ARE e-TARGETS GOODENOUGH?

By

Peter Smith and David Stewart

Electronic targets have moved into the mainstream of long range target shooting and are now used regularly in premier competitions including Australia's National Championships. Suspicion of electronic targets is starting to divide the shooting community with some shooters now refusing to attend major shoots on eTargets while others seem to be happy with anything; in between are those who see it as their duty to support competitions despite possible target problems.

The question of suitability of electronic targets for premier competitions has been around for a while and a few years ago many people, including us, tried to specify an acceptable eTarget accuracy in terms of a maximum angular error. One of the best known attempts was made by Bryan Litz which can be found on the web at

http://appliedballisticsllc.com/Articles/Etargets.pdf (1)

At the time it seemed a reasonable approach, but the recent availability of reliable independently measured target data has allowed a more advanced analysis of the **effect of target inaccuracy on the order of place-getters** in major long range shoots.

Monte Carlo Simulations are widely used in industry to test proposed changes to a process before expensive modifications are made to equipment or practice. The simulations use statistical information from actual data to build a model of the process which can then be run hundreds or thousands of times on a computer to investigate the effects of small changes.

For our investigation we first build a 'model' of a competition using shot position data obtained from: **http://shooting.hexsystems.com.au/competition (2)**

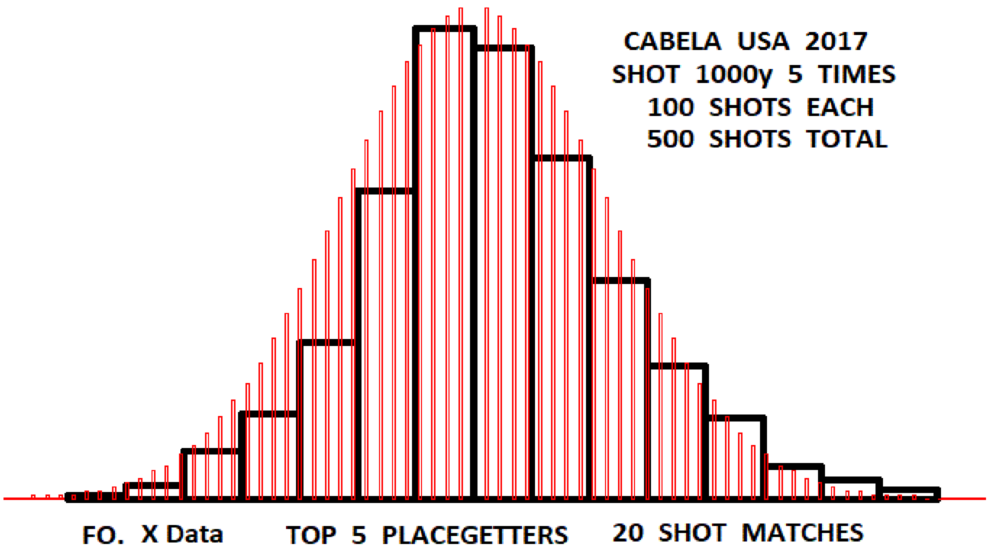
By far the best available data set is that from *Cabela's Mid-Atlantic Long Range Regional Championship* held in June 2017.

SHOOT	DISCIPLINE	DISTANCE	SHOTS PER PERSON
CABELLA (USA) 2017	FO	1000, 1000, 1000, 1000, 1000y	100

Only the shots from the top 5 place-getters were considered.

All of the shooting in this competition was over 1000 yards and each competitor fired 100 shots, thus providing a large data set for analysis. Testing showed that the data conformed to a Gaussian or 'Normal' distribution as is required for a Monte Carlo simulation.

The plot below illustrates the distribution of the Cabela "X" data in black and a superimposed Gaussian distribution in red. The "Y" data was an even better fit. Interestingly the X measurements are often skewed a little to one side as they are here, presumably the result of imperfect wind reading.



