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Yaesu FTM-400DR and FT1DR Dual Band Analog/Digital Transceivers

Yaesu's comprehensive entry into the VHF/UHF digital voice arena.

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Yaesu has entered the Amateur Radio VHF/UHF digital voice fray in a big way, beginning with the FT1DR dual band, dual mode handheld, followed by the FTM-400DR dual band, dual mode mobile, and most recently the DR-1 dual band, dual mode repeater introduced at the 2013 ARRL and TAPR Digital Communications Conference.[1] At press time, the handheld and mobile were on the market, the repeater was undergoing beta testing at several sites, and one final piece — the *WIRES-X* Internet linking controller — hadn't yet been released. Yaesu is headlining the new products as *System Fusion*, emphasizing that they aim to maintain compatibility between conventional FM and Yaesu's choice of digital voice modulation, C4FM. The mobile and handheld radios also have built-in Automatic Packet Reporting System (APRS) capabilities with an integrated GPS receiver.

In this article, I'll review the FT1DR and FTM-400DR radios. Even though digital voice has been with us for over a decade, it's still unfamiliar territory for many hams, so I'll also weave in some commentary on how digital voice is evolving in Amateur Radio, and where Yaesu's System Fusion fits into the puzzle. Other puzzle pieces include D-STAR, APCO-25, and DMR (Digital Mobile Radio, commonly called MOTOTRBO, a Motorola tradename).

So we now have four *incompatible* digital voice modes heading into common use in Amateur Radio. Common? Compared to analog FM, the digital voice modes are still pretty small, but D-STAR, APCO-25 and DMR have a significant number of users and repeaters. D-STAR and DMR have extensive, worldwide networks in operation. Digital voice is here to stay, but which mode? Or could it be *all* of them, and more?

[1]Video of the RP-1 introduction is at **arvideo news.com/hrn/HRN_Episode_0099.html.**

The FTM-400DR Mobile

Even without the C4FM digital mode, the FTM-400DR mobile and FT1DR handheld radios compete at the top of the heap. They are full-featured and well-designed *analog* FM radios that include APRS packet. The FTM-400DR mobile in particular is a striking departure from typical FM mobiles with a large, *color* touchscreen display. As it replaces the FTM-350, it loses the low-power 222 MHz transmit capability, but gains a built-in GPS. The control head has only four knobs (two volume controls, two multifunction "tuning" dials) and five buttons. That simplicity belies a depth of features and settings accessed by a series of on-screen menus.

The control head is taller and narrower than usual. The radio is a full V/V-U/U dual bander, displaying and receiving two frequencies at once. The alphanumeric characters are large and stacked vertically instead of the usual side-by-side (hence the narrower control head). They are easy to see, even in daylight in a vehicle, as long as the display isn't in direct sunlight.

The operating band can be selected either by pressing its corresponding dial knob, or by touching the display directly. After discovering that the display is a touchscreen, I intuitively touched the top and bottom band rows to select them without even thinking about it. The selected band is highlighted by brighter characters. Compared to a modern smartphone, the resistive touchscreen takes a pretty good poke to get it to register. All the buttons, including the on-screen items, respond with a variety of beeps. Different pitches or doubled beeps can aid in operation for visually impaired hams, or for drivers who want to keep their eyes on the road.

The menu system begins with four main on-screen, touch-accessed menu buttons across the bottom of the display. You can select your own "most-used" function for

Bottom Line

The FTM-400DR and FT1DR are full feature, high-end transceivers that showcase Yaesu's comprehensive entry in the Amateur Radio digital voice arena. Coupled with the DR-1 repeater, System Fusion offers something for both digital radio enthusiasts and traditional FM users.

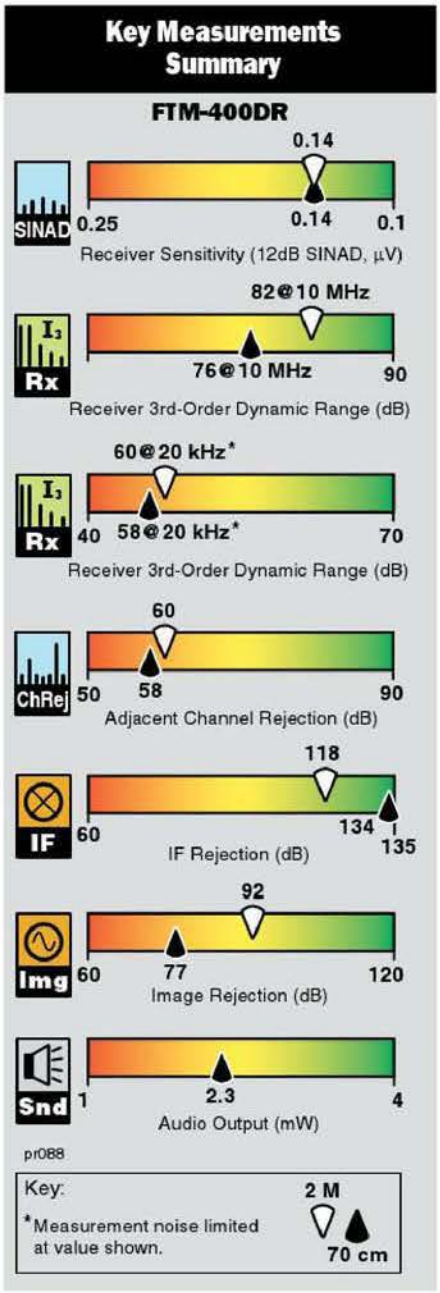


Figure 1 — The FTM-400DR control head with its mounting bracket inserted into the CD player slot in the author's dashboard. The display is showing the bearing and distance to an APRS station.

each of them. Additional menus open by pressing the F button, or holding the DISP/SETUP button. The display fills with the second layer of menus and options, most accessed by a direct touch on the screen (or turning and pressing the top dial), with some leading to another layer or two of options and menus. With more room to display real words, there are fewer cryptic abbreviations, though some options require deeper knowledge of the function being accessed.

