cannot fit on individual maps. A comprehensive topographic map symbols booklet is available at `https://pubs.usgs.gov/gip/TopographicMapSymbols/topomapsymbols.pdf`.

Below the name printed in the lower right there is a date (2004), ⑪ . It represents the last time the map was revised. Keep in mind that any new land or housing development often drastically affects the accuracy of what is displayed on the map.

The middle section on the bottom of the map contains perhaps the most important information. See Figure 9.20. Beginning with the scale, ⑫ , the 1:24,000 means that for every inch on the map there are 24,000 inches (2000 feet) on the ground. The contour interval, ⑬ , identifies the vertical distance traveled between each contour line. Keep in mind that the ground can change slope between contour lines without showing up as a new contour line.

The magnetic declination for the area is depicted just to the left of the scale, ⑭ . The line with the star represents true north. The map is always oriented to true north therefore the edges of the map can also be used as true north lines. The line marked "MN" is magnetic north and is labeled with the degrees of declination. In this example the declination is 11°. The line labeled "GN" is grid north the angle between the UTM grids and true north (0° 10′).

To the right of the Scale there is a quadrant location map depicting where the quadrant is in relation to the state, ⑮ , and a legend informing which 8 quadrants border this map, ⑯ .

The lower left-hand corner—see Figure 9.21 on page 126—shows information on when the map was originally made (1978) and the last time it was revised (2004), ⑰ . This section also identifies the datum used (NAD27), ⑱ .

Reading Coordinates

Normally, when given an object on a 2-D set of axes, it is relatively easy to find its coordinates, as long as there are enough tick marks on the horizontal and vertical axes. However, on a 7.5′ Topo map, Lat/Long is marked every 2.5′ on the edges of the map and then at graticule marks where the

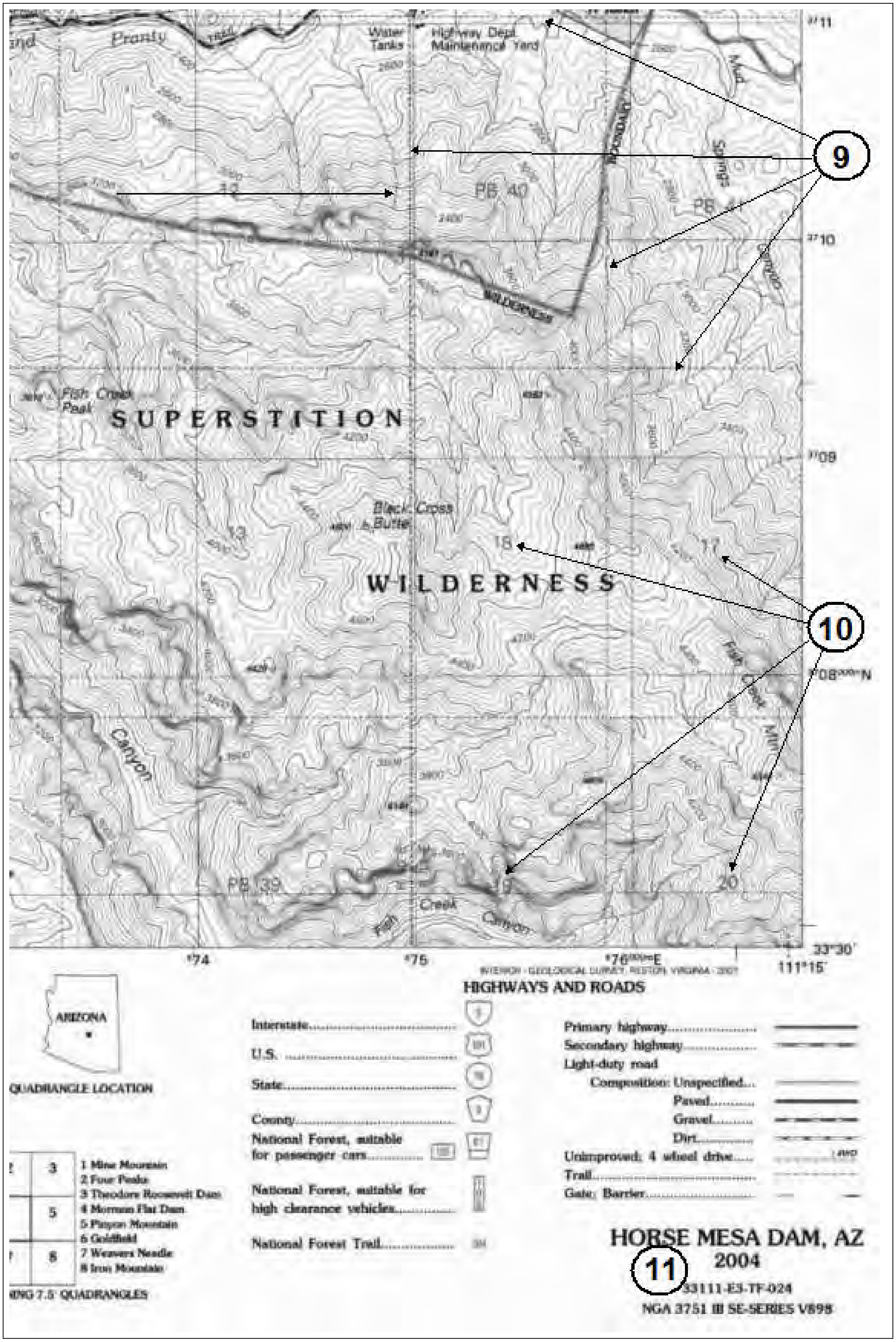

Figure 9.19. Lower right of a topo map

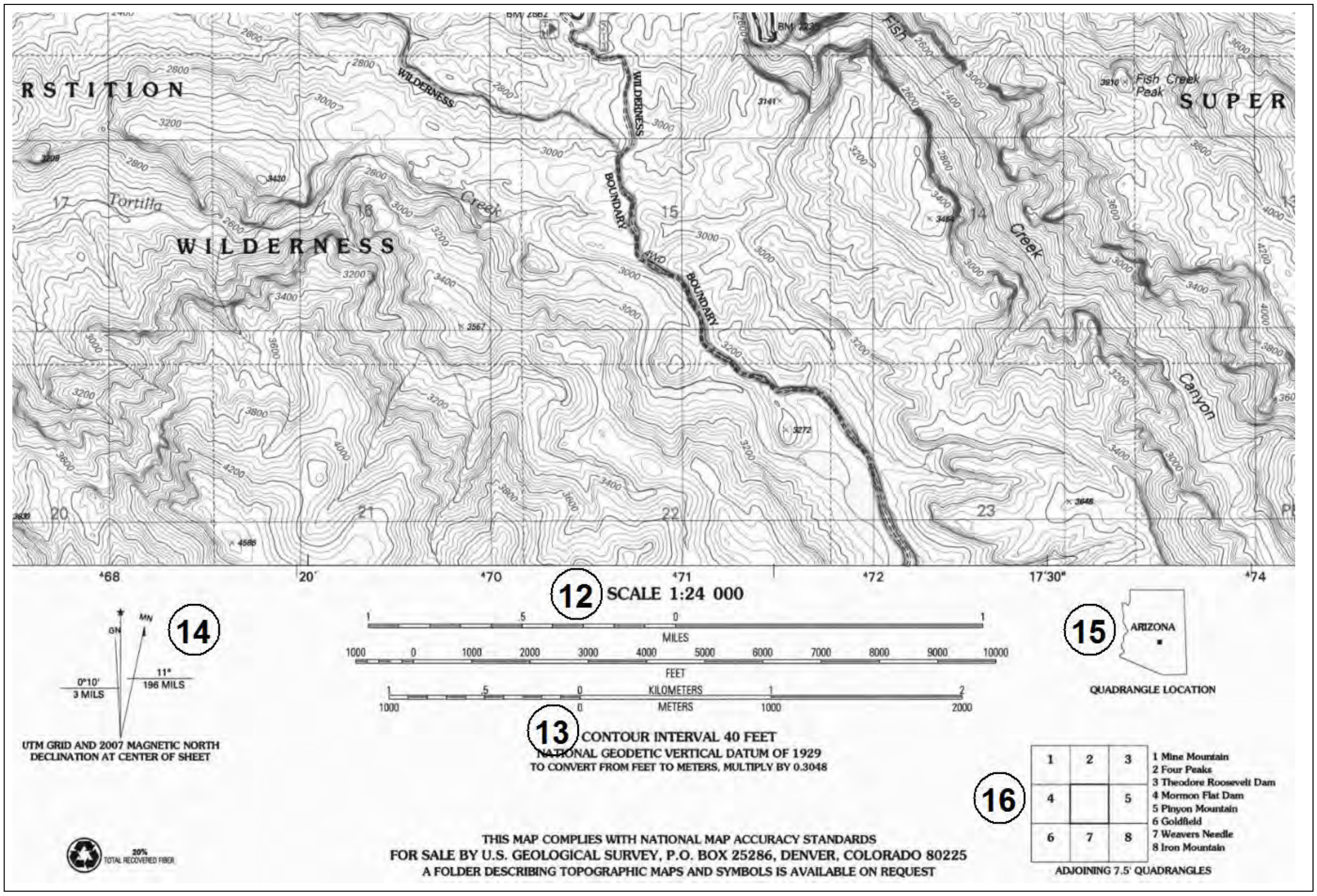

Figure 9.20. Lower middle of a topo map

2.5′ of latitude and 2.5′ of longitude meet in the middle of the map essentially dividing the map into 9 rectangles. The distance between a degree of latitude is consistent across the globe because they are parallel to each other but a degree of longitude varies because the lines are not parallel and connect the poles, rather like orange slices. UTM is marked every 1000 meters on the edges of the map and the distance between coordinates is consistent because it is a grid system and not angular.

Finding the Lat/Long coordinates of an object on a 7.5′ Topo map

The map tool that helps in this case looks like the ruler shown in Figure 9.22 on the next page. It is specifically designed for 7.5′ Topo maps.

This ruler is about 8″ long. It covers an angle of 2.5′. This coincides with the angle between successive grid marks in the latitude direction (vertical) on the map. The angle on the ruler between 0′ and the 1′ mark is divided into 10 major units, each representing 0.1′. Each of these in turn is divided into 10 minor units representing 0.01′. Other map rulers have the distance between 0′ and 1′ divided into 60 segments, each representing 1″.

On any standard 7.5′ Topo map, placing this tool vertically with the zero mark coinciding with the bottom right-hand corner of the map has its 2.5′ mark directly over the first Lat/Long mark, and so on up the axis for the other two marks.[14] So the ruler can be used to measure the latitude of a point of interest directly. This is explained in Figure 9.23 on page 128.[15]

[14] It is important to check this first. Sometimes maps are printed from software, and the printer may re-scale the output. An alternative way of checking is to go to the scale of the map, see 12 in Figure 9.20, and confirm that 2000 feet on the scale is exactly one inch when measured with a ruler.

[15] The images in Figures 9.23 through 9.27 were created by Art Pundt. Used with permission.

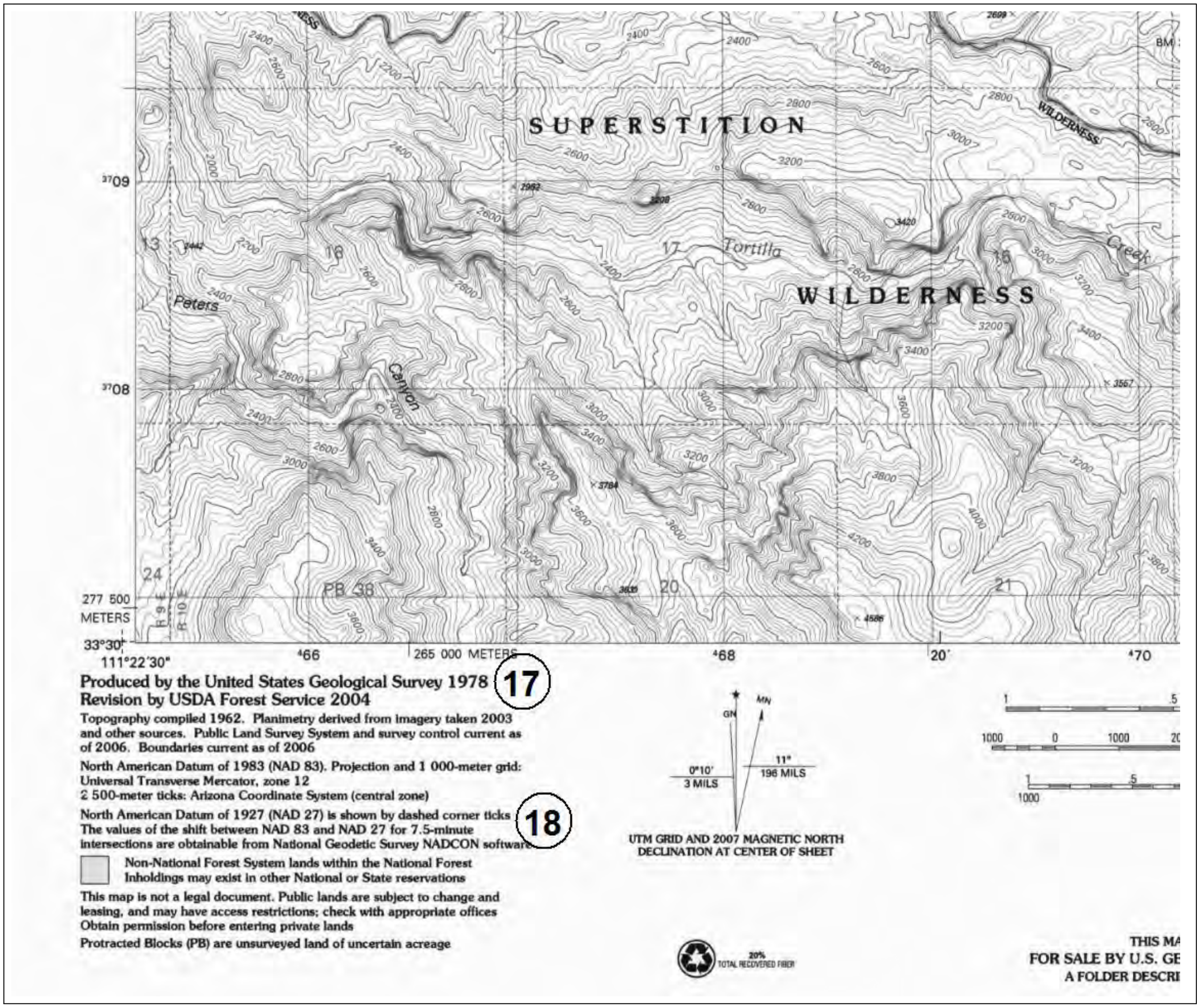

Figure 9.21. Lower left of a topo map

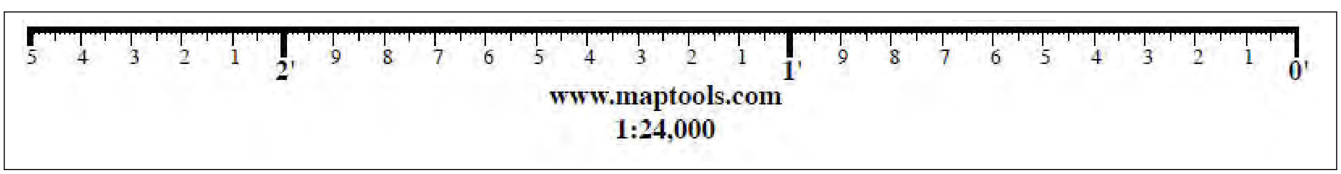

Figure 9.22. A Lat/Long ruler for a 7.5' Topo map (not to scale)

Notice in Figure 9.23 on page 128 that the coordinates of the bottom right-hand side of the map are latitude 111°0'0" and longitude 36°0'0". The first vertical mark is at 2'30" (2.5'), which is shorthand for latitude 36°0'0" + 2'30" = 36°2'30". The first horizontal mark is at 2'30" (2.5'), which is shorthand for longitude 111°0'0" + 2'30" = 111°2'30".

On a typical map, there is no horizontal line through 36°2'30", nor a vertical line through 111°2'30". However, if there were, they would intersect at the + symbol, called a "graticule". To help find the latitude and longitude of a point of interest, it helps to add these lines.

Just by eye-balling it can be seen that if the ruler were placed horizontally with the zero mark coinciding with bottom right-hand corner of the map then its 2.5' mark would not fall on the first horizontal Lat/Long mark—it would pass it. This is generally true—longitude marks are closer together

Table 9.2. Key 7.5' Topographic Map Features

1	Name of map
2	Names of adjoining maps
3	Map series, 7.5 minute
4	Latitude and Longitude coordinates
5	Latitude and Longitude markers
6	UTM grid coordinates
7	UTM grid
9	Township section gridlines
10	Section number
11	Date map was revised
12	Map scale
13	Contour interval
14	Declination
15	Quadrant location
16	Adjoining maps
17	When map originally made
18	Map datum

than latitude marks. So although the ruler can be used to determine latitudes directly, that technique will not work for longitudes. Some might think that a longitude ruler should be created. However, the distance between longitude marks on a map varies according to the longitude, so this would require different rulers for each longitude. However, there is a way to determine the longitude using the existing ruler in a diagonal fashion, and this is explained in Figure 9.24.

The technique outlined in Figure 9.24 assumes that the point of interest is in the rectangular region bounded diagonally by the bottom right-hand corner and the + symbol mentioned earlier. There are three other + symbols on the map, and drawing horizontal and vertical lines through them and their corresponding marks on the edges of the map divides the map into nine regions, as shown in Figure 9.25 on page 130. If the point of interest was in the middle region, then Figure 9.25 on page 130 shows how to find the coordinates of that point. This technique also works for any of the nine regions.

Finding the UTM coordinates of an object on a 7.5' Topo map

Although it is possible to crudely estimate the UTM coordinates of a point of interest, any sort of accuracy requires the use of a map tool similar to that shown in Figure 9.26 on page 131. It is specifically designed for 7.5' Topo maps.

Using this tool is considerably easier to use than its Lat/Long counterpart. This procedure is explained in Figure 9.27 on page 132. The vertical line identified by the number 342 is the grid line that represents the Easting. The horizontal line identified by the number 3881 is the Northing. The top right-hand corner of the map tool is placed at the point of interest, with the sides parallel to the UTM grid lines. The 342 grid line crosses the map tool at 340 meters, and the 3881 grid line crosses the map tool at 280 meters. The final coordinates of Blue Lake are $342000 + 340 = 342340$ and $3881000 + 280 = 3881280$.

Section 9.4
Compass

There are several types of compasses available but the best compass for search and rescue use is the orienteering base plate compass with a declination adjustment feature. Figure 9.28 on page 133 shows

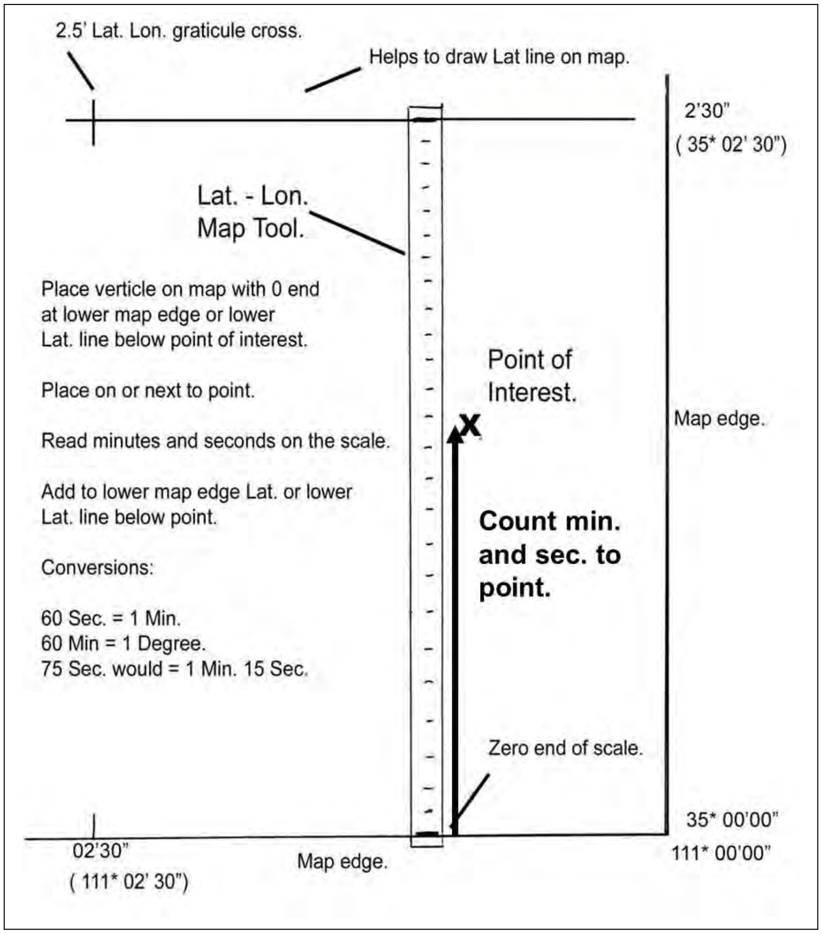

Figure 9.23. Finding the latitude of a point of interest

the components and terms of a compass, which should be studied carefully before continuing. A good quality base plate compass for use in SAR should have the following features.

