Interpreting *QST*'s New Propagation Charts for Low Power and Low Antennas

The monthly propagation charts in the "How's DX?" column are computed for a high-power amateur "superstation." But you can definitely use the charts for a modest setup, as well. Here's how.

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October 1994 *QST* introduced a new format for the propagation charts that appear each month in the "How's DX?" column.[1] Some readers have expressed concern about the "unreal" station values chosen to prepare the charts, those listed in Table 2 of that article. Instead, shouldn't the values be chosen for a more typical amateur station? To recap briefly, the charts are calculated for a CW transmitter power of 1500 W with high dipoles (100 ft) for the lower frequency bands, three-element Yagis at 100 feet for 20 and 17 meters, and four-element Yagis at 60 feet for the higher frequency bands. The man-made noise level specified for receiving was quiet, typical of rural areas.

[1]Notes appear on page 36.

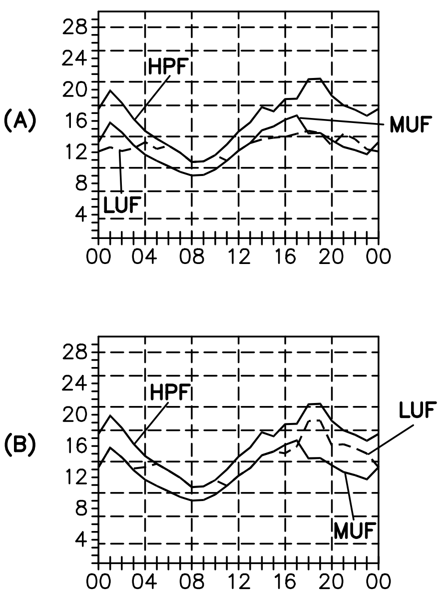

Figure 1—Propagation probabilities from mid-USA to Central Asia for April (any year) with an observed solar flux value of 80. The path length is 7728 statute miles. At A, curves for the superstation, and at B, curves for a modest station described in the text. Note that the HPF and MUF curves are identical, not affected by station equipment; only the LUF curves differ. Also note that at B, much information is lost on the time and frequency boundaries for possible contacts.

Granted, that setup describes a "superstation"—a "big gun" station—that is available to only a small percentage of radio amateurs. So what good are the charts to the average amateur? The short answer is that a superstation best defines the probable time and frequency *boundaries* for making amateur contacts. In other words, if we consider a particular path, those boundaries define the earliest probable time for a band to open and the latest time for it to close.

Let's investigate this further. Assume it is April and that we live in the central part of the US. The observed 2800-MHz solar flux is 80, and we want to know the probable propagation conditions to Central Asia. Figure 1 graphs the *IONCAP* results. First let's examine curves for the superstation (Figure 1A). You will recall that the MUF curve refers to the median Maximum Usable Frequency, that is, the MUF that occurs 50% of the days in a month. Similarly, LUF refers to the Lowest Usable Frequency, with the LUF being that which occurs 50% of the days in a month.[2] The term HPF refers to the Highest Possible Frequency, which occurs 10% of the days in a month.

From the sections of the chart where the LUF (broken line) is below the median MUF (lower solid line), we see that on 50% of the days in April, 20 meters will be open from about 0030 to 0230 UTC (all times quoted in this article are UTC times). A marginal opening should exist from about 1330 (when the MUF rises above the 14 MHz line) to 1500, when the LUF crosses over the 14 MHz line. The HPF (upper solid line in Figure 1A) shows that on 10% of the days in April, 17 meters should be open from 0000 to 0200 and again from 1530 to 2100. In addition, a one-hour-long 15-meter opening should develop around 1800 UTC on 10% of the days in April.

