Skewed Path to FT5ZM on 10-Meters
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The January/February 2014 FT5ZM DXpedition to Amsterdam Island in the southern Indian Ocean gave many DXers a new DXCC country. The FT5ZM team did an excellent job handing out QSOs. Visit http://www.amsterdamdx.org for more details on this DXpedition (the team, the island, QSL procedures, etc)

Did you work them on 10-Meters? If so, did you find that your directional antenna was pointed in an unexpected direction? For example, after the DXpedition I received an e-mail from Ed N4II commenting that he and several others in south Florida worked FT5ZM on 10-Meters not via the true great circle path to the southeast, but rather along a skewed path on headings between 60 and 75 degrees (essentially to the northeast). What we'll do in this article is answer two fundamental questions with respect to skewed paths: Why wasn't the true great circle path available? And what enabled the skewed path? Along the way we'll learn about great circle paths, worldwide F2 region ionization and how propagation predictions work. Let's get started with great circle paths.

The shortest distance between any two points on a globe is a short great circle path (commercial airliners generally fly great circle paths to minimize fuel consumption unless their path is modified by winds, terrestrial weather storms, geomagnetic field storms or political issues). Going the opposite way around from the short path is the long great circle path. Figure 1 shows great circle paths (dotted black lines) out of FT5ZM in 10 degree increments (thanks to NM7M SK for the software that generates these maps).

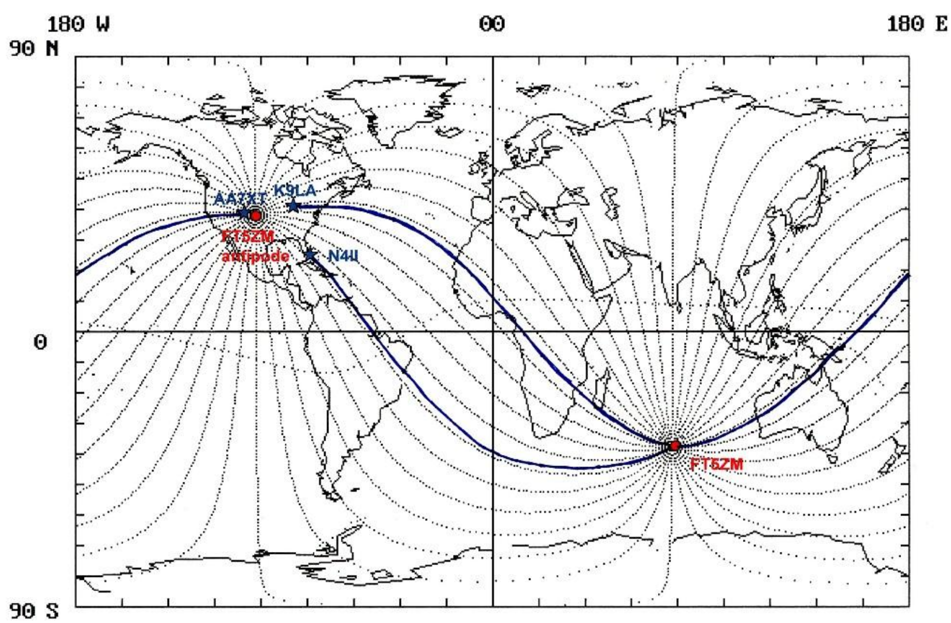

Figure 1 – Great circle paths out of FT5ZM

FT5ZM is the red dot in the southern Indian Ocean. The other red dot (in North America) is the FT5ZM antipode. The antipode of a location is the point on Earth that is exactly on the opposite side of the Earth. For the record, the FT5ZM antipode is in southeast Colorado. All great circle paths out of FT5ZM arrive at the antipode. Locations in North America that are east of the FT5ZM antipode have their short great circle paths to FT5ZM in an easterly direction. Locations in North America west of the FT5ZM antipode have their short great circle paths to FT5ZM in a westerly direction. Locations exactly on the antipode longitude can either go north or south – both are the same distance. The dotted line meandering above and below 0 degrees geographic latitude is the magnetic equator.

