

Meetings Fri 27 Nov, Wed 30 Dec

Nov/Dec 2009

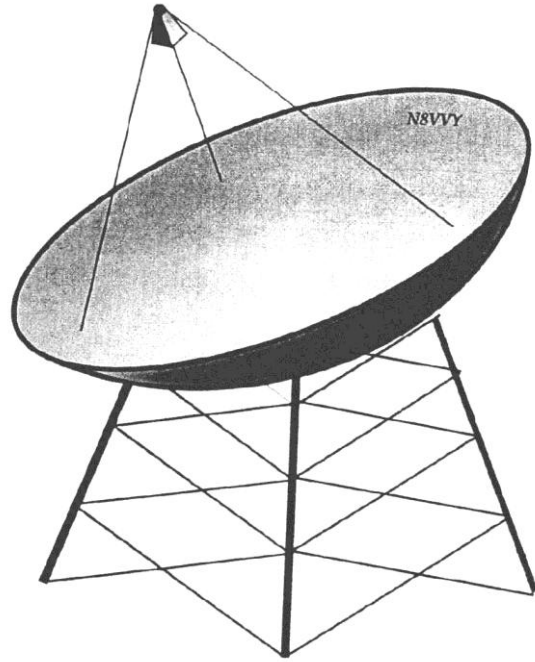
# ANOMALOUS PROPAGATION

Newsletter: **The Midwest VHF / UHF  
Society**

**Editors:**

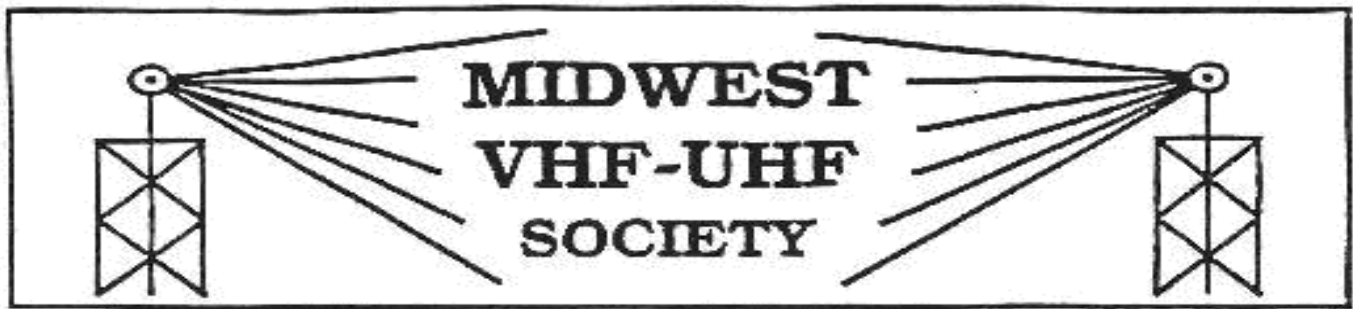
Gerd Schrick, WB8IFM  
4741 Harlou Drive  
Dayton, OH 454 32  
(937) 253-3993  
WB8IFM@AMSAT.ORG

Steve Coy, K8UD  
3350 Maplewood Dr.  
Beavercreek, OH 45434  
(937) 426-6085  
K8UD@ARRL.NET



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Nov/Dec 2009

**Upcoming Meetings Fri 27<sup>th</sup> of Nov and Wed 30<sup>th</sup> of Dec**  
at the Hometown Buffet near SR 725 and Yankee Rd. in Centerville

**MVUS Sunday Net at 14:30 UT (currently 10:30 AM local time, EDT).**  
**The net frequencies are primarily 144.280 Mc and 28.960 Mc.**

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## Upcoming Events:

Digital Conference in January: no date and location decided yet.

Hello All

I volunteered to host the **2010 Southeastern VHF Conference** here at the new Space Science Center, located on the **Morehead State University campus, on April 23 & 24, 2010**. This is a great chance to see the new Space Science building (and Star Theater with its laser light show, etc.).

I would like to invite all the great guys from the MVUS group to come down and enjoy the conference! I intend to have a open house/hospitality cookout on that Thursday, at my house, as we have no "surplus tour" to go

on. Any questions, please feel free to email me.

