Some Reflections on WRTC 2006—Part 1

Dean Straw, N6BV, Team Leader at PT5J (with Mark Obermann, AG9A)

First, I want to thank the Northern California Contest Club for nominating me as Team Captain for one of the two US National WRTC teams. This type of team was designed to honor the host countries and organizing committees from previous WRTC events. For the US the first WRTC was held in Seattle in 1990, and the second WRTC was held in San Francisco in 1996. (There were also National WRTC Teams from Slovenia and Finland, where WRTCs were held in 2000 and 2002, respectively.)

Because of the way qualifications were ranked for selection to WRTC 2006, frankly I wouldn't have been able to qualify on my own. Most of the contests I have operated since I returned to the Bay Area in 1998 have been at multi-multi operations out at N6RO's place. Single-operator, all-band scores counted more for WRTC 2006 qualification.

Same Playing Field

WRTC has been billed as "the ham radio Olympic Games," a way of determining the best operators in the world, using a level playing field. From the official Web site for WRTC 2006:

"The World Radiosport Team Championship — WRTC in short — represents a large gathering of the world's best in radio traffic — as selected Regionally — coming from some 35 different countries and all continents in the spirit of competition, using the same playing field and allowing pure skills to determine world champions in two-man team, 24-hour nonstop competition in Florianopolis, the state of Santa Catarina, Brazil."

In my opinion, the organizers in Brazil did an absolutely amazing job trying to reach the goal of "same playing field." They set up 47 identical, brand-new antenna installations with towers, log-periodic 20/15/10 meter beams, 2 element 40 meter beams and 80 meter loaded dipoles at each of the stations. As best they could, the Brazilian organizers tried to ensure that the stations were located with clear shots to the major population areas for the contest — Europe, the USA and Japan.

The organizers put in a truly mind-boggling amount of time and effort. They placed many stations at existing ham locations, as might be expected. But they also negotiated with city and national authorities to put many other stations at completely new locations. For example, my partner Mark Obermann, AG9A, and I enjoyed the facilities at a research facility that studied aquatic life (shrimp, shellfish and fish). This site had never seen a ham radio installation before. But there we were, with a brand-new 50 foot high tower, loaded with shiny new antennas and rotator.

Other WRTC 2006 stations were located in city parks, and many stations were located at the houses of non-hams, somehow recruited to allow a large amount of antenna hardware to be placed at their residences. And each house was taken over by two "Type-A" contesters and a referee for 24 hours!

The Brazilian organizers also worked tirelessly with the local electrical power company in Florianopolis to minimize power-line noise at each location. Even so, some stations experienced very bad local power-line QRN during the actual competition. My understanding was that some of the noise came from defective streetlamps that started arcing when they turned on after nightfall. Arcing streetlamps would not have been noticed when the local electrical crew was out to replace defective insulators or pole hardware — during the daylight hours.

Now, let me emphasize that to the extent that everything wasn't perfect — that the playing field wasn't precisely level for everybody — is not a reflection of any lack of effort on the part of the Brazilian organizers. I can't even begin to imagine the amount of effort they put into making this WRTC 2006 successful. The amount of time spent negotiating — and implementing — such arrangements had to be incredible. Kudos to the PYs!

Summary of the Final Results

Table 1 summarizes the results for the Top Four WRTC 2006 stations, along with the 31st ranked station, operated by my partner AG9A and myself. More later on the results for this lower ranked station. Note also that I could not get exact latitude/longitude locations for many of the other WRTC 2006 stations.

The top-ranked station, PT5M, outdid the competition in terms of total QSOs, while still maintaining a competitive multiplier total. The second team, PW5C, apparently placed more emphasis on

Table 1

Rank	Station	Operators	Total QSOs	Total Mults
1	PT5M	VE3EJ, VE7ZO	2369	230
2	PW5C	N6ML, N2NL	2200	241
3	PT5Y	K1DG, N2NT	2124	230
4	PW5X	UT4UZ, UT5UGR	2304	204
31	PT5J	N6BV, AG9A	1736	181

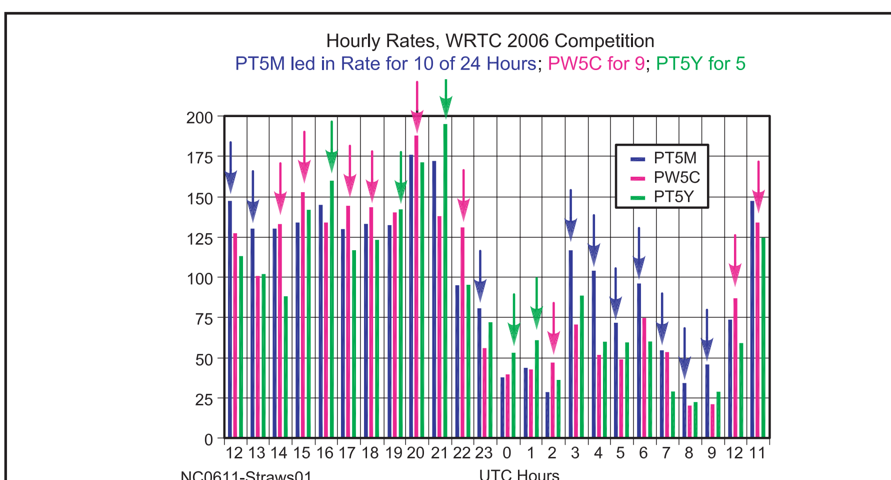

Figure 1—Hourly rates for Top Three stations in WRTC 2006. Note that PT5M led in rate for 10 hours out of the 24 hours in the contest; PW5C for nine hours; PT5Y for five hours. Obviously, rate rules!

