Contents

Chapter 1

What is Amateur (Ham) Radio?

For more than a century, a growing group of federally licensed radio hobbyists known as Amateur Radio — or "ham radio" — operators has had a front-row seat as radio and electronics have broadened our horizons and touched virtually all of our lives. Hams *pioneered* personal communication, even in the days before the telephone and household electricity were commonplace and the Internet not yet conceived. The word "radio" — or "wireless" — still evokes awe.

Today we enjoy wireless amenities that range from the ubiquitous mobile phone to sophisticated smartphones, tablet devices, and diminutive netbook PCs that go just about anywhere. Personal communication is the goal. The original "personal wireless" communication, Amateur Radio remains vital and active today. In this chapter, Rick Lindquist, WW1ME provides an overview of Amateur Radio activities and licensing requirements.

1.1 Do-It-Yourself Wireless

Amateur (or "ham") Radio operators have at their fingertips the ability to directly contact fascinating people they may never meet who live in distant places they'll never visit. They do this without any external infrastructure, such as a cell phone network or the Internet, sometimes using simple, inexpensive — often homemade — equipment and antennas. Since the earliest years of wireless communication, these radio experimenters, largely self-taught, developed and refined the means to contact one another without wires connecting them.

As a radio amateur, you can meet new friends, win awards, exchange "QSLs" (the ham's business card), challenge yourself and others in on-the-air competitions, educate yourself about radio technology, contribute to your community, travel, promote international goodwill, and continue the century-old wireless communication tradition. Your station is yours and yours alone, and it's independent of any other communication network.

Let's take a closer look.

AN AMAZING CENTURY OF HAM RADIO

Today we think of "wireless" as a relatively modern term that applies to a wide variety of electronic devices, but it's actually been around for more than a century. Wireless communication was a goal of early experimenters in the late 19th century and early 20th century. Equipment and methods for early wireless often were crude and rudimentary — a simple crystal radio (primitive "solid state" technology) to listen, and a spark gap transmitter to send Morse code, coupled with what was then called an "aerial." Little to no ready-made equipment was available, and parts for these early radio do-it-yourselfers were expensive and hard to obtain. On a good night, their transmissions might even span 50 miles! In the early 20th century, when not everyone had a telephone and calling long-distance was pricey, ham radio was, in more contemporary terms, "really cool technology."

In 1914, just two years after these early hams were required to hold licenses from the federal government, inventor and industrialist Hiram Percy Maxim, 1AW, and radio enthusiast Clarence Tuska, 1WD, established the American Radio Relay League (ARRL) to bring these US radio hobbyists under one tent to serve their common interests. These two founding fathers of ham radio and their peers would be awestruck to see how the world of Amateur Radio and wireless technology has expanded and evolved in the intervening century.

While Maxim and Tuska were not the first hams, the organization they founded, the ARRL — the national association for Amateur Radio — has championed and sustained these radio pioneers and their successors. Now 100 years down the road — light years in terms of radio science and technology — Amateur Radio continues to adapt to the times. While many traditions continue, today's ham radio is not the ham radio of yesteryear.

Fig 1.1 — For decades, hams such as Tammy Scheirman, VA6TSS, have volunteered their skills to assist in everything from storm spotting to disaster relief. Here, Tammy has deployed an array of mobile state-of-the-art technology during a mock disaster exercise she took part in with her club, the Foothills Amateur Radio Society of southern Alberta, Canada. [Jerry Clement, VE6AB, photo]

Fig 1.2 — Scouting's annual Jamboree On The Air (JOTA) is an opportunity for youngsters to get on the air under the supervision of a radio amateur to meet other Scouts, as Ramdrick Despabiladeras (left) and Connor Lee Cordell are doing at the 2014 K6M JOTA operation in California. [Christopher Cordell, AA6FF, photo]

Fig 1.3 — NASA Astronaut and radio amateur Reid Wiseman, KF5LKT, spent about six months aboard the International Space Station during 2014. He spoke to students on Earth as part of the Amateur Radio on the International Space Station (ARISS) program. [NASA photo]

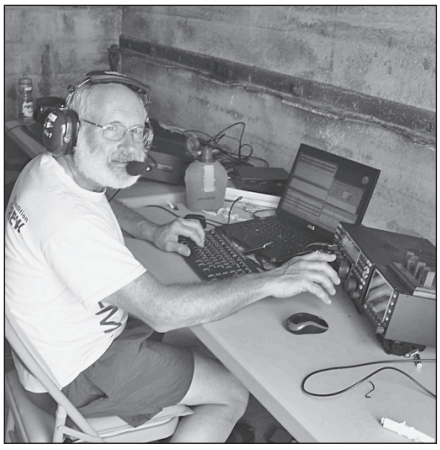

Fig 1.4 — Hams travel to all parts of the world to "activate" rare and unusual locations, sometimes making many thousands of contacts with other hams around the globe. Glenn Johnson, WØGJ, was among a team of radio amateurs to operate during 2015 from Navassa Island in the Caribbean.

Fig 1.5 — Kristina Whitley displays her excitement after making a contact at W4FOS, the Chesapeake Center for Science and Technology High School Amateur Radio Club station in Chesapeake, Virginia, during the ARRL School Club Roundup. [Photo courtesy Richard Siff, W4BUE]

THE ORIGINAL PERSONAL COMMUNICATION

In this age of multiple sophisticated communication platforms, it's not uncommon for people to ask, "Ham radio? Do they still *do* that?" Yes, "they" do. But, given the proliferation of communication alternatives, the larger question may be, *Why*?

Ham radio is a do-it-yourself (DIY) technological and social medium — *personal* communication with no bills, minutes or data plans. It's personal communication that's "off the grid," a wireless service you can rely on when other services aren't available.

It doesn't cost a lot to get into Amateur Radio and participation is open and accessible to everyone. Hams are mothers, fathers, and children of all ages, ethnic backgrounds, physical abilities, and walks of life who belong to a unique worldwide community of licensed radio hobbyists. Some are even well-known celebrities. All find joy and excitement by experiencing radio communication and electronics on a very personal level across a spectrum of activities.

The Federal Communications Commission (FCC) grants licenses in the Amateur Radio Service. With an emphasis on "service," the FCC has laid down five essential principles underlying Amateur Radio's fundamental purpose (see sidebar "Ham Radio's Rules of the Airwaves"). These recognize ham radio's value to the public as a "voluntary noncommercial communication service, particularly with respect to providing emergency communications." The service also exists to continue and expand Amateur Radio's "proven ability" to advance the state of the radio art, as well as both technical and communication skills. Further, the FCC says, the Amateur Radio Service should help to expand the "existing reservoir of trained operators, technicians, and electronics experts," and continue and extend the radio amateur's "unique ability to enhance international goodwill."

HAMS ARE EVERYWHERE

Spotting a radio amateur can be easy. The driver of that car sporting an "odd-looking" antenna may be a ham equipped for mobile operation. Your neighbor on the next block with the wires strung between trees or, perhaps, a tower supporting what looks like a very large television antenna probably is one too.

Modern technology continues to make ham radio more accessible to all, including those living on tight budgets or facing physical challenges. People lacking mobility may find the world of Amateur Radio a rewarding place to find lasting friendships — on the next block, in the next state, or around the globe.

Hams are ambassadors. For many radio

Ham Radio's Rules of the Airwaves

International and national radio regulations govern the operational and technical standards of all radio stations. The International Telecommunication Union (ITU) governs telecommunication on the international level and broadly defines radio services through the international *Radio Regulations*. In the US, the Federal Communication Commission (FCC) is the federal agency that administers and oversees the operation of nongovernmental and nonmilitary stations — including Amateur Radio. Title 47 of the *US Code of Federal Regulations* governs telecommunication. The Amateur Radio Service is governed by Part 97.

Experimentation has always been the backbone of Amateur Radio, and the Amateur Service rules provide a framework within which hams enjoy wide latitude to experiment in accordance with the "basis and purpose" of the service. The rules should be viewed as vehicles to promote healthy activity and growth, not as constraints that lead to stagnation. The FCC's rules governing Amateur Radio recognize five aspects, paraphrased below, in the Basis and Purpose of the Amateur Service.

- Amateur Radio's value to the public, particularly with respect to providing emergency communication support
- Amateur Radio's proven ability to contribute to the advancement of the radio art
- Encouraging and improving the Amateur Service through rules that help advance communication and technical skills
- Maintaining and expanding the Amateur Service as a source of trained operators, technicians and electronics experts
- Continuing and extending the radio amateur's unique ability to enhance international goodwill

The Amateur Radio Service rules, Part 97, are in six sections: General Provisions, Station Operation Standards, Special Operations, Technical Standards, Providing Emergency Communication and Qualifying Examination Systems. Part 97 is available in its entirety on the ARRL and FCC websites (see the Resources section at the end of this chapter for further information).

Hams on the Front Lines

Over the years, the military and the electronics industry have often drawn on the ingenuity of radio amateurs to improve designs or solve problems. Hams provided the keystone for the development of modern military communication equipment, for example. In the 1950s, the Air Force needed to convert its long-range communication from Morse code to voice, and jet bombers had no room for skilled radio operators. At the time, hams already were experimenting with and discovering the advantages of single sideband (SSB) voice equipment. With SSB, hams were greatly extending the distances they could transmit.

Air Force Generals Curtis LeMay and Francis "Butch" Griswold, both radio amateurs, hatched an experiment that used ham radio equipment at the Strategic Air Command headquarters. Using an SSB station in an aircraft flying around the world, LeMay and Griswold were able to stay in touch with Offutt Air Force Base in Nebraska from around the globe. The easy modification of this ham radio equipment to meet military requirements saved the government millions of dollars in research costs.

More recent technological experimentation has focused on such techniques as software defined radio (SDR). This amazing approach enables electronic circuit designers to employ software to replace more costly — and bulkier — hardware components. It's no coincidence or surprise that radio amateurs have been among those investigators doing the ground-level research and experimentation to bring this technology from the laboratory to the marketplace. Transceivers built on the SDR model now are making inroads within the Amateur Radio community and represent the likely wave of the future in equipment design.

Affirming the relationship between Amateur Radio and cutting-edge technology, Howard Schmidt, W7HAS, was White House Cybersecurity Coordinator from 2009 to 2012. An ARRL member, Schmidt is one of the world's leading authorities on computer security, with some 40 years of experience in government, business and law enforcement. Schmidt credits ham radio with helping to launch his career. "Building … computers to support my ham radio hobby gave me the technical skills that I needed to … start doing computer crime investigations and work on the early stages of computer forensics, in turn enabling me to start working on cybersecurity issues," he says. Hams are often found in industry and the military as technology presses ahead.

amateurs, a relaxing evening at home is having a two-way radio conversation with a friend in Frankfort, Kentucky or Frankfurt, Germany. Unlike any other hobby, Amateur Radio recognizes no international or political boundaries, and it brings the world together in friendship.

1.1.1 Making it Happen

A major feature of Amateur Radio's 100-year heritage has been the ham's ability to make do with what's at hand to get on the air. It is in the pursuit of such hands-on, do-it-yourself activities that this *Handbook* often comes into play, especially as electronic components are more plentiful today and circuit designs increasingly complex and creative.

Amateur Radio has always been about what its participants bring *to* it and what they make *of* it. Even today many enthusiasts enjoy making their own radio communication gear. Hams contact each other using equipment they've bought or built, or a combination of the two, over a wide range of the radio spectrum. The methods hams use to keep in touch range from the venerable Morse code — no longer a licensing requirement, by the way — to voice, modern digital (ie, computer-coded) modes, and even television.

The hybridization of Amateur Radio and computers and the Internet continues to blossom, as hams invent ever more creative ways to exploit this technology and make it an essential station component. Today it's possible for a ham to control a transmitting and receiving station via the Internet using nothing more than a laptop or smartphone — even if that station is thousands of miles distant. The wonder of software defined radio (SDR) techniques has even made it possible to create *virtual* radio communication gear. SDRs require a minimum of physical components; sophisticated computer software does the heavy lifting!

1.1.2 Your Ham Radio Comfort Zone

Amateur Radio offers such a wide range of activities that everyone can find a comfortable niche. As one of the few truly *international* hobbies, ham radio makes it possible to communicate with other similarly licensed aficionados all over the world. On-the-air competition called contesting or "radiosport" — just to pick one activity many hams enjoy — helps participants to improve their skills and stations. Further, ham radio offers opportunities to serve the public by supporting communication in disasters and emergencies, and it remains a platform for sometimes cutting-edge scientific experimentation. Many of those who got into ham radio at a young age credit that involvement with later success in technological careers.

