System 88

The Oehler System 88 provides precise measurements of initial velocity and bullet flight time. Accurate predictions are made using the measured performance of your rifle with your ammunition.

The primary components of the System 88 are shown in the case. This includes the two controller units, GPS and network antennae, battery charger, suggested laser rangefinder with appropriate reflector target, and the little green USB stick radio. Skyscreens, microphones and other support items are packed in a separate case.

Rugged shock wave sensors (microphones) were developed for the System 88. These sensors are typically mounted on either a square frame or on simple linear frame made of readily available PVC pipe.

Proven Oehler Skyscreen III units are used for muzzle velocity measurement. Screens are typically used with a spacing of 8 or 9 feet (or three meters) to provide measurement accuracy of 0.1 percent. Accurate initial velocity measurements are essential to accurate determination of ballistic coefficient.

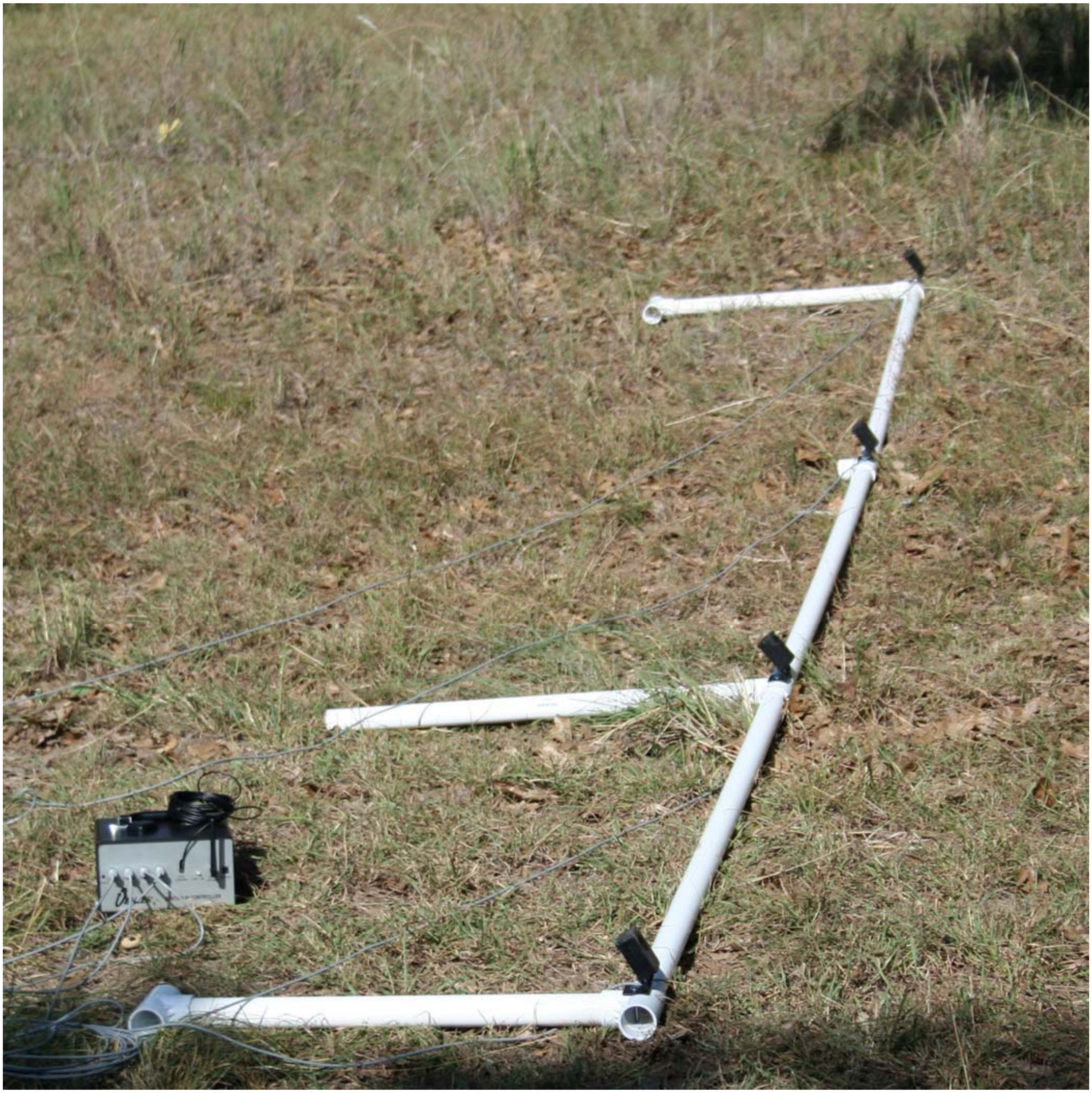
A small radio plugs into the USB connector of practically any Windows (XP to 10) laptop to link two or more controller units into a network. The little green stick needs only to communicate with the nearest controller unit. The controller radios will normally operate with the provided "rubber ducky" antenna at distances up to one mile. Difficult conditions such as heavy adjacent timber and over flat moist ground may require a larger antenna at the target. All system monitoring and control are via the laptop.

