

AMATEUR DIGITAL VOICE

The Six Modes, and How to Start

A 30-minute introduction for hams new to the digital modes

Presented by _____

AGENDA

What this covers

1

It is really about the internet

The part nobody says out loud

2

Where to point the radio

Two bands, and a surprising reason

3

The six modes

Where each came from, and what makes it itself

4

Six vocabularies, six ideas

Why they feel harder than they are

5

Which one, and how busy is it

The honest answer, including the quiet ones

6

What trips everyone up

Five things that cost people their first evening

START HERE

It is really about the internet

The magic is not the modulation. It is that your repeater or hotspot links over the internet to the whole world.

WHAT YOU THINK YOU ARE BUYING

A radio that sounds different

Clearer audio, a screen with names on it, and a mode your friend keeps talking about.

WHAT YOU ARE ACTUALLY BUYING

A door into a network

With a handheld and a decent connection you can hold an ordinary conversation with someone across an ocean — from indoors, on a few milliwatts.

Get your head around that one idea and everything else in this talk follows from it.

WHERE IT LIVES

Two bands. That is the whole answer.

Buy a dual-band digital radio and a hotspot and you are equipped for essentially all of amateur digital voice.

70 CENTIMETRES

420 – 450 MHz

Dominant. Most repeaters, nearly all hotspots, all six modes.

2 METRES

144 – 148 MHz

Major. D-STAR, DMR and Fusion repeaters in quantity.

Everything else is a footnote.

33 cm is a real but niche corner. 23 cm is D-STAR's quiet home. 1.25 m deserves better than it gets. Below 6 m there is essentially nothing, and there are good reasons for that.

70 cm did not win on merit

It won because of where somebody else's business happened to be.

1

Commercial land mobile lives at 400–470 MHz

Taxi fleets, utilities, warehouses, public safety — licensed on that band, all of them.

2

So that is where the factories built

Motorola, Hytera, Kenwood and Icom made radios there by the million — and repeaters, duplexers and antennas with them.

3

So that is where the cheap hardware is

New and surplus. A ham buying a 70 cm digital radio is buying into somebody else's economy of scale.

4

So that is where the hobby went

The same story runs at 136–174 MHz, which is exactly why 2 m is the strong second.

Digital voice did not pick its home. It moved in where the rent was cheap.

THE SIX MODES

Six modes, and only one was built for us

Amateur radio has not one digital voice mode but a family of them, each born in a different decade for a different reason.

BORROWED FROM INDUSTRY

DMR · NXDN · P25

Commercial and public-safety standards. Hams adopted them because the radios already existed and were cheap.

BUILT FOR HAMS, BY ONE MAKER

D-STAR · C4FM

D-STAR from JARL and Icom, Fusion from Yaesu. Designed for the hobby — but each with essentially one manufacturer behind it.

BUILT BY HAMS, IN THE OPEN

M17

Open protocol, open codec, open hardware. The only one of the six where the whole stack can be read, studied and changed.

That one distinction explains most of what follows — the vocabulary, the prices, the closed codecs, and why M17 exists at all.

D-STAR — the pioneer

ORIGIN

JARL and Icom, ~2001

VOCODER

AMBE

SIGNATURE TRAIT

Callsign routing

- Where amateur digital voice began. Developed in Japan around the turn of the millennium as an open standard by JARL, the Japanese national society, and brought to market almost entirely by Icom.
- Its voice channel carries your callsign in every transmission — which is what makes callsign routing possible. A gateway can route a call to a specific station by their call, anywhere in the world.
- Far more common today is linking a repeater or hotspot to a reflector — REF, XRF, DCS and the modern XLX — where many systems meet in one conversation. That architecture is the template every later mode borrowed.
- It can sound slightly more robotic than newer modes — the price of being first.

DMR — the commercial standard hams adopted

ORIGIN

ETSI, 2005

VOCODER

AMBE+2

SIGNATURE TRAIT

TDMA: two conversations, one channel

- A European commercial standard, published by ETSI in the mid-2000s for business and professional radio. Hams adopted it for one simple reason: the radios are everywhere and inexpensive.
- Its signature trait is TDMA — two time slots alternating on one frequency, so a single repeater carries two independent conversations at the same time. No other mode here does that.
- Today it is the most popular amateur digital voice mode, with worldwide networks — BrandMeister, TGIF, FreeDMR and others — organised around talkgroups.
- The price of admission is the codeplug. Programming the radio is where nearly everyone gets stuck first, and it is the honest reason some people give up.