Fig 1.6 — Nine-year-old Priya, the daughter of Chad, WE9V, made some RTTY [radioteletype] contacts during the June 2014 Kids Day activity, which is aimed at giving unlicensed youngsters a chance to experience ham radio firsthand. [Chad Kurszewski, WE9V, photo]

Ham radio's horizon extends into space. The International Space Station boasts a ham radio station, and most ISS crew members are Amateur Radio licensees. Thanks to the program Amateur Radio on the International Space Station (ARISS), suitably equipped hams can talk directly with NASA astronauts in space. Hams also contact each other through Earth-orbiting satellites designed and built by other radio amateurs, and they even bounce radio signals off the Moon and back to other hams on Earth.

Hams talk with one another from vehicles, while hiking or biking in the mountains, from remote camp sites, or while boating. Through a plethora of activities, hams learn a great deal, establish lifelong friendships and, perhaps most important, have a *lot* of fun. Along the way, radio amateurs often contribute a genius that propels technological innovation.

Most likely you're already a ham or at least have experimented with radio and electronics yourself and are thinking about getting your ham license. This *Handbook* is an invaluable resource that reveals and explains the "mysteries" governing electronics in general and in radio — or wireless — communication in particular, especially as they pertain to Amateur Radio.

1.1.3 What's in it for Me?

As a community *of* communities, Amateur Radio can be whatever *you* want it to be. Whether you are looking for relaxation, excitement, enjoyment or a way to stretch your mental (and physical) horizons, Amateur Radio can provide it — even for those with time and money constraints. However it happens, communication between individuals is at the core of nearly all ham radio activities. In its most basic form, ham radio is two people saying "Hello!" to each other over the air, perhaps using inexpensive handheld transceivers or even homemade gear. In "Hamspeak," a two-way, on-the-air communication is known as a "QSO" — an old radiotelegraph, or Morse code, abbreviation often pronounced "CUE-so."

Ham radio can also be a group activity. Hams with common interests often gather on the airwaves to share their thoughts and even pictures. These get-togethers are called "nets" or "roundtables," depending on their formality. When hams meet on the air for an extended on-the-air conversation, they sometimes call it "ragchewing."

Nets form when like-minded hams gather on the air on a regular schedule. Nets often provide an on-the-air venue to find other hams with similar interests both inside and outside of Amateur Radio. Topics may be as diverse as vintage radio, chess, gardening, rock climbing, railroads, computer programming, teaching or an interest in certain types of radio equipment. Faith-based groups and scattered friends and families may also organize nets. You can find your special interest in *The ARRL Net Directory* on the ARRL website (**www.arrl.org/arrl-net-directory**).

1.2 Joining the Ham Radio Community

Morse code has been a major player in Amateur Radio's legacy, although it was a roadblock to some. Today it's no longer necessary to learn the code to become an Amateur Radio licensee. You still must hold a license granted by the Federal Communications Commission (FCC) to operate an Amateur Radio station in the United States, in any of its territories and possessions or from any vessel or aircraft registered in the US. There are no age or citizenship requirements to obtain a US Amateur Radio license, and the cost is minimal, sometimes free. Ham radio exams are regularly passed by children not yet in their teens!

The FCC offers three classes — or levels — of Amateur Radio license. From the easiest to the most difficult, they are Technician, General and Amateur Extra Class. Applicants must take and pass a multiple-choice written examination for each license. Official question pools for all ham radio license classes are publically available. The higher you climb the ladder, the more challenging the test and the more generous the operating privileges. To reach the top — Amateur Extra — you must pass the examinations for all three license classes.

1.2.1 Moving Through the Ranks

Most people start out in Amateur Radio by getting a Technician Class license or "ticket," as a ham license is sometimes called. Obtaining a Technician license requires passing a 35 question multiple-choice exam. The test covers FCC rules and regulations governing the airwaves, courteous operating procedures and techniques and some basic electronics. The privileges earned give Technicians plenty of room to explore and activities to try. For some, the Technician is the only ham license they'll ever want or need.

Technicians enjoy a wide, but somewhat limited, range of voice and digital radio operating privileges. These include access to some "high frequency" (HF or short-wave) frequency "bands" or segments of the radio spectrum. Depending upon license class, hams have access to up to 10 distinct HF bands in the range from 1.8 MHz to 29.7 MHz, where most direct international communication happens. (Frequency and wavelength terms are explained in the **Electrical Fundamentals** chapter.) Technicians also have all amateur privileges in the VHF-UHF and microwave spectrum, though, which allow operation on widely available FM voice repeaters. A repeater greatly extends the communication range of low-power, handheld radios or mobile stations too far apart to communicate with each other directly. The "Tech ticket" is a great introduction to the fun and excitement of ham radio and to the ways of the hobby.

By upgrading to General Class, a Technician licensee can earn additional operating privileges, such as access to all of the Amateur Radio HF bands. Upgrading to General entails passing another 35 question multiple-choice exam. In addition to Technician privileges, Generals enjoy worldwide communication using voice, digital, image and television techniques.

Reaching the top rung of the Amateur Radio ladder — Amateur Extra Class — means passing a more demanding 50 question examination. Amateur Extra licensees enjoy privileges on all frequency bands and communication modes available to hams. The exam may be challenging, but many hams consider it well worth the effort!

1.2.2 Study Aids

You can prepare for the exam on your own, with a group of friends or by taking a class sponsored by a ham radio club in your area. The ARRL offers materials and lesson plans for hams wishing to teach Amateur Radio licensing classes. Anyone can set up license classes. Many Amateur Radio clubs hold periodic classes, usually for the Technician license. The ARRL supports Registered Amateur Radio Instructors, but registration is not necessary to conduct a class. Check the ARRL website, **www.arrl.org**, for classes, clubs or volunteer examiners (VEs) in your area (more on VEs below).

Help is available at every step. The ARRL publishes study materials for all license classes. Visit the ARRL website or contact the ARRL's New Ham Desk for more information on how to get started. The Resources section at the end of this chapter includes an address and telephone number. The ARRL can help you find ham radio clubs in your area as well as ARRL-registered instructors and local Volunteer Examiner teams. Additional information on the ARRL website includes frequencies hams can use, popular operating activities, and how to order the latest ARRL study guide.

For newcomers seeking to obtain a Technician license, *The ARRL Ham Radio License Manual* includes the complete, up-to-date question pool, with the correct answers and clear explanations. The manual assumes no prior electronics background. It delves into the details behind the questions and answers, so you will *understand* the material, rather than simply memorize the correct answers.

If you already have some electronics background or just want brief explanations of the material, you might find *ARRL's Tech Q&A* manual a more appropriate choice. It also includes the entire Technician question pool to help you prepare.

When you are ready to upgrade to a General Class license, *The ARRL General Class License Manual* or *ARRL's General Q&A* can help you prepare. In like fashion, *The ARRL Extra Class License Manual* and *ARRL's Extra Q&A* will guide your study efforts for the Amateur Extra Class license. Check the ARRL website for detailed information on these and other license study options.

1.2.3 Taking the Test

While the FCC grants US Amateur Radio licenses, volunteer examiners (VEs) now administer all Amateur Radio testing. Other countries have adopted similar systems. Ham radio clubs schedule regular exam sessions, so you shouldn't have to wait long or travel far once you're ready. Exam sessions often are available on weekends (frequently at ham radio gatherings called "hamfests") or evenings. Most volunteer examiner teams charge a small fee to recover the cost of administering the test and handling the FCC paperwork.

The ARRL is a Volunteer Examiner Coordinator (VEC) and supports the largest VE program in the nation. More information about the VE program is available on the ARRL website.

The questions for each 35 or 50 question test come from a large "question pool" that's specific to each license class. All three question pools — Technician, General and Amateur Extra — are available to the public in study guides and on the

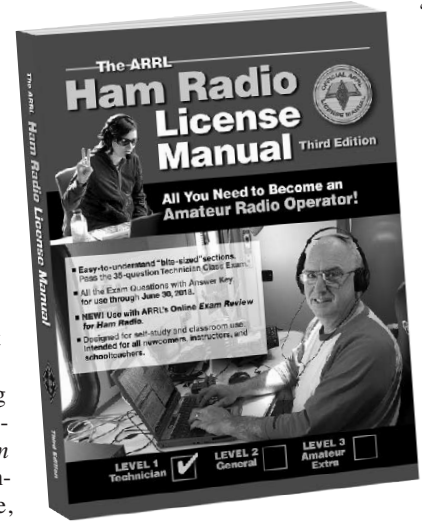

Fig 1.7 — *The ARRL Ham Radio License Manual* contains all the information you need to study for your Technician class license.

Internet. If you're studying, make sure you're working with the latest version, since question pools are updated on a set schedule. The Resources section at the end of this chapter has more information on where to find the question pools.

1.2.4 Your Ham Radio Mentor

Ham radio operators often learn the ropes from a mentor. In ham radio parlance, such an experienced ham willing to help newcomers is called an "Elmer." This individual teaches newcomers about Amateur Radio, often on a one-to-one basis. Your local ham radio club may be able to pair you up with an Elmer who will be there for you as you study, buy your first radio and set up your station — which many hams call their "radio shack" or "ham shack," a term held over from the days when ham stations often were in small buildings separate from the owner's residence. Elmers also are pleased and proud to help you with your first on-the-air contacts.

Elmers who belong to the international Courage Handi-Hams organization (**www.handiham.org**) focus on making study materials and ham radio station operation accessible to those with physical disabilities. Local Handi-Hams assist such prospective radio amateurs in getting licensed, and the Handi-Ham System may lend basic radio gear to get the new ham on the air.

1.2.5 Your Ham Radio Identity

Ham radio operators know and recognize each other by a unique call sign (some hams shorten this to simply "call") that the FCC

ARRL — the national association for Amateur Radio®

The American Radio Relay League (ARRL) is the internationally recognized society representing Amateur Radio in the US. Since its founding in 1914, the ARRL — the national association for Amateur Radio — has grown and evolved along with Amateur Radio. ARRL Headquarters and the Maxim Memorial Station W1AW are in Newington, Connecticut, near Hartford. Through its dedicated volunteers and a professional staff, the ARRL promotes the advancement of the Amateur Service in the US and around the world.

The ARRL is a nonprofit, educational and scientific organization dedicated to the promotion and protection of the many privileges that ham radio operators enjoy. Of, by and for the radio amateur, ARRL numbers some 160,000 members — the vast majority of active amateurs in North America. Licensees can become Full Members, while unlicensed persons are eligible to become Associate Members with all membership privileges except for voting in ARRL elections. Anyone with a genuine interest in Amateur Radio belongs in the ARRL.

The ARRL volunteer corps is called the Field Organization. Working at the state and local level, these individuals tackle ARRL's goals to further Amateur Radio. They organize emergency communication in times of disaster and work with agencies such as American Red Cross and Citizen Corps. Other volunteers keep state and local government officials abreast of the good that hams do at the state and local level.

When you join ARRL, you add your voice to those who are most involved with ham radio. The most prominent benefit of ARRL membership is its monthly journal *QST*, the premiere Amateur Radio magazine issued monthly in print and digital form. *QST* contains stories you'll want to read, articles on projects to build, announcements of upcoming contests and activities, reviews of new equipment, reports on the role hams play in emergencies and much more.

Being an ARRL member is far more than a subscription to *QST*. The ARRL represents your interests before the FCC and Congress, sponsors operating events throughout the year and offers membership services at a personal level. These include:

- low-cost ham equipment insurance
- the Volunteer Examiner program
- the Technical Information Service (which answers your questions about Amateur Radio technical topics)
- the QSL Service (which lets you exchange postcards with hams in other countries to confirm your contacts with them)

For answers to any questions about Amateur Radio, e-mail, call or write ARRL Headquarters. See the Resources section at the end of this chapter for contact information.