I also ask humbly if there are any folks out there who would like to participate in any capacity in the conference to get in touch with me: articles for the proceedings, presentations, test equipment bench, hospitality committee, etc. All help gratefully accepted (very small ham community here, and none of us has any conference hosting experience...).

Your friend, **Jeff Kruth WA3ZKR**  
<[KMEC@aol.com](mailto:KMEC@aol.com)>

## De N8ZM

As I sit here thinking about what to write this month, the thought comes to mind of how fortunate we have been to get to know each other through this marvelous hobby called amateur radio. In the Dayton area, there is a weekly unofficial gathering of mostly MVUS members lovingly called Lunch with the Geeks, or LWTG. I don't know whose wife or teenage offspring came up with that, but unpretentious souls that we are, we have adopted it. It is always a lively gathering, with many conversations on different subjects running in a sort of series-parallel sequence as each of us shifts our attention around the table. A lot of important MVUS planning gets done there, for example the December FMT that we are planning.

Naturally, any project involving frequency measurement usually finds John, N8UR, concocting new ways to make these projects challenging for the participants, including those of us tasked with getting it on the air. This time around, we are going to provide signals on three HF bands, and on 2M, that will allow the participants to perform a study of how propagation affects their off-air measurements. Our signals will be roughly 15 watts CW on each band, for the duration of some 36 hours. Of course we will ID every 10 minutes to keep it all legal. I expect that there will be a formal announcement elsewhere in this issue with nominal frequencies, etc. This project will take the efforts of several of us, most notably Mike, W8RKO, to provide the transmitting site and antennas, and Daun, N8ASB, and Bruce, ND8I, to quickly build the 15-watt HF amps. There will be the usual highly stable and accurate 10 MHz source as the reference for the PTS synthesizers so that we will know our frequency so accurately that NIST will be having second thoughts. (Greenspan once talked of stock market irrational exuberance; at MVUS, our sin is irrational over-engineering). So keep some time open between Christmas and New Years to play FMT with us!

**Speaking, briefly, of the holidays, our annual Holiday get-together is scheduled for Wednesday, December 30<sup>th</sup>, at the Hometown Buffet, at 7:00 PM. Bring the family!**

I had an e-mail from Mike, W8RKO, the other day. As you may know, the project to get our 1296 beacon antenna on one of the local TV towers has not been moving very quickly due mainly to funding. When the FCC delayed the digital switchover (again), it cost the stations a lot of money in electricity to keep the analog station on the air longer; money they would have liked to spend on other projects, like tower painting. This was especially tough on our Public TV station host, who was planning to get his towers painted with that money. We would have been able to take advantage of the guys being on the tower to put up our beacon and repeater antennas, and possibly one for the transponder if desired. But Mike's message reported that one quote received thus far was for several tens of thousands of buckaroos, which is well out of our range. So we will wait a bit longer to see if a better quote comes along. Meanwhile, we might want to keep our eyes open for an alternative site so that we can get the beacon up and running soon.

Meanwhile, we are almost ready to start testing of noise diodes and zeners for our noise source project. I hope to have Noise/Com NC302L diodes shortly, and a constant current source to drive them built as well. I found a very simple circuit that uses an LM117 and a resistor, and probably a bypass cap for stability that should work very nicely. Mike, W8RKO, has built a prototype PCB for me to work with, and Bruce, ND8I, and Steve, K8UD, are providing zeners from their collections for us to try.

**The meeting this month will on the usual 4<sup>th</sup> Friday, which is the day after Thanksgiving. And if you missed it above, in December we are meeting on the 30<sup>th</sup>, since the 4<sup>th</sup> Friday is Christmas. See you there!**

Tom, N8ZM, 11-09

*Happy Thanksgiving  
Merry Christmas  
+ a Happy New Year*

The Editors

## This and That 11/12-09

**Quiet Zone.** Many Oktoberfest guests visit the quiet stalls in order to use their cell phones. For this reason it was planned in the year 2005 to install a [Faraday cage](#) around the toilets and to prevent telephoning with a mobile telephone. However such constructions are not certified in Germany, and so instead signs were placed warning toilet users not to use cell phones in the stalls. [Wikipedia]

**LEDs.** "Hey, Drew, You ever count the LEDs in your room? What? You know, all the LEDs glowing on your peripherals and chargers... Sometimes after I turn out my reading light, I lie in bed and count them like little colored stars. Wow... look at `em all! I must have 50! And half of them are blinking! Isn't it thrilling? A roomful of technology in standby mode, ready to leap to life and serve us!" [Doonesbury "Flashback" by G.B.Trudeau]

