DETAILED TEST RESULTS ON SEVEN TOWNSVILLE KONGSBERG TARGETS

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and

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With extra thanks to

Denis Russell
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Eric Christie
Steve Durham
Wayne Swift

who put in a lot of time, work, and sweat to make the testing happen.

The purpose of the electronic target testing conducted at the Harvey Range Shooting Complex on the 10th February 2016 was to :-

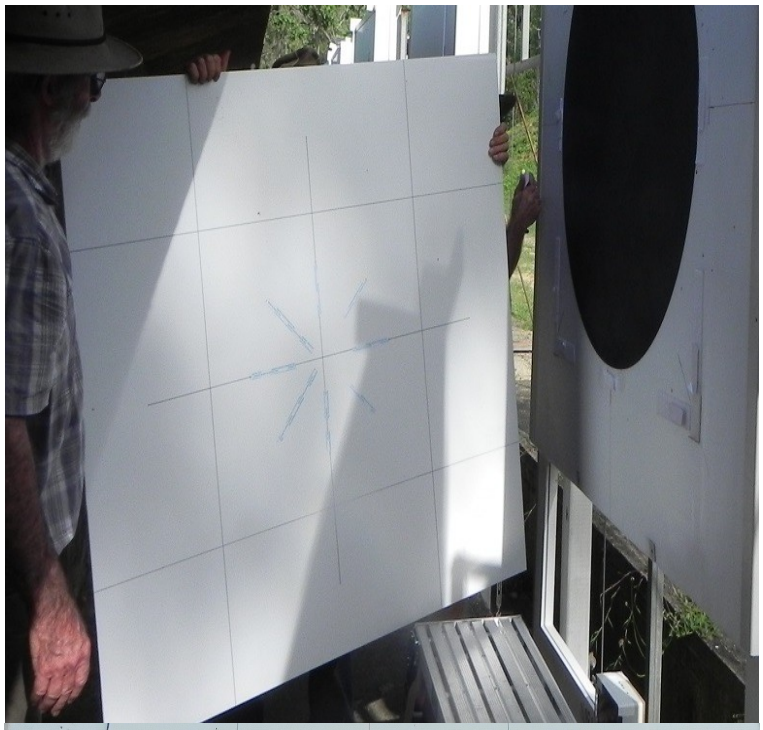
1. Establish a rigorous testing method for electronic targets which can reliably assess other methods of target management. Established methods such as shot counts and target records will need modification as shooting styles and accuracy change, and without some standard way to monitor actual target accuracy these may be misleading.

2. Measure and compare the accuracy of targets of the same make and model in new, slightly degraded and very degraded condition. The targets tested were all Kongsberg Model H1H purchased within the last two years.

Testing Procedure

The faces of the selected targets had a horizontal and vertical line marked through the respective centre points of the sides to indicate the geometric centre of the target.

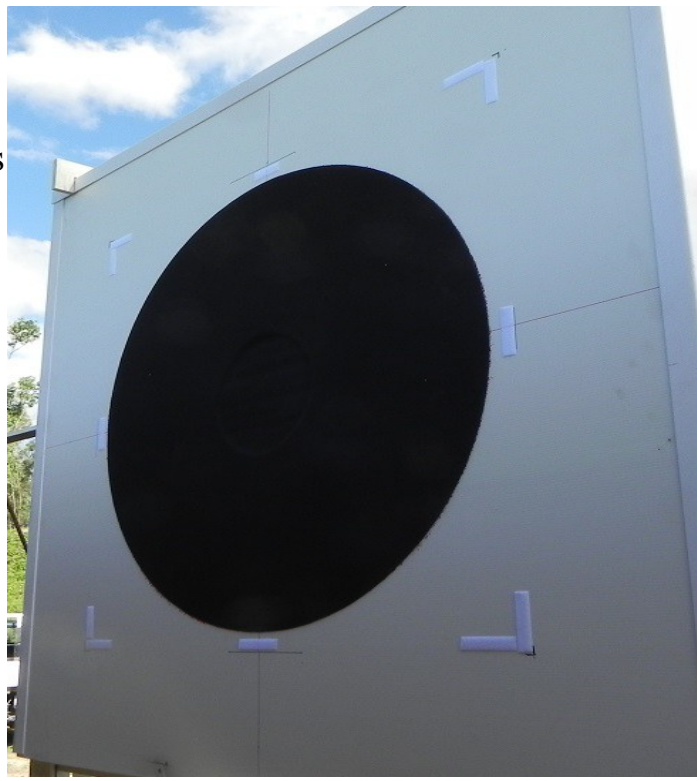
Test sheets were 1200mm square sheets of white Corflute of 5mm thickness with a 400mm diameter black aiming mark fastened to the targets with double sided tape to allow easy removal of the aiming mark for measuring of the shot positions.



The aiming mark used was a circle cut from an ICFRA 700 yard centre but the actual aiming mark used is irrelevant as long as the shooters can use it.

Important was to duplicate the set up of the target so it was tested with identical layers of material on the front face as are used in competition. In addition to the aiming mark the test sheet was ruled into 16 squares of 300 mm using black marker pen to assist observers map shots. This ensured holes and monitor positions were never mismatched.

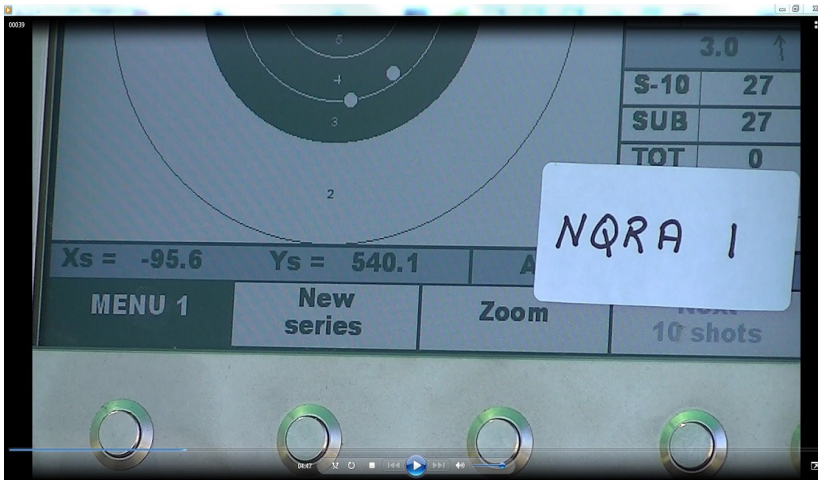
The Corflute sheet was fixed to the target using Velcro at 12 positions around the edge. Centre lines on the target were transferred to the test sheets using a straight edge and red marker pen. The target identification number was written on the sheet and the top edge marked.



During testing, temperature and humidity were recorded in the butts with a Kestrel 3000 and reference marks were made on the Corflute to check its dimensional stability.

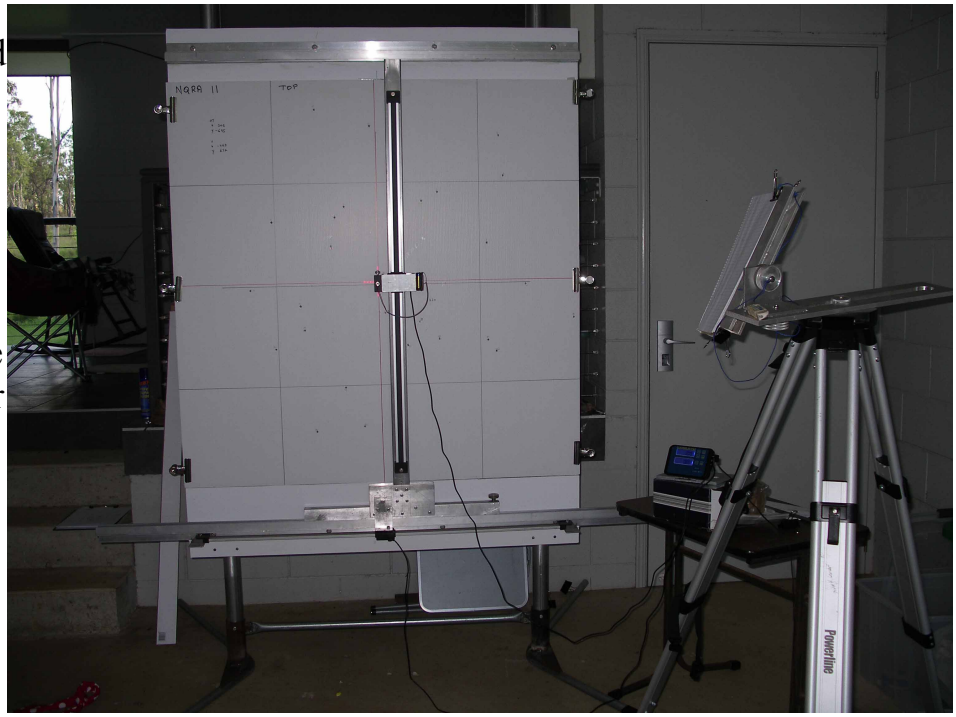
The testing was undertaken from 800 metres using three different .308 rifles fitted with telescopic sights and fired from a rest. 800m (880 yards) was chosen to spread the shots across the entire test sheet. Carefully placing 30 shots across the test sheet, not spilling any off the edges towards target sensors, yet with few shots close together is not easy. 30 shots was chosen to ensure solid statistical results. A wind coach adjusted the sights to distribute the shots around the sheet. Most of the testing used NRAA issue .308 WHBC 155gn ammunition. Any other ammunition is noted in the results and representative muzzle velocities were recorded for each batch of ammunition using a LabRadar.

On the mound the x-y coordinates of each shot were recorded independently by two people. Approximate shot position was relayed by radio to the butts where each observed shot was mapped on a sheet drawn up to mimic the test sheet. After each 10 shots the target was lowered and small numbered patches were placed over the shot holes. Thirty verifiable shots were fired on each test sheet. Any shots very close together in a sequence of ten were discounted and cut from the test with additional shots fired to make up the number. On the new targets only, shots that landed outside the test sheet were measured with a steel rule and included in the test data.



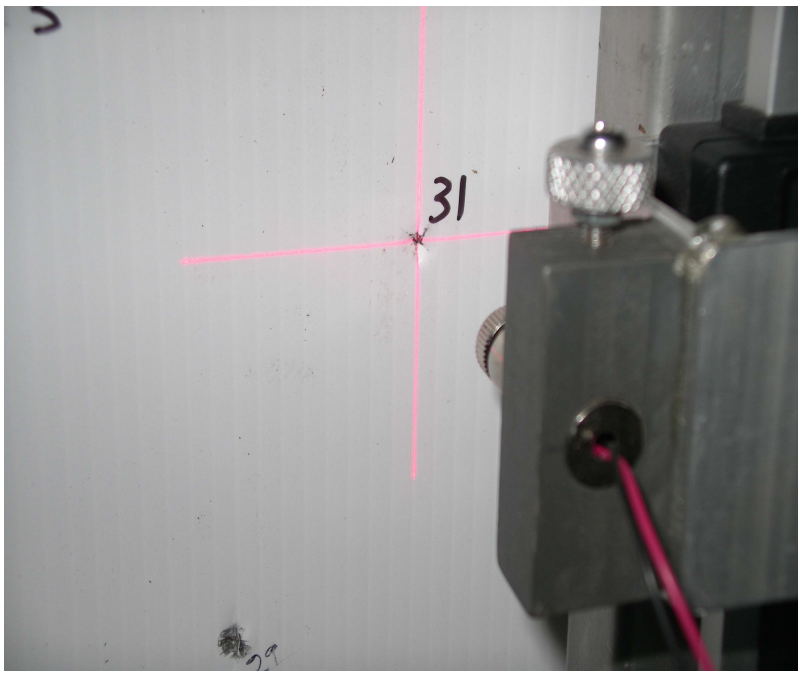
The mound monitor data were recorded by two independent observers plus a video camera. This was a final double check in case of any dispute.

