BC Chrono™ System

System 89 Ballistic Coefficient Chronograph

A conventional chronograph only measures velocity near the muzzle. The BC Chrono™ System measures both muzzle velocity and the time-of-flight from gun to distant target. An accurate ballistic coefficient requires both measurements. The System 89 makes both measurements and computes the exact BC for your ammo and your gun.

Crude predictions based on G1 or G7 used with nominal ballistic coefficients often miss at long range. You don't trust book values for muzzle velocity; why would you trust book values for ballistic coefficient? To get an accurate ballistic coefficient for your ammo and gun, you must measure the muzzle velocity and the time-of-flight to a long range target. Just like muzzle velocity, ballistic coefficients depend on your ammo lot and rifle.

Standard G1 and G7 drag functions will provide accurate predictions if the ballistic coefficient is calibrated to your specific gun and ammo. Even radar-based custom drag functions for a particular bullet must be calibrated to fit the unique load and the rifle. The Oehler System 89 measures initial velocity and time-of-flight so that shooters can calibrate the exact ballistic coefficients for their loads and guns. The System 89 follows its big brother System 88 by several years. It takes advantage of the lessons learned during field use of pioneer systems. The '89 has been simplified for easier operation and greater reliability. A robust radio link connects gun and target. Accurate measurements of time-of-flight are made without relying on temperamental GPS.

The System 89 costs only one-fifth that of the System 88, but it retains the capability to accurately calibrate the drag of your bullets!

The System 89 employs two identical controller units. Each has a rechargeable lithium battery and each includes a radio. The gun unit captures initial velocity using three Skyscreen IIIs. The skyscreens also signal the start of the time-of-flight measurement. The target unit uses four microphones to triangulate apparent hit location and to signal the end of flight time. The system is controlled by a Windows® computer connected via USB cable. A single shooter can operate both gun and computer.

The microphones of *fly-over* or *fly-thru* targets require that the bullet be supersonic. The microphones sense the Mach cone of the bullet for accurate time-of-flight measurements all the way down to Mach 1.0.

The easiest target array to use has the four microphones lined up on the ground perpendicular to the bullet's expected path. An array 15 feet long will typically detect bullets passing within 10 feet of the array.

A square *fly-thru* array may be used for increased scoring accuracy. You get better scoring, but it is more difficult to set up and you have a smaller window. The maximum size of the square is 10 feet.

For time-of-flight measurements at subsonic terminal velocities, you can use an impact plane. A sheet of plywood or even dry-wall material to which the microphones are mounted will suffice. The microphones detect the impact of the bullet on the sheet. Multiple sheets can be used to form a larger wall.

The all-important initial velocity and time-of-flight are displayed immediately following each shot. The system uses your input values for atmosphere and lets you select a drag model (G1, G7, custom, etc.) from its computer library. It automatically computes your calibrated ballistic coefficient for each shot. At the end of a test, the system provides a complete report. It also keeps an Excel® file including all raw data collected for the test. Tests can be replayed using different drag functions or revised conditions.

Measurements with the target at the Mach 1.2 range provide the most valuable drag information with minimal effort. This calibration yields accurate predictions down to sonic velocities. For improved predictions through the sonic range, you can fire a second test with a target located nearer the expected Mach 1.0 range. Software is provided to join results of this second test to the first by using the proven "stepped BC" method. An impact target may be used for accurate time-of-flight results extending down into the subsonic range.

The System 89 measures the calibrated ballistic coefficient for each bullet fired. At very long ranges, the shot-to-shot uniformity of the ballistic coefficient becomes even more important than uniform muzzle velocity. Shooters find uniformity of ballistic coefficient and muzzle velocity is more important than simply looking for highest velocity and BC. The System 89 measures the uniformity of both muzzle velocity and ballistic coefficient so that you can select the most accurate loads.

The recorded muzzle velocity and time-of-flight to the long range can be used to calibrate other ballistic programs, including those using custom drag functions. After you have measured actual muzzle velocity and time-of-flight you must adjust the ballistic coefficient (or drag function) in the external program until the predicted time-of-flight agrees with the measured time-of-flight. Even the sophisticated Hornady 4DOF program anticipates calibration by allowing the Axial Form Factor to be adjusted over a limited range.

The latest version of ***Ballistic Explorer***® Windows® software is included with each system. We find it invaluable for test interpretation and often use it to compare loads and to display results as a function of time.

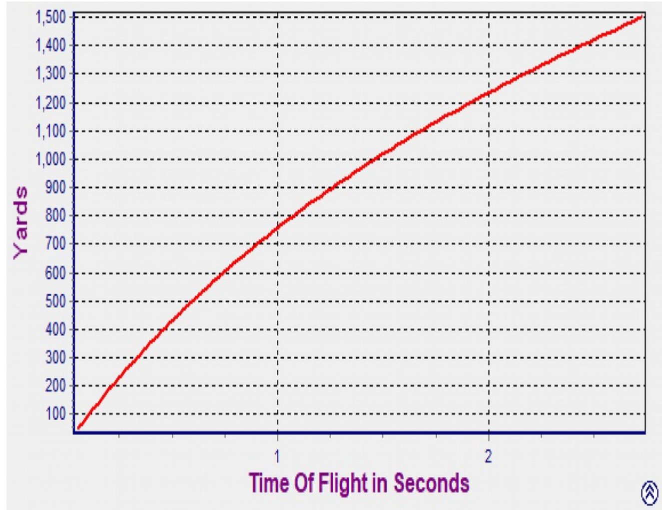
TOF and BC in more detail ...

