D-STAR

This article is about a digital voice mode used in amateur radio. For the physical quantity, see Specific detectivity. For the concept in robotics, see D* search algorithm.
For more details on this topic, see List of amateur radio modes.

D-STAR (**Digital Smart Technologies for Amateur Radio**) is an FDMA and GMSK digital voice and data protocol specification developed in the late 1990s by the Japan Amateur Radio League for amateur radio. There are newer digital radio modes used by amateurs, D-STAR was the first packet-based standard designed and widely used specifically for amateur radio.

Digital voice modulation uses less bandwidth than older analog voice modes such as amplitude modulation, frequency modulation, and single sideband. The quality of the data received is also better than an analog signal at the same signal strength, as long as the signal is above a minimum threshold, and there is no Multipath propagation.

D-STAR compatible radios are available for VHF, UHF, and microwave amateur radio bands. In addition to the over-the-air protocol, D-STAR also provides specifications for network connectivity, enabling D-STAR radios to be connected to the Internet or other networks, allowing streams of voice or packet data to be routed via amateur radio.

The only manufacturer to offer D-STAR compatible radios is Icom. As of February 1, 2013, no other amateur radio manufacturer supports D-STAR, which requires a proprietary AMBE codec owned by Digital Voice Systems, Inc.

1 History

In 1999 an investigation was put into finding a new way of bringing digital technology to amateur radio. The process was funded by the Japanese government and administered by the Japan Amateur Radio League. In 2001, D-STAR was published as the result of the research.

In September 2003 Icom named Matt Yellen, KB7TSE (now K7DN), to lead its US D-STAR development program.[1]

Starting in April 2004 Icom began releasing new "D-STAR optional" hardware. The first to be released commercially was a 2-meter mobile unit designated IC-2200H. Icom followed up with 2 meter and 440 MHz handheld transceivers the next year. However, the yet to be released UT-118 add-on card was required for these radios to operate in D-STAR mode. Eventually Icom began selling the card and once installed into the radios it provided D-STAR connectivity for each of the transceivers. The June 2005 edition of the ARRL's QST magazine reviewed the Icom IC-V82.

JARL released some changes to the existing D-STAR standard in late 2004. Icom, aware that the changes were coming, had placed the release of their hardware on hold for a period of as much as a year while they awaited the changes. As soon as the changes were out, Icom announced they would be able to finish up and release equipment.

The Icom ID-1 1.2 GHz mobile radio was released in late 2004. The ID-1 was the first and only D-STAR radio that provides digital data (DD) mode operation. In this mode data via TCP/IP can be transferred at 128 kbit/s.

The first D-STAR over satellite QSO occurred between Michael, N3UC, FM-18 in Haymarket, Virginia and Robin, AA4RC, EM-73 in Atlanta, Georgia while working AMSAT's AO-27 microsatellite (Miniaturized satellite) in 2007.[2] The two operators used a variety of Icom gear to make the contact and experienced slight difficulty with doppler shift during the QSO.

As of late 2009 there are around 10,800 D-STAR users talking through D-STAR repeaters which have connectivity to the Internet via the G2 Gateway. There are around 550 G2 enabled repeaters now active. Note, these numbers do not include users with D-STAR capabilities but not within range of a repeater, or working through D-STAR repeaters that do not have Internet connectivity.

The first D-STAR capable microsatellite was scheduled for launch during early 2012. OUFTI-1 is a CubeSat and is built by Belgian students at the University of Liège and I.S.I.L (Haute École de la Province de Liège). The name is an acronym for *Orbital Utility For Telecommunication Innovation*. The goal of the project is to develop experience in the different aspects of satellite design and operation.[3][4] The satellite weighs just 1 kilogram and will utilize a UHF uplink and a VHF downlink.[5]

2 Technical details

The system today is capable of linking repeaters together locally and through the Internet utilizing callsigns for routing of traffic. Servers are linked via TCP/IP utilizing proprietary "gateway" software, available from Icom.

ing over the 2 m (VHF), 70 cm (UHF), and 23 cm (1.2 GHz) amateur radio bands. There is also an interlinking radio system for creating links between systems in a local area on 10 GHz, which is valuable to allow emergency communications oriented networks to continue to link in the event of internet access failure or overload.