Fig 1.8 — Young Mailie Danilchik, K7MKD, of Poulsbo, Washington, got her license at age 10. Her dad Paul is NT7U, and she said that getting her ham ticket was "a father-daughter bonding project." The cat is still studying for her ham ticket. [Paul Danilchik, NT7U, photo]

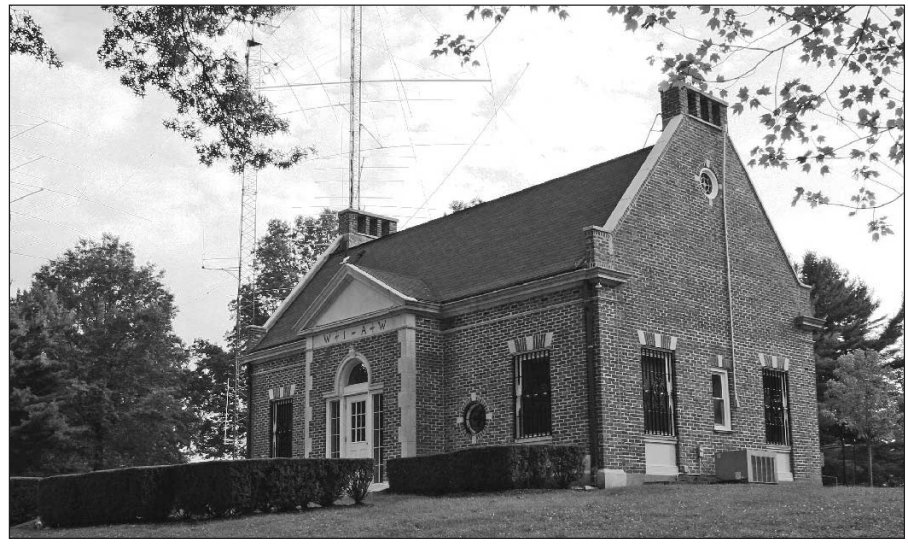

Fig 1.9 — This iconic brick building houses W1AW, the station operated by the ARRL in Newington, Connecticut, and known around the world. W1AW memorializes Hiram Percy Maxim, one of the founders of the ARRL. Visitors are welcome and often operate the station. [Rick Lindquist, WW1ME, photo]

Fig 1.10 — Voice modes are the most popular way hams use to communicate with each other. ARRL Emergency Preparedness Manager Mike Corey, KI1U, makes a few single-sideband mode contacts from Maxim Memorial Station W1AW at ARRL Headquarters in Connecticut.

issues when you get your license. Your call sign not only identifies your station on the air, it's an individual ham radio identity, and many hams become better known by their call signs than by their names! Although the FCC still issues hard-copy licenses, once your license and call sign grant appear online in the FCC's active Amateur Radio Service database, you have permission to operate.

A call sign also identifies the issuing country. US call signs, for example, begin with W, K, N or A followed by some combination of letters and one numeral. Each combination is different. One well-known ham radio call sign is W1AW, assigned to the Hiram Percy Maxim Memorial Station at ARRL Headquarters in Newington, Connecticut.

FCC-assigned call signs come in several flavors, with the shortest — and typically most desirable — combinations available only to Amateur Extra Class licensees. The FCC routinely assigns initial call signs to new Technician licensees in the longest format. These call signs start with two letters, a numeral from 0 to 9, and three more letters. The first part of a call sign including the numeral is called a *prefix*. The part following the numeral is called a *suffix* and is unique to a specific licensee. Typical prefixes in Canada are VE and VA, while the common prefix in Mexico is XE.

At one time, the numeral indicated a US station's geographical region — 1 for New England, 6 for California and 9 or Ø (zero) for the Midwest. The FCC has made ham radio call signs portable, however — just like telephone numbers. So a call sign with "1" following the prefix may belong to a ham located in Florida.

You don't have to keep the call sign the FCC assigns. For a modest fee, the FCC's *vanity call sign* program permits a ham to select a new personalized call sign from among the database of certain unassigned call signs, based on the applicant's license class.

1.3 Your Ham Radio Station

Amateur Radio costs as much or as little as your budget and enthusiasm dictate. Most hams set up home-based stations. By tradition the room or place where a station is located is your "ham shack," but many thrifty hams carry their stations with them in the form of relatively inexpensive handheld transceivers, some quite compact. Without requiring any antenna beyond the one attached to the radio itself, such radios can accompany you when you're out and about or traveling.

On the other end of the scale, radio amateurs serious about radio contesting or DXing (contacting distant stations in other countries) often invest in the latest equipment and extensive antenna systems. Most hams fall somewhere between these extremes. They have a modest equipment complement, simple wire antennas between two trees and maybe a small "beam" (directional antenna) on a backyard tower or mast. Whatever your investment level, you'll be able to talk around the world.

Fig 1.11 — Some hams enjoy building their own equipment, and many are quite good at repurposing or recycling outdated technology. Richard Calhoun, W6DZT, built this power amplifier in a discarded personal computer enclosure, bought through an online auction site for a few dollars. [Richard Calhoun, W6DZT, photo]

Fig 1.12 — Amateur Radio has brought a new level of social activity to the Collington continuing care community in Maryland. Formation of a community radio club means that downsizing retirees now can continue to enjoy ham radio, as Karl Edler, KB3US (left) and Dick Wilder, K3DI, are doing. [Jamie Windon photo]

1.3.1 How Much Does It Cost?

Early radio amateurs generally built their own gear, mainly out of necessity; there were no well-stocked radio emporiums in the early 20th century. Constructing ham radio equipment from kits became popular in the mid-20th century, and several manufacturers still provide parts kits and circuit boards to make it even easier to build equipment yourself. A lot of hams still enjoy designing and building their own equipment (called "homebrewing") and the resulting cost savings. Many of these amateurs proudly stand at the forefront of technology and keep up with advances that may be applied within or even outside the hobby. Indeed, the projects you'll find in this *Handbook* provide a wide variety of equipment and accessories that make ham radio more convenient and enjoyable.

Today's radio amateurs most often start out using off-the-shelf commercially-made transceivers purchased new or on the used

Hamfests

Amateur Radio's broader social world extends beyond making on-the-air acquaintances. Regular ham radio gatherings, usually called "hamfests," offer opportunities to meet other hams in person — called "an eyeball contact" in ham parlance. Hams also enjoy buying, selling and trading ham radio equipment and accessories in the hamfest "flea market." *Every* ham loves a bargain. Other hamfest visitors take advantage of classroom sessions or forums to learn more about particular aspects of the hobby.

Hamfests are great places to get good deals on gear — some vendors offer substantial hamfest discounts — and to expand your knowledge. Thousands of radio amateurs from the US and around the world gather each spring at Dayton Hamvention® in Ohio. This truly international event epitomizes the goodwill that exists among the world's Amateur Radio enthusiasts.

The annual Dayton Hamvention attracts upward of 20,000 hams from around the world to meet and greet, learn, buy, sell and trade.

market, perhaps at a ham radio flea market or hamfest or through an Internet auction or classified ad site. An abundance of ham gear is readily available, and there's something out there to meet your needs within your budget. Used VHF or VHF-UHF (or "dual-band") handheld transceivers often are available for $100 or so, and the entrance of Chinese manufacturers into the ham radio market has resulted in a significant reduction in the price of some types of brand new gear.

Those interested in HF work can get in on the ground floor with a used, but serviceable, transceiver in the $200 to $500 range, and an excellent selection of new transceivers is available in the $500 to $1500 range. "Flea-power" CW (Morse code) transceivers covering single bands sell new for less than $100 in kit form; a new four-band CW transceiver manufactured in China and marketed by a US ham radio manufacturer is available for less than $300. An HF antenna such as a simple backyard dipole suspended from available trees is both inexpensive and effective. You'll find some great equipment choices advertised in ARRL's monthly journal, *QST*. In addition to advertising new ham gear, *QST* includes comprehensive equipment reviews.

More elaborate antennas and various accessories can add appreciably to the cost of your station, but less-expensive alternatives are available, including building your own.

1.3.2 Computers and Ham Radio

The marriage of ham radio and computers is solid and longstanding. Radio amateurs have discovered that interconnecting their PCs with their ham stations not only makes operating more convenient but can open the door to additional activities on the ham bands. Most radio amateurs now have a computer in the shack, often one that's dedicated to ham radio tasks. Software is available for many ham radio applications, from record keeping to antenna and circuit design.

Probably the most common use for a computer in the ham shack is logging — keeping a record of — contacts. This is especially true for contesters, where speed and accuracy are paramount. While there's no longer a legal requirement to maintain a detailed logbook of your on-the-air activities, many hams still keep one, even for casual operating, and computer logging can make the task less tedious (see sidebar "Keeping a Log").

Many computer logging applications also let you control many or most of your radio's functions, such as frequency or band selection, without having to leave your logging program. It's also possible to control various accessories, such as antenna rotators or selection switches, by computer.

Via your computer's soundcard, you can enjoy *digital modes* with nothing more than a couple of simple connections, operating software (often free) and an interface. RTTY (radioteletype) and PSK31 are two of the most popular HF "keyboard-to-keyboard" digital modes. PSK31 lets you communicate over great distances with a very modest ham station, typically at extremely low power levels.

Computers also can alert you to DX activity on the bands, help you practice taking Amateur Radio license examinations or improve your Morse code abilities. Many ham radio organizations, interest groups and even individuals maintain websites too.

Fig 1.13 — Ham radio contesting or "radiosport" attracts thousands of participants. Here, Dr Carol Milazzo, KP4MD, operates during the January ARRL VHF Contest from California. [Dr Carol Milazzo, KP4MD, photo]

Keeping a Log

Keeping a log — on paper or using your computer — of your on-air activity is optional, but there are some important reasons for doing so. These include:

Awards tracking — A log lets you track contacts required for DXCC, WAS and other awards. Some computer logging programs do this automatically, so you can see how well you are progressing toward your goal.

An operating diary — A log book is a good place to record general information about your station. For example, you may want to note comparisons between different antennas or pieces of equipment based on reports from other stations. Your log is also a logical place to record new acquisitions (complete with serial numbers in case your gear is ever stolen). You can track other events as well, including the names and call signs of visiting operators, license upgrades, contests, propagation and so forth.

Legal protection — Good record keeping can help you protect yourself if you are ever accused of intentional interference or ever have a problem with unauthorized use of your call sign.

Paper or Computer?

Many hams, even some with computers, keep "hard copy" log books. A paper log is low tech; it doesn't consume power, it's flexible and can never suffer a hard-drive crash! Preprinted log sheets are available, or you can create your own customized log sheets in no time using word processing or publishing software.

On the other hand, computer logging offers many advantages, especially for contesters, DXers and those chasing awards. For example, a computerized log can instantly indicate whether you need a particular station for DXCC or WAS. Contesters use computer logs to manage contact data during a contest and to weed out duplicate contacts in advance. Most major contest sponsors prefer to receive computer log files, and some do not accept paper logs at all. Computer logs can also tell you at a glance how far along you are toward certain awards and even print QSL labels. And of course computer logs make it easy to submit your contacts to ARRL's online Logbook of The World.

Several of the most popular computer logging programs (and regular updates) are available at no cost, while others are available for a small fee. You also can purchase logging software from commercial vendors. Some are general-purpose programs, while others are optimized for contesting, DXing or other activities. Check the ads in *QST* and compare capabilities and requirements before you choose.

1.4 Getting on the Air

Amateur Radio is a *social* activity as well as a technical pursuit. It's a way to make new friends and acquaintances on the air that you may later meet in person. Some ham radio relationships last a lifetime, even though the individuals sometimes never meet face to face. Ham radio can be the glue that keeps high school and college friends in touch through the years.

Amateur Radio also can cement relationships between radio amateurs of different nationalities and cultures, leading to greater international goodwill and understanding — something that's especially beneficial in this era of heightened cultural tensions and misperceptions. When you become an Amateur Radio operator, you become a "world citizen." In return you can learn about the lives of the radio amateurs you contact in other countries.

"*What do hams say to each other?*" you might wonder. When they meet for the first time on the air, hams exchange the same sorts of pleasantries that anyone might when meeting face to face. Ham radio operators exchange name and location (abbreviated "QTH" by hams) and — specific to hamming — radio signal reports indicating how well they're hearing (or "copying") each other over the air. This name/location/signal report pattern is typical, regardless of radio mode. With these preliminaries out of the way, ham radio conversations often focus on equipment or may extend to other interests.

Although English is arguably the most common language on the ham bands (even spoken by hams whose first language may be something other than English), English speakers can make a favorable impression on hams in foreign countries if they can speak a little of the other person's language — even if it's as simple as *danke*, *gracias* or *arigato*.

Fig 1.14 — After watching her dad operate the radio for months, this Michigan youngster made some radio contacts of her own during the January 2014 Kids Day event. [Photo courtesy of Michael A. Rudzki, N8MR]

1.4.1 Voice Modes

We've mentioned the use of voice (or "phone," short for "radiotelephone") and Morse code (or CW) on the amateur bands. Although more hams are embracing digital modes every day, phone and CW by far remain the most popular Amateur Radio communication modes. Ham voice modes are amplitude modulation (AM), which includes the narrower-bandwidth single sideband (SSB), and frequency modulation (FM). For the most part, SSB is heard on HF, while FM is the typical voice mode employed on VHF, UHF and microwave bands.

