D-STAR

For the Second Century of Amateur Radio

Single-sideband, repeaters, packet radio, and microprocessor technology all took radio to new levels. Now D-STAR's protocols are opening up new possibilities for casual users, system builders, group leaders, and good, old ham radio experimentation. Just as high-speed digital networks led to brand-new ways to communicate, D-STAR brings digital systems to the amateur bands to create entirely new radio systems and services. Turn the page and discover a whole new perspective on amateur radio...

ICOM®

D-STAR
The History

D-STAR, a standard published in 2001, is the result of three years of research funded by the Japanese government and administered by the JARL to investigate digital technologies for amateur radio. The research involved Japanese radio manufacturers and other observers. Icom provided the equipment used for development and testing. D-STAR radios and repeaters have been tested extensively over the past two years and are now ready for public use.

D-STAR
An Overview

D-STAR is an open protocol–although it is published by JARL, it is available to be implemented by anyone. (For definitions and explanations of terms, there is a glossary on page 6.) While Icom is the only company to date that manufactures D-STAR-compatible radios, any equipment or software that supports the D-STAR protocol will work with a D-STAR system. D-STAR systems can be built using both commercial and homebrew equipment and software.

In a D-STAR system, the air link portion of the protocol applies to signals travelling between radios or between a radio and a repeater. D-STAR radios can talk directly to each other without any intermediate equipment or through a repeater using D-STAR voice or data transceivers. The gateway portion of the protocol applies to the digital interface between D-STAR repeaters (see figure 1).

D-STAR also specifies how a voice signal is converted to and from streams of digital data, a function called a codec. The selected codec is known as AMBE (Advanced Multi-Band Excitation) and the voice signal is transmitted in the D-STAR system at 4800 bits/second. (4.8 kbps).

Digital Data

D-STAR systems support both high-speed (128k bps) and low-speed (4800 bps) digital data, depending on FCC rules restricting the signal bandwidth. On 144 and 440 MHz, low-speed data can be sent simultaneously with the digitized voice signal, like having both a packet link and FM voice in the same radio. The connection to low-speed D-STAR radios is via an RS-232 interface or USB 1.0. High-speed data is currently available only on the 1.2 GHz band. An Ethernet connection is used for high-speed D-STAR data. Ordinary terminal emulation software (low-speed) or a Web browser (high-speed) will do just fine for exchanging data (see figure 2).

Figure 1

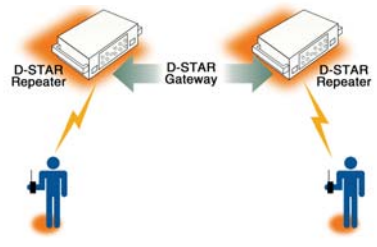
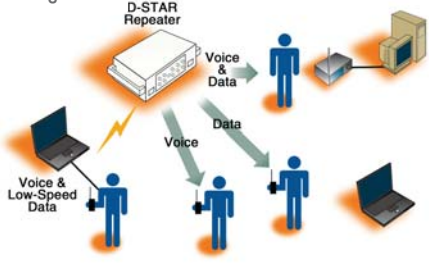


Figure 2



Applications

Handheld and mobile radios

Worldwide Connections

For voice conversations, D-STAR repeaters act just like familiar analog repeaters - everyone listening can hear your transmissions. Because your call sign is incorporated into every transmission, the D-STAR repeater "registers" your call sign and shares it around the D-STAR system. If you travel into a new D-STAR repeater's coverage area, register with a short transmission and your location will be quickly updated around the D-STAR network. This allows you to call someone registered with any other D-STAR repeater, no matter where that may be. If you call someone registered elsewhere, your voice will be routed to the appropriate repeater in digital form, where it is then heard just as you would expect if you were both using the same repeater!

Low-speed data

Many data communications needs don't require high-speeds, particularly for emergency communications. Status reports, damage assessment, shift changes, resource requests - all they take are a few keystrokes. D-STAR combines voice and low-speed data into a single channel simultaneously. There's no need for a separate TNC and radio. Just connect your laptop or PDA and go.

