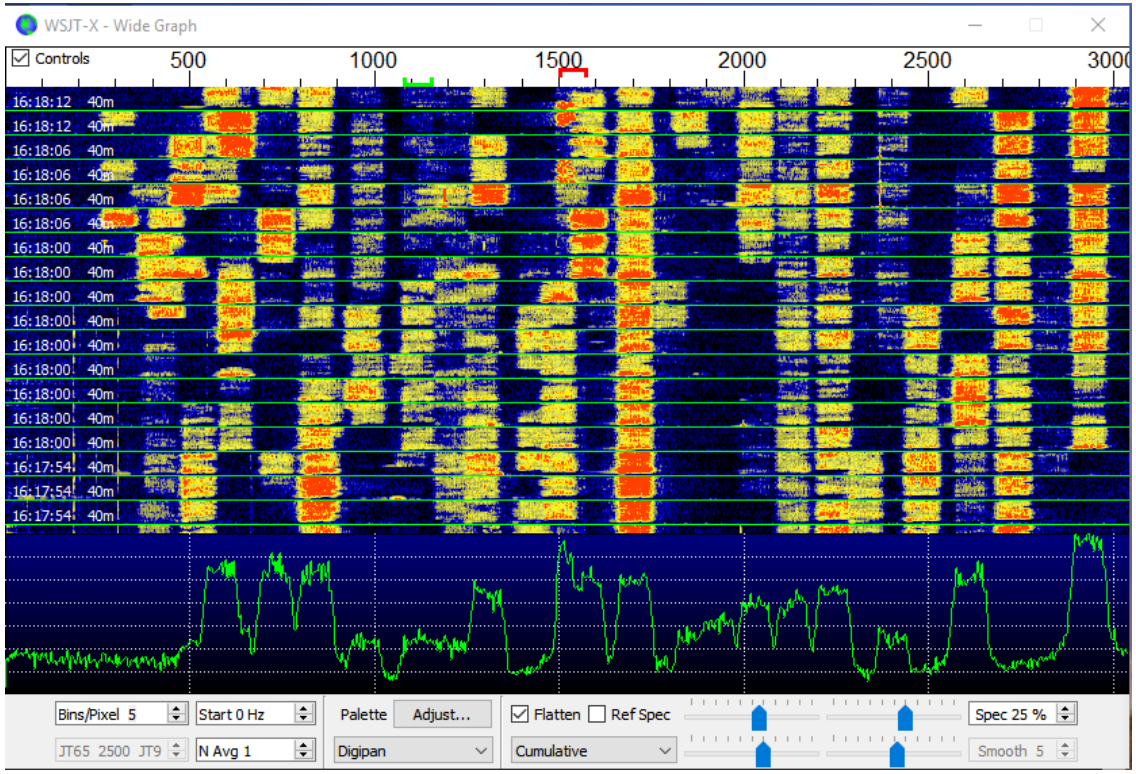
WSJT: Brief History



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Overview

- WSJT: digi-modes for Weak Signal DXing
- Why ? (motivation, goals)
- What ? (what can these modes do ?)
- How ? (how do they work ?)
- Current examples: FT8, Q65
- Q & A, open conversation …

WSJT: Weak-Signal Communication

- ***WSJT*** – 2001 – VHF+: meteor scatter, EME, …; (HF: QRP DXing)
- ***MAP65*** – 2006 – Wideband (90 kHz) EME: multi-decode, adaptive polarization
- ***WSPR*** – 2008 – QRP propagation probe
- ***WSJT-X*** – 2012 – All bands, many modes
  LF MF HF VHF UHF SHF
- Today: ~ 40,000 active users, world-wide

Why ?