The great majority of ham radio HF phone operators use SSB (subdivided further into upper sideband and lower sideband), but a few still enjoy and experiment with the heritage "full-carrier AM." Once the primary ham radio voice mode, this type of AM still is heard on the standard broadcast band (530 to 1710 kHz). Today's AM buffs appreciate its warm, rich audio quality, and the simplicity of circuit design encourages restoring or modifying vintage radios or building from scratch. For more information about AM operation, visit **www.arrl.org/am-phone-operating-and-activities**.

1.4.2 Morse Code

Morse code was the very first radio transmission mode, although it wasn't long before early experimenters figured out how to transmit the human voice and even music over the airwaves. Morse is also the original digital mode; the message is transmitted by turning a radio signal on and off (a "1" and a "0" in digital terms) in a prescribed pattern to represent individual letters, numerals and characters. This pattern is the International Morse Code, sometimes called the "radio code," which varies in many respects from the original Morse-Vail Code (or "American Morse") used by 19th century railroad telegraphers. Leaning on longstanding tradition, hams often refer to Morse transmissions as "CW," after an archaic definition for "continuous wave" which described the type of radio wave involved.

Federal regulations once required that prospective radio amateurs be proficient in sending and receiving Morse code in order to operate on "worldwide" (ie, shortwave or HF) ham bands. Although this is no longer the case for any class of Amateur Radio license in the US, many hams still embrace CW as a favorite mode and use it routinely. Hams typically send Morse code signals by manipulating a manual telegraph key, a "semi-automatic" key (called a "bug") or a CW "paddle" and an electronic keyer that forms the dots and dashes. Most hams decipher Morse code "by ear," either writing down the letters, numerals and characters as they come through the receiver's headphones or speaker or simply reading it in their heads. Some use one of the available computer-based or stand-alone accessories that can translate CW into plain text without the need to learn the code.

Hams who enjoy CW cite its narrow bandwidth — a CW signal takes up very little of the radio spectrum — simpler equipment and the ability of a CW signal to "get through" noise and interference with minimal transmitting power. CW is a common low-power (QRP) mode.

1.4.3 FM Repeaters

Hams often make their first contacts on local voice repeaters, although in recent years the nearly ubiquitous cell phone has reduced the popularity of — and even the need for — repeaters for everyday ham communication. Repeaters can greatly extend the useful range of a typical handheld FM transceiver much in the same way a cell tower retransmits your voice or text messages, and they carry the vast majority of VHF/UHF traffic, making local and even regional mobile communication possible for many hams. Located on

Fig 1.15 — Jerry Clement, VE6AB, tests a homemade solar power system of his own design, while operation from the badlands of eastern Alberta, Canada.

hilltops, tall buildings or other high structures, repeaters strengthen signals and retransmit them. This provides communication over much farther distances than would be possible when operating point to point or "direct." The wider coverage can be especially important if the repeater is ever pressed into service during an emergency.

Typically, hams use repeaters for brief contacts, although socializing and "ragchewing" are routine on some "machines," as repeaters are often called. All repeater users give priority to emergency communications. Most repeaters are maintained by clubs or groups of hams. If you use a particular repeater frequently, you should join and support the repeater organization. Some hams set up their own repeaters as a service to the community.

The best way to learn the customs of a particular repeater is to listen for a while before transmitting. Most repeaters are *open*, meaning that any amateur may use the repeater, although repeaters typically require users to transmit an access tone (which you can select on any modern FM transceiver). A few repeaters are *closed*, meaning that usage is restricted to members of the club or group that own and operate the repeater. Some repeaters have *autopatch* capability that allows amateurs to make telephone calls through the repeater. The *ARRL Repeater Directory* shows repeater locations, frequencies, capabilities and whether the repeater is open or closed.

1.4.4 Digital Modes

Radioteletype (RTTY — often pronounced "Ritty") is a venerable data communication mode that remains in wide use today among radio amateurs. While RTTY does not support the features of newer computer-based data modes, it is well suited for keyboard-to-keyboard chats with other stations. It also is the most popular mode for worldwide digital contests and remains in common use among DXers and DXpeditions. RTTY was originally designed for use with mechanical teleprinters, predating personal computers by several decades. Today, Amateur Radio RTTY uses soundcard-equipped computers and dedicated RTTY software.

An HF digital mode for general domestic and DX contacts is PSK31, a keyboard-to-keyboard mode that's especially effective for very low power (QRP) communication. It's easy to transmit and receive PSK31 using a PC and software — typically free — that operates via a PC soundcard. Most digital modes use the same basic PC/soundcard setup and new modes are developed on a regular basis.

One of the more recent software-based, soundcard modes is JT65 by Nobel laureate and radio amateur Joe Taylor, K1JT, who developed the software for this mode as part of *WSJT* (*Weak Signal communications by K1JT*). See **physics.princeton.edu/pulsar/k1jt/**. JT65 uses 64 audio tones to transmit information. Contacts in this mode, which often take place on the HF bands, are a bit different than typical two-way conversations. Stations take turns during synchronized 60-second transmissions cycles that alternate between odd and even minutes on the clock, until concluding the contact.

JT65 rivals Twitter in its brevity. Stations can transmit only about 13 characters each time, but the data are repeated each cycle to maximize information transfer. Successful JT65 contacts can take place under adverse radio conditions and using extremely low signal levels; a transmitter output power of 20 W is considered high power in the JT65 world.

Another digital mode, packet radio, is much less popular in today's ham radio world than it was in the 1990s. Packet's most important applications today include networking and *unattended* operation. The most common uses are the worldwide DX station spotting network, the Automatic Packet/Position Reporting System (APRS) and regional or local general-purpose networks.

APRS

Developed by Bob Bruninga, WB4APR, APRS or the Automatic Packet/Position Reporting System (**www.aprs.org**) is used for tracking stations or objects in motion or in fixed positions and for exchanging data. It uses the *unconnected* packet radio mode to graphically indicate objects on maps displayed on a computer monitor. Using unconnected packets permits all stations to receive each transmitted APRS packet on a one-to-all basis rather than the one-to-one basis required by connected packets.

As with other packet transmissions, APRS data are relayed through stations called *digipeaters* (digital repeaters). Unlike standard packet radio, APRS stations use generic digipeater paths, so the operator needs no prior knowledge of the network. In addition, the Internet is an integral part of the system that is used for collecting and disseminating current APRS data in real time.

Virtually all VHF APRS activity occurs on 2 meters, specifically on 144.39 MHz, the recognized APRS operating channel in the US and Canada. On UHF, you'll find APRS activity on 445.925 MHz.

Many groups and individuals that participate in public service and disaster communications find APRS a useful tool. Others use it to view real-time weather reports. APRS also is useful to track roving (i.e., mobile) operators in certain ham radio operating events and supports the exchange of short messages.

1.4.5 Image Communication

Users of current technology often enjoy sharing photos or even talking face-to-face. While not as sophisticated, several ham radio communication modes allow the exchange of still or moving images over the air. Advances in technology have brought the price of image transmission equipment within reach of the average ham's budget. This has caused a surge of interest in image communication.

Amateur TV (ATV) is full-motion video over the air, sometimes called "fast-scan TV." Amateur Radio communication takes on an exciting, new dimension when you can actually *see* the person you're communicating with. In addition, ATV has proved to be very useful in emergency and disaster communication situations. Amateur groups in some areas have set up ATV repeaters, allowing lower-power stations to communicate over a fairly wide area. Since this is a wide-bandwidth mode, operation is limited to the UHF bands (70 cm and higher).

Digital ATV folds nicely into a newer Amateur Radio technological initiative called high-speed multimedia (HSMM) radio. The ham bands above 50 MHz can support computer-to-computer communication at speeds high enough to support multimedia applications — voice, data and image. One approach adapts IEEE 802 technologies, particularly

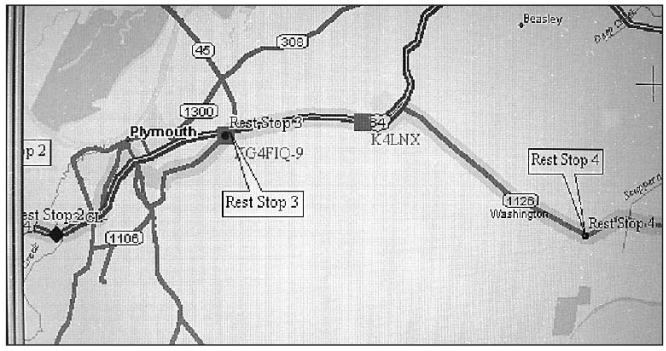

Fig 1.16 — APRS is a popular ham radio digital mode that allows tracking of mobile stations transmitting beacons via packet radio as they travel.

Fig 1.17 — Japanese Astronaut Koichi Wakata, KC5ZTA, served as the host for a successful final commissioning pass in April 2014 for the Amateur Radio on the International Space Station "Ham Video" system.

802.11b, operating on specific Amateur Radio frequencies in the 2400-2450 MHz band.

SSTV or "slow-scan TV" is an older, narrow-bandwidth image mode that remains popular in Amateur Radio. Instead of full-motion video, SSTV enthusiasts exchange photographs and other static images. Individual SSTV pictures take anywhere from 8 seconds to about 2 minutes to send, depending on the transmission method. These days most SSTV operation is done in color, using computers and soundcards in conjunction with software that's often free. Images are converted into a series of audio tones representing brightness level and colors. Since SSTV is a narrow-band mode, it is popular on HF on the same frequencies used for voice operation.

1.5 Your Ham Radio "Lifestyle"

After some on-the-air experience, many Amateur Radio enthusiasts focus on a particular mode or operating style and may identify themselves primarily as contesters, DXers, CW operators or VHF-UHFers. Others center their operating on such activities as specialized or experimental modes, mobile ham radio, very low-power operating (known as "QRP") and radio direction finding (RDF).

1.5.1 Ham Radio Contesting — Radiosport

Ham radio contesting, often called "radiosport," continues to grow in worldwide popularity. Hardly a weekend goes by when there isn't a ham radio contest of some sort. These on-the-air competitions range from regional operating events with a few hundred participants to national and worldwide competitions with thousands of stations on the air at the same time, attempting to communicate with one another for points.

Objectives vary from one event to another, but ham radio contests typically involve trying to contact — or "work" — as many *other* contest participants on the air within a specified period. In each contact, participants exchange certain information, often a signal report and a location, as the contest's rules dictate. A lot of contest scoring schemes place a premium on two-way contacts with stations in certain countries, states or zones. Top scorers in the various entry categories usually get certificates, but a few events offer sponsored plaques and trophies. Competition can be fierce among individual contesters and among contest clubs.

There are contests for nearly every mode and operating preference available to Amateur Radio — voice, Morse code and digital modes. Some members of the contesting community are earnest competitors who constantly tweak their stations and skills to better their scores. Others take a more casual approach. All have lots of fun.

In the ARRL International DX Contest, for example, participants try to contact as many DX (foreign) stations as possible over the course of a weekend. Experienced hams with top-notch stations easily contact 1000 or more stations in more than 100 different countries in a single weekend, but even operators with more modest stations can make lots of contacts.

Other popular contests include state QSO parties, where the goal is to contact stations in as many of the sponsoring state's counties.

Fig 1.18 — Retired Oakland Athletics and Boston Red Sox baseball All Star Joe Rudi, NK7U, enjoys contesting and DXing from his well-equipped station in Oregon.

ARRL November Sweepstakes (SS) is a high-energy US-and-Canadian contest that attracts thousands of operators each fall. One weekend is dedicated to CW, another to voice. VHF, UHF and microwave contests focus on making contacts using our highest-frequency bands. Digital-mode contests have gained in popularity in recent years, thanks to computer soundcards, radios that offer digital-mode capabilities, and often-free software.

You can find information on contests each month in ARRL's monthly membership journal *QST;* the contest calendar on the ARRL website also provides up-to-date information on upcoming operating events. The ARRL's bimonthly publication *National Contest Journal* (*NCJ*) focuses on topics of particular interest to contesting novices and veterans alike. For timely contest news and information, check "The ARRL Contest Update" e-newsletter at **www.arrl.org/contest-update-issues**, available every other week via e-mail and on the ARRL website.

ARRL FIELD DAY

An emergency communication training exercise with some elements of a contest, ARRL Field Day (FD) prompts thousands of participants outdoors the field on the fourth full weekend of June. Portable gear in tow, hams take to the hills, forests, campsites, parking lots and even emergency operations centers or vans to take part. Tracing its origins to the 1930s, Field Day started out as a way to publicly demonstrate ham radio's ability to operate "in the field" and "off the grid." The goal is not only to make lots of contacts but to operate successfully under

the sorts of conditions that could prevail in the aftermath of a disaster or emergency.

