Digital Modes:The RF "Footprint"

In a Message system the objective is to move digital messages (with optional binary attachments) *error free* and with the smallest "RF Footprint"

We can express an "RF Footprint" in terms of the " spectrum area" a message takes….

The bandwidth required x the time to forward

(expressed as KHz – seconds/Message Kbyte)

e.g. Forwarding a 1 Kbyte message in 15 seconds using 2 KHz bandwidth has a footprint of 30 KHz-seconds/Kbyte
(the *smaller* the RF Footprint the better!)

Robustness Issues: How susceptible is a mode to a non perfect channel

Wideband and Narrow band each have pros and cons:

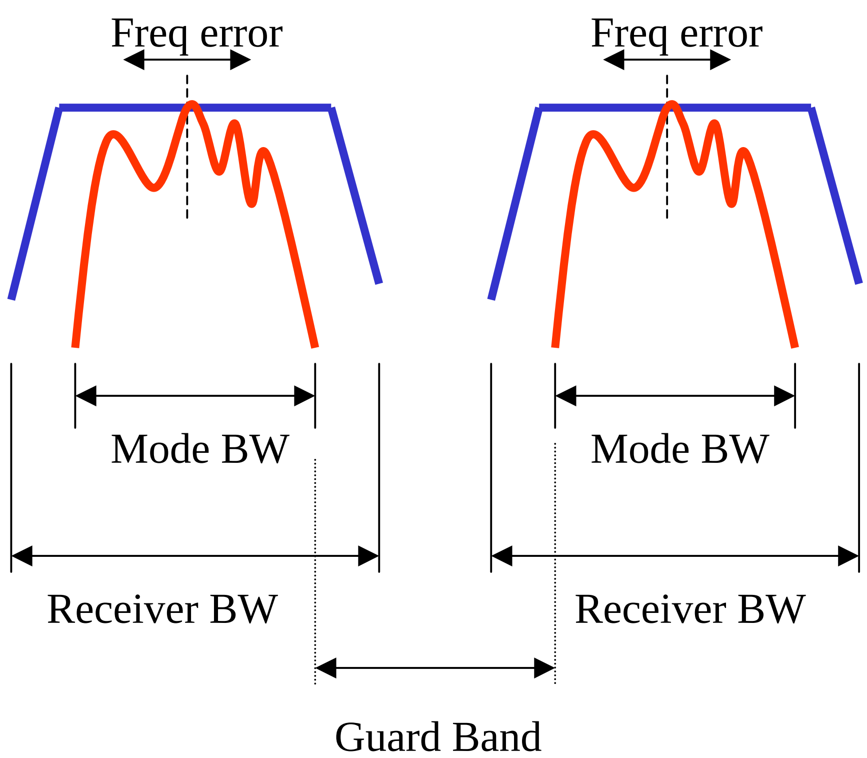
Wideband (up to 2.7 KHz) uses frequency diversity to improve robustness (effective on fading, multi-path and some QRM) The most effective wide band modes allow variable degrees of redundancy to "best fit" the modulation to the channel.

Narrowband modes concentrate power into a narrow spectrum for improved S/N (or lower power) but at the expense of reduced robustness to multi-path, fading and QRM.

The most effective mode is the one that forwards the message "error free" in a *real* HF channel with minimum RF footprint.

RF Footprints: Calculating channel spacing for message forwarding

"Listening" Servers must accommodate frequency errors and operate with practical receiver filters. This requires some guard band.



Practical HF Channel spacing:
Freq errors: +/- 100 Hz
Minimum receiver BW = mode bw + 200 Hz
Nominal guard band: 200 Hz
Nominal channel spacing: Mode BW+ 200 Hz

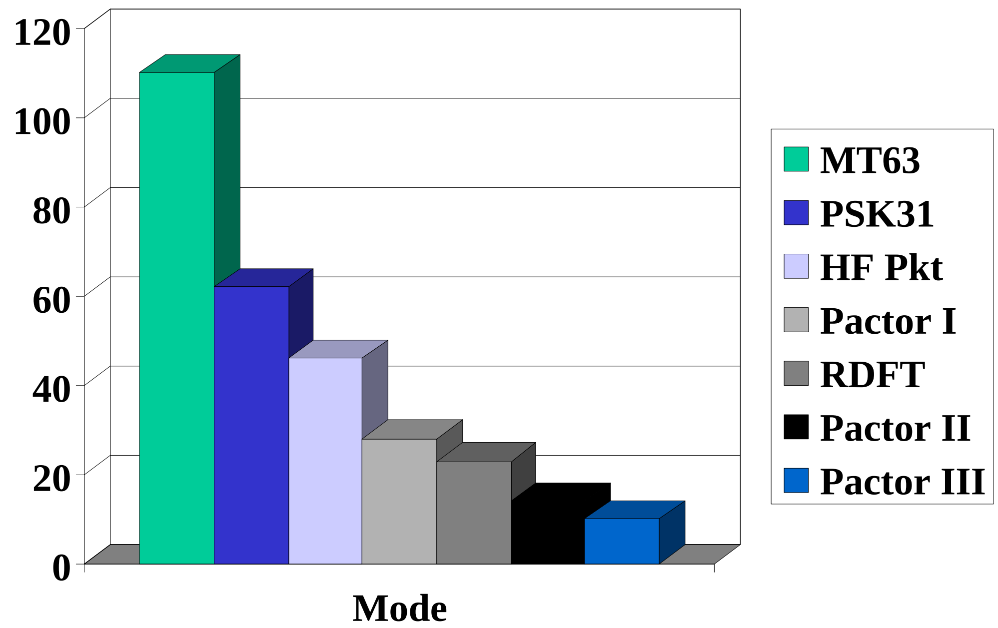
This is a realistic goal with typical modern Amateur receivers…

Stabilized accurate oscillators and Precision DSP receiver filtering *could* reduce Guard band requirements.