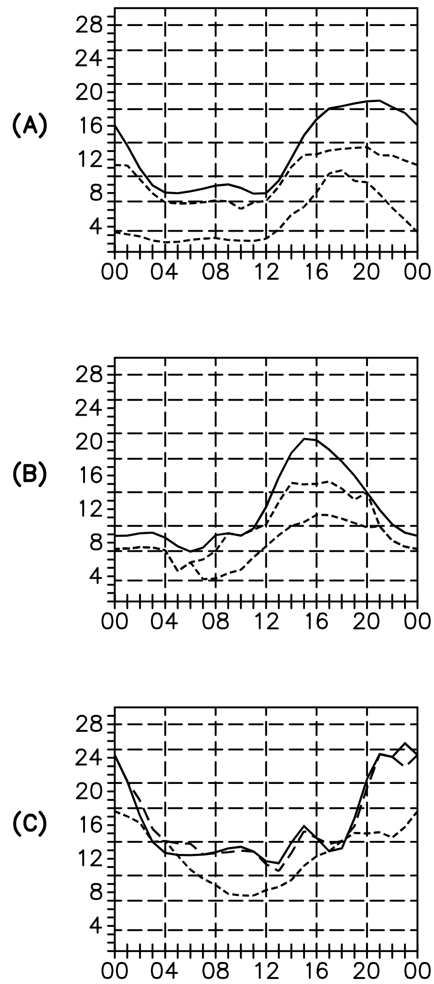

Figure 2—From top to bottom, MUF and LUF probabilities for short, medium, and long-distance paths: at A, East Coast to West Coast; at B, mid-USA to Western Europe; and at C, mid-USA to Australia. These charts are for February (any year) and a 2800-MHz observed solar flux value of 75. The upper LUF curve is for a modest station, as described in the text, and the lower LUF curve is for the superstation. Receiving antennas were held constant for these calculations.

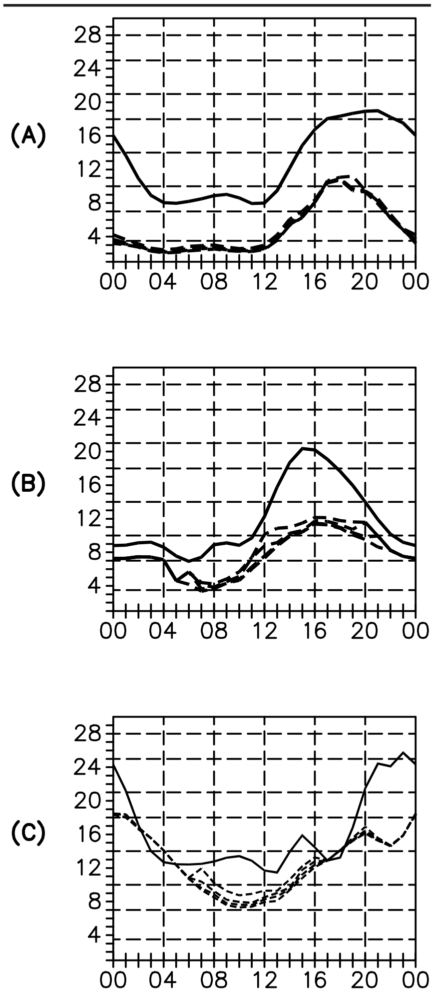

Figure 3—MUF and LUF probabilities for four antenna heights over average earth. LUF curves in each chart (top to bottom) are for antenna heights of 50 feet, 75 feet, 100 feet, and 125 feet. Transmitter antenna gains, transmitter power, receiver antennas and receiver noise levels were held constant for all antenna heights.

Curves for the Modest Station

Now let's examine Figure 1B, charted for the same path but for a more modest amateur station. These curves are for a typical residential station running a 100-W transmitter with dipole antennas at 50 feet for 80, 40 and 30 meters, and small Yagis (5 dBd gain) at 55 feet for 20, 17, 15, 12 and 10 meters. The receiver noise level is –136 dBW, typical for residential areas.

Note, first of all, that the HPF and the median MUF in Figure 1B are *identical* to those in Figure 1A. Power levels and antennas almost never affect the MUF. The LUF curve, however, is a different story, showing that on 50% of the days there will be no amateur-band openings at all during the 24-hour day. But a more serious consequence is that in Figure 1B we've lost useful information on any *potential* band openings. This chart does show a frequency window at 1600, but that occurs outside any amateur band. The chart also shows the probability of 20, 17 and 10-meter openings on 10% of the days in April (about three days).