multiplier hunting than raw QSO rate, although they also had a large QSO number. The challenge for any "morning-after" analyst is to try to separate the effects of:

- Operator skill
- Station design
- Station terrain
- Multiplier strategy
- Rate strategy
- Other problems (noise, perhaps)

For example, Figure 1 shows the hourly rates over the whole 24 hour WRTC 2006 contest for the Top Three stations. PT5M had the best rate for 10 out of those 24 hours. Second-ranked PW5C led for 9 hours, while third-ranked PT5Y led for 5 hours. Figure 1 would seem to indicate that a strategy of going primarily for rate was the winning approach. For example, you might expect that sitting on a frequency running rate calling CQ would bring in many multipliers, but not necessarily! More on this later.

Figure 2 is a bar graph showing the total QSOs on each band, separating the geographic targets of Europe and USA/Canada. Here it can be seen the PT5M team greatly dominated the other stations to the USA on both 40 and 15 meters while having a competitive QSO total to Europe on all the bands.

Many of you know that one of my favorite subjects in ham radio is trying to determine the effects of local terrain on the launch of HF signals. What I'd like to examine here is how the top results were related to having superior locations and how much were they related to strategy.

The Effects of Terrain: The Top Four Stations

When I discuss the following terrain analyses, I want to emphasize that I am not just sitting back, idly criticizing the hard work and the fantastic hospitality of our Brazilian hosts. But it is necessary to understand that the state of Santa Catarina, where Florianopolis is located, is a mountainous place.

Most of the stations used in WRTC 2006 were positioned on fairly narrow coastal plains, near the saltwater. Most QTHs that I examined were located at least some distance from the mountains, which were generally located inland from the coastal plains. (Yes, there were a few mountains right down at the seashore, but in general the mountains formed "backbones" inland.)

Figure 3 is a screen grab from *Google Earth* for a view of the PT5Y station and the area north of Florianopolis, viewed from the south. Here, the eye of the observer has been placed at 3000 feet above the ocean. This gives some 3D perspective to the terrain from PT5Y to Europe — a lovely downhill shot! In the direction of the USA there is a hill about 3000 feet from the tower.

With most of the stations I examined in this study, the most favored direction was toward Europe, although there were some notable exceptions where Europe was badly blocked (see later section on PT5G). Many of the shots toward the USA/Japan were at least partially blocked by inland hills. How badly those hills affected the antenna responses depended on the height of the hills and on how far they were away from the tower.

The rugged terrain and lush greenery in Florianopolis reminded me a lot of my own Hawaiian homeland. Setting up 47 exactly equal stations in KH6 would be a daunting task, let me assure you. In the following terrain analyses, particularly where a profile of a terrain is shown using HFTA (*HF Terrain Analysis*, the program included with the 20th edition of *The ARRL Antenna Book*), you should remember that the terrain profiles are purposely distorted to show as much terrain change as possible.

For example, Figure 4 overlays the terrain profiles from PT5M toward Europe (a heading of about 30° from southern Brazil) and also the terrain profile toward the East Coast of the US (a heading of about 340°). Each profile starts at the base of the PT5M tower, which was located at 3046 feet ASL (above sea level). The profile toward the USA drops down fairly uniformly (after the bump about 3000 feet from the tower base) to an altitude of 2750 feet at a distance of 12,891 feet from the tower. The terrain seems to fall off steeply in Figure 4, but in truth the slope is only –1.3°.

The slopes look steeper than what they really are because the x- and the y-axes for Figure 4 have different scales. The y-axis ranges from 3100 to 2730 feet, a change of only 630 feet, while the x-axis shows a change of 20,000 feet. This unequal scaling emphasizes the slope changes, and is a distortion that is purposely done in *HFTA*. Otherwise, graphing the terrain profile with equal x-axis and y-axis scaling would make the slopes look pretty much like almost horizontal lines,