**Press one.** In our modern, digitized world, there is no longer a margin for error; there is only yes or no, right or wrong, absolutely essential or unemployed. Press a "2" instead of a "3" on some bureaucracy's automated phone system, and you are doomed to wander forever in a hell realm of unwanted options. [William Falk]

**Car Thefts are down.** Thanks largely to ignition locks, GPS tracking devices, and other anti-theft technology, car theft in the US is at a 20-year low. The chance of a car being stolen, in fact, is less than half what it was in 1991. [USA Today]

**"Climate is what we expect, weather is what we get."** [Mark Twain]

**Our Weather.** The world's weather is perpetually on the move, pushed and shaped by air currents in the atmosphere. The way the atmosphere moves is extremely complex, driven by the very large inequality in temperature between the tropical boiler house and the two polar refrigerators. [Ross Reynolds]

**Mission Statements.** Several samples: **Disney** - To make people happy. **Google** - To do no evil. **Merck** - To preserve and improve human life. **Mary Kay** - To give unlimited opportunity to women.

**Giant Redwood.** Redwoods the size of a Saturn Rocket sprouting from the ground like giant beanstalks, their butts blackened by fire. [Joel K. Bourne, Jr., National Geographic]

**Watching TV.** A recent study of more than 45,000 adults linked reading the Newspaper with high levels of happiness, while watching lots of TV correlated with low happiness levels. [Consumer Reports on Health]

**How to get a Good Dog Picture.** Rubberband a strip of well blotted, cooked bacon around your camera lens. Most dogs won't be able to look away for hours. [Alicia Thomasville, Yardley. PA]

**Dim Sun.** "Large-Area OLEDs Fulfill International Lighting Specs" The perception of this light is similar to sunlight or what is delivered by incandescent bulbs. [Novaled AG in ECN Mag]

**Information Overload.** "I got the feeling that the people I know are talking faster than they used to, like they doubt whether there would be enough time for me to listen because the competing flood of information is so immense." [Frank Schirmacher in "Der Spiegel"]

**"It's how you don't say it that matters."** According to the manufacturer, a Rolls Royce never breaks down; it simply "fails to proceed." [Speak Up Column, Dayton daily News]

**Clean Water.** Americans flush down their toilets 6.8 billion gallons of water every day, while 1.2 billion people worldwide have no access to clean water. [1999 Statistics]

**American Settlers.** When European settlers first came to North America, they saw flocks of geese so big that it took them 30 minutes to all take flight and forests that seemed to stretch to infinity. They came to two conclusions: that God's plans for humanity could be completed here, and that they could get really rich in the process. [David Brooks, NYT]

## Miniature Atomic Clocks

by John Ackermann N8UR

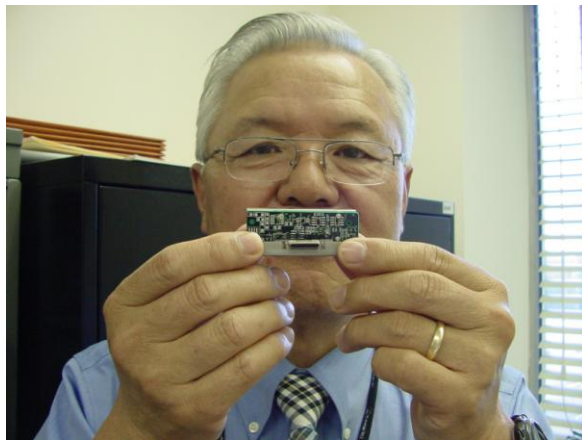
We think of atomic clocks – which use the highly stable resonance of a state transition in atoms of cesium, rubidium or hydrogen – as large pieces of laboratory equipment. The highest performance atomic standards used in national physics laboratories are, in fact, room-sized pieces of equipment. This is in part because getting the highest accuracy requires measuring the atomic state for a long time, and trapping the atoms in a long (as much as 2 meters) chamber allows this.

While commercial cesium beam and hydrogen maser standards are all rack-mount pieces of gear, there have been miniature Rubidium standards available commercially for over 20 years, and some of these are available surplus at very affordable prices. One of these, pictured below, is 3.5 x 5.1 inches, and only an inch thick. Rubidium standards can be small because they use an optical system that consists of a lamp, gas cell, and photodetector and these can be miniaturized quite well.