Highlighted with solid blue lines in Figure 1 are short great circle paths from N4II to FT5ZM (a southeasterly heading out of N4II), from K9LA to FT5ZM (an easterly heading out of K9LA) and from AA7XT to FT5ZM (a westerly heading out of AA7XT – AA7XT is included to help with answering the aforementioned second question – also see footnote 1 at the end of this article). These North America locations are the blue stars.

To answer the first question (why wasn't the true great circle path available?), we'll look at a worldwide map of F2 region ionization. Figure 2 (thanks to Proplab Pro V3) is this map, with the blue stars the same locations as in Figure 1. The overhead Sun is the yellow Sun-like dot off the eastern coast of South America. The cross-hatched area (kind of tough to see) is the dark ionosphere.

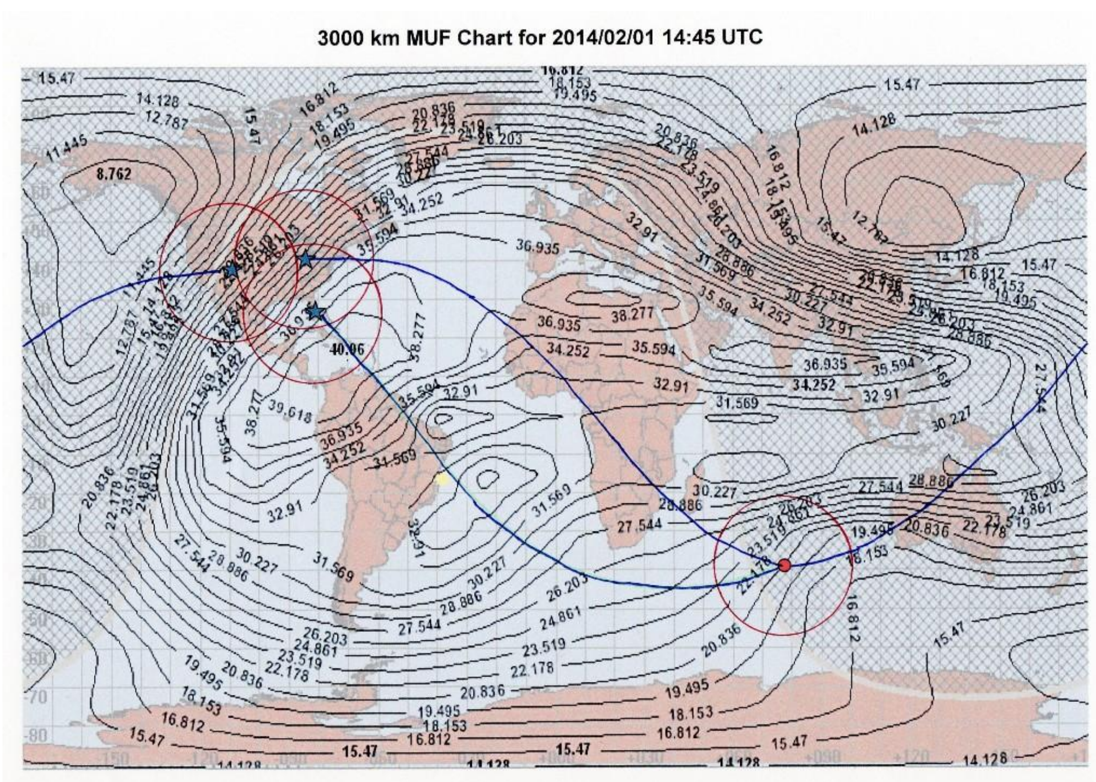

Figure 2 – Worldwide F2 MUF map with great circle paths

Figure 2 shows contours of the MUF (maximum useable frequency) in MHz at 1445 UTC for the one-month period centered on February 1, 2014. These are monthly median values, implying 50% probability. On any given day in this one-month period, the MUF could be several MHz higher or lower than the designated value. To generate this map for best accuracy in the vicinity of FT5ZM, I downloaded ionosonde data at Perth, Australia and varied the sunspot number to force the F2 region model in Proplab Pro V3 to agree with the monthly median Perth data.

