Microwave Operating

Roadrunners Microwave Group, May 2015

Microwave Operating

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“If I have seen further than others, it is by standing upon the shoulders of giants.” Sir Isaac Newton

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What I have learned about proper microwave operating is fundamentally attributable to my association with members of the Northern Lights Radio Society, who have guided me on my journey to access these bands. -- WØJT

NORTHERN LIGHTS RADIO SOCIETY

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KBØZEV / WØJT – Learning by Doing

ARRL 10 GHz & Up Cumulative Contest

Year	Class	Total Score	National Place in Class	Number of QSO's	Number of Uniques	Distance Points	Best Dx
2001	10G	807	? (poor)	9	7	107	38
2002	10G	555	? (poor)	6	5	55	20
2003	10G	2,856	93	35	13	1,556	138
2004	10G	32,001	23	196	22	29,801	332
2005	Up	92,235	2	499	20	90,235	282

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Full Disclosure – (Fame can be Fleeting!)

Year	Class	Total Score	National Place in Class	Number of QSO's	Number of Uniques	Distance Points	Best Dx
2005	Up	92,235	2	499	20	90,235	282
2006	Up	49,212	7	239	18	47,412	233
2007	Up	14,603	17	99	22	12,403	303
2008	10G	58,952	6	285	23	56,652	296
2009	10G	32,112	8	221	21	40,012	254
2010	n/a	0	"Last"	0	0	0	0
2011	10G	29,410	18	148	23	27,110	247
2012	10G	33,413	17	161	25	30,913	314
2013	10G	44,924	7	191	18	43,124	333
2014	10G	25,183	17	112	20	23,183	344

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- Is your rig putting out as much RF as you think it is?
- Are you on the same frequency as the other operator?
- Is your antenna providing the gain that it should be?
- Do you even know where your antenna is pointing?
- Do you even know where you *want* to point?
- Do you know when to call and when to listen?
- Location, location, location, i.e. the Real Estate Agent's mantra becomes the microwave Ham Radio Operator's mantra.

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Measuring RF power at microwave frequencies may be a bit of a challenge…

A Diamond SX-1000 meter can handle the 902 and 1296 MHz bands, but not really the microwave bands higher than that.

An HP432A power meter with an 8478B thermistor can measure 18 GHz RF frequencies easily and detect very low power levels (0.01 mW to 10 mW full scale – have you got an attenuator handy?)

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Do you know your operating frequency – How well?

- High-precision frequency meter, e.g., HP5342A
- 10 MHz Frequency standard (GPSDO, Rubidium) may be needed to get accuracy as well as precision!
- Listening to another operator who is on frequency may be good enough!

Record your frequency offset for the band:

10368.100 ≠ 144.100000

Consider putting the actual IF frequency that corresponds to 10368.1 into a memory of the IF radio for future reference.

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Know your Antenna Gain is (at least) reasonable

- Antenna Range at Local Hamfest?
- Antenna Range at a CSVHFS Annual Meeting?
- A Well-Equipped Friend who can Measure it?
- If you can't actually measure its gain, at least you should be sure that your dish is not Pringle-shaped!

This bent dish had about 15 db less gain than it should have!

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Know Where Your Antenna is Pointing

- Azimuth usually obvious, except in the case of a Pringle-shaped dish.
- Reflection off of large objects like water tanks or downtown skyscrapers may come into play, also.
- Elevation can be tricky – there is no surface on an offset feed dish that is parallel or perpendicular to the ground. You may need an inclinometer (and know what the angle of a particular surface should be), or a friend who can set up at the same elevation a long distance away that you can aim at and peak the signal, then attach a bubble level with that angle shown as level.

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Know Where Your Antenna is Pointing

Note, in the picture, the hardware store “inclinometer” on a flat (but not level) surface of the rig, in this case, the boom holding the feed horn. Use it to initially set the dish elevation then get it out of the way!

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View from a roadside pulloff (left) that overlooks skyscrapers in downtown Minneapolis in the distance (see zoomed in view in the right-hand picture). Aiming at downtown buildings allowed me to work a bunch of other stations who also could point at downtown.

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Remember, your -3db beamwidth on a 30+ db gain dish is similar to the width of your fist at arm's length, so you need to be pretty close to the correct direction to begin with or you won't hear the other station.