- Declination adjustment.
- 1° to 2° graduation marks.
- Direction of travel arrow.
- Index mark.
- North-South orienting lines.[16]

A term that is used frequently when dealing with compasses is **Azimuth**. An azimuth is the angle of horizontal deviation, measured clockwise, of a bearing from a standard direction, such as north or south. See Figure 9.30 on page 133.[17]

The compass is a relatively simple instrument for finding direction. The compass works by aligning its magnetic compass needle with the magnetic force lines of the Earth's magnetic field at that location. The compass needle does not necessarily point to the magnetic north pole or to true north. To determine true north it is necessary to apply a declination adjustment to the reading obtained. There are rules for doing this (in Arizona: Map to Field subtract declination; Field to Map: add declination) but using a declination adjustable compass is the preferred method for working with azimuths from map to field and vice versa. Once the declination is set for the area all the azimuths are true and match the map that also uses true geographic directions and not magnetic directions. This can serve to reduce navigation errors.

[16] Orienting lines are sometimes called Meridian lines.
[17] Left-hand image downloaded from `http://www.rmg.co.uk/server/show/conMediaFile.3599`.

To begin to understand the compass the cardinal points of the compass need to be discussed. The compass is divided into 360° with North being 0° or 360°, East being 90°, South being 180°, and west being 270°. See Figure 9.29 on page 133.[18] A mnemonic that is sometimes used to remember the order of the cardinal points is "**N**obody **E**ats **S**hredded **W**heat" applied clockwise.

Often in SAR, to determine locations in the field, an azimuth is taken from the current location to an object, or a back azimuth is taken from an object to the current location.[19] See Figure 9.30. It is critical to identify whether the azimuth is a true azimuth (corrected for declination) or a magnetic azimuth (not corrected for declination). Some users always use magnetic azimuths because their equipment cannot be adjusted for declination with the most notable of those users being aviation. For ground based SAR units either type of azimuth can be used but it is often easier to use the true azimuth since the map, compass, and GPS all "speak the same language".

The biggest contributor to compass error is the user. One degree of error equates to almost 100 feet of error over the course of one mile. See Table 9.4 on the next page.[20]

The biggest contributor to compass error is the user.

To minimize compass error be careful when taking an azimuth. If possible choose short segments along a course of travel to minimize the potential error. Do not forget to look at the map and use terrain

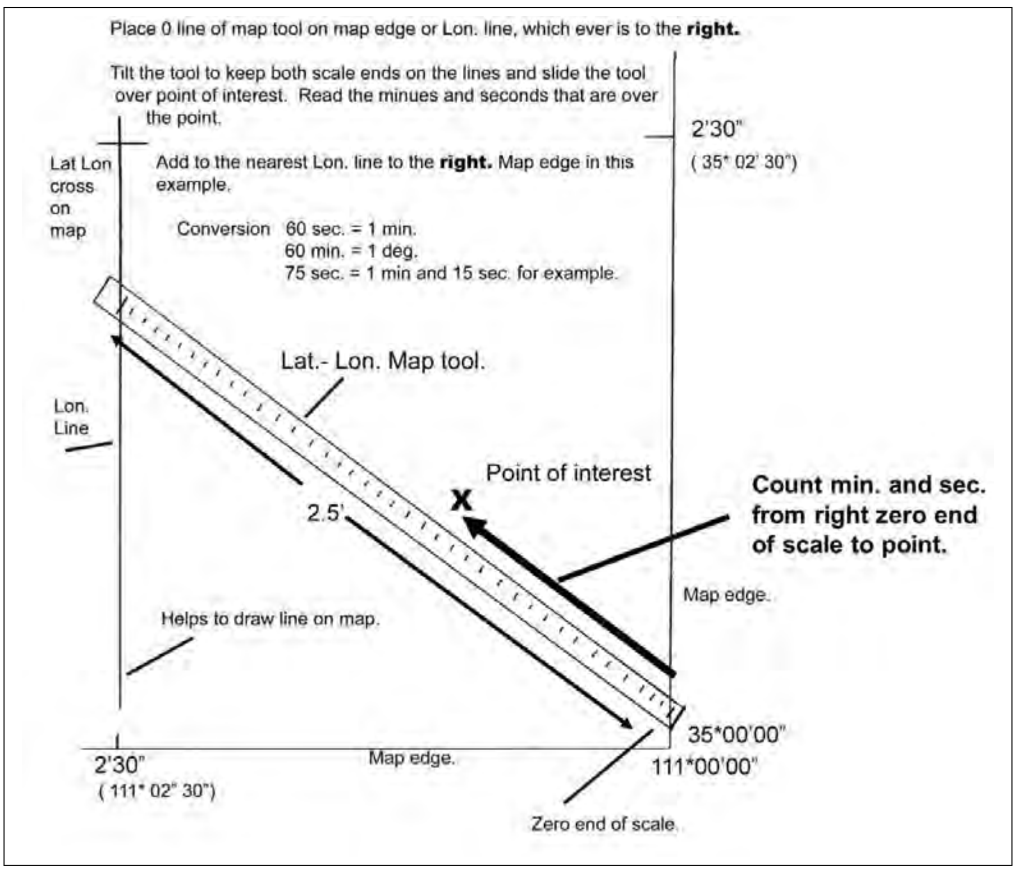

Figure 9.24. Finding the longitude of a point of interest

[18] Downloaded from `http://www.inkscapeforum.com/viewtopic.php?f=8&t=237`

[19] The rule to determine a back azimuth from an azimuth is summarized by the mnemonic "**LAMS**": **L**ess than 180°, **A**dd 180°. **M**ore than 180°, **S**ubtract 180°.

[20] For the mathematically inclined, the error after traveling a miles in a direction d degrees from the correct direction is $2 \times 1760 \times a \sin(\pi d/360)$.

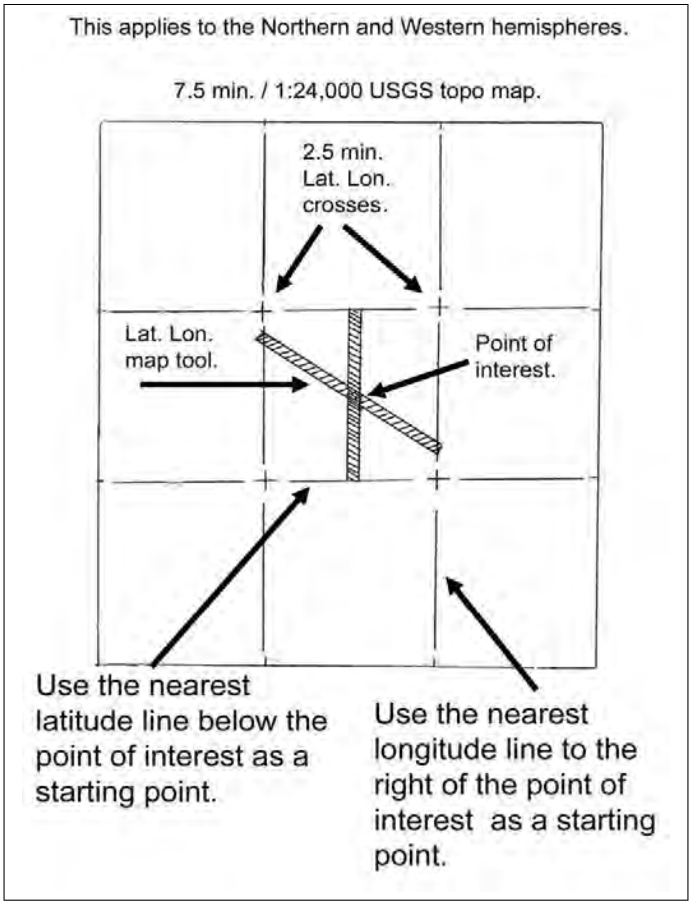

Figure 9.25. Finding the lat/long of any point of interest

reading skills together with the compass. In fact, most competent navigators use terrain reading and recognition as a large component in their navigation, and use a compass as a back up.

Table 9.4. Error over one mile

Error in bearing (°)	1	2	3	4	5	6	7	8	9	10	11	12
Error after one mile (yards)	31	61	92	123	154	184	215	246	276	307	337	368

Using a Baseplate Compass

To properly use the baseplate compass

1. Stand with the compass level and in front, waist high, with the direction of travel arrow pointing away from the current location.
2. Pick the object required to take an azimuth to.
3. Rotate the compass and body until the direction of travel arrow is pointing at that object.
4. Box the needle by turning the bezel (the movable ring surrounding the compass capsule) until the North Orienting Arrow inside the capsule aligns with the magnetic compass needle.
5. Read the bearing at the index mark—the bearing from the current location to the object.

Having mastered this field bearing technique the SAR team member can use the following techniques with a map to determine the current location of an object or of self.

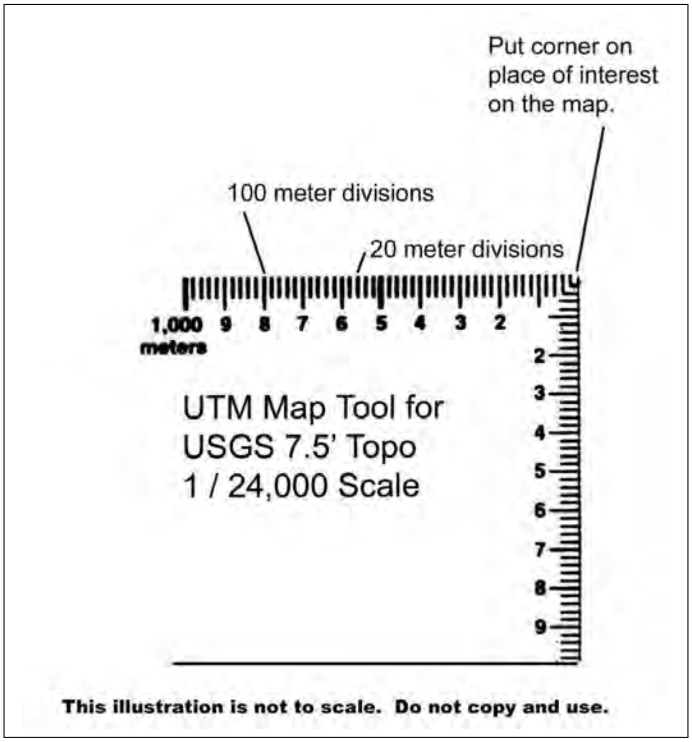

Figure 9.26. A UTM map tool for a 7.5' Topo map (not to scale)

- **Intersection**. Used to locate an object.
  1. Take two field bearings to the same object from widely-spaced different locations (perhaps as much as a quarter mile apart).
  2. Plot those bearings on a map.
  3. Where the bearings intersect on the map is the location of the object.
- **Resection**. Used to locate self at current location.
  1. Take two field bearings to two different objects that can be seen in the field and can be identified on the map.
  2. Plot those bearings on the map.
  3. Where they intersect is the current approximate location.

  It is important to note that the farther away the objects are from the current location the less accurate the sighting may be. It is also best to try to sight objects that are about 90° apart from each other.

It is very important to make sure that the compass is away from iron metal objects such as radios, batteries, vehicles, magnets, power lines, fence lines, belt buckles, knives, guns, and rings. Metal objects can dramatically affect the magnetic needle in the compass and contribute to error.[21]

> *Metal objects can dramatically affect the magnetic needle in the compass and contribute to error.*

[21] A compass has be used to locate a buried vehicle. A sedan, which had been swept off the Redington Road, Tucson, at the Buehman Wash, was located by compass in an open area that was a flat sand bar. The top of the windshield on the driver's side was about 6" below the surface of the expanse of flat sand.

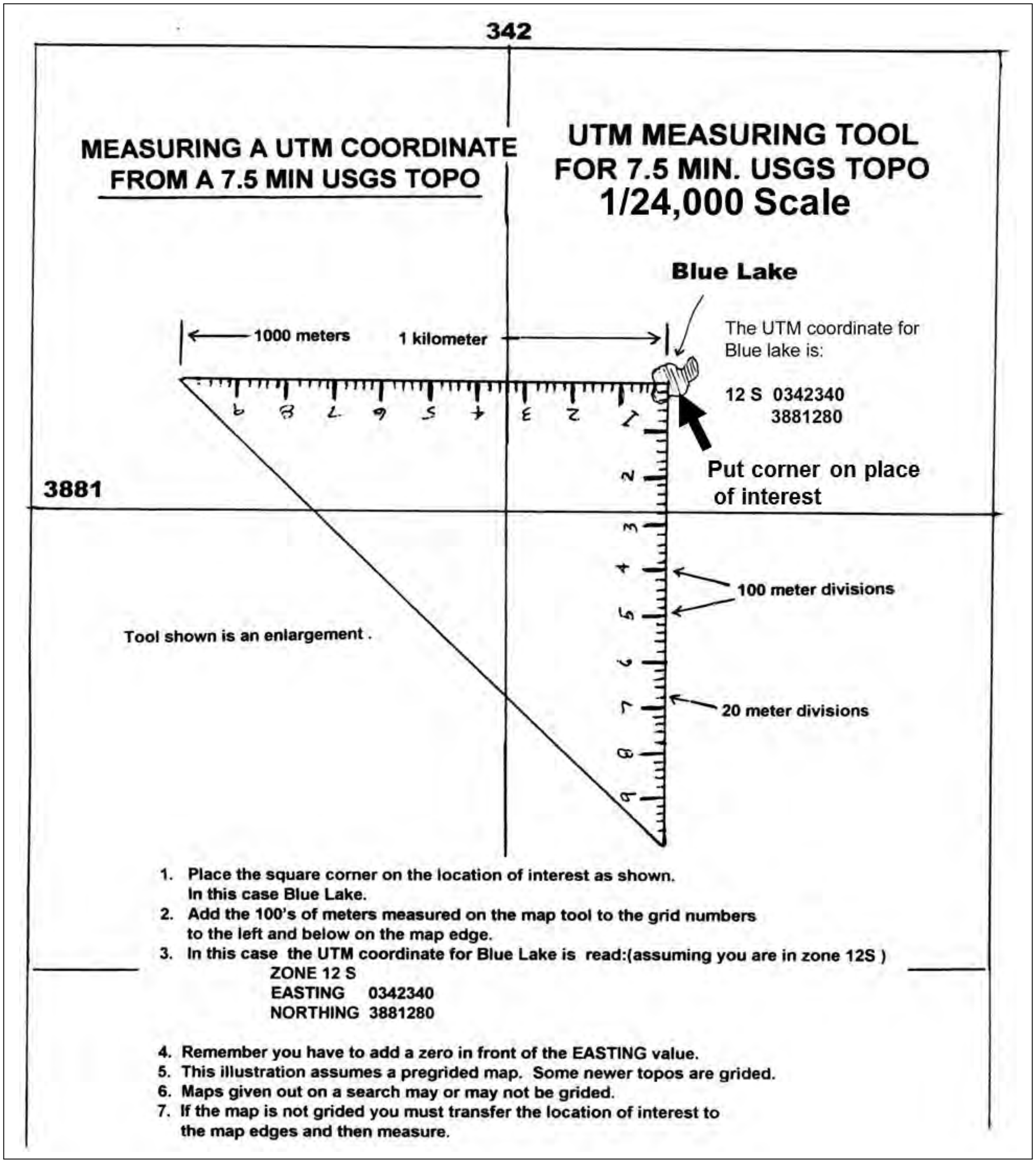

Figure 9.27. Finding the UTM of any point of interest

Using the Compass as a Protractor

There is no need to orient a map magnetically to north with a compass to plot azimuths on the map as some techniques show. Those techniques are cumbersome and inefficient for use in SAR. Using the compass as a protractor is a much better method and it can be done on the hood of the truck or in a vehicle cab since magnetic interference is not an issue with this method. The compass by default is also a simple circular protractor which can be used to measure navigational angles on a map. In this compass as a protractor process it is important to note that the magnetic needle plays no part when plotting simple azimuth angles onto the map or measuring azimuth angles from a map.

- **Plot azimuth on map.**

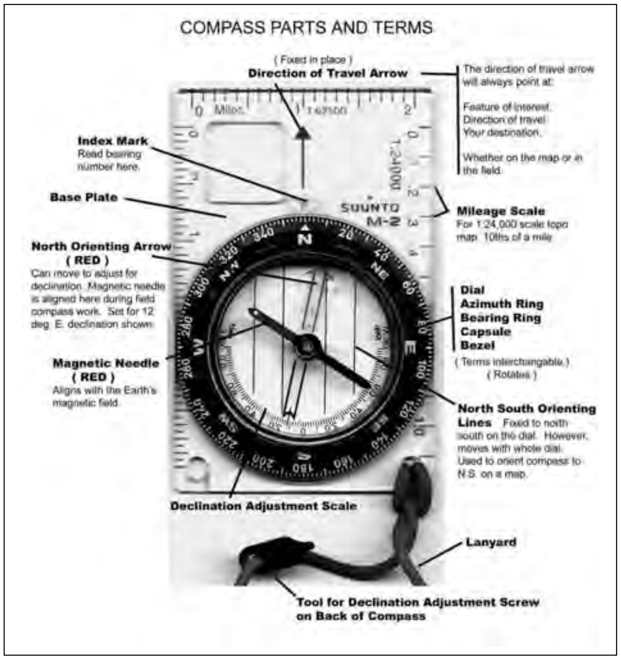

Figure 9.28. An example of a base plate compass with declination adjustment

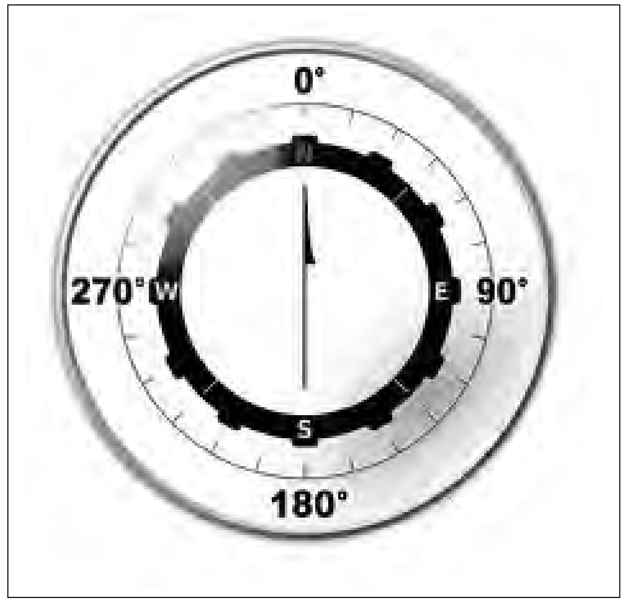

Figure 9.29. Cardinal points of the compass

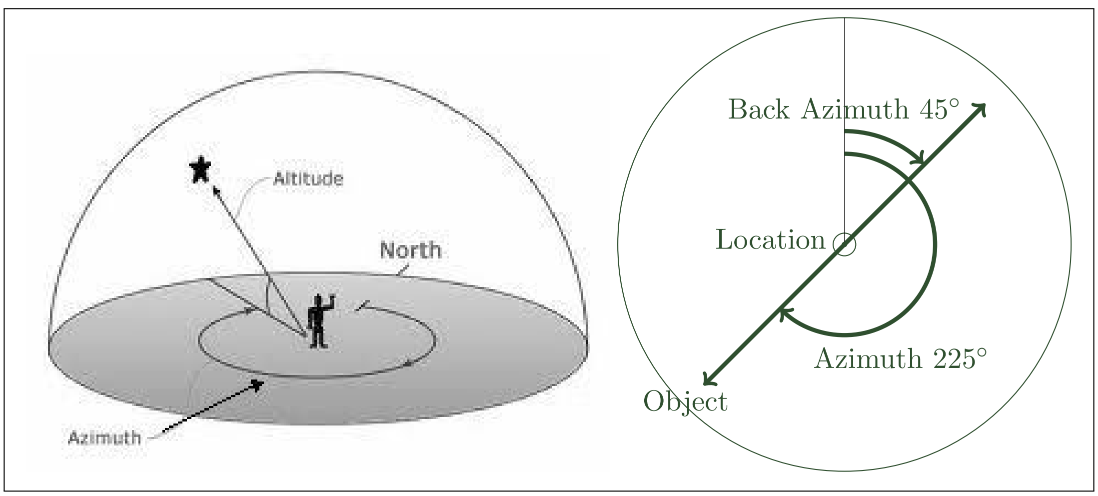

Figure 9.30. Azimuth and Back Azimuth

To plot an azimuth that has been taken in the field onto a map (assuming the compass is declinated and are plotting true bearings)

1. Place either bottom corner of the compass at the current location.
2. Rotate the whole compass, not the bezel, until the orienting lines in the compass dial are parallel to the north/south edge of the map (also called a neat line) and the north portion of those lines are pointed to the northern part of the map. The North Orienting Arrow on the compass bezel must also point generally north but is slightly offset due to the declination adjustment. The direction of travel arrow on the front part of the compass baseplate must also be pointed on the map in the direction in which the field azimuth was taken.
3. Draw a line from the back corner to the front corner on the same compass edge resting on the current location on the map.
4. This line represents field azimuth on the map.