- VHF DXing is a challenge
  - My start: solar cycle 19; IGY 1957-58
- Hams like to “keep score”
  (DXCC, WAS, VUCC, contests, …)
- Voice, CW limitations
- We’re in the Digital Age !
- Even *minimal* QSOs are fun !
- Overall goal: push fundamental weak-signal communication limits

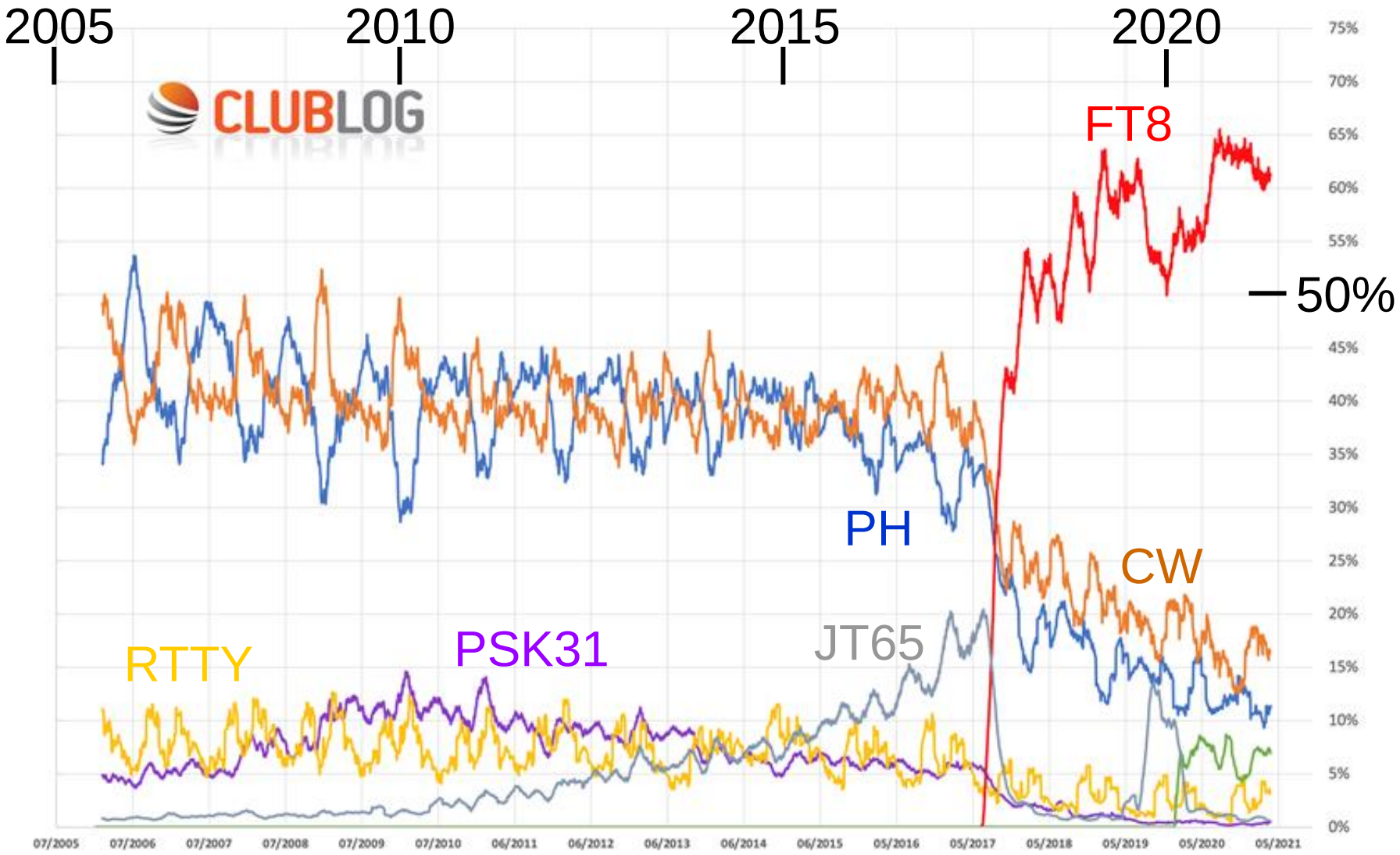
What ?
Tools designed for job:

- Meteor scatter: ~~FSK441~~ MSK144
- EME: ~~JT65~~ Q65
- QRP propagation probe: WSPR
- HF VHF UHF DXing: FT8
- Contesting: FT4
- LF and MF DXing: FST4, FST4W

Why ?
… are these modes so popular ?