But what about the other 27 days of the month? If you had only these modest-station curves available, you'd just be guessing about possible contacts on this path with more than 100 W or with antennas higher than 55 feet. If you *could* make contacts, how much more power would you need: 500 W? The legal limit? Or how high an antenna: 75 feet? 100? And at what times of the day?

Figure 1B gives almost no information in answer to these questions, since the median time and frequency boundaries are not indicated. About all we can say for certain is that we should avoid times when the LUF curve is well above the median MUF curve. It is for this reason that the "superstation" parameters are used for the *QST* curves—to show the probable boundaries for *any* amateur station. So when you use the charts, just keep in mind that they do represent boundaries.

By the way, do not be discouraged by the bleak outlook for modest stations from Figure 1B; most paths are not so gloomy.

Using the Published Charts with a Modest Station

Is there a way to use the published charts and compensate for low power and low antennas? Yes there is, but it's not a simple matter of adding or subtracting decibels and coming up with a firm result. Some general guidelines can be drawn from Figures 2 through 6. These are charts of the median MUF and LUF results for various differences in the station complement and the ionosphere. The HPF curves are omitted to avoid confusion from too many lines. All charts show the same three paths: short in length, medium, and long-distance. The shortest path (at A in each figure) is between the East Coast and the West Coast, 2435 miles. The medium-length path (at B) is between mid-USA and Western Europe, 4345 miles, and the longest path (at C) is mid-USA to Australia, 8843 miles. All charts are for February (for any year), and all but Figure 6 are for an average observed solar flux of 75, about what we are currently seeing.

Figure 2 shows the probabilities for the superstation and for a modest station. *IONCAP* calculations for lower power and lower antennas indicate what many amateurs already know from experience—a band will often open sooner and close later for the superstation than for the modest station. For example, Figure 2A indicates that on 50% of the days, the 40-meter band for the modest station will be marginally open for contacts from the East Coast to the West Coast for 8 hours, from about 0400 to 1200. For the superstation, 40 meters will be open for 17 hours—9 hours longer—from 2200 to 1500. (Longer band openings won't always take place for superstations, however. From Figure 2A, the time frame for the 17-meter opening is 1700 to 2200 for both the modest station and the superstation. Of course the received signal strengths from the two stations will differ during this opening!)

And as experience has also shown, *IONCAP* reports (in Figure 1) that for some long-distance paths, contacts may be possible from a superstation at times they are not very likely from a modest station. Great distances alone, however, don't mean there will be no band openings for modest stations. To wit, from Figure 2C for a winter month and for a lower level of solar activity than was used for Figure 1, we see a predicted opening from mid-USA to Australia on 12 meters, albeit brief, at 2300 UTC. And yet the path to Australia, Figure 2C, is 1115 miles longer than the path of Figure 1. The difference in path latitudes is the primary reason for this. Paths that cross the equator usually experience higher MUFs than those that don't.

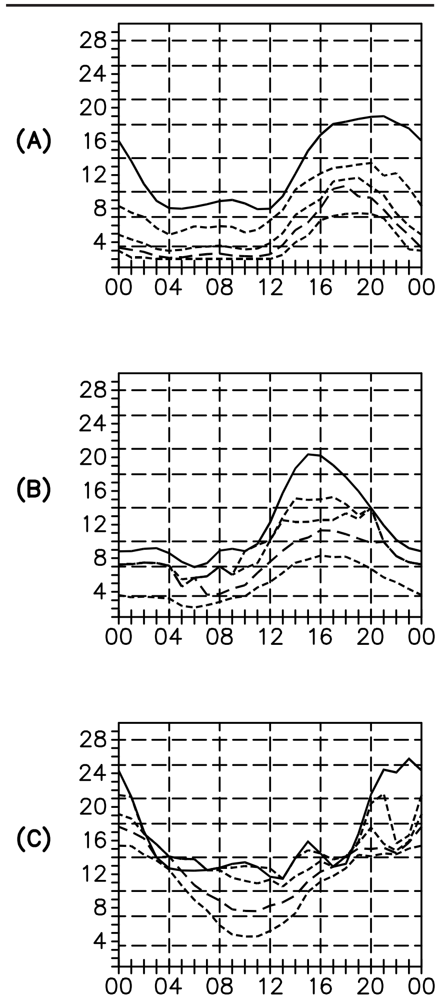

Figure 4—MUF and LUF probabilities for four different transmitter power levels. LUF curves in each chart are 5 W at the top, then 100 W, 1500 W, and the 100 kW broadcast station at the bottom. Antenna gains, antenna heights and receiver noise levels were held constant for all power levels.