Just as proven skyscreens are used with a long baseline to provide accurate velocities, distance measurements to the terminal target must be accurate to 0.1%. Oehler uses modified Leupold RX-1200i rangefinders to provide 0.1 yard resolution to a range of 999.9 yards. The use of the proper reflective target is essential for accuracy at long ranges; just ask any surveyor. The rangefinders from Oehler have been individually tested to assure adequate accuracy at long ranges.

This is our initial test of the System 88 over extended range. Some civilian shooters (such as Dr. Oehler) prefer to shoot from a stool. No electric power or communication lines are required. The little green stick in the computer talks to the controller; the controller listens to the skyscreens and also communicates with the downrange controller.

Military users often prefer the solid support of the ground. Shooting stool, bench, and awning are optional. Here the skyscreens are placed directly on the ground. Note simplicity of set up.

The square array is preferred for the terminal target with supersonic bullets. A microphone is mounted at each corner. It provides accurate target hit location in addition to the time-of-arrival signal. The target frame is made of common PVC pipe. The frame will be shot, sooner or later.



The horizontal line or "fly-over" target is frequently used because it is convenient. Four microphones are mounted in a line transverse to the bullet path and they hear the Mach cone of a passing bullet. The complete array (and even the controller) can be mounted behind a barrier to shield the microphones from stray bullets. The target scoring of the line target is not as accurate as that of the square array, but the simple line target provides time-of-flight measurements comparable to the square target for velocities over Mach 1.1.

The vertical line or “fly-by” target is used at midrange. High trajectories pass far above an array on the ground and microphones can’t hear the distant bullets. The effective window of the vertical array extends to the top of the array. The array is typically placed a few feet to the left of the line-of-sight. This arrangement is best used to evaluate drag functions with the system measuring both short-range and long-range ballistic coefficients on the same shot.

For subsonic bullets, there is no Mach cone and acoustic targets won't work. You must use an impact plane of steel plate, plywood, or even drywall. Two or more microphones are clamped to the back of the sheet where they listen as a stethoscope to hear the bullet's impact on the plate. Accurate arrival-time signals are given, but no hit location is provided.

Imagine the task of *exact truing* this array of rifles with ten shots each at a thousand yards. Estimates of the total elapsed time vary with the amount of the bet. Forty-five minutes gets you even money. Firing rate is limited only by *"No more than one bullet in the air at one time."* An assistant to load magazines is allowed.

There are very few 1500 yard instrumented test ranges outside the government. The Downrange Farm range of Boone Ballistics in Alabama is a prime example of the expected use of the System 88. This is the view from the 1000 yard firing position.

The concrete block protects a survey pin establishing location to millimeter accuracy. There are two parallel rows of such markers at 100 yard intervals extending from the target back to the 1500 yard firing point.

Although Downrange Farm is located in a rural forested area, a permanent impact berm is provided. The frame structure is built to support either an acoustic target or impact plane. A flyover array can be located behind the railroad tie barrier.

Radio propagation is more difficult because the timber and flat moist ground tend to absorb radio energy. A parabolic antenna is permanently installed offset from the target area. Note the presence of the railroad tie barrier under the target frame. The fly-over acoustic target array with its controller box can be placed behind the barrier to protect it from stray bullets. The string stretched between two surveyed pins shows the exact location of the target line.

A square acoustic target array is placed in the frame. It is easy to adjust the target so that it is plumb, square and at the proper range. The lower two microphones are hidden behind the barrier just in case of a low shot.

A piece of drywall material is hung in the frame to detect subsonic bullets. Two microphones are mounted behind the lower corners of the sheet.

The microphone is clamped to the back of the drywall so that it can sense the impact of the bullet on the plane. Speed of sound through the drywall is many times faster than through air; no compensation for the time delay from impact to microphone is needed. A microphone at each corner provides redundancy.

A fly-by vertical target is mounted on a trailer so that it can be moved to the desired range.

Heart of the range instrumentation is the *Oehler Trailer* that can be easily moved to establish a new firing point. The trailer includes a stand-up firing bench for the gun and computer along with the welcome shade. An extended skyscreen rail can be attached to the shooting bench and is best supported by using two tripods. It is a definite advantage to have a qualified spotter along-side to observe apparent impacts.