- **Take azimuth from map.**

To take an azimuth from the map for use in the field (assuming the SAR team member is using a declinated compass)

1. Place either bottom corner of the compass on the first feature of interest on the map and the front corner along the same compass edge on the second feature of interest on the map.
2. Rotate the bezel so that the orienting lines in the dial are parallel to the north/south edge of the map and the north portion of the orienting lines are pointed to the north part of the map. The North Orienting Arrow must also point generally to the north.
3. Read the azimuth at the index mark which is the azimuth from the first feature to the second that the SAR team member should follow in the field. The azimuth at the index mark must not be changed until the destination has been reached.

On his blog *Delirious Ramblings*,[22] Dave Laplander described this process, which is paraphrased here.[23]

"I knew where I was (lower arrow in Figure 9.31) and I knew where I wanted to go (upper arrow). To measure the angle I simply positioned the edge of the compass's baseplate along the line I wanted to walk and then turned the dial until the compass's orienting lines pointed north on the map. Figure 9.32 shows a closer view so you can see the orienting lines pointing true north.

The angle I needed to walk was then readily visible under the compass's index pointer: 18° True. And once I knew the angle I needed to walk I simply oriented the compass so that the red sighting line aligned with the compass needle and started walking."

Figure 9.31. Taking azimuth from map

Figure 9.32. Orienting lines parallel to map NS lines

Once again it is important to note that when using the Compass as a Protractor technique the magnetic needle is used when taking or following an azimuth in the field but not when using the compass to measure or plot azimuth angles on the map.

Declination in Detail

Almost everyone has seen the familiar pattern that happens when iron filings are sprinkled near a bar magnet—the magnetic field creates lines of force, see Figure 9.33 on the next page. The Earth has its own magnetic field and lines of force, not unlike a bar magnet. A compass aligns its needle with the line of force through its location indicating Magnetic North—the direction towards the Magnetic North Pole. The **Magnetic North Pole** is that point on the surface of the Northern Hemisphere

[22] `http://del.typepad.com/del/2010/03/use-your-magnetic-compass-as-a-protractor.html`
[23] Used with permission.

at which the Earth's magnetic field points vertically downwards; in other words, a magnetic compass needle points straight down when it is over the Magnetic North Pole.

The **North Pole**, sometimes called the Geographic North Pole, is that point in the Northern Hemisphere where the Earth's axis of rotation meets the Earth's surface. At any point on Earth, the direction towards the North Pole is called True North.

The North Pole and the Magnetic North Pole do not coincide. In fact over time, the magnetic pole moves—at the moment at almost 40 miles a year. Figure 9.34 shows its movements over time.[24]

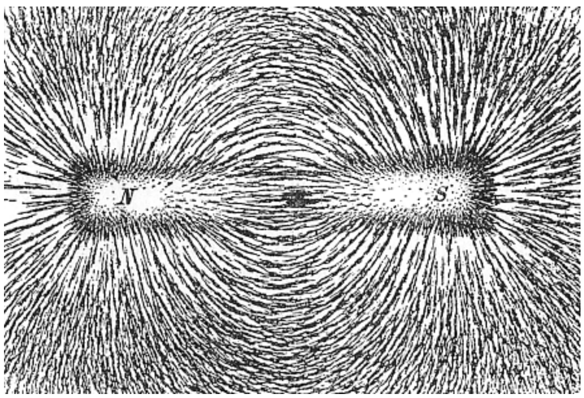

Figure 9.33. Magnetic lines of force of a bar magnet shown by iron filings on paper

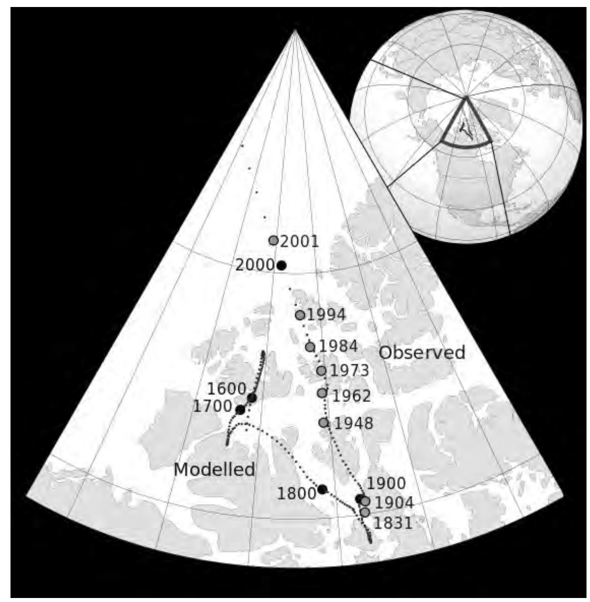

Figure 9.34. Location of Magnetic North Pole over time

In general at any location on the Earth, true north and magnetic north do not align—the angle between them is called the **magnetic declination** or just declination. (Declination is sometimes called Variation.) Figure 9.35 on the next page shows the declinations throughout the U.S. in 2010.[25] A compass located on the dark line passing near New Orleans points true north, because that is the line indicating 0° declination. East of this line, the magnetic north pole pulls a compass needle farther and farther to the West of the north pole—the angle of compass declination is West Declination. Moving west of this line pulls a compass needle farther and farther to the East.

Declinations in Arizona are between about 10° and 12°, so someone following a compass needle (without adjusting for magnetic declination) for 1 mile who thinks they are traveling due north are off course by between 307 and 368 yards, see Table 9.4 on page 130.

Global Positioning System

The *Global Positioning System*, GPS, has become an essential tool for SAR and other emergency services. This system allows locations to be marked accurately and allows users to input coordinates into a GPS receiver and navigate to those coordinates very accurately in all types of weather, in the dark, and in flat featureless terrain that makes navigating with other techniques difficult.

GPS has become very prevalent outside of the emergency services as well. It is a relatively cheap but sophisticated technology that more and more members of the public are relying upon. Many GPS

[24] Downloaded from `http://en.wikipedia.org/wiki/File:Magnetic_North_Pole_Positions.svg`. Image ©Tentotwo.
[25] Downloaded from `http://www.ngdc.noaa.gov/geomag/declination.shtml`.

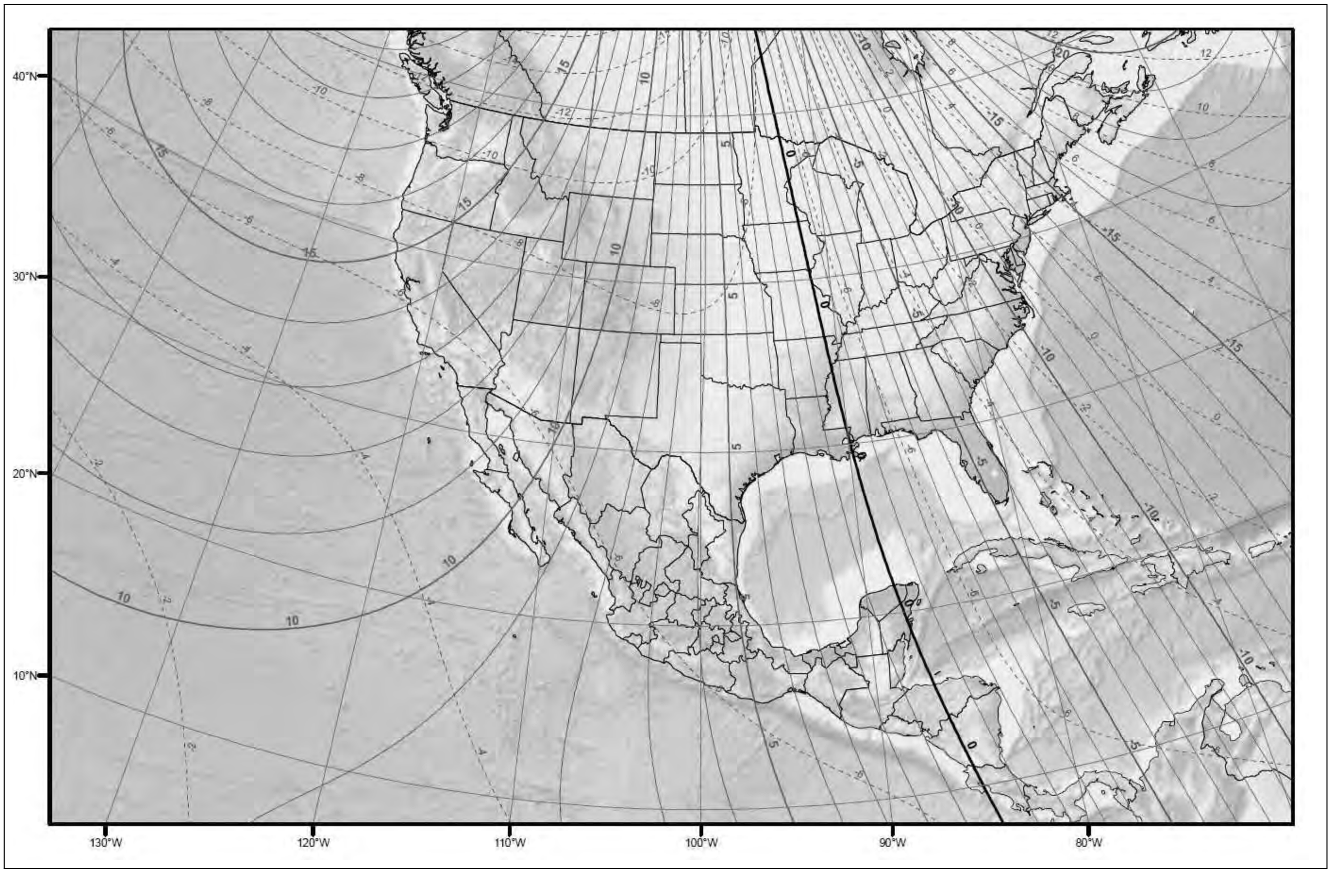

Figure 9.35. Declination in the U.S. 2010

users do not receive any training about the technology and its limitations. The use of GPS without training or other navigation skills to back up the GPS has been a contributor to more than a few SAR missions around the country—see the final paragraph on page 175. "*For less than $100, you can get a pocket-sized gadget that will tell you exactly where you are on Earth at any moment. As long as you have a GPS receiver and a clear view of the sky, you'll never be lost again.*" Famous last words.[26]

As emergency responders it is critical to understand the technology, its benefits, its limitations, and to employ it appropriately to save lives.

GPS is a navigation system with three major components (see Figure 9.36 on the next page).[27]

1. The space component or segment—the satellites that transmit information.
2. The control component or segment—the ground stations that monitor and adjust the satellites.
3. The user component or segment—the GPS receiver.

In order for GPS to work the satellites must be "healthy" and provide accurate timing information to the GPS receiver. The GPS receiver must have good line of sight to the satellites. At any given location on earth a GPS receiver should be able to see six satellites. There are a variety of GPS receiver manufacturers and models. It is critical to learn about the model that the SAR team member plans to use by reading the owner's manual and practicing with it before using it on a SAR mission. Each manufacturer and model are slightly different but some commonalities remain among units.

When a GPS is turned on it begins searching for satellites. Once it has acquired signals from three satellites it displays a location. This location is commonly known as a 2-D location in that the GPS receiver is providing horizontal location information but no elevation information. Once the fourth

[26] `http://electronics.howstuffworks.com/gadgets/travel/gps.htm`.
[27] Downloaded from `http://www.techamor.com/content/global-positioning-system`.

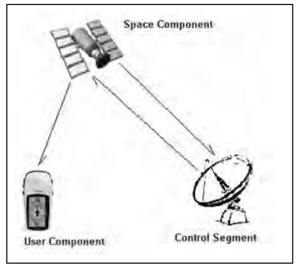

Figure 9.36. GPS system

and additional satellites are received the location becomes a 3-D location with horizontal location information as well as elevation information. 2-D location information can be unreliable and before navigating it is wise to wait for a 3-D location fix.

Critical to the operation of GPS is the understanding of map datums and coordinate formats. A user must be able to navigate through the menus to find the settings pages to change these two components. As discussed on page 105, map datums are mathematical models of the size and shape of the earth. Not all datums agree. It is critical to match the map datum of the map being used with the map datum being used by the GPS for navigation. Otherwise there are datum shift error which can degrade SAR operations. When transmitting data between units it is a good practice to confirm the map datum that the coordinates are coming from. Coordinate format was also discussed on page 115. Identify which coordinate format is being used and set the GPS to match that format. Forcing the coordinates from one format into another can cause significant error. This type of error is most common with Lat/Long.

It is critical to match the datum of the map with the datum of the GPS.

Beyond setting up the datum and coordinate format, the GPS user must be able to mark locations such as a clue found during a search and to create a waypoint by entering coordinates from a map or another team to navigate to that location. Each GPS may be slightly different in how that is done. To mark a location there is often a key on the face of the GPS that is pressed and held until a "mark" screen appears. A name can then be given to that waypoint. To enter a waypoint from information taken from another source such as a map or another team there is often a "create waypoint" menu item that allows the user to enter a name and then the coordinates for that location. A good user always confirms that the GPS is in 3-D mode before marking a waypoint. It is also a good habit to check the waypoint list in the GPS after marking or creating a waypoint to make sure that it saved into the memory properly.

Most handheld GPS units give only line-of-sight distances between locations. The GPS may not know that there is a canyon or river between locations that makes walking a straight course impossible. It is essential to combine GPS use with good map reading skills.

All GPS units have some sort of map page. Some are very basic with just the waypoints that are saved in the memory along with a breadcrumb trail that the user has traveled while others may have base road maps through topographic maps installed on them.

GPS units can provide a lot of useful data such as the estimated time to travel between locations, speed of travel, elevation, whether the user is on or off course, azimuth (or bearing) from the user to a location, the time of sunrise and sunset, moonrise and moonset, tides, and many more. It is important to learn about the features on the user's GPS.

One technique that is very useful for SAR operations is the track log feature of most GPS units. This feature can be set to collect track information for a team conducting a search. At the end of the search the track can be downloaded and overlaid on a map to show where the team searched. This aids the Incident Management Team during debrief and for planning future operations.

As stressed previously GPS is a technology that should not be used alone. It must be used in conjunction with map and compass skills.

GPS must be used in conjunction with map and compass skills.

There are certain skills that a GPS user must be able to complete, if needed.

GPS Competence Checklist

1. Adjust settings (distance units, bearing display)
2. Be familiar with the GPS menu pages.
3. Assess the satellite page for the position condition (2D, 3D, DGPS fix). Generally it is best to wait for a 3D fix or 4 our more satellites being used for navigation before taking or reporting a position.
4. Be able to change coordinate formats.
5. Be able to change map datums.
6. Be able to take coordinates in one format/datum, enter them, save them, and convert the coordinates to another format/datum.
7. Mark a waypoint.
8. Enter a new waypoint from coordinates provided.
9. Edit waypoint information
10. Set up a Go-To to a waypoint.
11. Access the track log.
12. Save a track log with a name.
13. Clear the track log before starting an assignment
14. Have the cables to upload/download GPS information to a computer.

The following are some cautionary notes that GPS users should be aware of.

- GPS is a relatively delicate instrument that can break and it relies upon batteries. Be careful with it and carry extra batteries.
- It is easy to over-rely on GPS. Do not get in the habit of using it as the sole source of navigation information.
- Satellite signals can bounce off of canyon walls creating a multi-path situation that degrades location information. Be alert when using GPS in canyon areas.
- 2-D navigation mode can be relatively unreliable. Try to obtain a 3-D fix before navigating.
- The GPS needs a good sky view for best operation. The user may need to move around to allow the receiver to see the satellites.
- Cold temperatures can affect the LCD display. Keep the GPS close to the body when using it in cold temperatures.
- GPS receivers do not calculate slope distance. The GPS sees every location as if it were on the surface of a sphere so if the location is on a mountain peak or a canyon bottom the distance from the user to that location may be different that what is displayed on the GPS.
- Other people and agencies may not be well trained. Ensure that everyone understands which coordinate format and datum are being used.
- Because GPS is used so much in SAR operations it should be easily accessible. Do not bury the GPS in the bottom of a pack.
- The biggest error in GPS operation is that of the human operating the GPS. An inadvertent key stroke could impact data entry. Double check the work and practice with the GPS before needing it.

Section 9.5
Conclusion

This chapter is not meant to make the reader a competent backcountry navigator. Seek out quality training in navigation that includes field exercises. In addition, having taken more in-depth navigation courses it is incumbent to practice those skills. SAR members are asked to plot locations on maps; derive coordinates of locations from maps; enter information into GPS; navigate between locations using terrain reading, compass skills, and GPS skills; and be able to describe what the team did on a search by referring to maps. Know how to do this. The Incident Management Team counts on its SAR members to do these accurately.

CHAPTER 10

Tracking

Lord, give me the strength upon this day to cut the sign along the way.
Lord, give me the sight upon this time to see the picture and cut the sign.
Lord, give me the knowledge upon this track to find the lost and bring them back.
Amen — Wayne Runkles

The focus of this chapter is not on teaching man-tracking, but on introducing it.[1] Man-tracking is a skill that takes many years to learn and to do well, and one chapter cannot possibly show a searcher everything that is needed to accomplish the task. The purpose of this chapter (and the associated field exercise) is to understand not only how difficult tracking is, but also to show that SAR missions can be more successful if trackers and man-tracking skills are used effectively. Learning to track is similar to learning to drive a car—it can feel scary in the beginning, but after some practice the preparation and techniques become second nature.

Sign

As SAR volunteers, the goal is to help recover the lost individual. But it is important to understand that the searchers are not just looking for a person. They should be looking for any physical indication that the lost individual has left behind. They should be looking for "Sign".

What is a sign? Sign is all evidence, not just footfalls, of a person's passage or presence. Signs that are easy to see might include discarded clothing, a lost hat, a water bottle, or a candy wrapper. The harder to see signs are the broken twigs, bruised vegetation, and compressed leaves left behind when a foot strikes the ground, in other words, any change of the natural vegetation or ground composition.

Good trackers understand the patience and concentration it takes to notice a sign. Being "track aware" on a SAR mission could someday save a life.