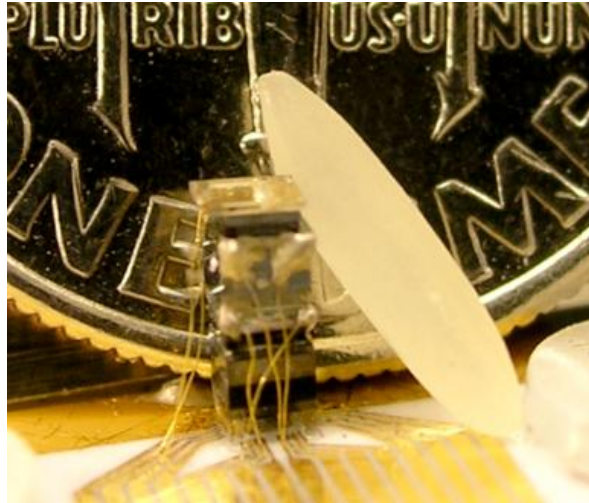
However, there have been some truly tiny atomic standards announced in the last few years, though I don't think any of these are commercially available yet.

In 2003, the Office of Naval Research announced an ultraminiature Rubidium standard that has a volume of 40cc (about the size of a matchbox) and draws only 1 watt of power. It's claimed to have an error of "about 1 second in 10,000 years," which for the time-nuts among us translates to about 3 parts in  $10^{-11}$ . Unfortunately, I haven't found any articles that really describe its specifications, but here's a picture:



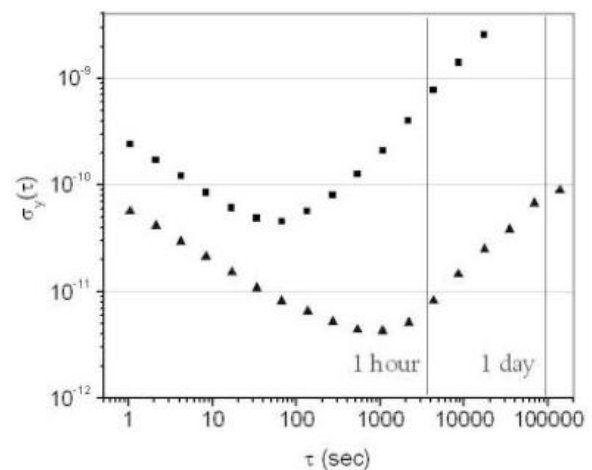
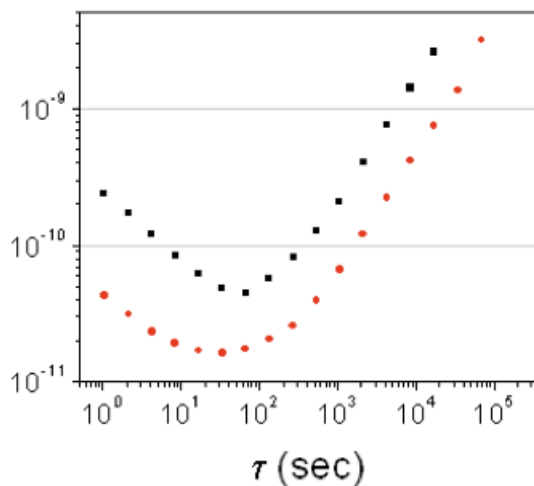
This standard's tiny size is based in part on its use of a laser rather than a gas-filled bulb.

Moving even further on the tiny scale, the National Institute of Standards and Technology (“NIST”) in 2004 announced a “chip scale” atomic clock using cesium atoms, but measuring an optical frequency transition rather than the traditional microwave (9.192 GHz) transition frequency. This clock is the size of a grain of rice and draws only 75mw!



While this clock is amazingly tiny, its performance is limited and it is subject to frequency drift with temperature as well as from contamination in the tiny gas cell; it drifted about  $2 \times 10^{-8}$  (that's about 2 Hertz at 100 MHz) per day. NIST has done another prototype using a Rubidium cell rather than Cesium, and it performs better (the red line is the Rb clock; black is the original Cs version):

The Rubidium version has short term stability that's similar to a quite good, and much larger, oven crystal oscillator. However, this unit draws more power (195mw). Another version of the clock was built using a new method to keep impurities out of the gas cell, and it showed much better long-term performance (the dots are the original Cesium version; the triangles are the new Rubidium version with the cleaner gas cell):



Again, these are all very experimental units and there's no indication when, if ever, they might come to market.

