PROPOSED DESIGN AND STRATEGY FOR A RADIO DIRECTION FINDING NETWORK USING DOPPLER ANTENNAS, PACKET, SPREAD SPECTRUM, AND TRANSMITTER SIGNATURES BY DIGITAL SIGNAL PROCESSING

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I. BACKGROUND

Radio Direction Finding (RDF), also commonly referred to simply as DF, has been around for a long time, pretty well ever since radio began. For serious needs such as locating spies during war and malicious or inadvertent interference, some very sophisticated and expensive equipment has been applied. Amateurs have enjoyed the sport of “fox hunts”, or “T-hunts”, as they are frequently called, on a lesser scale. Small, isolated groups of hams have been experimenting with DF equipment and techniques of generally much lower quality than in the professional environment. This generalization applies to most aspects of amateur radio, of course, where cost by far outweighs other limiting factors that professionals can afford to trade off.

II. THE MENACE: JAMMERS, BLOCKERS, CROSS-BANDERS AND KERCHUNKERS

The recent rise in malicious radio interference is noteworthy. This situation calls for immediate, serious endeavours on the part of radio amateurs to police their ranks, at least in highly populated, (yes, also polluted! --RF-wise is not the only way) cosmopolitan areas, such as the San Francisco Bay Area. A number of causes are undoubtedly responsible:

A. Amateur transceivers have become so advanced that they are often already capable of transmitting outside of their designated ham bands (and nearly always capable of receiving past the band limits).

B. When not capable of out-of-band transmission initially, they can often be easily modified to do so; in one case I heard of, when the CMOS backup battery is removed, the microcontroller reverts to a boot-up mode wherein it is required to reset the band limits!

C. No-code licence and the VEC’s: these factors have greatly increased the growth rate of our amateur ranks, and it is a highly debatable issue, but the bottom line appears to be that we may be acquiring a greater number of “kooks” among us.

D. Whereas in the past hams tended to be more technically oriented, the “communicator personality” seems to the dominant one today, which is not to say that’s bad; consider the abundance of valuable ARES contributions. It is my impression that some of the electronics “nerds” among us may be interested in fooling around with touch-tone access to repeaters that they are not authorized to use, but the "jammer" type of personality is more likely to represent some kind of behavioral problem which more easily "slips through the cracks" of the currently easier to obtain amateur licence.

III. THE BIG DANGER: WHAT HAPPENED IN SWEDEN

In Sweden, no-code licencing began quite a few years ago. Then, after some time, there began to arise a great amount of malicious interference and illegal transmissions. The Swedish equivalent of the US. FCC apparently became so frustrated with tracking down jammers and illegal transmissions that they imposed restrictions on transmitting equipment which, as far as amateurs in Sweden are concerned, boil down to the following:

NO EQUIPMENT THAT CAN BE EASILY ADAPTED TO OUT-OF-BAND TRANSMISSION CAN BE OPERATED OR EVEN OWNED BY AMATEURS!!!

Actually, that may not be such a bad idea. If such equipment is liberally sold, it is bound to be abused. In the **U.S., MARS** operation requires special permits to have equipment modified. In Sweden, apparently all sellers will lose their permits to distribute equipment if they are caught supplying such equipment as described above.

In fact, the "Swedish **FCC"** apparently pulled off a real "sting" operation. They appeared at a ham gathering on one occasion and offered to test the quality of the hams' equipment. They convinced the hams to leave all their equipment on a table, and then they proceeded to test each unit for potential out-of-band transmission. Any units that "passed" the test were **CONFISCATED!!!**

Needless to say, they got away with that trick only once. The amateur grapevine travels just as fast over there as anywhere! And that's not the worst of it; apparently, what the above law means is that

NO HOMEBREW TRANSMITTING EQUIPMENT IS ALLOWED IN SWEDEN

because of the preemptive "bottom line" restriction above. I wonder how the "legal beagles" in our amateur communities of North America would deal with that kind of imposition!

The question is: **DO WE WANT THIS TO HAPPEN IN THE UNITED STATES, OR CANADA (or anywhere else)?**

If you agree that something serious needs to be done to eliminate abuse of our amateur bands, I would appreciate hearing from you on any ideas you may have, and I hope this paper gets some groups taking some action elsewhere.

IV. THE PROPOSED PLAN

What I am embarking on has two main aspects, individual DF'ing and networked cooperation. Emphasis will be on an improved design for the Roanoke type of Doppler antenna implementation to be used at either individual fixed/mobile DF units or the proposed network “system nodes“.