Antenna Height

Aside from the time of day, the time of year and the level of solar activity, the following factors determine the LUF: transmitter and receiver antenna heights, transmitter and receiver antenna gains, transmitter power, and man-made noise level at the receiver site. Of these, transmitter power, antenna gains and the noise level at the receiv-

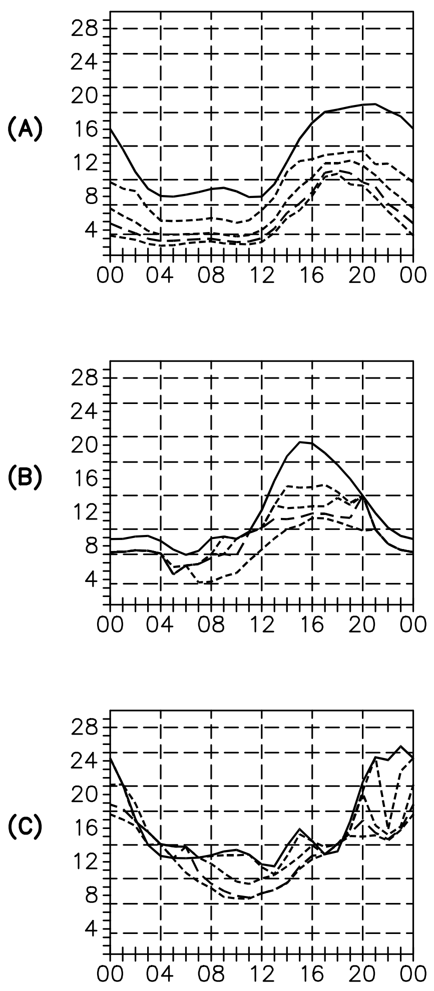

Figure 5—MUF and LUF probabilities for four levels of man-made noise at the receiver site. LUF curves in each chart (top to bottom) are for man-made noise levels of –125 dBW (typical for industrial areas), –136 dBW (residential), –148 dBW (rural), and –164 dBW (remote). Antenna gains, antenna heights and transmitter power levels were held constant for all noise levels.

ing location are the most significant. It may come as a surprise that antenna height is not always a big factor as far as the LUF is concerned. The results of varying transmitter antenna heights from 50 to 125 feet are shown in Figure 3. You'll note that the four LUF curves of Figure 3A almost merge into one thick line.

However, greater antenna height can be an advantage at certain times of the day for some paths, indicated by a spreading of the LUF curves. Under conditions when the LUF is just below an amateur band, high antennas can widen the QSO window enough to enable contacts that may be impossible with low antennas. Figure 3B depicts such a situation for 30 meters at 1200. Here, *IONCAP* indicates that stations with high antennas will likely have "armchair copy" from stations in Western Europe, whereas those with low antennas will find the European signals to be down in the noise and unreadable.