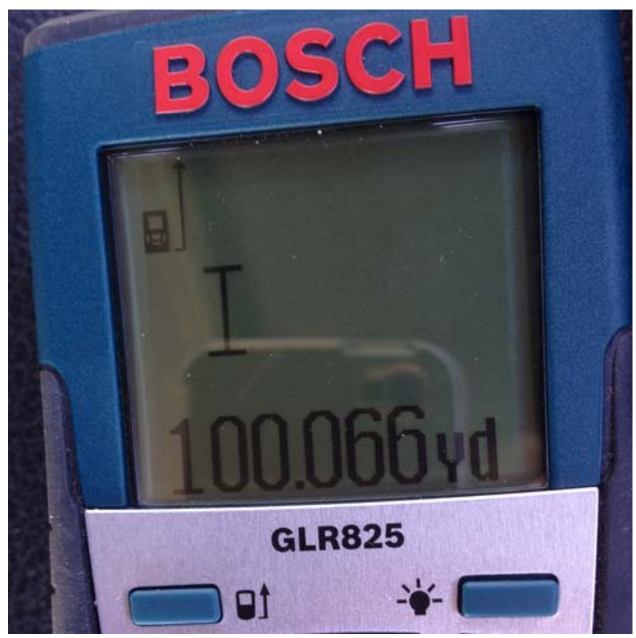
The stand-up bench is not conventional, but is very convenient for the varied activities required during firing tests. The stand-up bench has proven to be stable, especially if the shooter is the only occupant of the trailer.

A disadvantage to the stand-up bench on the trailer is that skyscreens must be mounted higher in the air. Taller tripods are required. At least we are not in the mud shooting prone.

Each rangefinder from Oehler has been checked against precision surveyed markers. Here is a boxful in process.

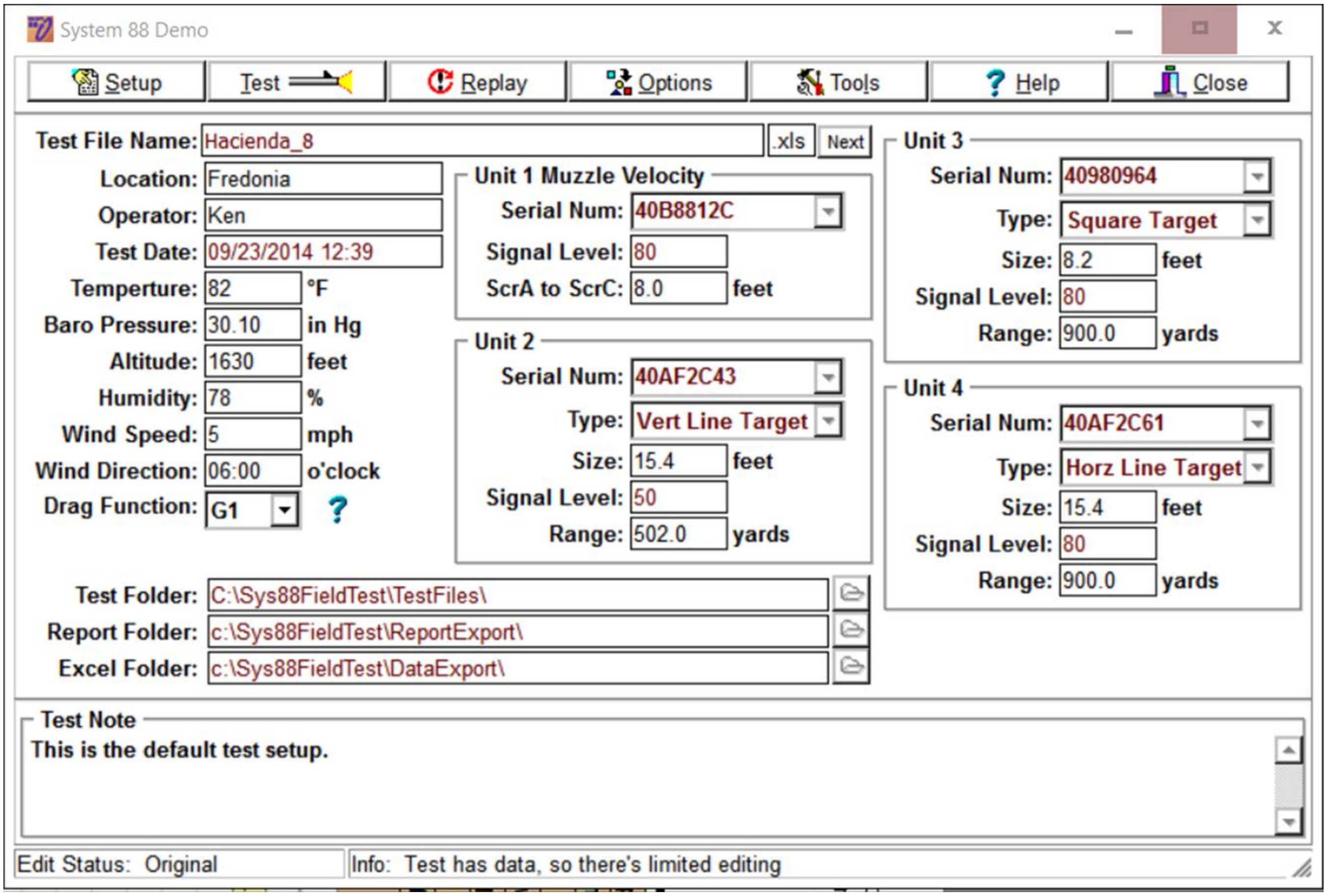
Permanent survey pins are located along each side of the firing lane at 100 yard intervals.