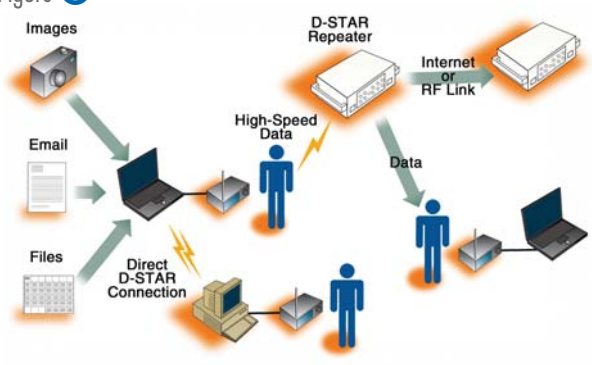
High-speed data

A high-speed D-STAR connections looks just like an Ethernet connection to your laptop or other network device. Why run cables for a temporary or portable installation when mobile rigs will do the job? Connect across miles instead of meters! If a D-STAR repeater offers a broadband Internet connection, you have worldwide connectivity through your radio.

Emergency communications managers can put D-STAR's high-speed data capabilities to work building systems that support their "served agency" with IT tools they understand and expect; email, file transfer, and Web browsing. Spreadsheets, graphics, maps, lists, Web pages - all flow easily through the D-STAR system (see figure 3).

If a picture is worth a thousand words, why not use D-STAR to paint the image? Weather and traffic information from the Internet are available via a D-STAR repeater's broadband connection. Add a digital camera to a laptop and your D-STAR radio becomes a Web cam. Emergency management is greatly enhanced when images are available. The next time your group helps out on race day, D-STAR can make it possible to send photos at the finish line, on the course - anywhere your operators are.

Figure 3



Applications

Repeaters and repeater systems

Repeater links and groups

D-STAR gateway protocols and software support linking repeater systems over a few miles or around the world. A regional group of repeaters create a D-STAR Zone, shown in Figure 4, working together and addressable in the D-STAR system as a unit. Whether you live in the wide-open spaces or a densely populated area, D-STAR repeaters can be tied together to make up the repeater system you want using either Internet or microwave links. Local servers can be included in a D-STAR Zone to provide services such as file-sharing or Web pages via the D-STAR link.

Repeater system management

Repeaters linked with D-STAR can also share information using the same D-STAR link. This information includes repeater operating information and statistics. System designers can add entirely new functions, sharing weather and control information, for example. Another possibility is "smart systems" that track interference or user location.

6.25 kHz channels = more repeaters

If you've tried to coordinate a repeater channel on 2-meters or 440 MHz in any metropolitan area, you know how crowded the bands are! The D-STAR voice and low-speed data signal offers a significant improvement in spectrum efficiency, requiring only a 6.25 kHz channel instead of the 20, 25, or even 30 kHz of analog wide-band FM. As shown in Figure 5, D-STAR repeaters can be interleaved between existing channels or as multiple repeaters deployed in the spectrum of only one analog FM repeater.

D-STAR Registry

As authorized users make their initial transmission to a D-STAR system, the call sign information attached to the digitized voice packets is recorded by the repeater controller. The controller then shares the information with other D-STAR systems through the D-STAR registry. The registry is maintained on several servers located around the world as shown in Figure 6–currently Japan, the United States, and the UK. When an authorized D-STAR user makes a call to a call sign not currently registered on that repeater system, the registry allows the repeater controller to route the call to the repeater on which the targeted user was last registered.