Any point on Figure 2 can be considered the mid point of a 3000 km hop via the F2 region. The value at that point (interpolation is needed between the contour lines) is the MUF over this 3000km hop length. For a shorter hop, the MUF will be a little lower since the wave encounters the ionosphere at a slightly higher angle. For a longer hop, the MUF will be a little higher since the wave encounters the ionosphere at a slightly lower angle. For example, the MUF for a 4000 km hop (the accepted limit of a hop at the higher end of the HF bands) is about 10% higher than the 3000 km MUF. I mention this as our propagation predictions essentially use 4000 km hops for predicting F2 region openings.

This concept of using 4000 km hops comes from the fact that it has been found from many observations that F2 region propagation beyond 4000 km does not appear to fail until the ionosphere fails to support propagation at one of two ‘control points’ on the great circle path at 2000 km from each end. This is the reason why there are red circles on Figure 2 centered on FT5ZM, N4II, K9LA and AA7XT. The circles have a radius of 2000 km, and thus are the control points around the compass for paths out of these four locations. If the MUF is very close to 28 MHz at the two control points (remembering to take into account the 10% increase from the previous paragraph and allowing for the daily variation), then F2 region propagation is likely for the entire path.

From the red circle around FT5ZM we see that headings from about northwest through northeast are the only ones that could support 10-Meters at the given time of day because of the lower MUFs at higher southern latitudes. In actuality this is pretty much true for the entire day. Thus the great circle path to N4II (again highlighted in blue) is not available, even though the N4II end can support 10-Meters. Also, the solid blue great circle path to AA7XT is not available at either end. Finally, the solid blue great circle path to me (K9LA) is right on the verge of being available (I did work them on an easterly heading along the true great circle path).

Now we know why N4II (and AA7XT) did not work FT5ZM along their short great circle paths. The N4II end could support 28 MHz but the FT5ZM end could not. AA7XT was hit with a double whammy – neither end could support 28 MHz. This brings us to the second question – what enabled the skewed path?

To understand what enabled the skewed paths out of N4II and AA7XT, we’ll use the same worldwide MUF map as in Figure 2 but now we’ll include the actual reported headings out of N4II (we’ll use the mid point of 67.5 degrees) and out of AA7XT (to the northeast over Europe). See Figure 3.