Remember, you need to have no significant obstructions nearby, like trees, bushes, or tall corn crops. (Hence, NLRS rovers swear *at* cornfields and swear *by* soybean fields.)

But you don't necessarily need a completely clear line of sight all the way from one end to the other. NLRS started making treks to the north and south shores of Lake Superior to shoot across the flat surface of the lake, but have since made contacts in the 300-400 Km range over land with one end mildly elevated (e.g., Buck Hill, Burnsville MN, EN34ir to southern MN and northern IA, or to Lake Superior).

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Beamwidth, of course, is also a function of the dish size and gain. Bigger dishes are harder to point due to narrower beamwidth.

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Typical Dish Pointing Routine

1. (Usually) start with dish level (i.e., with the *signal* parallel to the ground, not necessarily the dish itself, esp. if offset-fed.)
2. Point dish in the direction of the other station, as best you can estimate it.
3. Scan back and forth a bit while listening carefully. If a signal is heard, adjust to peak the signal, and lock the azimuth.
4. Tweak elevation adjustment to further maximize the signal. Failure to do this step WILL lose you some contacts.
5. All the above assumes you are already tuned to the correct working frequency, know where you are, know where the other station is, and know the bearing between your location and their location.

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So, How do you Know Where You Want to Point?

- Topo Maps, and Map-Reading Skills
- Grid Square to Grid Square Bearing and Distance Calculator
- GPS (So You Know Where YOU Are Located!)
- Compass-Reading Skills

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Topographic Maps

Delorme 3D Topo Quads – no longer sold, required multiple CD's or DVD's for a single state, and sold one state at a time. Maps were USGS Quads.

Delorme Topo USA – also no longer sold, but purchase price included maps of the entire USA at multiple magnifications.

Delorme Topo North America – the current product, one purchase includes maps of North America (i.e., not only USA, but Canada and Mexico) so a better deal. You can import other layers such as USGS Quads (if you have them), satellite imagery, etc., to supplement the raw topo maps.

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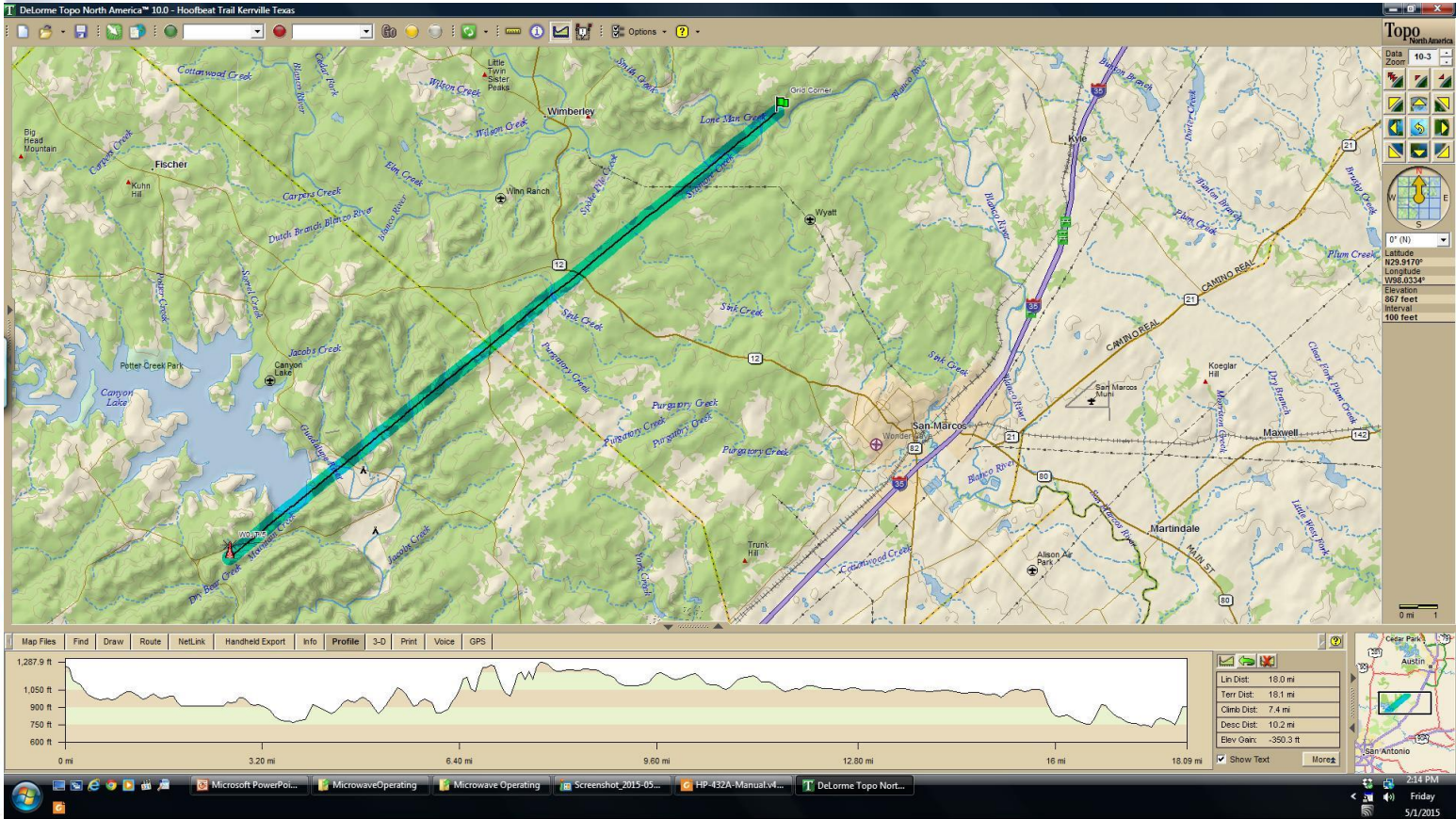