The control head cannot be attached to the radio body, and connects with a 9.8 foot cable using RJ-10 4p4c plugs. The microphone plugs into the radio body using an RJ-12 6p6c connector. You'll need an extension if the radio body is going to be fairly remote. My Yaesu FT-8900 mic plugged into that radio's control head, and I thought I wouldn't like the FTM-400DR's configuration until I put it in my car temporarily. Turns out it would have been inconvenient for the mic cord to be coming from the head, at least in that case.

The FTM-400DR's control head comes with a stand that holds it upright. Yaesu and third parties have other mounting options, or it would be easy to build yourself one. When I did my temporary mobile installation, I hunted around for a spot to put it. Right on the dash was the most visible, but even the mid-April North Carolina sun made it too hot. Then I tried sliding the thin, flat flange on the bottom of the mount into the slot of my car radio's CD player, and voilà! Figure 1 shows my installation.

The radio body is a little smaller than most, with heat-sink ribs along the bottom, small fins and a quiet fan on the back. Also on the body are the SO-239 antenna connector (no pigtail), a ⅛ inch speaker jack, a slot for a micro-SD card, a 10-pin mini-DIN for a packet TNC (more on that later), and what looks like a mini-USB jack, but isn't. It's for "data," and more on that later, too. The big, top-facing speaker sounds good, and it's plenty loud. After previously reviewing two mobiles with volume control issues, I paid careful attention to the Yaesu. The steps taper down to zero smoothly with plenty of resolution to set it just where you want.

Back on the display (Figure 2), the upper band (Band A) and the lower band (Band B) have completely independent sets of 500 memories. Only Band A does C4FM digital, and only Band B does APRS. APRS can run in the background while you operate FM or C4FM on Band A, but of course if you use 144.39 for APRS, any 2 meter transmitting you do on Band A will temporarily mute the Band B receiver. If you have the radio set to beacon your position, that short burst from Band B will mute Band A. Band A can operate on UHF at will, and APRS will have no effect. Band B will mute Band A when in VHF.

The display can show frequency or your own eight-character alphanumeric label. If you use alphanumerics, the frequency still shows up in small numbers. The remainder of the main display feels uncluttered, and it uses color to good effect to separate the information it imparts. A large vertical bar on the left is green for receive, red for transmit. A thin horizontal line below the alphanumeric label shows the relative volume setting — useful because you may be a few button-pushes away from opening the squelch to set volume on a quiet channel. Below that is a meter bar for relative receive and transmit levels. It has an uncalibrated ruler above it (no S-9 indication), but the first ⅔ of the meter bar

is white, and the right ⅓ is red. Finally, the display shows the operating mode (FM, DIGITAL, and AUTOMATIC, more later), and a few more little icons for other features. Missing: any indication of the tone mode (CTCSS or DCS).

One of the default bottom-row MENU items is SCOPE, which turns the bottom of the display into a band scope, showing either a slice of spectrum in VFO mode, or a range of memory channels in memory mode.

The physical DISP button toggles the whole display through up to four other views, including a compass rose (see Figure 1), an altitude graph, a clock/stopwatch/timer, and a GPS satellite display. Each deserves more description than I have space for, but two points stand out. Both C4FM digital and APRS use the built-in GPS to determine your position (and send it to other stations), and the compass rose will display that for the selected A or B band, pointing to the received station and showing your distance to them.

The satellite display page told me that the GPS receiver often had trouble acquiring enough satellites for a location fix in my shack on the top floor of a typical wood-frame and shingle-roofed house, and when sitting inside my car under the metal roof. It worked fine right by a window, or directly under the car windshield. GPS receivers in consumer electronics such as smartphones haven't needed "a clear view of the sky" for some time now.

The memory system takes good advantage of the big display. Enter a frequency in VFO mode using either the microphone buttons or the on-screen keypad you can bring up, hold the F/MW (memory write) button, and the memory list pops up as a scrollable display, with four memory channels in view at once. Dial "over" the memory channel you want to enter. If it's already got something in it, your new information replaces that temporarily until you commit it. Then you can enter an alphanumeric label with an on-screen keyboard. I found the small "typewriter" buttons a little hard to hit reliably, but editing is easy.