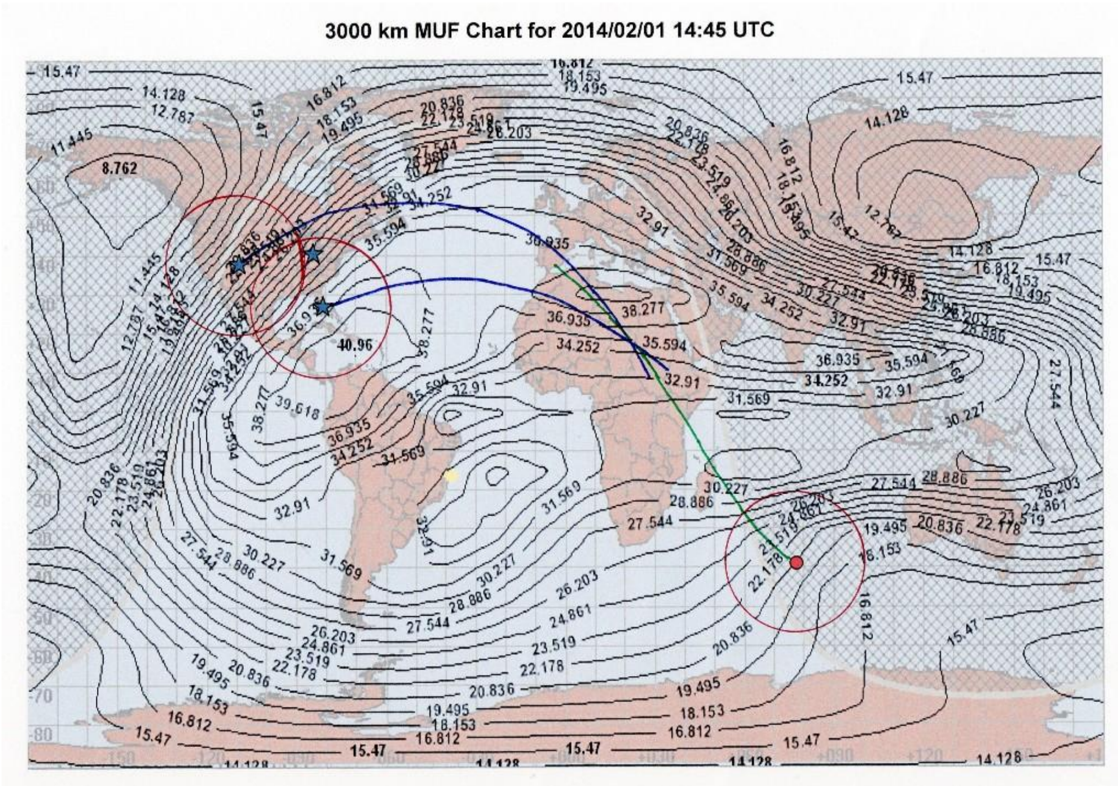

Figure 3 – Worldwide F2 MUF with skewed paths

For N4II, his red circle still shows his end of the solid blue 67.5 degree great circle path can support 28 MHz. For AA7XT, his red circle now shows his end of the solid blue 45 degree great circle path can support 28 MHz.

Note that I extended these reported headings out of N4II and AA7XT until they intersected over northern Africa. This suggests that this is the area in which the skew of each path took place to put it onto a great circle path into FT5ZM. I also took the liberty of adding the great circle path out of FT5ZM to this intersection (highlighted in green). The heading out of FT5ZM to this skew point can now support 28 MHz.

This area being the skew point makes a lot of sense, as it’s in the equatorial ionosphere where the highest electron densities exist. A quick look at the horizontal electron density gradients in this area suggests refraction is not the skewing mechanism. It is more likely that reflection with some loss (or even scatter) was the skewing mechanism.

Now we have a good idea of what enabled the skewed path. The RF from N4II and AA7XT headed out on headings that could support 28 MHz and skewed (thanks to the robust equatorial ionosphere) onto a heading into FT5ZM that could support 28 MHz.

Some final comments are in order. First, N4II reported that 20-Meters through 10-Meters exhibited the observed skew. Figure 2 suggests that 12-Meters had the same problem as 10-Meters – the lack of enough ionization around FT5ZM. But based on the MUF data in Figure 2, 15-Meters, 17-Meters and 20-Meters could have been supported along the short great circle path. Why they weren't could be due to the FT5ZM Yagi pointed in a more northerly heading and/or increased ionospheric absorption as the true great circle path goes right under the overhead Sun (most absorption). More work is needed here.

Second, many 160-Meter operators reported hearing FT5ZM from other than their great circle path. For details on this, visit http://k9la.us. Then click on the 160m link on the left side of the page. Download the pdf titled "Arrival Direction of FT5ZM in NA on 160m – Rev C".

In summary, we've answered with good confidence the two fundamental questions with respect to FT5ZM skewed paths on 10-Meters – why wasn't the true great circle path available and what enabled the skewed path. In doing this, we learned about great circle paths, we learned that F2 region MUFs are highest around the equator and lowest at the higher latitudes, and we learned how our propagation prediction programs assess whether a path can support a given frequency.

Footnote 1

Figure 1 shows that AA7XT is very close to the FT5ZM antipode. You've probably read about the magical qualities of being very near a station's antipode. Signals could arrive from many directions. And there can be a signal enhancement with all the signals from different directions adding in-phase.

These two qualities need to be tempered with real-world physics. First, on the higher bands, is the ionization high enough along the many paths to support the given frequency? And on the lower bands, is ionospheric absorption low enough along the many paths to give useable signals? Second, if many signals manage to arrive, are they equal enough in amplitude and close enough in phase to give a noticeable enhancement with a reasonable probability?

This is an interesting topic that can generate some interesting claims. I believe it is best to work with both observations and science to arrive at a reasonable conclusion.