# Hack the Air

## Amateur radio in the 21st century

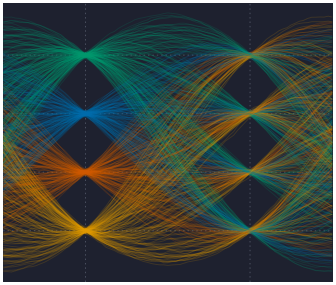
**Vlastimil Slinták · OK5VAS**

OpenAlt 2026 · Brno · uart.cz



Background: WebSDR waterfall, Evesiesta, CC BY-SA 4.0, Wikimedia Commons

# Who am I



## Vlastimil Slinták

**OK5VAS** — licensed since January 2025

- hardware design, embedded and software — studied telecommunications, BUT Brno
- NPR hardware and firmware, **PacketRF**
- contributor to M17 and **LinHT**
- writing at **uart.cz** github.com/slintak
- earlier: **Meshtastic** (LinuxDays 2024), **LinHT** (OpenAlt 2025)

Art: simulated eye diagram of M17 4-FSK (RRC, $\alpha = 0.5$), tools/eye_art.py · uart.cz/category/radioamateri-en

# Demo time

$ _

LIVE DEMO · NPR / PacketRF

# Volunteer: three steps

1. Plug in the PacketRF with a data USB cable.
2. Wait for an address `10.26.0.x` (a few seconds, DHCP)

```
$ ip -br addr   # new interface enx…
```

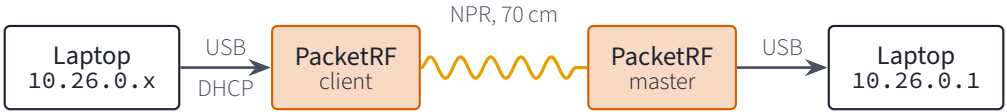
3. Send a message:

```
$ echo "hello OpenAlt" | nc -u -w 1 10.26.0.1 5000
```

No gateway, no DNS — your internet stays as it is. No `nc`? `echo hello > /dev/udp/10.26.0.1/5000` (bash)

LIVE DEMO · NPR / PacketRF

# Send a packet through the air




```
$ echo "hello OpenAlt" | nc -u -w 1 10.26.0.1 5000
```

**No Wi-Fi. No internet. Just radio in the 70 cm ham band.**

# The application sees IP

## All the weirdness is below it.

```
udp.port == 5000

Source     Destination Proto
10.26.0.35 10.26.0.1   UDP
10.26.0.35 10.26.0.1   UDP
10.26.0.35 10.26.0.1   UDP

IPv4, TTL: 62
UDP, Dst Port: 5000
Data: hello OpenAlt 1
```

from the test capture, 4 Nov 2026, master's USB interface

| | |
|---|---|
| source | 10.26.0.x |
| destination | 10.26.0.1 |
| protocol | UDP/5000 |
| TTL | 64 → 62 |
| data | hello OpenAlt |

TTL 2 lower: two routers,
client and master — over radio.

# What you have just seen

## A classic TCP/IP network. Over radio.

## Built from open projects by radio amateurs.




Today 70 cm — NPR also runs on 2 m, Hamnet on 2.3 and 5 GHz.

**Without sharing, this would not exist.**

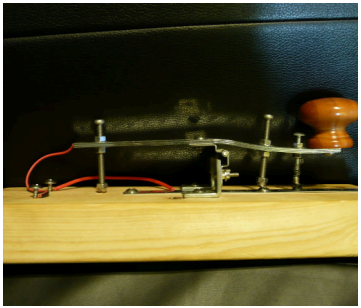
NPR by F4HDK — hackaday.io/project/164092 · uart.cz/2956 · github.com/slintak/PacketRF

# What is amateur radio?

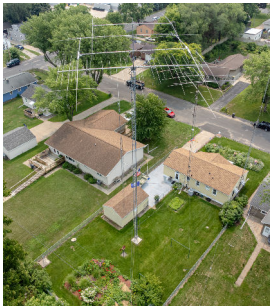
What comes to your mind?

