

Braille Alphabet and Numbers

The braille system of reading and writing, used by people who are blind, is created by using raised dots to form characters (letters, numbers, punctuation) that can be read by touch. Numbers are formed by placing the braille number sign (#) before the braille letters A through J. Close your eyes and try to read the braille alphabet with your fingers.

a	b	c	d	e	f	g	h	i	j
1	2	3	4	5	6	7	8	9	0

k	l	m	n	o	p	q	r	s	t
---	---	---	---	---	---	---	---	---	---

u	v	w	x	y	z	,	.	?
---	---	---	---	---	---	---	---	---

Capital sign

Number sign

Reading braille takes many years of practice. Here are some short phrases for you to hone your skills.

Hint: Scouts are asked to always ...

Hint: Scouts are asked to do this each day.

Hint: The two newest required-for-Eagle merit badges are...

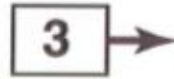
Marking Trails

Following trail signs can be tricky when the markers have faded or crumbled from age, weathering, or other types of damage. In situations where signs are absent or inadequate, hikers may create temporary trail markers using the available materials, such as twigs or pebbles. Or you can leave simple trail signs for others to follow by scratching in the ground with a stick. A pointed arrow means "This is the trail," while an X warns "This isn't the trail—don't go this way." A square with a number in it and with an arrow can mean, "Proceed in this direction, as many steps as the number says." A circle with a dot in its center specifies that "This is the end of the trail," or it may mean "I have gone home."

Scout trail signs



"This is the way."



"Proceed 3 steps
this direction."



"This is not
the trail."



"End of the trail"
or "Gone home."



When following a trail marked with these kinds of impermanent or improvised signs, use your eyes and do not rush. Be sure each sign is actually a marker and not something you are imagining. If you suspect you have missed a sign, return to the spot where you brushed out or undid the last one and start again. (If you fail to erase the signs as you go, you may cause great confusion for other hikers or even yourself the next time you travel the same path.)



Markers may be adapted from Native American trail signs, using grass knotted into tufts, sticks pushed into the ground, small stones stacked in low cairns, or pebbles arranged as arrows.

Leaving No Trace

Trail signs can be either permanent or temporary. Temporary blazes are used especially in wilderness areas. No-trace principles apply, however, regardless of whether the area is heavily hiked or virtually untrammeled. When you lay out a trail for your patrol or troop to follow, be sure afterward to remove your temporary trail markers. Generally, the person who marked the trail is responsible for removing the markers. Or, in a group of hikers, the last person down the trail may have the job of clearing away your temporary markers. Do not remove or alter permanent trail signs.

Rescue Signals

Knowing basic rescue signals could save your life, the life of a fellow Scout, or even your family. To attract the attention of rescuers, use signals to make yourself audible or visible.



Audible Signals

If you become separated from your group, shout for anyone within earshot, and use your whistle (which you should always carry with you). Searchers may be close to you but unable to see you. To signal your location, blow on a whistle in groups of three blasts. (A combination of any three signals is a universal sign of distress.)

Ground-to-Air Signals

To attract the attention of aircraft overhead, lay out large, angular ground signals. You can make standard ground-to-air symbols (shown in the illustration) by arranging brightly colored tents, tarps, rescue blankets, or strips of fabric in an open area; by stamping down sand or snow with your boots; by pulling out clumps of turf; or by lining up branches, logs, stones, or any available materials that contrast in color with the background. Make the symbols as big as you can—10 feet high or larger, if possible.

Construct these signals quickly, if you have reason to expect an air search. Search planes will likely cover a large expanse in a systematic pattern, flying over small sections of the area one after another and crossing off a section if no trace of you is seen there. If you are in that section and searchers fail to see you, then you might have a long wait before they return for a second look. To make your position known as soon as possible, lay out ground signals without delay.

V	X	N	Y	↑
REQUIRE ASSISTANCE	REQUIRE MEDICAL ASSISTANCE	NO	YES	PROCEEDING IN THIS DIRECTION

Ground-to-air signals are passive visible signals, requiring no further effort once completed. Such signals work even if you are asleep or ill when a search plane comes. Upon rescue, dismantle all ground signals.



Use any items you have that might help rescuers see you. An orange cloth, orange garbage bag or poncho, bright clothing, or anything brightly colored can help attract rescuers' attention. Search-and-rescue personnel report that it is difficult to see someone who is standing motionless on the ground and not trying to attract

attention. Things that move are more noticeable than things that stay still. You can increase your chances of being seen by making a tripod to suspend your orange poncho or bright clothing so that it flutters in the breeze.

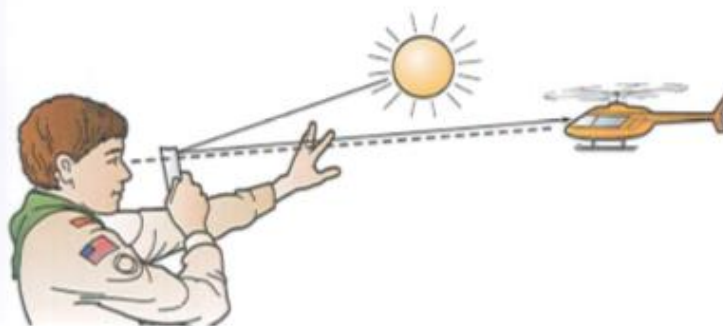
People sometimes hide from rescuers, mistakenly thinking they will get in trouble for being lost. Do not hide! Focus on getting found. Do what you safely can to help rescuers see or hear you, but avoid putting yourself in danger. Do not do anything that might cause you physical harm. An injury would only make matters worse. Also avoid aimless wandering, which could get you even more lost. You might move to a clearing so that rescuers can see you more easily, but do not move far from where you were when you first realized you were lost. Rescuers might be Scout leaders, police officers, national guard members, or firefighters, but often they are volunteers. Don't make their job harder than it already is. Stay put in a safe location. Rescuers may have a large area to search—do not make it bigger by moving around a lot.

Active Visible Signals

Besides constructing ground signals, use *active* signals such as mirrors, fires, smoke, and flares. Smoke is most visible in daylight; fire at night. Much of the United States is under a constant fire watch, and any unusual smoke will be investigated (probably by air) even if no one knows you are missing. Make a dense column of smoke by laying wet, green leaves and branches, evergreen boughs, or moss on a fire.