C4FM / System Fusion — the gentle on-ramp

ORIGIN

Yaesu, 2013

VOCODER

AMBE+2

SIGNATURE TRAIT

AMS: analog and digital share one channel

- Yaesu's digital mode, launched in 2013, transmitting C4FM — four-level FSK — and speaking the same AMBE+2 vocoder as DMR.
- Its signature trait is Automatic Mode Select. A Fusion repeater or radio hears analog FM and digital C4FM on the same channel and answers each in kind.
- That made it the gentlest upgrade path ever offered to a club: replace the analog repeater with a Fusion machine and the analog operators never lose access. Nobody has to be told their radio no longer works.
- Networking comes in two flavours — Yaesu's own Wires-X, and the open YSF reflector world the hotspot community built around the protocol. That split confuses newcomers more than anything else about the mode.

P25 — the public-safety mode

ORIGIN

APCO, 1990s

VOCODER

IMBE (Phase 1)

SIGNATURE TRAIT

Professional gear, professional standard

- APCO Project 25 is the North American public-safety digital standard — police, fire and EMS across the continent.
- The widely used Phase 1 speaks IMBE on FDMA: one 12.5 kHz channel, one conversation, no time slots. Phase 2 adds two-slot TDMA and AMBE+2, but it is a public-safety feature rarely seen on the ham bands.
- Hams run it almost entirely on surplus commercial gear — used Motorola and other public-safety radios that reach the used market as agencies upgrade. That gives the mode its flavour: rugged hardware and a strong crossover with the scanner world.
- One quiet advantage: the IMBE patent has expired, so P25 transcodes in free software. No dongle required — which is not true of the AMBE family.

NXDN — the narrow one

ORIGIN

Icom and Kenwood, ~2006

VOCODER

AMBE+2

SIGNATURE TRAIT

6.25 kHz — the narrowest in common use

- A commercial standard developed jointly by Icom, as IDAS, and Kenwood, as NEXEDGE, in the mid-2000s.
- Its signature trait is bandwidth. NXDN's narrow mode fits a voice channel into 6.25 kHz — a quarter of a classic 25 kHz analog channel, and half of everything else in this talk.
- In the commercial world that meant more channels in the same spectrum. In the amateur world it makes NXDN the quiet efficiency champion — capable, clean, and running on solid surplus hardware.
- The honest problem is company. It has one of the smallest operator pools of the six, and a capable mode with nobody on it is still a mode with nobody on it.

M17 — the open-source newcomer

ORIGIN

The ham community, ~2020

VOCODER

Codec 2 (open)

SIGNATURE TRAIT

Open at every single layer

- The youngest mode here and the only one designed by hams, for hams, from scratch — an open-source project started around 2020 by Wojciech Kaczmarek, SP5WWP, and a growing community.
- The specification is public, the reference implementations are open source, and — the part that matters most — it uses Codec 2, a free and open vocoder, instead of the patented AMBE family every other mode here depends on.
- No licence fees, no proprietary chips, nothing you cannot study or improve. It was built so the transcoding problem would never need a hardware dongle at all.
- It is the smallest community here and the one moving fastest. Full-duplex repeater hardware is scarce, so it lives largely on hotspots rather than hilltops.

THE SIX MODES

All six, side by side

MODE	ORIGIN	VOCODER	SIGNATURE TRAIT
D-STAR	JARL / Icom, ~2001	AMBE	Callsign routing; the original reflector world
DMR	ETSI, 2005	AMBE+2	Two time slots on one frequency; cheap radios
C4FM	Yaesu, 2013	AMBE+2	Analog and digital share one channel
P25	APCO, 1990s	IMBE	The professionals' mode, on surplus pro gear
NXDN	Icom + Kenwood, ~2006	AMBE+2	Ultra-narrow 6.25 kHz channels
M17	Ham community, ~2020	Codec 2	Open source at every layer

Look down the vocoder column. That one column explains more about this hobby than any other fact in this talk — and the next section is why.

Six vocabularies. About six ideas.

A newcomer is handed Color Code, DG-ID, RAN, NAC, CAN. Five terms, five modes, and nobody says the obvious thing.

They are all the same thing.

Every one of them is the digital descendant of CTCSS — a code that says this transmission is for this system, so a radio can ignore everything else. Five terms collapse into one idea, and you have four fewer things to learn.

The whole of digital voice works like this. There are about six concepts underneath all six modes. What varies is almost entirely the words.