Figure 4

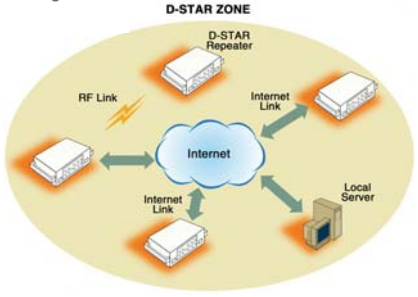


Figure 5

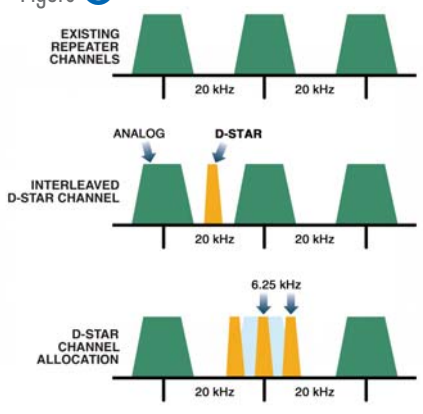


Diagram not to scale

Applications

New services and system examples

Information and services – the D-STAR Kiosk

Imagine arriving in town as a visitor or on business. Connect a laptop or PDA to your D-STAR handheld, key in a few simple characters, and request a "what's happening" report from a local D-STAR kiosk server. In seconds, you're viewing text listing meetings, clubs, electronics stores, and events. Need a weather check? A few more characters and the screen fills with the current report.

D-PRS®

The low-speed data ports of D-STAR handheld radios are compatible with the GPS NMEA data interface. With GPS data integrated into the D-STAR digital data stream, your location data is forwarded to the D-PRS server where gateway software connects you to the APRS® reporting system. The interface is built-in to D-STAR radios - no separate TNC and transceiver required!

IRLP and Echolink Gateway

It's only natural that D-STAR's digital voice capabilities link up with the most popular repeater sharing applications of all; Echolink and IRLP. Since your voice is already digitized within the D-STAR system, a gateway to and from other digital voice systems will be a natural and expected future addition.

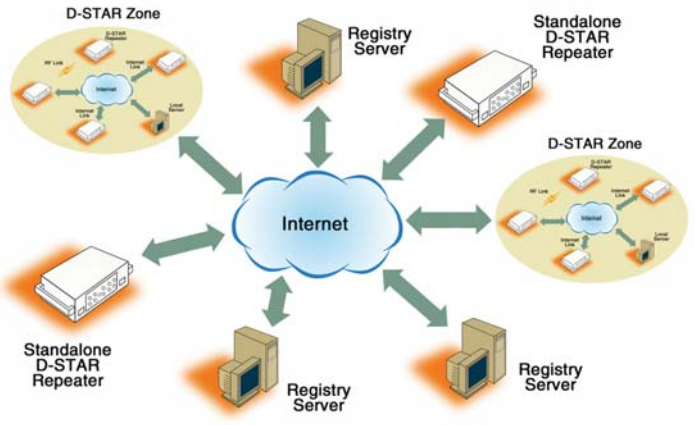
Remote Control and Monitoring

Since D-STAR's data looks just like any other Internet data to a browser or Web application, why not use D-STAR's high-speed data to build a link to your club's HF station? Want to control your electronics at home? Either high-speed or low-speed D-STAR data can do the job. D-STAR is built to support 21st century tools - the Web, networking, Ethernet, TCP/IP - so free your imagination!

Application Developers

The open D-STAR protocol provides a rich, exciting set of tools with which hams can experiment and build. Icom supports developers with the D-STAR forums at www.icomamerica.com/amateur/dstar- please join this growing community. In addition, Icom is preparing technical support documentation for the developer, such as protocols and interface descriptions.

Figure 6



Glossary

Air Link: the portion of data transmission that takes place as a radio signal. The D-STAR air link includes both modulation methods and data packet construction.

Area: The geographical region served by one D-STAR repeater.

Authorization: Adding a user to the D-STAR registry.

Bridge: A connection between just two devices, such as between two ID-1 transceivers.

Client: A program that requests data (programs, Web pages, documents, etc.) from servers.

Codec: Code/Decode, a circuit or program that translates an analog signal to and from digital form, usually refers to an audio signal, such as voice or music. Different codecs, such as AMBE or MP3, have different rules for the translation between analog and digital.

Controller: The part of a D-STAR repeater that handles and routes the voice and data streams either between modules or between modules and the gateway.