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Delorme maps can be useful for planning, doing initial scouting of possible operating locations, drawing of terrain profiles from one location to another, and can be annotated in quite a variety of ways. I have been using them for years and highly recommend them.

No map, however useful, even when augmented by overhead satellite imaging, can completely replace the scouting of microwave operating locations by actually visiting them. An otherwise “perfect” location may be impossible to access due to private roads, or may be blocked by tall trees, or may have other impediments to its use.

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Knowing where you want to point, continued…

- Maidenhead Grid Square to Maidenhead Grid Square (6-digit), Bearing and Distance Calculators
  - Stand-alone PC programs
  - Microsoft Excel spreadsheets (VBA code)
  - Palm Pilot programs
  - Smart phone (both Android and IOS) “apps”
- GPS (So You Know Where YOU Are Located!)
- Compass-Reading Skills

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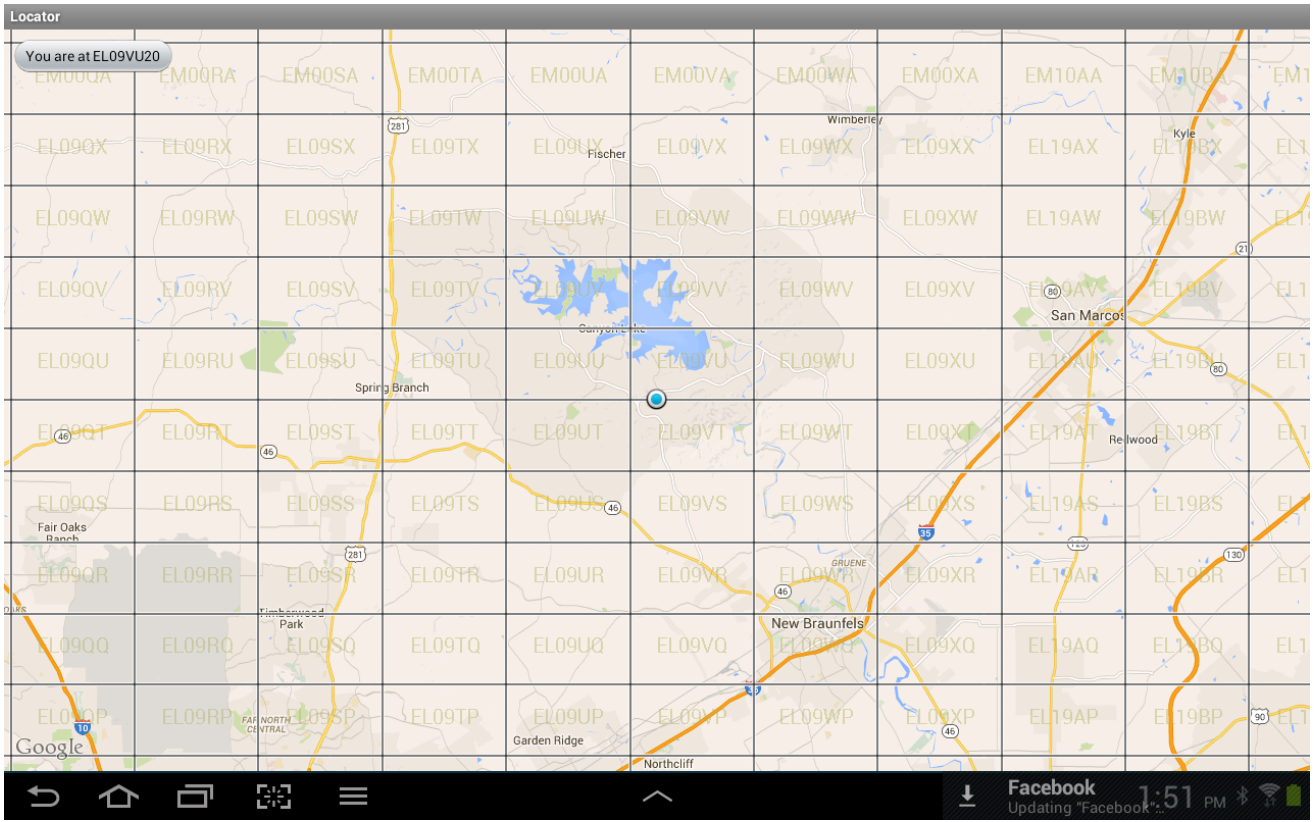
QTH Locator app for the Android smart phone or tablet. It reads your device's internal GPS and plots a map with grid squares.