Band A and Band B each have 500 *independent* memory channels and there is no "copy and paste" function to share them without using computer software. Also, I was disappointed to find that there is no memory bank feature. Individual memory

Table 1
Yaesu FTM-400DR, serial number 3J020450

Manufacturer's Specifications	Measured in ARRL Lab
Frequency coverage: Receive, 108-137 MHz (AM), 137-300 MHz (FM), 300-336 MHz (AM), 336-999.99 MHz (FM, cellular blocked). Transmit, 144 – 148, 430-450 MHz.	Receive, 108-136.995 MHz (AM), 137 – 299.995 MHz (FM), 300 – 335.995 MHz (AM), 336 – 823.990, 849.010 – 868.990, 894.040 – 911.990, 943.510 – 956.990, 988.510 – 999.990 MHz (FM); transmit, as specified.
Modes: FM, digital voice, data.	As specified.
Power requirements: Nominal 13.8 V dc. Receive: 500 mA. Transmit, at 50 W RF output: 11 A at 144 MHz, 12 A at 430 MHz.	At 13.8 V dc: Receive, 1 A (max volume, max lights, no signal, one receiver), 1.1 A (max volume, max lights, both receivers), 423 mA (standby, min lights). Transmit (hi/med/low): 146 MHz, 8.2/4.5/2.6 A; 440 MHz, 9.6/5.8/3.3 A.
Minimum operating voltage: Not specified.	Operation confirmed at 11.7 V dc. RF output at 144 MHz, 41/19/4.9 W.
Receiver	**Receiver Dynamic Testing†**
FM sensitivity: (12 dB SINAD), 0.2 µV (137 – 150 MHz), 0.25 µV (150 – 174 MHz), 0.3 µV (174 – 222 MHz), 0.25 µV (222 – 300, 336 – 420 MHz), 0.2 µV (420 – 520 MHz), 0.4 µV (800 – 900 MHz), 0.8 µV (900 – 999.99 MHz).	FM (12 dB SINAD), 0.14 µV (144 and 440 MHz), 0.14 µV (WX), 0.85 µV (223 MHz), 0.65 µV (902 MHz).
AM sensitivity: 10 dB S/N, 0.8 µV (108 – 137, 300 – 336 MHz).	AM (10 dB S+N/N), 0.46 µV.
FM two-tone, third-order IMD dynamic range: Not specified.	20 kHz offset, 146 MHz, 60 dB*, 440 MHz, 58 dB*; 10 MHz offset, 146 MHz, 82 dB, 440 MHz, 76 dB.
FM two-tone, second-order IMD dynamic range: Not specified.	146 MHz, 91 dB, 440 MHz, 109 dB.
Adjacent-channel rejection: Not specified.	20 kHz offset, 146 MHz, 60 dB, 440 MHz, 58 dB.
Spurious response: Not specified.	IF rejection: 146 MHz, 118 dB; 440 MHz, >134 dB. Image rejection: 146 MHz, 92 dB, 440 MHz, 77 dB.
Squelch sensitivity: 0.16 µV (144/430 MHz).	At threshold, 146 MHz, 0.13 µV, 0.28 µV (max), 440 MHz, 0.12 µV, 0.32 µV (max).
S meter sensitivity: Not specified.	S-9, receiver A, 2.3 µV (144 MHz), 2.48 µV (440 MHz); receiver B, 2.11 µV (144 MHz), 3.12 µV (440 MHz).
Audio output: 3 W at 10% THD into 8 Ω.	2.3 W at 7.5% THD into 8 Ω (max output). THD at 1 V rms, 2.2%.
Transmitter	**Transmitter Dynamic Testing**
Power output: 50, 20, 5 W (hi, med, low).	146 MHz and 440 MHz, as specified.
Spurious signal and harmonic suppression: >60 dB.	≥70 dB. Meets FCC requirements.
Transmit-receive turnaround time (PTT release to 50% of full audio output): Not specified.	Squelch on, S-9 signal, 146 MHz, 60 ms; 440 MHz, 80 ms.
Receive-transmit turnaround time ("tx delay"): Not specified.	146 MHz, 60 ms; 440 MHz, 80 ms.
Size (height, width, depth): Control panel, 2.8 x 5.4 x 1.2 inches (including protrusions); main chassis, 1.7 x 5.5 x 5.9 inches. Weight, 2.7 lbs (panel, rear chassis, cable).	
Price: FTM-400DR, $695; BH-2A Bluetooth mono headset, $80; BU-2 Bluetooth adapter, $80; CD-40 charger cradle for BH-2, $25; PA-46B power supply for CD-40, $20.	

†Receiver A and B measured identically, unless noted. DV not tested; C4FM FDMA signal generator was not available.
*Measurement was noise limited at the value indicated.

channels can be selected for scanning or skipping, but I like being able to group otherwise disparate memories together in banks such as "Local Repeaters" or "Bike Event." Other Yaesu radios, including the FT1DR handheld, *do* have memory banks.

Also unusual: the memory system doesn't remember mode (FM, AM receive, and a couple of versions of digital that I'll detail later). That's because Yaesu emphasizes System Fusion, or the accommodation between analog and digital. They recommend using their *automatic* mode system that will select whatever mode is being received, and set the transmitter for that mode (except for AM, which is receive-only). That works well if someone else is talking first. But if you've been listening to a digital signal (so the mode is set to digital), and then dial in a *quiet* analog repeater in memory, you have to remember to change the mode yourself. If you don't, you'll give the repeater a blast of digital. (Like most digital systems, the C4FM digital transmission sounds like a buzzy noise on an analog receiver.) If the repeater uses just carrier squelch, all the listeners will be treated to your buzz. If the repeater uses tone squelch, it will remain quiet.

Tone frequency and tone mode are also not as "memorized" as in other radios, including other Yaesu radios. Memory channels *will* retain those parameters as you switch from one memory to another, but if you change a tone mode or frequency on the fly, the memory holds the change without being re-stored. Ditto the repeater offset. That's not a complaint! It's just a different way of doing things. But note that the FT1DR handheld *does* require re-storing a memory to learn a new CTCSS tone or offset. So if you adopt C4FM and acquire both radios, you'll have to keep the differences in mind. The '400 includes the usual CTCSS and DCS. Setting the mode (encode, encode/decode, DCS, and so on) and the parameters (CTCSS frequency, DCS code) are done in different menus.