All the information about the NIST clocks, and the graphs, are from <http://tf.nist.gov/ofm/smallclock/CSAC.html>.

## 10 GHZ Cumulative – 2009

Another great year here for the 10 GHz+ cumulative contest here in Michigan. Fuel was much cheaper than last year, so there was more rover activity. Both weekends found rover activity along Lake Erie and Lake Michigan.

In August we had a large group on Lake Erie, at Sterling State Park, EN81hv, Monroe Mi. Also at couple of locations inland. GP Hill EN82em. Rovers were K8JA, KB8U, AA2LY, W8ISS, WA8VPD, WB8TGY, NE8I. Roving along Lake Michigan, were W9NU, KB8U, WB8TGY, NE8I. Home stations active were WW8M, WE9Y, K8MD and K2YAZ. Sunday, we had some rain scatter. On Lake Erie, in Ohio, were WA8RJF, WA3TTS and KB8VAO. In Ontario, there were several rover stations operating. Sunday WB8TGY and myself successfully explored several new rover locations north of Traverse City along Lake Michigan. At times, things were busy on 10,368.100, and some of us moved from .100 to .150. Nice to hear all the activity. My big station died. Was not able to fix it in the field. Two UT.085 jumpers failed. Had to use my back up station. Always test everything. Microwave Activity Days help here.

Second weekend. Had AA2LY at Sterling. Roving along Lake Michigan were W9NU, WW8M, K8JA, WB8TGY, KB8U, W8ISS, WA8VPD and NE8I. Operating as 2 groups. Saturday, one group W9NU, K8JA, KB8U and WA8VPD operated along the upper peninsula Lake Michigan shoreline, along US-2. The rest of us operated at Point Betsie, EN64uq and at other NW Michigan rover spots. We managed contacts on 24 GHz across Lake Michigan with K3SIW and W9SNR. Conditions were so so. Home stations on were K2YAZ, K8MD and WE9Y. Rovers on the Wisconsin side of Lake Michigan were: K3SIW, W9SNR, W9SZ, WA9O, and AA9IL. Home stations were: K2YAZ, W9ZIH and N4PZ.

Sunday, all of us started at AJ scenic overlook EN74at. We managed some >400km contacts with W9ZIH and N4PZ. Then we had some more 24 GHz and 47 GHz contacts. Split up into 2 groups. One staying at Point Betsie then moving to AJ scenic overlook. The other group K8JA, W8ISS, NE8I was traveling south along

Lake Michigan.

We tried a new rover stop, Manistee Hill EN64vh. From there we went to Ludington State Park, EN64ar, and Muskegon Beach EN63uf. Sunday afternoon (3PM) produced some super Lake effect conditions. It did not matter where one aimed the antenna, super strong signals. Signals from the other side of the lake were extremely strong. We were also getting rain scatter over Illinois, and some other mode that we are still scratching our heads over. By sunset, conditions improved again and signals became even stronger. We were on the edge of a rain storm. We tried 24 GHz several more times, but there we did not have any success.

One of the things you learn, is that roving along one side of a Lake, generally, you can work the other side, and inland on the other side. To work inland on your side is more difficult. One exception is from Sterling EN81hv; because it is flat there, and no dunes are in the way. Along Lake Michigan, which is lined with dunes, this is not possible. So where we tried to work K8MD, several times, it did not work. However, W9SZ was working him with ease from the other side of the lake.

I accumulated about 6K points. Filled 2 log pages. Best 10 GHz was 428 KM. Best 24 GHz was 111 KM. Meanwhile, a great time was had by all.

One idea tossed around, was for next August, to go on a group expedition somewhere. Like we did on Lake Superior a couple years back. Lake Huron, Lake Erie were mentioned. Let's see what happens. See where the price of fuel heads. What activity might happen on the other side.

Another thing several of us would like to see the VUAC do, is add a third and fourth weekend to the 10 GHz cumulative. Such as 3rd weekend in October or May. Then in February for the higher bands. Drier winter air might help.