Within the D-STAR Digital Voice protocol standards (DV), voice audio is encoded as a 3600 bit/s data stream using proprietary AMBE encoding, with 1200 bit/s FEC, leaving 1200 bit/s for an additional data "path" between radios utilizing DV mode. On air bit rates for DV mode are 4800 bit/s over the 2 m, 70 cm and 23 cm bands.

In addition to digital voice mode (DV), a Digital Data (DD) mode can be sent at 128 kbit/s only on the 23 cm band. A higher-rate proprietary data protocol, currently believed to be much like ATM, is used in the 10 GHz "link" radios for site-to-site links.

Radios providing DV data service within the low-speed voice protocol variant typically use an RS-232 or USB connection for low speed data (1200 bit/s), while the Icom ID-1 23 cm band radio offers a standard Ethernet connection for high speed (128 kbit/s) connections, to allow easy interfacing with computer equipment.[7]

2.1   Gateway server

The current gateway control software rs-rp2c version 2.0, more commonly called "Gateway 2.0". Though most Linux distributions should be suitable, the recommended configuration uses CentOS Linux 5.1 with the latest updates, typically running (kernel 2.4.20. glibc 2.3.2 and BIND 9.2.1 or later). The CPU should be 2.4 GHz or faster and the memory should at least be 512 MB or greater. There should be two network interface cards and at least 10 GB free of hard drive space which includes the OS install. Finally for middleware, Apache 2.0.59, Tomcat 5.5.20, mod_jk2 2.0.4, OpenSSL 0.9.8d, Java SE 5.0 and postgreSQL 8.2.3 are utilized, but these can be different as updates occur.

Along with the open-source tools, the Icom proprietary dsipsvd or "D-STAR IP Service Daemon" and a variety of crontab entries utilize a mixture of the local PostgreSQL and BIND servers to look up callsigns and "pcname" fields (stored in BIND) which are mapped to individual 10.x.x.x internal-only addresses for routing of both voice and data traffic between participating gateways.

During installation, the Gateway 2.0 software installation script builds most of the Web-based open-source tools from source for standardization purposes, while utilizing some of the packages of the host Linux system, thus making CentOS 5.1 the common way to deploy a system, to keep incompatibilities from occurring in both package versions and configuration.

Additionally, gateways operating on the U.S. trust server are asked during initial setup to install DStarMonitor

ICOM IC-91AD handheld transceiver with the D-STAR UT-121 digital voice board installed

This allows amateur radio operators to talk to any other amateurs participating in a particular gateway "trust" environment. The current master gateway in the United States is operated by the K5TIT group in Texas, who were the first to install a D-STAR repeater system in the U.S.[6]

D-STAR transfers both voice and data via digital encod-

which is an add-on tool that allows the overall system administrators to see the status of each Gateway's local clock and other processes and PIDs needed for normal system operation, and also sends traffic and other data to servers operated under the domain name of "dstarusers.org". By this means a complete tracking of user behaviour is technically possible. Installation of this software also includes JavaAPRSd, a Java-based APRS interface which is utilized on Gateway 2.0 systems to interface between the Icom/D-STAR GPS tracking system called DPRS to the more widely known and utilized amateur radio APRS system.

2.1.1 How Gateway 2.0 works

Each participating amateur station wanting to use repeaters/gateways attached to a particular trust server domain must "register" with a gateway as their "home" system, which also populates their information into the trust server—a specialized central gateway system—which allows for lookups across a particular trust server domain. Only one "registration" per trust domain is required. Each amateur is set aside eight 10.x.x.x internal IP addresses for use with their callsign or radios, and various naming conventions are available to utilize these addresses if needed for specialized callsign routing. Most amateurs will need only a handful of these "registered" IP addresses, because the system maps these to callsigns, and the callsign can be entered into multiple radios.