At the conclusion of the tests the Corflute sheets were stripped from the targets and the location of each hole measured on a purpose built machine using two electronic measuring scales to provide a simultaneous readout of the *x* and *y* coordinates of each numbered shot. The two scales were adjusted to be exactly orthogonal and the measuring head incorporated a crossed laser beam to allow precise positioning.



The test sheets were adjusted on the machine so that the horizontal (red) centre line measured zero for "*y*" on both sides of the sheet, after which the head was moved to the centre of the sheet and both scales zeroed.

Each shot position was measured and recorded with the head being brought back to the centre for a check after every three to five shots. The resolution of the scales is 0.01mm but repeatability of hole centre measurements varied to a difference of 0.3mm.



Both sets of measurements were entered into a spreadsheet for processing. The monitor data were entered from one set of records and then checked against the second set.
The measured impact data were entered and then compared graphically against the monitor measurements after removing the acoustic centre error. Any significant variation triggered an examination of the mound video followed by a remeasure of the shot position.

Results and Discussion

At its most basic level the testing of an electronic target involves firing a number of shots into the target through a test sheet, measuring the actual shot positions and comparing them to the reported positions from the electronics. The resultant measured errors consist of :-

1. A constant positioning error (acoustic centre vs geometric centre or centring error)

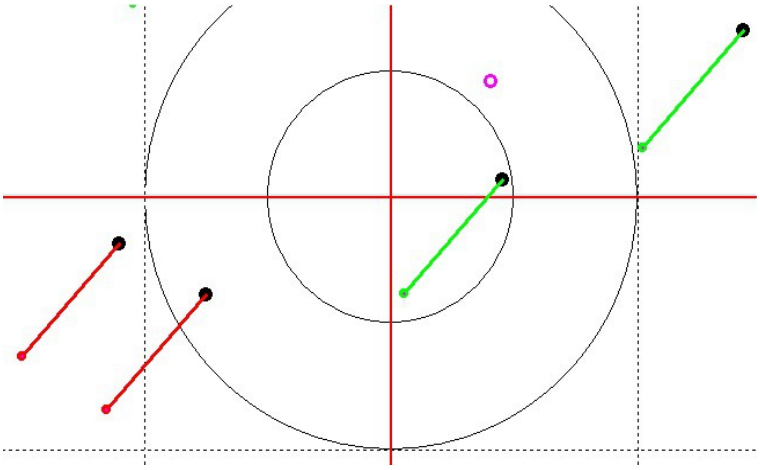
2. A random error from the acoustic / electronic measuring system.

The main focus of these tests is the random measuring error but to obtain this the centring error first has to be determined for each target and then subtracted from the measured errors. This is done by calculating the centre of the group (average shot position) for both the monitor and impact positions and then using the vector difference between them as the centring error. This is equivalent to sliding the test sheet until best fit is obtained with the reported shot positions. In general, the centring error was not large.

X centre error (horizontal)	**Varied from -2.7 to + 1.7 mm**
Y centre error (vertical)	**Varied from - 6.6 to - 15.1 mm**

The vertical error is considerably larger than the horizontal and the fact that all are negative indicates that the horizontal line used to locate the geometric centre should have been approximately 10mm lower on all the targets.

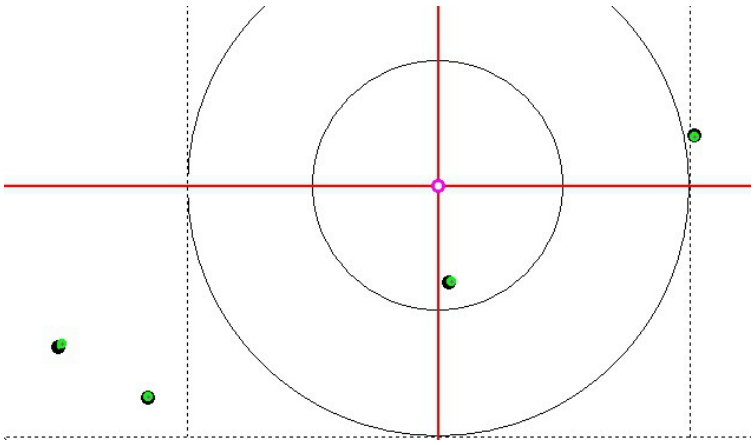
This is a greatly exaggerated illustration of portion of an uncentred group. This error is constant and should not be ignored but it is automatically catered for by a shooter when he adjusts his sights in any shoot where each shot position is relayed to the shooter and the error is not excessive.



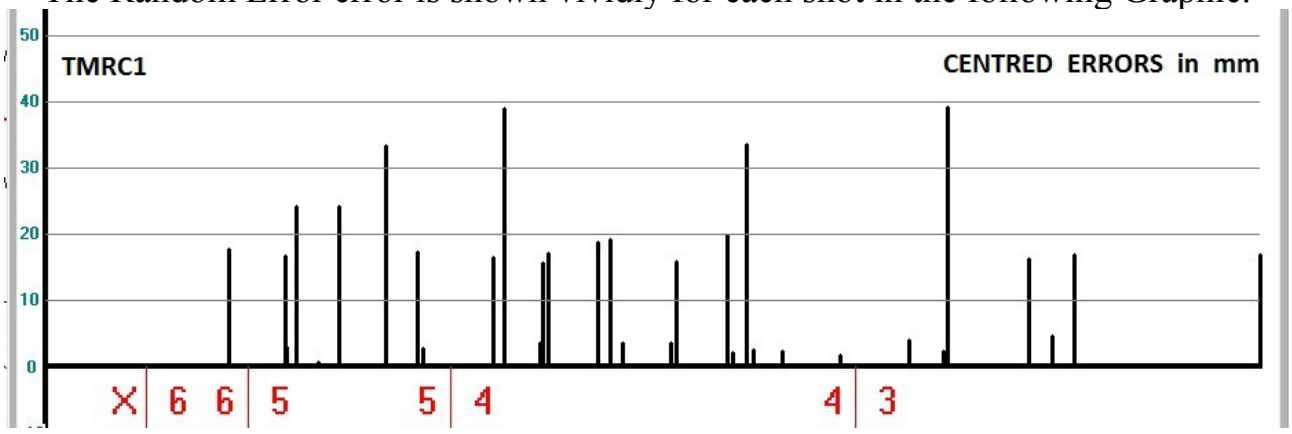
Shot Position in Black, Monitor Position in Colour

What remains after removing centring error is a representation of the variability of the target.

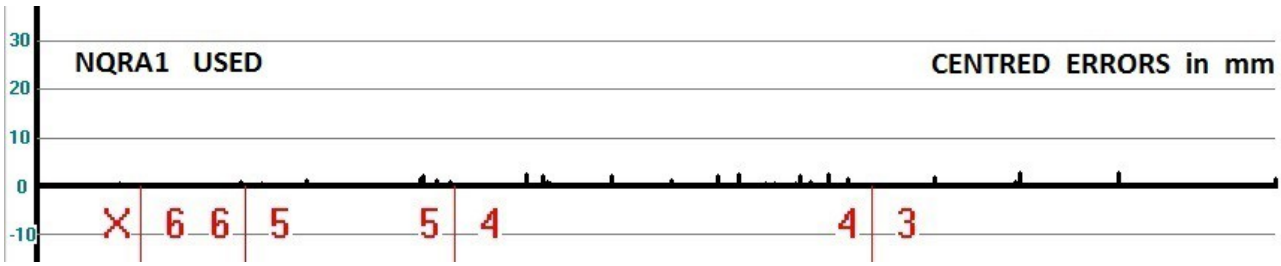
Usually the errors are too small to see in this type of Graphic.



The Random Error error is shown vividly for each shot in the following Graphic.



This represents a very poorly maintained target.



This in contrast is a very good result from one of the used NQRA targets. Note that these errors show approximately real size and are almost trivial.

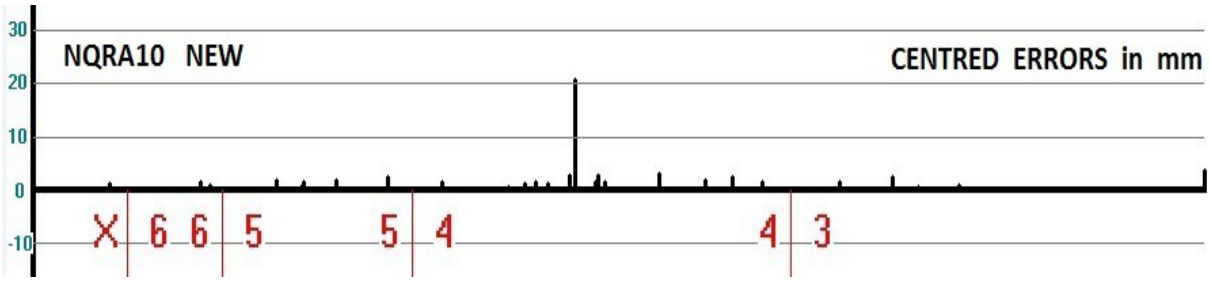
The targets tested were:

Three new targets :	NQRA 9, NQRA 10, NQRA 11
Three used targets:	NQRA 1, NQRA 2, NQRA 3
One badly degraded target:	TMRC 1

It should be noted that the TMRC 1 target was allowed to degrade past the normal refurbishment point to provide the required comparison.

For the purposes of testing and comparison the targets will be considered as a measuring machine so the target error is the linear distance between the actual shot position and the reported shot position.

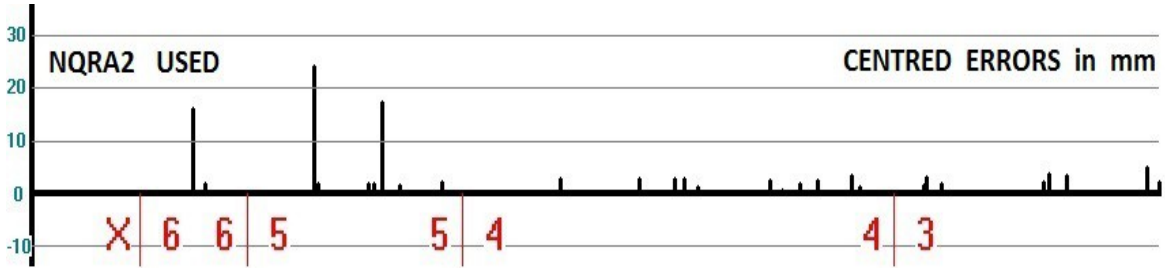
Of the new targets NQRA 9 and 11 were almost identical with average errors of 1.6mm and 1.7mm. The average for target NQRA 10 was 2.3mm but this increase was entirely caused by the 20.7mm error in shot No. 29. See below.



The monitor record and the position measurements for this shot have been rechecked and there is no mistake. At more than five standard deviations away from the average, the probability of this error is approximately once in 10 million shots. It is far more likely to be caused by a glitch in the electronics.

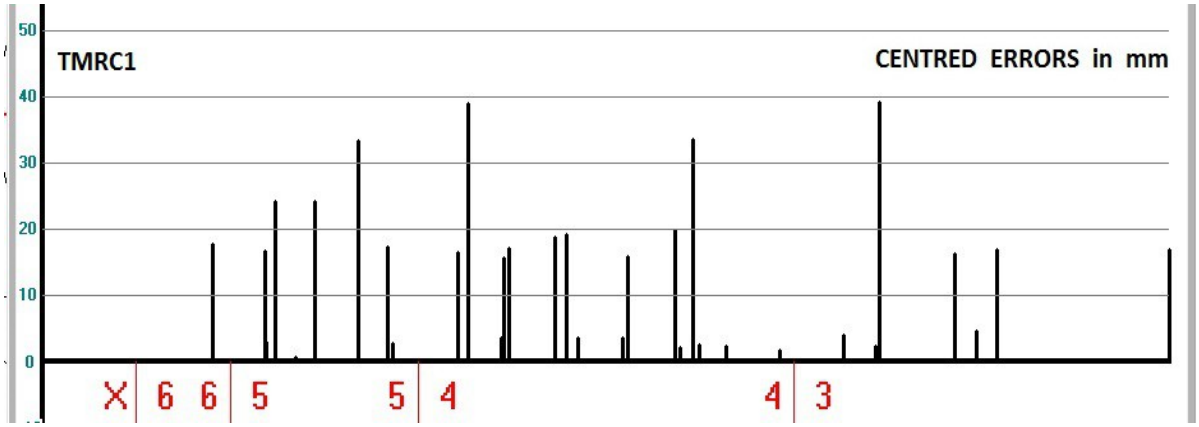
The used targets NQRA 1 and 3 were indistinguishable from the new ones giving average errors of 1.6mm and 1.4mm respectively.