A Gaussian Distribution has been superimposed so you may judge if the results are Random enough to be used for Statistical predictions.

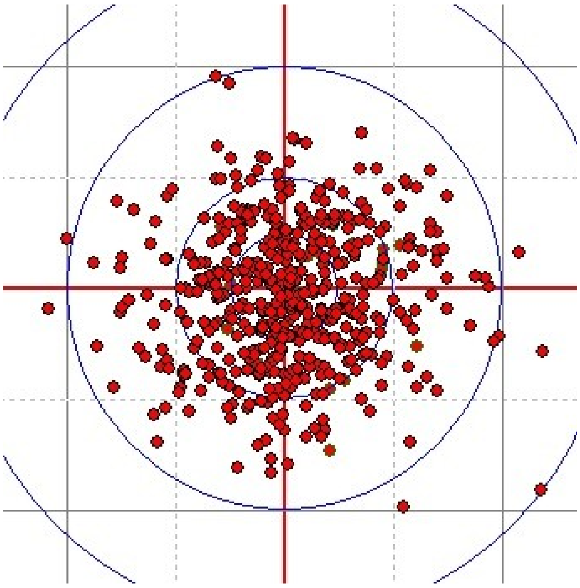
The Simulation

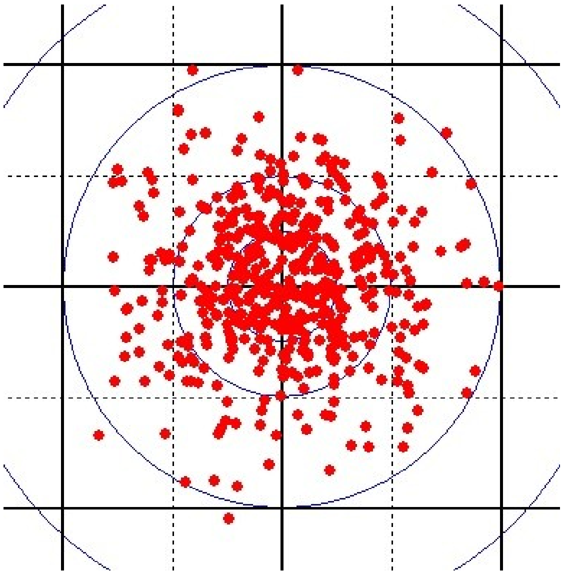
First the range of Standard Deviations is derived for the top five shooters from analysis of their shot positions, then the deterioration of scores from placing 1 to placing 5 is noted and an incremental increase in SD is allocated to cover this range of abilities.

These values are used to create simulated groups of shots which then match as well as possible the actual shots.

The images below are for the Cabela data and show the actual shot positions on the left with the simulated positions on the right. Although line and shot depiction differ slightly because they were produced in different programmes, the shape and density of the simulated pattern faithfully replicates the original.

.

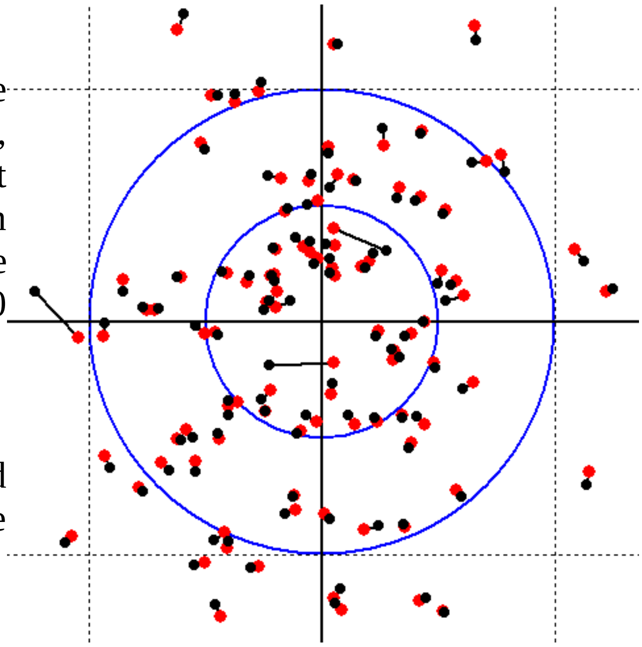




CABELA Actual Data. SD x 0.28 min. SD y 0.29 min.	COMPUTER generated data. SD x 0.28 min. SD y 0.29 min.