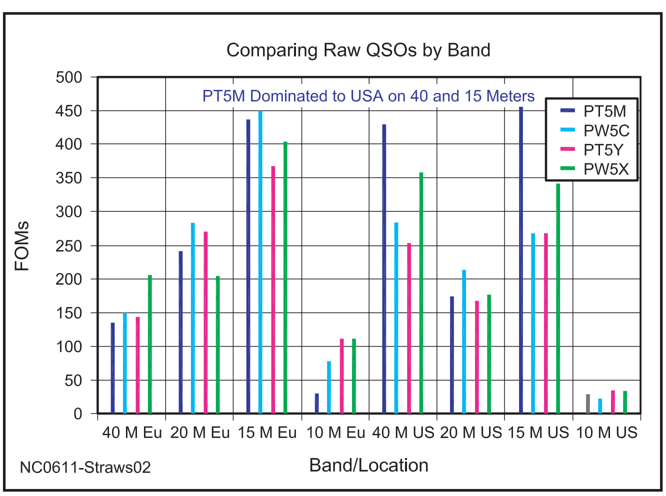

Figure 2—Comparing raw QSO totals by band for the Top Four stations in WRTC 2006. PT5M would appear to have had a significant competitive advantage toward the USA on both 40 and 15 meters, while remaining competitive into Europe on all the bands.

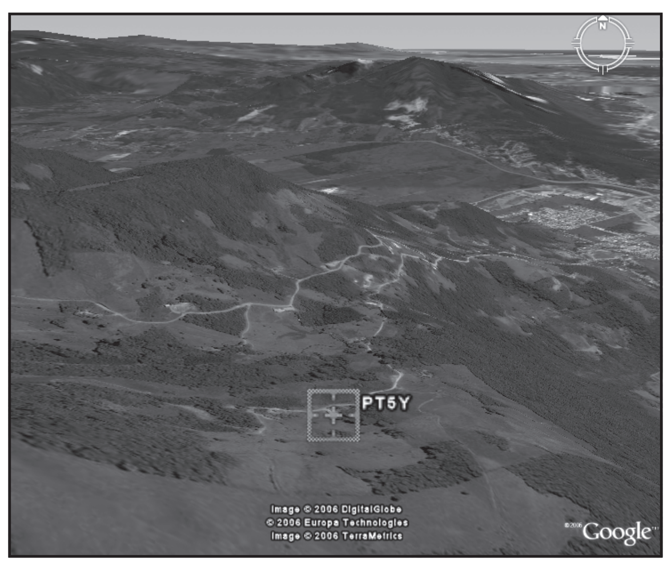

Figure 3—*Google Earth* view of the topography in the Florianopolis area. This 3D view is looking at the PT5Y QTH from the south. Note the lovely drop-off toward a heading of 30° toward Europe. There is a hill in the direction of the USA (340°), about 4000 feet from the tower base.

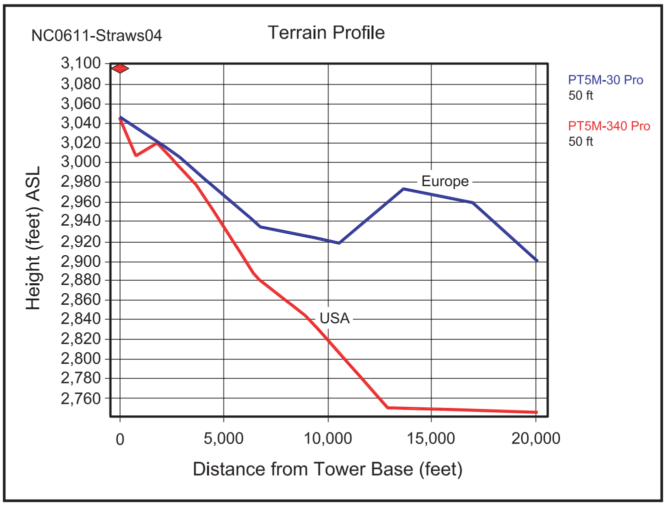

Figure 4—Terrain profiles toward Europe and toward the USA from PT5M. The ground slopes down in both directions but the slopes are only about 1° due to differences in the x- and y-axes in this *HFTA* graph.