# Radios, antennas and Morse code?

## Contacts around the world, contests for as many contacts as possible…







**Yes, that too. But far from only that.**

Wikimedia Commons: straight key, CC BY-SA 3.0 · contest station 2017, Ptolusque, CC BY-SA 4.0 · antenna tower, Wikideas1, CC0

# Amateur radio is not nostalgia for old radios.

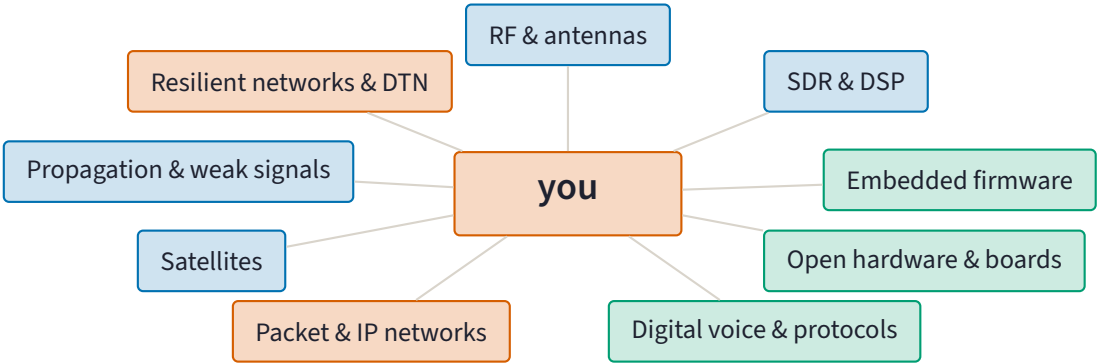
## It is a ticket into the technology the modern world runs on.

# A learning tool, not a museum

- **Take it apart** — do not just use technology, rebuild it into something its maker never planned
- **Learn by doing** — a cheap handheld today; antennas, modulation, DSP, protocols and your own PCB in six months
- **Build real infrastructure** — repeaters, Hamnet, packet networks that people actually use
- **Skills that pay off** — telecom, embedded, RF, networking

After Chris Boden, “New Crew Radios”, youtube.com/shorts/Xg2jFrhWSpo

# Amateur radio is not one hobby



**You do not have to like all of amateur radio.**

**Find your rabbit hole.**

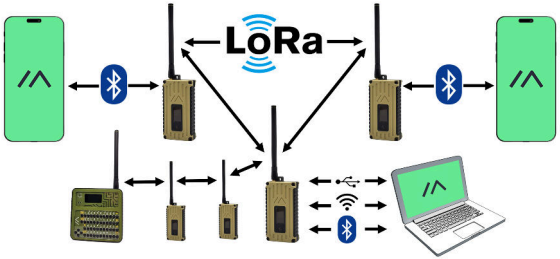
# For years I ignored amateur radio




- My grandfather was a ham
  — homemade radio, piles of QSL cards
- 59, 73, contacts, contests
  — it did not attract me
- Why would I want a licence?
  — I did not know

Foto: TRIO TS-520S transceiver (Kenwood), Zalasem1, CC BY 4.0, Wikimedia Commons

# LoRa first: Meshtastic → MeshCore



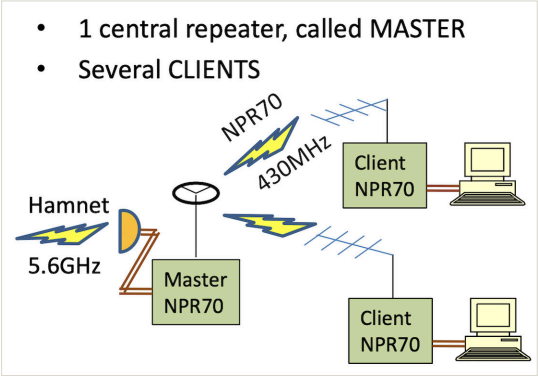



- LoRa mesh, 868 MHz band, no licence
- messages over hills, no network
- in Czechia, now mostly **MeshCore**

intro to Meshtastic
LinuxDays 2024
(recording)

LinuxDays 2024: Intro to the LoRa network Meshtastic (CZ) · youtu.be/pqmU8-VLUg0 · diagram: from the LinuxDays 2024 talk · photo: my solar node