There is a tone mode unique to some Yaesu radios. They call it Pager Mode, and it lets you be more selective in who will be alerted to your call. You can have the radio set off a bell when its code is received, and numerical codes can choose who the receiver is and identify the sender. Clever, but other brand radios can't join the fun, nor can my older Yaesu FT-8900.

Table 2
Yaesu FT1DR, serial number 3F030471

Manufacturer's Specifications	Measured in ARRL Lab
Frequency coverage: Receiver A, 0.5 – 30, 108 – 137 MHz (AM), 30 – 76, 137 – 999 MHz (FM, cellular blocked); 76 – 108 MHz (WFM); Receiver B, 108 – 137 MHz (AM), 137 – 580 MHz (FM); transmit, 144 – 148, 430 – 450 MHz.	Receive and transmit, as specified (774 – 803 MHz blocked).
Modes: FM, digital voice, data; AM and WFM (receive only).	As specified.
Power requirements: Receive, 150 mA (mono band receive), 220 mA (dual band receive), 45 mA, standby (battery saver on). GPS on, additional 30 mA. Digital mode, additional 60 mA. Transmit, 1.7 A (5 W, 144 MHz), 2.0 A (5 W, 430 MHz) at 7.4 V dc.†	Battery power, 8.4 V dc (full charge): Receive, 379 mA (max volume, backlight on, mono band receive); 272 mA (max vol, backlight off, mono band receive); 456 mA (max vol, backlight on, dual band receive); 48 mA standby. GPS on, additional 24 mA. Digital mode, additional 60 mA. Transmit, Hi/L3/L2/L1: 146 MHz, 1.68/1.06/0.73/0.44 A. 440 MHz, 2.0/1.29/0.84/0.42 A. External power, 13.8 V dc: Receive, 225 mA (max vol, backlight on mono band receive), 350 mA (max vol, backlight on, dual band receive).Transmit, Hi/L3/L2/L1: 146 MHz, 0.98/0.76/0.55/0.32 A 440 MHz, 1.26/0.92/0.61/0.3 A. Charging with external 13.8 V dc, 217 mA with power off.
Receiver	**Receiver Dynamic Testing***
Sensitivity, AM, 10 dB SN: 3 µV (0.5 – 30 MHz), 1.5 µV (108 – 137 MHz). WFM, 1.5 µV (76 – 108 MHz). FM, 0.35 µV (30 – 54 MHz), 1 µV (54 – 76 MHz), 0.2 µV (137 – 140 MHz), 0.16 µV (140 – 150 MHz), 0.2 µV (150 – 174 MHz), 1 µV (174 – 222 MHz), 0.5 µV (300 – 350 MHz), 0.2 µV (350 – 400 MHz, 0.16 µV 400 – 470 MHz),1.5 µV (470 – 540 MHz), 3 µV (540 – 800 MHz), 1.5 µV (800 – 999 MHz).	Receiver A, AM, 10 dB S+N/N: 0.71 µV (1 MHz), 0.66 µV (15 MHz), 0.59 µV (29 MHz), 0.56 µV (120 MHz). WFM, 12 dB SINAD: 0.8 µV (100 MHz). FM, 12 dB SINAD :0.18 µV (52 MHz), 0.17 µV (146 MHz), 2.75 µV (222 MHz), 0.17 µV (440 MHz), 1.4 µV (902 MHz). Receiver B, AM 10 dB S+N/N: 0.6 µV (120 MHz). FM, 12 dB SINAD: 0.18 µV (146 MHz), 3.1 µV (223 MHz), 0.18 µV (440 MHz).
FM two-tone, third-order IMD dynamic range: Not specified.	Receiver A, 20 kHz offset, 61 dB (146 MHz), 59 dB (440 MHz). 10 MHz offset, 79 dB (146 MHz), 61 dB (440 MHz). Receiver B, 20 kHz offset, 58 dB (146 MHz), 63 dB (440 MHz). 10 MHz offset, 73 dB (146 MHz), 61 dB (440 MHz).
FM two-tone, second-order IMD dynamic range: Not specified.	Receiver A, 91 dB (146 MHz), 101 dB (440 MHz). Receiver B, 91 dB (146 MHz), 100 dB (440 MHz).

Figure 2 — The FTM-400DR set up for full rate data communication on Band A (top) and analog FM voice on Band B. There are independent volume controls and dial knobs for each band. The functions of the buttons along the bottom of the touchscreen can be changed by the user.