A. Improved Hardware/Firmware and Methodology at DF Units

1. Improving individual fixed/mobile DF capability

The traditional DF’ing loops, portable beams, switched dual rubber ducks, body shielding an HT with no antenna when close to a “fox“, etc., are all fine as an add-on capability, but chances are the bad guys are going to be too cagey, as they have been recently in the San Francisco Bay Area, for such methods to be adequate. What is needed is an instant response capability.

I am revising the so-called Roanoke Doppler antenna system as described in the radio direction finding handbook published by TAB Books [I]. That design is somewhat out of date and a microcontroller such as the Intel 8751 can handle the job more flexibly. In addition, once you have the power of this microcontroller, why not utilize its built-in UART to pass data and control to and from other DF system components?

The Roanoke Doppler antenna system operates on the principle of electronically simulating physical rotation of a vertically polarized ground plane antenna in a horizontal plane, by switching on only one of four antennas at a time. This is accomplished using diodes, RF chokes, feed-through capacitors and quarter-wave coax sections to isolate the diodes from the antennas and the feed point. Control and data acquisition is achieved by a combined function circuit that cycles through switching of the diodes! at 8 KHz while simultaneously filtering out the resulting superimposed 2 KHz audio tone, using a concurrently switched capacitor filter and some op amps with feedback for amplitude regulation. The tone then passes into a positive-edge zero-crossing detector followed by determination of the time of the waveform peak relative to the base 2 KHz clock cycle derived from the 8 KHz that is switching antennas and capacitors in the filter. Relative to the 2 KHz clock, direction of the RF wavefront is then indicated by turning on one of typically 8 or 16 diodes in a circular display arrangement, which may be calibrated by rotating the antenna platform on top of a car, for example.

There are a number of improvements that I am investigating:

a. Using the 8751 microcontroller to generate the antenna switching pulses and switching the capacitors by utilizing some of its 32 I/O port lines

b. Generating a “spread spectrum“ like effect in place of the 2 KHz audio tone, i.e., using something like a Gold or Barker code, spreading the switching effect all over the audio spectrum, so that there would not be just a single audio tone that may get wiped out by modulation on the received signal.

c. Providing for some multipath recognition capability by taking into consideration more than just a phase angle of a supposed pure sine wave resulting from a single RF wavefront being phase modulated by antenna "rotation", i.e., some further attributes of the resulting modulation need to be recorded, e.g. binary code switching sequences being "distorted" into other patterns whose parameters quantify something like an antenna pattern profile; this obviously ties in with the "audio spread spectrum" idea.

2. Providina network nodes with advanced DF features

At a number of San Francisco Bay Area hill top sites, with the cooperation of repeater groups that will be undoubtedly keen to help discourage malicious jamming, etc., there will be Doppler antennas connected to secondary remotely controllable receivers. These receivers will comprise a special set of "system nodes", and will be vectored simultaneously onto a frequency to be monitored upon request, tentatively by packet in the initial design.

At the system nodes, there will be installed copies of the *8751* based controller **I** am designing, which will tune the monitoring receivers at these sites and send out, over a packet network, the observed bearing, along with a time tag and any other available information.

Additional features being contemplated:

a. Sianature analvsis
A "signature" of the transmitter being monitored can be determined. Apparently, all transceivers coming off a given production line share common characteristics with regard to how their **PLL's** lock on over time from initial turn-on, e.g. creating a particular "signature" in terms of spectrum sweeping as they lock on.

b. Uploadina data from mobile/portable laptops
Information will be recorded at one or more sites where DF teams can access it to assist in localizing a malicious jammer, for example. As team members close in, they can upload further more accurate bearings using mobile packet with lap top **PC's**.

c. Spread spectrum for the control links
If the "bad guys" get nasty and start interfering with the operation of this system, we may need to resort to spread spectrum on 440 MHz or higher for the control links.

d. Diaital maps from USGS to help locate the "bad guys"
In fact, some of our DF teams may even use one of those new car navigation systems, which will direct them on an optimal path toward a jammer.

e. Diaitized audio announcement of map coordinates
Wouldn't that be slick! Perhaps a jammer will become so embarrassed that he will get off the frequency! If he continues to play games, the DF teams will

simply find it easier to locate him.

f. Civil lawsuits for deprivation of repeater use
If the FCC or the Federal Government cannot not slap an adequate penalty on a jammer, some of us that are affected should technically "fine" the jammer ourselves, using the civil courts, on the grounds of interfering with our collectively arranged phone patch privileges, for example.

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VI. REFERENCES

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