Most stations are set up outdoors and use emergency power sources, such as generators, solar panels, wind turbines and occasionally even water wheels. Creativity reigns when it comes to power sources! Over the years, Field Day's contest-like nature has led to plenty of good-natured competition among clubs and groups. Field Day stations range from simple to elaborate. If a real disaster were to strike, stations such as these could be set up quickly wherever needed, without having to rely on commercial power.

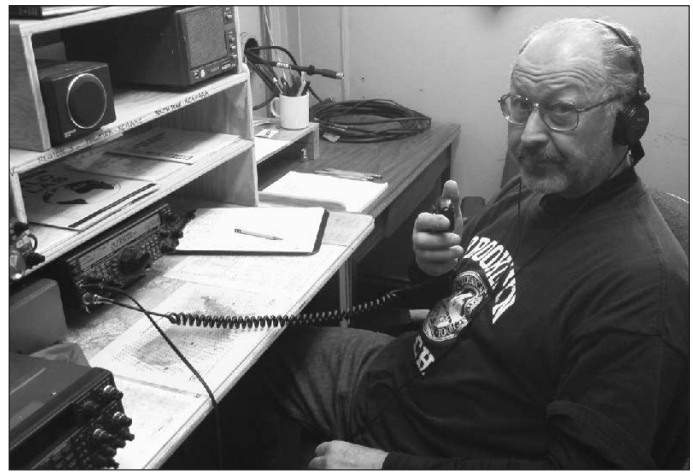

Fig 1.20 — Oceanographer Ron Flick, K6REF, took some time to get on the air from McMurdo Station, Antarctica, as KC4USV while on a research trip. [Courtesy of Ron Flick, K6REF]

1.5.2 Chasing DX

People unfamiliar with ham radio often ask, "How far can you talk?" Well, "talking far" is what chasing "DX" is all about. DX stations are those in distant places around the world. Chasing DX is a time-honored ham radio tradition. Hams who focus on contacting stations in far-flung and rare locations are called "DXers." Ham radio pioneers a century ago often competed in terms of how far *they* could talk; spanning the Atlantic via ham radio in the early 1920s was a stupendous accomplishment in its day. DXers often have as a goal attaining DX Century Club (DXCC) membership, earning a place on the vaunted DXCC "Honor Roll" or entering the annual ARRL DX Challenge.

Working DX does not necessarily require an expensive radio and huge antenna system. It's possible to work a lot of DX all over the world with very low power and/or with modest antennas, including wires hung from trees or mobile (ie, vehicle-mounted) antennas.

Some hams specialize in certain ham bands to work DX, such as 160 meters, where DXing can be challenging due to the low operating frequency involved as well as frequent noise and infrequent DX propagation. Others prefer "the high bands," such as 20, 15 and 10 meters, where DX typically is more common and, in fact, typically abounds in times of favorable propagation.

DXPEDITIONS

DXers who have run out of new countries to work sometimes couple a love of ham radio and travel to *become* the DX! "DXpeditions" are journeys by hams to "rare" countries having few or no hams, where they set up a station (or stations), often making thousands of contacts in the space of a few days. They not only have a great time but can promote international goodwill.

Some DXpeditions are huge productions. Early in 2011, an international team activated Antarctica's South Orkney Islands, which have no indigenous population. South Orkney Islands count as a separate country (or "entity") for the DXCC award. In the space of about two weeks, the team completed nearly 64,000 two-way contacts with other hams around the world from their remote encampment. Members of the worldwide Amateur Radio community dig deep into their pockets to fund DXpeditions such as this one, which cost upward of $350,000. The 2012 HKØNA Malpelo Island DXpedition off the coast of Colombia logged more than 195,000 contacts on 160 through 6 meters, breaking the record for a "non-hotel, non-fly-in" DXpedition!

Most DXpeditions are smaller affairs in which one or two operators may combine a vacation with some on-air fun. Activity often

Fig 1.19 — ARRL Field Day is the largest Amateur Radio event on the planet, with tens of thousands of hams participating in the 24-hour event each June. These members of the Cheshire County DX Club of Keene, New Hampshire, are enjoying the fun and camaraderie that this popular operating event evokes. [Heather Goodell, photo]

Fig 1.21 — Saraj Cory, KU6F, takes part in "The Day of YLs" contest. She made more than 325 contacts in 44 states and several countries. "YL" (for "young lady") is an old ham radio slang term for a female Amateur Radio operator. Its counterpart is "OM," which stands for "old man."

QSL Cards

Long before the Internet and e-mail, hams began the custom of exchanging postcards that became known as QSL cards or simply QSLs. "QSL" is another radiotelegraph, or Morse code, abbreviation that means "I confirm receipt of your transmission." A QSL card contains information to verify that a two-way contact took place. Exchanging QSL cards can enhance your ham radio enjoyment and even lead to a regular correspondence.

Hams still take great pride in having distinctive QSL cards to exchange following a contact, although today, thanks to the Internet, electronic means exist, such as ARRL's Logbook of The World (see sidebar, "Logbook of The World") to confirm contacts.

DX stations, especially those in very rare places, are often inundated with QSL cards and requests from US hams. To ease the cost and administrative burden, most DX QSLs travel via QSL bureaus, which ship cards in bulk, then sort and distribute them on the receiving end. The Outgoing QSL Service is available to ARRL members at nominal cost. The incoming QSL bureaus are available to all amateurs. Bureau instructions and addresses are on the ARRL website.

Logbook of The World

Instead of exchanging and collecting QSL cards, more and more radio amateurs are taking advantage of the ARRL's Logbook of The World to confirm contacts for award credit. LoTW is a world repository of individual radio contact records submitted by users. When both participants in a radio contact submit matching QSO records to LoTW, the result is a virtual QSL that each ham can apply toward ARRL award credit. Uploading contact data costs nothing; users only pay to "redeem" their QSO credits for an award, such as ARRL's DXCC, VUCC, WAS and the WPX Award sponsored by CQ Communications.

Once signed up as a Logbook user, you can submit new contact records whenever you wish. Your submissions are matched against those of other Logbook users. Whenever a match occurs, you receive instant credit for the contact.

To minimize the chance of fraudulent submissions, all LoTW QSO records are digitally "signed" by the licensee, who must hold an LoTW certificate. LoTW began operation in 2003 and in 2014 had more than 65,000 users and more than half a billion QSO records in the system. Visit the Logbook of The World website, **www.arrl.org/logbook-of-the-world**, to learn more.

peaks in conjunction with major DX contests. If you don't want to drag your radio and antennas along, fully equipped DX stations sometimes are available to rent in more-frequented locations, such as Hawaii and the Caribbean islands.

DX SPOTS AND NETS

The beginning DXer can get a good jump on DXCC by frequenting the DX spotting sites on the Internet. A DX spotting website is essentially an Internet clearing house of reports — or "spots" — posted by other DXers of stations actually heard or worked. The DX Summit website, **www.dxsummit.fi**, hosted in Finland is a popular one. Users around the world post spots in real time. Each lists the call sign and frequency of the DX station as well as the call sign of the station that posted the spot. Knowing where the DX station is being heard can tell you if you're likely to hear the DX station at *your* location.

DX nets offer another DX gateway. On DX nets, a net control station tracks which DX stations have checked into the net, then allows individual operators on frequency to try working one of the DX stations. This permits weaker stations to be heard instead of their signals being covered up by stations calling in a "pileup."

1.5.3 Operating Awards

Earning awards that reflect Amateur Radio operating accomplishments is a time-honored tradition. Literally hundreds of operating awards are available to suit your level of activity and sense of accomplishment.

WORKED ALL CONTINENTS

The Worked All Continents (WAC) certificate is a good starting point for newcomers. Sponsored by the International Amateur Radio Union (IARU), earning WAC requires working and confirming contacts with one station on each of six continents (excluding Antarctica).

WORKED ALL STATES

Hams who can confirm two-way ham radio contacts with stations in each of the 50 United States can apply for the popular ARRL's Worked All States (WAS) award. Those who enjoy operating different bands and a seek a greater challenge may attempt the ARRL's 5-Band WAS (5BWAS) award by confirming contacts with all 50 US states on each of the 80, 40, 20, 15 and 10 meter bands.

Fig 1.22 — The ARRL Worked All States (WAS) certificate is awarded for confirming contacts with hams in all 50 states. Confirmations may be made by traditional paper QSL cards, or electronically through ARRL's Logbook of The World online database.

A twist on the WAS award is the ARRL's Triple Play Award. Introduced in 2009, it was an instant hit. To earn the Triple Play Award, an amateur must contact other amateurs in each of the 50 US states using voice, Morse code and a digital mode, such as RTTY or PSK31. All qualifying contacts must be confirmed via the ARRL's Logbook of the World (LoTW — see sidebar, "Logbook of The World). The Triple Play Award is available to hams worldwide.

DX CENTURY CLUB

The most prestigious and popular DX award is the DX Century Club (DXCC), sponsored by the ARRL. Earning DXCC is quite a challenge. You must confirm two-way contact with stations in 100 countries (or "entities," as they're known in the DXCC program). Hams with very simple stations have earned DXCC. Operating in various DX contests when stations all over the world are looking for contact is a good way to combine DXing and contesting and to get a leg up on earning DXCC . There's also a 5-Band DXCC (5BDXCC) for earning DXCC on each of five bands, 80, 40, 20, 15 and 10 meters.

Top-rung DX enthusiasts have been challenging themselves and each other through the ARRL DXCC Challenge. This ongoing activity involves confirming contacts with DXCC entities on all bands from 160 through 6 meters.

VHF/UHF CENTURY CLUB

Hams who operate on the VHF and UHF bands have a "century club" of their own, the VHF/UHF Century Club. Instead of working 100 DXCC entities, participants earn awards for making two-way contacts with a specified number of Maidenhead 2° × 1° grid locators or "grid squares," as they're more commonly known. Grid squares are designated by a combination of two letters and two numbers and represent a specific area on the globe. For operations on 6 meters, 2 meters and satellite, operators must contact 100 individual grid squares. More information is on the ARRL website, **www.arrl.org/awards/vucc**.

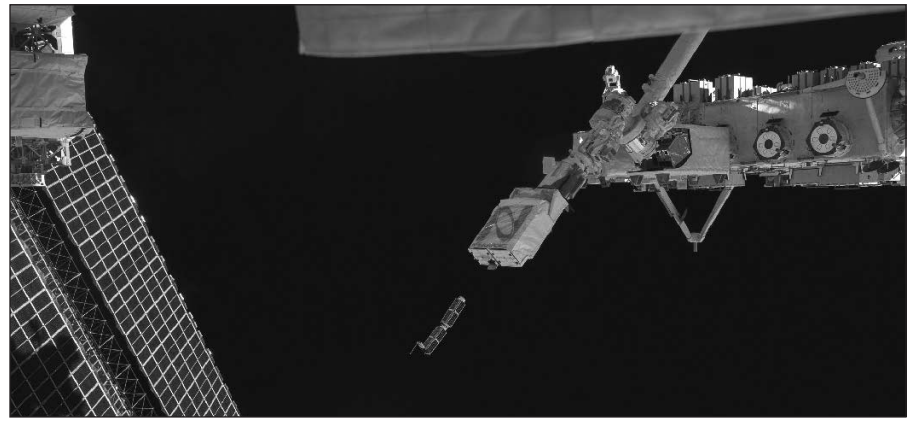

Fig 1.24 — Tiny Amateur Radio "CubeSats" are deployed into orbit from a robotically controlled launcher on the International Space Station, after traveling into space on a cargo rocket. The advent of CubeSats and the availability of launches from the ISS have made it easier and cheaper to put all sorts of satellites into orbit. [NASA photo]

1.5.4 Satellite Communication

Amateur Radio established its initial foothold in space in 1961, with the launch of the OSCAR 1 satellite (OSCAR is an acronym for Orbiting Satellite Carrying Amateur Radio). Since then, amateurs have launched dozens of satellites, most of the low-earth orbit (LEO) variety and a small number in the high-earth orbit category. The history of Amateur Radio satellites and information on which ones are in operation is available on the AMSAT website, **www.amsat.org**.

Amateurs have pioneered several developments in the satellite industry, including low-earth orbit communication "birds" and PACSATs — orbiting packet-radio bulletin board systems — and CubeSats which are standard-sized miniature satellites constructed by student teams around the world. Operating awards, are available from ARRL and other organizations specifically for satellite operation.