Three fires, spaced equally apart, make a standard distress signal. Build the second and third fire relays about 50 yards from the fire that is burning, locating them so the three form the points of a large triangle. Keep a torch of flammable material near the blazing fire, and as soon as you hear an approaching aircraft, quickly light the additional fires. *Be certain you can contain any fire you start.* An out-of-control blaze would put you in grave danger.

On a sunny day, airborne rescuers can see the flash of a mirror from many miles away. If the mirror in your survival kit has an aiming device, use it. If not, hold the mirror in one hand near your face, extend your other hand in front of you, and tilt the mirror until you can fill your empty palm with reflected light. Make a V with your illuminated fingers, then sight across the top of the mirror and through the V toward an approaching aircraft and drop your empty hand out of the way. Repeat these steps frequently to adjust your aim. A glass mirror reflects light best, but if you have no mirror you can use a bright can lid, a piece of foil, or any other shiny, reflective object.





If using rescue flares or smoke devices, follow the directions carefully. Such devices typically can be used only once, so activate them only when you have sighted or heard the approach of a search plane.

Survival Kit

Always be prepared by carrying the Scout Basic Essentials. In an emergency, they can help you out of a jam.

- Pocketknife or multitool
- First-aid kit
- Extra clothing
- Rain gear
- Water bottle
- Flashlight
- Trail food
- Matches and fire starters
- Sun protection
- Map and compass

Also carry a whistle and a mirror. Signaling mirrors are available in most Scout shops, sporting goods stores, and outdoor-supply stores.

Wear or carry something bright. An orange poncho, a space blanket (Mylar® emergency blanket), or a colorful piece of plastic is light, packs easily, and can be used as a shelter as well as a signaling device. By being prepared, you give yourself the best possible chance of being found.

Improvised Signals

If you did not carry signaling devices with you, look around for whatever you can find or make. Use rocks or logs to lay out ground signals. Use a piece of broken glass or a shiny credit card surface to reflect light like a mirror.

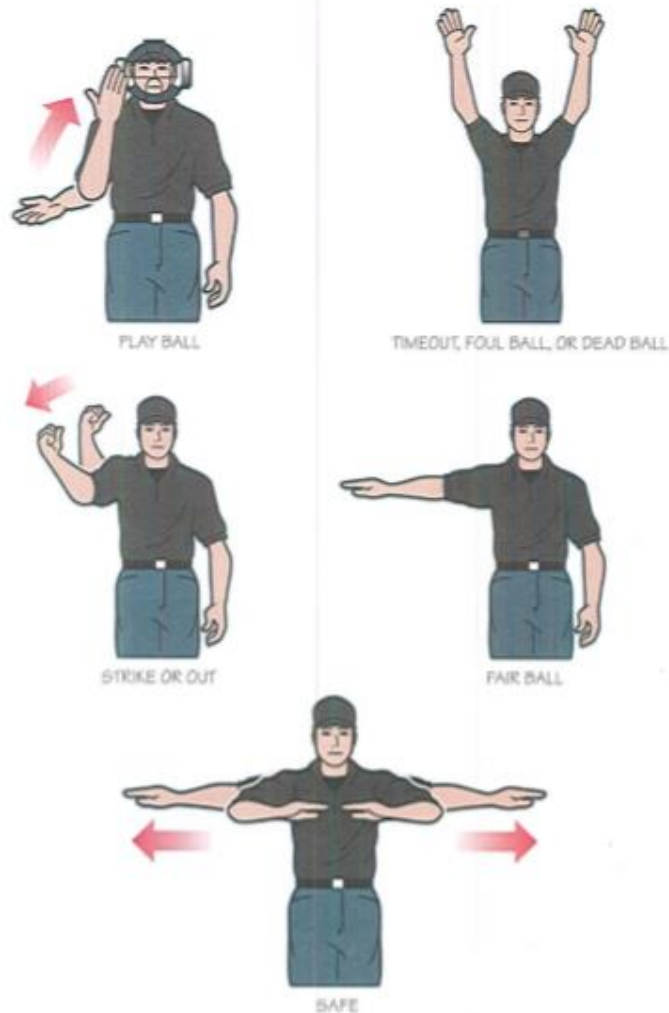
If you have ever heard a beaver slap its tail on the water, you know the sound can carry a great distance in the woods. To improvise a sound-signaling device, imitate a beaver by smacking two hard logs together.

Radio Beacons

Emergency, position-indicating radio beacons are monitored by aircraft and orbiting satellites. The satellites work together (through triangulation) to determine your location and provide the information to operations centers, which then mobilize search-and-rescue personnel. If you carry a radio beacon, use it if you need help, but remember that it is not a toy. Do not play with the beacon or allow others to play with it, and never experiment with it. Do not test it—it has a self-test function.



Emergency radio beacon



In baseball, umpires use hand gestures to call balls and strikes, to call a player out or safe, to indicate foul and fair balls, and to enforce other rules of play.

Signals in Sports and at Work

A police officer directs traffic with hand signals, a construction foreman signs instructions to a crane operator, and a baseball umpire signals that a runner is safe: These are a few of the many ways in which signs and signals are used in sports and in workplaces. Many types of activities have their own standard hand signals, but these may vary from place to place and among different users. As with any kind of signal, both the sender and the receiver need to know and understand the signals that are being used.

Sports Officials Hand Signs and Signals

Many sports rely on umpires, referees, or other types of officials to ensure that the game is played by the rules. Illustrated here are examples of the hand signals the officials use in popular team sports.

Other sports such as soccer, field hockey, lacrosse, rugby, and water polo also have officials using well-established signals to control play and to inform players and spectators about rule infractions.

A football game is full of signs, signals, and codes. Coaches signal plays with signs and gestures, the quarterback calls plays using codes, and the defense calls its counter plays, to which the offense may respond with another flurry of signs and verbal codes.



FOUL



JUMP BALL



TRAVELING



TECHNICAL FOUL



INBOUND PASS

Basketball referees use hand gestures to start and stop the clock, to signal shooting and scoring, and to call fouls and violations.