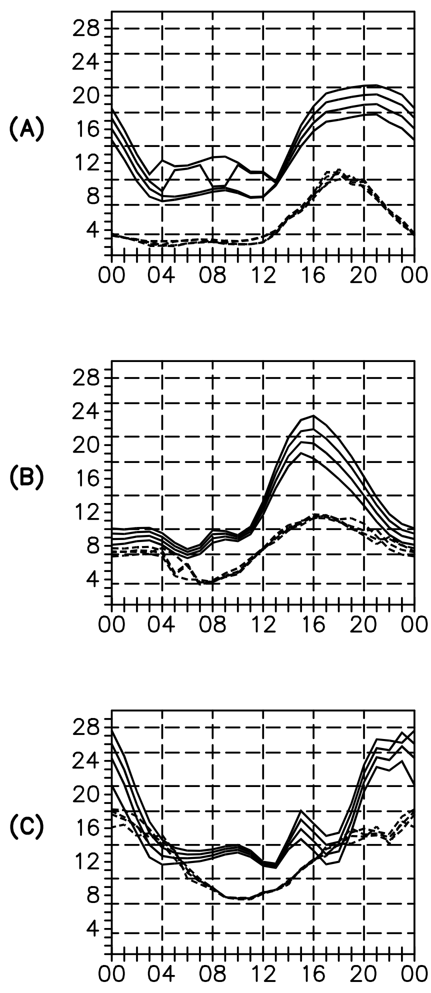

Figure 6—MUF and LUF probabilities for four levels of solar activity for February (any year). The 2800-MHz solar flux levels in each chart (top to bottom) for both sets of curves are 95, 85, 75 and 65. Antenna gains, antenna heights, transmitter power levels and noise levels were held constant for all solar activity levels. With increasing levels of solar activity, the MUF increases at a faster rate than the LUF.

Power Levels and Noise Levels

Figure 4 shows the results with three amateur-transmitter power levels—5 W, 100 W and 1500 W. And just to show how much you do (or don't) gain with *really* high power, a curve for a 100 kW broadcast station is included for comparison. As you can see from Figure 4C for Australia, even at the broadcast-station power level, the LUF is not always far below the median MUF. While increasing your transmitter power does enable the receiving station to hear you better, that does nothing as far as your ability to hear the other station. It often happens that DX stations can *hear* US stations but are unable to make two-way contact with their low power. Even so, DXers will be quick to point out that the increased power will give you an edge over the weaker signals in a pileup.

In this article I have not included charts for varied antenna gains, but the effect would be exactly the same as changing the transmitter power level; a 10-dB gain in antenna performance produces the same result at the receiver site as a 10-dB gain in transmitter power. But of course that 10-dB antenna gain improves the other station's signal by 10 dB when *you* are doing the receiving.

Figure 5 shows the effects of different noise levels at the receiver site—typical levels for industrial areas, residential areas, rural areas and remote areas. The value for industrial areas, 125 dB below 1 W at 3 MHz, equates to an S-meter reading slightly below S6 if we equate S9 to 50 μV across 50 Ω and if we assume an S unit to be 6 dB. The remaining noise levels are progressively lower in strength. As we all know, high noise levels at the receiver site can completely mask weaker incoming signals.

Day-to-Day Changes

The charts published in *QST* are prepared in advance of the period they cover, using a predicted level of average solar activity. Even if the prediction is quite accurate on the average, the solar activity level will vary over the monthly period covered by the charts. Figure 6 displays the effects of "long-term" variations in solar activity—longer than just a day or two. (Although *IONCAP* is not intended to calculate probabilities for less than a calendar month, experience indicates that the calculated results are useful for a shorter term if the level of solar activity has remained relatively constant for several days running.)

The LUF curves published in *QST* assume that the Earth's geomagnetic activity is low. Observations indicate that the LUF rises with increasing values of K and A indices, whose values are broadcast hourly by WWV and WWVH. Furthermore, we know that the LUF also depends on day- to-day propagation conditions, just as the MUF does. When solar activity increases, so do path losses from absorption at lower frequencies. Therefore, on exceptionally good days when propagation conditions support the HPF, the LUF will be somewhat higher than the *QST* curves indicate. Figure 6 shows the degree of such changes for a fixed set of antennas, power and receive noise level. As you can see, the MUF increases at a faster rate than the LUF for increased levels of solar activity.

In summary, don't give up on using the monthly charts if you have only a modest station or if you run QRP. Just remember the old adage that frequencies slightly below the MUF are always the best to use. You can work the world with 5 W if you choose your frequencies carefully and if you are persistent. The curves will give you a wealth of useful information when you go looking for contacts, guiding you to the best bands and the best times to fill your logbook with DX calls.

Notes

1 Jerry Hall, K1TD, "Those New *QST* Propagation Charts," *QST*, Oct 1994, pp 27-30.

2 Some propagation experts use the term LUF to mean the lowest usable frequency for 90% reliability. This reliability level is more useful for broadcast station planning than for Amateur Radio needs. We have chosen to use a less conservative 50% level for required reliability in the "How's DX?" graphs. QST