The Leupold rangefinders provide range readout to 0.1 yard or meter.



Set up firing point and intermediate targets at approximate range. Record exact distance to surveyed marker.

A “radio check” at the 1500 yard firing point indicates proper radio operation with the radio located at the target. The parabolic or dish antenna at the target provides ample signal over the extended range.



The main or setup screen is limited to inputs essential to the measurements. The user must record the atmospheric conditions and the drag function assumed for the bullet. He must select the proper radio identification for each controller unit, the type or function of the unit, the signal threshold level, and the target size and range. The entries show in red are locked or permanent; the black entries may be edited during subsequent replay.

There is always a compromise between quantity of data to be recorded for each test and the operator's time during the test. It is the user's responsibility to record all the supplemental information regarding the gun and ammunition. A sample test log book has been developed and is included with the System 88. This log book includes provision for the minimum supplemental information expected when the test results are reviewed at later times.

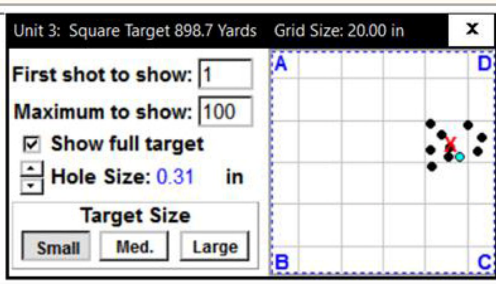
Test Name: Hacienda_8

123 Omit/Restore | Target | Printout | Options | Note | Help | End Replay

Round Number	Muzzle Unit VelAC	Muzzle Unit Prf Vel	Vert Line Target 500.7 Y T.O.F.	B.C.	Vel-T	Horz.	Vert.	Square Target 898.7 Y T.O.F.	B.C.	Vel-T	Horz.	Vert.	Horz Line Target 898.7 Y T.O.F.	B.C.	Vel-T	Horz.	Vert.
1	2701	1.8	0.67670	0.430	1828	105.1	154.8	1.48335	0.411	1265	31.7	7.3	1.48252	0.411	1266	46.6	102.8
2	2694	3.6	0.67946	0.428	1818	105.0	144.4	1.49359	0.407	1254	44.8	5.1	1.49295	0.407	1255	48.5	102.5
3	2698	2.7	0.67766	0.430	1825	98.8	150.7	1.48519	0.410	1264	22.1	5.8	1.48433	0.411	1265	33.9	103.7
4	2708	3.7	0.67525	0.429	1831	104.9	164.3	1.48515	0.407	1260	27.4	13.2	1.48444	0.407	1261	42.1	105.3
5	2686	1.8	0.68270	0.424	1806	103.7	151.7	1.50147	0.405	1246	22.9	-1.9	1.50041	0.406	1247	39.1	113.5
6	2701	3.7	0.67889	0.424	1816	100.9	165.9	1.49074	0.406	1255	22.2	18.6	1.48975	0.407	1257	36.9	120.8
7	2700	2.7	0.67735	0.429	1825	106.0	158.2	1.48163	0.412	1268	40.1	18.1	1.48091	0.412	1269	47.6	115.2
8	2683	1.8	0.68173	0.430	1814	113.0	153.7	1.49394	0.411	1257	31.2	2.9	1.49253	0.412	1259	56.8	119.4
9	2692	3.6	0.68003	0.428	1817	102.7	149.2	1.48721	0.412	1263	47.1	12.1	1.48683	0.412	1264	48.3	101.8
10	2695	2.7	0.67901	0.429	1820	116.8	158.3	1.49257	0.407	1255	36.4	2.6	1.49139	0.408	1256	62.7	111.6