Measurements

By the time a SAR responder is called to a search, the Incident Commander has identified the IPP and possibly a direction of travel. They have also developed the LPQ, which includes the subject's sex, age, size, weight, hair color and clothing worn. With luck, it also includes a description of the type of shoe the subject was wearing and perhaps a drawing of the sole or lug pattern. A description of the shoe type and size is helpful to understand what type of track to look for in the field. If the shoe can

[1] Some of this chapter is based on the Central Adirondack Search and Rescue Team's document "Introduction to Human Tracking for Search and Rescue Volunteers". Used with permission. Most of it is based on the work of the Mohave County SAR.

be measured, then the overall length (A), the length of the heel (B), the width of the ball (C), and the width of the heel at its widest point (D), can be obtained. See Figure 10.1. The Step Length is the distance from the rear of the heel strike to the rear of the next heel strike.[2] See Figure 10.2 on the next page. Step length can vary due to terrain, the gait, or the subject's condition.

Figure 10.1. Full track measurements

The searcher uses a blank Tracking Pad, see Figure 10.3 on page 143, to record the details, see Figure 10.4 on page 143. It is rare to find a full track in the field, so all measurements of lengths and widths are crucial.

Tracking Stick

Most trackers use a tracking stick of some sort to use as a tool for measuring the step and foot print lengths. An inexpensive and easy-to-make tracking stick is a piece of doweling about $\frac{3}{4}$ inch in diameter and about 3 to 4 feet long. For markers, O-rings or rubber bands can be used.

One method used to set up the tracking stick is to mark the heel-to-heel step length on the tracking stick by measuring from the stick's point towards the handle and using one of the O-rings or rubber bands. Then, mark the length of the footprint on the stick forward of this O-ring. So, looking down the stick there is the length of the footprint followed by the distance to the rear of the next heel strike. That distance represents the length of the undisturbed soil between successive tracks.

If done correctly, then when laid just above the ground with the O-ring closest to the handle over the heel of one track, sweeping left-to-right then right-to-left should pick up the heel of the next track.

Trained Trackers

There is a limited supply of skilled trackers. A trained tracker has the ability to determine much about the individual or persons being sought from the presence of sign, including a person's weight, height, and many characteristics and traits, as well as the persons physical condition. The basic tracking

[2] Step Length is sometimes called the Stride Length. Unfortunately, stride length is an ambiguous term. It is not only used to measure heel-to-heel, it is also used to measure toe-to-heel (see `http://www.bear-tracker.com/trackingstick.htm` and `http://adirondack-history.com/mantrack2.htm`), and heel-to-heel of the same foot (that is, twice heel-to-heel, see `http://www.oandp.org/jpo/library/1990_02_107.asp` and `http://www.livestrong.com/article/438170-the-average-walking-stride-length/`). To avoid any confusion, the unambiguous term Step Length is used throughout this manual. If the term stride length is used on a SAR incident, then it must be accompanied by an exact explanation as to which of the three meanings it refers to.

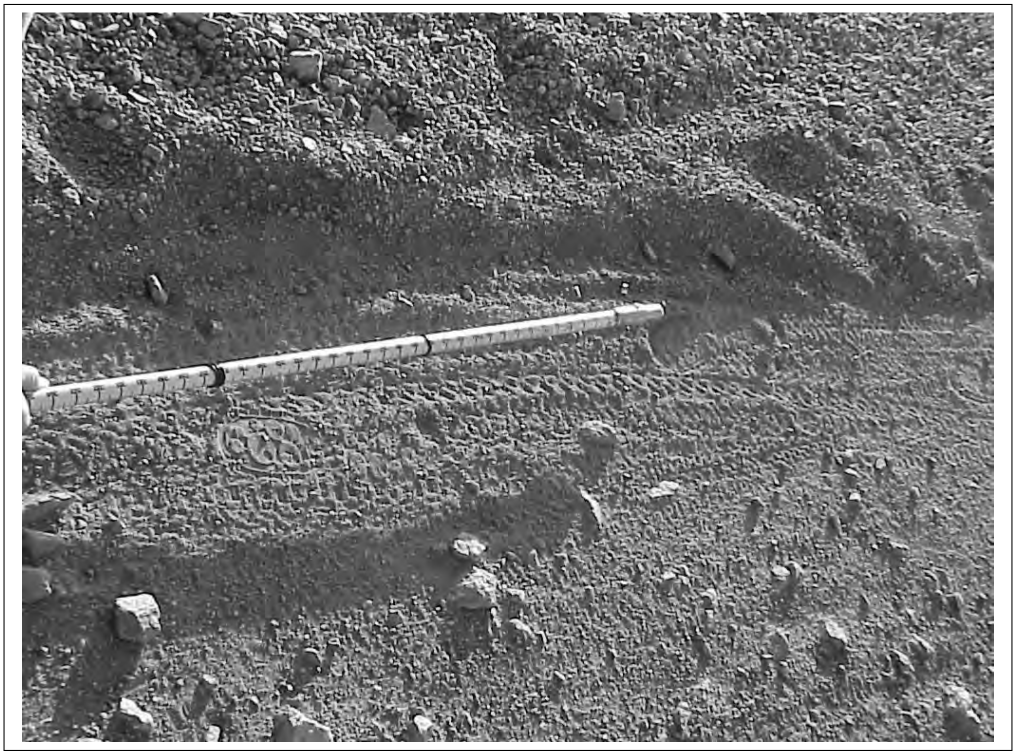

Figure 10.2. Step length—the distance from heel to heel

techniques are similar to the so-called "old Indian" method of the broken stick, an overturned rock, or the misplaced leaf.

The tracker determines the direction the subject has taken, which allows concentrating search efforts in a small area, and provides a high probability of finding the individual. Other advantages, in addition to reducing time, include a considerable savings in manpower, and the ability to search at night.

A tracking team normally consists of three people: a Point person and two Flankers. The Point is the person who follows the tracks. The Flankers position themselves on either side of the Point one or two steps behind. The Flanker's responsibility is to detect any sudden change in direction of the subject's direction of travel.

The Flankers should not advance beyond the Point's position, and the entire team should not advance beyond the last track. Flankers also serve as navigators and maintain radio contact with the Incident Command Post.

Being Point is tiring, so the Flankers should rotate in and out of this position to maintain concentration and reduce stress.

Once a track has been found and identified as the subject's, a circle should be drawn around it to identify it as important and alert others to it. Additional markings, such as a chem light, assist in locating or enhancing it. See Figure 10.5 on the next page. The track's location must be recorded utilizing a GPS unit or by determining location with a map and compass.

Track

Figure 10.6 on page 144 shows examples of fresh track. The biggest problem for trackers is to have the readable sign obliterated. This erosion can be caused by:

- Wind, see Figure 10.7 on page 144.
- Rain.
- Snow.
- Water.
- People.
- Time, see Figure 10.8 on page 144.

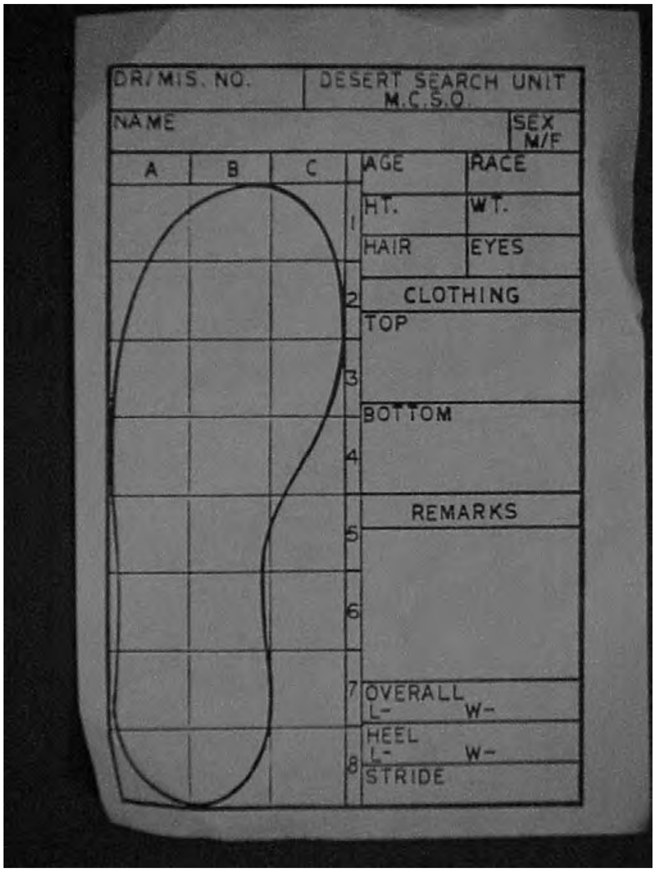

Figure 10.3. Blank Tracking Pad

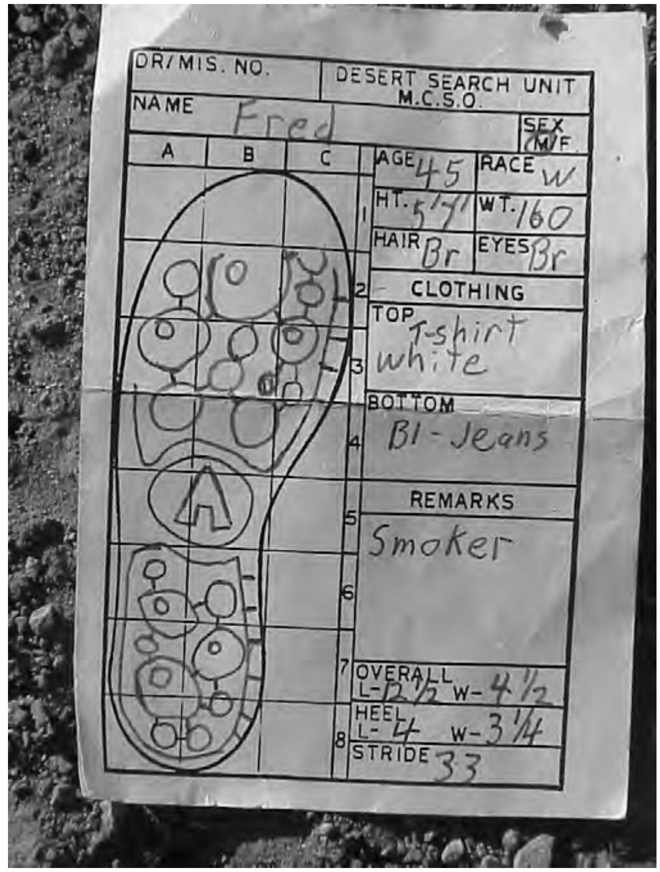

Figure 10.4. Completed Tracking Pad

Figure 10.5. Circling a track

Full Track

Figure 10.9 on the next page shows an example of a full track. They are generally rare to find in the field. Note the absence of toe description.

Figure 10.6. Fresh tracks

Figure 10.7. Erosion due to wind

Figure 10.8. Erosion due to time

Figure 10.9. Full track—note the absence of toe description

Partial Track—Heel Strike

The top left-hand-side of Figure 10.10 on the next page shows an example of a heel strike. These are the most common partial track found in the field. Generally they are the deepest imprint. Successive heel strikes can be used to measure the step length.

Partial Track—Toe Dig/Toe Strike

The center of Figure 10.11 shows an example of a toe dig. They are less common to find in the field than a heel strike. Successive toe digs can be used to measure the step length.

Figure 10.10. Heel Strike—below rock on top left-hand-side

Figure 10.11. Toe Dig—in the center, between two rocks

Lighting

Lighting plays a very important role in tracking. Figure 10.12 on the next page shows the same track under four different lighting conditions (clockwise starting from top left): early natural light at a low angle, natural light under cloud cover, very bright artificial light, and high intensity light spot. Artificially lighting should be low intensity.

The best position to view tracks is if the light source (the sun during the day and artificial light at night) is on the far side of the track from the observer so that the small features of the tracks produce shadows. Figure 10.13 on the next page shows the result when the track is between the light source (top of image) and the tracker (bottom of the image). Figure 10.14 on the next page shows the result when the light source is between the tracker and the tracks.

Disturbances

A disturbance is any change in the natural vegetation or ground composition. Examples of this include a broken twig (Figure 10.15 on page 147), broken soil (Figure 10.16(a) on page 147), and rocks moved(Figure 10.16(b) on page 147).

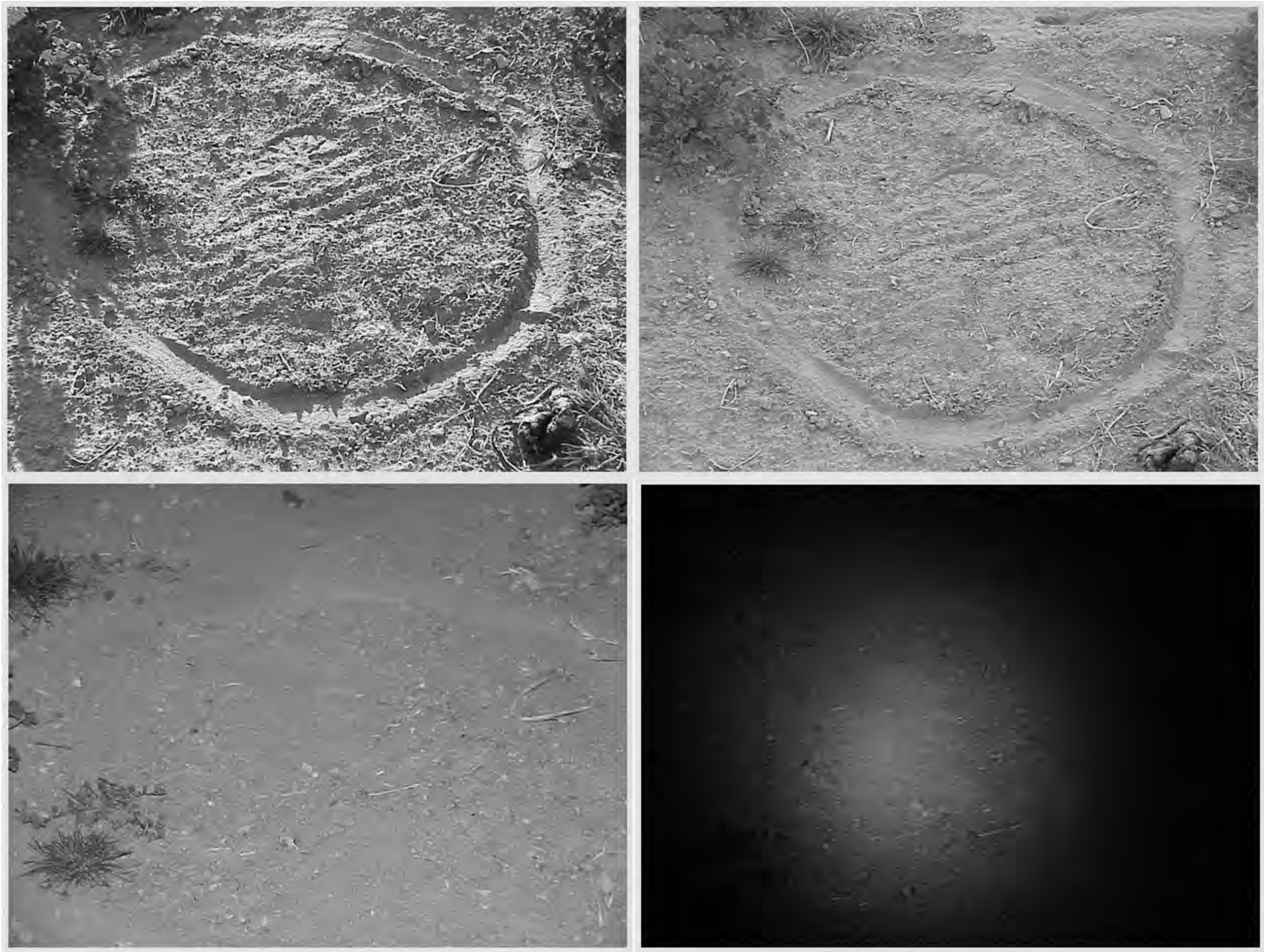

Figure 10.12. Same track under different lighting conditions

Figure 10.13. Backlit track

Figure 10.14. Forwardlit track

Figure 10.15. Broken twig

(a) Broken soil

(b) Rocks moved

Figure 10.16. Examples of ground disturbances

CHAPTER 11

Communications

Communication problems are the single most common deficiency in a SAR operation. This chapter deals with radio and telecommunication issues.

> *Communication problems are the single most common deficiency in a SAR operation.*

There are differences between radio communications in regular law enforcement patrol and in SAR communications. Typically a county sheriff's office and other emergency service agencies have a radio communications system consisting of one or more frequencies and several mountain-top repeaters. The frequencies may be designated for geographical areas or for functional use areas such as patrol, detectives, administration, and special operations. The mountain top repeaters serve to extend the range of the individual radios so that someone in Williams, Arizona, can talk to someone in Flagstaff, Arizona. That communication is difficult if the radios use a line of sight communication, also known as simplex, due the distance involved and the terrain between those locations.

Repeater Operations

A repeater works by having a radio "talk" into the repeater on one frequency and then the repeater retransmits that signal on another frequency. So a repeater has a transmit and receive frequency pair. Repeaters also generally use a subaudible tone or PL tone.[1] This tone is not audible to the human ear but serves to activate the repeater. This is useful when there are several repeaters in an area that may use the same frequency pair. The PL tone allows only the desired repeater to be activated. There are some systems that are voted systems. In a voted system there is one frequency pair and one PL tone for multiple repeaters and a voter unit determines which repeater is the best one to use based on signal strength. An example of a voted system is the Arizona Interoperable Radio System or AIRS. AIRS usually has several repeaters assigned to a specific frequency pair and PL tone in a region. When a user presses the push-to-talk button on the radio the signal goes out and the voter determines which repeater is the best to use and activates that one. The repeater effectively extends the range of a portable or mobile radio by being placed on high terrain so that the user can transmit to the repeater which will then repeat the transmission from its location on high terrain using higher power.

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[1] PL stands for "Private Line". It is the Motorola terminology for CTCSS (Continuous Tone Coded Squelch System). Other terminologies are "QC", the RCA abbreviation for "Quiet Channel", and "CG", the General Electric abbreviation for "Channel Guard".

Simplex Operations

Simplex radio operations use one frequency to both transmit and receive and may or may not have a PL tone. This type of radio communication does not use a repeater and is limited to line-of-sight communications. Essentially the radios talking to each other in this mode must be close enough and be free of major terrain obstacles that could block the signal from getting from one radio to the other. Simplex communications are effective when one unit is working in a canyon and cannot access a repeater and another unit is on the rim of the canyon acting as a relay. Simplex is also used for tactical communications between units working in relatively close proximity that do not need a repeater to extend their range. An example of a simplex frequency is the AZ State SAR frequency (155.160 MHz).

Temporary or Human Repeaters

In areas where the terrain does not allow for units to access an established permanent repeater, such as rugged mountainous or canyon terrain, a temporary repeater or human relay may be established to allow for communications. There are many different models of temporary repeaters ranging from trailer mounted units (see Figure 11.1) to units that require only two hand-held radios (see Figure 11.2). Human relay or repeater points require a person to camp at a specified point and act as a relay. This person needs to have adequate equipment to maintain that position including appropriate radio equipment, batteries, food, water, and shelter. A human relay might also serve as a weather spotter for the incident.