- HF: Work the World with low power, compromise antennas
- VHF+: extend your distance range
- Boost your DXCC/WAS/VUCC score
- Make “near-impossible” QSOs
  - Meteor scatter, EME, aircraft scatter, …
- *WSJT-X*: “The finest arcade game in radio land”

ClubLog Modes: 636M QSOs



Weak-Signal S/N Limits

Mode	S/N (dB)	Target Applications
SSB	~ +5	
RTTY	-5	
MSK144	-1 to -8	Meteor Scatter
CW	~ -10	
FT8	-21	HF VHF UHF
Q65-30A	-25 to -27	Troposcatter, Ionoscatter, …
Q65-60A	-28 to -30	EME
FST4-60	-28	LF MF
WSPR	-31	Propagation probe
FST4W-120	-33	LF MF Propagation probe
FST4W-1800	-45	LF MF Propagation probe

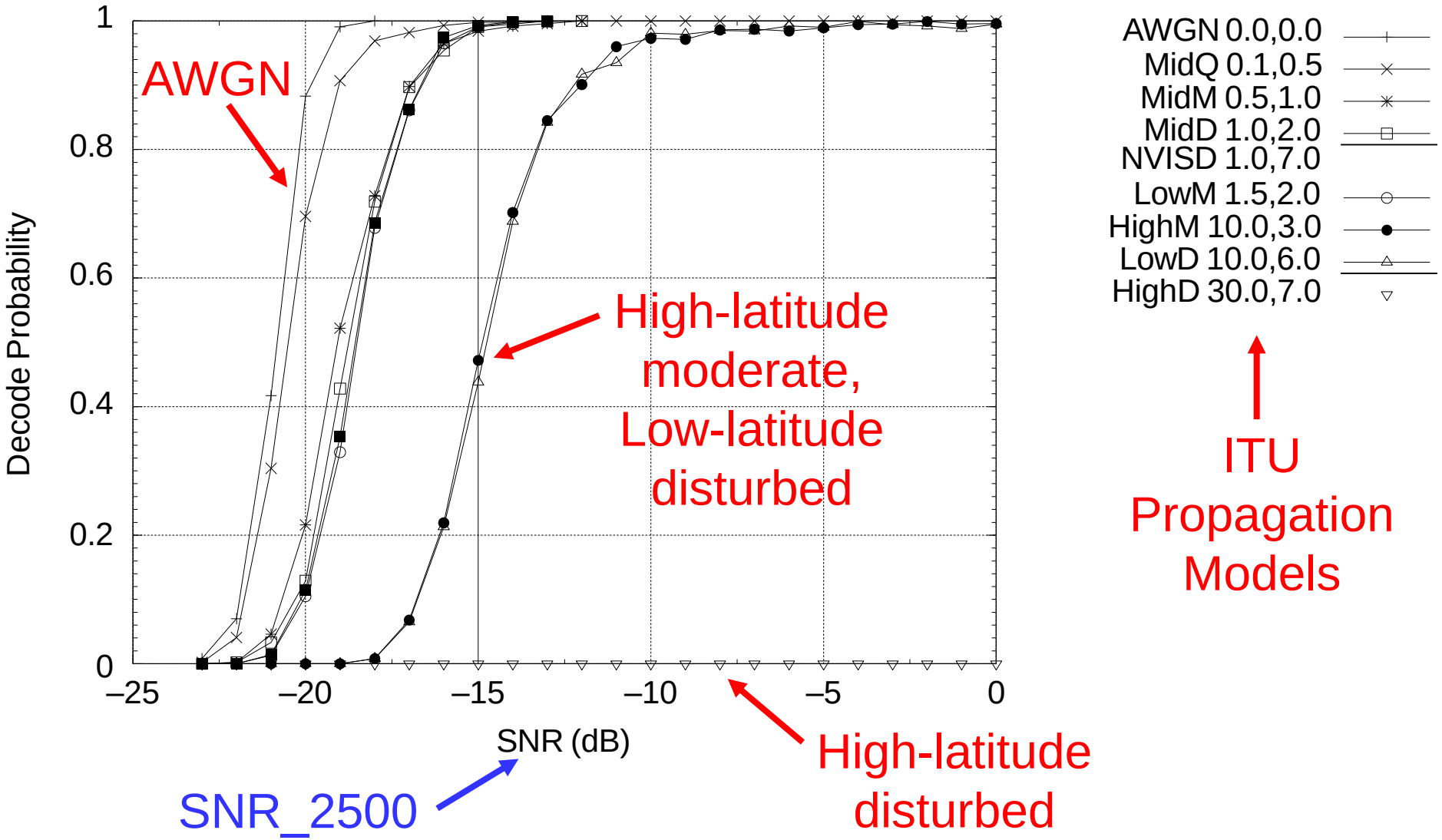
How? Protocol Designer's Tools

- Information throughput rate
- Constraints on message format
- Source encoding (compression)
- Error detection (parity, CRC, …)
- Error correcting code (ECC)
- Code alphabet (number of different symbols)
- Modulation type (OOK, FSK, PSK, QAM,…)
- Synchronization method
- Symbol rate (baud)
- Bandwidth (Hz)

Example #1: FT8

- Introduced July 2017
- Designed for multi-hop E-skip on 6m
- Short, structured messages
- Fast minimal QSOs
- Timed T/R sequences, 15 s
- Works well at S/N ≥ -21 dB
- Highly effective for HF, VHF DXing
- Not for casual chats or rag-chewing!

FT8: Decoder Performance



FT8: Protocol Details

- Messages “source-encoded” to 77 bits
- Error detection: 14-bit CRC
- Error correction: LDPC (174,91) code