Summary

	Muzzle Unit VelAC	Muzzle Unit Prf Vel	Vert Line Target 500.7 Y T.O.F.	B.C.	Vel-T	Horz.	Vert.	Square Target 898.7 Y T.O.F.	B.C.	Vel-T	Horz.	Vert.	Horz Line Target 898.7 Y T.O.F.	B.C.	Vel-T	Horz.	Vert.
Avg	2696	2.8	0.67888	0.428	1820	105.7	155.1	1.48948	0.409	1259	32.6	8.4	1.48861	0.409	1260	46.2	109.7
SD	7	0.7	0.00214	0.002	7	5.4	6.7	0.00573	0.003	6	9.2	6.9	0.00559	0.003	6	8.8	7.0
High	2708	3.7	0.68270	0.430	1831	116.8	165.9	1.50147	0.412	1268	47.1	18.6	1.50041	0.412	1269	62.7	120.8
Low	2683	1.8	0.67525	0.424	1806	98.8	144.4	1.48163	0.405	1246	22.1	-1.9	1.48091	0.406	1247	33.9	101.8
ES	25	1.9	0.00744	0.006	25	18.0	21.5	0.01984	0.007	22	25.0	20.5	0.01950	0.007	22	28.8	19.1
Group Size						21.9					28.0					29.9	
Radial SD						8.6					11.5					11.2	



This shows the operator's screen after firing a ten-shot test. It includes data from each round along with the summary of each parameter. The test can be replayed after test completion so that items such as sensor spacing, air temperature, or even drag function can be edited.

System 88 Sample Report

Test File Name: Hacienda_8.xls
Location: Fredonia
Operator: Ken
Test Date: 09/23/2014 12:39
Temperture: 82 °F
Baro Pressure: 30.10 in Hg
Altitude: 1630 feet
Humidity: 78 %
Wind Speed: 5 mph
Wind Direction: 06:00 o'clock
Drag Function: G1
Edit Status: Original
Test Folder: C:\Sys88FieldTest\TestFiles\
Report Folder: c:\Sys88FieldTest\ReportExport\
Excel Folder: c:\Sys88FieldTest\DataExport\
Test Note: This is the default test setup.

Unit 1 Muzzle Velocity ----------
Serial Num: 40B8812C
Signal Level: 80
ScrA to ScrC: 8.0 feet
Unit 2 --------------------
Serial Num: 40AF2C43
Type: Vert Line Target
Size: 15.4 feet
Signal Level: 50
Range: 502.0 yards

Unit 3 --------------------
Serial Num: 40980964
Type: Square Target
Size: 8.2 feet
Signal Level: 80
Range: 900.0 yards
Unit 4 --------------------
Serial Num: 40AF2C61
Type: Horz Line Target
Size: 15.4 feet
Signal Level: 80
Range: 900.0 yards

Round	Muzzle Unit		Vert Line Target 500.7 Y					Square Target 898.7 Y					Horz Line Target 898.7 Y				
Number	VelAC	Prf Vel	T.O.F.	B.C.	Vel-T	Horz.	Vert.	T.O.F.	B.C.	Vel-T	Horz.	Vert.	T.O.F.	B.C.	Vel-T	Horz.	Vert.
1	2701	1.8	0.67670	0.430	1828	105.1	154.8	1.48335	0.411	1265	31.7	7.3	1.48252	0.411	1266	46.6	102.8
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---------- SUMMARY ----------

	Muzzle Unit		Vert Line Target 500.7 Y					Square Target 898.7 Y					Horz Line Target 898.7 Y				
	VelAC	Prf Vel	T.O.F.	B.C.	Vel-T	Horz.	Vert.	T.O.F.	B.C.	Vel-T	Horz.	Vert.	T.O.F.	B.C.	Vel-T	Horz.	Vert.
Avg:	2696	2.8	0.67888	0.428	1820	105.7	155.1	1.48948	0.409	1259	32.6	8.4	1.48861	0.409	1260	46.2	109.7
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High:	2708	3.7	0.68270	0.430	1831	116.8	165.9	1.50147	0.412	1268	47.1	18.6	1.50041	0.412	1269	62.7	120.8
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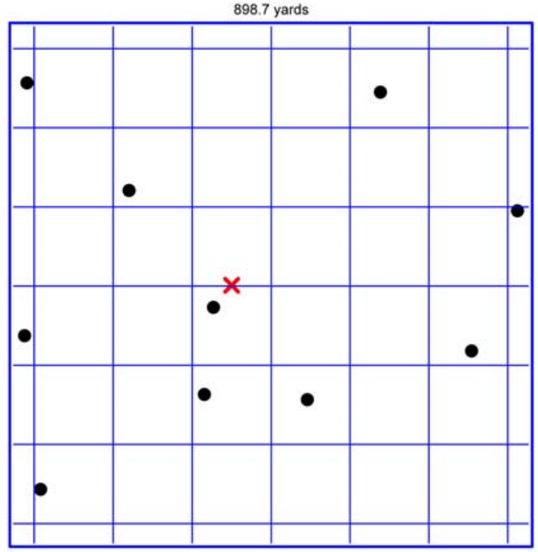
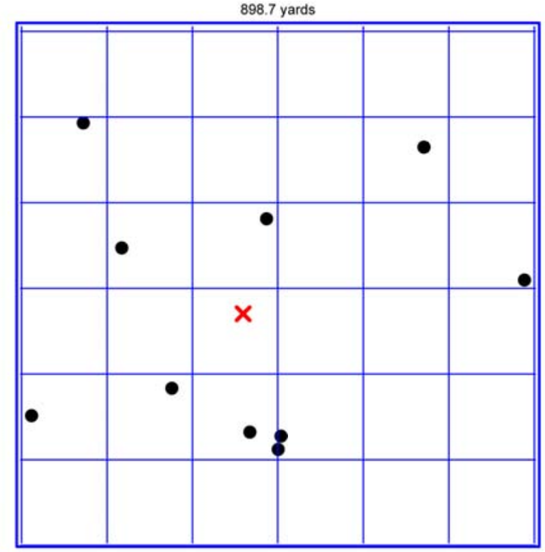
ES:	25	1.9	0.00744	0.006	25	18.0	21.5	0.01984	0.007	22	25.0	20.5	0.01950	0.007	22	28.8	19.1
Group Size:							21.9					28.0					29.9
Radial SD:							8.6					11.5					11.2