Satellite operation is neither complex nor difficult; it's possible to work through some satellites with nothing more than a dual-band (VHF/UHF) handheld radio and perhaps a small portable antenna. More serious satellite work requires some specialized equipment. You may be able to work several Amateur Radio satellites (OSCARs) with the equipment that's now in your shack!

AMATEUR RADIO IN SPACE

In 1983, ham-astronaut Owen Garriott, W5LFL, operated the first ham radio station in space, communicating with earthbound hams from the space shuttle *Columbia*. NASA subsequently made Amateur Radio a part of many shuttle missions and later a permanent presence aboard the International Space Station. The Russian *Mir* space station also was equipped with ham radio, and since those early days, dozens of astronauts and cosmonauts from several countries have communicated from their orbital perches with hams on earth. NASA has promoted ham activity aboard spacecraft because of its proven educational and public relations value — and because ham radio could be used for backup communication in a pinch.

The Amateur Radio on the International Space Station (ARISS) program, **www.arrl.org/amateur-radio-on-the-international-space-station** and **www.ariss.rac.ca**, is the international organization for ham radio in space. ARISS is a consortium of the ARRL, AMSAT and NASA. The all-volunteer program seeks to inspire students worldwide to pursue careers in science, technology, engineering and math by making available opportunities to speak with on-orbit ISS crew members via ham radio. The ARISS International Working Group includes representatives of nine countries, including the US, several European nations and Japan, Russia and Canada. ARISS-provided ham gear on two ISS modules makes possible analog voice and digital communication between earthbound hams and the ISS crew as well as with the onboard ISS digipeater packet radio mailbox and APRS digipeater.

Most ISS crew members are Amateur Radio licensees. During scheduled contacts with demonstration stations set up in schools around the world, students are able to ask the astronauts questions about their time in space and life aboard the space station. These voice contacts typically take place using VHF FM (2 meter) equipment. Some Amateur Radio satellites have been launched from the ISS.

Fig 1.23 — Island County Amateur Radio Club members Jon Edwards, AE7TE (right), and Wayne Jeffers, WJ7H, use hand-held antennas and radios to successfully contact NA1SS on the International Space Station from the club's ARRL Field Day site on Washington's Whidbey Island. Hams can use the same sort of basic equipment to operate through Amateur Radio satellites. [Vince Bond, K7NA,

1.5.5 QRP: Low-Power Operating

A very active segment of the Amateur Radio community enjoys operating with minimal transmitting power. They call themselves "QRP operators" or "QRPers" after the Morse code abbreviation for "I shall decrease transmitter power." According to the FCC rules regulating Amateur Radio, "An amateur station must use the minimum transmitter power necessary to carry out the desired communications." The FCC allows most hams to transmit or "run" up to 1500 W (watts), and many hams run 100 W. QRPers, however, typically use 5 W or less — sometimes *far* less (one ham achieved WAS while running 2 milliwatts — that's two-thousandths of a watt!).

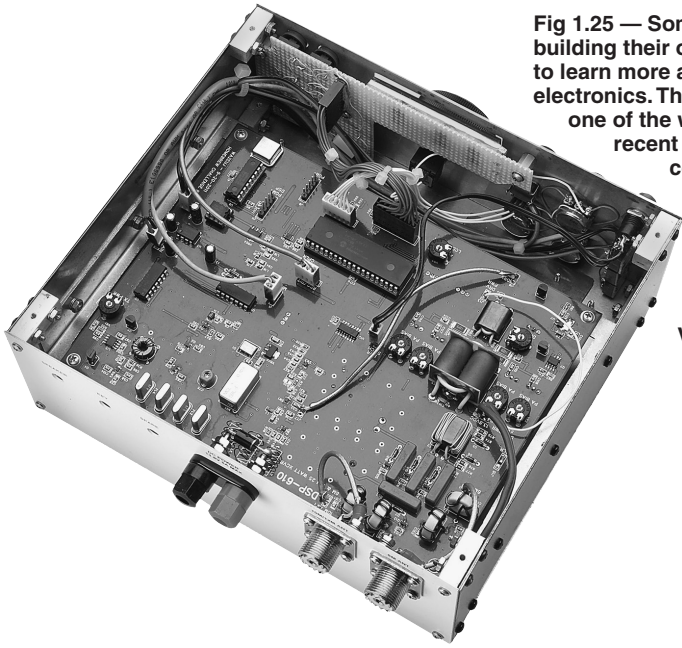

Fig 1.25 — Some hams enjoy building their own equipment to learn more about radio and electronics. This photo shows one of the winning entries in a recent ARRL "homebrew" competition — a complete transceiver for the 6, 10 and 12 meter amateur bands designed and built by Jim Veatch, WA2EUJ.

Operating QRP can be challenging. Other stations may not hear your signal as easily, so patience becomes a real virtue, both for the low-power enthusiast and the station on the other end of the contact. What their stations lack in transmitting power QRPers make up for with effective antennas and skillful operating, and they make contacts around the world. This operating style has become so popular that many contests now include an entry category for stations running 5 W or less output power.

One of the best reasons to operate QRP is that low-power equipment typically is lightweight and less expensive. Many QRP operators enjoy designing and building their own "flea-power" transceivers, and various organizations support low-power operating by offering kits, circuits and advice. A few commercial manufacturers also market QRP equipment and kits. The QRP Amateur Radio Club International (**www.qrparci.org**) is perhaps the oldest organization to advance and promote QRP as a ham radio way of life. In addition to sponsoring various operating events throughout the year, QRP ARCI publishes *QRP Quarterly*, which includes articles of interest to both QRP operators and the broader ham radio community.

1.5.6 Operating Mobile

Many hams enjoy operating on the fly — usually from a car or truck but sometimes from a boat, a motorcycle, a bicycle and even while on foot (sometimes called "pedestrian mobile" or "manpack radio")! Operating radio gear installed in a motor vehicle is the most common form of "mobile," and manufacturers today offer a wide range of ham radio gear, including antennas, designed for such work. A mobile station can be as simple as a basic VHF or dual-band VHF/UHF radio and a little antenna attached magnetically to the roof, or as complex as an HF station and a more substantial antenna system. Some mobile stations are very sophisticated, with capabilities that rival those of many fixed stations.

While most hams who operate mobile use FM or SSB, a significant number operate CW while on the road. It takes a bit of practice, in part because the operator must learn to understand (or "copy") Morse code without having to write it down.

Hams on bicycle treks or hikes carry along lightweight radio gear. A lot of cyclists or hikers pack a small ham radio transceiver and wire antenna along with their sleeping bag, food and water.

1.5.7 VHF, UHF and Microwave Operating

Hams use many modes and techniques to extend the range of their line-of-sight VHF, UHF and microwave signals. Those who explore the potential of VHF/UHF communication often are called "weak-signal" operators to differentiate them from FM operators who communicate locally — although the signals involved often are not really *weak*.

These enthusiasts and experimenters probe the limits of propagation in the upper reaches of the Amateur Radio spectrum, often with the goal of discovering just how far they can communicate. They use directional antennas (beams or parabolic dishes) and very sensitive receivers. In some instances, they also employ considerable transmitter output power. As a result of their efforts, distance records are broken almost yearly. On 2 meters, for example, conversations between stations hundreds and even thousands of miles apart are not uncommon even though the stations are far beyond "line of sight" separation. Maximum distances decrease as frequencies increase, but communication regularly can span several hundred miles, even at microwave frequencies.

Weak-signal operators for many years depended on SSB and CW, but computer/sound card-based digital modes are now part of their arsenal. These modes use state-of-the-art digital signal processing (DSP) software for transmitting and receiving very weak signals that can be well below levels that the human ear can detect.

MOONBOUNCE (EME)

EME (Earth-Moon-Earth) communication, commonly called "moonbounce," fascinates many amateurs. The concept is simple: Use the Moon as a passive reflector of VHF and UHF signals. Considering the total path of some 500,000 miles, EME is the

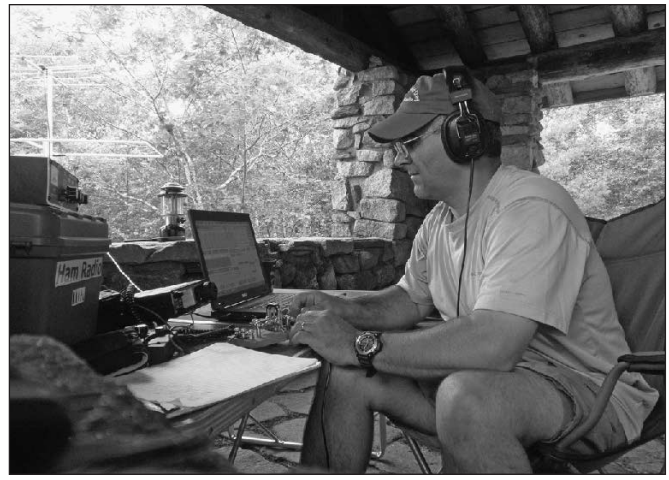

Fig 1.26 — Combining his love of the outdoors and Amateur Radio, Pete Harrison, AA1PL, spent one ARRL Field Day operating at low power from the Ledges Shelter on the Escoheag Trail in Rhode Island's Acadia Wildlife Management Area. [Pete Harrison, AA1PL, photo]

ultimate DX — at least to date. The first two-way amateur EME contacts took place in 1952.

In its earliest days EME was a CW mode activity requiring large antennas and high power. Advances in technology, such as low-noise receivers and digital signal processing (DSP) tools, have made EME contacts possible for more and more amateurs with modest stations.

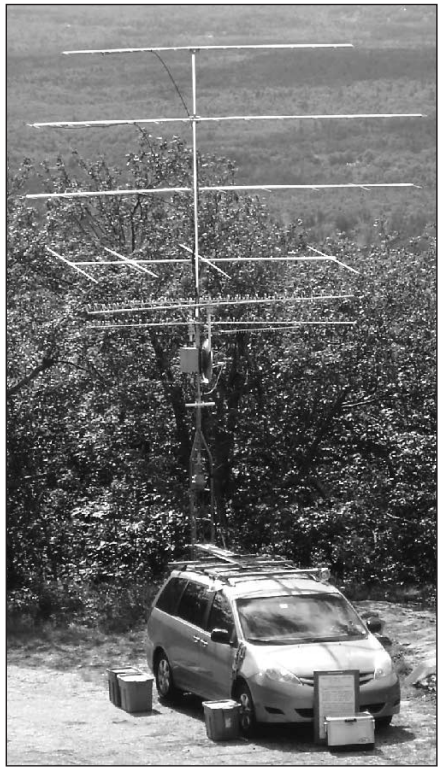

Fig 1.27 — His vehicle supporting a variety of antennas, Ed Parsons, K1TR, set up on Wachusett Mountain near Princeton, Massachusetts, to take advantage of the elevation — and the terrific views — while operating during the 2013 ARRL June VHF Contest. He won the Single-Operator, Low Power category! [Ed Parsons, K1TR, photo]

METEOR SCATTER

Years ago hams discovered they could bounce signals off the ionized trails of vaporized matter that follow meteors entering Earth's atmosphere. Such trails often can reflect VHF radio signals for several seconds, during which stations can exchange extremely brief reports. During meteor showers, the ionized region becomes large enough — and lasts long enough — to sustain short contacts. It's exciting to hear a signal from hundreds of miles away pop out of the noise for a brief period!

Amateurs experimenting with meteor-scatter propagation use transmitter powers of 100 W or more and beam antennas. Most contacts are made using SSB, CW or digital modes. Although most SSB and CW QSOs are made during annual meteor showers, digital mode contacts are possible any day of the year.

Nobel laureate astrophysicist and radio amateur Joe Taylor, K1JT, has developed open-source *Windows* and *Linux* software (under the *WSJT* umbrella) for weak-signal digital communication via meteor scatter, moonbounce and similar techniques on VHF and UHF, as well as for HF skywave propagation. Taylor says on his *WSJT* home page (**physics.princeton.edu/pulsar/K1JT**) that his program "can decode fraction-of-a-second signals reflected from ionized meteor trails and steady signals 10 dB below the audible threshold."

1.5.8 Vintage Radio

Many, if not most, veteran radio amateurs have a nostalgic streak, and this extends toward vintage radio gear. Present-day commercial Amateur Radio equipment has reached a level of complexity that often requires specialized test and troubleshooting equipment to repair or align. Modern component manufacturing technology such as surface-mount devices (SMDs) has become so commonplace that a modular approach to equipment repair is commonplace; rather than troubleshoot and replace a defective component, many manufacturers now prefer to swap out an entire module.