The gateway machine controls two network interface controllers, the "external" one being on a real 10.x.x.x network behind a router. A router that can perform network address translation on a single public IP address (can be static or dynamic in Gateway 2.0 systems) to a full 10.x.x.x/8 network is required. From there, the Gateway has another NIC connected directly to the D-STAR repeater controller via 10BaseT and the typical configuration is a 172.16.x.x (/24) pair of addresses between the gateway and the controller.

2.1.2 Differences between Gateway 1.0 and 2.0

The main differences between Gateway 1.0 and 2.0 are the addition of a relational database (PostgreSQL) for more flexibility and control of updates, versus the previous use of only BIND for "database" activities, the addition of both an administrative and end-user Web interface for registration which was previously handled via command-line commands by the Gateway 1.0 system administrators, dropping the requirement for static public IP addresses for gateways, and the ability of the software to use a fully qualified domain name to find and communicate with the trust server, allowing for redundancy/failover options for the trust server administrators. Finally, a feature called "multicast" has been added for administrators to be able to provide users with a special

"name" they can route calls to which will send their transmissions to up to ten other D-STAR repeaters at the same time. With cooperation between administrators a "multicast group" can be created for multiple repeater networks or other events.

Another additional feature of Gateway 2.0 is the ability to use callsign "suffixes" appended to the user's callsign in a similar fashion to the repeaters and gateways in the original system, which allow for direct routing to a particular user's radio or between two user radios with the same base callsign, by utilizing the 8th most significant field of the callsign and adding a letter to that location, both in the gateway registration process on the web interface, and in the radios themselves.

2.1.3 Gateway 1.0 control software

The Gateway 1.0 software was similar to Gateway 2.0, and utilized Fedora Core 2+ or Red Hat Linux 9+ OS on a Pentium-grade 2.4 GHz or faster machine.

2.1.4 Add-on software

Various projects exist for gateway administrators to add "add-on" software to their gateways, including the most popular package called "dplus" created by Robin Cutshaw AA4RC. A large number of Gateway 2.0 systems are offering services added by this software package to their end-users, and users are getting used to having these features. Features include the ability to link systems directly, "voice mail" (a single inbox today), ability to play/record audio to and from the repeaters connected to the Gateway and the most important, the ability for DV-Dongle users to communicate from the Internet to the radio users on the repeaters.[8]

There is often a misconception by users and system administrators alike that the Gateway 2.0 systems have these add-on features from dplus by default, a testament to the popularity of this add-on software. Dplus software development has an active following, and features such as multiple repeater/system connections similar to the type of linking done by other popular repeater-linking systems (IRLP and EchoLink) are being worked on.

3 D-RATS

See also: Amateur Radio Emergency Service

D-STAR is able to send data to emergency responders in the event of a disaster. Served agencies can relate to sending e-mail or other documents to someone. The quantity of data sent can be higher compared to traditional amateur modes. voice and even CW are capable of getting a

message through albeit slowly, but D-STAR can transfer documents, images, and spreadsheets.

D-RATS is a D-STAR communications tool that supports text chat, TCP/IP forwarding, file transfers, and can act as an e-mail gateway. There is also the ability to map user's positions using the D'PRS function of D-STAR. The application is written in Python/GTK and is cross-platform. It runs on Windows, Mac OS X, and Linux. The application was developed by Dan Smith (KK7DS) for the Washington County Amateur Radio Emergency Service in Oregon.[9]

It was in the Great Coastal Gale of 2007 the Washington County ARES group was able to test D-STAR during this series of several strong Pacific storms that interrupted conventional communication systems for up to one week. Primary emergency traffic for the American Red Cross and the Vernonia, Oregon Fire Department was handled by the group using traditional FM voice because the group had no D-STAR repeater equipment available. Once the situation's communication needs became established the D*Chat messaging function was used to send small text transmissions via D-STAR simplex at distances of up to seventeen miles.[10]