- Synchronization: three 7x7 Costas arrays
- Modulation: 8-GFSK ➔ 3-bit symbols
  6.25 baud, BW=50 Hz
- Tx duration: (174/3 + 3×7)/6.25 = 12.64 s

FT8: Good Features

- “Meeting place” (3-5 kHz) on each band
- Decode all signals in passband
- State-of-the-art decoder: 50% copy at -21 dB (with AP, to -24 dB)
- False decodes very rare
- No partial copy or corrupted messages
- ➔ Signal subtraction works !

Example #2: Q65

- Structured messages: again, 77 bits
- Error detection: 12-bit CRC (not sent)
- ECC: QRA (63,13) code, 6-bit symbols
- Modulation: 65-FSK
- Synchronization: 22 “tone 0” symbols
- Submodes: T = 15 30 60 120 300 s,
  tone spacings = A B C D E
- 85 symbols at (for example) 1.667 baud

Recommended Q65 Submodes

- EME
  - 50,144 MHz: Q65-60A
  - 432 MHz: -60B
  - 1296 MHz: -60C
  - 10 GHz: -60D
- 6m ionoscatter: -30A, -120E
- 6m TEP: -15C, -30C
- 10 GHz tropo-, rain-scatter: -60D
- 10 GHz aircraft scatter: -15C

Future path? Wish List?

- All signals now in ~3 kHz slice, per band

  (Can this possibly make good sense ???)
- Wider spectral slices needed ?
- SDR technology ➔ wider Rx bandwidths
- IARU Band Planning Committee …
- More contesting features ?

WSJT-X Programming Details

- User interface: C++ and Qt
- Number crunching: Fortran
- Core developers: K1JT, G3WJS (SK), K9AN, IV3NWV, DG2YCB, N9ADG, G3WDG
- Open source: GPLv3 license
- Version control with git:

$ git clone https://git.code.sf.net/p/wsjt/wsjtx