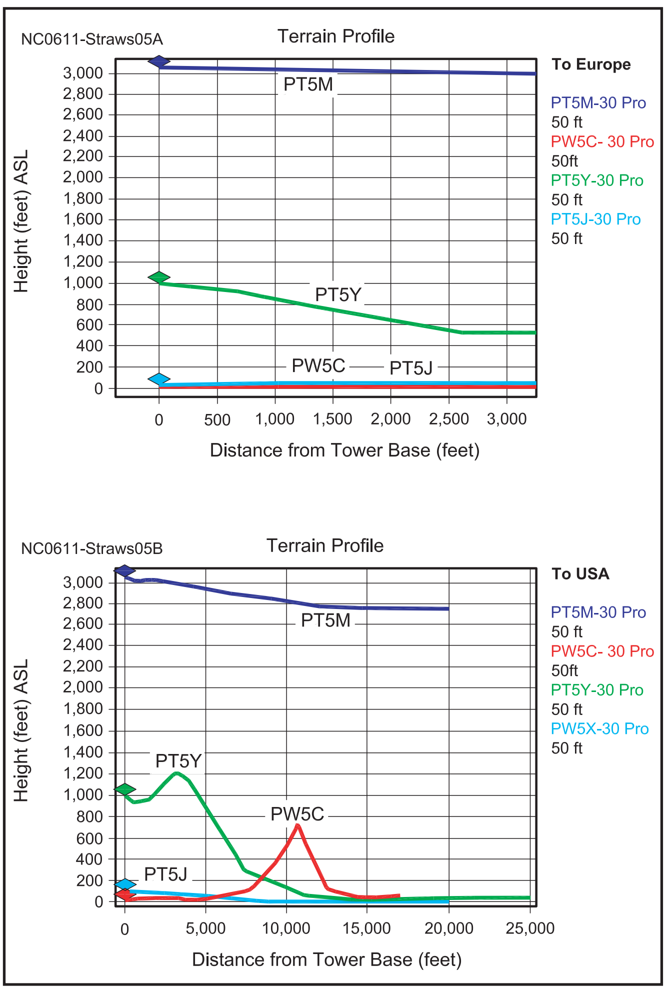

Figure 5—At A, a "true-perspective" view of the terrain profiles toward Europe from the Top Four WRTC 2006 stations, using equal scaling on both x- and y-axes. The PT5Y terrain slopes down such that the equivalent height of the tri-bander antenna on 15 meters was about 65 feet, compared to the actual physical height of 50 feet. At B, HFTA terrain profiles toward the USA.

with some very small squiggles in them.

See Figure 5A, which is a "true-perspective" view of the terrains toward Europe for the four top stations. The downward slope at PT5Y gave that station an "effective height" of 65 feet on 15 meters when the actual tri-bander was mounted at 50 feet (as were all the WRTC 2006 stations). Figure 5B shows a true-perspective view of the terrains toward the USA for the same stations.

Getting Terrain Data: *Google Earth*

For coverage of the USA, we Americans are blessed by having access to free digital terrain data on the Internet; this comes from the USGS (US Geological Survey). The theory is that in a democracy the data generated by the government should belong to the people in that democracy. Other countries look at things in a different manner, usually preferring to keep such data proprietary to their governments.

Thus, about the only source of reasonably accurate terrain data worldwide outside the USA is that captured by satellites (for example, LandSat or the Space Shuttle Radar Topography Mission). The data released to the public is less accurate, generally speaking, than the original survey data because of security concerns from other governments, and so as not to compete with paper topographic maps sold by these individual governments.

But the space-derived data will give you a reasonable idea of the layout of the terrain. Such data make it possible to read latitude/longitude and altitude at the crosshair of the mouse cursor using *Google Earth*. This is an incredible program with superb, and ever-expanding, capabilities. You'll need a fast Internet connection to use *Google Earth*, but you'll see the world in a different light once you start playing with this program. [Hint: Find and examine the pyramids at Giza, Egypt. You'll be amazed.]

And yes, you'll see altitudes in many areas of the world that don't look quite right — certain places near the shoreline around Florianopolis — places that are clearly in the Atlantic Ocean — can show altitudes as much as 20 feet high. This is obviously impossible — the only "hills" on the ocean are waves and these are, of course, transient. Figure 5B shows a conventional HFTA view of the terrains toward the USA for the same stations.

Generating Terrain Profiles Using *Google Earth*

Let's start by analyzing the terrains at the Top Four stations in WRTC 2006: PW5M, PW5C, PT5Y and PW5X. I used a utility program I wrote called *Range/Bearing* to compute range and bearing between two points entered manually from the

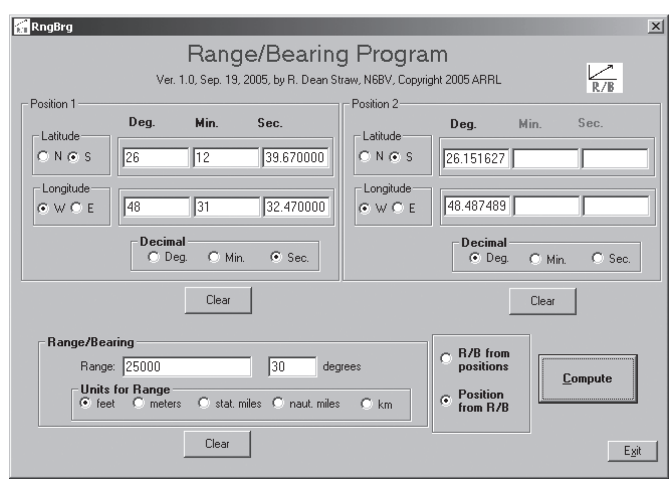

Figure 6—Screen shot of *Range-Bearing* program.

cursor positions using *Google Earth*. The first point was always the latitude/longitude of the tower for the station being analyzed, and the others were points along a radial line drawn from the tower base at the antenna heading of interest. From Florianopolis the heading toward most of Europe is 30° and toward the East Coast of the USA the heading is 340°.