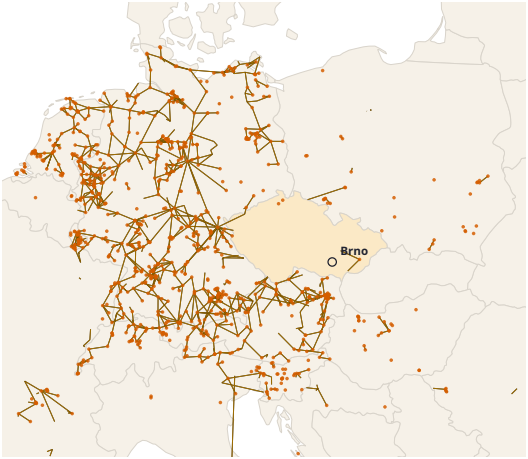
# Looking for more networks: packet radio




- **Hamnet** — IP backbone, 5 GHz links
- **New Packet Radio** — IP on 70 cm
- open hardware and firmware

*“Wait — I can route IP over a radio I understand and can modify?”*

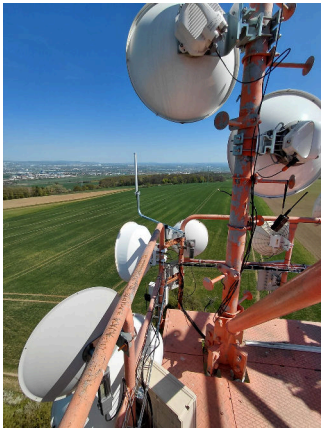
# Hamnet: an amateur IP backbone




- 2.3 / 5 GHz links between hills
- routed IP, 44.x addresses
- Wi-Fi hardware, typically **MikroTik**
- started by Austrian and German hams
- ≈ 940 sites in operation, in Czechia only 3
- Alps: webcams at mountain huts

Map: sites answering ping and radio links, hamnetdb.net (5 Nov 2026, ping in the last 2 h), borders: Natural Earth · hamnet.eu · hamnetdb.net · FOSDEM 2025: HAMNET status update

# Hamnet here: work in progress





**With Robin OK2AWO we are building Hamnet near Brno**

only a handful of live sites in Czechia so far

- MikroTik, 5 GHz
- real operating experience
- a backbone for NPR and other experiments

Photo: mine

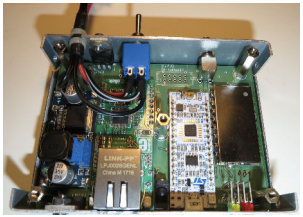
# NPR: that was the opening demo




- 70 cm and 2 m, one **master**, many **clients**
- a classic TCP/IP network over ham RF
- the last mile to Hamnet — or standalone
- raw 110 kbit/s – 1 Mbit/s, ping 0.3 – 1.3 s
- a lab: TDMA, embedded, RF, real operation

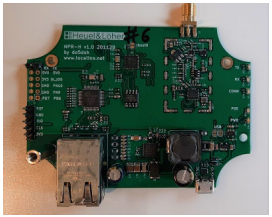
NPR by F4HDK — hackaday.io/project/164092 · uart.cz/2773 · NPR-H by DO5DSH, localino.net · CQ DL 3/2021, 3/2022 · hackaday.io/project/175907 · photo: mine

# One open design, many builders



**F4HDK · FR**

original NPR70



**NPR-H · DO5DSH · DE**

7 W, PoE, 2 m + 70 cm

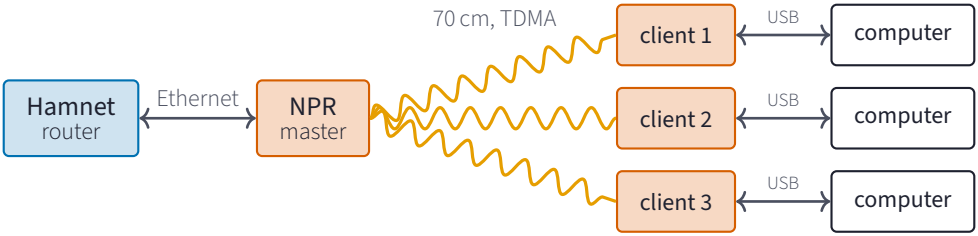


**PacketRF · OK5VAS**

RP2350, USB-C, own FW

NPR by F4HDK — hackaday.io/project/164092 · photo: NPR-H by DO5DSH, localino.net · CQ DL 3/2021, 3/2022 · hackaday.io/project/175907 · uart.cz/2956 · github.com/slintak/PacketRF