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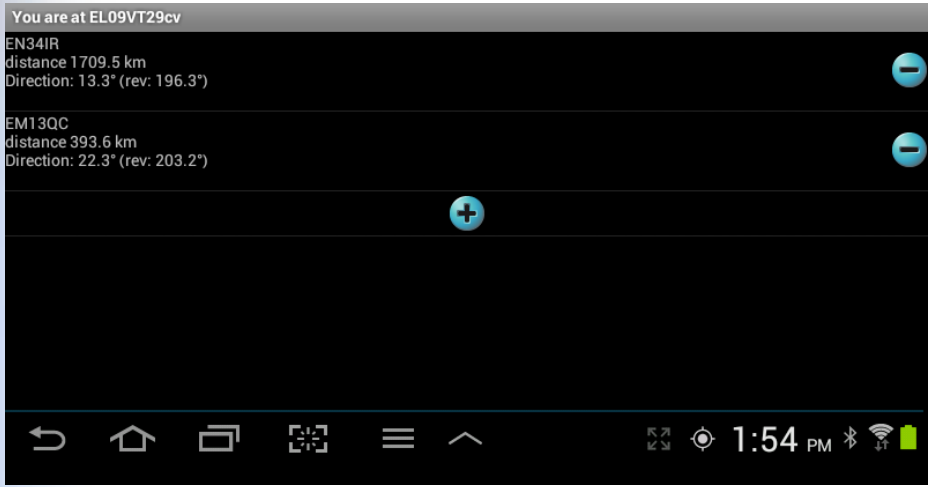