To test the effect of target inaccuracy the SDx and SDy values measured in the various target tests are used to randomly introduce errors to the simulated shot positions to produce a second set of positions.

At right is a magnified screenshot from the programme. Original shot positions are in red, black indicates the new position after any target error is added. This is a simulation of an imaginary imperfect target chosen to illustrate serious random errors plus a gross error of 30 mm at an error rate of 1 in 30 shots.



Obviously, Gross Errors may cross a line and change the score but there are far more line crossings by the smaller random errors.

Both groups of shots are then scored by the customary system to produce a table of 'original' and 'degraded' scores for each shooter.

The two sets are sorted based on the 'original' scores and any out of order degraded scores are noted and counted. These are called conflicts and are presented as a percentage of all 'shots' generated.

The table at right shows an example of one run with one change of place in the first three shooters and two changes in the first five.

To satisfy the variability inherent in this process, this is repeated many many times and the results averaged.

One Run Score	One Run Error
978.000030	973.000031
976.000031	974.000027
969.000027	968.000023
968.000022	973.000022
961.000022	960.000020
TRUE SCORES	Conflicts123
IN ORDER	1
	Conflicts12345
	2

Results

In order to evaluate the merits of the different targets each simulation was run 10,000 times with a record kept of how often the target error changed the order of the top three and top five places from the original. The table below shows the odds of the different systems getting it right, expressed as a percentage.

USA FO SHOOT					
FO CABELA 2017				ODDS OF CORRECT PLACINGS(%)	
TARGET	SD x	SD y	GROSS ERROR	1-2-3 CORRECT	1-2-3-4-5 CORRECT
‘PERFECT’ PAPER	0.2 mm	0.2 mm		97 %	94 %
'ATHERTON' PAPER	0.98 mm	0.73 mm		90 %	81 %
NEW HEXTA	1.35 mm	1.22 mm		87 %	75 %
USED HEXTA	1.77 mm	1.62 mm		84 %	71 %
KONGSBERG 1	1.41 mm	1.16 mm		87 %	75 %
KONGSBERG 2	1.41 mm	1.16 mm	*	84 %	70 %
KONGSBERG 3	1.45 mm	0.93 mm	***	80 %	63 %
KONGSBERG 4	0.91 mm	0.44 mm	****	82 %	66 %
KONGSBERG 5	6.19 mm	6.12 mm		70 %	48 %
KONGSBERG 6	11.7 mm	13.8 mm		60 %	34 %
SILVER MOUNTAIN Best Set-up	9.0 mm	9.0 mm		65 %	41 %
SILVER MOUNTAIN Angle Corrected	17.7 mm	22.1 mm		53 %	25 %
SILVER MOUNTAIN No Correction	20.3 mm	24.7 mm		51 %	23 %

SDx is the standard deviation of the Horizontal Target error and SDy is the standard deviation of the Vertical Target error**.** The actual error made by the target is the vector addition of the horizontal and vertical errors. The asterisks (*) indicate the number of “Gross Errors” recorded on these targets in the 30 shot test. See **Explanation of Target Differences** on Page 7 for details.

CONCLUSIONS

First, the effects of accuracy errors introduced by imperfect paper faces are presented as these are the benchmarks against which the electronics are compared. One paper face is assumed to be almost perfect which is achievable if the faces are directly printed on the Corflute, and the other is from actually measuring a set of well made targets at the Atherton Rifle Club which had been assembled using a two sheet aiming mark. Details at

https://sites.google.com/site/etargetcomparison/home/7-paper-targets **(3)**

No allowance has been made for human marker error.