When a DMR operator says “talkgroup” and a D-STAR operator says “reflector module,” they are describing the same room.

CONCEPT ONE

Who you are

Every transmission has to say who sent it. The modes disagree entirely about what form that answer takes.

	DMR	D-STAR	C4FM	NXDN	P25	M17
Identity	DMR ID	Callsign	Callsign	Unit ID	Radio ID	Callsign
Form	a number	—	—	a number	a number	in the stream

The split down the middle is numbers versus callsigns — and it has one enormous consequence.

A number has to be issued by somebody. That is the entire reason RadioID.net exists. If a network routes on numbers, someone must hand them out and prevent collisions. If it routes on callsigns, nobody needs to — yours was issued years ago.

The registry is not a policy choice. It is a mathematical consequence of the identity format.

CONCEPT TWO

What lets you in

This row causes more confusion than any other, because people mistake it for the row before it.

	DMR	D-STAR	C4FM	NXDN	P25	M17
Access code	Color Code	—	DG-ID	RAN	NAC	CAN

Five different names. One idea. All of them are CTCSS wearing a digital hat.

WHAT IT DOES

A repeater or radio ignores traffic that does not carry the matching code. It is not security — anyone can set it and it is not secret. It is a filter, so two systems sharing a frequency do not open each other's squelch.

THE TRAP

This is a gate, not a badge. It says nothing about who you are. An operator who calls their DG-ID their “Fusion ID” has crossed row one and row two — and that mistake is extremely common.

D-STAR is the odd one out with no access code at all — its gating happens through callsign routing and gateway registration instead.

CONCEPT THREE

The room you are talking in

Where does your voice go once it leaves the repeater? Here the words diverge most violently.

	DMR	D-STAR	C4FM	NXDN	P25	M17
Destination	Talkgroup	Reflector + module	Room, or DG-ID	Talkgroup	Talkgroup	Reflector + module
Addressed by	a number	a letter	depends	a number	a number	a letter

THREE AND TWO

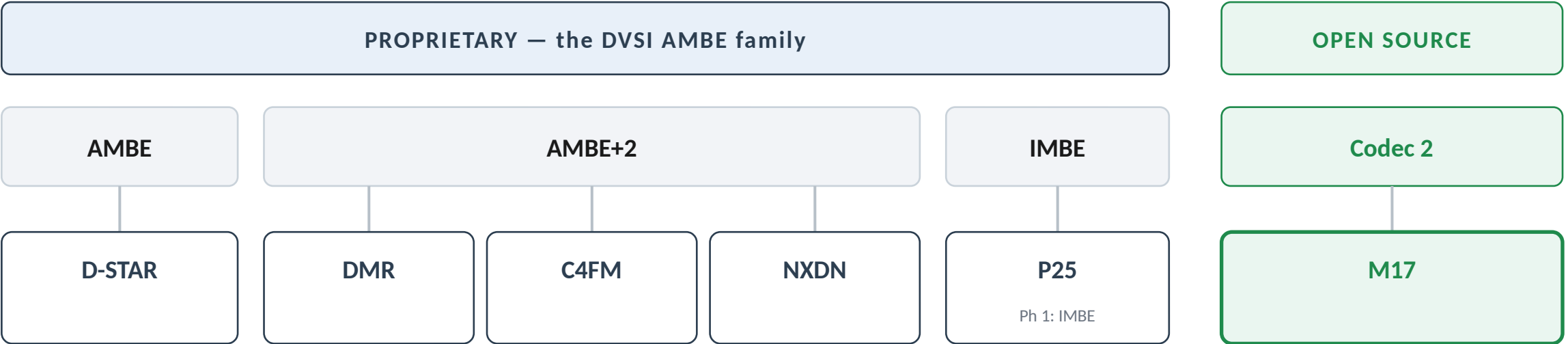
Three modes call it a talkgroup and address it with a number. Two call it a reflector module and address it with a letter. Different word, same thing: a shared meeting place you connect to and disconnect from.

AND THEN THERE IS C4FM

DG-ID appears in this row and the previous one. On some systems it gates access; on others it also selects the destination. That double duty is real, not a mistake in the table — and it is exactly why C4FM and DMR operators talk past each other.

The voice itself

Underneath every digital voice mode is a vocoder — the thing that turns speech into bits. It is the hinge the whole digital voice world turns on.