Manufacturer's Specifications	Measured in ARRL Lab
Adjacent-channel rejection: Not specified.	20 kHz offset: Receiver A, 67 dB (146 MHz), 63 dB (440 MHz). Receiver B, 67 dB (146 MHz), 55 dB (440 MHz).
Spurious response: Not specified.	IF rejection: Receiver A, 98 dB (146 MHz), 102 dB; (440 MHz). Receiver B, 107 dB (146 MHz), 128 dB (440 MHz). Image rejection: Receiver A, 94 dB (146 MHz), 53 dB (440 MHz). Receiver B, 101 dB (146 MHz), 74 dB (440 MHz).
Squelch sensitivity: Not specified.	At threshold, Receiver A, 146 MHz and 440 MHz, 0.13 µV (min), 0.31 µV (max). Receiver B, 146 MHz, 0.14 µV (min), 0.26 µV (max), 440 MHz, 0.15 µV (min), 0.28 µV (max).
S-meter sensitivity: Not specified.	S-9 indication, Receiver A, 4.67 µV (146 MHz), 5.75 µV (440 MHz). Receiver B, 5.75 µV (146 MHz), 5.55 µV (440 MHz).
Audio output: at 10% THD, 200 mW with 8 Ω load at 7.4 V dc; 400 mW at 13.8 V dc.	10% THD with 8 Ω load: 382 mW at 8.2 V dc, 419 mW at 13.8 V dc. THD at 1 V rms, 1.9%.
Power output: 5.0 W (Hi), 2.5 W (L3), 1.0 W (L2), 0.1 W (L1).	Battery power, 8.4 V dc Hi/L3/L2/L1: 146 MHz, 4.5/2.5/1.0/0.12 W 440 MHz, 3.9/2.3/0.8/0.08 W. External 13.8 V dc input, Hi/L3/L2/L1: 146 MHz, 5.2/2.5/1.0/0.1 W 440 MHz, 5.0/2.3/0.8/0.08 W.
Spurious signal and harmonic suppression: ≥60 dB (Hi/L3 L2), ≥50 dB (L1).	As specified. Meets FCC requirements.
Transmit-receive turnaround time (PTT release to 50% of full audio output): Not specified.	Squelch on, S-9 signal, 146 and 440 MHz, 80 ms (Receiver A and B).
Receive-transmit turnaround time ("tx delay"): Not specified.	146 MHz, 25 ms, 440 MHz, 30 ms. (Receiver A and B).

Size (height, width, depth): 4.2 x 2.6 x 1.2 inches (including protrusions); antenna, 6.9 inches.
Weight: 9.0 ounces (with battery and antenna).

Price: $430. MH-85 hand microphone with camera, $135.

†FNB-102LI 7.4 V, 1800 mAh Li-ion battery and PA-48B wall charger supplied. Available options: extra FNB-102LI battery, $75; FNB-101LI 7.4 V, 1100 mAh Li-ion battery, $60; CD-41 drop-in charger cradle, $40; FBA-39 battery case for 3 AA cells, $35; SDD-13 cigarette lighter dc power cable with filter, $25.
*DV not tested; C4FM FDMA signal generator was not available.

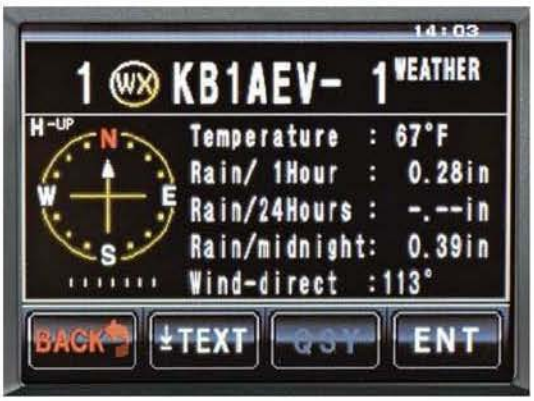


Figure 3 — The FTM-400DR receiving weather information via APRS.

The microphone that ships with the '400 is Yaesu's old standby, the MH-48. In addition to the usual 16-button array for DTMF in transmit and frequency entry in receive, the A-B-C-D buttons are assigned to select the operating band (A and B), take the dial to the squelch-level function (C), and toggle through the four main display options (D). Four more P buttons can be programmed by you to get to specific settings or options faster than stepping through menus. The '400 also has five levels of transmit audio gain.

Wrapping up this radio's take on conventional features, the '400 has the usual range of scanning options for hold and resume times, lockouts, and so on. The *resume* time (how long it waits to begin scanning after it stops on an active channel) can be set to 1, 3, or 5 seconds. The *hold* time (how long it waits after the signal drops) is fixed at 2 seconds. I'd like to see more (longer) options. There are nine upper/lower limits for VFO scanning, and the HOME channel can be checked every 3 seconds for activity (called DW, or Dual Watch). If the HOME channel is quiet, doing this briefly flashes the display to the HOME channel and takes a little hole out of the audio. Finally, the minimum setting of the time-out timer is 5 minutes, but could be shorter because many repeater timers are 3 minutes.

APRS on the FTM-400DR

The FTM-400DR includes a packet modem and firmware for APRS operation, and a built-in GPS receiver (with a jack for an external GPS receiver but no provision for using just an external antenna). The settings and menus for APRS are extensive, letting you send a beacon after you've made a turn, and sending beacons more often when you're moving quickly than when you're moving slowly. But like the FTM-350 it replaces, the '400's packet capability begins and ends with APRS. If you want to do more, the mini-DIN on the back is designed to interface with an external modem/TNC.

APRS operation is fun. The display can be set to show a screen whenever a new or updated APRS signal is received. That screen includes the call sign, distance, direction, speed, altitude, and message or weather info being sent by the transmitting station (see Figure 3). Or you can watch the compass rose to see the call sign, direction, and distance for every signal as it's received.

The on-screen keyboard lets you compose a message, and the radio logs incoming and outgoing messages and the most recent 100 call signs received. APRS can run in the background (though it does tie up the B Band) with minimal disruption while you play FM or C4FM on the A Band.