Target 2 returned an average error of 3.9mm, two and a half times the average of the good targets. The majority of this increase is due to shots 24, 25, and 32. See Below.



It is significant that these three shots are reasonably close to the target centre, the area that sustains the heaviest damage from shooting and suggests early stages of target degradation.

Target TMRC 1 had degraded well past the point where it should have been repaired and this is reflected in the errors which averaged 14.2mm and were now larger and fairly uniformly distributed across the entire test area.



Unfortunately at the time of writing no data was available for the number of shots that had been recorded on each of the targets although this is being sought, and it is hoped this information shows a direct correlation between shots fired and loss of accuracy. There is also going to be a strong influence from the type of shooting (Target Rifle vs F Class) and also the ranges at which the targets are used. Shorter ranges and F Class shooters concentrate more damage near the centre of the target and accelerate the degradation of accuracy.

It is strongly recommended for the future that accurate records be kept of the number of shots fired on each target and that matches be organised so that F Class shooters are not concentrated on a small number of targets.

Full testing of the type done in this exercise is hard work, time consuming and expensive and would be impractical on a large number of targets. A system needs to be developed to allow assessment of the need for repair based on usage, type of shooting, and visual appearance of the target, plus a limited amount of testing.

Based on the results presented it may be possible to asses degradation from a more limited test concentrated closer to the centre of the target and possibly undertaken as part of a normal club shoot.

Because the tests were so detailed, and possibly unique, they represent a wealth of information which should be reported in full. The following two page concise report for each target gives particulars in excruciating detail.

The table of errors represents CENTRED errors and is reported in various ways, each one best suited to a particular application.

The X (horizontal) and Y (vertical) errors are components of the total ACTUAL error. This is a convenient way to divide up errors to simplify measurement and analysis which shooters should relate to.

Radial error is also tabulated because it relates directly to scoring. Most of the Radial errors on all targets except TMRC 1 have a small negative value which indicates that the targets show most shots slightly closer to the centre rather than further away. Since on good targets this is a small error in all cases, and all targets show a similar trend, the effect on ranking order of shooters in a competition is benign. Badly degraded targets are another story.

Some Standard Deviations are given in the Concise reports for completeness but you may gain more by examining the Graphics for each Target.

SDs are metrics of target variability useful for predicting the probability of different errors which is a complex topic all by itself and is left out of this basic report.

The only thing to note is that probability is usually predicted from a knowledge of **BOTH MEAN and STANDARD DEVIATION**. Because the X and Y errors have already been corrected for centre error, by definition the mean of both the X and the Y error is zero. Thus SDx and SDy are unique in that they stand alone as good predictors of errors within a Normal distribution.

Which begs the question – do all or most of the errors fit a Normal distribution ?

This report is intended to be objectively about what was measured so that will be left to another discussion.

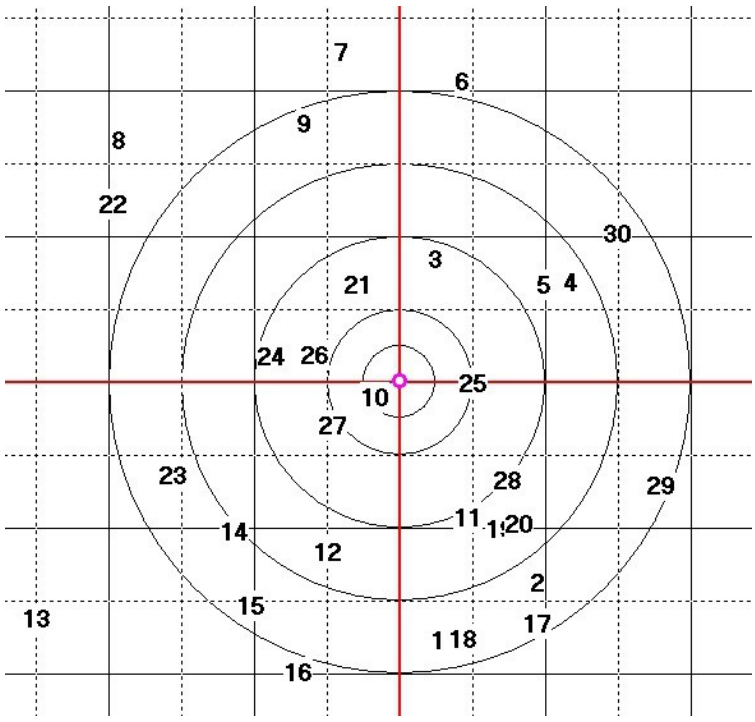
NQRA1

30 SHOTS at 880 Yards
X SPAN 1003.80 mm
Y SPAN 995.63 mm
CENTRE FITTED REPORT
X CENTRE SHIFT -0.19 mm
Y CENTRE SHIFT -10.87 mm
Shown Further from Centre 0
Shown Closer to Centre 30

308 WIN MV 2900 f/s 155 grain projectiles
Estimated Velocity at target 1460 f/s
Air Temperature 32.5 deg C . Humidity 65 %
Test Sheet Stability < 1 mm movement over 800 mm.

RAW MEASUREMENTS

No	Impact X	Impact Y	Monitor X	Monitor Y
1	58.3	-415.0	58.8	-403.5
2	219.1	-323.0	217.8	-310.5
3	53.5	196.9	52.9	206.2
4	272.6	160.4	270.5	170.8
5	228.2	157.0	226.3	166.7
6	97.1	483.1	96.1	492.3
7	-97.0	529.1	-95.6	540.1
8	-455.8	388.6	-453.0	398.1
9	-158.2	415.6	-157.1	425.1
10	-44.8	-24.0	-43.9	-12.6
11	105.2	-217.6	104.6	-205.9
12	-120.1	-273.1	-119.5	-261.5
13	-587.9	-380.0	-586.2	-368.1
14	-271.2	-240.9	-269.6	-229.9
15	-244.3	-359.0	-243.3	-348.1
16	-166.8	-466.6	-166.2	-455.3
17	216.0	-387.3	215.5	-375.7
18	97.4	-413.0	97.1	-401.7
19	157.1	-235.9	155.4	-223.3
20	187.3	-227.2	186.6	-215.9
21	-72.0	155.6	-71.5	166.0
22	-464.7	286.1	-462.0	295.4
23	-369.2	-148.7	-366.6	-137.2
24	-210.2	41.5	-207.6	51.9
25	113.6	-2.3	112.9	8.8
26	-141.2	43.7	-139.8	53.8
27	-111.8	-69.6	-110.7	-58.8
28	169.6	-157.9	168.4	-146.6
29	415.9	-166.2	413.7	-154.3
30	346.4	239.3	344.3	249.4

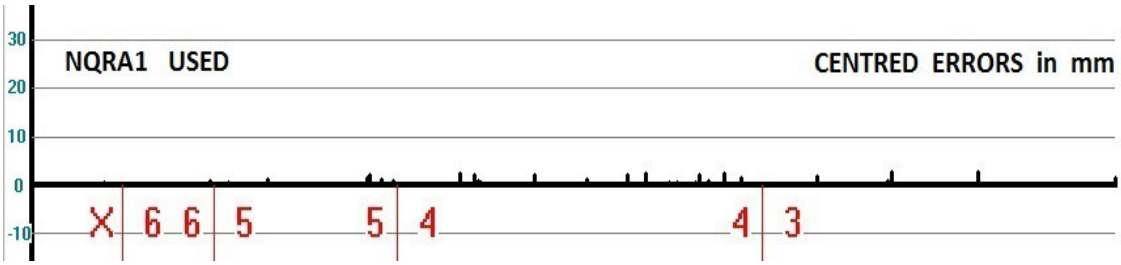


SHOT POSITIONS

Grid in minutes and half minutes (880 yards)

CENTRED ERRORS

No	X	Y	Rad	Lin
1	0.3	0.6	-0.5	0.7
2	-1.4	1.7	-2.2	2.2
3	-0.8	-1.6	-1.8	1.8
4	-2.3	-0.5	-2.1	2.3
5	-2.1	-1.2	-2.4	2.4
6	-1.2	-1.6	-1.9	2.0
7	1.2	0.2	0.0	1.2
8	2.6	-1.3	-2.8	2.9
9	0.9	-1.4	-1.6	1.7
10	0.7	0.5	0.0	0.8
11	-0.8	0.8	-1.2	1.2
12	0.4	0.7	-0.8	0.8
13	1.5	1.0	-1.8	1.8
14	1.4	0.2	-1.2	1.4
15	0.8	0.0	-0.5	0.8
16	0.4	0.4	-0.5	0.6
17	-0.7	0.7	-1.0	1.0
18	-0.5	0.5	-0.6	0.7
19	-1.9	1.7	-2.5	2.5
20	-0.9	0.4	-1.0	1.0
21	0.3	-0.5	-0.5	0.6
22	2.5	-1.5	-2.9	2.9
23	2.4	0.6	-2.5	2.5
24	2.4	-0.4	-2.3	2.4
25	-0.9	0.2	-0.8	1.0
26	1.2	-0.7	-1.4	1.4
27	0.9	-0.1	-0.8	0.9
28	-1.4	0.5	-1.5	1.5
29	-2.4	1.1	-2.6	2.6
30	-2.3	-0.8	-2.3	2.4



X, 6, 5, 4, 3 indicate Score or how far shot is from the centre.

BARS ARE REAL ERROR SIZE

ACOUSTIC CENTRE SHIFT

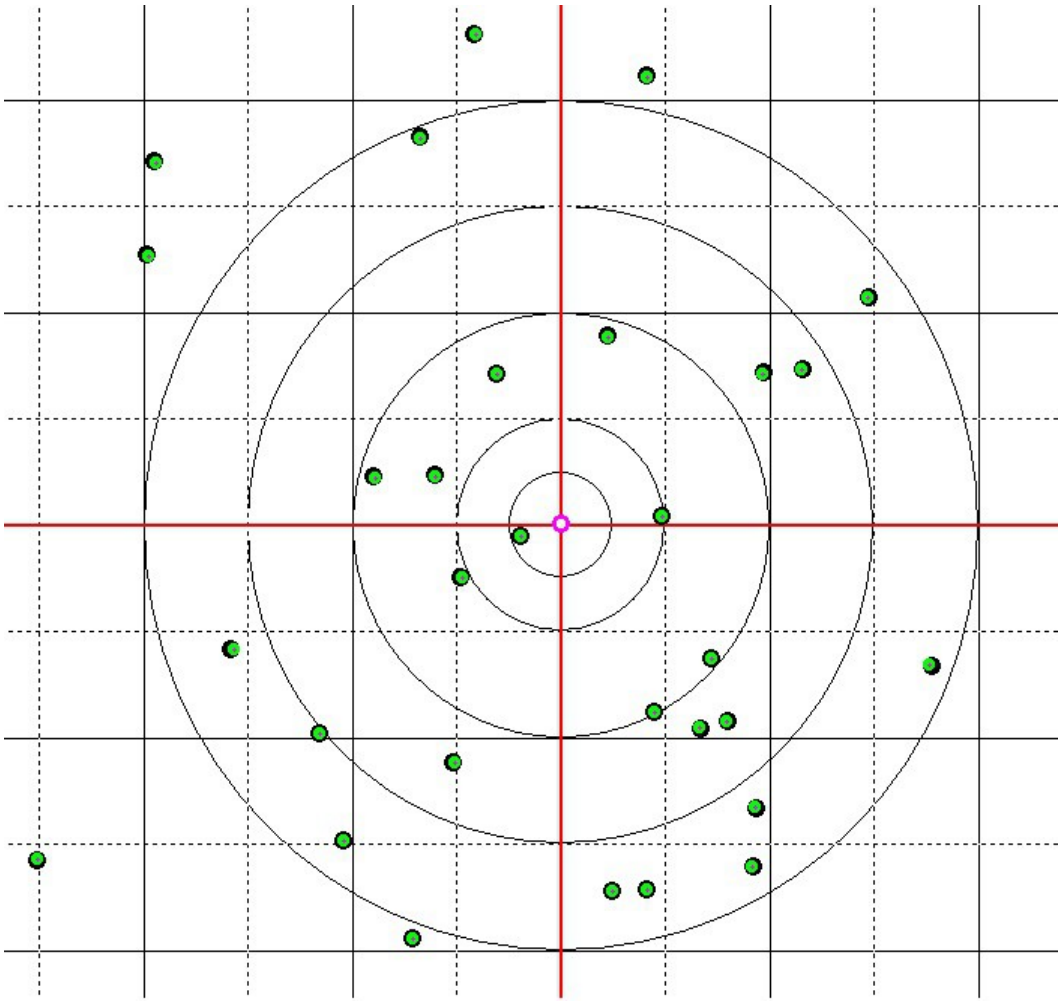
Depends on how accurately Aiming Marks are fixed to target.