The procedure was tedious, but it generated what I think are reasonable results. First, I computed the latitude and longitude for a point that was located 20,000 feet away from the tower base, at the desired heading. I used this as a target for the "Ruler, Line" function in *Google Earth*. See Figure 6, a screen grab of *Range/Bearing* for the location of the PT5Q station.

If there were tall mountains beyond a distance of 20,000 feet, I extended the evaluation distance to include them. The longest-distance line I used in all the WRTC 2006 analyses I did was 40,000 feet, and at that distance even 3000 foot hills had virtually no effect on the elevation-patterns computed by *HFTA*.

Once I generated a reference line at the desired heading from the tower base on the *Google Earth* display, I carefully moved the cursor along that line (pausing where significant changes in altitudes showed up) and wrote down the latitude/longitude and altitude for each such point. I used more points where the terrain changed rapidly, for example, in mountainous areas.

Finally, once I had a table of latitude-longitude-height data written down, I would type in the latitude/longitude information into *Range/Bearing*. I could thus compute the distances from the tower base for each altitude point. Then I used *Notepad* to enter the distance-altitude pairs beyond the tower base into an *ASCII *.PRO* file that *HFTA* could use. Whew… talk about labor intensive.

Each new station position required about 30 minutes to generate two *HFTA *.PRO* files, one toward Europe and one toward the USA. This was not a lot of fun, but I don't see many alternative methods to getting the data. So what kind of results came out of all this manual labor?

Results from HFTA

Figure 7 shows the 28 MHz computed elevation responses to Europe for the Top Four stations in WRTC 2006, along with an overlay of the range of elevation angles required from PY5 to all of Europe over the entire 11-year solar cycle. (The statistical elevation angle came from a special computation I ran for Florianopolis. Similar data for Rio de Janeiro is on the CD that accompanies the 20th edition of *The ARRL Antenna Book*.)

You'll note that the takeoff angles are generally quite low. This is due to the long distance to Europe from southern Brazil. Indeed, the statistical peak elevation angle is 1°, occurring some 16 percent of all the times when the 10 meter band is open between southern Brazil and Europe. The angles less than 5° account for 65 percent of the openings, statistically speaking.

Overlaid on Figure 7 is a table showing the number of 10 meter European QSOs made by each station during WRTC 2006. The number of QSOs is fairly small, so conclusions must necessarily be tentative — 10 meters wasn't open that much to Europe in July 2006, after all. But the calculated patterns suggest rather strongly that the PT5Y terrain should be superior to the other stations, as the terrain profile in Figure 5 suggests.

The computed "FOM" (Figure of Merit) for PT5Y is 12.5 dBi compared to PW5X at 9.9 dBi, a 2.6 dB difference. I use a rule-of-thumb that a new layer of weak signals is opened up for every 2 dB increase in signal strength. I'll deal more with FOM comparisons later.

By itself, the QSO data doesn't pinpoint the reason why PW5X had the same number of QSOs as PT5Y, while having what looks like a less potent signal into Europe on 10 meters at low takeoff angles; however, PW5X might have made a strategic decision to concentrate more heavily on 10 meter QSOs, knowing that the band wouldn't be open that much at this stage of the 11-year solar cycle.

Figure 8 shows the computed 10 meter responses toward the US East Coast from Florianopolis, Brazil. On this path the terrain at PT5M appears to offer a significant advantage, although the patterns for the other stations are not bad at all. Once again, the number of QSOs made is fairly small, making general conclusions difficult to support without more data.

Figure 9 compares the elevation responses for the Top Four stations into Europe on 15 meters. Again, low angles are dominant on this path, where elevation angles less than 9° account for about 67 percent of all openings. Once more, it appears that the PT5Y station has an edge, having access to perhaps another layer of weak signals compared to the others.

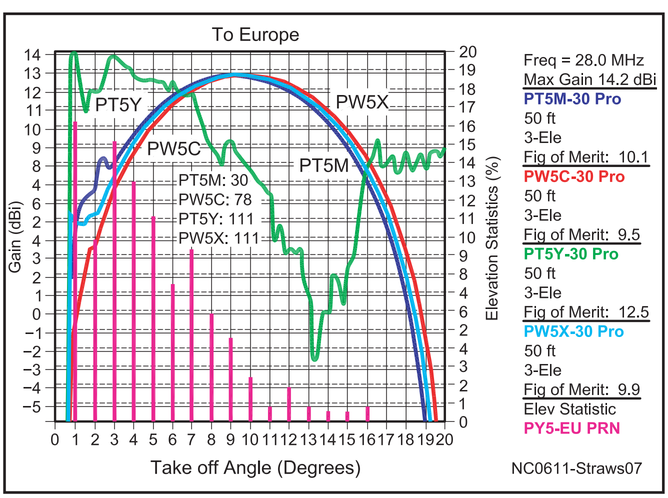

Figure 7—*HFTA* response for Top Four stations toward Europe on 10 meters. The table of numbers shows the QSOs into Europe for each station. PT5Y would appear to have an advantage by about 2.5 dB on average over all the statistically relevant elevation angles.