An ability for amateurs to send files during this weather event would have greatly increased the capacity for ARES to help during the emergency.[10] Although D*Chat was a useful means of communication D-RATS was developed to help fill the gaps that may have been lacking.[10] Another improvement over D*Chat that D-RATS provides is form support. Users can set up frequently used forms well before they're necessary and when the need comes all that's required is to fill in the fields. In this way, for example, emergency forms from the Red Cross, National Traffic System, or the Incident Command System, such as the FEMA standard ICS-213, could be generated and sent.

4   Criticisms

Proprietary codec

Like other commercial digital modes (P25, TETRA, DMR, DPMR, NXDN, System Fusion), D-STAR uses a closed-source proprietary voice codec (AMBE) that's patented by Digital Voice Systems, Inc. (DVSI)[11] because it was the highest quality and only codec available in silicon when the system was released. Unfortunately, amateur radio operators do not have access to the specification of this codec or the rights to implement it on their own without buying a licensed product. Amateurs have a long tradition of building, improving upon and experimenting with their own radio designs. The modern digital age equivalent of this would be designing and/or implementing codecs in software. Critics say the proprietary nature of AMBE and its availability only in hardware form (as ICs) discourages innovation. Even critics

praise the openness of the rest of the D-STAR standard which can be implemented freely. An open-source replacement for the AMBE codec would resolve this issue. Also, 'vendor lock-in' is often cited as an issue with only one major manufacturer making most or all of the equipment.

Bruce Perens, K6BP, amateur radio and open source advocate, evangelized the need for an open source codec for amateur radio.[12] David Rowe, VK5DGR, has implemented an Alpha-test replacement codec under the LGPL and is continuing in its development.[13]

Trademarked name

Despite many protestations from the Pro-D-STAR lobby that the standard was developed by the JARL and D-STAR is not only an Icom system, the mark 'D-STAR' is itself a registered trademark of Icom.[14] According to the United States Patent and Trademark Office, a trademark is defined as "a word, phrase, symbol or design, or a combination of words, phrases, symbols or designs, that identifies and distinguishes the source of the goods of one party from those of others."[15] While Icom does hold a trademark for its stylized D-STAR logo, Digital Voice Systems, Inc. (DVSI)[16] has patented the voice technology.

Usable range compared to FM

D-STAR, like any digital voice mode has comparable usable range to FM, but it degrades differently. While the quality of FM progressively degrades the further a user moves away from the source, digital voice maintains a constant voice quality up to a point, then essentially "falls off a cliff".[17] This behavior is inherent in any digital data system, and it demonstrates the threshold at which the signal is no longer correctable, and when data loss is too great, audio artefacts can appear in the recovered audio.

Emergency Communications Concerns

D-STAR's performance envelope relies heavily on internet connections. During widespread disasters that compromise commercial telecommunications infrastructure, D-STAR systems (and other modes that rely on the internet such as Winlink) may suffer outages or performance degradation that severely impacts operations. Without simulating such outages during drills, it is difficult to assess the impact of or establish D-STAR service recovery procedures in the event of such failures. As of the fall of 2011, there has been almost no discussion in the ham radio literature regarding actual drills where D-STAR systems were tested with completely failed or even intermittent telecommunications infrastructure. Comprehensive emergency communications plans used by ARES and other such organizations should address the possibility that such systems may not function as intended during major disasters.