X - 0.19 mm Y - 10.87 mm

Target Errors have been broken into an X (Horizontal) and Y (Vertical) component. Shooters instinctively think this way, we have measured the target this way, and it is a very convenient way to simplify calculations.

	AVERAGE mm (880 Yards)	SD (880 Yards)
X component	Zero (because group is centred)	1.50 mm 0.006 minute
Y component	Zero (because group is centred)	0.92 mm 0.004 minute
Actual Direct (Lin)	1.60 mm [1] 0.007 minute	0.75 mm [2] 0.003 minute

SD values may be used to predict the probability of future errors which is left to another document.
NOTE however, that maximum predicted errors in a number of shots is a <u>multiple</u> of the SD value.



RED is expansion, GREEN contraction of reported shot positions.

AVERAGE RADIAL SHIFT is 1.46 mm INWARDS

Errors are usually too small to show with a very good target on a map of this type. See previous Graphic.

1 Being a direct distance , this error is always positive. The SD if often greater than the Average. See Footnote 2.
2 When it is impossible for an error distribution close to zero to spill into the negative region, the distribution is not a Normal Distribution. This is usually the case with Actual Direct Errors which are always positive. It now becomes a FOLDED NORMAL DISTRIBUTION. Calculation and use of SD now becomes complex. Many have wrongly applied the rules for a Normal Distribution to this case. Often the results only differ slightly but it really should be avoided. Applying this to make predictions is complex and best avoided.

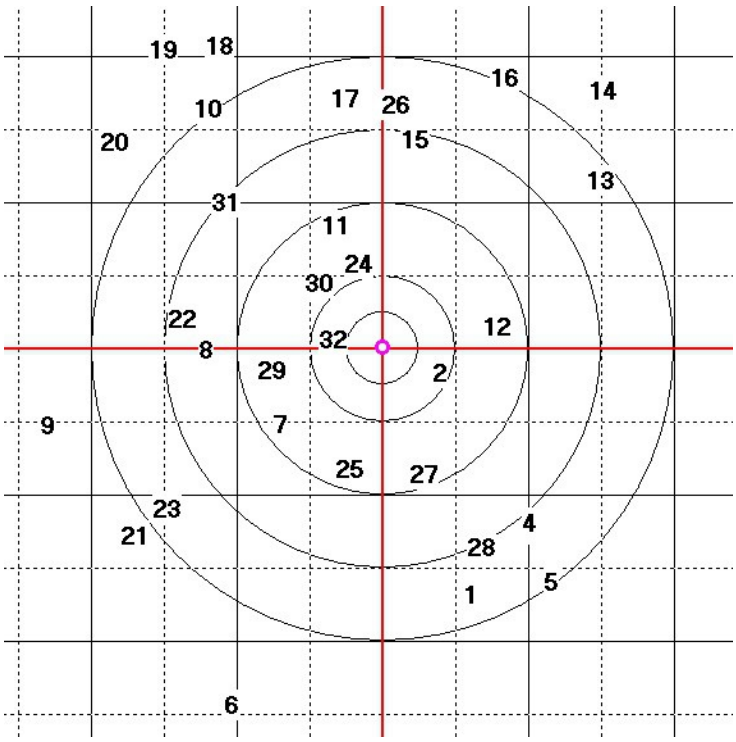
NQRA2

32 SHOTS at 880 Yards
X SPAN 891.22 mm
Y SPAN 1056.00 mm
CENTRE FITTED REPORT
X CENTRE SHIFT 1.70 mm
Y CENTRE SHIFT -9.92 mm
Shown Further from Centre 8
Shown Closer to Centre 24

308 WIN MV 2920 f/s 155 grain projectiles
Estimated Velocity at target 1470 f/s
Air Temperature 32.5 deg C . Humidity 67 %
Test Sheet Stability < 1 mm movement over 800 mm.

RAW MEASUREMENTS

No	Impact X	Impact Y	Monitor X	Monitor Y
1	139.6	-393.7	137.7	-384.5
2	91.5	-38.3	90.1	-30.5
3	234.3	-287.4	231.4	-278.2
4	234.1	-277.1	231.8	-268.5
5	268.8	-371.9	265.7	-362.4
6	-244.5	-570.5	-244.4	-562.1
7	-165.1	-120.8	-165.8	-112.1
8	-285.5	-0.6	-284.8	7.8
9	-539.5	-121.5	-540.0	-113.7
10	-282.8	384.6	-282.5	392.1
11	-77.1	198.9	-77.3	207.0
12	182.0	36.0	179.1	44.3
13	348.1	269.6	344.6	276.5
14	351.7	413.8	348.7	422.0
15	49.5	335.9	47.5	342.8
16	193.9	434.9	190.9	443.6
17	-63.7	402.5	-64.9	410.5
18	-264.0	485.5	-263.5	492.8
19	-355.3	479.9	-354.2	485.5
20	-431.9	332.7	-431.0	339.9
21	-399.4	-299.2	-399.3	-290.2
22	-323.7	48.5	-322.7	57.1
23	-348.2	-254.7	-347.5	-245.6
24	-40.8	137.1	-41.4	171.1
25	-54.1	-192.2	-67.5	-169.6
26	19.2	390.6	18.8	398.1
27	64.7	-200.6	62.7	-190.8
28	156.1	-316.3	154.0	-306.4
29	-179.9	-33.2	-179.9	-24.5
30	-103.6	105.0	-104.1	113.2
31	-254.1	235.2	-253.5	243.3
32	-82.0	16.3	-94.7	38.0

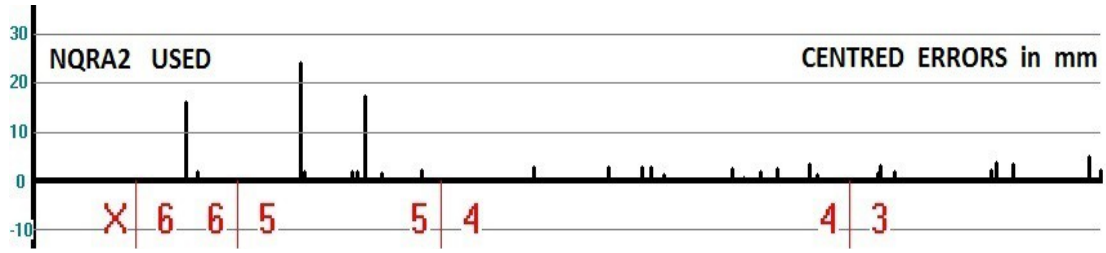


SHOT POSITIONS

Grid in minutes and half minutes (880 yards)

CENTRED ERRORS

No	X	Y	Rad	Lin
1	-0.2	-0.8	0.6	0.8
2	0.3	-2.1	1.2	2.1
3	-1.2	-0.7	-0.3	1.4
4	-0.6	-1.3	0.6	1.5
5	-1.4	-0.5	-0.5	1.4
6	1.8	-1.5	1.0	2.4
7	1.0	-1.3	0.5	1.6
8	2.4	-1.5	-2.0	2.8
9	1.2	-2.1	-0.5	2.4
10	2.0	-2.5	-3.1	3.2
11	1.5	-1.8	-1.9	2.4
12	-1.2	-1.7	-1.2	2.0
13	-1.8	-3.1	-3.0	3.5
14	-1.3	-1.7	-2.1	2.2
15	-0.3	-3.0	-2.9	3.0
16	-1.3	-1.2	-1.7	1.8
17	0.5	-1.9	-1.9	2.0
18	2.2	-2.7	-3.3	3.5
19	2.8	-4.3	-5.1	5.1
20	2.6	-2.7	-3.7	3.8
21	1.8	-0.9	-0.6	2.0
22	2.7	-1.3	-2.7	3.0
23	2.4	-0.8	-1.1	2.6
24	1.1	24.1	23.7	24.1
25	-11.7	12.7	-13.1	17.3
26	1.3	-2.4	-2.1	2.7
27	-0.3	-0.1	0.0	0.3
28	-0.4	0.0	-0.2	0.4
29	1.7	-1.2	-0.8	2.1
30	1.2	-1.8	-2.1	2.1
31	2.3	-1.8	-2.9	2.9
32	-11.0	11.8	1.0	16.2



X, 6, 5, 4, 3 indicate Score or how far shot is from the centre.

BARS ARE REAL ERROR SIZE

ACOUSTIC CENTRE SHIFT

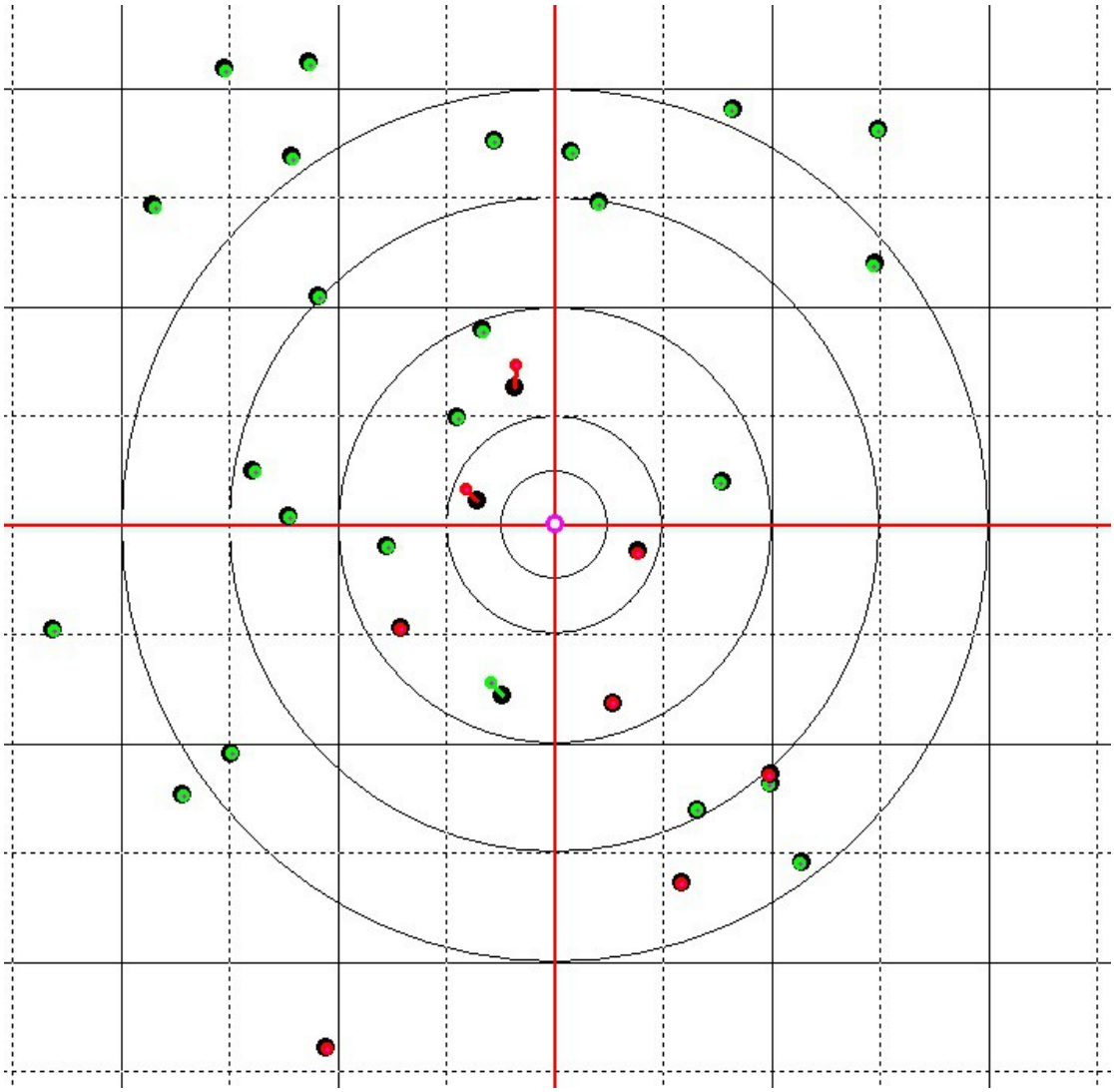
Depends on how accurately Aiming Marks are fixed to target.