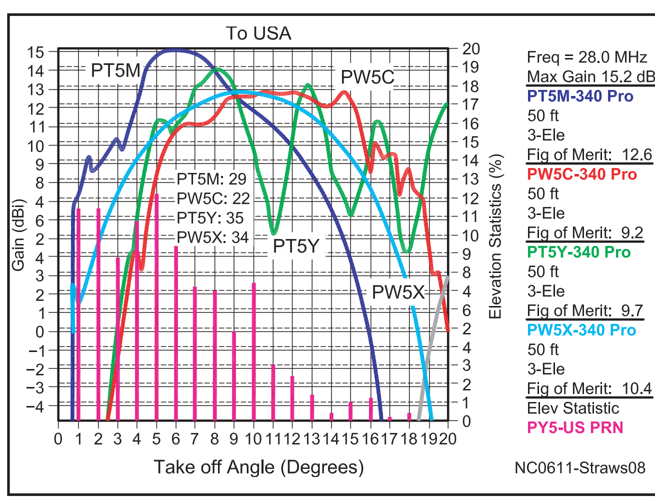

Figure 8—Responses for Top Four stations toward the East Coast of the USA on 10 meters. PT5M appears to be top dog in this direction.

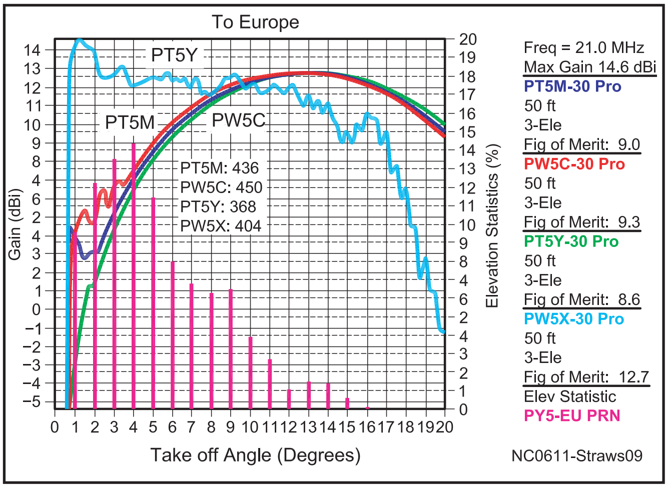

Figure 9—Responses for Top Four stations toward Europe on 15 meters. Again, PT5Y would appear to be stronger than the other three.

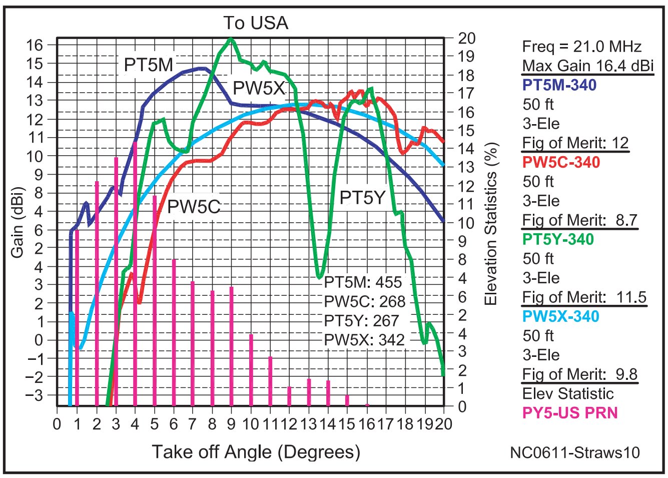

Figure 10—Responses for Top Four stations toward the USA on 15 meters. The nod goes to PT5M, and VE3EJ/VE7ZO appear to have taken advantage by racking up more than 100 QSOs over their nearest rivals.

Note that the number of QSOs made on 15 meters to Europe from PT5Y doesn't validate the terrain advantage. Again, a different operating strategy might be showing here, a factor unrelated to any terrain advantage or disadvantage. (For example, the PT5Y beam may have been pointed more often toward the USA than the other PT5/PW5 stations.)

Or it simply may be that beyond a certain threshold, signal strength doesn't mean that much. For example, Figure 9 shows about a 5 dB difference between the response for PT5M and PT5Y at a 4° takeoff angle. If the resulting signal in Europe is S9+20 for PT5Y, how disastrous is a signal level of "only" S9+15 for PT5M? In either case there would be sufficient signal strength in Europe to control a pileup, even an unruly one!

On the other hand, if the PT5Y signal is only S2 in Europe, a 5 dB difference puts PT5M at a significant disadvantage. The other three top stations all had very similar responses toward Europe on 15 meters, even if they were about 4 dB down from PT5Y in general. I'm sorry, Doug and Andy, but the question is hanging out there: Did you "leave something on the table" by not fully exploiting what seems like a superior location toward Europe from PT5Y?