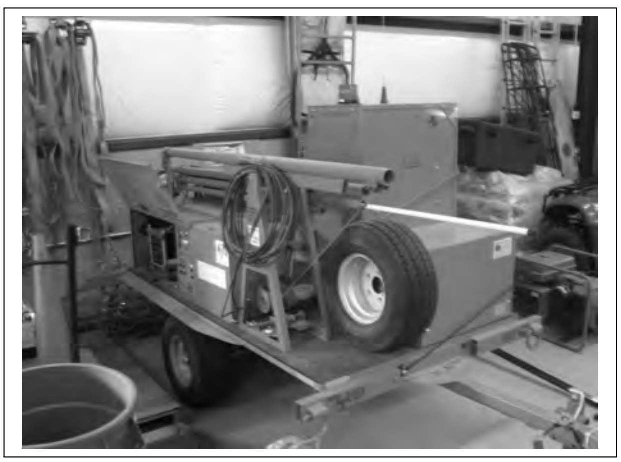

Figure 11.1. A trailer-mounted portable repeater unit

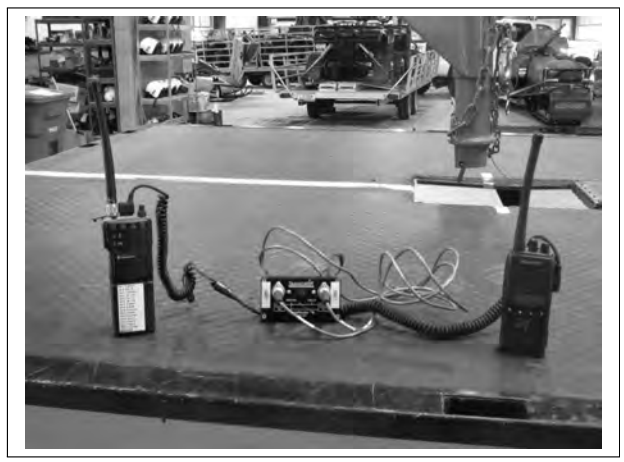

Figure 11.2. A portable repeater using two hand-held radios

There are some vehicle repeaters in use around the state that can enhance radio communications options. Coconino County has vehicle repeaters in most patrol vehicles and all SAR vehicles. The vehicle repeater is connected to the mobile radio in the vehicle. When a deputy or volunteer exits the vehicle and is using a portable radio the vehicle repeater can be turned on. The portable radio is then set to a specific channel to talk to the vehicle which repeats that transmission on the frequency that is selected on the mobile radio. The mobile radio receives any transmissions as normal and then they are repeated through the vehicle repeater to the portable radio.

Documentation of Radio Traffic

Repeated frequencies in use by law enforcement or other public safety agencies are often recorded at a dispatch center. These recordings are sometimes used as evidence in criminal proceedings and can be requested by the media as public information. Generally simplex frequencies are not recorded by a dispatch center because the dispatch center may not hear these transmissions between units. The benefit of having a recorded frequency is that the communications can be reviewed at a later time if needed while unrecorded simplex communications rely on a written communications log for review at a later time.

Common Radio Frequencies In Use In SAR Operations

In Arizona there are several frequencies that are in use in most parts of the state for SAR operations. These are a combination of repeated and simplex frequencies.

State SAR Frequency (VSAR16)

In general, most SAR units have access to the AZ State SAR frequency of 155.160 MHz.[2] This frequency is also used for land SAR nationwide however some ambulance services use this frequency in parts of the United States. This is a simplex frequency but some counties have installed or are installing repeaters on this frequency with the 155.160 (narrowband) MHz as the repeater output or receive frequency.

Fire Mutual Aid (VFIRE21)

Many EMS and Fire agencies use VHF Fire Mutual Aid also known as VFIRE21 (154.280 (narrowband) MHz) for interagency communications. Often, EMS helicopters (HEMS) also use this frequency to communicate with ground units for landing instructions when they are on approach to an accident scene.

Arizona Interoperable Radio System (AIRS)

Throughout Arizona an interoperable radio system has been installed called the Arizona Interoperable Radio System (AIRS). Arizona has been divided into several AIRS regions. Each region has a frequency pair and specific PL tone for that region (AIRS1, AIRS2, AIRS3, AIRS4, AIRS5). The AIRS suite at each site consists of a VHF, a UHF, and an 800 MHz radio so that if one unit is using UHF on AIRS2 that transmission is broadcast on AIRS2 VHF, AIRS2 UHF, and AIRS2 800 MHz allowing for interoperable communications between units or agencies in disparate radio systems.

In each AIRS region there are also tactical frequencies assigned which are not interoperable because they do not use a repeater. Each of tactical frequencies are radio-band specific. For example, VTAC13 is a VHF (denoted by the V) tactical frequency (denoted by TAC) and UTAC13 would be a UHF (denoted by U in the title) tactical frequency.

Federal/Non-Federal VHF SAR Operations Plan

The Federal/Non-Federal SAR and Operations Plan as outlined on page 39 of the National Interoperability Field Operations Guide (NIFOG) published by the U.S. Department of Homeland Security Office of Emergency Communications (available from `http://www.dhs.gov/files/publications/gc_1297699887997.shtm`) is reproduced in Figure 11.3 on the next page.

[2] Some jurisdictions may use a different designated frequency for SAR. For example, Maricopa County Sheriff's Office utilizes 159.09 MHz simplex and repeatered.

Federal / Non-Federal VHF SAR Operations Interoperability Plan

Suggested SAR Function	Frequency (MHz)
Ground Operations	155.1600 narrowband FM (or wideband FM till 1/1/2013)
Maritime Operations *	157.050 or 157.150 (VHF Marine ch.21A or 23A) as specified by USCG Sector Commander
Air Operations – civilian	123.100 MHz AM (may not be used for tests or exercises)
Air Operations – USCG/Military	345.0 MHz AM for initial contact only, then move to 282.8 MHz AM or other working channel
Air rescue assets to air rescue assets (deconfliction)	As charted on standard air chart or MULTICOM 122.850 (south or west sector) & 122.900 MHz (north or east sector), or as specified by FAA. 122.850 may not be used for tests or exercises
Ground to Air SAR working channel	157.175 83A (21A, 23A, 81A alternates as specified by local USCG Sector Commander) **
Ground to Maritime SAR working channel	157.050 21A (23A, 81A, 83A alternates as specified by local USCG Sector Commander) **
Maritime/Air/Ground SAR working channel *	157.175 83A (21A, 23A, 81A alternates as specified by local USCG Sector Commander) **
EMS / Medical Support	155.3400 (wideband FM)
Hailing* & DISTRESS only - Maritime/Air/Ground	156.800 VHF Marine channel 16

*** Use VHF Marine ch.16 to make contact (30 seconds max.), then move to appropriate working channel as directed by local USCG Sector Commander. Non-maritime use of any VHF Marine channel requires FCC Special Temporary Authority or appropriate license. VHF marine channels use wideband FM, emission 16K0F3E**

** VHF Marine channels: 16=156.800 21A=157.050 22A=157.100 23A=157.150 81A=157.075 82A=157.125 83A=157.1750

Direction from USCG, FCC, or FAA overrides information in this table. This table does not convey authority to operate.

Figure 11.3. Federal/Non-Federal VHF SAR Operations Plan

Amateur Radio

Amateur Radio (HAM) is a good alternative or back-up to a specific county radio system. There are many HAM repeaters dispersed throughout the state. HAM radio requires a license from the FCC. To obtain the license an individual must take and pass an amateur radio exam. This exam is offered by many amateur radio clubs at various times.

Some HAM repeaters have auto-patch capability that allows a HAM operator to use the repeater as a telephone for short telephone calls. Some repeaters are internet linked (IRLP), which allows a HAM using a radio in Tucson to contact a HAM using a radio in Flagstaff, for example.

HAM operators can also use Automatic Position Reporting System (APRS) where a radio is linked to a GPS unit to transmit position information of that radio. This can be an effective tool for incident management staff to monitor the location of teams in the field.

For more information about HAM radio contact a local HAM club or visit `www.arrl.com`.

Arizona Statewide Interoperable Channel Plan—Priority Programming Guides

The Statewide Interoperability Executive Committee (SIEC) has approved these “priority programming guides” to standardize and increase interoperable communications throughout the state in the

VHF, UHF, 700, and 800 MHz bands. It is suggested the each agency incorporate these channels into their channel plan the next time their radios are programmed, but no later than the narrowbanding deadline of January 1, 2013.

Statewide VHF Priority Programming Guide

	CURRENT NAME	BAND-WIDTH	RX FREQ MHz	RX CTCSS Hz	TX FREQ MHz	TX CTCSS Hz
1	VAIRS1	12.5 kHz	155.4750	CSQ	155.1900	141.3
2	VAIRS2	12.5 kHz	155.4750	CSQ	155.1900	131.8
3	VAIRS3	12.5 kHz	155.4750	CSQ	155.1900	110.9
4	VAIRS4	12.5 kHz	155.4750	CSQ	155.1900	123.0
5	VAIRS5	12.5 kHz	155.4750	CSQ	155.1900	167.9
6	SAR NFM	12.5 kHz	155.1600	CSQ	155.1600	127.3
7	VFIRE21	12.5 kHz	154.2800	CSQ	154.2800	CSQ
8	VMED28	12.5 kHz	155.3400	CSQ	155.3400	CSQ
9	VLAW31	12.5 kHz	155.4750	CSQ	155.4750	CSQ
10	VCALL10	12.5 kHz	155.7525	CSQ	155.7525	156.7
11	VTAC11	12.5 kHz	151.1375	CSQ	151.1375	156.7
12	VTAC12	12.5 kHz	154.4525	CSQ	154.4525	156.7
13	VTAC13	12.5 kHz	158.7375	CSQ	158.7375	156.7
14	VTAC14	12.5 kHz	159.4725	CSQ	159.4725	156.7
15	VTAC36*	12.5 kHz	151.1375	CSQ	159.4725	136.5
16	VTAC37*	12.5 kHz	154.4525	CSQ	158.7375	136.5

*NOTE: The use of tactical repeater pairs VTAC36/37 will supersede the use of VTAC11-14 since their Rx/Tx frequencies will be in use. In other words:

- VTAC36 uses the Rx of VTAC11 and the Tx of VTAC14 with a 8.335 MHz separation.
- VTAC37 uses the Rx of VTAC12 and the Tx of VTAC13 with a 4.285 MHz separation.

Note: VTAC33 and VTAC34 were replaced by VTAC36 and VTAC37 on January 11, 2012.

Figure 11.4. Statewide VHF Priority Programming Guide—Effective 1/11/2012

Statewide UHF Priority Programming Guide

	CURRENT NAME	BAND-WIDTH	RX FREQ MHz	RX CTCSS Hz	TX FREQ MHz	TX CTCSS Hz
1	UAIRS1	12.5 kHz	460.3750	CSQ	465.3750	141.3
2	UAIRS2	12.5 kHz	460.3750	CSQ	465.3750	131.8
3	UAIRS3	12.5 kHz	460.3750	CSQ	465.3750	110.9
4	UAIRS4	12.5 kHz	460.3750	CSQ	465.3750	123.0
5	UAIRS5	12.5 kHz	460.3750	CSQ	465.3750	167.9
6	UAIRS_D	12.5 kHz	460.3750	CSQ	460.3750	100.0
7	UCALL40	12.5 kHz	453.2125	CSQ	458.2125	156.7
8	UCALL40D	12.5 kHz	453.2125	CSQ	453.2125	156.7
9	UTAC41	12.5 kHz	453.4625	CSQ	458.4625	156.7
10	UTAC41D	12.5 kHz	453.4625	CSQ	453.4625	156.7
11	UTAC42	12.5 kHz	453.7125	CSQ	458.7125	156.7
12	UTAC42D	12.5 kHz	453.7125	CSQ	453.7125	156.7
13	UTAC43	12.5 kHz	453.8625	CSQ	458.8625	156.7
14	UTAC43D	12.5 kHz	453.8625	CSQ	453.8625	156.7
15	MED-5D	12.5 kHz	463.1000	CSQ	463.1000	136.5
16						

Figure 11.5. Statewide UHF Priority Programming Guide—Effective 1/11/2012

Statewide 800 MHz Priority Programming Guide

ZONE	NAME	BAND-WIDTH	RX FREQ MHz	RX CTCSS Hz	TX FREQ MHz	TX CTCSS Hz
1	8AIRS1	20 kHz	866.0125	CSQ	821.0125	141.3
2	8AIRS2	20 kHz	866.0125	CSQ	821.0125	131.8
3	8AIRS3	20 kHz	866.0125	CSQ	821.0125	110.9
4	8AIRS4	20 kHz	866.0125	CSQ	821.0125	123.0
5	8AIRS5	20 kHz	866.0125	CSQ	821.0125	167.9
6	8CALL90	20 kHz	866.0125	CSQ	821.0125	156.7
7	8TAC91	20 kHz	866.5125	CSQ	821.5125	156.7
8	8TAC91D	20 kHz	866.5125	CSQ	866.5125	156.7
9	8TAC92	20 kHz	867.0125	CSQ	822.0125	156.7
10	8TAC92D	20 kHz	867.0125	CSQ	867.0125	156.7
11	8TAC93	20 kHz	867.5125	CSQ	822.5125	156.7
12	8TAC93D	20 kHz	867.5125	CSQ	867.5125	156.7
13	8TAC94	20 kHz	868.0125	CSQ	823.0125	156.7
14	8TAC94D	20 kHz	868.0125	CSQ	868.0125	156.7
15	8AZTAC5†	20 kHz	866.0375	CSQ	821.0375	156.7
16	8AZTAC5D†	20 kHz	866.0375	CSQ	866.0375	156.7

† The use of 8AZTAC5 and 8AZTAC5D are unique to Arizona with the approval of the Region 3 - 800 MHz Regional Planning Committee.
Note: The names of 8TAC95 and 8TAC95D were changed to 8AZTAC5 and 8AZTAC5D on January 11, 2012.

Figure 11.6. Statewide 800MHz Priority Programming Guide—Effective 1/11/2012

Statewide 700 MHz Priority Programming Guide

	NAME	BAND-WIDTH	RX FREQ MHz	RX NAC	TX FREQ MHz	TX NAC
1	7CALL50	12.5 kHz	769.24375	3966 or $F7E	799.24375	659 or $293
2	7CALL50D	12.5 kHz	769.24375	3966 or $F7E	769.24375	659 or $293
3	7MED65	12.5 kHz	769.39375	3966 or $F7E	799.39375	659 or $293
4	7MED65D	12.5 kHz	769.39375	3966 or $F7E	769.39375	659 or $293
5	7TAC55	12.5 kHz	769.74375	3966 or $F7E	799.74375	659 or $293
6	7TAC55D	12.5 kHz	769.74375	3966 or $F7E	769.74375	659 or $293
7	7FIRE63	12.5 kHz	769.89375	3966 or $F7E	799.89375	659 or $293
8	7FIRE63D	12.5 kHz	769.89375	3966 or $F7E	769.89375	659 or $293
9	7TAC56	12.5 kHz	770.24375	3966 or $F7E	800.24375	659 or $293
10	7TAC56D	12.5 kHz	770.24375	3966 or $F7E	770.24375	659 or $293
11	7LAW61	12.5 kHz	770.39375	3966 or $F7E	800.39375	659 or $293
12	7LAW61D	12.5 kHz	770.39375	3966 or $F7E	770.39375	659 or $293
13	7GTAC57	12.5 kHz	770.99375	3966 or $F7E	800.99375	659 or $293
14	7GTAC57D	12.5 kHz	770.99375	3966 or $F7E	770.99375	659 or $293
15	7CALL70	12.5 kHz	773.25625	3966 or $F7E	803.25625	659 or $293
16	7CALL70D	12.5 kHz	773.25625	3966 or $F7E	773.25625	659 or $293

Figure 11.7. Statewide 700MHz Priority Programming Guide—Effective 1/11/2012

Table 11.1. Separate AIRS and 800 MHz Zones

Zone 1	Name	Bandwidth kHz	TX Freq MHz	TX CTCSS Hz	RX Freq MHz	RX CTCSS Hz
1	8CALL90	20	821.0125	156.7	866.0125	CSQ
2	8CALL90D		SIMPLEX	156.7	866.0125	CSQ
3	8TAC91	20	821.5125	156.7	866.5125	CSQ
4	8TAC91D		SIMPLEX	156.7	866.5125	CSQ
5	8TAC92	20	822.0125	156.7	867.0125	CSQ
6	8TAC92D		SIMPLEX	156.7	867.0125	CSQ
7	8TAC93	20	822.5125	156.7	867.5125	CSQ
8	8TAC93D		SIMPLEX	156.7	867.5125	CSQ
9	8TAC94	20	823.0125	156.7	868.0125	CSQ
10	8TAC94D		SIMPLEX	156.7	868.0125	CSQ

Table 11.2. Separate AIRS and 800 MHz Zones

Zone 2	Name	Bandwidth kHz	TX Freq MHz	TX CTCSS Hz	RX Freq MHz	RX CTCSS Hz
1	AIRS1	20	821.0125	141.3	866.0125	CSQ
2	AIRS2	20	821.0125	131.8	866.0125	CSQ
3	AIRS3	20	821.0125	110.9	866.0125	CSQ
4	AIRS4	20	821.0125	123.0	866.0125	CSQ
5	AIRS5	20	821.0125	167.9	866.0125	CSQ

Requirements

Prior to becoming field deployable the searcher must be able to demonstrate the use of the communications equipment used by the agency or team that they belong to. Often this will include demonstrating how to check out radio equipment from a radio cache, physically operating the radio and the necessary controls (on/off switch, volume control, squelch control, and channel selector). Depending on the agency or team a SAR member may need to operate a portable (hand-held) radio, a mobile (vehicle mounted) radio, or a base station (fixed in a building) radio. Additionally the radio might be used on simplex (line of sight) frequencies or on repeated frequencies that utilize repeaters located on high points around the area. Some of the frequencies might be shared with other law enforcement or emergency services functions. It is critical that the SAR member understand the policies related to the use of the frequencies that they are likely to be operating on. Properly receiving and transmitting information over the radio should also be demonstrated. Some new SAR members may be intimidated by the radio, having never had to use that type of equipment before. To use the radio effectively a SAR member should think about the following when using the radio:

- Select the appropriate radio channel or frequency per the communications plan.
- Listen to make sure that there is not other traffic being passed.
- Think about what you need to say before depressing the push to talk switch.
- Speak in clear text with no codes (except where a code has been specifically briefed for the incident like a code for a deceased person).
- Consider the type of information that you may be transmitting to be sure that it is appropriate to send by radio.
- When transmitting coordinates or spelling a name phonetically speak relatively slowly so that the recipient has time to write down the information.

- Pay attention to the radio while conducting SAR operations in case someone is calling you to pass along information. Be ready to write down information communicated to you so that you do not have to ask for the information to be repeated several times.

Radio communications are a critical component to SAR and emergency response. Take the time to learn about and become proficient with the communications equipment that you will be using on a SAR mission as it could very well save the subject's life or even your own.

Interpersonal Communication

Just as important as radio communications is interpersonal communication. A team must be able to communicate within the team and with others to effectively transfer important information. New members to a team may be reluctant to speak up if they have an idea or see a problem. It is critical that team leaders actively communicate with all members of the team. That includes both listening and talking. Encouraging everyone to participate in discussions will improve operations. The National Wildfire Coordinating Group has included the following Communication Responsibilities for all personnel in the Incident Response Pocket Guide:

- Brief others as needed.
- Debrief your actions.
- Communicate hazards to others.
- Acknowledge messages.
- Ask if you don't know.

Everyone on a SAR team has a responsibility to participate actively in the mission that they are assigned. That includes searching and communicating findings and concerns with other members of the team and the Incident Management Team. Information gathered during an incident must be communicated to the appropriate personnel as it may have a significant impact on search planning.

Communications Summary

Communications is an essential tool for SAR personnel performing a mission. Critical information needs to be relayed in a timely manner. A good communication plan should be developed before units head into the field. Communications should be tested periodically to determine if there are communication difficulties, which should be reported to the incident management team during a debriefing so that they can be remedied for future operations.

CHAPTER 12

Incident Command System

ICS was designed for a fire incident, which is a known problem at a known location, but a search is an unknown problem at an unknown location, so ICS has to be massaged to work well with searches.

Background

This chapter is a brief introduction to the Incident Command System. For a more in depth understanding, either attend the ICS 100, 200, and 300 courses, or study Reference [Deal].[1]

Homeland Security Presidential Directive 5 requires that all federal agencies develop an Incident Command System (ICS) to facilitate a national, coordinated response to domestic emergencies.[2] A corresponding directive from then State of Arizona Governor Napolitano was issued stating that ICS will be used by all state agencies to manage all-hazard incidents, which includes SAR incidents.