# NPR network: master and clients

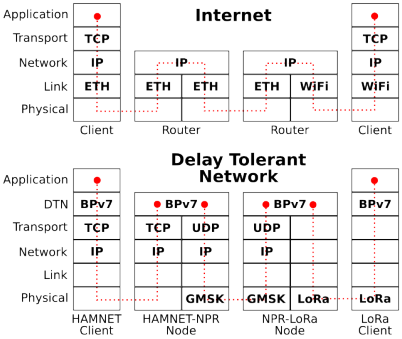



- the master allocates airtime
- clients get addresses over the radio
- an ordinary PC behind each client
- proxy ARP: no broadcasts on air

NPR by F4HDK — hackaday.io/project/164092 · uart.cz/2956 · github.com/slintak/PacketRF · uart.cz/category/radioamateri-en: „Addressing and ARP in NPR networks“

# And above all I wanted to try DTN

## Delay-tolerant networking: a network that waits.

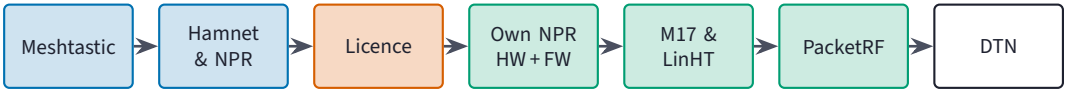



- **store-and-forward**: data wait in a node for a link
- HF, satellites, mobile nodes, emergencies
- Bundle Protocol v7, experimental in PacketRF
- **cislunar** (G4DPZ): DTN all the way to the Moon

Explored the least — and attracts me the most.

uart.cz/category/radioamateri-en: „Delay-Tolerant Networking for Amateur Radio“ · uart.cz/2956 · github.com/slintak/PacketRF · Cislunar Amateur DTN (G4DPZ) · RFC 9171

# And that is why I finally got a licence




That was my path. And now: what else is happening in amateur radio today.

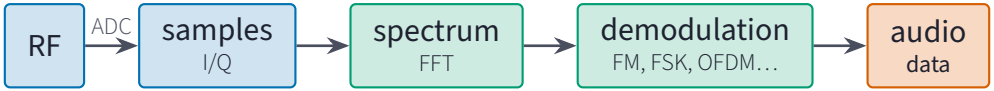
# Where hams do what

## A map of the bands — and of today's projects (orange = in this talk).

| band | range | what happens there |
|---|---|---|
| **HF** 1,8–30 MHz | worldwide (ionosphere) | voice (SSB), CW, FT8, JS8, Winlink (VARA, Mercury) |
| **VHF** 6 and 2 m | tens of km (repeaters) | FM, DMR, M17, APRS, packet radio (AX.25), NPR, meteor scatter |
| **UHF** 70 cm | tens of km | repeaters, M17, NPR, satellites, SSTV from the ISS |
| **microwaves** 1,2–10 GHz+ | line of sight (bounces: aircraft, rain, Moon) | Hamnet, QO-100, ham TV, EME, DTN to the Moon (cislunar) |

# Radio is software today

**On every band — from HF to microwaves.**

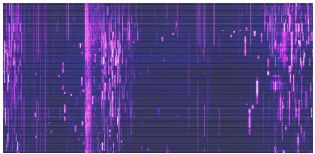






**USB stick**

RTL-SDR for a few euros



**over the network**

Ethernet SDR, WebSDR



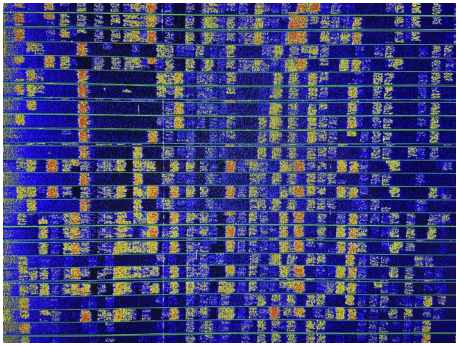

**transceiver**

the IC-705 is an SDR inside

Photo: mine (IC-705, 20 m) · RTL-SDR: Joeceads, CC BY-SA 4.0 · WebSDR waterfall: Evesiesta, CC BY-SA 4.0 · gnuradio.org · sdrpp.org