As expected the target's ability to accurately rank the shooters in a competition declines as target errors increase.

1/ No target is perfect. Even extremely good paper targets, marked, scored and Range Officered to perfection, introduce some inevitable uncertainty to places in major shoots. A different scoring system with better sampling from closer rings on a target would improve this but is unlikely to happen. Note that 10 ring Long Range targets are no better because the rings are separated by the same distance. Scores may be different but the <u>differences</u> between scores remain the same.

2/ In scoring performance, there is very little difference between the best of the closed chamber targets and the 'Atherton Paper' target which is representative of most if not all of the paper targets in use in Australia. From our testing in both Cairns and Herberton the Hexta targets do not produce the random “gross” errors sometimes seen in both series of tests of the Kongsbergs in Townsville. **(4), (5), (6)**

3/ The occasional larger error actually has a much smaller effect on score than most expect. It is the unending train of smaller errors that dominates. This means that Kongsberg Targets in tip top condition are not as far behind Hextas as many think. They may be less desirable in other ways, for example there is no permanent record and they are more difficult to refurbish.

4/ Closed chamber targets must be well maintained and this should be transparent to shooters to hold the levels of score degradation to a minimum. If repaired before a major shoot, they can still deliver top performance for the approximately 2000 shots on each target in a these competitions. (200 shots in a Lead-up plus Queens and ten shooters to a target.)

5/ Silver Mountain Targets are a real dilemma. The results show just how important is a perfect set-up and the major improvement comes from holding the target absolutely rigid. Some may think SMT's have been treated too harshly. In fact, errors introduced by them at the very long distances will be significantly worse that reported. This is because the Velocity of projectiles will be well down at 1000y compared to our measurements at 900y. Also, some cartridges will be impacted far more than others at the very long ranges, destroying any level playing field that would exist at shorter distances.

If SMT does successfully introduce an eight sensor target, it may perform better. But the bottom line is that it will still be an open sensor target which SMT themselves admit can never equal a closed chamber target.

6/ Shooters and administrators should very carefully consider target accuracy performance before purchasing a system. This needs to be done in the context of the purpose of the target. Club shoots may be more social affairs, but travelling across Australia for a major shoot may cost $5000 or more and overseas much more. If administrators provide Targets that have little chance of getting the top places in correct order, it is very unfair to shooters and ultimately destructive to the shooting sport.

7/ When evaluating electronic target systems it is very important to distinguish between **accuracy** and **reliability**. Communication and power supply issues are reliability problems but cause shooters to lose confidence in the system and then blame every poor result on the target. In our testing of the Kongsberg system in Townsville there were almost 500 shots well spread on the targets without a single miss being reported and the largest error recorded on a target with less than 5000 shots on it was 28 mm.

Because this investigation is a simulation based on the Cabela's competition the numbers given in the results table are only correct for that competition on that range with those competitors. The odds will change for other ranges, distances and shooters but the relative differences between the different targets will remain.
If anything the results in the table understate the effects on competition placings because no consideration has been given to the possibility of shooters below number five in the list coming up and displacing people in the first five.

An attempt to simulate an Australian Queens competition was abandoned due to the massive increase in programme complexity to simulate six different distance for each shooter, and because there is no accuracy data available for the different target systems at any of the shorter ranges. The much smaller group size at short range will mean that the shots are clustered around the scoring rings and the potential for place changes is high for even small target errors.

Explanation of Target Differences

Hexta

Used Hexta had been repaired after around 5000 shots and had accumulated a further 1900 shots when tested.