TOUCHDOWN



FIRST DOWN



PERSONAL FOUL



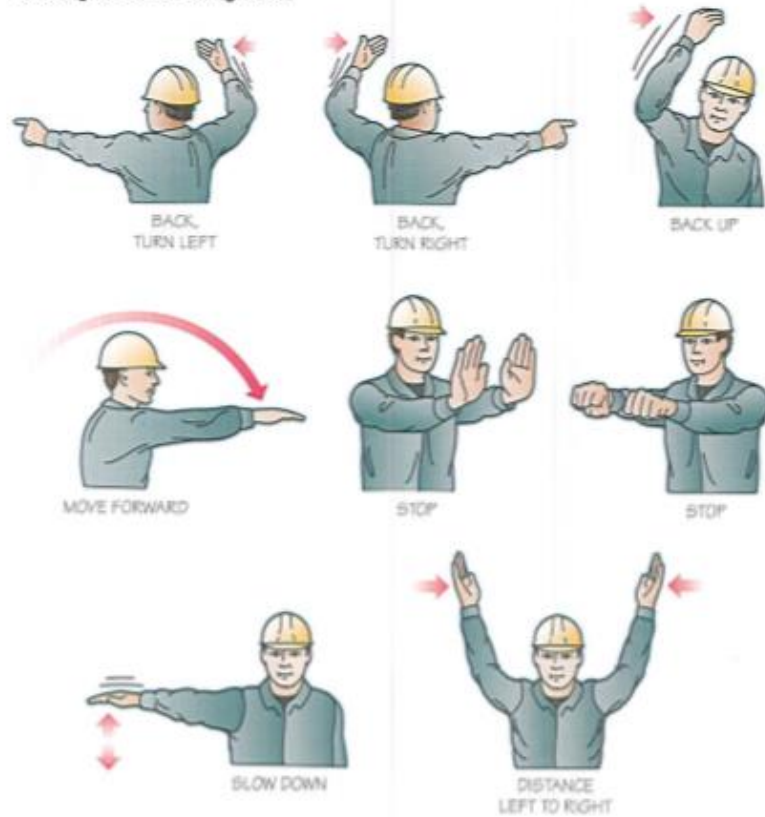
TIME OUT



HOLDING

Football referees use gestures to signal such things as first downs, touchdowns, timeouts, and infractions of the rules.

Hand signals for directing trucks



Equipment Operator Hand Signs

Construction sites can be dangerous and noisy places—so noisy that shouted instructions cannot be heard above the din of machinery and equipment. For communications on construction sites, standardized systems of hand signals have been developed. Different hand signs may be used at different worksites or by different equipment operators, so it is essential that both the signaler and the receiver know beforehand what the hand signals mean.

Concrete truck driver hand signals



As trucks or equipment come onto a construction site, a guide is usually assigned to direct the driver to a particular location using a set of directional hand signals. If the truck is delivering concrete, a specific set of signals is used to direct the positioning of the boom for pouring the concrete, and to start the pump, adjust pump speed, add water to the concrete mix, and stop pumping.

Crane operator hand signals



For a crane operator, hand signals sometimes mimic the actions of the machine. For example, the signaler may move a hand in a circular motion overhead to direct the operator to hoist (move up) the load, or circle a hand held downward at the level of the waist to signal for lowering the load. Other signals direct the positioning of the boom to safely deliver the load. In crane operations, the standard signal for "stop" is the arm extended straight out to the side and held rigidly. The hand moved rapidly left to right from the stop position signals an emergency stop.



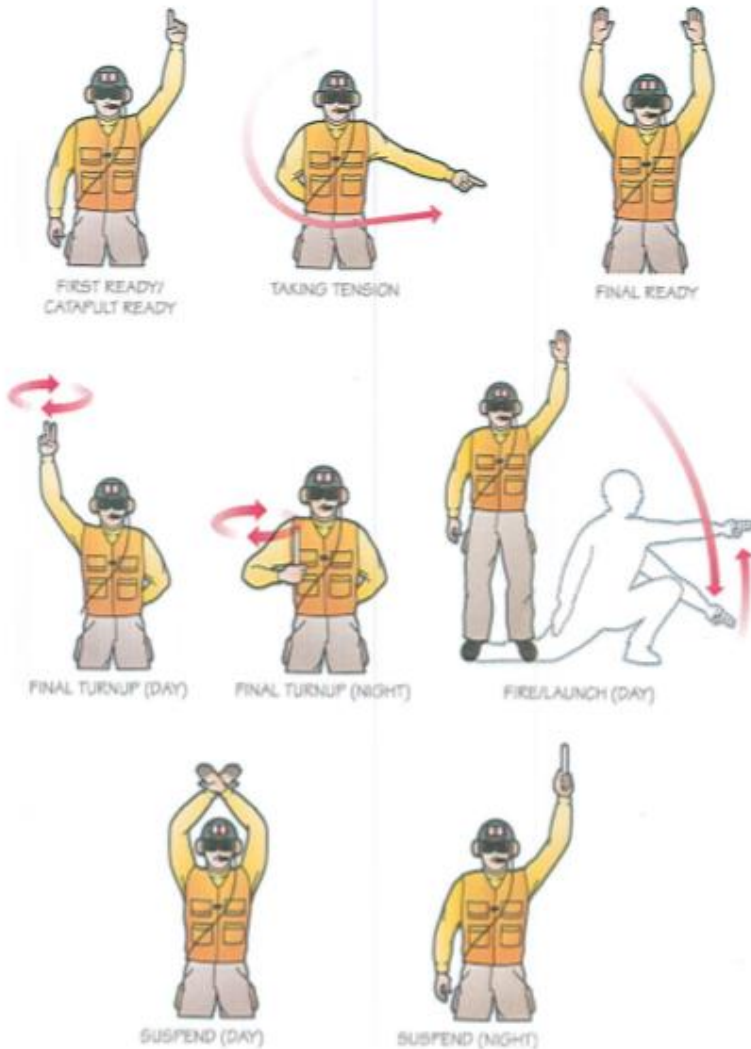
Aircraft Carrier Catapult Crew Signals

The flight deck of an aircraft carrier during flight operations has been described as "controlled chaos." Jets are catapulted into the air while other aircraft are landing or being parked, refueled, or loaded with armaments. The noise of jet engines and rotors is so great, members of the deck crew must communicate mostly through hand signals.

To direct a plane on the flight deck, more than 30 hand signals are used. The general sequence to launch a jet is to position the plane at the rear of the catapult (a device for slinging a plane off the deck at high speed), attach a launch bar and holdback to the plane's nose gear, raise the jet blast deflector behind the plane, make final safety checks, and then release the holdback to launch the plane down the deck for takeoff. Throughout this process, hand signals relay vital information between the deck crew and the pilot. Only a few of the many signals are shown here.