According to Ken Hill,[3] "*The first function to break down in the search for a lost person is the management function, and when this happens it affects virtually every component of the search operation, most especially and unfortunately its outcome. When the [Incident Commander] loses control of the incident, confusion reigns, tempers flare, the media gets hostile, and the search becomes a protracted and painful ordeal.*"

Symptoms that the management of a SAR incident is malfunctioning include

- Lack of accountability (including unclear chain of command and supervision).
- Poor communication (including radio and terminology problems).
- Lack of an orderly, systematic planning process.
- Being reactive rather than proactive.
- Lack of documentation detailing what has been done.

These problems can be mitigated by using the Incident Command System (ICS).

> *Problems with managing a SAR incident can be mitigated by using the Incident Command System.*

ICS Overview

An ICS organization is modular and flexible.

[1] Some ICS courses are available online. See `http://www.training.fema.gov/is/crslist.asp`.
[2] See `http://www.dhs.gov/xabout/laws/gc_1214592333605.shtm#content`.
[3] Part of this chapter is based on the ideas of Ken Hill (Reference [Hill 1]). Used with permission.

- It develops in a top-down fashion. Initially there is usually only the Incident Commander in the organization, but as the incident becomes larger and more complex, the size of the organization grows. Then, as the incident winds down, the organization shrinks. So the organization expands and contracts as needed.
- The incident objectives determine the organizational size.
- Only functions/positions that are necessary are filled. The responsibilities of unfilled functions/positions are assumed by the immediate superiors.
- There is an orderly line of authority within the ranks of the incident management organization (Chain of Command).
- Every individual has one, and only one, designated supervisor to whom they report (Unity of Command).

The ICS provides consistent and efficient guidelines for the management of an incident, so that

1. The roles and functions of the **Incident Management Team**, are clearly defined and coordinated ensuring that search management is a team effort.
2. **Sound Management Principles** are specified and used permitting leaders to maintain control of the incident.
3. **Common Terminology** is provided allowing people to communicate effectively.
4. All actions taken on behalf of the lost subject are goal-directed rather than resulting from isolated decisions: that is, they are driven by operational objectives, thereby contributing to an overall **Incident Action Plan** for finding the subject.
5. All decisions, clues, and activities are **Documented**. ICS provides a comprehensive set of forms for keeping a written record of the incident.

These concepts are discussed in turn. However, to quote Paul Anderson, "*in practice ICS is not as organized as it appears, and it often takes more than one Operational Period before all components of the system are synchronized.*"

1. **Incident Management Team (IMT)**
   The Incident Management Team is the overhead team responsible for managing the search and devising an Incident Action Plan for finding the lost person. There are five basic functions that must be performed during the incident. See Figure 12.1.

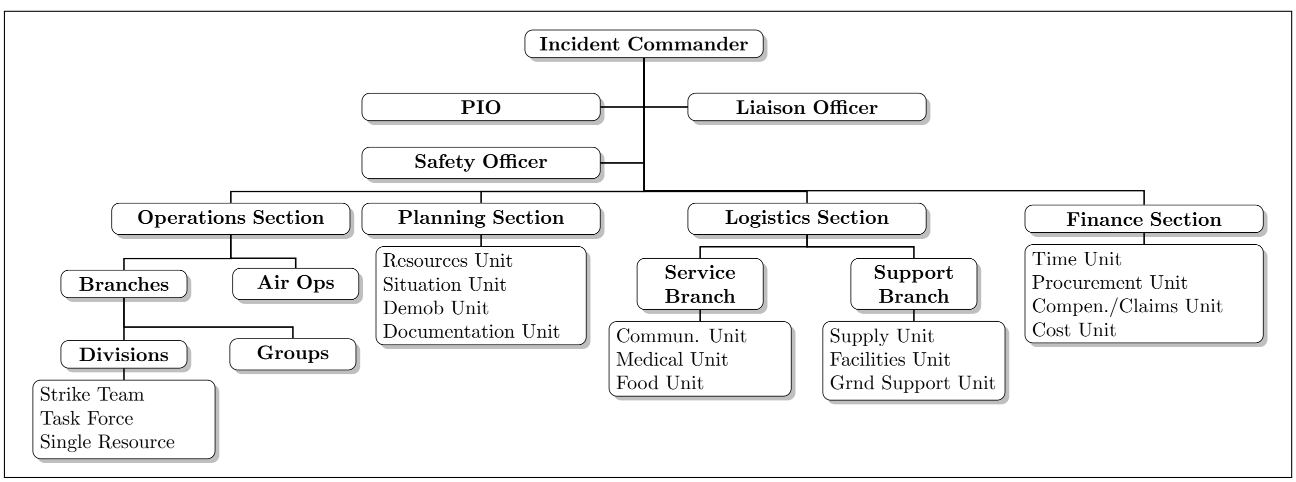

Figure 12.1. ICS Structure

   a) **The Command Function**
      Although search management is a team effort, someone has to be responsible for leading the overhead team and overseeing all on-scene activities. The person who performs this function is

called the Incident Commander. They set the Incident Objectives and ensure that other members of the overhead team implement those objectives. While they supervise the performance of other search functions (for example, decisions concerning search tactics), they do not become overly involved with any particular function, because this detracts from their ability to maintain "the big picture" on the incident. The Incident Commander delegates authority, but not responsibility.

> *The Incident Commander delegates authority, but not responsibility.*

As needed, the Incident Commander delegates some authorities to the Public Information Officer, the Safety Officer, and the Liaison Officer.

i. Public Information Officer (PIO). The PIO is responsible for interfacing with the public and media and/or with other agencies with incident-related information requirements.
ii. Safety Officer (SOFR). The SOFR monitors incident operations and advises the Incident Commander on all matters relating to operational safety, including the health and safety of emergency responder personnel.
iii. Liaison Officer (LOFR). The LOFR is the point of contact for representatives of other governmental agencies, nongovernmental organizations, and/or private entities.

b) **The Planning Function**

Searching for a lost person involves gathering information (lost person data, witness reports, clues, weather forecasts, etc.) and, based on that information, acquiring and applying search resources (ground searchers, helicopters, dogs, etc.) to specific areas of the search. The Planning Section Chief performs this function (in consultation with the Operations Chief and approved by the Incident Commander). They take the Incident Objectives (for example, "Confine the subject to within an area of 8 square miles." "Search high probability areas with a high probability of detecting the subject." "Find the subject before nightfall.") set by the Incident Commander and translate them into an operational strategy, including an assessment of the resources necessary to implement the strategy. For example, in an Area Search they are responsible for segmenting the search area on a map and—based on a review of the behavior of past lost persons of a similar type—assigning probabilities that the subject is located within each segment; they decide where to set up containment points for keeping the subject from leaving the area; and they keep a careful record of the extent to which different segments of the search area have been searched.

> *The Planning Section Chief takes the Incident Objectives set by the Incident Commander and translates them into an operational strategy, including an assessment of the resources necessary to implement the strategy.*

Generally, the Planning Section Chief is in charge of both documentation (keeping accurate records of search progress) and investigation (acquiring the information necessary to conduct a successful search).

As needed, the Planning Section Chief delegates some authorities to the Resources, Situation, Demob, and Documentation Unit leaders.

i. Resources Unit Leader. The Resources Unit ensures that all assigned personnel and other resources have checked in at the incident. This unit keeps track of the current location and status of all assigned resources and maintains a master list of all resources committed to the incident.

ii. Situation Unit Leader. The Situation Unit collects, processes, and organizes ongoing situation information. It prepares situation summaries, develops projections and forecasts of future events related to the incident, and prepares maps and gathers and disseminates information and intelligence for use in the IAP.
iii. Demob Unit Leader. The Demobilization Unit develops an Incident Demobilization Plan that includes specific instructions for all personnel and resources that require demobilization.
iv. Documentation Unit Leader. The Documentation Unit maintains accurate and complete incident files, including a complete record of the major steps taken to resolve the incident. It provides duplication services to incident personnel; and files, maintains, and stores incident files for legal, analytical, and historical purposes.

c) **The Operations Function**
The Operations Section Chief makes tactical decisions about how to apply available resources to implement the search strategy set by the Planning Section Chief.[4] For example, if the Planning Section Chief wants a certain degree of coverage in a particular segment, the Operations Section Chief decides whether to use grid searchers, trackers, dog teams, aircraft, or some other search resource in order to complete the search strategy. They prepare the assignments and commit searchers to the field.

> *The Operations Section Chief makes tactical decisions about how to apply available resources to implement the search strategy set by the Planning Section Chief.*

As needed, the Operations Section Chief establishes Divisions and Groups. Divisions are associated with physical or geographical areas of operation within the search area, for example, "Division A consists of Segments 1 through 7". Groups are associated with functional areas of operation for the incident, for example, the Medical Group or the Investigative Group.

d) **The Logistics Function**
Logistics is an important supportive function. Someone has to ensure that searchers are fed and have a place to rest, that adequate transportation is available, that a communications system is established, that helicopters have a place to land, that medical services are available for injured searchers, and that order is maintained at the search base. Anything that is necessary to support the search incident is provided and supervised by the Logistics Section Chief.

> *Anything that is necessary to support the search incident is provided and supervised by the Logistics Section Chief.*

e) **The Finance/Administration Function**
The Finance/Administration Function is responsible for managing all financial aspects of the incident. Not all incidents require a Finance/Administration Section. The Finance/Administration Section Chief processes workers compensation claims, contracts, payment for paid personnel, and equipment time-keeping. These functions are very important and while the Finance Section Chief is not seen on many incidents the Incident Commander is responsible for making sure that these issues are handled. While less likely in a SAR incident the Finance/Administration Section Chief can have significant influence over strategy and tactics based on the money available for the incident.

2. **Sound Management Principles**

[4] Strategy involves the "big picture"—the overall plan, and how those plans will achieve the goals and objectives. A tactic is an action that leads to the execution of the strategy. For example, a strategy might be to search particular segments. The search technique used to search a particular segment is a tactic.

As applied to search and rescue, ICS specifies a number of guidelines for optimal management of the search incident. Some of these include:

- **Operational Periods (OP)**.
  The number of hours for which search managers can remain effective, rational decision-makers is limited. Normally, the quality of thinking processes begins to wane after 8 hours of duty and becomes severely impaired after 12 hours. The usual full operational period therefore consists of 12-hour shifts, with an overlap of approximately one hour at shift changes so that the next overhead team can be adequately briefed. In other words, the work shift is longer than the Operational Period. In urban searches the Operational Period is sometimes set at 8 hours, rather than 12. The start and length of the first full and subsequent operational periods should be proposed by the Planning Section, confirmed by the Logistics Section, and given final approval by the Incident Commander. The operational period is the period of time scheduled for completion of a given set of actions called for in the IAP.
- **Manageable Span of Control**.
  The number of people that a manager can effectively supervise is limited, especially during a SAR incident. ICS recommends that the number of supervised people is between 3 and 7, with 5 suggested as an optimum. When the number becomes larger than this, it is time to delegate authority to assistants, to whom the manageable span of control also applies. The size of the current organization and that for the next operational period are determined through the incident planning process.

> *ICS recommends that the number of supervised people is between 3 and 7, with 5 suggested as an optimum.*

- **Decision by Consensus and Consultation**.
  In search management, the basic tenet is "Never Plan Alone". Consultation requires discussion, and discussion facilitates a rational and systematic approach to search planning, where ideas are analyzed and reevaluated through dialogue. For example, although the Incident Commander has sole responsibility for establishing the incident objectives, they consult with members of the overhead team before doing so. Similarly, the Planning Section Chief draws upon all available expertise when assigning priorities to different segments of the search area.
- **Being Proactive Rather than Reactive**.
  A proactive search manager anticipates events before they occur and is fully prepared to cope with emerging problems or difficulties. Bad weather, injuries, accidents, equipment failures, and the depletion of resources are planned for rather than merely reacted to. Most importantly, search managers must have at their disposal a preplan, which guides many of the decisions that have to be made during a search emergency. A good preplan anticipates such problems and suggests optimal courses of action for each.
- **Resource Management**.
  Resources at an incident must be managed effectively. Maintaining an accurate and up-to-date picture of resource utilization is a critical component of incident management.

> *Maintaining an accurate and up-to-date picture of resource utilization is a critical component of incident management.*

  Resource management includes processes for:
  - Ordering resources.
  - Dispatching resources.

- Categorizing resources. For example, there are three ways to temporarily organize resources: as single resources, as strike teams, or as task forces.
  - **Single Resources**. As the name implies, a single resource is an individual piece of equipment, or group of individuals, with an identified supervisor. Examples of a single resource are: a helicopter with pilot, an air scent dog with handler, a UAV with "pilot", an ATV with driver, a hasty search team with leader.
  - **Strike Teams**. A strike team consists of resources of the same kind with common communications and a leader. Examples of a strike team are: an 8-man team created from four 2-man hasty teams to search a segment, or two horses and their riders.
  - **Task Forces**. A task force consists of resources of different kinds with common communications and a leader. An example of a task force is an air-scent dog and handler together with an additional person to handle communications.
- Tracking resources. The status of a resource that is checked-in but not checked out, fall into one of three categories.
  - Assigned. Currently working on an assignment under the direction of a supervisor.
  - Available. Ready for immediate assignment and has been issued all required equipment.
  - Out-of-Service. Neither available nor ready to be assigned (for example, maintenance issues, rest periods).

  The physical process of keeping track of resources can be done in various ways., using

- **Common Terminology**

  For effective management, everyone must speak the same language. A number of central terms basic to ICS have already been introduced, such as "Incident Commander" and "Operational Period". Others follow.

  - Position Titles. At each level within the ICS organization, individuals with primary responsibility have distinct titles, as do their assistants. See Table 12.1. Titles provide a common standard for all users, and also make it easier to fill ICS positions with qualified personnel. ICS titles often do not correspond to the titles used on a daily basis.

Table 12.1. ICS Position Titles

Organizational Element	Position Titles	Support Position Titles
Incident Command	Commander	Deputy
Command Staff	Officer	Assistant
General Staff	Chief	Deputy
Branch	Director	Deputy
Division or Group	Supervisor	—
Unit	Leader	Assistant

  - Incident Facilities. Common terminology is used to designate the facilities in the vicinity of the incident area that are used in the course of incident management activities. See Figure 12.2.[5] These include
    - Incident Command Post (ICP), where the Incident Commander oversees the incident.
    - Staging Areas, where resources are kept while waiting to be assigned.
    - Base, where primary logistics functions are coordinated and administered.
    - Camps, where resources may be kept.
    - Helibase/Helispot, where helicopter operations are conducted.

  The terms "base camp" and "rendezvous" which are sometimes used in SAR, are not in the ICS vocabulary, and their use should be discouraged.

[5] Downloaded from `http://training.fema.gov/EmiWeb/IS/ICSResource/assets/incidentfacilities.pdf`.

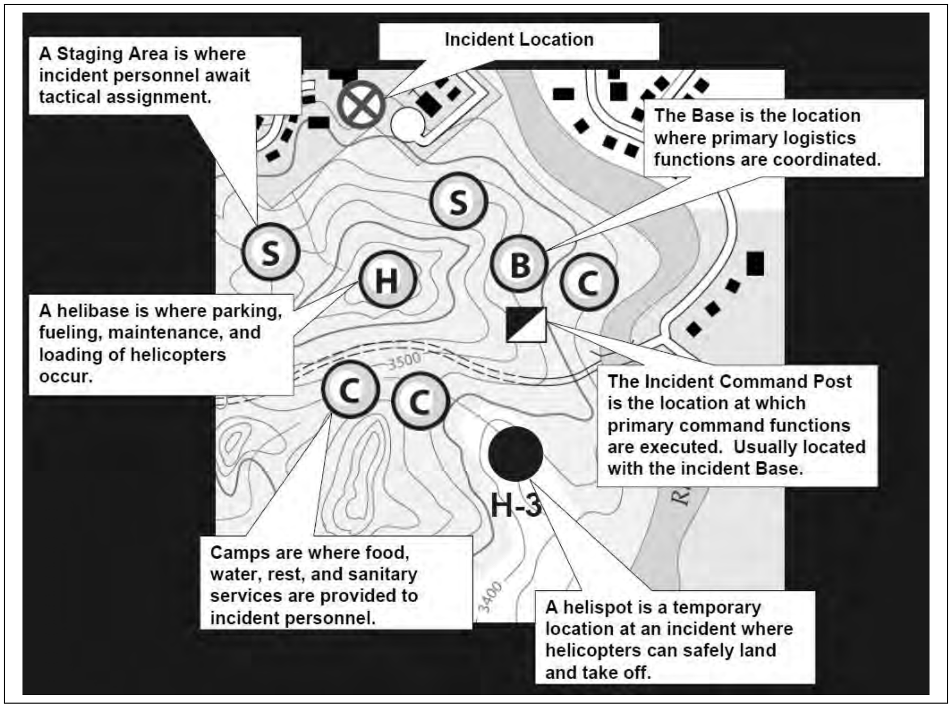

Figure 12.2. Incident Facilities

- Resource Descriptions. Major resources—including personnel, facilities, and major equipment and supply items—used to support incident management activities are given common names and are “typed” with respect to their capabilities, to help avoid confusion. ICS identifies resources as tactical or support resources.
  - Tactical Resources. Personnel and major items of equipment used in the operation.
  - Support Resources. All other resources required to support the incident (for example, food, communications equipment, supplies).

  In English, the expressions “type of resource” and “kind of resource” could be used interchangeably. Not so under ICS. The word “Kind” describes what the resource is, while the word “Type” describes its capability. For example, a helicopter is a kind of resource.
- Divisions and Groups are ways of partitioning an incident into manageable pieces. A Division is a geographical region established using boundaries. For example, if there were 12 regions to search, that exceeds the span of control, then the search area could be divided into two Divisions, called Division A and Division B, each containing 6 regions. A Group is a collection of people established by function, that is, what it does. For example, the Medical Group consists of the following people, or the Investigative Group consists of the following people.
- SAR Buzzwords. More specific to SAR are the following important words that everyone involved with the management of a SAR incident should understand: Place Last Seen (PLS), Last Known Position (LKP), and Initial Planning Point (IPP), Consensus, Probability of Area (POA), Rest of the World (ROW), Probability of Detection (POD), and Cumulative Probability of Detection (CPOD).
- Plain Language. The use of plain language, rather than 10-codes, in an emergency response is the ICS norm.

3. **Incident Action Plan**

All operational and logistical decisions are guided by reference to the Incident Action Plan (IAP), prepared by the overhead team for the next Operational Period. Basically, the IAP provides a framework for search strategy and tactics, keeps managers informed of the status of search resources, and encourages the overhead team to be proactive rather than reactive.

The most important components of the IAP are covered by adhering to the following order.

- What must be done? Identify the Incident Objectives by completing the ICS 202 form. Incident objectives can be prioritized by
  - Life and Safety. Objectives that deal with immediate threats to the safety of the public and responders are the first priority.
  - Incident Stabilization. Objectives that contain the incident to keep it from expanding, and objectives that control the incident to eliminate or mitigate the cause are the second priority.
  - Property/Environmental Conservation. Objectives that deal with issues of protecting public and private property, or damage to the environment, are the third priority.
- Who is responsible for doing it? Create an organization chart of the overhead team by completing the ICS 203 form.
- Who does what? Assign the resources by completing multiple ICS 204 forms.
- A safety message is a critical component in the IAP. The safety message covers safety issues that may arise during the incident based on the objectives, the resources used, the weather, the location of the incident, and fatigue related issues. This is included in the ICS 204 form.
- How do we communicate with each other? Create a communications plan by completing the ICS 205 form.
- What is the procedure if a searcher is injured? Create a medical emergency plan by completing the ICS 206 form.
- Where is it happening? Create a map of the search area.

The Incident Action Plan is updated during the current Operational Period for the next Operational Period.

Every incident, large or small, requires some form of an IAP. For most incidents that are small, the IAP is developed by the Incident Commander and verbally passed on to subordinates and assigned resources.

Every incident, large or small, requires some form of an IAP.

4. **Documentation**

All decisions, schedules, plans, forecasts, clues, reports, and investigative results should be documented in such a way that they are immediately accessible and legible. The “acid test” for the adequacy of documentation is whether the search managers (specifically, the Planning Section Chief), after the search is over, can describe all significant events that occurred during the incident. ICS provides most of the forms necessary for thorough documentation of the incident.