# HF below the noise: FT8 and JS8Call

**A few watts, a wire antenna — and contacts across continents.**



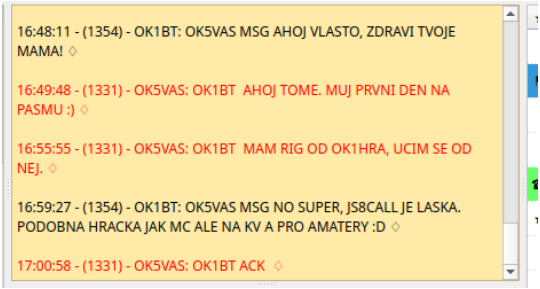
- **FT8** (WSJT-X): 15 s cycles, down to $\approx -20$ dB SNR
- **JS8Call**: FT8 modulation, free text
- JS8 Slow: 25 Hz wide, down to $-28$ dB SNR
- relays and store-and-forward via other stations

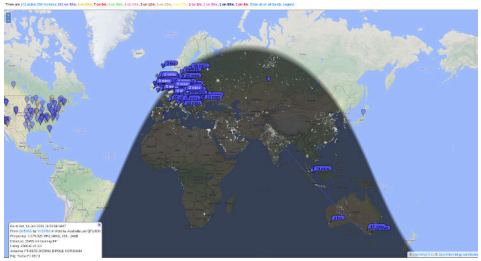
**A signal you cannot hear,**
**a computer can read.**

FT8 waterfall in WSJT-X: Denis Apel, CC BY-SA 4.0, Wikimedia Commons · WSJT-X (K1JT) · js8call.com · JS8Call User Guide

# My first day on HF

## An Icom borrowed from OK1HRA, 40 m, JS8Call.



**15 405 km**

at SNR −24 dB, 40 m, JS8

- 102 receptions from 17 countries in a day
- furthest: VK3TNU, Australia

Screenshots: mine, 13 Jun 2026 — JS8Call and pskreporter.info (map: OpenStreetMap)

# Winlink: e-mail where there is no internet




## Who uses it

- sailors at sea
- expeditions, huts, remote places
- emergency communication

## How

- e-mail, forms, position
- over HF from anywhere
- the heart of the system is the modem

# VARA: the modem for Winlink

## Why it is good

- OFDM soundcard modem
- any SSB radio
- adapts to conditions: 500 Hz or 2.3 kHz
- repeats broken blocks (ARQ)
- ≈ 8 kbit/s in 2.3 kHz

## But

- closed, a single binary
- Windows only
- full speed is paid
- the de-facto transport for Winlink

Technically really good — and a black box at the same time.

# Mercury: an open HF modem

- HERMES: e-mail where there is no internet
- OFDM modes from FreeDV, LDPC, 16-QAM, MFSK
- 200 Hz – 2.1 kHz, adaptive, down to $\approx -11$ dB SNR
- ARQ + HARQ, fountain-coded broadcast
- VARA-style TCP API: apps work unchanged
- Linux, Windows, macOS, RPi, Android, iOS



**GPL-3.0**

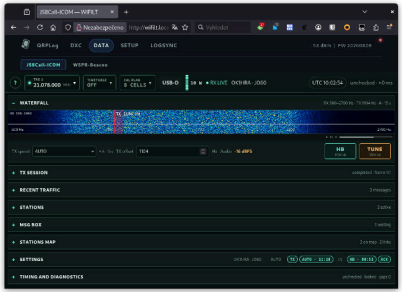
# Same API, different worlds

| | VARA | Mercury |
|---|---|---|
| source | proprietary, closed | GPL-3.0, on GitHub |
| platform | Windows binary | Linux, Win, macOS, RPi, mobile |
| API | TCP interface | the same TCP interface |
| on air | VARA only | not compatible with VARA |
| you can… | use it | read, port, change, study it |