Silver Mountain

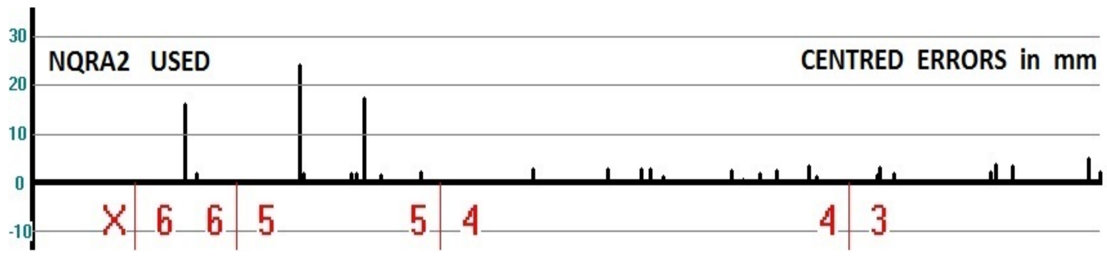
No Correction represents the system set up on a target mounted on old frames with considerable movement. The chronograph sensor was carefully mounted in accordance with the instructions but no other corrections were made.

Angle Corrected is the same set-up as above but with corrections for range misalignment entered into the software.

Best Set-up included all angle correction plus the target frame was locked and tied down to prevent any movement of the target during testing.

Kongsberg

The Kongsberg targets had to be handled a little differently because the target testing showed two distinct error patterns – a constant stream of small errors and occasional much larger ones as shown in the error plot below for NQRA 2.



Errors in mm on Vertical axis

To simulate this type of target error the SDx and SDy values were calculated **without** the three gross errors included and then a 'gross' error was added to individual shots at the same rate they occurred in the tests, so for example for this target an error of 19.2 mm was added to shots at the rate of 1 in 10.

The full data used for the Kongsberg targets is displayed in the table below.

Target		SDx	SDy	Gross Error
Kongsberg 1	New Target	1.41	1.16	Nil
Kongsberg 2	New Target	1.41	1.16	20.7 mm @ 1 in 30
Kongsberg 3	Used with 2812 shots	1.45	0.93	19.2 mm @ 1 in 10
Kongsberg 4	Used with 5042 shots	0.91	0.44	16.8 mm @ 1 in 8
Kongsberg 5	Rebuilt with 1840 shots	6.19	6.12	Nil
Kongsberg 6	Used with 8985 shots	11.72	13.79	Nil

Kongsberg 3 and 4 are actually the same target tested at different times. The lower SD's for the second test is not a mistake and most likely results from the cool overcast weather when the second tests were done.

The results for Kongsberg 5 should not be taken as representative of all rebuilt targets. The target had almost 9000 shots on it when repaired and it is impossible to say whether the poor results are due to the rebuild or a pre-existing fault in the target. No other tests of rebuilt Kongsberg targets have been performed.

. . . ◊ . . .

This report has been kept as concise and simple as possible. If you are interested, there is a wealth of information on accurately measured target errors available for public viewing at: https://sites.google.com/site/etargetcomparison/home/

which, in conjunction with actual shoot data now to be found on the web is a boon for anyone researching targets and shooting.

In conclusion it is necessary to pay tribute to the many, many days of work Peter Smith put into writing and testing the simulation software programme. The first version showed some inconsistency during testing and was eventually scrapped and a completely new programme written that has proven to be rock solid and consistent under everything we have thrown at it.

Notes

(1) **Accuracy Considerations for Electronic Targets by Brian Litz**
http://appliedballisticsllc.com/Articles/Etargets.pdf
(2) **Hexta Database of Scores**
http://shooting.hexsystems.com.au/competition
(3) **Accuracy and Precision of Paper Targets by Peter Smith**
https://sites.google.com/site/etargetcomparison/home/7-paper-targets
(4) **Long Range Testing Of The Hexta Target System by David Stewart and Peter Smith**
https://sites.google.com/site/etargetcomparison/home/4-hexta
(5) **Original Tests on Townsville Kongsbergs by Peter Smith and David Stewart**
https://sites.google.com/site/etargetcomparison/home/5-kongsberg
(6) **Follow-up Tests on Townsville Kongsbergs by David Stewart**
https://sites.google.com/site/etargetcomparison/home/5-kongsberg