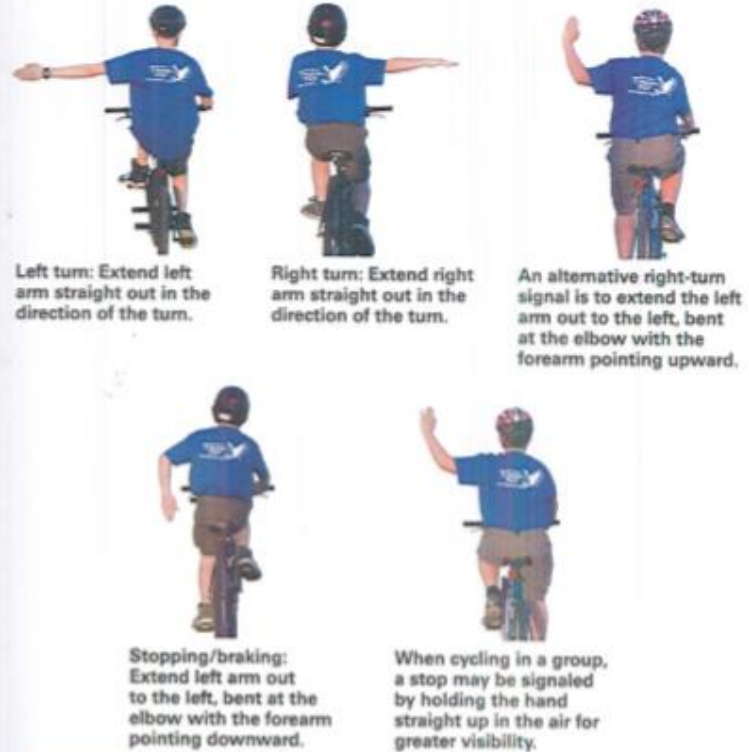


Aircraft carrier catapult crew signals



Cyclist Hand Signals

Cyclists (and some motorists) make hand signals to indicate their intentions to other traffic. Similar to automobile signaling, cyclists use three main signals: left turn, right turn, and stopping. Cyclists in a group may use additional signals to communicate with other riders.



To signal to a group of cyclists to slow down, extend the arm outward and move the hand up and down as if gently patting an invisible dog.



Sound Signals

You might not often think of them, but you are familiar with sound signals in many parts of your life. Most schools use a bell system to start and end the school day and to signal class changes, breaks, and lunch. Car alarms are sound signals that are meant to attract attention and discourage thieves. Fire alarms are mainly sound signals, with some also flashing warning lights. Outdoor sirens are sounded to signal emergencies such as severe weather and tornadoes.

Trains

As a warning to motorists and pedestrians, trains must sound their whistles or horns continuously for at least 15 seconds as they approach railroad crossings, giving the required long-long-short-long sequence of whistle or horn blasts. This sequence, which is similar to the letter Q in Morse code, is not so much a letter as it is a sequence of sound fluctuations that are unmistakable from other nearby noises to make it useful as a warning. About a dozen other standard train-whistle calls are also used, mostly to communicate with railroad workers along the rails or in rail yards. Whistles are used to give instructions, as a safety signal, and to warn workers when a train is about to start moving.



Horn Signals

Engine Horn	Meaning
"O" is a short blast; "—" is a long blast.	
O	Apply brakes. Stop.
OO	Engineer's answer to any signal unless otherwise specified.
OOO	When standing, back up; when running, stop at next station.
OOOO	Engineer's request for signals.
OOOOOOOOOO, etc.	Person or livestock on track (series of short blasts).
-----, etc.	Approaching stations, junctions, or railroad crossings at grade (series of long blasts) without stopping.
-OO	A second section is following; call for other trains to signal.
-OOO	Flagman to go out to protect rear of train.
---	Release brakes. Proceed.
-O-	Train is approaching public crossing at grade.
---	Flagman may return from west or south.*
---	Flagman may return from east or north.*

*These horn signals may be followed by "O" or "OO" or "OOO" when several tracks are in use. The number of short blasts corresponds to the track number.

Military Communications

The armed services have traditionally used various sound signals, such as bugle calls to signal reveille, morning colors, assembly, attention, retreat, and taps. At sea, boatswain (bosun) pipes were first used because their high pitch could be heard above the sound of wind and waves. Aboard ships today, boatswain's pipes are still used to call activities and ceremonies such as "pipe aboard," "away boats," "all hands on deck," and "carry on."

Military units may use whistle signals in drill or formation maneuvers and short-range communications.

1. One long blast means "silence," "attention," or "look for my next signal."
2. Two short blasts mean "all right."
3. A succession of long, slow blasts means "go out," "move farther way," "advance," or "scatter."
4. A series of short, sharp blasts means "rally," "come together," or "close in."
5. Three short blasts followed by one long blast means "leaders, come here."
6. Three short blasts mean "danger," "alarm," or "caution."
7. A succession of alternating long and short blasts means "mess call."



Boatswain's pipe

Boating Signals

Vessels operating in U.S. waters that exceed certain length and propulsion (power or sail) requirements must have a whistle, horn, or bell and use sound signals when navigating in low-visibility conditions, to get the attention of other vessels, or to signal danger or distress. Often, these signals are repeated every two minutes until the situation is resolved: the fog lifts, for example. Sound signals notify other vessels that someone is near them.

These signals are commonly used:

- Irregular sounds that cannot be mistaken for other signals are used to attract attention.
- Long continuous blasts signal distress.
- One short blast means the vessel intends to turn to starboard (to the right).
- Two short blasts means the vessel intends to turn to port (to the left).

When you use any type of watercraft, make it a point to carry some sort of sound signaling device. Your rescue whistle (which you should always have with you) can be used to signal distress when you are canoeing or kayaking.



Sound-only signals have their limitations. Louder noises can drown them out. Motorists with the volume cranked up on their car stereos may not hear the wail of a fire truck or the whistle of an approaching train. Pedestrians listening to music through headphones may fail to hear an oncoming car. To be more noticeable, therefore, warning signals often combine sounds with lights. Many buildings have fire alarms with flashing lights, and emergency vehicles such as ambulances are equipped with both sirens and lights. People who are deaf or hard of hearing may use devices that flash or dim the lights in their home whenever the doorbell rings. Cell phones can be set to vibrate to signal incoming calls when the ringer is turned off or inaudible.