73, Lloyd NE8I/r EN74 etc.

## Signal to Noise vs the Human Ear

from The Weak-Signal Capability of the Human Ear by Ray Soifer, W2RS  
In a paper of the *Proceedings of the 2002 Central States VHF Society Conference*

### Conclusions

The AMSAT ZRO Tests, in which several hundred amateurs participated in a controlled experiment over more than seven years, established that many good operators, approximately the top quartile of test participants, were able to copy by ear a sequence of five random digits at a key-down SNR of  $-3.6$  dB in a noise bandwidth of 100 Hz, with a few (4%) able to reach  $-6.6$  dB. The median participant required a SNR of  $-0.6$  dB. Given the test conditions, these findings are considered to be accurate plus/minus approximately 3 dB. A study of the W2RS 144 MHz EME log from 1985 to 1995, when the author operated with 150W output to a single Yagi antenna, yielded fairly comparable results.

The W2RS EME log also shows that in prearranged schedules, when operators know what they are listening for, contacts were completed with SNRs at least 3 dB lower than was possible in random operation. Only four stations could be worked on random, out of 37 worked in total. For a good weak-signal operator in a prearranged EME schedule, copy by ear down to  $-6$  or  $-7$  dB key-down SNR in a 100 Hz bandwidth, equivalent to  $-23$  or  $-24$  dB average at 2.5 kHz, would not be unreasonable to expect (again, plus/minus approximately 3 dB).

Signal-processing techniques developed by SM5BSZ and WB9UWA may be able to improve upon the performance of the unaided ear by as much as 2-3 dB, depending upon the characteristics of the received signals.

### Propagation in Fog! (From ALRP 042--16 Oct, 2009)

....After recent items in this bulletin about VHF propagation and fog banks, Len Halvorsen, WA2AMW wrote: "The comments from Alan, KI6HPO, reminded me of an article I read many years ago about a VHF/UHF Propagation Enthusiast in Hawaii, who would search for (Tropo?) Propagation Ducts to the mainland by driving up the side of the volcano (the access road to the observatory telescopes) and stopping at various altitudes to test for existing propagation conditions to the west coast. He would often find paths to the mainland that were open only from within a narrow band of altitude on the side of the volcano. Above and below that band the propagation corridor did not exist, nor was it accessible from his mobile/portable equipment".

Carson Haring, AC0BU of Corydon, Iowa says he was surprised to see VHF fog propagation a subject of discussion, because he assumed it was common knowledge. "Here in southern Iowa, where I work removing trees under the power lines from before the sun rises, I very often have assumed that fog influences propagation on 2 meters. Many summer mornings from the time we get to the work site until the fog burns off, (maybe 9 or 10 am) I can reliably use 2 meters for long distance QSOs from my bucket truck mobile". ....

### Height and Range (Family Radio Pamphlet)

Q: What about range over open water?

A person 6' tall, for example, standing on flat beach looking out over the ocean can see roughly 3.5 miles to the horizon, when the earth begins to curve away. Another 6' person standing on a raft in calm water could communicate with the other 6' person from an approximate distance of 7 miles — since nothing would be interfering with their line of sight.

Enable both individuals to climb 10 feet in the air and the distance expands to 10.7 miles. At 50 feet high, the radios could communicate at 20.1 miles. The potential range escalates as the height of the radios increases.



# How did so many stations in Michigan get on 24 and 47 GHz?

Wed, Oct 28, 2009

Good question. Been asked this question by several microwave hams.

Determination. Mutual help. Share resources. Set a goal, make it happen. Regular activity.

Last count; 6 on 24 GHz. 5 on 47 GHz. Plus a couple of loaner stations. WW8M, WA8HGX and myself, purchased a set of DB6NT transverters, and got them on the air. Then came others. Notably K2YAZ, K8EB. The SBMS website has a good basic affordable HB mixer design which WB8TGY, WA8VPD and K2YAZ used and got working. WA8VPD got really good at mounting the diodes for 47 GHz. Test equipment, and experience is usually the problem. (Regular get-togethers and work sessions help. Once you have a working station, then it is easier to tweak and get a home brew station working. With lower bands, there is a fair bit of test equipment available. At 24 and 47 GHz, not much. It helps to have microwave building experience.