Cost

D-STAR does significantly add to the cost of a radio, which is a barrier to the adoption of the technology. In 2006 the cost of a D-STAR radio was compared to that of a standard analog radio, and the price difference was nearly double.[18] This is due partly to the per-unit cost for the voice codec hardware and/or license and partly to manufacturer research and development costs that need to be amortized. As is the case with any product, as more units are sold, the R&D portion of the cost will decrease over time. The D-STAR capable radios also cost more than their equivalents from other brands, even before the D-STAR options boards are added (in the UK as of April 2011, Martin Lynch & Sons' website lists the Icom 2820 (without D-STAR) at £489, while the equivalent Yaesu, the FT8800, is listed at just £337).

Questionable legality

Many have argued that the proprietary codec constitutes a form of encryption, and encryption is prohibited by almost every country's amateur radio licence conditions. According to FCC rules, if the algorithm is publicly published or otherwise widely available enough that transmissions are not secret, it is considered encoding rather than encryption. Unfortunately D-STAR uses AMBE, a non public codec. However, French regulators, in April 2010, have issued a statement that rules D-STAR illegal in France, due to the ability to create a connection to the internet with it and the proprietary nature of the codec used. The French Amateur Radio society, DR@F - Digital Radioamateur France has an online petition against this ruling, calling for the government to allow the mode, as to ban it would deny them 'fundamental rights'.[19]

5   Non-Icom D-STAR Repeaters

The world's first non-Icom D-STAR repeater GB7MH, fully linked to the K5TIT G2 network and D-Plus, went live on 10 September 2009, in West Sussex, England. Whilst waiting for the DSL line installation, the repeater is connected to the Internet via a 3G dongle from network operator "Three". The system is built around Satoshi Yasuda's GMSK Node Adapter, a Mini-ITX system running CentOS 4, a Tait T800 repeater and G2 code written by G4ULF. All the usual G2 features such as callsign routing, D-Plus linkage and DPRS via D-STAR Monitor are supported.

Today a home-brewed D-STAR repeater can be built using open source software, used commercial radio equipment and a computer. One group advocating the construction of home-brewed D-STAR repeaters is Free-Star. Free-Star is an experimental approach to the implementation of a vendor neutral, and open source, digital communication network for amateur radio.[20]

6   Compatible   programs   and   projects

D-StarLet

A Web-based text messaging application using D-STAR digital data technology.

D-StarLet is an open source client-server solution that allows content creation and modification from certain persons. D-StarLet interfaces with a D-STAR radio through the serial port. It works with Windows (98+), Linux (Red Hat 7.3+), Apple Mac OS X, and others.

D-PRS interface

D-PRS is GPS for ham radio. Includes DStarTNC2, javAPRSSrvr, DStarInterface, and TNC-X

DStarMonitor

A Java application run on the repeater gateway PC which logs activity on the attached repeaters. Additional features include APRS object representation of each repeater.

DStarQuery

DStarQuery monitors the low-speed data stream of a D-STAR radio looking for queries sent from a remote station. When a valid query is received, a predefined sequence is executed and the results transmitted from the station running DStarQuery. For example, a station transmits "?D*rptrs?" and it is received by a DStarQuery station which responds with a list of local repeaters.

The program D-PRS Interface includes a "Query" entry field that streamlines this process allowing the user to simply enter the desired command. Most DStarQuery systems will respond with a list of available commands when "?D*info?" is received.

Dstar Comms PRO

An advanced software application for use with DStar enabled radios. Supports advanced text chat, personal messaging with auto-reply and inbox, e-mail gateway and a beacon mode. GPS Tracking / Logging and a GPS Beacon emulator and Internet linking. New features are added weekly and users can suggest new features through the Dstar Comms forum. www.dstarcomms.com

DStar TV

Slow Scan TV for DStar radios and video streaming for Icom ID-1 by GM7HHB. Runs on Windows XP and Vista.

7   Home-brew D-STAR radio

See also: Amateur radio homebrew

The first presumed D-STAR radio including pictures and diagrams can be found at Moetronix.com's Digital Voice Transceiver Project. This page includes the schematic, source, and whitepaper.