C4FM Digital Voice

Yaesu's digital voice mode, C4FM, isn't compatible with any of the other digital voice systems in common use in Amateur Radio. Okay, you probably knew that. Well, it isn't *proprietary*, either. Yaesu uses a newer version of the AMBE vocoder chip that Icom used for D-STAR (the most recent Icom models do their vocoding in software without the chip, but still licensed through DVSI). As with D-STAR, anyone can buy them, and Yaesu says the protocol will be published, so anyone can be compatible.

Yaesu says they chose C4FM because it is newer and better. I can't debate that (other, more technical hams do). I've been listening to it for a while now, and I can say, "It sounds digital." All of the digital voice modes, including C4FM, offer high clarity and near zero background noise down to the threshold. All sound a little different.

I rounded up some hams to do a very *un*-scientific test between handhelds at low signal levels, and the performance was also similar. The biggest difference I hear is at the margins, when signals are weak, the bit error rate gets high, and the voice garbles. D-STAR and C4FM can sound pretty rough. APCO-25 and DMR handle it a little more gently.

But mostly C4FM works fine. I think it's more important to focus on what Yaesu is *doing* with their digital system, and compare as much of that as I can to D-STAR (I'm not familiar enough with DMR to do it justice). And the first thing to repeat is that Yaesu is trying very hard to attract analog FM users. That's the essence of System Fusion.

The DR-1 Repeater

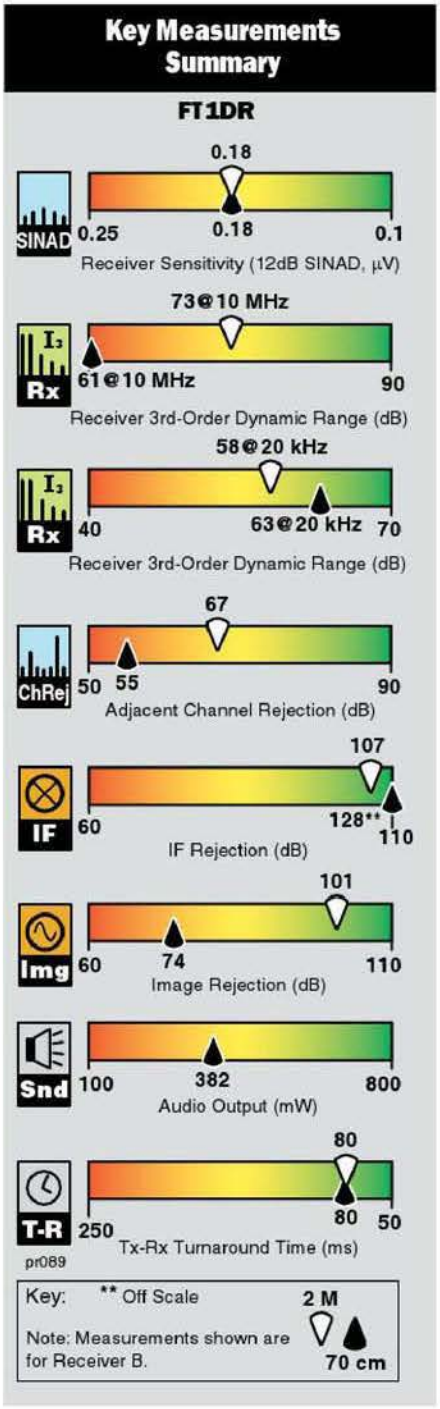
Repeaters are vital to VHF/UHF FM and to digital voice. Alinco introduced a ham radio digital voice handheld about 15 years ago, but with no repeaters to provide area-wide coverage, it was pretty much a novelty. Icom's D-STAR launch came complete with repeaters and an Internet linking system. While the user radios were also high-end analog FM radios, the D-STAR repeaters were digital-only. The system occupied only 6.25 kHz of spectrum, compared to about 16 kHz for FM, and 12.5 kHz for the other digital modes, including Yaesu's C4FM. That allowed frequency coordinators to squeeze D-STAR repeaters into geographic areas without available spectrum for another analog or wider digital mode repeater.

During my review period, Yaesu released some of its DR-1 repeaters to volunteers for a beta test, and one of them went on the air in my area. While the hams who received the repeater agreed not to release their results until the trial was over, I could at least see how the radios and repeaters performed together.

Yaesu designed the DR-1 to be a drop-in replacement for an existing VHF or UHF repeater. It will interface to existing controllers and run analog FM, and then there are some options for integrating C4FM. The first option is that users who have a C4FM radio can transmit to the repeater in digital, while the repeater continues to output analog FM — it simply demodulates the digital signal and the applies the decoded voice to the FM modulator. Analog and digital users can talk to each other in the same conversation.

There's no huge advantage to this technically. The digital signal is noise-free *to* the repeater, but the digital user is still listening in analog, and that analog output still lacks the crispness of a fully digital signal. The digital radios don't currently have a mode that locks transmit to digital and receive to analog. In "automatic" mode, when the radio receives an analog signal, the transmitter switches to analog, too. The local guy's workaround was to *transmit* in digital on Band A, while *receiving* in analog on Band B. The analog-digital hybrid avoids the social stigma of being exclusionary, while introducing the concept of digital to the analog users. At least, that's the plan.

The second option is to repeat analog signals as analog, and digital signals as digital. They occupy the same frequency, and it's one-at-a-time, or first-come, first-served. The repeater can't do both analog and digital at the same time. In this beta test, the users didn't have control over which mode the repeater would be in, but I'm guessing it could eventually be a user option. APCO-25 repeaters have been dual-mode since their beginning, though I'm not aware of any that ran digital-in, analog-out.