X 1.70 mm Y - 9.92 mm

Target Errors have been broken into an X (Horizontal) and Y (Vertical) component. Shooters instinctively think this way, we have measured the target this way, and it is a very convenient way to simplify calculations.

	AVERAGE mm (880 Yards)	SD (880 Yards)
X component	Zero (because group is centred)	3.24 mm 0.014 minute
Y component	Zero (because group is centred)	5.56 mm 0.024 minute
Actual Direct (Lin)	3.89 mm [1] 0.06 minute	5.12 mm [2] 0.022 minute

SD values may be used to predict the probability of future errors which is left to another document.
NOTE however, that maximum predicted errors in a number of shots is a multiple of the SD value.



RED is expansion, GREEN contraction of reported shot positions.

AVERAGE RADIAL SHIFT is 0.95 mm INWARDS

Errors are usually too small to show with a very good target on a map of this type. See previous Graphic.

1 Being a direct distance , this error is always positive. The SD if often greater than the Average. See Footnote 2.
2 When it is impossible for an error distribution close to zero to spill into the negative region, the distribution is not a Normal Distribution. This is usually the case with Actual Direct Errors which are always positive. It now becomes a FOLDED NORMAL DISTRIBUTION. Calculation and use of SD now becomes complex. Many have wrongly applied the rules for a Normal Distribution to this case. Often the results only differ slightly but it really should be avoided. Applying this to make predictions is complex and best avoided.

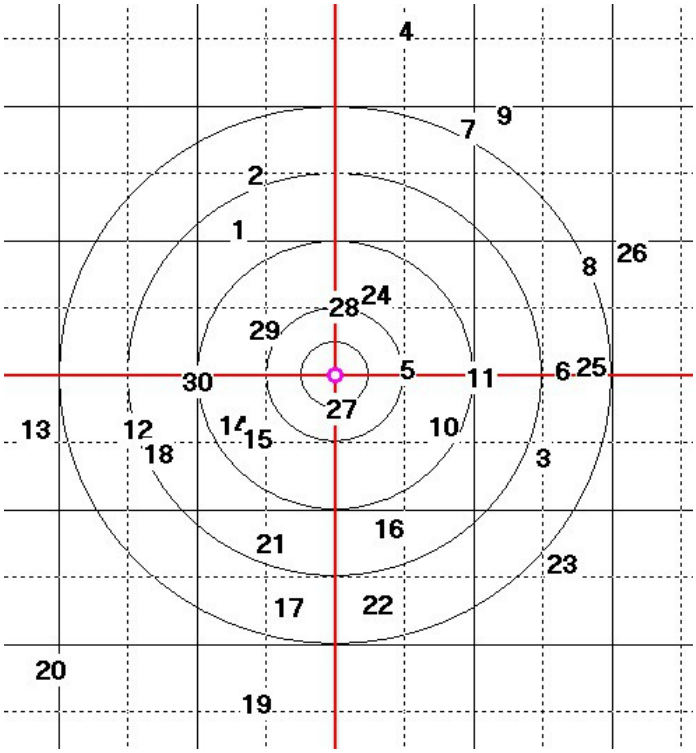
NQRA3

30 SHOTS at 880 Yards
X SPAN 1009.60 mm
Y SPAN 1169.00 mm
CENTRE FITTED REPORT
X CENTRE SHIFT -0.44 mm
Y CENTRE SHIFT -6.66 mm
Shown Further from Centre 2
Shown Closer to Centre 28

308 WIN MV 2900 f/s 155 grain projectiles
Estimated Velocity at target 1460 f/s
Air Temperature 32 deg C . Humidity 70 %
Test Sheet Stability < 1 mm movement over 800 mm.

RAW MEASUREMENTS

No	Impact X	Impact Y	Monitor X	Monitor Y
1	-167.3	258.6	-166.0	264.0
2	-138.2	352.9	-136.8	358.2
3	348.8	-137.8	347.6	-130.7
4	116.0	604.5	116.6	611.4
5	119.2	17.0	119.7	22.6
6	382.3	13.6	380.8	20.4
7	220.2	434.5	219.1	439.4
8	425.7	195.7	424.6	202.2
9	281.8	457.9	280.3	463.0
10	179.0	-82.6	177.9	-75.5
11	242.4	2.6	241.6	9.1
12	-340.7	-87.3	-338.0	-80.5
13	-511.5	-87.6	-511.2	-80.8
14	-177.0	-81.8	-175.2	-74.1
15	-135.6	-105.5	-135.0	-98.7
16	86.2	-260.5	86.1	-252.3
17	-84.9	-397.8	-84.0	-390.6
18	-304.9	-131.8	-302.5	-124.8
19	-138.5	-564.5	-137.1	-558.2
20	-486.2	-506.1	-484.5	-498.8
21	-113.2	-285.6	-112.1	-277.9
22	67.9	-393.1	68.2	-385.8
23	377.8	-323.0	377.7	-315.8
24	64.1	146.8	64.0	153.0
25	428.5	21.5	427.7	28.6
26	498.1	220.2	496.5	226.6
27	4.8	-52.1	6.3	-44.7
28	9.5	124.8	10.4	131.1
29	-123.8	84.3	-122.1	90.1
30	-236.9	-5.1	-233.9	2.0

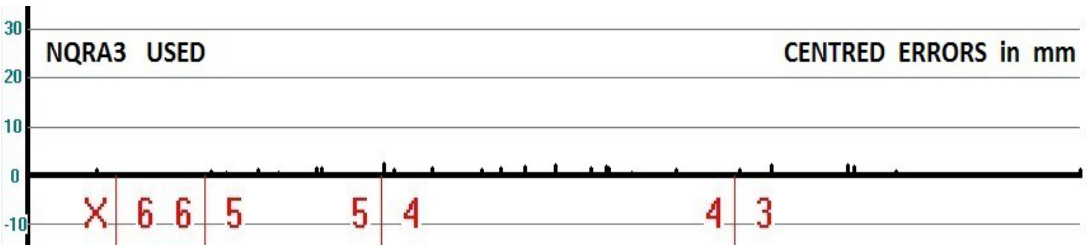


SHOT POSITIONS

Grid in minutes and half minutes (880 yards)

CENTRED ERRORS

No	X	Y	Rad	Lin
1	0.9	-1.3	-1.6	1.6
2	1.0	-1.4	-1.6	1.7
3	-1.6	0.5	-1.7	1.7
4	0.2	0.2	0.3	0.3
5	0.0	-1.0	-0.4	1.0
6	-1.9	0.2	-1.9	1.9
7	-1.5	-1.7	-2.2	2.3
8	-1.5	-0.1	-1.4	1.5
9	-1.9	-1.5	-2.2	2.4
10	-1.6	0.4	-1.6	1.6
11	-1.2	-0.1	-1.2	1.2
12	2.2	0.1	-2.2	2.2
13	-0.1	0.1	0.1	0.2
14	1.3	1.0	-1.6	1.7
15	0.2	0.1	-0.2	0.2
16	-0.6	1.6	-1.7	1.7
17	0.5	0.6	-0.7	0.8
18	1.9	0.3	-1.9	1.9
19	1.0	-0.4	0.1	1.0
20	1.3	0.6	-1.4	1.4
21	0.7	1.1	-1.3	1.3
22	-0.1	0.6	-0.6	0.6
23	-0.5	0.5	-0.7	0.7
24	-0.5	-0.4	-0.5	0.6
25	-1.2	0.4	-1.2	1.3
26	-2.1	-0.3	-2.0	2.1
27	1.0	0.7	-1.2	1.2
28	0.5	-0.4	-0.5	0.6
29	1.2	-0.8	-1.5	1.5
30	2.6	0.4	-2.6	2.6



X, 6, 5, 4, 3 indicate Score or how far shot is from the centre.

BARS ARE REAL ERROR SIZE

ACOUSTIC CENTRE SHIFT

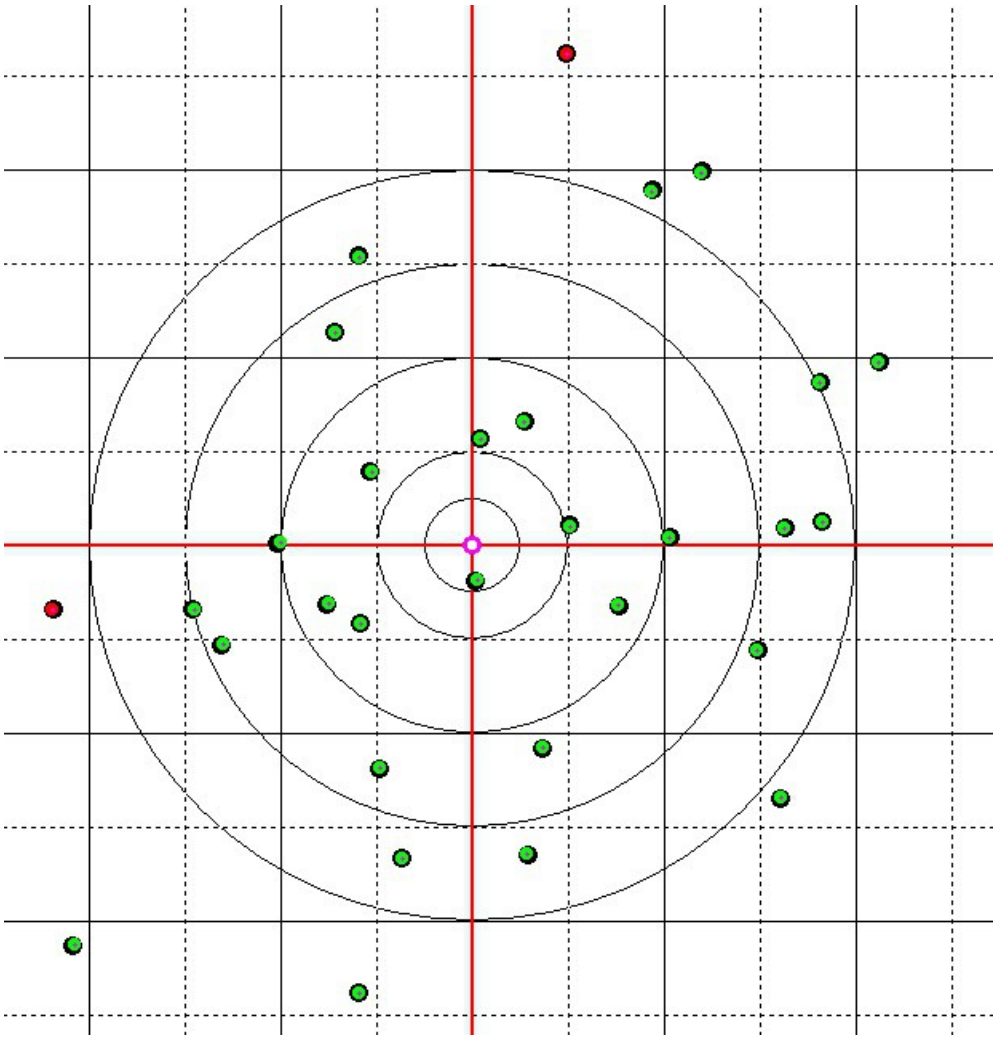
Depends on how accurately Aiming Marks are fixed to target.