Appendices

APPENDIX A

Lost Person Data

Section A.1
Lost Person Behavior

Table A.1. Lost Person Behavior[1]

Children 1–3	They are unaware of the concept of being "lost". Navigational skills and sense of direction are almost nonexistent. They tend to wander aimlessly. They often seek out the most convenient location to lie down and go to sleep: • Inside a log. • Under a thick bush. • Under an overhanging rock. • Under a picnic table. • Inside an automobile trunk. • Inside an abandoned appliance. They are almost always very difficult to detect, as they are frequently out of sight and will rarely answer searchers' calls. Because they tend to seek shelter in poor weather, their chances of survival are often quite good. However, their temperature coping mechanisms are not as strong as older children so their urgency factor rating is high. Children (all ages) are rarely able to find their own way out of the woods. **Implications for search planning:** a highly thorough search may be necessary. As small children rarely travel far, containment is not usually a high priority when search resources are scarce.
Children 4–6	They are capable of traveling farther than younger children. They have a concept of being lost and will generally try to return home or go back to someplace familiar. They are frequently drawn away from homes or campsites by animals, following older children, or just exploring. Similar to younger children, they will usually seek shelter when tired, at nightfall, or when the weather becomes bad. Having been taught to avoid strangers, few children of this age will answer searchers calling their name, nor will they show themselves when searchers are near. Children (all ages) are rarely able to find their own way out of the woods. **Implications for search planning:** a highly thorough search may be required, with searchers focusing on visual clues.

Children 7–12	Their navigational and directional skills are much more developed than those of the younger child, and they are learning to construct primitive "mental maps" of their environments, which may be highly inaccurate. They frequently become lost while attempting a short cut to a familiar location. They may become extremely upset and confused when lost, seeming to react very irrationally. Lost children of this age frequently resort to trail running, which may take them some distance from the PLS. Subjects of this age may respond more maturely if accompanied by a friend or sibling. Children (all ages) are rarely able to find their own way out of the woods. **Statistical data:** an analysis of 9 cases of missing children (7-12 yrs) by Hill (1996) revealed that: • 89% (8 out of 9) survived. • 55% (5 out of 9) of the cases involved 2 or more subjects. • No child of this category found his/her own way out of the woods. **Implications for search planning:** because of the distance they tend to travel, combined with their panicky state, the search for a child of this age can be particularly difficult. Containment of trails, roadways, and other travel aids is a top priority.
Climbers	They are usually well equipped and self sufficient. They tend to remain on or near designated routes. A common factor for missing climbers is weather or hazardous conditions which limit their capabilities. Other important factors are falling debris and avalanches. **Implications for search planning:** technical expertise is usually needed for both search and rescue (or recovery) of climbers.
Despondents	These are individuals with a history of depression or suicide attempts, or who are explicitly described by family or friends as having been severely depressed or suicidal just before the incident. It is not usually their intention to travel very far, but to find a place where they can be alone and possibly contemplate suicide. Despondent individuals are frequently located at the interface between two types of terrain (for example, forest and meadow), and sometimes in a "scenic location" where they can sit and meditate, such as on a hill overlooking a lake or city. Despondents will rarely answer searchers' calls, and will sometimes avoid or even hide from search teams. There is an extremely high fatality rate for this category, as despondents rarely take steps to protect themselves from the weather, and, in addition, drugs or alcohol may be involved. **Statistical data:** an analysis of 16 cases of missing despondents by Hill (1996) revealed that: • None walked out to safety on their own. • None of the cases involved two or more subjects. • Only 35% survived (the remainder died from exposure or suicide). **Implications for search planning:** the search for a despondent individual, even in moderate weather, should be considered highly urgent, likely requiring medical treatment and rescue. Containment is not normally a high priority. While the search area may not be particularly large, the search should be thorough, as these subjects are often hard to detect and may not respond to sounds. Focus on likely spots and visual search methods.
Elderly	It is important not to underestimate the older subject merely because he or she is over the age of 65. Studies of elderly outdoor sportsmen, such as hunters, hikers, and fishermen, reveal that they are capable of traveling just as far when lost as younger subjects (Hill, 1992). More importantly, the elderly subject often behaves more rationally when lost than does his/her younger counterpart. The elderly subject may be more willing to build a shelter and prepare to be rescued by searchers. However, if the older person has Alzheimer's disease or some other form of dementia, then the incident should be treated as a walkaway situation. Therefore, for adult subjects, it is the Lost Person's Category, not his or her age as such, that is significant for search planning.

<table>
<tr><td>Fishermen</td><td>Shore fishermen often become lost while traveling on a trail to or from their fishing site. Boat fishermen sometimes become disoriented while trying to find the spot from which they launched their boat. They may become overcome by darkness and forced to land in some unfamiliar location. There is a somewhat higher possibility of drowning for boat fishermen than for shore fishermen, especially if there is alcohol involved.
Statistical data: an analysis of 25 cases of missing fishermen by Hill (1996) revealed that:
• 88% of subjects survived (the remainder died of drowning or exposure).
• 25% found their own way back to safety.
• 32% of the cases involved 2 or more subjects.
Implications for search planning: a thorough investigation is imperative. For shore fishermen, identify the subject's favorite fishing sites, and whether he/she liked to move around a lot. Direction of wind and current may be important for locating the landing sites of lost boaters.</td></tr>
<tr><td>Hikers</td><td>Hikers are trail-oriented and often become lost when their trail is obscured for some reason, or when they encounter a confusing junction of intersecting paths.
Because of their reliance on trails, hikers tend to travel farther than other lost person categories, although extreme distances are less frequent than for hunters.
They are often less prepared and "woods-wise" than hunters and fishermen.
Statistical data: an analysis of 501 cases of lost or overdue hikers (Mitchell, 1985) revealed the following characteristics:
• Only about 40% were considered to be adequately equipped.
• 92% did not travel after the first 24 hours.
• Between 30% and 40% traveled at night.
• About 40% were located by a "hasty search".
An analysis of 24 cases of missing hikers (adults only) by Hill (1996) revealed that:
• 29% found their own way back to safety.
• 92% survived.
• 42% of the cases involved two or more subjects.
Implications for search planning: Containment is a top priority, especially trail blocks. Clue-aware searchers should be tasked to run all likely trails, paths, roads, and similar travel aids.</td></tr>
</table>

Hunters	Their concentration on game often distracts them from navigation. Hunters frequently become disoriented while chasing wounded game into thick areas of trees or brush. They tend to overextend themselves in darkness and push beyond their physical abilities. When game laws prescribe the wearing of “hunter orange”, these subjects can be easily detected from a distance or from a helicopter. Many hunters will fire shots if they believe searchers are looking for them, and will respond to sounds if they are able. Due to ego or game laws, many hunters will go to great lengths to walk out unassisted by search teams. The “typical” hunter will attempt to build a shelter at night, then walk out of the woods at daybreak. On average, about one in three lost hunters will manage to find their own way out. **Statistical data:** an analysis of 167 cases of lost or overdue hunters by Mitchell (1985) revealed the following characteristics: • One in three missing hunters was overtaken by nightfall. • 39% followed a natural drainage. • Between 45% and 80% traveled at night. • 90% did not travel after the first 24 hours. • Between 25% and 45% found their own way out of the woods. An analysis of 100 cases of lost or overdue hunters by Hill (1996) revealed that: • 16% of the cases involved 2 or more subjects. • 93% survived. • 24% found their own way out of the woods. **Implications for search planning:** containment is a priority, as some hunters travel long distances on trails or woods roads. Attraction methods (sirens, whistles, gunshots) may also be effective. Also look for clues off the trails, such as in drainages or along river banks.
Miscellaneous	This category includes gatherers (for example, mushrooms, berries, other fruit), nature photographers, rock hounds, and people engaged in some outdoor occupational activity, such as surveyors, forestry employees, conservation officers, and park rangers. Many are inadequately equipped or clothed for an extended duration outdoors. Many subjects in this category are found away from trails, depending on the nature of the activity in which they had been involved. They are frequently located near natural boundaries, such as rivers and lake shores. **Statistical data**: an analysis of 26 cases of lost persons engaging in miscellaneous outdoor activity by Hill (1996) revealed that: • 96% survived. • 23% of the cases involved two or more subjects. • 31% of subjects found their own way back to safety. **Implications for search planning:** investigation is especially important for a subject of this “mixed bag” category. Effort should be made to identify the relevant locations which may have attracted the person, as these may be the most likely to contain clues.

Skiers	Most are young and in fairly good physical condition. They are usually well equipped and dressed for the weather. Most become lost because they took the wrong route, or misjudged time and/or distance. Some skiers are made immobile by injury and may be vulnerable to hypothermia. They are usually wearing brightly colored clothing, which makes them highly detectable against the snow. With the advent of ski areas charging the lost person for search and rescue services, more skiers may use searchers as "offset aiming points" so they may find their own way out and avoid costs. **Statistical data**: an analysis of 26 cases of lost persons engaging in miscellaneous outdoor activity by Hill (1996) revealed that: • 50% found their own way back to safety. • When found by search teams, only 50% were mobile. • 83% stopped moving within the first 24 hours. • Between 30% and 45% traveled at night. **Implications for search planning:** visual trackers should be especially effective for locating missing skiers.
Walkaways	These are individuals who "walk away" from a constant-care situation, whether a hospital or a residence. This includes people with senile dementia (for example, Alzheimer's disease), mentally retarded individuals, as well as person suffering from some debilitating form of mental illness (for example, psychosis). They rarely understand they are lost, and their wanderings may seem non-purposeful or at least non-predictable. They are almost never dressed appropriately for wet or severe weather conditions. They rarely respond to callers, and in some instances, such as with mentally retarded subjects, they may hide or even run from searchers. Persons suffering from Alzheimer's disease (or related illnesses) may be attempting to return to some former home or place where they once enjoyed being (however far away that place may be). They often walk in a straight line until running into a barrier, then turn and continue in another directions (the so-called "pinball effect"). Eventually, they become entangled in brush or mired in mud, unable to continue. Some have even walked straight into a lake and drowned. Walkaways who are allowed some independence by an institution (or a person managing home care) with respect to going outside unsupervised, may travel farther than persons requiring more supervision. The fatality rate for subjects in this category is extremely high. **Statistical data on Walkaways.** An analysis of 22 cases of missing walkaways (general category) by Hill (1996) revealed that: • 45% were found dead (from exposure or drowning). • None walked out to safety on their own. • None called for help or answered searchers' calls. **Statistical data on Alzheimer's patients in particular:** An analysis of 25 incidents involving missing Alzheimer's patients revealed the following characteristics: • Average age was 73 years (59% male). • Not one Alzheimer's subject called for help from searchers. • 28% were found dead. • They were found a median distance of 1/2 mile from the PLS. **Implications for search planning:** the search for a walkaway should be considered highly urgent. Man-trackers and trailing dogs may be especially effective, with air scent dog teams employed in high probability areas with dense vegetation. Because walkaways are usually very difficult to detect, often hidden under brush or in thickly treed areas, a highly thorough search may be necessary. Alzheimer's patients, mentally retarded individuals, and other institutionalized walkaways are often found somewhere on the grounds of their respective institutions, so a thorough search should begin there. Containment of Alzheimer's patients is not normally a high priority, compared to other lost person categories, as these walkaways seldom travel great distances. However, be warned that some allegedly "frail" Alzheimer's patients have traveled much farther than their caretakers had expected. As well, mentally retarded subjects have been known to hide from searchers and to flee when spotted. Recurring discrete patrols focusing on visual searching may be helpful.

<table>
<tr><td>Youths 13–15</td><td>Frequently become lost in groups of two or more people, while engaged in exploring or some other “adventuring” activity. When in groups, they will rarely travel very far. They will usually respond to searchers’ calls. They often resort to direction sampling, looking for some familiar place or landmark.
Statistical data: an analysis of 20 cases of missing youths by Hill (1996) revealed that:
• 60% of the cases involved 2 or more missing subjects.
• All subjects survived.
• Only 10% found their own way out of the woods.
Implications for search planning: containment is not usually a high priority unless the subject is alone.</td></tr>
</table>

Table A.2. Overview Lost Person Behavior

<table>
<tr><td>Overview: Lost Adults</td><td>• Will bushwhack when they are “positive” they know the right direction.
• Will usually stay on a trail if not absolutely certain of the correct direction.
• May climb a hill to improve their view.
• Rarely move around randomly.
• Rarely attempt to travel in an arbitrary straight line.
• Will rarely reverse direction on a trail unless absolutely certain they have been going the wrong way.
• May attempt to apply “woods wisdom”, such as traveling downstream.
• May “regress” to less effective methods when panicky.</td></tr>
<tr><td>Overview: Lost Children</td><td>• Have relatively poor “mental maps” of their environment.
• Will usually search for familiar places rather than for routes (travel aids).
• Are rarely good at judging direction or distance.
• Often become lost when taking a “short cut” (ages 7 to 12).
• Will often try “trail running” (ages 7 to 12).
• May move randomly or unsystematically (ages 1 to 6).
• May be extremely panicky.
• Are rarely able to find their own way out of the woods.
• Rarely answer searchers calling their name.</td></tr>
</table>

[1] Courtesy of Ken Hill, as quoted in NASAR’s “Managing The Lost Person Incident”.

Section A.2

Lost Person Behavior Distance Traveled

Arizona

Be cautious when using data with only a few cases.

All distances in miles.

Table A.3. Distances Traveled by Lost Persons in Arizona, USA

Mission	Category	Cases	Min	25%	50%	75%	100%	Mean	Note
Aircraft	Crashed	9	0.21	0.46	4.24	14.75	36.48	8.95	
Aircraft	Missing	1	66.07	66.07	66.07	66.07	66.07	66.07	
Aircraft	Overdue	0	0.00	0.00	0.00	0.00	0.00	0.00	
ELT	ELT	3	2.88	3.93	4.98	21.52	38.05	15.30	
PLB	PLB	5	0.01	0.06	2.07	4.98	17.47	4.92	
Search	Alzheimer	55	0.01	0.20	1.08	3.69	74.22	4.12	
Search	Alzheimer	54	0.01	0.19	1.07	3.58	26.41	2.83	without 1 outlier
Search	Camper	13	0.14	0.71	0.96	2.58	3.98	1.67	
Search	Child (1–3)	8	0.09	0.19	0.53	1.03	1.53	0.64	
Search	Child (4–6)	11	0.23	0.51	1.05	2.24	3.79	1.57	
Search	Child (7–12)	21	0.05	0.56	0.85	2.49	16.40	2.64	
Search	Despondent	36	0.06	0.34	0.78	3.88	23.97	3.20	
Search	Despondent	35	0.06	0.32	0.75	3.39	14.27	2.61	without 1 outlier
Search	Elderly	33	0.18	0.52	1.39	5.60	58.10	5.18	
Search	Elderly	31	0.18	0.36	1.31	5.23	12.29	2.72	without 2 outliers
Search	Hiker	698	0.01	1.04	1.79	3.63	47.20	3.21	
Search	Hunter	49	0.01	0.79	1.65	4.04	33.35	3.35	
Search	Hunter	48	0.01	0.78	1.63	3.93	17.14	2.72	without 1 outlier
Search	Mental	33	0.02	0.35	1.17	3.09	64.31	5.02	
Search	Mental	32	0.02	0.28	1.16	2.93	28.22	3.17	without 1 outlier
Search	Not necessary	15	0.27	0.99	5.71	14.27	32.09	8.81	
Search	Other	74	0.05	0.81	2.03	4.38	43.44	5.58	
Search	Overdue	35	0.06	1.63	4.51	13.07	25.73	7.10	
Search	Runner	2	2.45	6.58	10.71	14.84	18.96	10.70	
Search	Snow ski & board	3	0.41	0.81	1.20	1.88	2.55	1.39	
Search	Suspended	2	0.75	1.87	2.98	4.10	5.21	2.98	
Search	UDA	8	0.15	0.25	3.00	7.22	15.24	4.54	
Search	Walkaway	62	0.03	0.65	1.31	4.19	42.86	4.29	
Search	Walkaway	60	0.03	0.58	1.28	3.78	21.45	3.04	without 2 outliers
Search	Youth (13–15)	17	0.10	0.36	0.84	1.42	18.66	2.43	
Vehicle	2-wheel	36	1.09	4.68	8.43	20.72	157.85	23.69	
Vehicle	4-wheel	47	0.06	4.81	9.58	17.53	99.25	14.12	
Vehicle	ATV	19	0.15	1.55	6.25	10.35	21.07	6.25	
Vehicle	Bike	9	0.83	1.19	2.99	7.11	16.73	5.02	
Vehicle	Horseback	3	0.21	0.30	0.38	1.11	1.84	0.81	
Vehicle	Motorcycle	12	1.65	3.38	10.25	17.34	40.84	12.27	
Vehicle	Tractor	1	1.69	1.69	1.69	1.69	1.69	1.69	
Vehicle	UTV	8	1.33	2.86	7.18	11.66	15.33	7.51	
Water	Boater	2	3.46	3.65	3.84	4.03	4.22	3.84	
Water	Bystander	1	1.12	1.12	1.12	1.12	1.12	1.12	
Water	Canoer	1	0.06	0.06	0.06	0.06	0.06	0.06	
Water	Fisherman	1	0.05	0.05	0.05	0.05	0.05	0.05	
Water	Rafter	3	1.11	3.48	5.84	8.14	10.44	5.80	
Water	Swimmer	3	0.02	0.09	0.15	12.13	24.10	8.09	
Water	Tuber	2	0.09	0.28	0.47	0.66	0.85	0.47	

Collected by Arizona Division of Emergency Management, 2009–Oct. 2016. Compiled by Robert Stuckenschneider, PhD.

The following decisions were made by the compiler and Sgt. Aaron Dick, Coconino County Sheriff's Office, regarding how the data in Table A.3 was represented.

1. *In six instances there were calculated outliers. Without getting into a discussion whether outliers should or should not be included, we chose to present the data twice; once with the outliers included and a second time without the outliers. It is incumbent upon the user to determine the appropriateness of choice. In all cases the outliers were the maximums. Their impact was most significant upon the maximum and the mean. The outliers had minimal impact on the other calculations.*
2. *The collected data showed a single search for a group of individuals as separate searches for each individual in the group. To minimize skewing the data, we made every effort to sort through the data and condense the data into the single search only. If the single search found individuals from the group at different locations, with a separation distance of 0.1 miles or greater, then we treated it as a multiple search.*

Explanation of Table A.3 on the previous page. Look at the row for Hikers. There were 698 people in this category. 25% of them were found within a circle of radius 1.04 mi centered at the IPP. 50% were found within a 1.79 mi radius, 75% within a 3.63 mi radius, and 100% within a 47.20 mi radius. None were found within 0.01 mi of the IPP.

Nova Scotia

Table A.4. Distances Traveled by Lost Persons in Nova Scotia, Canada

Category	Cases	25%	50%	75%	90%	Range	Survived
Children (1–6)	16	0.50 km	1.03 km	1.81 km	2.02 km	0.10–2.65 km	100%
		0.31 mi	0.64 mi	1.12 mi	1.26 mi	0.06–1.65 mi	
Children (7–12)	15	0.80 km	1.48 km	2.50 km	3.20 km	0.14–8.00 km	96%
		0.50 mi	0.92 mi	1.55 mi	1.99 mi	0.09–4.97 mi	
Youths (13–15)	23	0.86 km	1.49 km	3.00 km	4.18 km	0.40–7.00 km	100%
		0.53 mi	0.93 mi	1.86 mi	2.60 mi	0.25–4.35 mi	
Misc. Adults	49	0.75 km	1.70 km	3.57 km	7.82 km	0.10–19.00 km	98%
		0.47 mi	1.06 mi	2.22 mi	4.86 mi	0.06–11.81 mi	
Despondents	26	0.40 km	0.81 km	1.28 km	1.60 km	0.10–3.38 km	54%
		0.25 mi	0.50 mi	0.80 mi	0.99 mi	0.06–2.10 mi	
Dementia	41	0.40 km	1.00 km	1.46 km	2.40 km	0.10–5.43 km	73%
		0.25 mi	0.62 mi	0.91 mi	1.49 mi	0.06–3.37 mi	
Fishermen	38	0.92 km	1.77 km	4.15 km	6.01 km	0.45–17.70 km	91%
		0.57 mi	1.10 mi	2.58 mi	3.73 mi	0.28–11.00 mi	
Hikers	53	1.35 km	2.23 km	4.80 km	7.52 km	0.22–24.00 km	94%
		0.84 mi	1.39 mi	2.98 mi	4.67 mi	0.14–14.91 mi	
Hunters	127	1.30 km	2.39 km	3.83 km	8.00 km	0.10–19.31 km	94%
		0.81 mi	1.49 mi	2.38 mi	4.97 mi	0.06–12.00 mi	

Compiled by Ken Hill, Halifax Regional SAR, August, 2006.