Ballisticians write their basic equations in terms of time, but shooters think in terms of range. Flying bullets recognize time, but not range. Time and range are connected in ballistic calculations by the oft misunderstood drag function. We use standard G1 or G7 drag functions because custom drag functions are difficult to obtain. Custom drag functions are typically measured with Doppler radar systems. (If the radar can't track your bullet for a couple of miles, then you can't get a complete drag function.) Just as we know that we must measure the muzzle velocity of our ammo from our gun, we now learn that we must also measure drag from our ammo and our gun. We don't claim to measure the entire drag function, but with the System 89 we can accurately determine points on the true curve of range versus time.

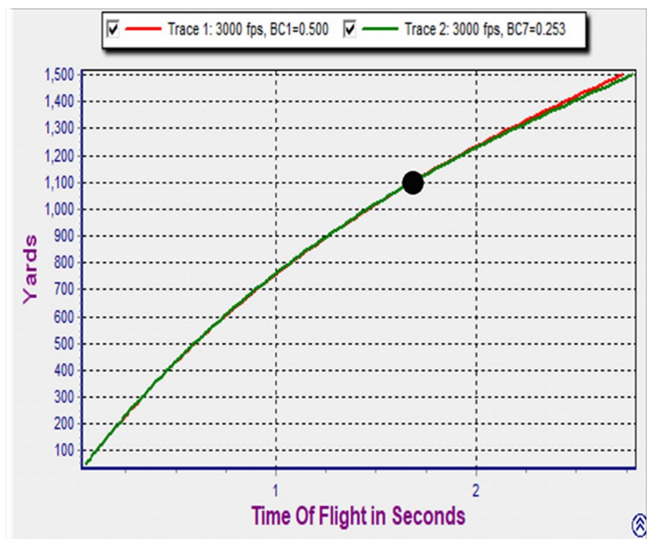
Engineers often make accurate measurements using imperfect instruments. The engineer *calibrates* his instrument by using it to measure a known exact value or calibration point. The engineer's most valuable calibration point is at the high end of the meter scale. The shooter's most valuable calibration points are at long range. If you can reliably predict parameters at long range, then intermediate ranges take care of themselves.

Graphs or curves help us to visualize what happens. We expect to see graphs of drop, wind drift or remaining velocity plotted versus range. The curve of travel distance versus time is most useful. This curve can be used to *calibrate* ballistic predictions.

If the measured time at a long distance doesn't fit the predicted time, then you must change or calibrate the prediction.



For example, here is a red curve illustrating the distance traveled versus time for a bullet having a G1 ballistic coefficient of 0.500 and launched at 3000 feet per second. It's simple, but tells much.



Here are two distance versus time curves using G1 and G7 at the same muzzle velocity. We choose the ballistic coefficients so that times-of-flight match at 1100 yards. The green G7 curve completely obscures the red G1 curve out to approximately 2 seconds or 1200 yards. The difference in zero-adjust remains less than 0.1 mil out to 1350 yards where the bullet has fallen subsonic.

If you calibrate ballistic coefficient using time-of-flight to a long range, any reasonable drag function may be used.

For many years we have followed the arguments for G1 vs G7 vs custom radar drag functions. There are good arguments on all sides, but you cannot assume that any drag function will fit your bullet from your gun. Before you can trust any drag function or ballistic coefficient to make predictions for your ammo and gun, you must measure how your ammo and gun perform

Years ago we found that we could make very similar predictions for the same bullet using different drag functions. Just because the predictions are the same doesn't prove that either drag functions or ballistic coefficients are correct. Even if two drag functions are forced to give the same predictions, they may both be wrong. If the first prediction misses the measured time, the second prediction will do the same. The correct prediction must match reality. You must first **measure** the time-of-flight to the long range and then force your prediction to match. You **calibrate** your prediction (typically by adjusting the ballistic coefficient or axial form factor) so that the predicted curve passes through the measured point. The System 89 makes the measurements and calibrates your prediction.

General Forrest allegedly said that to win a battle, "Get there firstest with the mostest." The long range shooter wants his bullets ***firstest, mostest, and samest.***

- The bullet with the shortest time-of-flight will be the the *firstest.* It will have the least drop.
- The bullet retaining the *mostest* of its initial velocity all the way to the target shows the shortest lag time and least wind deflection.
- The *samest* bullets with the least variation in time-of-flight give the smallest vertical dispersion at the target and the best fit between prediction and shooting.