X - 0.44 mm Y - 6.66 mm

Target Errors have been broken into an X (Horizontal) and Y (Vertical) component. Shooters instinctively think this way, we have measured the target this way, and it is a very convenient way to simplify calculations.

	AVERAGE mm (880 Yards)	**SD (880 Yards)**
X component	Zero (because group is centred)	1.29 mm 0.006 minute
Y component	Zero (because group is centred)	0.79 mm 0.003 minute
Actual Direct (Lin)	1.36 mm [1] 0.006 minute	0.65 mm [2] 0.003 minute

SD values may be used to predict the probability of future errors which is left to another document.
NOTE however, that maximum predicted errors in a number of shots is a multiple of the SD value.



RED is expansion, GREEN contraction of reported shot positions.

AVERAGE RADIAL SHIFT is 1.23 mm INWARDS

Errors are usually too small to show with a very good target on a map of this type. See previous Graphic.

1 Being a direct distance , this error is always positive. The SD if often greater than the Average. See Footnote 2.
2 When it is impossible for an error distribution close to zero to spill into the negative region, the distribution is not a Normal Distribution. This is usually the case with Actual Direct Errors which are always positive. It now becomes a FOLDED NORMAL DISTRIBUTION. Calculation and use of SD now becomes complex. Many have wrongly applied the rules for a Normal Distribution to this case. Often the results only differ slightly but it really should be avoided. Applying this to make predictions is complex and best avoided.

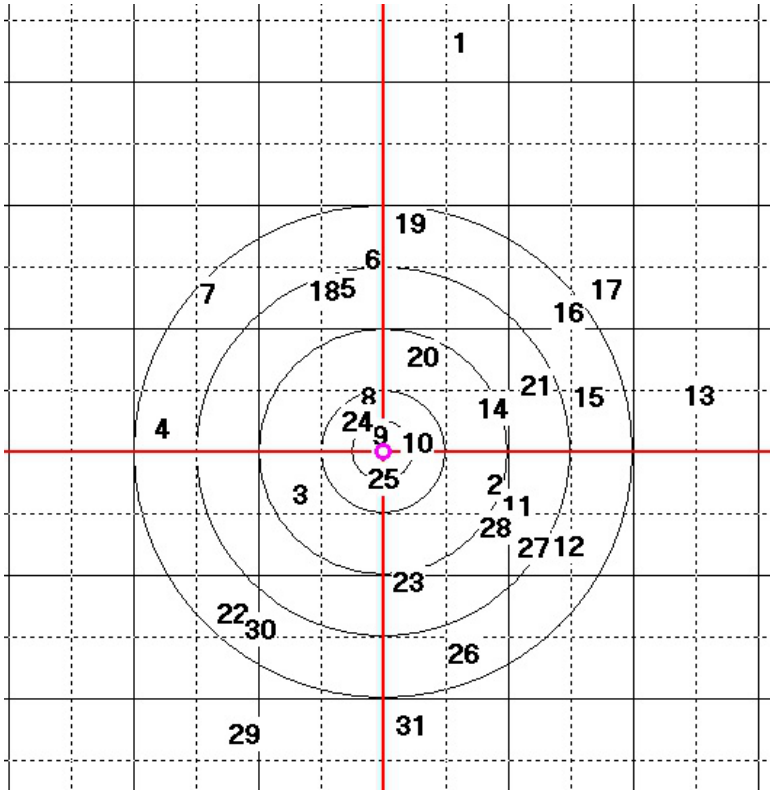
NQRA9

31 SHOTS at 880 Yards
X SPAN 1004.50 mm
Y SPAN 1314.00 mm
CENTRE FITTED REPORT
X CENTRE SHIFT 0.53 mm
Y CENTRE SHIFT -10.61 mm
Shown Further from Centre 3
Shown Closer to Centre 28

308 WIN MV 2960 f/s 155 grain projectiles
Estimated Velocity at target 1500 f/s
Air Temperature 34.5 deg C . Humidity 60 %
Test Sheet Stability < 1 mm movement over 800 mm.

RAW MEASUREMENTS

No	Impact X	Impact Y	Monitor X	Monitor Y
1	141.0	781.0	141.2	793.9
2	206.9	-59.3	204.6	-48.6
3	-159.3	-76.2	-158.7	-65.3
4	-417.6	48.7	-415.9	59.7
5	-68.9	314.1	-67.9	323.5
6	-23.5	369.9	-22.8	378.9
7	-332.1	303.7	-329.5	313.0
8	-30.3	109.2	-30.6	119.7
9	-7.8	33.2	-8.3	43.9
10	58.6	19.8	57.3	30.4
11	246.7	-98.0	244.9	-86.6
12	342.2	-174.1	339.7	-162.5
13	587.0	111.5	586.3	122.2
14	201.8	86.8	200.2	97.3
15	378.9	108.4	376.1	118.2
16	341.1	267.8	338.5	276.9
17	413.0	313.4	410.7	323.1
18	-114.3	309.4	-112.8	319.3
19	46.2	437.7	46.4	446.6
20	69.5	184.1	69.5	193.5
21	281.4	130.8	279.2	140.6
22	-287.5	-302.5	-287.0	-290.6
23	43.0	-242.9	42.0	-231.2
24	-51.2	60.7	-50.9	70.8
25	-4.7	-46.5	-4.9	-35.2
26	146.8	-378.6	146.1	-366.5
27	277.5	-177.9	276.0	-166.8
28	206.9	-139.3	204.7	-128.2
29	-264.5	-533.0	-263.3	-521.1
30	-234.6	-334.0	-234.4	-322.3
31	49.3	-515.6	48.6	-505.5

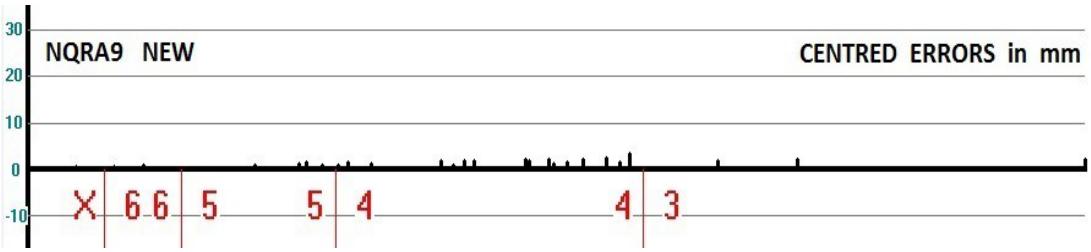


SHOT POSITIONS

Grid in minutes and half minutes (880 yards)

CENTRED ERRORS

No	X	Y	Rad	Lin
1	0.7	2.3	2.4	2.4
2	-1.7	0.1	-1.5	1.7
3	1.1	0.3	-1.1	1.2
4	2.2	0.4	-2.2	2.2
5	1.6	-1.2	-1.8	2.0
6	1.3	-1.6	-1.8	2.0
7	3.1	-1.4	-3.4	3.4
8	0.2	-0.1	-0.3	0.3
9	0.0	0.1	0.0	0.1
10	-0.8	0.0	0.5	0.8
11	-1.2	0.8	-1.5	1.5
12	-2.0	1.0	-2.2	2.2
13	-0.2	0.1	-0.2	0.2
14	-1.0	-0.1	-1.0	1.1
15	-2.2	-0.8	-2.4	2.4
16	-2.1	-1.5	-2.6	2.6
17	-1.8	-0.9	-1.9	2.0
18	2.0	-0.8	-1.7	2.1
19	0.7	-1.7	-1.7	1.8
20	0.5	-1.2	-1.2	1.3
21	-1.7	-0.8	-1.9	1.9
22	1.0	1.3	-1.7	1.7
23	-0.4	1.1	-1.1	1.2
24	0.9	-0.5	-1.0	1.0
25	0.3	0.7	-0.7	0.8
26	-0.1	1.5	-1.5	1.5
27	-1.0	0.5	-1.1	1.1
28	-1.6	0.5	-1.4	1.7
29	1.7	1.3	-2.0	2.2
30	0.7	1.1	-1.3	1.3
31	-0.2	-0.6	0.6	0.6



X, 6, 5, 4, 3 indicate Score or how far shot is from the centre.

BARS ARE REAL ERROR SIZE

ACOUSTIC CENTRE SHIFT

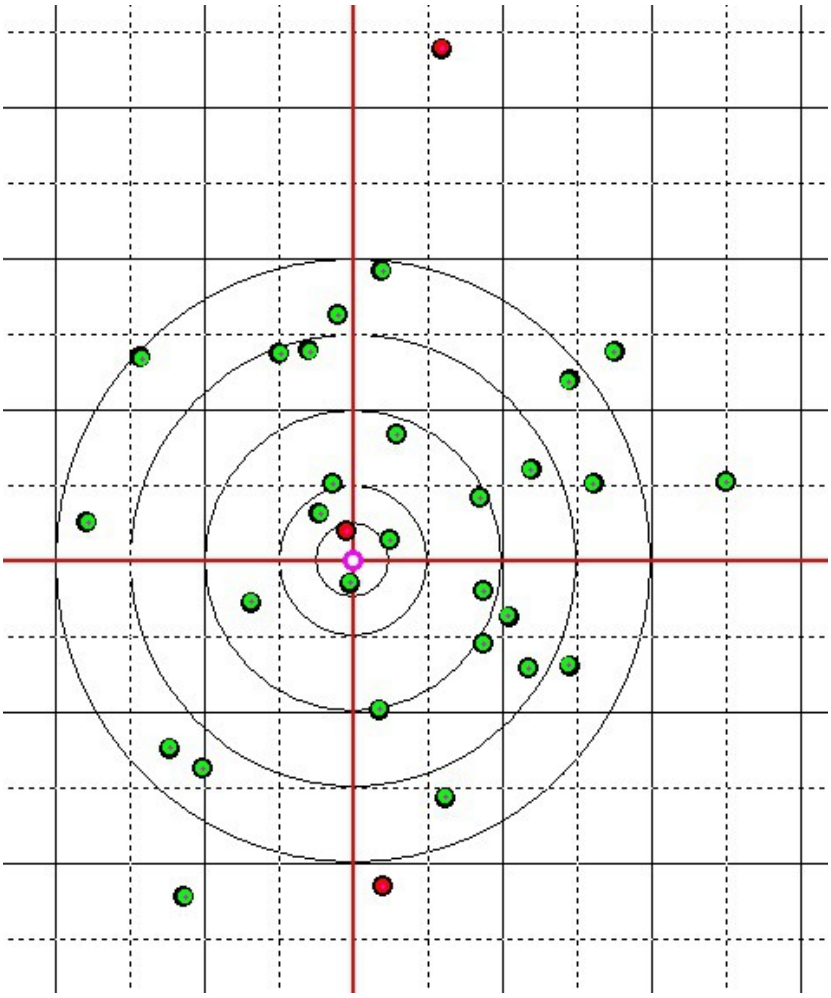
Depends on how accurately Aiming Marks are fixed to target.

X - 0.53 mm Y - 10.61 mm

Target Errors have been broken into an X (Horizontal) and Y (Vertical) component. Shooters instinctively think this way, we have measured the target this way, and it is a very convenient way to simplify calculations.

	AVERAGE mm (880 Yards)	**SD (880 Yards)**
X component	Zero (because group is centred)	1.39 mm 0.005 minute
Y component	Zero (because group is centred)	1.01 mm 0.004 minute
Actual Direct (Lin)	1.55 mm [1] 0.007 minute	0.74 mm [2] 0.003 minute

SD values may be used to predict the probability of future errors which is left to another document.
NOTE however, that maximum predicted errors in a number of shots is a multiple of the SD value.