Explanation of Table A.4. Look at the row for Children (1–6). There were 16 children in this category. 25% of them were found within a circle of radius 0.31 mi centered at the IPP. 50% were found within a 0.64 mi radius, 75% within a 1.12 mi radius, 90% within a 1.26 mi radius, and 100% within a 1.65 mi radius. None were found within 0.06 mi of the IPP.

Forested Wilderness Areas in U.S.

Table A.5. Distances Traveled for Lost Persons in Forested Wilderness Areas in U.S.

Category	**Cases**	**Hilly or Mountainous Terrain**					**Flat Terrain**				
		Median	25%	50%	75%	Max	Median	25%	50%	75%	Max
Children (1—6 yrs)	22	0.3 ⇓	0.1 ⇑ 0.5 ⇓	0.5 ⇑ 0.5 ⇓	1.5 ⇑ 1.4 ⇓	89% 1.6 ⇑ 2.6 ⇓	1.1	1.0—1.6	0.6—1.7	0.5—2.1	92% 0.0—2.2
Children (6—12 yrs)	24	1.6 ⇓	1.0 ⇓ 2.0 ⇓	0.5 ⇑ 2.1 ⇓	2.0 ⇑ 4.0 ⇓	92% 2.6 ⇑ 4.1 ⇓	1.2	0.8—1.2	0.7—2.0	0.2—2.2	92% 0.0—3.0
Elderly	24	1.2 ⇓	0.5 ⇓ 1.8 ⇓	0.0 2.4 ⇓	0.4 ⇑ 2.6 ⇓		1.0	0.8—1.0	0.7—1.2	0.1—1.3	93% 0.0—3.0
Hikers	44	2.5 ⇓	2.0 ⇓ 3.0 ⇓	0.6 ⇓ 2.0 ⇓	0.4 ⇑ 6.1 ⇓		2.0	1.4—2.4	1.0—3.2	0.2—3.3	94% 0.0—4.0
Hunters	100	2.0 ⇓	1.8 ⇓ 2.8 ⇓	0.7 ⇓ 3.1 ⇓	0.8 ⇑ 4.0 ⇓	93% 3.0 ⇑ 6.0 ⇓	1.6	1.0—1.6	0.9—2.2	0.1—2.3	89% 0.0—3.0
Misc.	15	1.6 ⇓	0.6 ⇓ 1.6 ⇓	0.0 3.0 ⇓	1.4 ⇑ 3.1 ⇓	84% 2.5 ⇑ 3.2 ⇓	1.6	1.1—1.6	0.5—1.8	0.1—2.8	89% 0.0—4.0

Table A.5 is a summary of some of the work of Syrotuck, see Reference [Syrotuck].

Explanation of Table A.5. Look at the row for Children (1–6). There were 22 children in this category. The median distance from the IPP for this category in Hilly or Mountainous Terrain was 0.3 miles downwards, and in flat terrain was 1.1 miles. 25% of the subjects in Hilly or Mountainous Terrain were found between 0.1 miles upwards and 0.5 miles downwards from the IPP, whereas in flat terrain they were found between 1.0 and 1.6 miles from the IPP.

Section A.3

Survivability

To quote Syrotuck (see Reference [Syrotuck, page 57]): *"It is difficult to predict who will and who will not survive under a given set of circumstances."*

By analyzing data from New York and Washington State, Syrotuck found that, **of those subjects who died**,

- 45% were dead within 1 day.
- 74% were dead within 2 days.
- 83% were dead within 3 days.
- 92% were dead within 4 days.
- The remaining 8% took longer than 4 days to die.

He also found that

- 4% of children died in good weather, whereas 66.6% died in bad weather.[2]
- 11% of adults died in good weather, whereas 53.3% died in bad weather.
- 35% of the elderly died in good weather, whereas 67% died in bad weather.

Kelley (see Reference [Kelley, pages 20–33]) also studied survivability and concluded that subjects[3] who died from hypothermia survived for a maximum of

[2] Bad weather is defined as temperatures below 45°F at any time while the subject is lost combined with some rain or snow, or temperatures above 45°F with extensive rain.

[3] Kelley defines a subject as being a 25-year-old male wearing clothing similar to a suit.

- 3 days when the temperature[4] was 0°F.
- 4 days when the temperature was 10°F.
- 6 days when the temperature was 20°F.
- 8 days when the temperature was 30°F.

However, at all these temperatures some subjects died from hypothermia on the first day—some within hours of being lost.

Adolph (see Reference [Adolph]) studied the days of expected survival of immobile, responsive subjects (these were military personnel who were not lost) in a desert environment in terms of the amount of water available. See Table A.6.

Table A.6. Days of Expected Survival in Terms of Available Quarts of Water and Temperature in Shade

Max. Temp °F	0	1	2	4	10	20
120	2	2	2	2.5	3	4.5
110	3	3	3.5	4	5	7
100	5	5.5	6	7	9.5	13.5
90	7	8	9	10.5	15	23
80	9	10	11	13	19	29

Explanation of Table A.6. Look at the row for 120°F. Subjects who had 0, 1, or 2 quarts of water available, had a life expectancy of 2 days. Those who had 4, 10, or 20 quarts of water available, had a life expectancy of 2.5, 3, or 4.5 days respectively.

Having said all this, be aware that there are some amazing survival stories. For example, on May 8, 2011, 56-year-old Rita Chretien of Penticton, B.C., was found after being lost for 48 days in the Nevada backcountry. The Chretiens were en route from their Penticton home to a Las Vegas trade show on March 19, 2011, when their 2000 Chevrolet Astro van became stuck on a muddy U.S. Forest Service road in a cold, untamed, mountainous, remote region near where Oregon, Idaho and Nevada meet. They got lost because they were "foolishly following a GPS without a lot of experience". Her husband went searching for help on March 22, but did not return. Rita survived for more than seven weeks by staying put, eating snow and granola bars. On May 16, 2011, the search for her husband, Albert, was suspended until weather and snow conditions improved.[5]

[4] This temperature includes the effects of wind chill.

[5] In August 2011, Elko County sheriff's deputies ended their efforts to locate Albert Chretien after attempts continued to offer no clues to the missing man's whereabouts. "We're assuming that he is deceased and that his remains have been scattered," said Elko County Sheriff's Lt. Marvin Morton. On September 29, 2012, his remains were found in a secluded area about 7 miles west of the vehicle by a pair of local hunters. The remains were intact and had not been scattered by animals. Chretien had been heading in the right direction and was not too far from a road, but his journey was likely hampered by deep snow.

APPENDIX B

Search Urgency Rating Chart

This chart is based on the work of Bill Wade. See Reference [Setnicka, pages 60–62].

Table B.1. Search Urgency Rating Chart

Factors	**Rating**
AGE OF SUBJECT:	
Very Young	1
Very Old	1
Other	2 – 3
MEDICAL CONDITION OF SUBJECT:	
Known/Suspected injured, ill, or mental problem	1 – 2
Healthy	3
Known fatality	3
NUMBER OF SUBJECTS:	
One alone	1
More than one (unless separated)	2 – 3
SUBJECT EXPERIENCE PROFILE:	
Not experienced, does not know area	1
Not experienced, knows area	1 – 2
Experienced, not familiar with area	2
Experienced, knows area	3
WEATHER PROFILE:	
Past and/or existing hazardous weather	1
Predicted hazardous weather (less than 8 hrs.)	1 – 2
Predicted hazardous weather (more than 8 hrs.)	2
No hazardous weather predicted	3
EQUIPMENT PROFILE	
Inadequate for environment and weather	1
Questionable for environment and weather	1 – 2
Adequate for environment and weather	3
TERRAIN/HAZARDS PROFILE	
Known hazardous terrain or other hazards	1
Few or no hazards	2 – 3
TOTAL: (between 7 and 21)	

One number in each category (row) is selected. In some categories there is a choice of numbers, for example, under "AGE OF SUBJECT:", "Other", either a "2" or a "3" can be selected. After selection, the numbers are totalled giving the numerical rating. The lower the numerical rating, the higher the relative emergency. See Figure B.1. All ratings are relative and their total indicates a possible relative urgency.

7	14	21
Highest Urgency	Intermediate Urgency	Lowest Urgency

Figure B.1. Relative urgency and numerical rating

All other factors bearing on the incident need to be evaluated by the Incident Commander to establish the final emergency level. However, if any of the categories in Table B on the previous page is rated a "1", then consider responding immediately with high priority. Otherwise, the preponderance of checked categories provides an indication of the urgency level.

In the event that there is more than one missing subject, a single search urgency rating chart is completed based on the worst case situation for each person in the group. This errs on the side of caution and generates a higher urgency rating compared to any individual in the group. The possibility that a group has split should always be considered and investigated.

APPENDIX C

Probability

We often speak of events and their chance, or probability, of occurring. Chance, or probability, is often used when the outcome of an event is not known exactly in advance. Probability is a part of our lives. Everyday we make judgements based on probability.

- There is a 90% chance that the Wildcats will win their game tomorrow.
- There is very little chance of winning the lottery.
- There is a 20% probability of rain today.
- There is a 90% probability the subject is in the search area.
- If the subject is in my assigned search area, then I had a 60% chance of finding him.

Probability is a measure of how likely it is for an event to happen. Mathematically probabilities apply to events and are numbers between 0 and 1. However, for everyday purposes, probabilities are often converted to percentages, so $0 = 0\%$ and $1 = 100\%$. In spite of what people say ("I am 110% sure it will happen"), probabilities cannot exceed 100%.

If the probability of an event happening is 0%, then that event is guaranteed not to happen. For example, the probability that a person will be younger tomorrow than today is 0%, or the probability that the sun will not rise tomorrow is 0%.

If the probability of an event happening is 100%, then that event is guaranteed to happen. The probability that the sun will rise tomorrow is 100%.

Table C.1 shows verbal cues for other probabilities.

Table C.1. Probabilities by Verbal Cues

Probability	Meaning
100%	Guaranteed to happen. A certainty.
90%	Highly likely to happen
80%	
70%	Likely to happen
60%	
50%	Even chance of happening
40%	
30%	Unlikely to happen
20%	
10%	Highly unlikely to happen
0%	Guaranteed not to happen. An impossibility.

The chances of winning the Arizona Lottery is 1 in 195,249,054, which is a probability of about 0.0000005%. So that event is very, very, very, unlikely to happen, but not an impossibility, because the probability is not 0%. After all, people do win the lottery.

Notice that the statements in the first paragraph of this chapter could also be written.

- There is a 10% chance that the Wildcats will not win their game tomorrow.
- There is very high chance of not winning the lottery.
- There is an 80% probability of no rain today.
- There is a 10% probability the subject is not in the search area.
- If the subject was in my assigned search area, then I had a 40% chance of not finding him.

So if P, as a percentage, is the probability of an event occurring, then $100 - P$ is the percentage probability of that event not occurring.

A potential SAR manager was a candidate to take the final 1-hour SAR Coordinators' exam, but he had not studied for it. He was relieved to find that the exam was a multiple-choice test with all answers to the questions being true or false. To pass he had to score 50%. He had taken a basic statistics course and remembered his instructor once performing a coin-flipping experiment. He decided to flip a coin he had in his pocket to get the answers for each question (with heads being true and tails being false) without looking at the questions. The instructor watched the candidate the entire hour as he was... flipping the coin... writing the answer on the answer sheet... flipping the coin... writing the answer on the answer sheet..., on and on. At the end of the hour, everyone else had left the room except for this candidate. The instructor walked up to his desk and interrupted the candidate, saying: "Listen, it is obvious that you did not study for this exam since you didn't even look at the questions. If you are just flipping a coin for your answer, why is it taking you so long?"

The stunned candidate looked up at the instructor and replied (as he was still flipping the coin): "Shhh! I am checking my answers!"

APPENDIX D

SAR Glossary

AAR	After Action Review. An AAR is a mechanism designed to evaluate an incident in order to improve performance by encouraging strengths and correcting weaknesses.
AZDEMA	Arizona Department of Emergency and Military Affairs. Their mission is to coordinate emergency services and the efforts of governmental agencies to reduce the impact of disasters on persons and property.
AIRS	Arizona Interoperable Radio System.
Agency Administrator	Chief executive officer (or designee) of the agency or jurisdiction that has responsibility for the incident. The designee might be the person to whom the IC reports. Usually the Agency Administrator is not on scene.
AOBD	Air Operations Branch Director. In ICS, a position in the Operations branch.
ASGS	Air Support Group Supervisor is primarily responsible for supporting and managing helibase and helispot operations and maintaining liaison with fixed-wing air bases.
Attraction	Either a feature that is likely to attract the subject's attention (Likely Spot), or a tactic used by a search team to help locate the subject, such as calling the subject's name or making loud noises.
Barrier	A feature that restricts travel in a given direction or brings about a change of direction.
Base	A base is where primary logistics functions are coordinated and administered.
Bogus Search	A search in which, unknown to the searchers, the subject is not missing.
Camp	A camp is where resources are kept.
CAP	Civil Air Patrol is a volunteer organization of aviation-minded members.
CART	Child Abduction Response Team.

CASIE	Computer Aided Search Information Exchange. The name of the DOS program. It has been replaced by Win CASIE III.
CERT	Community Emergency Response Team. CERTs are educated about disaster preparedness for hazards that may impact their area and trains them in basic disaster response skills, such as fire safety, light search and rescue, team organization, and disaster medical operations.
Choke Point	A narrow route providing passage from one region to another. Examples include a bridge or a pass. Sometimes called a bottleneck.
COML	Communications Unit Leader is responsible for developing plans for the effective use of incident communications equipment and fangcilities.
Command Staff	Under ICS, this consists of the PIO, the LNO, and the SOFR.
Contour Line	A contour line (AKA a contour) is a line on a map that connects points of equal elevation above sea level (or some other fixed reference).
CP	Incident Command Post.
CPOD	Cumulative Probability of Detection. The probability of multiple independent resources detecting the subject in a segment, assuming the subject is in that segment. It is a measure of how well the segment has been searched.
Datum Shift	A datum shift is where a coordinate is given in one datum and then plotted on a map that is in a different datum without correcting it.
Division	Under ICS, a division is a geographical regions established using boundaries.
ELT	Emergency Locator Transmitter. An ELT is a tracking transmitter that aids in the detection and location of aircraft in distress. It is activated on impact.
ESW	Effective Sweep Width. The distance two searchers must be apart, as they search in a grid pattern for an object that results in a *POD* of approximately 63%.
FLIR	Forward Looking Infrared. A thermal imaging device that can detect heat sources. It provides images of the ground based on temperature differences. Designed to be mounted on a helicopter or fixed-wing aircraft.
GAR	Green-Amber-Red. GAR Risk Assessment Model. An ORM risk assessment model that creates a “Go”-“No Go” decision tool.
General Staff	Under ICS, this consists of the OSC, the PSC, the LSC, and the FSC.
GIS	Geographic Information System. A GIS integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.
GPS	Global Positioning System. Based upon satellites, this device gives exact locations using latitude and longitude.
GRASS	Geographic Resources Analysis Support System. An open-source GIS program.

Group	Under ICS, a group is a collection of people established by function, that is, what it does.
Hasty Search	A search whose purpose is to cover the most obvious places a subject might be in the least time possible. Usually the first kind of search tactic to be utilized.
Hazard	A place where the missing person could be in danger.
Helibase	The main location for parking, fueling, maintaining, and loading of helicopters operating in support of an incident.
Helispot	A location where a helicopter can safely take off and land.
HRD Dog	Human Remains Detection Dog, AKA Cadaver Dog.
IAP	Incident Action Plan. An oral or written plan containing general objectives reflecting the overall strategy for managing an incident.
IC	Incident Commander. The individual responsible for all incident activities, including the development of strategies and tactics and the ordering and the release of resources.
ICP	Incident Command Post. The field location at which the primary tactical-level, on-scene incident command functions are performed.
ICS	Incident Command System. A standardized on-scene emergency management system. Also, Investigate, Confine, Search—which dictates the order of initial actions.
IMT	Incident Management Team. Under ICS, the IMT consists of the IC, the Command Staff, and the General Staff.
IPP	Initial Planning Point. The first LKP or PLS.
Lateral Range	One-half of the Spacing or Track Spacing and is the distance that an observer would need to sweep on either side of the track.
Likely Spot	A feature that is likely to attract the missing person. AKA attraction or magnet.
Limited Continuous Mode	This is the state of an incident where no active searching is done but if clues are discovered they are investigated and, if warranted, active searching resumes.
LKP	Last Known Position. The last known location of the missing subject determined by physical evidence such as a vehicle, a discarded object, or a footprint.
LPB	Lost Person Behavior. An analysis of how lost subjects behave by putting them into different categories.
LPQ	Lost Person Questionnaire. A written document that describes all available physical and mental characteristics of a lost person.
OP	Operational Period.
ORM	Operational Risk Management. A systematic process to continuously assess and manage risks. Developed by the U.S. Coast Guard.
OSC	Operations Section Chief.
PIO	Public Information Officer.
PLB	Personal Locator Beacon. The personal version of the ELT designed to be carried by a person on foot. It is activated manually.

PLS	Place Last Seen. The location where the missing subject was actually seen by another person.
POA	Probability of Area. POA applies to every segment and the ROW. The POA of a segment is the probability that the subject is in that segment taking into account all the searches that have taken place within the search area.
POC	Probability of Containment. POC applies to every segment. The POC of a segment is the probability that the subject is in that segment ignoring all searches that have taken place in every other segment. POC and ROW are incompatible.
POD	Probability of Detection. The probability of a resource detecting the subject in a segment, assuming the subject is in that segment. It is a measure of how well the segment has been searched by that resource.
PPE	Personal Protective Equipment.
PSC	Planning Section Chief.
ROW	Rest of the World. The ROW is the probability that the subject is outside the search area taking into account all searches that have taken place inside the search area.
Scenario	A plausible story that describes what might have happened.
Segment	A uniform region within the search area with well-defined boundaries, recognizable to resources in the field. The size of this region should be searchable by a resource in one Operational Period.
Single Resource	A single resource is an individual piece of equipment, or group of individuals, with an identified supervisor, that can be used in a tactical assignment.
Spacing	Describes the distance between ground searchers as they move in parallel along a constant heading or “track”.
Span of Control	The number of people that a manager can supervise effectively. ICS recommends that the number is between 3 and 7, with 5 suggested as an optimum.
SPE Model	Severity, Probability, Exposure. A risk management model that quantifies risk.
Staging Area	A staging area is where resources are kept while waiting to be assigned.
Strike Team	A strike team consists of resources of the same kind with common communications and a leader.
Strategy	Strategy involves the “big picture”—the overall plan, and how those plans will achieve the goals and objectives.
Tactic	Tactic is an action that leads to the execution of the strategy. For example, a strategy might be to search particular segments. The search technique used to search a particular segment is a tactic.
Task Force	A task force consists of resources of different kinds with common communications and a leader.
Track Spacing	Describes the distance between parallel search tracks conducted by one or more aircraft.

Track Trap Natural or man-made “traps” that capture evidence of a lost person passing. For example, footprints in sand or clothing caught in thorn bushes.

Travel Aids These are paths of little resistance to subjects. Travel aids are trails, pathways, roads, game trails, railroad tracks, ridges, valleys, dry washes, drainages, streams, shorelines, clearcuts, power lines, vegetation lines, or any area that provides a sense of direction and a path of little resistance.

UC Unified Command is an element in multi-jurisdictional or multi-agency domestic incident management. It provides guidelines to enable agencies with different legal, geographic, and functional responsibilities to coordinate, plan, and interact effectively.

UTM Universal Transverse Mercator (UTM) is a geographic coordinate system that uses a grid-based method to specify locations on the surface of the Earth.

YABI Yet Another Brilliant Idea.

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