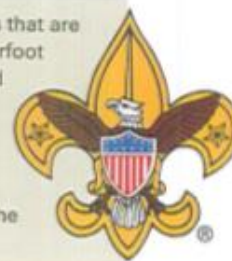
Symbols

In its simplest sense, a symbol is a picture, letter, character, or object that represents something. Symbols can be created to stand for ideas, words, actions, organizations, or almost anything.

One familiar example is the universal recycling symbol that appears on plastic bags, aluminum cans, and many other everyday objects. The recycling symbol represents an unending loop (like a Möbius strip) with three half-twisted arrows forming a triangle. It was designed by 23-year-old college student Gary Anderson to honor the first Earth Day in 1970. The symbol indicates that an object or material is recyclable, and it is also used on bins for storing and sorting recyclables.

Look for other symbols around your home, school, or troop meeting place. Your school mascot is a symbol. Your town or city might have its own symbol, or you might belong to a group that uses a special emblem.

Scouting has many symbols with meanings that are woven into the designs. Consider the Tenderfoot badge, a trefoil like the north point of an old compass. The shape of the badge signifies the way a Scout points the right way in life just as a compass does in the wilderness. The three points of the trefoil, like the three raised fingers of the Scout sign, represent the three parts of the Scout Oath.



Map Symbols

Knowing what map symbols mean is an essential skill. Map symbols use shapes and often colors to represent what is on the land. Similar symbols appear on topographical maps, highway maps, nautical charts, aeronautical charts, and other map types.

Open pit, mine	x
Index contour	—
Intermediate contour	- - -
Levee (with road)	—
Boundary	—
Power line	—
Telephone line	- - -
Railroad	—
Hard surface road	—
Improvised road	—
Unimproved road	- - -
Trail	- - -
Bridge	—
Zoo/bridge	—
Perennial stream	—
Water well, spring	+
Lake	—
Marsh (swamp)	—
Buildings (dwelling)	—
School, church, cemetery	—
Buildings (barns, etc.)	—
Sand area	—
Woods	—
Orchard	—
Swamp	—

Basic map symbols

The symbols are explained in the map key or legend located in a map's margins.

The legend, or key, typically provides other essential information:

- **Directions.** North is toward the top of most maps. A map will often have a true north arrow in its margin and an arrow showing the direction of magnetic north.
- **Scale.** The scale of a map compares the size of the map with the size of the area it represents. A map scale of 1:24,000 means that one inch on the map represents 24,000 inches or 2,000 feet on the ground.
- **Distances.** Bar scales can be used for measuring feet, meters, and miles on a map.
- **Date.** A map's date tells when it was drawn or last updated. An older map will not show new buildings, roads, trails, or other recent changes on the land.

The best maps for hiking are topographical maps that use contour lines to show the shape of the land—its hills, valleys, mountains, and plains. Each point on a contour line is the same elevation above sea level. Where the lines are close together, the land slopes steeply. Where the lines are far apart, the terrain is almost flat.

Contour lines are drawn in brown. Topographical maps use other colors for other features:

- Blue for water—ponds, lakes, streams, rivers, reservoirs
- Green for vegetation—forests, woodlands, grasslands, orchards
- Red or black for human-built structures—roads, rail lines, trails, buildings, boundaries
- White for open areas—fields, meadows, rocky slopes



These colors, while common, may not mean the same thing on all maps. Some maps show larger cities in yellow, airports in pink, and areas such as military bases in orange. Some maps are printed in only one color and may rely on shapes, symbols, patterns, and different styles of lettering (fonts) to indicate particular features, such as a flag atop a black square to represent a school, all-capital letters for the name of a road, and speckled patterns for marshes and swamps. Whenever you use a map that is new to you, be sure to check the map key or legend to familiarize yourself with the map's specific symbology (its system of signs and symbols).

Hazard and Safety Symbols

Hazard symbols are meant to alert people to dangers such as radiation, toxins, and chemical, flammable, and electrical hazards. Distinctive symbols also indicate the need for personal protective equipment like eye or hearing protection.



The general caution sign displays an exclamation point to attract attention. The skull and crossbones is often used to label poisons. The radioactive symbol's symmetrical three-sided shape can be easily recognized from any angle. The electrical hazard symbol warns of the danger of electrocution. Signs and symbols indicate when eye or hearing protection or other personal protective gear is required.



Besides providing information to help you stay safe, symbols may indicate the availability and locations of restrooms, litter containers, public transportation, and countless other conveniences and services.

Evacuation Route and Exit Signs

In many parts of the United States, natural disasters occur so frequently that evacuation routes have been established. Blue signs designate these routes, directing people to primary highways away from the danger.

In any building you enter, look for the fire exit or emergency exit signs or symbols, building maps that show the locations of evacuation routes, and signs or symbols that identify assembly areas where people should gather when they are clear of the building. Look for the fire hose or fire extinguisher signs. Also find the symbols that designate the locations of first aid kits, automated external defibrillators (AEDs), and emergency medical care.



Hurricane evacuation route





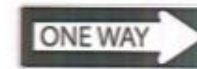
Traffic Signs

If you have gone any distance along a roadway, highway, or city street, you will have noticed traffic signs. Anyone who uses public roads, whether cyclist or motorist, must understand and know how to respond to traffic signs.

Traffic signs come in a great many shapes and colors, but they can be grouped into fewer than a dozen basic types:



Signs that are red are limited to stop, yield, and prohibition signs like "Do Not Enter" or "Wrong Way." These are regulatory signs.



Other regulatory signs usually have a white background with black letters. These include speed limit, one way, road closed, and keep right (or left) signs.



Yellow is used for warning signs about road conditions, lane changes, intersections, turns and curves, merging traffic, and much more.



Orange is the background color for temporary traffic-control signs. During road construction, orange signs warn of detours, closed lanes, changes in road conditions, and the presence of flaggers and construction workers.



Signs for school zones, pedestrian crossings, and bicycle lanes are yellow or fluorescent yellow-green.



Mileposts, street names, freeway entrances and exits, and other types of destination, distance, and guide signs have green backgrounds.