RED is expansion, GREEN contraction of reported shot positions.

AVERAGE RADIAL SHIFT is 1.24 mm INWARDS

Errors are usually too small to show with a very good target on a map of this type. See previous Graphic.

1 Being a direct distance , this error is always positive. The SD if often greater than the Average. See Footnote 2.
2 When it is impossible for an error distribution close to zero to spill into the negative region, the distribution is not a Normal Distribution. This is usually the case with Actual Direct Errors which are always positive. It now becomes a FOLDED NORMAL DISTRIBUTION. Calculation and use of SD now becomes complex. Many have wrongly applied the rules for a Normal Distribution to this case. Often the results only differ slightly but it really should be avoided. Applying this to make predictions is complex and best avoided.

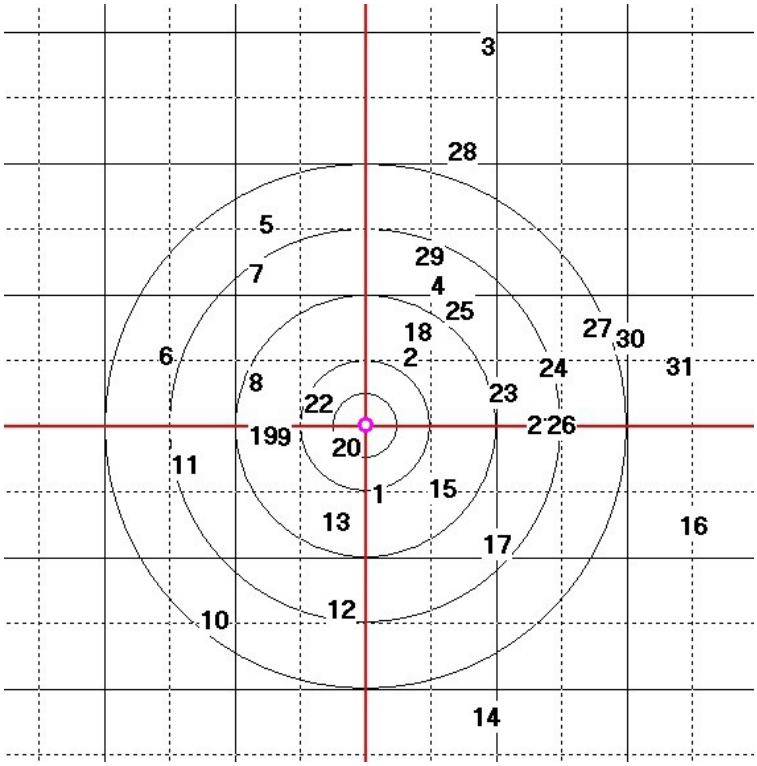
NQRA10

31 SHOTS at 880 Yards
X SPAN 942.80 mm
Y SPAN 1194.00 mm
CENTRE FITTED REPORT
X CENTRE SHIFT -1.78 mm
Y CENTRE SHIFT -8.96 mm
Shown Further from Centre 4
Shown Closer to Centre 27

308 WIN MV 2900 f/s 155 grain projectiles
Estimated Velocity at target 1460 f/s
Air Temperature 33 deg C . Humidity 62 %
Test Sheet Stability < 1 mm movement over 800 mm.

RAW MEASUREMENTS

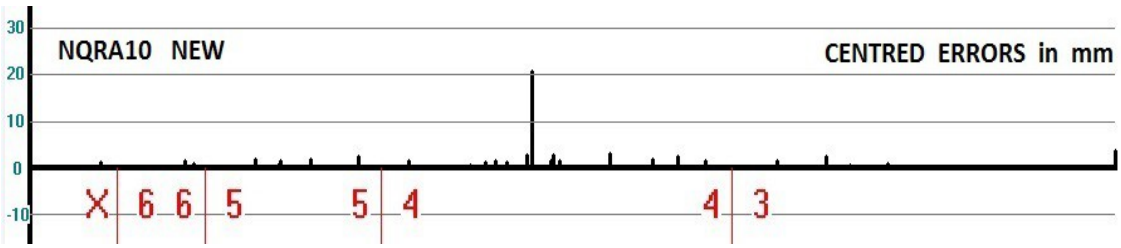
No	Impact X	Impact Y	Monitor X	Monitor Y
1	17.66	-116.73	20.2	-107.2
2	74.63	127.7	76.1	136.4
3	214	681	216.1	693.7
4	125.35	255.37	126.5	264.4
5	-182.5	364.55	-178.9	373
6	-362.8	129.2	-357.9	138.2
7	-201.96	276.68	-197.5	284.8
8	-201.12	82.05	-196.8	91.5
9	-152.46	-14.37	-148.7	-5.1
10	-277.73	-341.14	-273.5	-331.9
11	-328.64	-63.44	-324.1	-54.2
12	-49.85	-323.39	-47.1	-313.5
13	-59.22	-166.14	-55.9	-156.4
14	210.41	-513	212.4	-503.2
15	131.82	-107.53	132.9	-97.6
16	580	-174	581.7	-165.2
17	229.36	-205.99	230.6	-195.8
18	86.19	172.48	88.2	181.4
19	-189.37	-13.22	-185.6	-4.1
20	-41.81	-34.37	-38.8	-24.6
21	308.08	6.91	308.1	16
22	-90.44	45.29	-87.2	54.8
23	240	62.02	240.4	71.7
24	330.64	109.19	330.9	117.8
25	161.37	208.98	163.3	218.3
26	345.07	6.16	345.1	15.6
27	407.19	179.68	407.3	188.1
28	167.59	493.5	168.8	505.1
29	107.09	307.77	94.7	301.7
30	466.46	159.08	466.7	168.4
31	557.5	110.5	559.8	120.4



SHOT POSITIONS
Grid in minutes and half minutes (880 yards)

CENTRED ERRORS

No	X	Y	Rad	Lin
1	0.8	0.6	-0.8	1.0
2	-0.3	-0.3	-0.2	0.4
3	0.3	3.7	3.7	3.8
4	-0.6	0.1	-0.1	0.6
5	1.8	-0.5	-1.6	1.9
6	3.1	0.0	-3.1	3.1
7	2.7	-0.8	-2.6	2.8
8	2.5	0.5	-2.5	2.6
9	2.0	0.3	-2.0	2.0
10	2.5	0.3	-1.9	2.5
11	2.8	0.3	-2.7	2.8
12	1.0	0.9	-1.2	1.3
13	1.5	0.8	-1.5	1.7
14	0.2	0.8	-0.8	0.9
15	-0.7	1.0	-1.1	1.2
16	-0.1	-0.2	0.0	0.2
17	-0.5	1.2	-1.3	1.4
18	0.2	0.0	0.0	0.2
19	2.0	0.2	-2.0	2.0
20	1.2	0.8	-1.5	1.5
21	-1.8	0.1	-1.8	1.8
22	1.5	0.6	-1.5	1.6
23	-1.4	0.7	-1.4	1.6
24	-1.5	-0.4	-1.6	1.6
25	0.2	0.4	0.4	0.4
26	-1.8	0.5	-1.8	1.8
27	-1.7	-0.5	-1.8	1.8
28	-0.6	2.6	2.5	2.7
29	-14.2	-15.0	-15.9	20.7
30	-1.5	0.4	-1.4	1.6
31	0.5	0.9	0.6	1.1



X, 6, 5, 4, 3 indicate Score or how far shot is from the centre.

BARS ARE REAL ERROR SIZE

ACOUSTIC CENTRE SHIFT

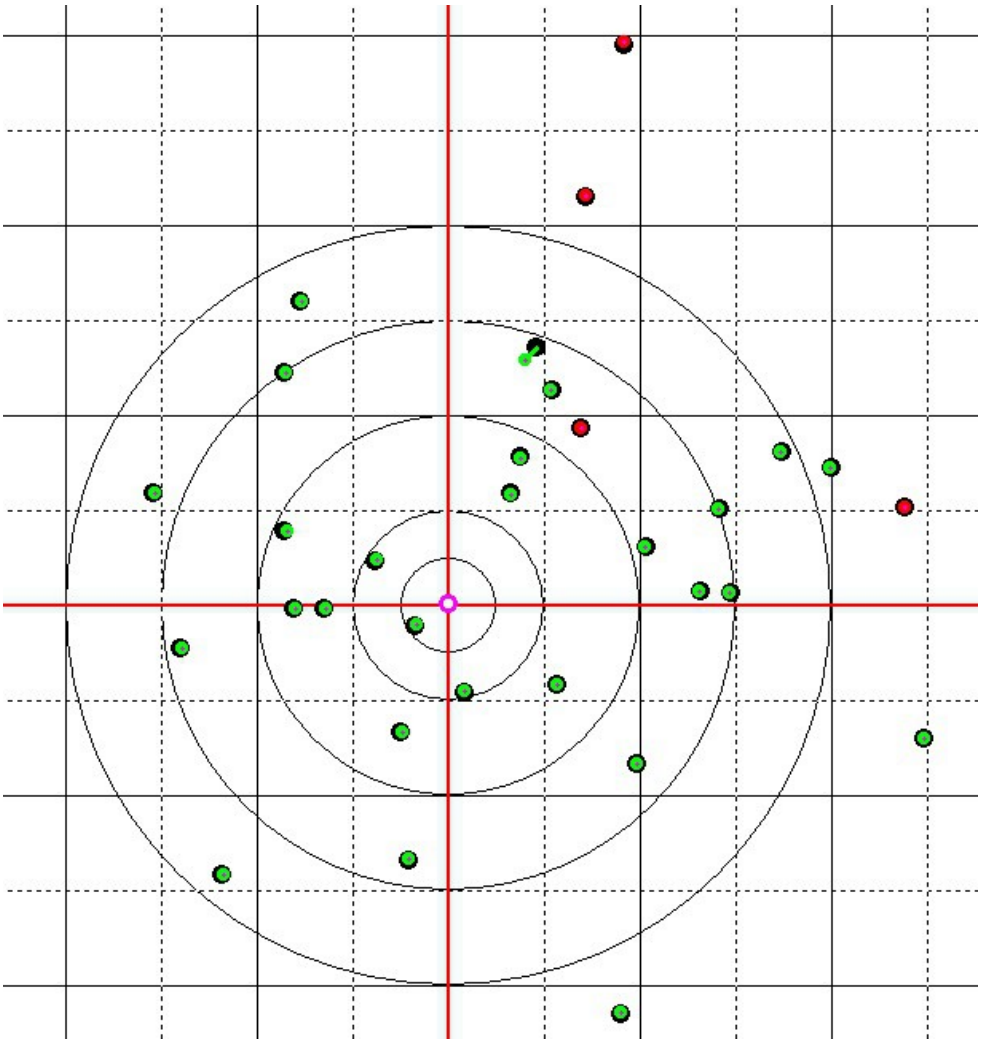
Depends on how accurately Aiming Marks are fixed to target.

X - 1.78 mm Y - 8.96 mm

Target Errors have been broken into an X (Horizontal) and Y (Vertical) component. Shooters instinctively think this way, we have measured the target this way, and it is a very convenient way to simplify calculations.

	AVERAGE mm (880 Yards)	**SD (880 Yards)**
X component	Zero (because group is centred)	2.97 mm 0.013 minute
Y component	Zero (because group is centred)	2.88 mm 0.013minute
Actual Direct (Lin)	2.26 mm [1] 0.009 minute	3.46 mm [2] 0.015 minute

SD values may be used to predict the probability of future errors which is left to another document.
NOTE however, that maximum predicted errors in a number of shots is a multiple of the SD value.



RED is expansion, GREEN contraction of reported shot positions.

AVERAGE RADIAL SHIFT is 1.5 mm INWARDS

Errors are usually too small to show with a very good target on a map of this type. See previous Graphic.