898.7 yards



898.7 yards



	A	B	C	D	E	F	G	H	I	J	K
1	**Test:**	Hacienda_8			**<<< Unit 1 Muzzle Velocity >>>**				**<<< Unit 3 >>>**		
2	**Location:**	Fredonia			**Unit 1 Ser Num:**	40B8812C			**Unit 3 Ser Num:**	40980964	
3	**Operator:**	Ken			**Scr Signal Level:**	80			**Unit 3 Type:**	Square Target	
4	**Test Date:**	09/23/2014 12:39			**ScrA to ScrC:**	8.0	**feet**		**Unit 3 Size:**	8.2	**feet**
5	**Temperature:**	82	**°F**						**Unit 3 Signal Level:**	80	
6	**Baro Pressure:**	30.10	**in Hg**		**<<< Unit 2 >>>**				**Unit 3 Range:**	900.0	**yards**
7	**Altitude:**	1630	**feet**		**Unit 2 Ser Num:**	40AF2C43					
8	**Humidity:**	78	**%**		**Unit 2 Type:**	Vert Line Target			**<<< Unit 4 >>>**		
9	**Wind Speed:**	5	**mph**		**Unit 2 Size:**	15.4	**feet**		**Unit 4 Ser Num:**	40AF2C61	
10	**Wind Direction:**	06:00	**o'clock**		**Unit 2 Signal Level:**	50			**Unit 4 Type:**	Horz Line Target	
11	**Drag Function:**	G1			**Unit 2 Range:**	502.0	**yards**		**Unit 4 Size:**	15.4	**feet**
12									**Unit 4 Signal Level:**	80	
13									**Unit 4 Range:**	900.0	**yards**
14											
15	**Test Folder:**	C:\Sys88FieldTest\TestFiles\									
16	**Reports Folder:**	c:\Sys88FieldTest\ReportExport\									
17	**Excel Folder:**	c:\Sys88FieldTest\DataExport\									
18	**Test Note:**	This is the default test setup.									
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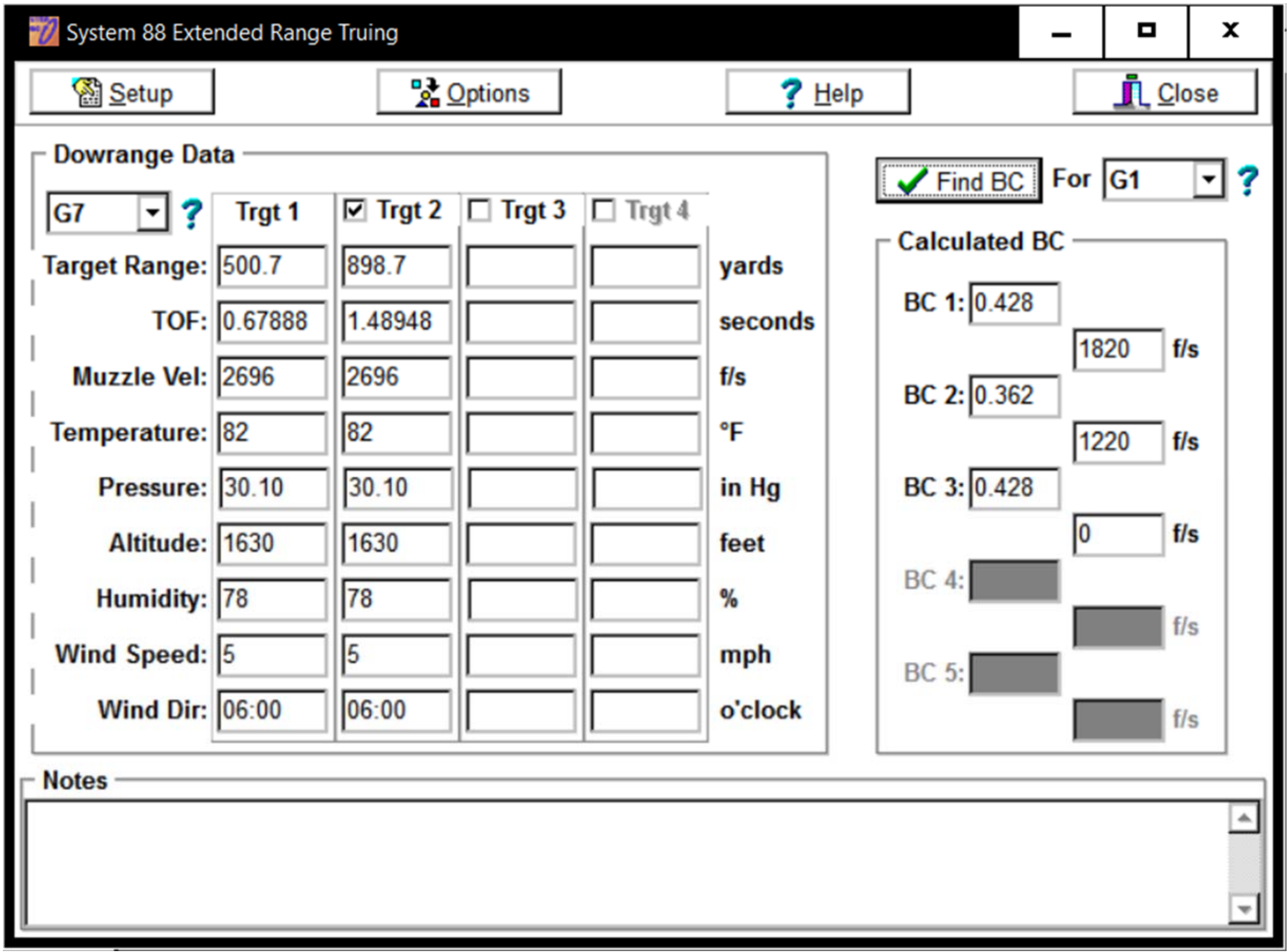
Test Setup / Test Data / Test Summary / Test Event Data