Yet many amateurs still would rather repair and adjust their own equipment and covet the days when this was simpler and easier. This is but one reason behind the surge in vintage radio collecting and operating. Others enjoy vintage gear for its lower cost and wider availability, the novelty of operating older gear on today's ham bands, and for its rarity and antique value. Many of these radios are affectionately called "boat anchors" by vintage radio aficionados, since early radio gear tends to be relatively large and heavy.

Some enthusiasts enjoy the challenge of collecting and restoring older radios, sometimes striving to bring the equipment back to its original factory condition. Other vintage radio enthusiasts may have a parallel interest in conventional AM voice transmission. These activities take vintage radio fans back to an era when it was much more common for amateurs to build their own station equipment.

1.5.9 Radio Direction Finding (DF)

DFing is the art of locating a signal or noise source by tracking it with portable receivers and directional antennas. Direction finding is not only fun, it has a practical side. Hams who are proficient at DFing have been instrumental in hunting down signals from illegal jammers and malfunctioning transmitters in addition to locating noise (interference) sources. Because DFing only involves receiving, it does not require a ham ticket, however.

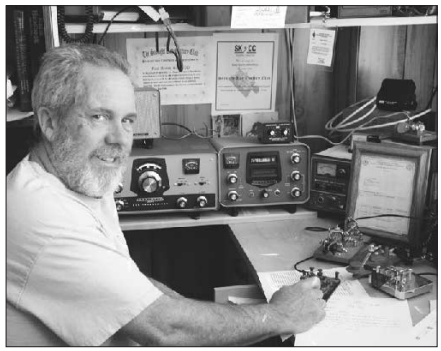

Fig 1.28 — Hams enjoy restoring and using old radio equipment. Rod Bunn, KA6ROD restored his Heathkit transceiver and station monitor to use during the annual ARRL Straight Key Night special operating event.

Fig 1.29 — Amateur Radio Direction Finding (ARDF) equipment need not be expensive. Yagis made from measuring tapes and PVC pipe are very popular for direction finding on 2 meters with a handheld transceiver. Here, Dan Slater, AG6HF (left), tests an antenna he built. [Joe Moell, KØOV, photo]

"Fox hunting" — also called "T-hunting," "radio-orienteering" or "bunny hunting" — is ham radio's answer to hide-and-seek. One player is designated the fox; he or she hides a transmitter, and the other players attempt to find it. Rules vary, but the fox must generally place the transmitter within certain boundaries and transmit at specific intervals.

Fox hunts differ around the world. American fox hunts often employ teams of fox hunters cruising in vehicles over a wide area. European and other fox hunters restrict their events to smaller areas and conduct fox hunts on foot. *Radiosport* competitions typically follow the European model and attract hundreds or more competitors.

DF techniques can come into play when tracking down sources of interference on the ham bands — intentional or inadvertent — or when there's a suspected "pirate" (unlicensed ham station) in the area.

1.6 Public Service

Providing communication in support of public service at no cost forms part of the Basis and Purpose of the Amateur Radio Service and has been a traditional responsibility of Amateur Radio from the start. Today, this most often involves ham radio's volunteer efforts during disasters and emergencies.

When Hurricane Sandy struck New York City and the Middle Atlantic States in the fall of 2012, the Amateur Radio community from Maine to the Carolinas responded to requests for assistance, activated local nets and supported the operations of the Hurricane Watch Net and the VoIP Hurricane Net. Hams volunteered around the clock to bridge the gap in the wake of downed utility lines to provide communication for evacuation efforts, as well as to link hospitals experiencing communications breakdowns, shelters, emergency operations centers and non-government relief agencies, such as The American Red Cross and The Salvation Army, which has its own Amateur Radio contingent, The Salvation Army Team Emergency Radio Network (SATERN). Radio amateurs also assisted after the storm by helping officials to assess damage. Many hams also are part of SKYWARN, which helps to identify and track severe weather activity via ham radio and coordinates its efforts with the National Weather Service.

Public service can take less dramatic forms: Hams also step forward to provide communication for walkathons, marathons, bike races, parades and other community events. The Boston and New York City marathons are two major events that welcome Amateur Radio assistance.

1.6.1 Public Service Communication

The ability to provide communication during disasters is a major justification for Amateur Radio's existence. Government officials on all levels and the general public have come to recognize that Amateur Radio works when other communications networks are unavailable. Despite the proliferation of cell phones and other personal communication devices, Amateur Radio continues to prove its value, since it can operate without an existing infrastructure. Ham radio doesn't need the mobile telephone network or the Internet.

Battery-powered equipment allows hams to provide essential communication even when power is knocked out. If need be, hams can make and install antennas on the spot from available materials. In the wake of hurricanes, forest fires, earthquakes and other natural disasters that cripple or compromise normal communications, hams may be called upon to handle thousands of messages in and out of the stricken region. The work that hams do during crisis situations cultivates good relations with neighbors and with local governments.

Amateur Radio operators have a long tradition of operating from back-up power sources. Through events such as Field Day, hams cultivate the ability to set up communication posts wherever they are needed. Moreover, Amateur Radio can provide computer networks (with over-the-air links as needed) and other services, such as video, that no other service can deploy on the fly, even on a wide scale.

1.6.2 Public Service Communication Organizations

Should a disaster or emergency arise, volunteer teams of amateurs from disaster response organizations cooperate with first responders such as police and fire personnel, and with the Red Cross and medical personnel to provide or supplement communication. Hams sometimes are called upon to fill the communication gap between agencies whose radio systems are incompatible with one another.

ARES AND RACES

Ham radio disaster response activities typically take place under the umbrella of the Amateur Radio Emergency Service (ARES®), sponsored by the ARRL, and the Radio Amateur Civil Emergency Service (RACES), administered by the Federal Emergency Management Agency (FEMA). RACES works with government agencies to maintain civil preparedness and provide communication in times of civil emergency. RACES is activated at the request of a local, state or

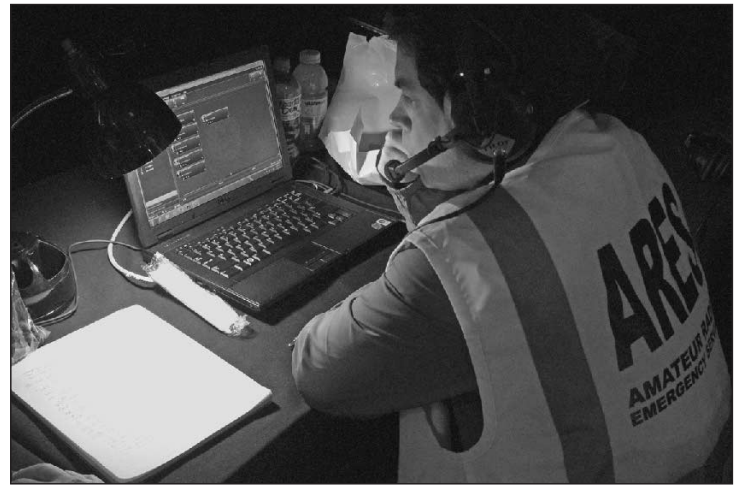

Fig 1.30 — At the 2014 Boston Marathon ARES volunteer Marek Kozubal, KB1NCG, deployed in an indoor command center to support communication for the annual event. [Courtesy of Paul Topolski, W1SEX]

federal official. To remain at the ready, hams affiliated with emergency communication teams assess their systems and themselves through regularly scheduled nets and simulated emergency tests (SETS).

ARES and RACES organizations frequently work hand-in-hand. Amateurs serious about disaster response communication typically are active in both groups or may carry dual ARES/RACES membership. FCC rules make it possible for ARES and RACES to use many of the same frequencies, so an ARES group also enrolled in RACES can work within either organization as circumstances dictate.

MILITARY AUXILIARY RADIO SYSTEM (MARS)

MARS is administered by the US armed forces. Its primary mission is to provide adjunct communication support to military and federal government homeland defense operations on a local, national and international basis. MARS volunteers joined Amateur Radio organizations to assist medical and humanitarian relief efforts in the wake of the devastating 2010 earthquake in Haiti. MARS has existed in one form or another since 1925.

There are three branches of MARS: Army MARS, Navy/Marine Corps MARS and Air Force MARS. Each branch has its own membership requirements, although all three branches require members to hold a valid US Amateur Radio license and to be at least 18 years old (in some cases, amateurs who are 17 years old may join with the signature of a parent or legal guardian).

MARS operation takes place on frequencies adjacent to the amateur bands and usually consists of nets scheduled to handle traffic or to handle administrative tasks. Various MARS branches also maintain repeaters or packet radio networks.

1.6.3 Public Service and Traffic Nets

The ARRL came into existence to coordinate and promote the formation of message-handling nets, so public service and traffic nets are part of a tradition that dates back almost to the dawn of Amateur Radio. In those early days, nets were needed to communicate over distances greater than a few miles. From their origination point, messages (also called "traffic") leapfrogged from amateur station to amateur station to their destination — thus the word "relay" in American Radio Relay League. It still works that way today, although individual stations typically have a much greater range.

Some nets and stations are typically only active in emergencies. These include Amateur Radio station WX4NHC at the National Hurricane Center, the Hurricane Watch Net, SKYWARN (weather observers), The Salvation Army Team Emergency Radio Network (SATERN), The Waterway Net and the VoIP (voice over Internet protocol) SKYWARN/Hurricane Net.

THE NATIONAL TRAFFIC SYSTEM (NTS)

The National Traffic System (NTS) exists to pass formal written messages from any point in the US to any other point. Messages, which follow a standard format called a "Radiogram," are relayed from one ham to another, using a variety of modes, including voice, Morse code, RTTY or packet. An NTS operator who lives near the recipient typically delivers the message by telephone.

During disasters or emergencies, radiograms communicate information critical to saving lives or property or to inquire about the health or welfare of disaster victims. At such times, the NTS works in concert with the Amateur Radio Emergency Service (ARES) and other emergency and disaster-relief organizations, such as the American Red Cross and The Salvation Army.

The NTS oversees many existing traffic nets, which meet daily. Most nets are local or regional. Handling routine message traffic such as birthday and holiday greetings keeps NTS participants prepared for emergencies.

Fig 1.31 — The Wilson High School Amateur Radio Emergency Communications team in Long Beach, California, is made up of young women. Here, team members practice passing and copying message traffic. [Devon Day, KF6KEE, photo]

1.7 Ham Radio in the Classroom

Amateur Radio is a terrific teaching tool! Many individuals began their path towards careers in electronics and wireless communication thanks to their experiences with Amateur Radio as children and teenagers.

Amateur Radio complements any school curriculum and gives students a chance to make a direct and immediate connection with their studies. For example, the math and science used in Amateur Radio apply equally in the classroom. Even geography takes on a new meaning when students are able to contact other countries around the globe and even to speak with the people who live in them!

Local volunteers are important to establishing an active Amateur Radio presence in schools. An HF or satellite station or even a VHF or UHF handheld transceiver tuned to the local repeater can prove an exciting and educational experience for pupils and volunteers alike.

Thanks to the Amateur Radio on the International Space Station (ARISS) program, amateurs all over the nation have made it possible for students to speak directly with astronauts in space via ham radio.

1.7.1 ARRL Amateur Radio Education & Technology Program

Through the ARRL Amateur Radio Education & Technology Program (ETP), Amateur Radio can become a valuable resource for the classroom teacher. The goal of the ETP is "to build a foundation of wireless technology literacy to US teachers and students." Launched in 2000 the program continues to offer resources to schools, including ham radio equipment, at no cost, thanks to the support of donors in the Amateur Radio community. The ETP emphasizes the integration of technology, math, science, geography, writing, speaking and social responsibility within a global society. Applying Amateur Radio as part of the class curriculum offers students a new dimension to learning. Each summer the ETP sponsors Teachers Institute on Wireless Technology sessions for educators, to enable them to make the most effective use of the ETP in their schools.

Amateur Radio emphasizes self-challenge, the value of lifelong learning and the importance of public service. From a more practical standpoint, future employers will be looking for candidates who are familiar not only with computers but with the sorts of wireless communication concepts used in Amateur Radio.

The ETP offers a range of resources to encourage educators. These include publications related to the use of technology in wireless communications; workshops, tips and ideas for teaching wireless technology in schools, community groups and clubs; and lesson plans and projects to help provide authentic, hands-on technological experiences for students.

Schools interested in incorporating Amateur Radio into their curricula, using it as an enrichment program or as a club activity may apply to become Project schools. See **www.arrl.org/education-technology-program** for more information on the ARRL Education & Technology Program.