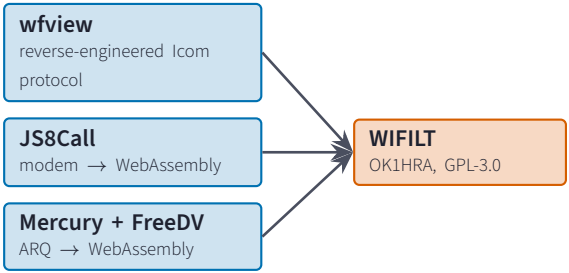
**When the modem is closed, you can only use it.**
**You cannot study it, port it, or fix it.**

# WIFILT: why open code pays off

## Icom in a browser, offline — JS8 and Mercury run in the phone.




server: an ESP32 in a box, or a PC




**Nobody started from scratch.**

**With a closed modem this would not work.**

github.com/ok1hra/wifilt (OK1HRA, GPL-3.0) · images from the WIFILT repository (OK1HRA) · wfview · js8call.com · JS8Call User Guide · github.com/Rhizomatica/mercury (GPL-3.0)

# What is a handheld?

**A handheld radio for the amateur bands — a walkie-talkie on steroids.**




- 2 m and 70 cm, around 5 W
- a few km direct, tens of km via a repeater
- FM, digital (DMR, M17…)
- from ≈ €25
- firmware = the whole radio

Photo (mine), from the left: Quansheng UV-K5 (FM) · TYT MD-UV380 (DMR, runs OpenRTX) · Retevis C62 (FM, OpenRTX port, LinHT donor)

# A handheld as a platform, not an appliance

- **M17**
  open digital protocol for voice and data, Codec 2
- **OpenRTX**
  open firmware for radios you already own
- **LinHT**
  a radio that *is* a Linux computer




M17 on TYT and Retevis with OpenRTX

m17project.org · github.com/M17-Project/M17_spec (GPL-2.0) · openrtx.org · github.com/OpenRTX/OpenRTX · github.com/M17-Project/LinHT-hw · photo: mine

# OpenRTX: open firmware

## For radios that already exist.

| radio | FM | M17 |
|---|---|---|
| TYT MD-380 / MD-390, Retevis RT3 | • | • |
| TYT MD-UV380, Retevis RT3s | • | • |
| Connect Systems CS7000-M17 (+Plus) | • | • |
| Module 17 (open-HW modem) | – | • |
| Radioddity GD-77, Baofeng DM-1801 | • | – |
| LilyGO T-TWR Plus, Talkpod A36plus | • | – |
| Radtel RT-890, TYT MD-9600 | ○ | ○ |
| **Retevis C62** | ○ | ○ |

• supported ○ in development – not available




Nokia 3310 with a new board: OpenRTX, M17, APRS

# Happening right now: Retevis C62

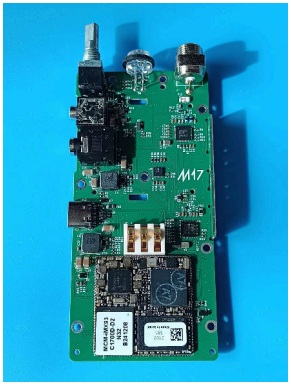
**A $60 handheld, reverse engineered in public.**




| | |
|---|---|
| SoC | ListenAI, Zephyr SDK |
| RE | flash dumps, DSP blob, calibration |
| Sep 2026 | M17 TX from an unmodified C62 |
| Oct 2026 | port PRs in the C62 branch |
| Nov 2026 | community builds: FM, M17, P25 |
| LinHT | same case — swap boards in minutes |

OpenRTX PR #510, #537, #548, #552 · etherham.com: “M17 Next: a $60 radio, a Linux HT…” · N4IRS c62-p25 build · photo: mine

# LinHT: a Linux computer in a handheld

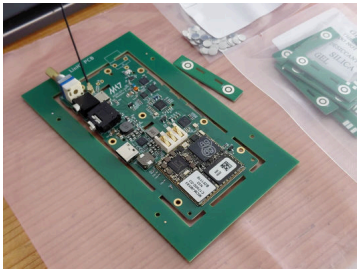



| | |
|---|---|
| CPU | i.MX93: 2× A55 1.7 GHz + M33 + NPU |
| memory | 2 GB RAM, 32 GB eMMC |
| RF | SX1255 I/Q transceiver, 70 cm |
| TX | ≈ 4.5 W (rev B) |
| I/O | network over USB-C, GNSS, audio |
| donor | Retevis C62: case, display, keys |
| OS | Yocto Linux |