For over 17 years, WW8M and I ran a work, help session every Wednesday night at Don's. Open offer to help anyone get on. Get ham microwave whatever working. Don had the test equipment. Plenty of experience, information, reference material. Had several hams show up from time to time over the years. Most activity, was usually just before a contest. Checking things out. See if it works. Fix it. It was a good idea when Bill W3IY came up with Microwave Activity Day. Promoted that as much as possible. Check out equipment BEFORE the contest. See if it was really working. Go to rover sites and try it out. Try out new or potential rover sites. Plus, promote microwave activity in general. Including to gain band experience. One goal, was to put some beacons on the air. But, this is another subject and story.

We decided that having a club, was not really going to get more stations on. Work and help sessions would. So, we decided against putting any effort into a club, and avoid the associated time killing business. Get things done instead wasting valuable time. Going to get something done is the objective. Set aside an evening, or a few hours. Determination! The most important part of a club, is a newsletter. Getting the word around. Information, ideas and activity. Sharing experiences. There are plenty of good newsletters around. MVUS, NTMS, UKmG and others. Then a good magazine, such as DUBUS. Suggest anyone with interest, subscribe to at least one of them. Then besides the dues, help write up an article or two. Hams will read a printed

newsletter. It usually winds up by the throne, and gets read and re read. Electronic letters, tend to get read once, then deleted and forgotten.

What Don promoted, was building a station, along the line of KK7B's conference and proceedings suggested advice. Build it on a wooden board. It is inexpensive, easy to mount things solid, drill holes, control grounds and transport. We promote the wood box design. Lots of surface space inside a box. This makes it more compact. More useful for a rover station. Be able to stack the boxes. Don standardized the size so it would just fit nice inside a rack mount. I went with that. Lucky to have a large supply of nice size wood boxes that my Dad saved for years. They came with "Australian Glazed Apricots". I still enjoy them. The goal is, everything, except the 12V supply, and antenna, is securely mounted on the board or in a box. Make solid connections. Make it reliable. Upgrade it, as better parts, ideas and things come along. At 24 GHz and 47 GHz, we found it was necessary to mount everything really close to the dish antenna. So, the wood box was mounted on back of the dish. Then all is designed to mount easily on a tripod. Ideally with Azimuth and Elevation. Needs to be lightweight and portable, so to fit inside the back seat, trunk, or other transport space, ready for use.

Over the years, built up a couple of stations on the Glazed Apricot boxes. The 10 GHz one, has become a very popular loaner station. 1W 15 dB horn. Complete with 2M IF. Easy to use. Just connect to a 12V source. Only requires an operator.

The basic problem, with activity in states like Michigan, is the distance between operators with interest. That distance, usually measured in driving hours. Ann Arbor to the Mackinaw Bridge, for example, is 5 hours of driving. Much more than a casual drive over to see the next station. As a result, many stations around the US, usually have to build 2 stations. One for themselves, and one to beg another ham to come along and use. Just so you have someone to talk with. The other option there, is building a beacon. Then drive around and learn what you can. The next level doubtlessly will be a beacon with receiver, controlled by some sort of robot, remote control. No, likely not internet. Problem would be, where you are, there might not be any or easy access to the Internet.

One already mentioned solution came about, to create a loanable working band set up. That could be loaned to another ham, so that they could get theirs going. Try some things out. Something that one does not have to depend on another ham to be there. Turn it on into a "beacon mode", and let it run. Play with the receiver, and vice versa. Reliable, easy to set up to use as

a signal source or a receiver. The long term project, will be to extend this to other bands. Then build more of them. My opinion is, that the current set of W1GHZ transverter boards, will make this very practical. One of my next projects, is to construct a simple basic loaner station using these boards for 902 and 1296.

Over a decade ago, I decided to get on all the microwave bands, as an effective rover. I started construction of a small portable station that eventually covered 1296 through 47 GHz. This is my Sackrider Hill Special. Everything can be carried in one trip. Station in one hand, battery and whatever else in the other. Don and I worked together on some equipment. Trials, were first on the bench. Next down the 700 ft long driveway. Then we had a 6 mile LOS path. Then a 12 mile LOS path, Sackrider Hill EN72vh, and a 45 mile path, GP Hill EN82em. Each station, each antenna, were optimized from these. Trial and error. Make things work. Make things work better.