Data from each test can be automatically exported to Excel files for replay, subsequent analysis and archival storage. All Excel file names are derived from the Test File Name of the original set-up.

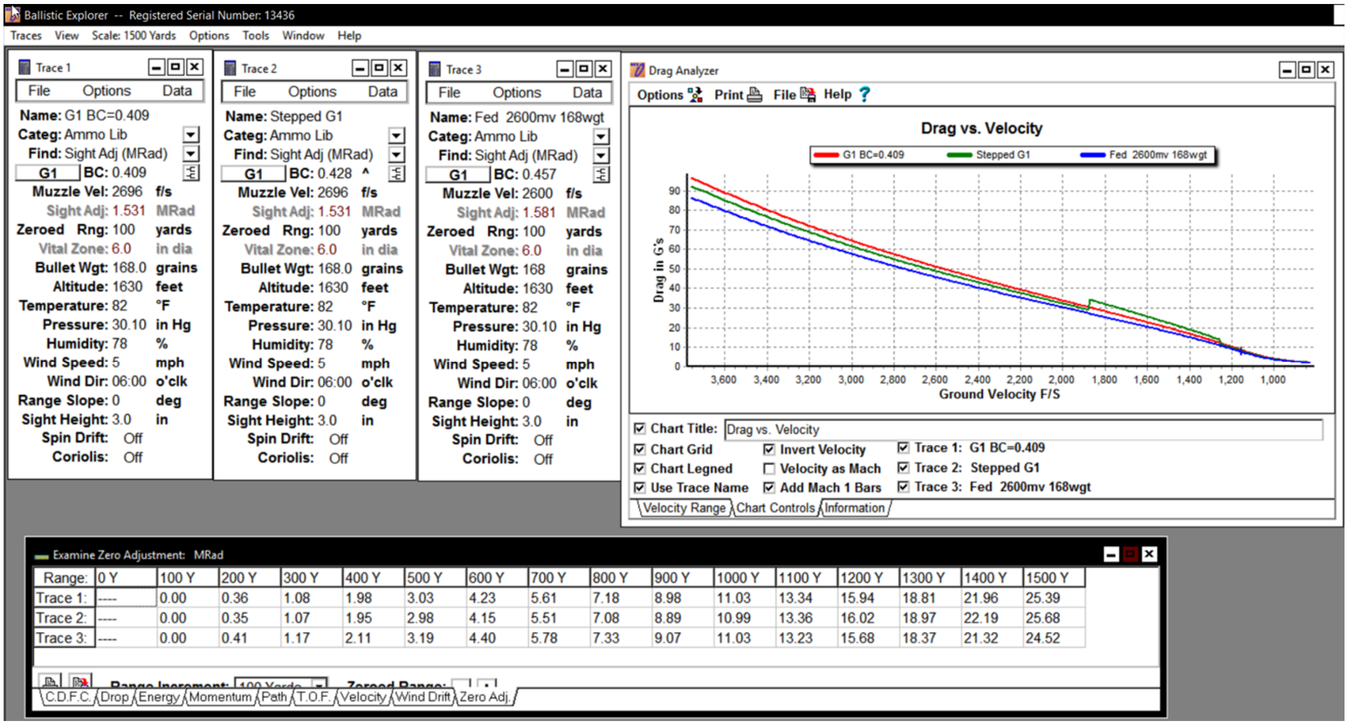
A	B	C	D	E	F	G	H	I
Screen A is seconds from midnight PC time. All other times are seconds after Screen A.								
Round Number	**Muzzle Screen A**	**Muzzle Screen B**	**Muzzle Screen C**	**Unit 2 Mic. A**	**Unit 2 Mic. B**	**Unit 2 Mic. C**	**Unit 2 Mic. D**	**Unit 3 Mic. A**
1	45863.1647	0.00148	0.002962	0.685085	0.687362	0.690226	0.69335	1.487385
2	45897.33409	0.001483	0.00297	0.687539	0.689646	0.692441	0.695515	1.498185
3	45931.80964	0.001481	0.002965	0.685608	0.687907	0.690782	0.693942	1.488961
4	45964.60049	0.001475	0.002954	0.683917	0.686324	0.689246	0.692399	1.488953
5	45994.53577	0.001488	0.002978	0.690876	0.693105	0.695942	0.699037	1.505444
6	46035.24675	0.001479	0.002962	0.687384	0.689849	0.692791	0.695959	1.49431
7	46058.92303	0.00148	0.002963	0.68587	0.688178	0.691056	0.694176	1.485911
8	46086.19309	0.00149	0.002982	0.690438	0.692591	0.69537	0.698422	1.498008
9	46107.35491	0.001484	0.002972	0.688106	0.690321	0.693157	0.696268	1.491839
10	46128.92182	0.001483	0.002969	0.688039	0.690218	0.693006	0.696053	1.496756

The System 88 records the time each "event" occurs. The operator's display converts these times into recognizable velocities, hit locations, and ballistic coefficients for the operator's convenience. The sacred raw data are times.



In the previously shown sample test, the BC observed at 900 yards was not the same as the BC observed at 500 yards. This implies that chosen G1 drag function does not fit the bullet exactly. The Extended Range Truing program takes the results from firing the same gun and ammo at different ranges and combines the test