Echolink: (www.echolink.org) and **IRLP** (Internet Relay Linking Project - www.irlp.net), systems that allow repeaters to share digitized voice signals using Voice-Over-Internet Protocol (VOIP) technology.

Encapsulate: To incorporate data packets from one protocol inside the data packets of another.

Ethernet: The set of protocols that control local area network (LAN) connections, described by the IEEE 802.3 standard.

FEC: Forward Error Correction, the process of adding information to data so that the receiver can correct errors caused by the transmission process.

Gateway: The part of a D-STAR repeater that connects the controller to other gateways via the Internet or an RF link.

IP: Internet Protocol, the protocol that controls how data packets are exchanged on the Internet.

Module: A D-STAR module is the part of a D-STAR repeater that implements voice or data communication over the air.

Register: Capture the call sign of a received signal and post it to the system registry for other D-STAR repeaters to use for the purposes of routing calls.

Registry: A shared data base of authorized user call signs and gateways.

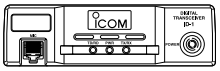
Route: To direct data packets to specific destinations.

Server: A computer that supplies data (programs, Web pages, documents, etc.) to clients when requested.

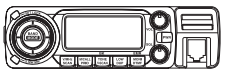
Zone: A group of D-STAR repeaters linked together and connected to other D-STAR systems by a single gateway.

What is a "Protocol"?

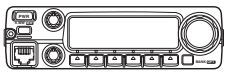
From the Wikipedia (www.wikipedia.com), In computing, a protocol is a convention or standard that controls or enables the connection, communication, and data transfer between two computing endpoints." Essentially, protocols are the "rules of engagement" between two devices that allow them to connect to each other and exchange data. Protocols don't guarantee that the data exchanged is correct or has meaning, they just describe how the data gets from one point to another. There are two D-STAR protocols; one for the air link that controls over-the-air transmissions and one that controls how information is exchanged between gateways. If you can create a radio or a program that plays by those rules, you can connect to the D-STAR world. Because D-STAR is an open protocol, all of the necessary information to play by those rules is publicly available



ID-1
Advanced 1.2GHz Mobile
10W Output Power
Wireless Internet/Network Access Capable
High Speed Digital Data, Digitally Modulated Voice,
& Analog Voice (FM) Communication



ID-800
2M/70CM Low Speed Digital Dual Mode Mobile
55W VHF/50W UHF Output Power
Callsign Squelch
Digital Data, Digitally Modulated Voice,
& Analog Voice (FM) Communication



IC-2200H
2M Analog/Low Speed Digital Mobile
65W Output Power
Optional D-STAR format Digital Operation
& NMEA Compatible GPS interface
Weather Alert

IC-V82 / IC-U82
2M or 70CM Analog/Low Speed Digital handheld
7W (2M) or 5W (70CM) Output Power
Optional D-STAR format Digital Operation
& NMEA Compatible GPS interface
CTCSS & DTCS Encode/Decode with Tone Scan

Technical Specifications

The following table compares D-STAR capabilities and costs with those of VHF Packet for both low-speed and high-speed systems. (Costs are based on equipment MSRP.) You can see that low-speed D-STAR links, which support simultaneous voice and data, cost no more than low-speed packet and are cost-competitive with even high-speed packet. High-speed D-STAR links provide approximately 10 times the performance of high-speed packet at less than three times the price.

	D-STAR	PACKET
VOICE CODEC	4800 bps AMBE	None
DATA SPEED	***LS:*** 4800 bps ***HS:*** 128k bps	***LS:*** 1200 bps ***HS:*** 9600 bps
BANDWIDTH	***LS:*** 6.25 kHz ***HS:***130 kHz	20 kHz
FREQUENCY	***LS:*** Any VHF/UHF band ***HS:*** 1.2 GHz (currently)	Any VHF/UHF band
COST*	***LS:*** IC-V82 or IC-U82 ($230) + UT-118 Module ($200) = Total $430 or ID-800 ($748) ***HS:*** ID-1 ($1600)	***LS:*** TNC($200) + IC-2200 ($230) = Total $430 ***HS:*** TNC ($400) + IC-2200 ($230) = Total $630