Another project is Satoshi Yasuda's (7M3TJZ/AD6GZ) experiments with a UT-118 DV adapter. This project involves interfacing Icom's UT-118 with other manufacturer's amateur radio tranceivers. With this project some VHF/UHF/SHF amateur radio tranceivers are capable of being adapted for D-STAR operation. This requires access to the receiver's discriminator and to the direct FM modulator of the radio, sometimes available at a 9600 bit/s packet interface. Satoshi's product is no longer available. There is an alternative available at www.dutch-star.nl

Antoni Navarro (EA3CNO) also has designed another interface based on a PIC microprocessor and UT-118 module.

With the raise of cheap RTL-chip based Software Defined Radios, there also appeared various software decoders to decode digital speech information carried by radio signals. Recently, this also includes D-Star. There are decoders available, either for the protocol data and for the digital speech content, but they are illegal because the protocol is under a registered trademark and AMBE2 is a proprietary codec.

8   Equipment

- Homebrew

  - **Decoder/Receivers:**

    - Reception done by a Software Defined Radio and decoding of the D-Star header information done by the program dstar.exe.[21]

    - Reception done by a Software Defined Radio and speech decoding done by the program DSD 1.7 (Digital Speech Decoder).[22]

  - **Repeater equipment:**

    - GMSK Node Adapter - these devices are hardware GMSK modems with firmware to take D-STAR protocol frames over a USB cable and provide the necessary logic and GMSK modulation to control a simplex node or a full duplex repeater. One repeater that is easily adaptable is the Kenwood TKR-820 as documented by K7VE.[23]

  - GMSK using a sound card - this method uses a computer sound card to generate GMSK modulation and de-modulation. The primary software for this method is developed by Jonathan Naylor.

- Icom D-STAR equipment

  - **Transceivers—D-STAR and Analog FM Capable:**

    - Icom ID-1: 23 cm digital voice and digital data mobile transceiver. Power is selectable at 1 W or 10 W. USB control port and Ethernet connection for data.

    - Icom IC-2820H/IC-E2820: 2 m / 70 cm twin band digital voice mobile transceiver. Power up to 50 W on each band. May be purchased with or without D-STAR module. The D-STAR module includes a built-in GPS receiver with accompanying antenna.

    - Icom ID-31 and ID-31A: 70 cm digital voice hand held transceiver (5W). Includes a built-in GPS receiver and repeater database.

    - Icom ID-51 and ID-51A: 2 m / 70 cm dual band digital voice hand held transceiver (5W). Includes a built-in GPS receiver and DSTAR repeater database. Also reception of broadcast FM, AM, and shortwave.

    - Icom ID-51 Anniversary Edition and ID-51A Plus: 2 m / 70 cm dual band digital voice hand held transceiver (5W). Identical to ID-51A but adds FM repeater directory and higher speed (3600 bit/s) DV data mode.

    - Icom ID-800H: 2 m / 70 cm dual band digital voice mobile transceiver. Power up to 55 W on 2 m and 50 W on 70 cm.

    - Icom ID-880H: 3rd gen 2 m / 70 cm digital voice mobile transceiver (50W).

    - Icom IC-80AD: 3rd gen 2m / 70 cm digital voice hand held transceiver (5W).

    - Icom IC-92AD: 2 m / 70 cm twin band digital voice hand held transceiver. Four power settings up to 5 W on each band. Rugged and submersible design, optional microphone with embedded GPS.

    - Icom IC-91AD/IC-E91 + D-STAR: 2 m / 70 cm twin band digital voice hand held transceiver. Power is selectable at 0.5 W or 5 W on each band.

    - Icom IC-2200H: 2 m single band digital voice mobile transceiver. Power up to 65 W. Must purchase optional D-STAR module.