Some “RF Footprints”

Using a channel spacing of Mode BW + 200 Hz we can calculate The raw RF footprint of a digital mode. The following for good channel conditions on all modes.

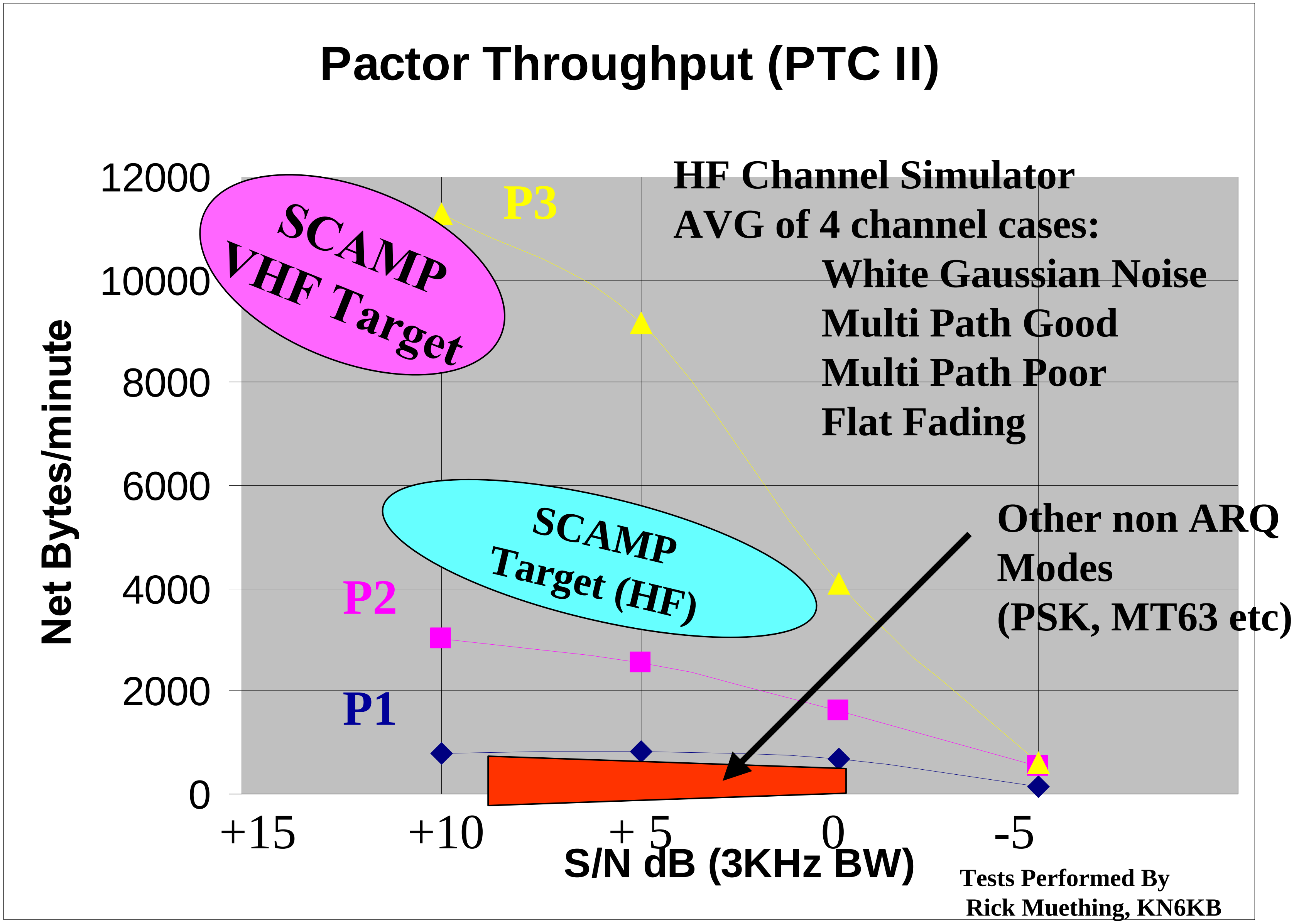
MT63: 2.2KHz/20ch/sec = 110 KHz-sec
PSK31: .25 KHz/4 ch/sec = 62 KHz- sec
HF Packet: 1.7KHz/37ch/sec = 46 KHz-sec
Pactor I: .55KHz/20ch/sec = 28 KHz-sec
RDFT: 2.2KHz/97 ch/sec = 23 KHz-sec
Pactor II: .7KHz/50 ch/sec = 14 KHz-sec
Pactor III: 2.4Khz/225 ch/sec = 10 KHz-sec



A useful metric but final mode comparisons *MUST* include ARQ and Message protocol overheads across multiple channel scenarios.

Throughput Benchmarks and Targets

(based on actual measured binary file transfers)



Digital Modes….Summary

Its now practical to build Digital modes using sound card and PC "DSP" processing but the results are still less optimum than High-performance dedicated DSP processors. (e.g PTC II etc)

For non keyboarding operation "wideband" modes can deliver higher throughput, more robustness and smaller overall RF footprints.

Sound card and dedicated DSPs also have many opportunities in new wide band (100 KHz) VHF/UHF modes.

We need to immediately simplify and modernize the rules for HF and VHF/UHF digital modes to provide an environment for experimentation and innovation. (e.g. band plan by bandwidth)