Software and system developers want to know the detailed technical specifications and the following table illustrates the main points of the D-STAR system. ***LS:*** Low Speed Data ***HS:*** High Speed Data

	D-STAR	PACKET
DATA INTERFACE	***LS:*** RS-232 or USB 1.0 ***HS:*** Ethernet	RS-232
DATA FORMAT	8-bit ASCII text	7-bit ASCII text
AIR LINK	D-STAR packet format and 0.5GMSK modulation	***LS:*** AX.25 using Bell 202 modulation ***HS:*** AX.25 using K9NG Bell 212A
NETWORK & TRANSPORT	***LS:*** transparent point-to-point ***HS:*** TCP/IP	AX.25 or TCP/IP

Data Interface

For low-speed D-STAR links (4800 bps), the data interface to your laptop or terminal is a familiar RS-232, three-wire connection (Rx Data, Tx Data, and signal ground) or a USB 1.0 interface, depending on the radio. For high-speed D-STAR (128k bps), the data interface is an Ethernet connection with the customary RJ-45 jack.

Air Link

Over the air, packet signals use FSK protocols originally designed for land-line applications and adapted to amateur radio. D-STAR uses the up-to-date modulation method of 0.5GMSK–Gaussian Minimum Shift Keying. GMSK provides improved performance over packet because it is designed for wireless links. Data is sent using the D-STAR packet format, which includes FEC (Forward Error Correction) and routing information. The data itself is encapsulated within the D-STAR packet as an Ethernet packet.

Network and Transport

Low-speed D-STAR data is a transparent "keyboard-to-keyboard" mode not associated with Internet or networking protocols. The D-STAR system provides reliable, transparent transport from user to user. High-speed D-STAR data appears at the data interface as an Ethernet packet suitable for encapsulation by the TCP/IP protocol stack. The Ethernet connection appears as a bridged, point-to-point connection between static IP addresses so that standard Internet application software can be used to transfer data across the D-STAR system.

You may download your own copy of the JARL's D-STAR Technical Specification at www.icomamerica.com/amateur/dstar.

*Prices subject to change.

Frequently held myths about D-STAR

Myth #1

"D-STAR only works on 1.2 GHz."

Low-speed D-STAR voice and data works just fine at 144 and 440 MHz. 1.2 GHz supports the bandwidth needs of high-speed data. Voice signals from high and low-speed D-STAR connections are completely compatible.

Myth #2

"There's no difference between D-STAR and packet."

Even D-STAR's lowest speed is competitive with the highest-performance packet systems available today. (see page 7 for detailed comparisons) D-STAR's simultaneous digital voice and data at 4800 bps is beyond the capability of any packet technology. High-speed D-STAR systems are ten times faster than the highest packet speeds.

Myth #3

"D-STAR is no different from IRLP or Echolink"

VOIP systems like IRLP and Echolink are only capable of routing voice signals. They don't support data exchange at any speed. Calls targeted to a specific user are not possible by any amateur technology except for D-STAR.

Myth #4

"D-STAR is just a digital party line!"

The ability of D-STAR repeaters to route data and digitized voice worldwide sets it far apart from a simple party line. Sophisticated D-STAR controllers and gateways implement modern telecommunications functions in an amateur package.

Myth #5

"D-STAR is a replacement for broadband home Internet"

Truly a fantasy! D-STAR can connect a user to the Internet, true, but all of the restrictions on commercial activity still remain in place. D-STAR will provide the tools for a lot of great amateur innovation, but it's not intended to replace Internet providers.

Myth #6

"I'll be locked into Icom equipment forever."

While Icom is the first manufacturer to support D-STAR, any manufacturer or amateur can use the JARL standards to create equipment - transceivers, repeaters, and gateways - compatible with the D-STAR system. As the D-STAR system grows, look for other manufacturers to join the fun.

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