Ken’s Saga of the ‘88

You might think that the System 88 and its applications were conceived as a finished product and quickly implemented. It wasn’t. This note describes how the system was developed over many years. Our thinking has matured as we’ve seen systems in use.

The germ of the System 88 goes back to an informal dinner during the 2010 SHOT. The Oehler clan enjoyed a pleasant meal and a good visit with several members of the long-range or “sniper” family. The following NRA annual meeting was in North Carolina and chief instigator Buford Boone arranged a visit to Ft. Bragg. I saw the planned use of our acoustic target to characterize individual rifles at long range. It was apparent that signal cables from the firing line to distant targets were not practical.

The idea of a system to better characterize rifle performance smoldered in my brain for the next year. Several binders were filled with information on various GPS and radio modules. In anticipation of an informal visit by Pete Gould, I prepared a short description of the System 88. Pete indicated that it may help the long-range shooter. I optimistically estimated completion in one year. In my computer files from the same period, I’ve found my first schematic and numerous emails to and from the gentlemen (Richard Larson and Henry Jacobs) who provided the software expertise for the system.

The system evolved from that one-page description to a production version. For the next three years I alternated the hats of the imaginary shooter using the system in the field, the imaginary ballistician applying the data provided by the system, the engineer wanting to make all the pieces work together with the software, the bean counter wanting to keep system prices low, and the banker financing the project.

At first we anticipated use of GPS equipment and surveying techniques to automatically measure the range from gun to target. We found that the required equipment was too expensive and the required software was too complicated.

Only the surveyor-grade laser instruments could provide the required range accuracy. They were too expensive for our budget. Leupold provided us with a sporting rangefinder modified to provide 0.1 yard resolution and suggested that we use it with a special reflective target. The modified rangefinder works well when used with our target. (We should realize that all surveyors use a reflector target.)

As with many self-funded projects, our estimate of the completion time was optimistic. There were no contract deadlines (or funding) so development continued at a relaxed pace. Our first full-scale testing firing of the production system was in the fall of 2014. The estimated one year extended into three years.

I originally believed that we could simply measure ballistic coefficients over a long range and that these improved ballistic coefficients would provide the accurate predictions required for “first shot hits”. Everyone had faith that the ballistic coefficient was a constant for any given bullet. The same bullet fired in different guns should show the same ballistic coefficient. If the ballistic coefficients didn't agree then the measurement was blamed. We fantasized that we might even be able to make simultaneous measurements over multiple ranges and develop improved drag functions for individual bullets. Actual use of the System 88 has proven our initial assumptions to be naive!

We learned that it is not enough to simply measure an accurate ballistic coefficient at a long range. Such measurements give excellent results with that one unique gun and load, but the results do not automatically transfer to a different gun. Just as we expect different guns to shoot different muzzle velocities with the same load, we now expect variations in ballistic coefficients with different guns. We can't even say with certainty that the same drag function will fit the same bullet fired in different guns. We may expect similar results from similar guns, but the small differences translate into misses at extended ranges. We accept that we must measure the muzzle velocity from individual guns, and now we see similar variations in ballistic coefficients. We can't pinpoint the causes of the variations, but we can clearly see them. Measuring the ballistic coefficient is as important as is measuring velocity.

Our tests have shown that if the ballistic coefficient is measured at the range corresponding to approximately 1350 fps or Mach 1.2, then we can make very accurate predictions out to this range. This is the easy part. Shooters have long known that things work well until you get close to the speed of sound.

The System 88 measures muzzle velocity and time-of-flight (TOF) to the target. Assuming that the bullet is governed by a specific drag function, knowing the exact range to target, and applying the meteorological conditions, we can find a unique ballistic coefficient that makes the predicted TOF match the measured TOF. If the TOF matches at the distant range, then the drop and wind drift also match at the long range.

Because we have the same muzzle velocity and TOF, we are not surprised that drop and wind estimates provided by G1 and G7 match at the target. We were mildly surprised to see very close agreement between predictions made at intermediate ranges using G1 or G7. If they both give the same answers, how can we say G7 is better than G1? How can we say that any new drag function is better when the old drag function can give essentially the same answers? (Yes, we know that G7 probably gives better predictions at ranges beyond transonic.)

What we have done is an instrumented version of the "truing" long taught by Todd Hodnett. Todd Hodnett has advocated "truing" the ballistic coefficient by finding the ballistic coefficient correctly predicting the actual drop observed at extended range. Such truing on observed drop versus range is valid, but it is difficult to actually measure the drop and to isolate the observed drop from causes other than range.

A welcome surprise during our tests was the excellent performance of the "flyover" microphone array. With this arrangement, the mics are simply placed in a line on the ground and we shoot over the line to record TOF at the target. The straight line does not provide the excellent scoring accuracy of the square array, but it still provides accurate TOF information. The simple straight line array of four microphones is exceptionally easy to deploy, it can be shielded from stray bullets, and the target scoring accuracy is adequate to assure proper TOF measurements.

We have also confirmed the use of our microphones attached to an impact plane (steel plate, sheet of plywood, or even drywall) as a target for subsonic projectiles. This arrangement provides the stop signal for those long ranges where the bullet has become subsonic and is invisible to the usual acoustic target

In summary,

- The exact form of the drag function is much less significant than is the absolute requirement for truing at extended range.
- There are differences in ballistic coefficients measured with different "identical" guns just as there are differences in muzzle velocities.
- Truing with the measurement of TOF is more precise than is truing by observing and estimating drop.
- The availability of the simple fly-over target makes the TOF truing quicker and easier.

What about Doppler radar? We don't claim that the System 88 will do everything a quality Doppler radar will do, but . . .

- The System 88 provides the information needed to make accurate long-range predictions.
- The System 88 makes accurate measurements of muzzle velocities and times-of-flight with a battery-operated man-portable system that requires no support crew.
- With the target located at the transonic range, the System 88 automatically provides a "trued" ballistic coefficient and muzzle velocity for each rifle.
- The System 88 collects data many times faster than does the Doppler and readily allows accumulation of statistically significant samples.
- A Doppler system to yield similar data typically costs five to twenty times the price of an Oehler System 88.

What about ranges extending into the transonic and subsonic? We have developed a procedure to accurately determine "stepped" ballistic coefficients and apply our measurements to extreme ranges. See the following paper on *Luckenbach Ballistics.*