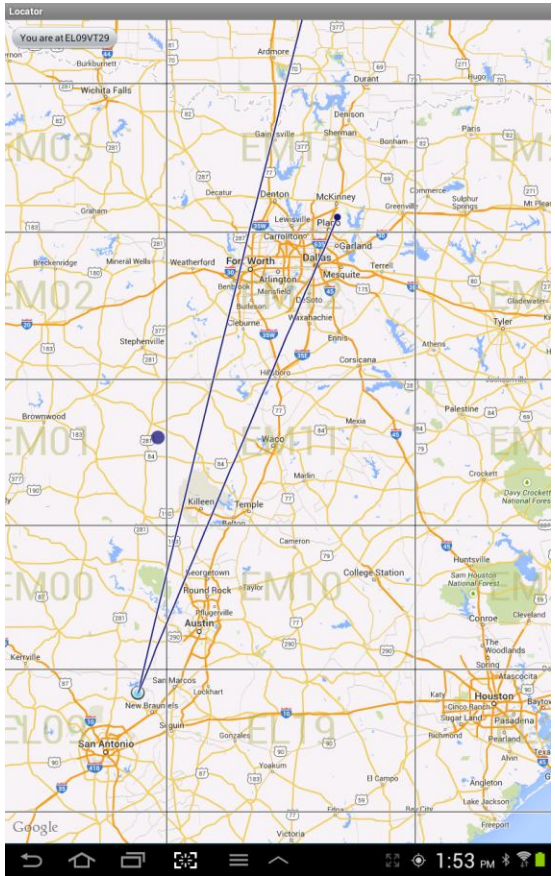

The **QTH Locator** app allows you to make a list of Maidenhead Grid Square locations and automatically show the distance and bearing to them from your current position.

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Know where you want to point

- Grid Square to Grid Square Bearing and Distance Calculators
- GPS (So You Know Where YOU Are Located!)
  - Garmin handheld GPS units are (the only?) models that have Maidenhead Grid Squares as one of the output units you can pick. Most (all?) other brands limit you to latitude, longitude, and other non-Maidenhead output units.
  - Some smart phone “apps” for GPS include MH Grids as output information, also.
- Compass-Reading Skills

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Know where you want to point

- Grid Square to Grid Square Bearing and Distance Calculators
- GPS (So You Know Where YOU Are Located!)
- Compass-Reading Skills
  - If you have a bearing computed from starting (your location) and ending grid squares, dial that into the compass and align the North-pointing needle with the body of the compass by pointing it.
  - Look for a landmark where your compass directs you, and point your dish at the same landmark.
  - May have to resort to asking another operator where (s)he is pointed. (It's always good to have friends!)

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An inexpensive but useful compass, readily available from most sporting goods stores…

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Know when to call and when to listen

- How accurate is your wristwatch?
- “Atomic” clocks and watches (they try to synchronize themselves to the WWVB atomic clock every morning at around 2-4 AM; it is more accurate to call them “radio-controlled clocks”
- “East is Even / West is Odd” Calling on Even and Odd Minutes (seldom used nowadays for 10 GHz contesting – Fixed stations listen “always” and rover stations beacon when they arrive at a new location that looks like it might work. Coordination on other frequencies or even by cell phone is also possible, has been allowed in the 10 GHz & Up Cumulative for years, and is now allowed in VHF and UHF contests also.

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Planning a successful microwave outing

1. Get as many participants as possible lined up ahead of time.
2. Get as many good operating locations as possible lined up and scouted out ahead of time. Last year's good site may not be this year's good site (vegetation, construction, etc.)
3. Get operators willing to work from semi-fixed or fixed locations, and operators willing to go out as rovers.
4. For maximum scores and maximum fun, keeping the numbers of operators in the two categories as close to equal as possible helps. (1 fixed and 11 rovers is not nearly as productive (or as fun) as 6 fixed stations and 6 rovers).

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Fixed stations line up side-by-side so that all have a clear shot in the direction where the rovers plan to operate.

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When rovers find a likely spot, they park in a safe manner that allows them to have access to the direction of the fixed station.

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Rovers have announced their intended starting point ahead of time, and know the location of the fixed site. Therefore both ends' 6-digit grid squares should be known ahead of time, and the bearings in both directions can be computed. The fixed stations point where the rovers are expected and listen. The rovers point to where the fixed stations are expected and when they are set up, 1 or 2 of them start beaconing in CW.

All rovers "net" to the beacon frequency.

If (any of) the fixed stations hear the rovers, they "net" to the beacon frequency and when rover beaconing stops, one of the fixed stations beacons back.

Fixed stations "net" to the beacon frequency if necessary, particularly if not all of them heard the rovers' beacon.

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Many years ago, we relied heavily on “coordination” via non-microwave frequencies or cell phones, but now it is quite common to not need those at all, if distances are kept short enough that SSB communication is usually possible.

If communication is established between the rovers and the fixed site, QSO’s can begin. Sometimes, not all of the stations on either end have heard the other end, and if those on either end are having a great deal of difficulty, they can ask for additional beaconing in either direction to get their dishes peaked optimally.

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One rover is designated as “lead rover”, and (s)he begins working the fixed stations in order.

Fixed stations hearing the best should be contacted first, giving the stations hearing more poorly additional time to tweak their tuning and aiming.