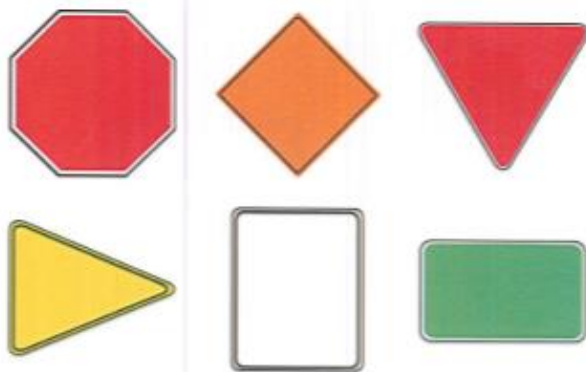
Blue is used to inform travelers about nearby services such as food, gas, lodging, tourist information centers, and hospitals.



Brown indicates public recreation and historical or cultural sites such as parks, landmarks, and historical markers.



Night speed-limit signs and truck regulatory signs have black backgrounds.



Sign Shapes

Certain types of signs have special shapes so that travelers can recognize them quickly and react appropriately. In general, the more sides a traffic sign has, the more critical is the message the sign sends.

A stop sign is an octagon (eight sides). Stop signs are the only traffic signs in the United States that can have eight sides.

Warning signs are diamond-shaped, and yield signs are downward-pointing triangles. A "No Passing Zone" sign is a triangle pointing to the side; that is, a pennant.

A rectangle that is higher than it is wide is used for regulatory signs such as speed limits. A wider-than-tall rectangle is used mainly for guide signs about highway entrances, exits, destinations, distances, and similar types of information.



The only circle-shaped road sign gives advance warning of a railroad crossing. A 12-sided crossbuck (X shape) also marks railroad crossings. These signs are uniquely shaped to help call drivers' attention to the extreme dangers of collisions between trains and vehicles.

Text Symbols and Emoticons

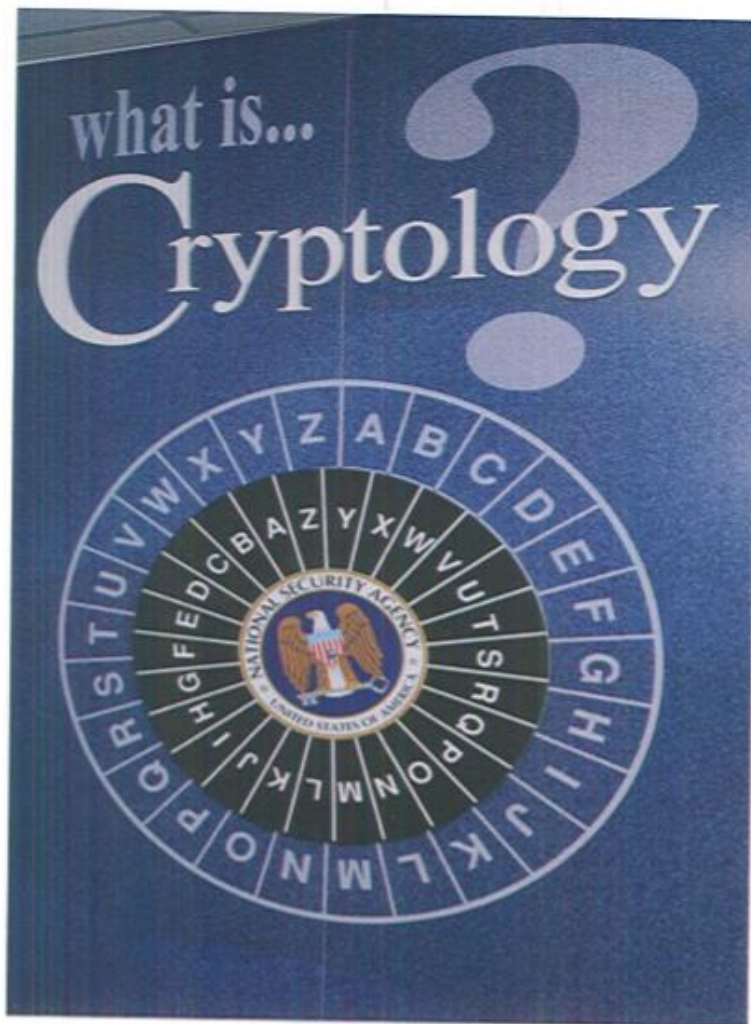
In emails and cell-phone text messaging, symbols save space and let users type less, communicate faster, and show their state of mind. Text symbols and emoticons typically represent facial expressions or suggest attitudes or emotions. They can also stand for objects, with complicated symbols that resemble pictographs (prehistoric drawings on rock walls). The chart shows a few standard emoticons as well as less-common text symbols. Dozens of such symbols are used.

EMOTICON	TEXT SYMBOL	MEANING
	:-)	Smiling
	:-D	Grinning
	:-(Sad
	:-\	Skeptical or undecided
	:-	Determined
	:O	Surprised
	d:-)	Baseball (cap)
	T+	Think positive
	(::X::)	Adhesive bandage
	^(00)^	Spider

Designing a Symbol

To design your own symbol, you must first decide what message you wish to communicate. Do you want to give information, convey a feeling, provide inspiration, or encourage action? What shape(s) and color(s) best match the message you wish to communicate? Is your design simple and easy to recognize?

Think about the elements of familiar symbols and what makes them effective. For instance, the three arrows of the universal recycling symbol can remind people to "reduce, reuse, and recycle." The symbol of your school or your favorite sports team may express traditions or inspire loyalty. Your city or town's symbol might convey the community's "personality" or its residents' way of life. In designing your own symbol, decide on its basic purpose and use simple, uncluttered elements of shape and color to clearly communicate your message.



While *cryptography* is the science of writing or creating hidden messages, *cryptology* is the science of reading or deciphering hidden messages.

Cryptography

In cryptography, secret codes or ciphers are used to hide (encode or encrypt) the true meanings of messages. Strong codes and ciphers use highly complex mathematical formulas and algorithms (multistep procedures) to secure them and keep them secret.

What Is a Code?

A code is a way to replace the actual words in a message with other words or symbols that hide the message's true meaning. One example is a dictionary code, a system in which two identical copies of a dictionary are used, one by the sender and one by the receiver of the message. The sender might create an unencoded message (called "plaintext") and then look up the page number in the dictionary where each word in the message appears. Each word is coded according to the word's position on the dictionary page. For example, the code number "4625" might mean, "Go to page 46 and look in the 2nd column for the 5th word down from the top." That word might be *bind*; using this system, the word *bind* when sent in code is "4625." The same procedure is followed to encode each word in the message, creating a coded message that consists only of numbers, with each group of numbers representing a word.