The dual mode repeater gave me a good chance to compare analog and digital performance. I was far enough from the repeater that a 100 mW signal was pretty noisy in analog. At "pretty noisy," I could switch to digital and have a good, mostly garble-free signal. Taking advantage of multipath, I could move a few inches and go from "pretty noisy" to "very noisy."

At that point, the digital signal was either mostly garbled, or not there at all. Now this wasn't in a lab, and multipath can affect analog and digital signals differently. But my results match what just about everyone reports — that a well-modulated analog signal can be copied a little below the point that a digital signal drops out. I wonder how much longer that will be the case? The ARRL Lab is working on tests that will hopefully answer that question.

When the DR-1 is used in fully-digital mode, though the analog-only users will not be able to listen to the conversation. On an analog receiver, the audio will be just that buzzy rush of noise. To avoid listening to the noise while still being able to monitor the repeater for analog use, every user will need to use tone-decode, either CTCSS or DCS depending on what the repeater tech set up for the repeater output. Technically and operationally, this is not a big deal.

Yaesu has announced, but at press time had not begun shipping, an updated version of their *WIRES* Internet linking system called *WIRES-X*. There are menus for using it in the FTM-400DR and FT1DR, but the radio's manual points the user to a downloadable *WIRES-X* manual, not yet released as I complete this review. The *WIRES* system is popular in Japan, but in the rest of the world IRLP and Echolink are the VoIP repeater networking systems of choice.

Other Digital Capabilities

Yaesu's digital signal is 12.5 kHz wide, and the data rate is also double D-STAR's at 9600 bits per second. From the user's perspective at least, Yaesu allocates it a little differently. D-STAR users sometimes complain that the 1200 bits of ASCII is wasted when they're not sending any data (which is most of the time in a voice conversation). If they have a GPS connected, they're sending that in the ASCII stream (and the newest Icom radios have built-in GPS, so they'll be doing more of that). But their point is they would have liked the option to dedicate *all* of their signal to voice to sound better, or all to data if they wanted to make *D-RATS* as efficient as possible.

Note that D-STAR does have an all-data version, but it's not part of Icom VHF/UHF radios. Yaesu caught that, and offers users the DN and VW modes. The manual never really expands the initials into words, but I think of them as "Digital Narrow" and "Voice Wide" although in both modes the RF signal is still 12.5 kHz wide. (The manual refers to DN as simultaneous voice/data communication mode, and VW as voice full-rate mode.) In DN mode, the voice audio isn't as full fidelity as VW because it's sharing the bits with error correction and a data field. VW uses the whole pie for voice. And yes, it sounds noticeably better.

In DN, the Yaesu radios send the user's call sign and its GPS position. The '400 mobile displays the call sign and the distance to the received station, if everybody's GPS is getting a fix. The FT1DR makes you hop to another display to get the distance. The mobile uses the S meter's space to display that information, so there's no signal-strength reading when copying a digital signal — just when you need it because you can't "hear" how strong a signal is. In VW, you get the call sign, but no distance info. On both mobile and handheld, you can switch to a compass rose display to see the direction and distance. You can store that info, or your own location, and use it to track your way to that location. Same for APRS stations. Lots to play with.

Send a Message...

How about that ASCII data? Icom makes you hook up an external device (a computer, maybe a tablet or phone today) into their serial port to tap that D-STAR stream and send to or read from it. Yaesu lets you blip in a message (80 characters max) with their on-screen keyboard. On the FT1DR you either twist the knob to scroll through the alphabet one letter at a time, or use the keypad like you did for text messages on an older cell phone.

The receiving station reads the text message right on their screen. I believe you need to stick in a micro-SD card for this to work. The manual wasn't specific about that, but that was the missing ingredient when I tried to do it. Words are broken at the end of a line with nary a hyphen to enhance readability, but it works. The messages stack up on the micro-SD card.

So far, so good on data use. But when I went looking for a way to use Yaesu's data stream from my *computer*, I couldn't find it. There are ports and plugs for cloning and programming and stuff, but nothing leads to that data. At least not yet. I wouldn't be surprised if Yaesu introduces an update to add it.

Both radios can be updated with software in the field. I performed an update on the FT1DR, and it was pretty easy. Hint: Heed Yaesu's warning to install their driver before connecting the data cable to your computer. Hint #2: Read the update instructions all the way to the end to find out how to check what the current version of firmware is in the radio because you may not need the update. Hint #3: The instructions say to use an external power supply, not the battery, during the update. If the battery dies mid-update, you could brick the radio.

One more thing about that messaging. On the FT1DR, you have to join a group to do it using Group Monitor (GM). Turn it on (it forces digital mode, doesn't work in analog) and the radio starts pinging to let anyone in receiving range (who also has their GM turned on) know you're there. On the receiving end, you see a list of everyone you hear, and you can "register" stations into groups. The radios continue to ping about every 20 seconds, and all this chatter serves to let you know who's still in range. If the '400 has heard from you lately, your call sign is lit up green (Figure 4). On the FT1DR, it's highlighted in black. Fall out, and you turn gray.

Figure 4 — In the Group Monitor mode, call signs of stations in range (W1AW) are highlighted in green.