- Icom IC-V82: 2 m single band digital voice hand held transceiver. Power up to 7 W. Must purchase optional D-STAR module.
- Icom IC-U82: 70 cm single band digital voice hand held transceiver. Power up to 5 W. Must purchase optional D-STAR module.
- Icom IC-9100: HF/VHF/UHF transceiver. Must purchase optional UT-121 D-STAR module.
- Icom IC-7100: HF/VHF/UHF transceiver. Includes built-in D-STAR capability and monochrome touchscreen.
- Icom ID-5100: 2 m / 70 cm twin band digital voice mobile transceiver with monochrome touchscreen. Power up to 50 W on each band. Includes D-STAR module standard with GPS receiver and antenna in the head. Higher speed (3600 bit/s) DV data mode possible with firmware upgrade.

- **Receivers:**
  - Icom IC-R2500: HF/VHF/UHF/SHF receiver/scanner. Must purchase optional D-STAR module.

- **Repeater equipment:**
  - Icom ID-RP2000V: 2 m digital voice repeater.
  - Icom ID-RP4000V: 70 cm digital voice repeater.
  - Icom ID-RP2V: 23 cm digital voice repeater.
  - Icom ID-RP2D: 23 cm digital data access point.
  - Icom ID-RP2C: Repeater controller. Can support up to four digital voice repeaters and digital data access points. Required to operate any Icom D-STAR digital voice repeater or digital data access point.

- Inet Labs
  - **Computer accessory:**
    - DV-Dongle: The dongle is a USB device with the AMBE codec built in. Amateurs can use this with a personal computer's audio system to communicate over the D-STAR network. This is a good option for experiencing D-STAR if there isn't a local D-STAR repeater or if there is a repeater but it's not associated with an Internet gateway.[24] The dongle works along with the DVTOOL software, a simple application that mimics the controls on a D-STAR radio, although the interface doesn't actually look like a radio panel. Note: Now available from a number of amateur radio dealers or by homebrew using documentation at Moetronix.
    - DV-AP: A DVAP Dongle (DV Access Point Dongle) is also a USB device that creates a connection to the D-STAR network through an Internet connected computer. But instead of using the computer's audio system, the DVAP Dongle has an antenna and a 10 mW two-meter transceiver that provides short-range over-the-air access using a D-STAR radio (usually a handheld). Note that a D-STAR radio is required. The DVAP does *not* convert an analog FM signal to D-STAR.

- Kenwood D-STAR equipment[25]
  - **Transceivers:**
    - Kenwood TMW-706S: 2 m / 70 cm dual band digital voice mobile transceiver. Power up to 50 W.
    - Kenwood TMW-706: 2 m / 70 cm dual band digital voice mobile transceiver. Power up to 20 W.

    Note: *These transceivers are not available in North America and appear to be OEM versions of the Icom ID-800H*

9 See also

- MDC-1200
- NXDN, a related commercial two-way digital radio standard with similar characteristics
- Project 25, a related digital radio standard sponsored by APCO
- Ricochet modems
- TETRA, a digital two-way radio standard in use outside of North America

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11   Journal

- ARRL: QST *Icom IC 2820H Dual Band FM Transceiver* Vol 91 No 11 November 2007 Page 74, by Steve Ford, WB8IMY does a review on the IC 2820H Dual Band FM Transceiver.

- RSGB: RadCom March 2008 (Vol 83 No 03) review of Icom IC-E2820 transceiver and overview of D-STAR.

- CQ-VHF: D-STAR in the Southeastern U.S., Greg Sarratt, W4OZK, (partial), http://www.cq-vhf.com/D-StarWin08.html

N1IC's Review of Icom ID-51 http://nicktoday.com/icom-id-51-id-51a-first-quick-review/

12   External links

- Icom D-STAR Microsite

- Alabama D-STAR Information

- D-STAR FAQ and Information

- Icom D-STAR information

- opendstar.org

- The Rain Report by J. Maynard, K5ZC

- dstarusers.org

- D-STAR video by the Washington County ARES group

- MOTOTRBO, a Motorola digital two-way radio system, based on DMR, an ETSI standard.

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13.1 Text

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