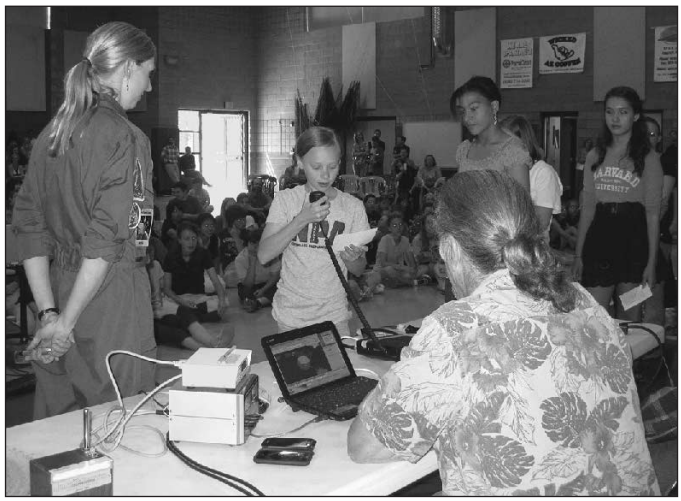

Fig 1.32 — Sixth-grade teacher Kaci Heins, KF7RCV (left in flight suit) stands by while one of her students in Flagstaff, Arizona, speaks with astronaut Joe Acaba, KE5DAR aboard the ISS during an Amateur Radio on the International Space Station (ARISS) school contact. Heins got her own ham ticket while preparing her class for the event. (Courtesy Kacy Heins, KF7RCV)

Fig 1.33 — At Eisenhower Middle School in Lawton, Oklahoma, Jada, KF5TAT (left) and Kerson, KF5TAQ sit at the Viking Radio Club station in the classroom of teacher Clifton Harper, KE5YZB. The school received a ham radio equipment grant through the ARRL Foundation and in 2012 Harper attended an ARRL Education & Technology Program Teacher's Institute on Wireless Technology at ARRL Headquarters. [Pamely Harper, KF5JXO, photo]

1.8 Resources

ARRL—the National Association for Amateur Radio
225 Main St
Newington, CT 06111-1494
860-594-0200
Fax: 860-594-0259
e-mail: **hq@arrl.org**
Prospective hams call 1-800-32 NEW HAM (1-800-326-3942)
www.arrl.org
Membership organization of US ham radio operators and those interested in ham radio. Publishes study guides for all Amateur Radio license classes, a monthly journal, *QST*, and many books on Amateur Radio and electronics.

Amateur Radio Service Rules & Regulations — FCC Part 97
Available on the ARRL website: **www.arrl.org/part-97-amateur-radio**
Available as a PDF file on the FCC website: **www.fcc.gov/Bureaus/Engineering_Technology/Documents/cfr/1998/47cfr97.pdf**

AMSAT NA (The Radio Amateur Satellite Corporation Inc)
10605 Concord St #304
Kensington, MD 20895
888-322-6728 or 301-822-4376
www.amsat.org
Membership organization for those interested in Amateur Radio satellites.

Courage Handi-Ham System
3915 Golden Valley Rd
Golden Valley, MN 55422
763-520-0512 or 866-426-3442
www.handiham.org
Provides assistance to persons with disabilities who want to earn a ham radio license or set up a station.

OMIK Amateur Radio Association
www.omikradio.org
OMIK, an ARRL affiliated club, is the largest predominately African-American Amateur Radio organization in the US. It promotes fellowship and Amateur Radio advancement and offers scholarships and other financial assistance for college-bound youth.

The ARRL Ham Radio License Manual
www.arrl.org/ham-radio-license-manual
Complete introduction to ham radio, including the exam question pool, complete explanations of the subjects on the exams. Tips on buying equipment, setting up a station and more.

The ARRL's Tech Q&A
www.arrl.org/shop/
Contains all of the questions in the Technician Class question pool, with correct answers highlighted and explained in plain English. Includes many helpful diagrams.

General Information and Other Study Material
The ARRL website (**www.arrl.org**) carries a wealth of information for anyone interested in getting started in Amateur Radio. For complete information on all options available for study material, check out the "Welcome to the World of Ham Radio" page, **www.arrl.org/what-is-ham-radio** and its associated links. You can also use the ARRL website to search for clubs, classes and Amateur Radio exam sessions near you.

1.9 Glossary

AM (Amplitude modulation) — The oldest voice operating mode still found on the amateur bands. The most common HF voice mode, SSB, is actually a narrower-bandwidth variation of AM.

Amateur Radio — A radiocommunication service for the purpose of self-training, intercommunication and technical investigation carried out by licensed individuals interested in radio technique solely with a personal aim and without pecuniary interest. (*Pecuniary* means payment of any type, whether money or goods.) Also called "ham radio."

Amateur Radio operator — A person holding an FCC license to operate a radio station in the Amateur Radio Service.

Amateur Radio station — A station licensed by the FCC in the Amateur Radio Service, including necessary equipment.

Amateur (Radio) Service — A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by licensed individuals interested in radio technique solely with a personal aim and without pecuniary interest.

AMSAT (Radio Amateur Satellite Corporation) — An international membership organization that designs, builds and promotes the use of Amateur Radio satellites, which are called "OSCARs."

APRS—Automatic Packet/Position Reporting System, a marriage of an application of the Global Positioning System and Amateur Radio to relay position and tracking information.

ARES (Amateur Radio Emergency Service) — An ARRL program for radio amateurs who participate in emergency communication.

ARISS — An acronym for Amateur Radio on the International Space Station. NASA, ARRL and AMSAT cooperate in managing the ARISS Program.

ARRL — The national association for Amateur Radio in the US; the US member-society in the ***IARU*** (International Amateur Radio Union).

ATV (Amateur television) — An Amateur Radio operating mode for sharing real-time video.

Band — A range of frequencies in the radio spectrum, usually designated by approximate wavelength in meters. For example, 7.0 to 7.3 MHz (megahertz) is the 40 meter amateur band. Hams are authorized to transmit on many different bands.

Bandwidth — In general, the width of a transmitted signal in terms of occupied spectrum. FCC definition: "The width of a frequency band outside of which the mean power of the transmitted signal is attenuated at least 26 dB below the mean power of the transmitted signal within the band."

Beacon — An amateur station transmitting communication for the purposes of observation of propagation and reception or other related experimental activities.

Beam antenna — A ham radio antenna having directional characteristics to enhance the transmitted signal in one direction at the expense of others. A "rotary beam" can be pointed in any direction.

Broadcasting — Transmissions intended for reception by the general public, either direct or relayed. Amateur Radio licensees are not permitted to engage in broadcasting.

Call sign — A series of unique letters and

numerals that the FCC assigns to an individual who has earned an Amateur Radio license.

Contact — A two-way communication between Amateur Radio operators.

Contest — A competitive Amateur Radio operating activity in which hams use their stations to contact the most stations within a designated time period.

Courage Handi-Ham System — Membership organization for ham radio enthusiasts with various physical disabilities and abilities.

CW — A synonym for radiotelegraphy (ie, Morse code by radio). CW is an abbreviation for "continuous wave," a term used in the early years of wireless.

Digital communication — Computer-based communication modes such as RTTY, PSK31, packet and other radio transmissions that employ an accepted digital code to convey intelligence or data.

Dipole antenna — Typically, a wire antenna with a feed line connected to its center and having two legs. Dipoles most often are used on the high-frequency (HF) amateur bands.

DSP (digital signal processing) — Technology that allows software to replace electronic circuitry.

DX — A ham radio abbreviation that refers to distant stations, typically those in other countries.

DXCC — DX Century Club, a popular ARRL award earned for contacting Amateur Radio operators in 100 different countries or "entities."

DXpedition — A trip to a location — perhaps an uninhabited island or other geographical or political entity — which has few, if any, Amateur Radio operators, thus making a contact rare.

Elmer — A traditional term for a person who enjoys helping newcomers get started in ham radio; a mentor.

Emergency communication — Amateur Radio communication during a disaster or emergency that support or supplants traditional means of telecommunication.

FCC (Federal Communications Commission) — The government agency that regulates Amateur Radio in the US.

Field Day — A popular, annual Amateur Radio activity sponsored by the ARRL during which hams set up radio stations, often outdoors, using emergency power sources to simulate emergency operation.

Field Organization — A cadre of ARRL volunteers who perform various services for the Amateur Radio community at the state and local level.

FM (Frequency modulation) — A method of transmitting voice and the mode commonly used on ham radio repeaters.

Fox hunt — A competitive radio direction-finding activity in which participants track down the source of a transmitted signal.

Fast-scan television — A mode of operation that Amateur Radio operators can use to exchange live TV images from their stations. Also called *ATV (Amateur Television)*.

Ham band — A range of frequencies in the radio spectrum on which ham radio communication is authorized.

Ham radio — Another name for Amateur Radio.

Ham radio operator — A radio operator holding a license granted by the FCC to operate on Amateur Radio frequencies.

HF (high frequency) — The radio frequencies from 3 to 30 MHz.

HSMM (high-speed multimedia) — A digital radio communication technique using spread spectrum modes primarily on UHF to simultaneously send and receive video, voice, text, and data.

IARU (International Amateur Radio Union) — The international organization made up of national Amateur Radio organizations or societies such as the ARRL.

Image — Facsimile and television signals.

International Morse Code — A digital code in which alphanumeric characters are represented by a defined set of short and long transmission elements — called "dots and dashes" or "dits and dahs" — that many Amateur Radio operators use to communicate.

ITU (International Telecommunication Union) — An agency of the United Nations that allocates the radio spectrum among the various radio services.

MARS — Military Auxiliary Radio System, a volunteer auxiliary communication program that supports the US Department of Defense and federal government homeland defense activities. Most MARS operators are Amateur Radio operators.

Mode — A type of ham radio communication, such as frequency modulation (FM voice), slow-scan television (SSTV), SSB (single sideband voice), CW (Morse code), or digital (eg, PSK-31 or JT65).

Morse code — A communication mode characterized by on/off keying of a radio signal to convey intelligence. Hams use the International Morse Code.

Net — An on-the-air meeting of hams at a set time, day and radio frequency, usually for a specific purpose.

Packet radio — A computer-to-computer radio communication mode in which information is encapsulated in short groups of data called packets. These packets contain addressing and error-detection information.

Phone — Emissions carrying speech or other sound information, such as FM, SSB or AM.

Public service — Activities involving Amateur Radio that hams perform to benefit their communities.

QRP — An abbreviation for low power.

QSL bureau — A system for sending and receiving Amateur Radio verification or "QSL" cards.

QSL cards — Cards that provide written confirmation of a communication between two hams.

QST — The monthly journal of the ARRL. *QST* means "calling all radio amateurs."

RACES (Radio Amateur Civil Emergency Service) — A radio service that uses amateur stations for civil defense communication during periods of local, regional or national civil emergencies.

RF (Radio frequency) — Electromagnetic radiation in the form of radio waves.

Radio (or Ham) shack — The room where Amateur Radio operators keep their station.

Radiotelegraphy — See **Morse code**.

Receiver — A device that converts radio signals into a form that can be heard or viewed.

Repeater — A typically unattended amateur station, usually located on a mountaintop, hilltop or tall building, that automatically and simultaneously receives and retransmits the signals of other stations on a different channel or channels for greater range.

RTTY (radio teletype) — Narrow-band direct-printing radioteletype that uses a digital code.

Space station — An amateur station located more than 50 km above Earth's surface.

SSB (Single sideband) — A common mode of voice of Amateur Radio voice transmission.

SSTV (Slow-scan television) — An operating mode ham radio operators use to exchange still pictures from their stations.

SWL (Shortwave listener) — A person who enjoys listening to shortwave radio broadcasts or Amateur Radio conversations. (A *BCL* is someone who listens for distant AM broadcast stations. Some SWLs also are BCLs.)

TIS (Technical Information Service) — A service of the ARRL that helps hams solve technical problems (**www.arrl.org/tis**).

Transceiver — A radio transmitter and receiver combined in one unit.

Transmitter — A device that produces radio-frequency (RF) signals.

UHF (Ultra-high frequency) — The radio frequencies from 300 to 3000 MHz.

VE (Volunteer Examiner) — An Amateur Radio operator who is qualified to administer Amateur Radio licensing examinations.

VHF (Very-high frequency) — The radio frequency range from 30 to 300 MHz.

WAS (Worked All States) — An ARRL award that is earned when an Amateur Radio operator confirms two-way radio contact with other stations in all 50 US states.

Wavelength — A means of designating a frequency band, such as the 80 meter band.

Work — To contact another ham.