- Why some bridges are free: DMR, C4FM and NXDN all speak AMBE+2, so the bits pass straight through.
- Why D-STAR is awkward: older AMBE, so the audio must be decoded and re-encoded — and the AMBE family is still licensed, which is why a hardware dongle turns up.
- Why P25 is different but not expensive: IMBE's patent has expired, so it transcodes in free software.
- Why M17 exists: Codec 2 is free and open from the ground up. It was built so the row would never need a dongle at all.

CONCEPT FIVE

How the channel is shared

Two radios cannot occupy the same space at the same time. There are only two answers.

TDMA — DMR ALONE

Two conversations take turns



One 12.5 kHz channel, split into two alternating time windows.
This is why DMR, alone, has time slots.

FDMA — THE OTHER FIVE

One channel, one conversation



D-STAR, C4FM, NXDN, P25 and M17. No slots. Simple, continuous,
and exactly how the systems they came from operate.

A time slot is not a digital voice concept. It is a DMR concept.

If you have been hunting for the time slot setting on your Fusion radio, this is why you cannot find it. There isn't one, and there was never meant to be.

Everything, on one screen

	DMR	D-STAR	C4FM	NXDN	P25	M17
Who you are	DMR ID	Callsign	Callsign	Unit ID	Radio ID	Callsign
What lets you in	Color Code	—	DG-ID	RAN	NAC	CAN
The room you're in	Talkgroup	Reflector	Room / DG-ID	Talkgroup	Talkgroup	Reflector
The vocoder	AMBE+2	AMBE	AMBE+2	AMBE+2	IMBE	Codec 2
Channel access	TDMA	FDMA	FDMA	FDMA	FDMA	FDMA
Registry needed	Yes	Gateway reg.	No	Yes	Yes — DMR's	No

This is the slide to photograph. Learn the six rows and the vocabularies stop mattering.

When someone says NAC, you hear access code. When someone says Unit ID, you hear identity. When someone says reflector module, you hear the room.

Where the words actively mislead you

Two modes using the same word for different things is far more dangerous than two modes using different words for the same thing.



“Radio ID” means two opposite things

In P25 it is your identity — on the ham bands, your DMR ID. In C4FM it is a factory-burned hardware serial you cannot change and which is not your identity at all.



DG-ID does two jobs

It gates access and it selects a destination, depending on the system. No other mode's access code does this, and it is the biggest single source of C4FM confusion.



“Reflector” is not one thing

D-STAR, M17, YSF and XLX reflectors are all called reflectors and none are interchangeable. The word describes a role — a server that fans one transmission out to many — not a standard.



Not every “ID” is a registration

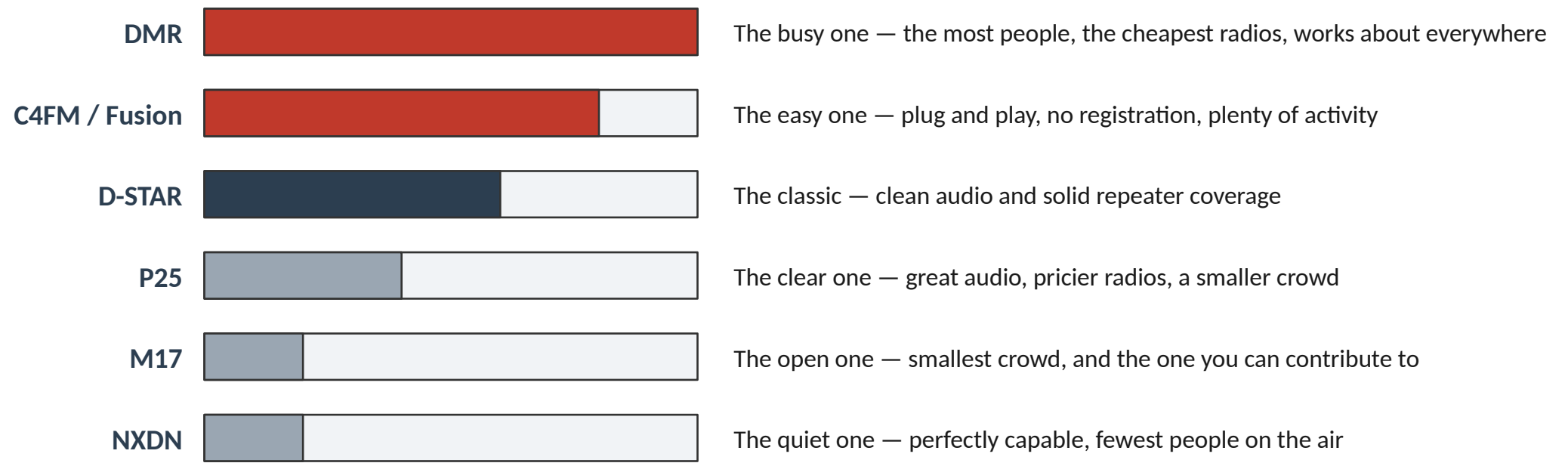
C4FM asks for none. M17 asks for none. P25 asks for one but it is DMR's. D-STAR registers but issues no number. Only DMR and NXDN work the way a newcomer expects.