... And Get the Picture

The optional MH-85 camera-mic (Figure 5) plugs into that little DATA jack on either radio. It works just like a speaker-mic, and it has a camera built in. There's no viewfinder. The '400 mobile can show you what you've just snapped (Figure 6), and if it wasn't quite right you can try again. On the FT1DR you're flying blind. There are no adjustments beyond image size and quality (not that great compared to a typical cell phone camera). File sizes are correspondingly small, and when you're sending this across the very limited bandwidth of the C4FM signal, size = time. The larger (320 × 240 pixels), better quality image takes about 30 seconds to send in DW mode. On the SD card, they are standard JPEGs.

Wait, DW Mode? Didn't I mention that earlier, as Dual Watch? This DW mode, which the manual refers to as "data full rate" is automatically selected when you send a photo. If you're in VW, a picture will go out as DW (I'm dubbing it Digital Wide...still unofficial). The manual's a little skimpy here, but I believe that when I sent a picture in DN, the picture seemed to take longer to transfer. Maybe. Again, I wouldn't be too surprised if full user access to the fastest (9600 bps) data stream became available some day.

And oh, yes, using Group Monitor, you can direct a text or picture to one specific radio.

Figure 5 — The MH-85 microphone includes a camera that can be used to snap and send photos with the FTM-400DR or FT1DR. The lens is in the top.

Figure 6 — A photo snapped with the MH-85 camera/mic, transmitted with the FT1DR, and received by the FTM-400DR.

About that Handheld...

The FT1DR (Figure 7) is fairly bristling with buttons on its face, and ports and more buttons on its sides, but only one knob. There are no connectors on top — the GPS antenna occupies the space between the rubber antenna (SMA male on the radio body) and knob. The left edge has PTT, MONItor (opens the squelch), VOL (hold and turn the knob to adjust the volume, or one quick press to mute), and ON-OFF/LOCK. The right edge has ports for a speaker mic, dc/charging, and a data connector that the camera-mic plugs into (and where I plugged in the included data cable when I updated the firmware). Below that is the slot for the micro-SD card.

On the front are the display (plenty readable, but not color or touch screen), busy lights for the A and B sides, and 18 more buttons, including the 16-button DTMF pad that doubles, triples, and maybe even quadruples for other functions. And a speaker. And yet the whole thing is tiny.

The bottom of the radio has rubber feet. Set it down and it grabs the table. You can still knock it over easily (top-heavy with the rubber antenna sticking up), but it won't slide.

Here are the important differences in the FT1DR. I already mentioned that its memory system hangs on to tone and offset a little tighter than the FTM-400 (you have to re-store a memory to get them to stick). There are 900 memory channels (*shared* between A and B sides, but digital only on A, and APRS only on B), and a bunch of other memory options, including 24 banks that hold 100 memories each.

It does have tone scan and a tone mode icon on the display. Alphanumeric names appear in small type below the frequency readout, and only when the radio is in mono-band mode (you can make the second band go away). You can't make the radio show *only* the alpha label. Too bad, because the alpha label holds an awesome *15 characters!*

The radio receives AM, FM and SW broadcast, almost dc to daylight (no SSB, and you'll need a little more than the rubber antenna for HF shortwave). The options for scan-resume are more generous (up to 10 seconds). Time-out timer options start at

Figure 7 — The FT1DR is tiny considering its extensive list of capabilities and features.

30 seconds. The noise-squelch level adjustment is buried deep in menus. The feature list is nearly endless, but I don't think I've missed any of the go-no-go stuff. The rest is just nice candy in a sweet radio.

The LOCK button locks the volume control, along with everything else. The knob does nothing when the radio is locked (and LOCK is a quick press of the power button on the side — nice!). It would be convenient if, when the radio is locked, the knob became a volume control, turning the nearly two-handed volume adjustment into an easy one-hander.

Editorial (A New Hope)

Not long ago I was a little unhappy at the thought of splintering Amateur Radio digital voice into a bunch of incompatible formats. Now I realize that this is the way of things. There is no question that digital moves fast and develops in many different ways. The big, plasma digital TV in the living room that I bought in 2007 is obsolete compared to what's available today.

Ham radio moves a lot slower. We are 99% analog in a 98% digital world. We won't change overnight, but at least some of our future will be tied to digital, and we can't get there with radios that do only one form of digital and never anything else. Yaesu says their C4FM is better, newer. How long until someone else introduces the next best thing? I am very glad they embraced digital — it sends a message to the ham radio world that we have a future, not just a glorious past. I do hope, though, that the manufacturers are looking into designing radios that will do multiple digital formats, easily upgradable when new ones are invented (and they will be).[2]

Each of the digital systems has a fan base that will adopt their systems. They may all thrive, or maybe one will "win." I hope, though, that hams will take a longer view, and look closely at the kinds of technology that will be fun today, fun tomorrow, and help us reach our future.

Manufacturer: Yaesu USA, 6125 Phyllis Dr, Cypress, CA 90630; tel 714-827-7600; **www.yaesu.com**.

[2]At press time, Connect Systems, Inc. (**www.connectsystems.com**) is working on a handheld that will operate with as many digital systems as they can license, including D-STAR, DMR, and possibly P25. And Whitebox, under development by Bruce Perens, K6BP, and Chris Testa, KD2BMH, is envisioned as a software defined radio that will do any digital mode they can license, but featuring a VHF/UHF version of *FreeDV* using CODEC2.

Click here for a video overview of the Yaesu FTM-400DR mobile transceiver and FT1DR handheld.