Figure 10 shows elevation responses for 15 meters from

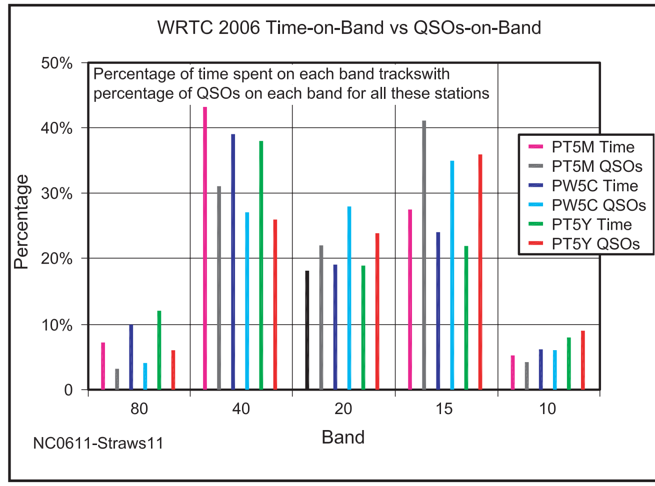

Figure 11—Comparison of the percentage of time spent on each band with the percentage of the QSOs netted on that band. There appears to be little disparity between effort expended and the resulting QSOs.

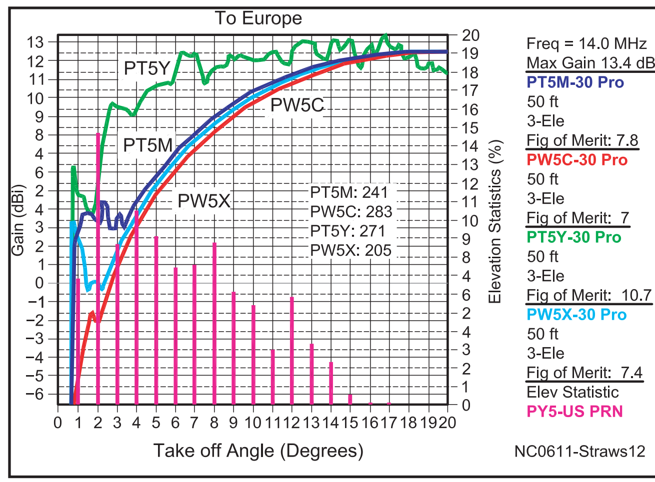

Figure 12—Responses for Top Four stations toward Europe on 20 meters. Although PT5Y is stronger than the others, the number of QSOs isn't remarkably different among the four stations. Maybe there is a "threshold effect" above which the signal strength isn't all that relevant.

southern Brazil to the US East Coast at a heading of 340°. Here, PT5M enjoyed an advantage at low takeoff angles, and it really did dominate in QSOs to the US, working 455 stations on 15 meters. PT5M's terrain gave it a significant advantage over the other Top Four stations, which was fully exploited. This is especially true during a low part of the solar cycle, where the elevation angles tend to be lower than the overall range shown in the elevation-angle statistics covering the entire 11-year solar cycle.

But what if one or more of the top stations purposely spent more time on a particular band? Wouldn't they have a higher QSO number there? Figure 11 graphs the percentage of time spent on each band by PT5M, PW5C and PT5Y, together with the percentages of total QSOs that each band represented. Each station has a pair of side-by-side bars on this graph for each band.

Figure 11 attempts to correlate effort (time) spent on each band with the resulting number of QSOs for that band. PT5Y spent 30 percent (7.2 hours) of its total operating time on 15

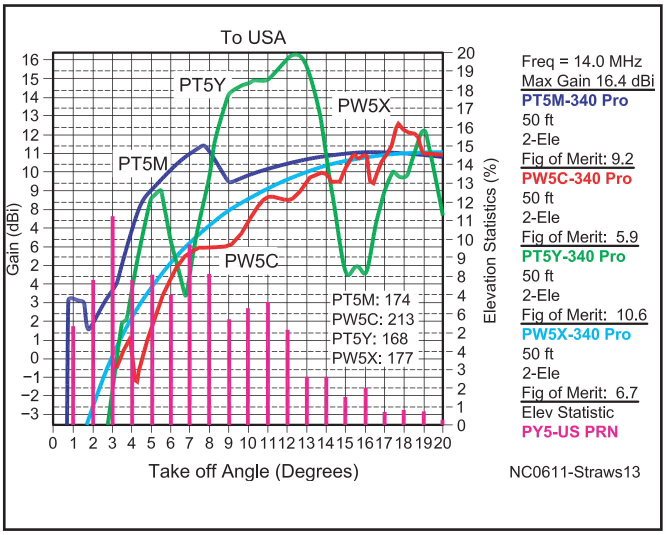

Figure 13—Responses for Top Four stations toward the USA on 20 meters. Again, PT5M looks like it is nominally stronger into the USA on 20 at low elevation angles.