This type of "book code" has many variations. In fact, any book can be used, not just a dictionary. Two copies of the same edition of the *Boy Scout Handbook* could be used, for example, and the code number "4625" might mean "go to page 46 and find the 25th word appearing on that page."

Cryptographers are people who are skilled at creating codes and ciphers. *Cryptanalysts* are skilled in code-breaking. Both kinds of specialists are usually well-educated in math.



Early cipher device of ancient Greece

What Is a Cipher?

A *cipher* differs from a *code* in that letters, instead of words, are replaced. A cipher changes or rearranges each letter in a message. For instance, a *substitution cipher* might replace the letters in the word TRUSTWORTHY to spell it AGWCADEGAMP, replacing each *T* with an *A*, each *R* with a *G*, etc.

The History of Cryptography

People have used secret codes for thousands of years. In ancient Greece, leaders of the city of Sparta wrote messages to their generals across the edges of strips of parchment wrapped in a spiral around staffs, or batons. Once the parchment was unrolled, the message could be read only by wrapping the strip around an identical staff belonging to the general to whom the message was addressed. This method is a type of *transposition cipher*—the message's letters or characters are reordered (transposed) instead of being replaced.

Hiding in Plain Sight

Some secrets rely not on ciphers, but on clever concealment. You are probably familiar with invisible ink made from milk or lemon juice, a method of concealment that dates to antiquity. The Roman philosopher and military commander of the early Roman Empire, Pliny the Elder (A.D. 23–A.D. 79), recommended using the milky juice of a common plant that turned clear as it dried. Messages also could be hidden in written material (whether ancient scrolls or modern books) by punching tiny holes under selected letters or words. The pinpricked letters spelled out the message when the page was held up to the light. Another method of revealing certain letters or words was to lay a grille (a cutout pattern of paper, metal, etc.) over written material to disclose a secret message hidden within the text.

The Italian philosopher and architect Leon Battista Alberti invented a cipher disk in 1467. He used two different alphabets arranged in two rings, with the larger ring encircling the smaller one. Lining up a letter from one ring with a different letter in the other ring created a simple substitution cipher that could be used to encrypt or decrypt a message.

In the early 18th century, the Freemasons began using a cipher commonly known as the "pigpen cipher" to keep their records and communications private. The method replaces letters with symbols that are fragments of a grid. Evidence suggests that George Washington's army used the cipher during the Revolutionary War, and it was used by both sides during the American Civil War. It is a simple substitution cipher. Using the example key shown in the illustration, the message "X MARKS THE SPOT" is enciphered as follows:

> ◻ ◻ ◻ ◻ ◻ > ◻ ◻ ◻ ◻ ◻
X M A R K S T H E S P O T

Thomas Jefferson invented a cipher wheel in the early 1790s. The device had a set of wooden disks, each with the 26 letters of the alphabet arranged around its edge. The order of the letters was random and different on each disk. The cryptographer spelled out a plaintext message on the cipher wheel and then copied down the line of characters above or below it to encipher the message. The receiver deciphered the message by rotating the disks on his matching cipher wheel so they spelled out the encrypted message on one row, which made the plaintext message appear on the row above or below it. Jefferson's cipher was among the most advanced of its day. The U.S. Army used a version of this cipher wheel from 1922 until the beginning of World War II.



Replica of a Confederate cipher disk; only five originals are known to exist today.



Thomas Jefferson's "wheel cypher"

During the American Civil War, signalmen waved flags back and forth in the wigwagging system to send messages in Morse code. The messages were sometimes encrypted with the cipher wheel before being transmitted by wigwag. Both sides in the Civil War tried to intercept and decipher the other side's messages to learn their plans.

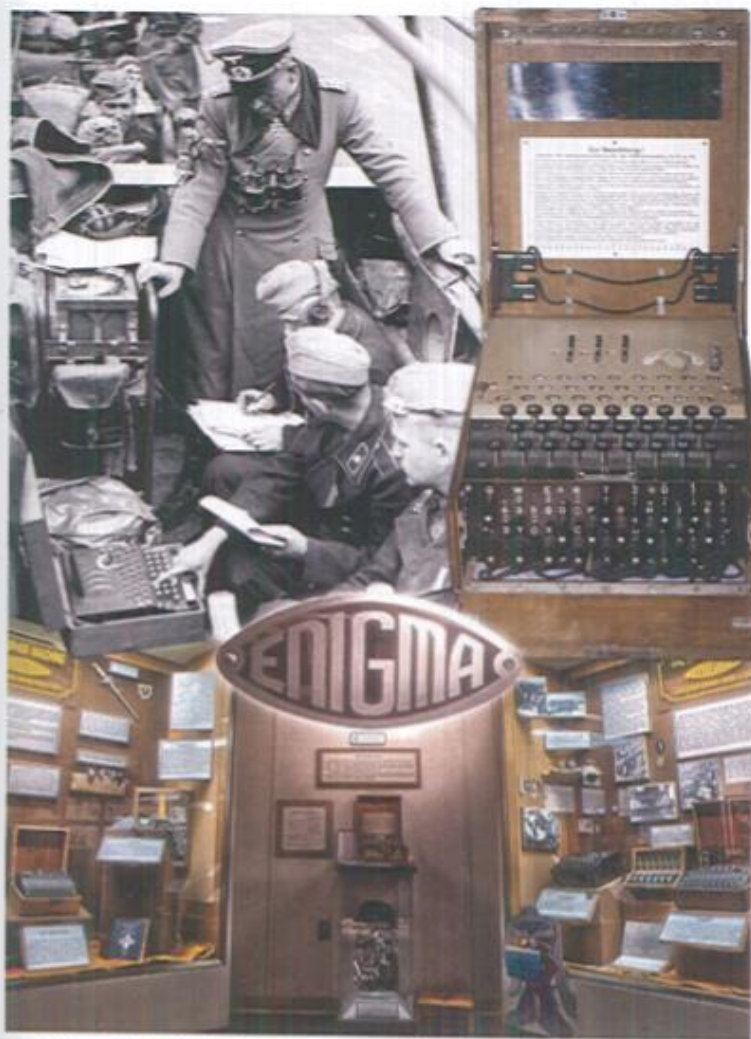
In 1942, during World War II, United States military intelligence successfully broke Japanese naval codes and learned that a large Japanese force was headed for the U.S. base on the Pacific island of Midway. Knowing the Japanese plan helped the U.S. Navy defeat the enemy force. The Battle of Midway was a major turning point in the war in the Pacific.