CHOOSING

How busy is each one, honestly

There is no best mode — only the best mode for you, and that usually means whichever one your local repeaters and friends already run.

PEOPLE TO TALK TO — one operator's honest rating, mid-2026



These ratings mix fact and judgment — activity and radio cost are countable, audio quality is not. Treat them as one operator's honest starting point, then go and listen for yourself.

CHOOSING

Where the radios actually come from

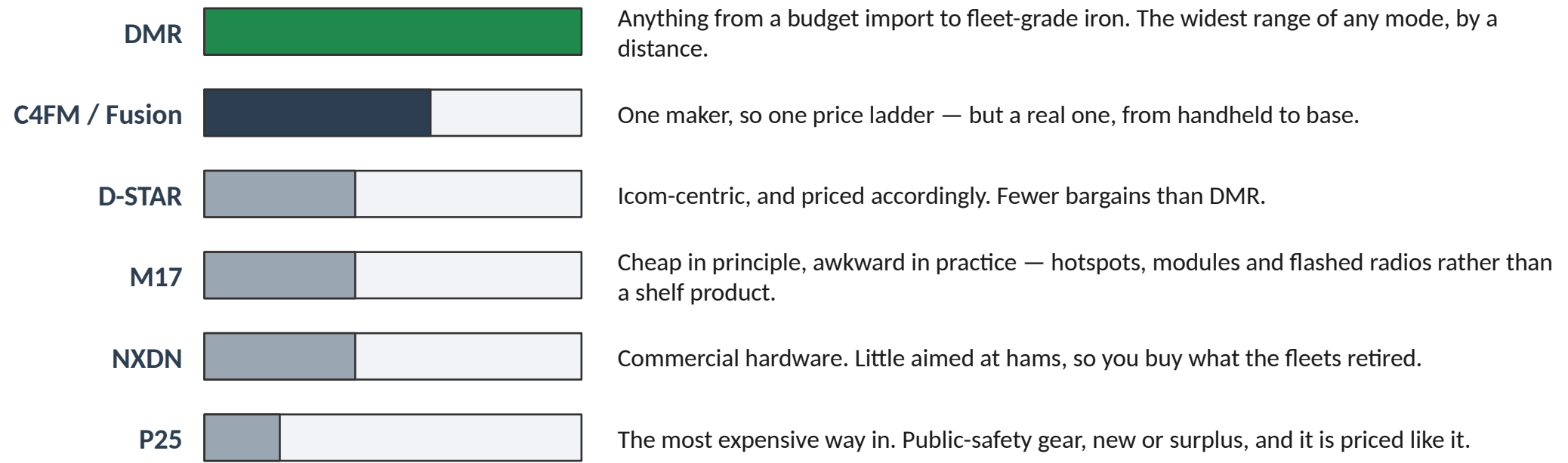
Two different markets feed this hobby — a new-radio market and a surplus one — and no two modes draw on them the same way.

MODE	NEW	USED / SURPLUS	WHO MAKES THEM
DMR	Many makers, new	Deep — commercial fleet turnover	Baofeng, Radioddity, Retevis · AnyTone, TYT, BTECH · Motorola, Hytera, Kenwood
C4FM	Yes — one maker	Thin	Yaesu
D-STAR	Yes	Modest	Icom, and Kenwood
NXDN	Commercial only	Surplus IDAS and NEXEDGE	Icom (IDAS), Kenwood (NEXEDGE)
P25	Rarely aimed at hams	This IS the market	Retired public-safety gear — Motorola and others
M17	Open hardware, emerging	—	Hotspots, modules, and OpenRTX-flashed radios

For P25 and NXDN, buying used is not the thrifty option — it is essentially the only option.

Cheapest to most expensive

Cheap radios and plenty of choice, rated together — because in practice they arrive together.



Longer bar = cheaper radios and more of them to choose from.