Rover stations hearing the most poorly should be put at the end of the rover rotation, so that they can have as much time listening to the earlier QSO’s, and use that time to optimize their tuning and pointing.

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Try to work in the same order if possible, to improve efficiency, e.g.:

Rover$_1$ works Fixed$_1$, Fixed$_2$, Fixed$_3$, … Fixed$_n$;

Rover$_2$ works Fixed$_1$, Fixed$_2$, Fixed$_3$, … Fixed$_n$;

Rover$_3$ works Fixed$_1$, Fixed$_2$, Fixed$_3$, … Fixed$_n$;

… etc. With good SSB signals and everyone tuned in and pointing correctly, it may be possible to work a station with full bi-directional exchange of information in 10-15 seconds, or 4-6 QSO's in a minute!

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Rain, Rain, Go Away?

As you might well imagine, rain falling directly over either the fixed or rover stations (or both) is, in the words of George Orwell, “Double Plus UnGood”. In general, rainwater getting into electronic components does NOT help them to work better (in fact, just the opposite), nor does it please most operators, even if they brought along rain ponchos.

Rain falling BETWEEN the fixed and the rover stations may be a Good Thing, due to the possibility of working via rainscatter.

Rainscatter signals have some similarity to aurora signals, tend to be distorted, and may be surprisingly easier to copy in FM mode than in SSB mode. You will need to be able to tilt your dish up above the horizon to take advantage of this mode.

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Scoring the 10 GHz & Up Cumulative Contest (SBMS 2.3 GHz & Up Contest is similar, but not identical)

1. You get 100 points (called QSO points) for each unique station you work during the contest. If you are in the “Up” category, you can count the other station as a unique on the 10 GHz band, and as another unique on the 24 GHz band, for example.
2. You get 1 point per Km of distance between your station and the station you work, so a single 100 Km contact is worth as much as ten 10 Km contacts.
3. You can work any given station on a given band as many times as you wish, as long as either end of the contact has moved at least 16 Km / 10 Miles.

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There remains some controversy over the 10 Mile / 16 Km move rule. Strict interpretation of the rules would have you draw a 10 mile / 16 Km radius circle around any spot that was worked from or worked to, and consider everything inside of that circle to be excluded from another contact. Liberal interpretation of the rules would say that if you drove 5 miles south, 1 mile east, and 4 miles north, you travelled 10 miles even though you are little more than a mile away from the prior location, you could count this as a new location. The Contest Branch seems unwilling to promulgate a precise definition, so you are somewhat on your own there. The “exclusionary radius” interpretation is the safest one.

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Because of the distance-based scoring (1 point per kilometer of distance), it is imperative that you be able to compute or measure the distance between each end of each QSO. The ARRL standard logging form has a column for distance and you will find it a lot less painful to have a program that tells you, for example, that the distance between EN34ir and EN37ed is 269.8 Km (round it to 270 Km), rather than measuring the distance on a map with a ruler and comparing that to the map scale.

I created an Excel spreadsheet (also works on most versions of the free Open Office software) that can do all the distance computations and scoring calculations for you automagically.

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Other tips…

SSB contacts tend to be quicker than CW contacts, but also require stronger signals and therefore tend to be at shorter distances (and therefore worth fewer points per contact).

If you barely work a station at 200 Km, or have to resort to CW, or fail to make a valid QSO at all, and the station is planning to make their next move to an even further location, do not assume that you won't make further contacts with them. Each location has its own propagation to you.

Early AM and late PM seem to be prime times for strongest propagation, and mid-day seems to have a "lull" in signal strength.

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Use headphones to help you dig out the weaker signals. And don't forget the CW key/paddles for the *really* weak ones.

An SDR with a panadapter may be very helpful at finding and homing in on very weak signals, but many LCD displays are very hard to read in outdoor sunlight.

Digital signal operation (e.g., JT65 mode) may allow you to extend your distances, but will probably slow you down a lot.

Operating solo is always harder than operating in a group.

> Group operations facilitate "netting" to the proper frequency, finding good operating spots (though sometimes the spots can lead to "disagreements"), helping you make emergency on-the-spot repairs to malfunctioning equipment, or loaning you an extra battery if yours goes dead. And remember how those friends helped you assemble your station, measure its power output and transmission frequency, and the gain of your antenna earlier?

Microwave Operating

You'll never get good at it

Unless you

At least **get started!**

73 de WØJT/5, EL09vu