results to determine a "stepped ballistic coefficient" profile. The program "trues" the results of the combined tests to fit a stepped BC using G1. The example shown uses the test data from Hacienda 8 to produce a stepped BC for G1 to fit the observed data. The results direct from the System 88 showed a G1 BC of 0.426 from gun to 500 yards and 0.409 from gun to 900 yards. The Extended Range Truing converted it to the stepped BC format with BC=0.428 down to 1820 fps, BC=0.362 down to 1220 fps, and 0.428 for the remainder of the flight.

This program can also be used to convert custom drag functions or published radar drag coefficient tables to the more common stepped BC tables.



Ballistic Explorer Version 6.6.0 and later includes a tool called Drag Analyzer. This tool is especially valuable to help visualize and compare the drag behavior of different drag functions. The graph shows the drag or deceleration of the bullet as a function of velocity for different drag functions. It reminds us of the high drag at high velocities, relatively smooth behavior down to the sonic region and a distinct decrease in drag at the speed of sound.

The bullet in the test (green curve) shows behavior more like G7 than G1. Compared to G1 measured at 500 yards (red curve), it had lower drag (higher BC) at the higher velocities and then an increase in drag as it approached sonic velocities. The published data (blue curve) anticipated lower drag and higher BC than were shown in the tests.

Comparing the Zero Adjust parameter shown in lower chart, predictions between both measured values agree to better than 0.1 mil out to 1200 yards. We expect that the stepped behavior is closer to reality; it was forced to match at both 500 and 900 yards. The published data shows a difference of 0.3 mils from our “trued” data at 1200 yards.