Within DMR alone:

budget imports — a working handheld for the price of a nice dinner · the ham sweet spot — AnyTone, TYT, BTECH, with the features you will actually use · commercial iron — Motorola, Hytera, Kenwood, and a deep surplus market behind them

CHOOSING

The honest sheet

MODE	WHAT IT GIVES YOU	WHAT IT COSTS YOU
DMR	Biggest user base and network. Cheap radios from many vendors. Two conversations per channel.	The codeplug is a steep first climb. Easy to overwhelm a brand-new operator.
C4FM	Painless analog-to-digital switching. Beginner and club friendly. No registration.	Effectively a single-vendor mode. The Wires-X versus YSF split confuses people.
D-STAR	First mode built for hams. Callsign routing. Mature worldwide network. Strong data side.	Gateway registration trips up newcomers. Historically Icom-centric. Single slot.
P25	Rugged, public-safety tested. Excellent audio. Transcodes in free software.	Radios are pricey. Small ham user base. More capability than most hams need.
NXDN	Very spectrum-efficient at 6.25 kHz. Clean for small regional networks. Solid hardware.	A small, niche following. Limited radio choice aimed at hams.
M17	Fully open — protocol and codec. No dongle needed. Hackable, and you can contribute.	Newest, with one of the smallest user bases. Limited hardware. Still maturing.

Pick the mode your community is already on, and the cons mostly stop mattering. A smaller network is only a downside if nobody you want to talk to is on it.

What trips everyone up

Five things, in the order they will bite you.

1

Register first. It is free, and nothing works until you do.

A DMR ID, a D-STAR registration, an NXDN UID. The most common newcomer mistake is keying up before registering and hearing nothing but silence.

2

Match the access codes, or you will hear nothing.

Colour code, DG-ID, NAC, RAN. One wrong digit and you transmit into silence. The radio is not broken.

3

Leave a gap before and between overs.

Internet links and transcoding add a beat of delay. Key up, count one, then speak — or the other operator hears “...anks for the call” instead of your callsign.

Notice what all three have in common: when digital goes wrong, it goes silent. No hiss, no crackle, no error message. Silence is the symptom.

Two more, and then go and listen

4

The digital cliff is normal, not a dying radio.

Analog FM fades and gets hissy as it weakens. Digital stays clean right up until it breaks into chirps and vanishes. That sharp edge is expected behaviour, not a fault — and it is why a marginal digital signal feels so much worse than a marginal analog one.

5

It is all in the clear, and keep analog handy.

Part 97 forbids encryption, so digital voice is not private and digital does not mean secret. And since nearly every DV radio also does FM, keep a few analog repeater and simplex channels programmed — they are the universal fallback when the network, or the power, is down.

The codeplug is the real learning curve — not the radio theory.

Programming the radio is where nearly everyone gets stuck. Start by building your own rather than importing somebody else's: a few zones and your hotspot, and learn as you build it.

THE NEXT STEP

Before you buy anything — go and listen

Every mode has a live dashboard showing who is transmitting right now. You do not need a radio to use one.

MODE	LISTEN NOW	TO GET ON
DMR	BrandMeister Hoseline — live audio in a browser	Register at RadioID.net
D-STAR	D-STAR Last Heard	Gateway registration required — do it first
C4FM	The YSF Reflector dashboard	No registration — point your hotspot at a reflector
M17	M17Web — reflector traffic in your browser	No registration — set your callsign
NXDN	NXDN North America dashboard	NXDN ID from nxdninfo.com
P25	P25 North America dashboard	Uses your DMR ID — nothing separate

Park on a busy dashboard, listen for a while, then use your radio's echo or parrot to check yourself before you call. Listening first is never wasted time.

IF YOU TAKE ONE THING AWAY

Six modes looks like six things to learn.

It is one thing, in six dialects.

Identity, an access code, a room, a vocoder, a way of sharing the channel, and sometimes a registry. Learn those six ideas and every mode becomes a translation exercise instead of a new hobby. Then pick whichever one your local repeater already runs, and go and listen to it.

Questions?

TAKE THIS AWAY

Every slide in this talk, written out at length

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Send your club here when the questions start:

www.n6jet.com — the Digital Voice Guides

Start here

Top Ten Must-Knows · What Bands Is Digital Voice On? · Which Mode Is Right for You?

The six modes

Each Mode Explained (in Brief) · Digital Voice Modes Compared · Pros and Cons

The translation

Rosetta Stone · Access and Squelch Codes · Reflectors and Talkgroups

Then go and listen

Where to Listen · The Digital Cliff · Glossary