Then the proof of the pudding: working from a scenic observation wooden deck, on top of Sackrider Hill. Located between Detroit and Chicago, a recreation area (State Park) on a ridge of hills. 17 years ago, it had a great view. Built on what used to be a state forest fire tower site.

All that remains now is part of the base. Shrubs and trees have grown and blocked the view. Attenuating the signal. Needs pruning! Bad. Also, it is a long walk up hill from the parking lot. Makes small, lightweight equipment, a big priority. A dozen trips, is no fun. Done a number of operations from there over the years.

Next problem is trying to get more stations on. Most are more than an hour's drive away. Too many hams, trying to get things working, ran into problems. Limited test equipment and experience. No one around to help. They just needed that little bit of help to overcome some brick wall problem. Also, they have this hay wire not portable station set up to plug into a 115 VAC wall outlet. So, I started making long drives. Mostly on weekends. Take the portable station along with an 1152 source, FS meter and portable power meter, and a box full of tools, charged batteries, goodies (portable junk box) and some hens teeth. Then, on the harder bands, like 24 GHz and 47 GHz, leaving a loaner station for a while to help them.

There are many ways and ideas, to promote activity and get more stations up and running. This is just a brief historic summary from Michigan.

73, Lloyd NE8I/r EN74 etc

**We Make Activity Happen.**

## Attenuation (in dB/100 Feet) of Popular Coaxial Cables

Cable Type	Frequency (MHz)								
	50	144	220	432	902	1296	2304	3456	5760
0.085-in semi-rigid	4.0	6.8	8.6	12.1	18.0	22.0	30.0	38.0	50.0
RG-58	3.6	6.5	8.5	12.0	17.8	21.0	32.0	41.0	57.0
0.141-in semi-rigid	2.4	4.1	5.1	7.4	11.0	13.0	18.0	22.0	30.0
RG-8, RG-213, RG-214	1.5	2.4	3.4	5.0	8.0	10.7	15.9	22.0	31.0
Belden 9913	0.9	1.5	2.0	2.9	4.2	5.1	7.3	9.8	15.0
1/2-in foam flex	0.6	0.9	1.3	1.9	2.9	3.7	5.4	7.1	9.9
RG-17	0.6	1.2	1.7	2.4	4.0	4.9	8.0	12.0	**
1/2-in foam Heliax (LDF)	0.5	0.8	1.1	1.5	2.2	2.6	3.8	4.8	6.5
7/8-in foam Heliax (LDF)	0.3	0.5	0.6	0.8	1.2	1.5	2.0	2.6	3.2
7/8-in air Heliax	0.3	0.5	0.6	0.8	1.1	1.4	2.0	2.6	*
1-in 75-ohm Hardline	0.3	0.5	0.6	0.9	1.3	1.6	**	**	**
1-5/8-in foam Heliax	0.2	0.3	0.4	0.5	0.8	1.0	1.4	*	*

## Return Loss vs. SWR (www.febo.com)

SWR	Return Loss (dB)	SWR	Return Loss (dB)	SWR	Return Loss (dB)
1.00	-	1.40	15.56	2.8	6.49
1.01	46.02	1.45	14.72	2.9	6.25
1.02	40.06	<b>1.50</b>	<b>13.98</b>	<b>3.0</b>	<b>6.02</b>
1.03	36.60	1.55	13.32	3.2	5.62
1.04	34.15	1.60	12.74	3.4	5.26
1.05	32.25	1.65	12.21	3.6	4.96
1.06	30.72	1.70	11.73	3.8	4.68
1.07	29.42	<b>1.75</b>	11.29	4.0	4.44
1.08	28.29	1.80	10.88	5.0	3.52
1.09	27.31	1.85	10.51	6.0	2.92
1.10	26.45	1.90	10.16	7.0	2.50
1.12	24.94	1.95	9.84	8.0	2.18
1.14	23.69	<b>2.0</b>	<b>9.54</b>	9.0	1.94
1.15	23.12	2.1	8.98	10.0	1.74
1.18	21.66	2.2	8.52	15.0	1.16
1.20	20.83	2.3	8.09	20.0	0.87
1.22	20.08	2.4	7.71	25.0	0.70
<b>1.25</b>	<b>19.09</b>	<b>2.5</b>	<b>7.36</b>	30.0	0.58
1.30	17.70	2.6	7.04	35.0	0.50
1.35	16.54	2.7	6.76	-	0