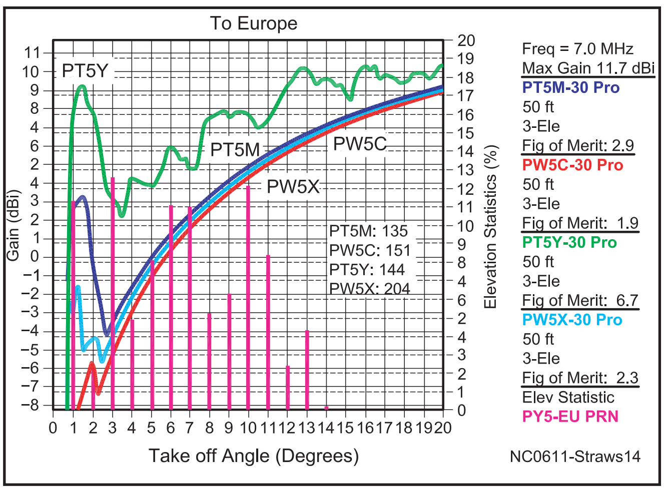

Figure 14—Responses for Top Four stations toward Europe on 40 meters. PT5Y doesn't appear to have made more QSOs because of a better terrain profile in that direction.

meters, with about 37 percent of the total QSOs (730) made there on 15 meters. This is an average rate of 101 QSOs per hour on 15 for PT5Y. By comparison, PT5M spent 38 percent (9.1 hours) of its time on 15, netting almost 41 percent of its QSOs (962) there, resulting in an average rate of 106 QSOs per hour.

Figure 12 shows the computed elevation responses for the Top Four stations into Europe on 20 meters. Again, PT5Y should have had a stronger signal at low elevation angles, with a Figure of Merit (FOM) some 3 dB stronger on average than the others. PT5Y had the second-highest QSO total on 20 into Europe, at 271 compared to PW5C at 283.

Figure 13 shows the computed responses for the Top Four stations on 20 meters to the USA. Again, PT5M should have enjoyed good signals in that direction, even though PW5C outdid PT5M in total QSOs by some 213 compared to 174 QSOs. PT5Y also had a good FOM on that path. The fact that 20 meters did not stay open overnight, as it had in the days prior to WRTC 2006, had a hand in the 20 meter QSO totals being lower than what I would have expected.

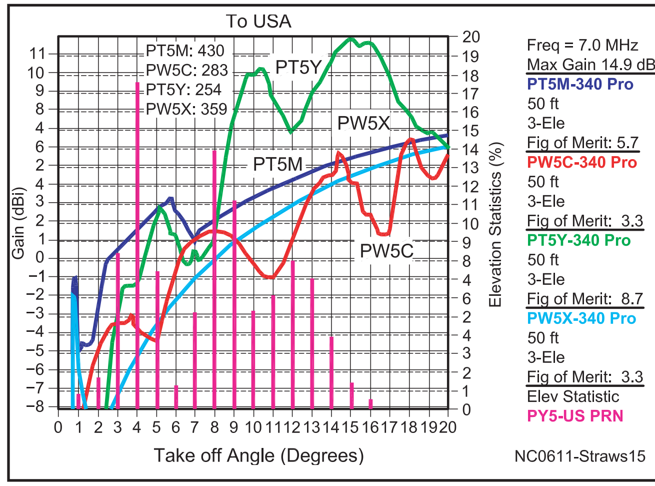

Figure 15—Responses for Top Four stations toward the USA on 40 meters. PT5M seems to have really exploited its advantageous terrain at low elevation angles toward the USA.

Figure 11 shows that PT5Y devoted 21 percent of its time on 20 meters, with 23 percent of its QSOs there. PW5C spent 23 percent of its time on 20, working 28 percent of its overall QSOs there. PT5M spent 20 percent of its time on 20, with 21 percent of its QSOs there. From these figures it's difficult to pinpoint effects of either terrain or strategy on the 20 meter results. All four top stations appeared to be equally effective on 20.

All in all, on 15 and 20 meters I don't see disproportionate amounts of time being spent on any one band by any of the top stations. When the bands were hot, the top stations were where the action was, moving down to lower bands as necessary to maintain rate when propagation changed. Not much of a surprise there.

Figure 14 shows the situation toward Europe on 40 meters. Once again, the terrain at PT5Y would seem to give that station a significant advantage at low angles, although once again the responses for the other stations are not all that bad, averaging about 4 dB less than PT5Y. Interestingly, PW5X had the most QSOs into Europe on 40 meters, indicating perhaps a strategic emphasis on Europe during the nighttime hours.

Figure 15 shows the 40 meter situation to the USA for the Top Four stations. PT5M had the highest predicted signal to the USA at low elevation angles and they took advantage of the terrain advantage by harvesting the highest number (430) of US QSOs on 40 meters. This was a rather wide margin over the others, since the second-highest 40 meter USA QSO total was only 83 percent, at 359 QSOs for PW5X.

To be continued...

The full article, in color, will be featured on the *NCJ* Website (**www.ncjweb.com**).

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