During the early days of World War II, cryptology experts in Poland—with help from the French—broke the seemingly unbreakable German Enigma cipher and shared their success with the British, who in turn shared the secret with their ally, the United States. Great Britain depended on supplies arriving by ship from the United States, but the ships were in constant danger of being hit by German submarines. The breaking of the Enigma cipher helped the allies locate and sink German subs before they could attack the supply ships, and ensured that allied commanders had the information they needed about enemy plans and movements. Many historians believe this cryptanalytic success was vital in shortening World War II in Europe.

The United States also began to analyze communications of the Soviet Union, and in 1946, partially decoded the ciphers that were used by Soviet spies in the United States. This project, called "Venona," took nearly 40 years, not ending until about 1980.

Modern Codes and Ciphers

The invention of machines and computers made codes and ciphers harder to break and easier to use, which has in turn made the art of codebreaking both harder and easier. Machine ciphers are stronger (less breakable) than manual systems and are widely used to secure important information. Modern encryption protects people's data and privacy. Cell phones, tablets, computers, and software use strong encryption technology to help protect banking and financial details, emails, text messages, and other personal information.



The National Cryptologic Museum, near Fort Meade in Maryland, displays many exhibits on the history of cryptology, including an Enigma machine.

The federal government is among the largest employers of mathematicians in the United States, and many of these mathematicians work to make or break codes and ciphers. Cryptographers and cryptanalysts are employed by the Department of Defense, the military, and other federal, state, and local agencies.

The Code Talkers

During World War II, the United States military had a secret code that baffled the enemy: Navajo “code talkers” adapted their complex native language to create an unbreakable system. They used everyday Navajo words to represent terms that did not exist in the Navajo language—“iron fish” for submarine, “tortoise” for tank, “potatoes” for grenades, etc. The code talkers often worked 35 hours straight without food or rest, relaying vital military communications without error. Only recently has the code talkers’ exceptional service been publicly recognized and honored, because the Navajo language remained potentially valuable as a secret code long after World War II ended. For more about Navajo and other Native American code talkers, see the *Indian Lore* merit badge pamphlet.

Creating Your Own Code

To create your own secret code, you can use any of the methods discussed above, such as a substitution cipher, pigpen cipher, or book code. You could make a device with rings or disks of letters, similar to the Alberti cipher disk or Jefferson’s cipher wheel. Or do research to find the code system you want to use, or make up your own code.

Whatever type of encryption you use, you must also make a key that gives instructions or shares the secret for deciphering the messages you write in that code. Give the key to the recipients of your messages so they will know how to convert the coded text back to the original (plaintext) information.





Resources

Scouting Literature

Boy Scout Handbook, Fieldbook; Communication, Digital Technology, Disabilities Awareness, Emergency Preparedness, Graphic Arts, Indian Lore, Programming, Radio, Railroadng, Search and Rescue, and Wilderness Survival merit badge pamphlets.

Websites, Tutorials, and Apps

American Sign Language

American Sign Language University
Website: <http://www.lifeprint.com>

dDeaf World
Website: <http://www.ddeafworld.com>

Handspeak®
Website: <http://www.handspeak.com>

Learn American Sign Language
tablet/smartphone app

Signing Savvy
Website: <http://www.signingsavvy.com>

Braille

Braille Alphabet
Website: <http://www.braillealphabet.org>

BrailleBack, tablet/smartphone app

Braille Bug®
Website: <http://www.braillebug.afb.org>

Braille Flash Cards

Website: <http://www.printableflashcards.net/preview/Braille>

Cryptography

Break the Code

Website: <http://www.cia.gov/kids-page/games/break-the-code>

CryptoClub

Website: <http://www.cryptoclub.org>

Crypto Museum

Website: <http://www.cryptomuseum.com>

Journey Into Cryptography

Website: <http://www.khanacademy.org/computing/computer-science/cryptography>

Secret Language: Cryptography

& Secret Codes

Website: <http://www.exploratorium.edu/ronh/secret/secret.html>

Morse Code

AE Morse Code Tutor,
tablet/smartphone app

Learn Morse Code

Website: <http://www.learnmorsecode.com>

Morse Code Machine

Website: <http://www.boyslife.org/games/online-games/575/morse-code-machine>

Morse-It, tablet/smartphone app

Nautical Flags

International Code Flags or Signaling Flags
Website: <http://www.boatsafe.com/nauticalknowhow/flags.htm>

Nautical Flags and Their Meanings
Website: <http://www.marine waypoints.com/learn/flags/flags.shtml>

Nautical Flags—International Code Flags
Website: <http://www.soundkeepers.com/kids/alphabet>

Rescue and Distress Signals

Basic Survival Strategy
Website: <http://www.cap-es.net/zips/bssh.PDF>

Boating Distress Signals
Website: <http://boatsafe.com/nauticalknowhow/distress.htm>

Camping Distress Signals
Website: <http://www.camping-field-guide.com/distress-signals.html>

Ground-to-Air Signals
Website: <http://www.cap-es.net/zips/gnd2airsignals.PDF>

Semaphore

Semaphore Flag Signaling
Website: <http://inter.scoutnet.org/semaphore>

Semaphore Flag Signaling System
Website: <http://www.marine waypoints.com/learn/flags/semaphore/semaphore.shtml>

Semaphore Flag Signaling
tablet/smartphone app

Trail Signs

Trail Signs & Blazes
Website: <http://www.inquiry.net/outdoor/skills/seton/blazes.htm>

Trail Signs of Direction
Website: http://www.inquiry.net/outdoor/skills/beard/signs_direction.htm

Trail Signs: Traditional
Website: <http://www.inquiry.net/outdoor/skills/b-p/signs.htm>

Wigwag and Other Signals

The Science Notebook
Website: <http://science-notebook.com/gilbert-signal01.html>

Sending WIGWAG Code
Website: <http://www.cranburyscouts.org/WigWagBL.htm>

Signalman Sam's Signaling Resource Page
Website: <http://www.cranburyscouts.org/SamsPage.htm>

Smiley Symbols Dictionary
Website: <http://www.planetpals.com/smiley.html>

Books and CDs

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Your Introduction to Morse Code (audio CDs). ARRL, 2008.

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U.S. Games Systems, 2006.

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