Authors: **Wojciech SP5WWP** · **Andreas OE3ANC** · **Vlastimil OK5VAS** (PCB design) — and the M17 community

# LinHT: rev C works



**3 units up and working, rev B issues solved.**

4 more ordered, goal ≈ 50 units for everyone interested — depends on the price of the CPU module with 2 GB RAM.

QR: LinHT talk, OpenAlt 2025

Photos: mine — CQ DL 11/2025 with LinHT on the cover, assembled rev C board in a C62 frame ·
github.com/M17-Project/LinHT-hw (CC BY-NC-SA 4.0) · OpenAlt 2025: LinHT — open-source SDR transceiver · youtu.be/PyispKXU68Y

# Why would you want Linux in a handheld?

- every mode is just software
- GNU Radio *in* the radio
- your own modem in Python or C
- `ssh` into the radio, `git pull` a new mode
- IP over USB-C — the radio as a network node
- GNSS + Linux: tracker, APRS, logger
- experiments: 64-QAM at 2 Mbit/s
- today FM, SSB, M17, TETRA RX

**Not “which modes?”** **but “what do you want to try?”**

 (CC BY-NC-SA 4.0)

# Pictures from space: SSTV from the ISS

## A cheap handheld, an antenna and an Android phone.





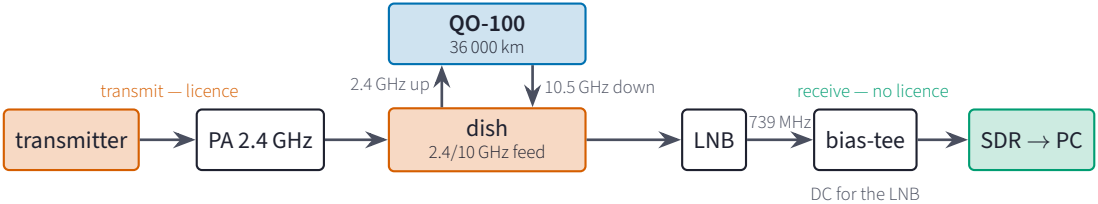

1. an ISS pass (AMSAT)
2. handheld on `145.800` MHz FM
3. **Robot36** phone app at the speaker
4. a picture from the ISS

SSTV = a picture encoded into tones (PD120 ≈ 2 minutes). ARISS transmits irregularly and announces dates in advance.

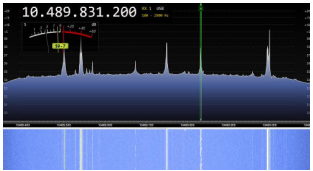
Right: my first reception from the ISS: Fram2Ham test, 437.550 MHz, 15 Feb 2025 (only part of the picture) · uart.cz/2675 · ariss.org · amsat.org/track · Robot36 (Android)

# QO-100: a satellite with a ham transponder

**Geostationary satellite Es'hail-2, 25.9° E — no pass tracking.**






- **narrowband**: SSB, CW, digital (FT8, JS8, FreeDV)
- **wideband**: ham TV in DVB-S2
- no dish: WebSDR in the browser
- me: DJ7GP feed, bias-tee and PA from SP5WWP — this summer

Photos: Petr OK2YB: QO-100, operator course of OK2KOJ at BUT Brno (2024, in Czech) · AMSAT-DL: QO-100 · BATC WebSDR

# Ham spirit × open-source spirit

## Appliance or platform? Operator or experimenter?

### Amateur service (ITU)

- self-training
- intercommunication
- technical investigation
- “progressive” (Amateur’s Code, 1928)

≈

### Free software

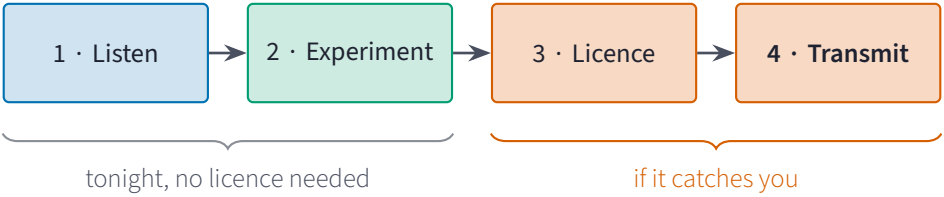
- run it
- study it
- modify it
- share it

**Open source is not something we bolt onto amateur radio.**

**In many ways, it is a return to its roots.**

ITU Radio Regulations, No. 1.56 — definition of the amateur service · The Amateur’s Code, Paul M. Segal, W9EEA (1928) · gnu.org/philosophy/free-sw — the four freedoms

# Your way in




The licence does not have to be the first step.

# Step 1: just listen

## You do not need a licence to receive.



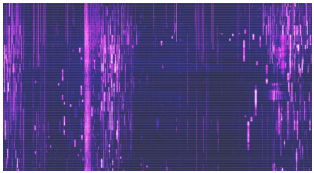
**Cheap handheld**

UV-K5 · ≈ €25




**USB SDR**

RTL-SDR · ≈ €30



**WebSDR**

in your browser · free

**What to listen to:** repeaters and APRS · SSTV from the ISS · aircraft (ADS-B) · HF and JS8/FT8 via WebSDR · QO-100 via WebSDR · satellites (SatNOGS)

uart.cz/2675 · RTL-SDR: Joeceads, CC BY-SA 4.0 · websdr.org, waterfall: Evesiesta, CC BY-SA 4.0 · readsb / tar1090 · satnogs.org (Libre Space Foundation)

# Step 2: experiment

**Receiving, decoding and building need no licence.**

## Decode

- HF via SDR: JS8, FT8, CW skimmer
- satellites and ISS: SSTV, telemetry
- APRS, packet: Dire Wolf

## Hack

- firmware: OpenRTX, UV-K5
- the source of M17, PacketRF, Mercury
- help with the C62 port

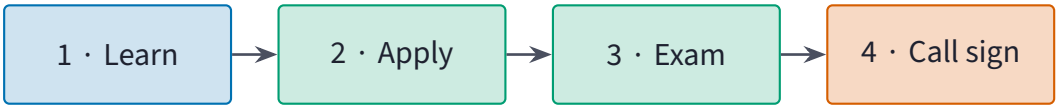
## Build

- an antenna (+ NanoVNA)
- a **SatNOGS** ground station
- a Module 17 or a PacketRF

satnogs.org (Libre Space Foundation) · pskreporter.info · reversebeacon.net · github.com/wb2osz/direwolf · openrtx.org · github.com/OpenRTX/OpenRTX · github.com/egzumer/uv-k5-firmware-custom

# Step 3: licence (in Czechia)

**Tip: go straight for HAREC (class A) — a bit more study, all bands, more power.**




`hamotazky.cz`
questions,
practice tests

ČTÚ e-portal or form
fee 600 CZK

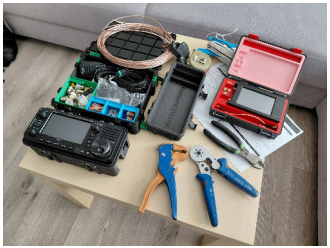
written test at ČTÚ
Prague, Brno, Ostrava
→ HAREC (A)
or NOVICE (N)

form 13N
fee 500 CZK
→ OK* call sign

ctu.gov.cz — exam · eportal.ctu.gov.cz/form/13N · hamotazky.cz (OK1GOD)

# Step 4: transmit



- at home and outdoors, portable
- local repeater, local club
- M17, APRS, packet on the air

- access to Hamnet and NPR
- satellites, even the ISS
- your own experiments on the air

Photos: mine (OK5VAS) — home station and portable kit

# Everything from the talk is online

- a free retelling of the talk
- slides in Czech and English
- links to sources and projects

`uart.cz/3061`



# Find what you enjoy.
# Learn it.
# Build it.
# Transmit.

Self-training, technical investigation, intercommunication —
that is why the amateur service exists.

# Questions?

Vlastimil Slinták · OK5VAS
uart.cz · github.com/slintak · packetrf.org