1 Being a direct distance , this error is always positive. The SD if often greater than the Average. See Footnote 2.
2 When it is impossible for an error distribution close to zero to spill into the negative region, the distribution is not a Normal Distribution. This is usually the case with Actual Direct Errors which are always positive. It now becomes a FOLDED NORMAL DISTRIBUTION. Calculation and use of SD now becomes complex. Many have wrongly applied the rules for a Normal Distribution to this case. Often the results only differ slightly but it really should be avoided. Applying this to make predictions is complex and best avoided.

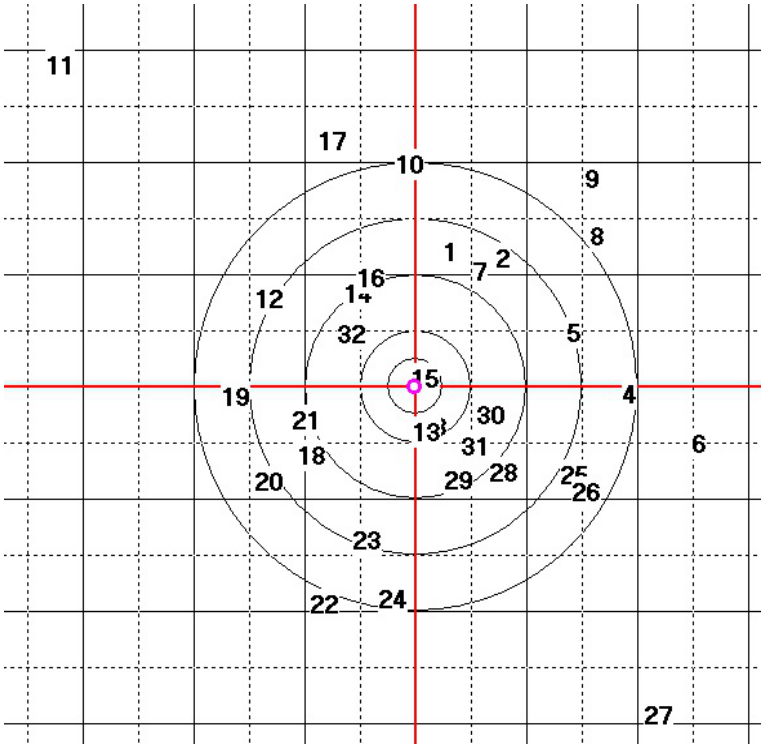
NQRA11

32 SHOTS at 880 Yards
X SPAN 1348.50 mm
Y SPAN 1357.00 mm
CENTRE FITTED REPORT
X CENTRE SHIFT 1.00 mm
Y CENTRE SHIFT -13.52 mm
Shown Further from Centre 7
Shown Closer to Centre 25

308 WIN MV 2940 f/s 155 grain projectiles
Estimated Velocity at target 1480 f/s
Air Temperature 34 deg C . Humidity 60 %
Test Sheet Stability < 1 mm movement over 800 mm.

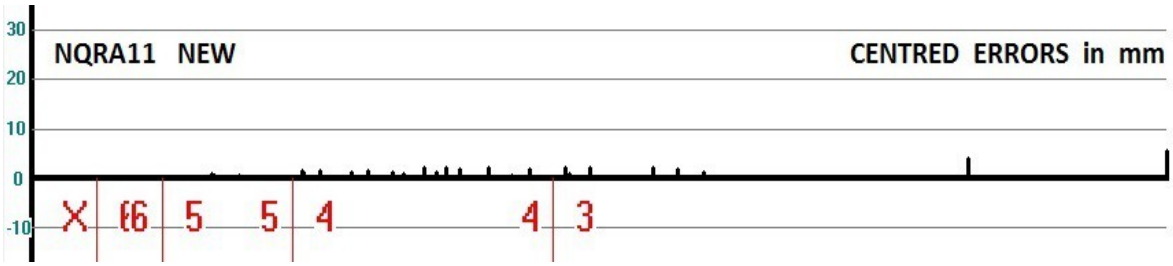
RAW MEASUREMENTS

No	Impact X	Impact Y	Monitor X	Monitor Y
1	69.43	280.7	67.8	292.7
2	182.23	267.39	180.8	279.8
3	48.8	-82.96	47.6	-69.7
4	448.18	-13.98	445.2	-0.9
5	330.74	112.39	327.7	124.9
6	595.5	-119	594.9	-106.9
7	133.7	240.93	132.5	253
8	381.22	313.92	378.6	325.8
9	369.57	434.07	367	446.3
10	-17.68	465.08	-16.9	477.3
11	-753	672	-755.3	691
12	-314.69	183.34	-313.5	197.2
13	19.13	-93.37	18.4	-79.9
14	-125.78	194.74	-125.5	208.5
15	16.41	16.82	15.7	30.7
16	-98.03	226.43	-97.9	239.4
17	-180.11	514.5	-178.9	528.8
18	-224.38	-142.33	-224.1	-127.8
19	-383.94	-19.39	-383.4	-4.7
20	-312.45	-197.61	-312.5	-183.2
21	-235.01	-69.4	-234.4	-55
22	-197.49	-454.09	-198.1	-439.7
23	-106.45	-319.58	-106.5	-305.2
24	-51.51	-441.69	-53	-427.5
25	331.76	-183.7	328.6	-169.5
26	357.14	-218.22	353.8	-204.3
27	508	-685	508.5	-675.4
28	182.43	-177.4	180.5	-163.2
29	86.71	-193.77	85.2	-180
30	155.94	-58.78	153.8	-45.3
31	123.42	-123.3	121.6	-109.6
32	-139.24	109.12	-139.6	122.9



SHOT POSITIONS

Grid in minutes and half minutes (880 yards)



CENTRED ERRORS

No	X	Y	Rad	Lin
1	-0.6	-1.5	-1.6	1.7
2	-0.4	-1.1	-1.2	1.2
3	-0.2	-0.3	0.2	0.3
4	-2.0	-0.4	-2.0	2.0
5	-2.0	-1.0	-2.3	2.3
6	0.4	-1.4	0.7	1.5
7	-0.2	-1.5	-1.4	1.5
8	-1.6	-1.6	-2.3	2.3
9	-1.6	-1.3	-2.0	2.0
10	1.8	-1.3	-1.5	2.2
11	-1.3	5.5	4.5	5.6
12	2.2	0.3	-1.8	2.2
13	0.3	-0.1	0.0	0.3
14	1.3	0.2	-0.7	1.3
15	0.3	0.4	-0.2	0.5
16	1.1	-0.6	-1.1	1.3
17	2.2	0.8	-0.2	2.3
18	1.3	1.0	-1.6	1.6
19	1.5	1.2	-1.6	1.9
20	1.0	0.9	-1.3	1.3
21	1.6	0.9	-1.8	1.8
22	0.4	0.9	-1.0	1.0
23	1.0	0.9	-1.2	1.3
24	-0.5	0.7	-0.6	0.8
25	-2.2	0.7	-2.2	2.3
26	-2.3	0.4	-2.1	2.4
27	1.5	-3.9	4.1	4.2
28	-0.9	0.7	-1.1	1.2
29	-0.5	0.3	-0.4	0.6
30	-1.1	0.0	-1.0	1.1
31	-0.8	0.2	-0.6	0.8
32	0.6	0.3	-0.4	0.7

X, 6, 5, 4, 3 indicate Score or how far shot is from the centre.

BARS ARE REAL ERROR SIZE

ACOUSTIC CENTRE SHIFT

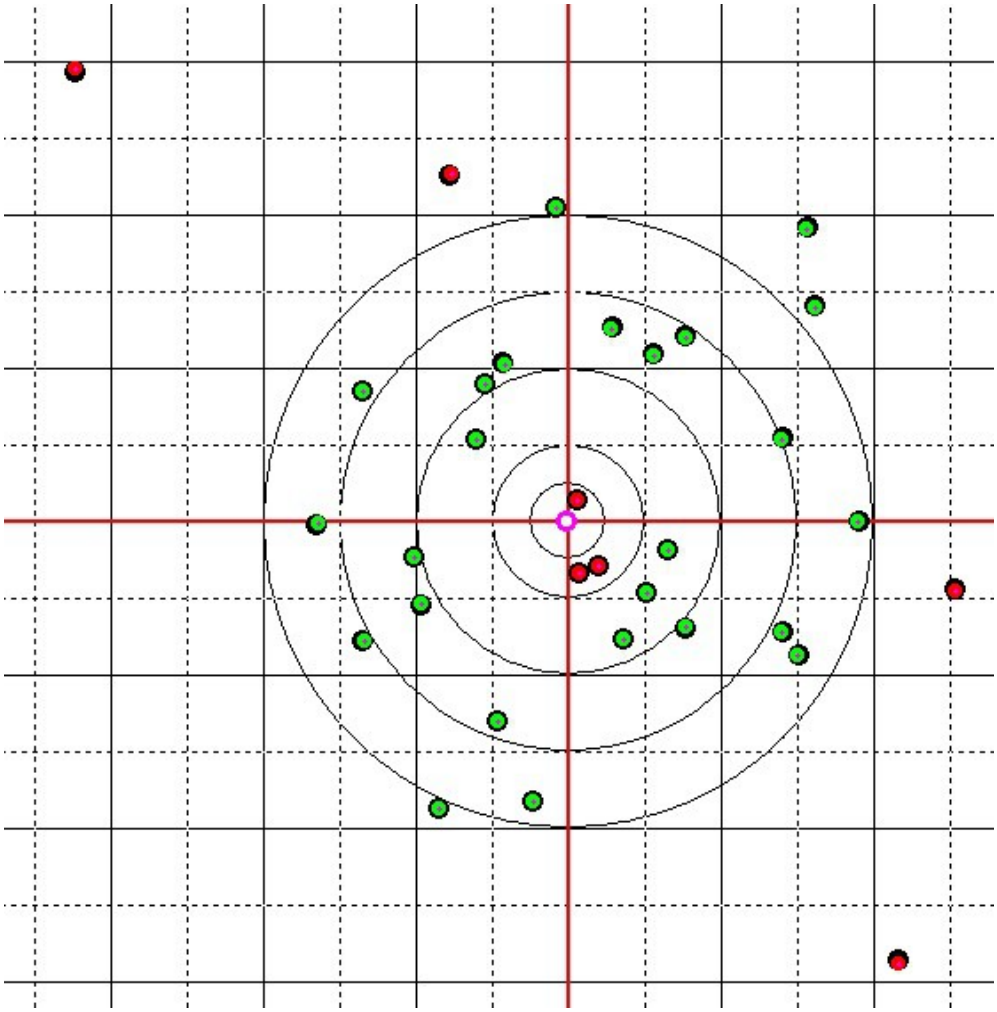
Depends on how accurately Aiming Marks are fixed to target.

X 1.0 mm Y - 13.52 mm

Target Errors have been broken into an X (Horizontal) and Y (Vertical) component. Shooters instinctively think this way, we have measured the target this way, and it is a very convenient way to simplify calculations.

	AVERAGE mm (880 Yards)	**SD (880 Yards)**
X component	Zero (because group is centred)	1.33 mm 0.006 minute
Y component	Zero (because group is centred)	1.47 mm 0.006 minute
Actual Direct (Lin)	1.67 mm [1] 0.006 minute	1.06 mm [2] 0.005 minute

SD values may be used to predict the probability of future errors which is left to another document.
NOTE however, that maximum predicted errors in a number of shots is a multiple of the SD value.



RED is expansion, GREEN contraction of reported shot positions.

AVERAGE RADIAL SHIFT is 0.79 mm INWARDS

Errors are usually too small to show with a very good target on a map of this type. See previous Graphic.

1 Being a direct distance , this error is always positive. The SD if often greater than the Average. See Footnote 2.
2 When it is impossible for an error distribution close to zero to spill into the negative region, the distribution is not a Normal Distribution. This is usually the case with Actual Direct Errors which are always positive. It now becomes a FOLDED NORMAL DISTRIBUTION. Calculation and use of SD now becomes complex. Many have wrongly applied the rules for a Normal Distribution to this case. Often the results only differ slightly but it really should be avoided. Applying this to make predictions is complex and best avoided.

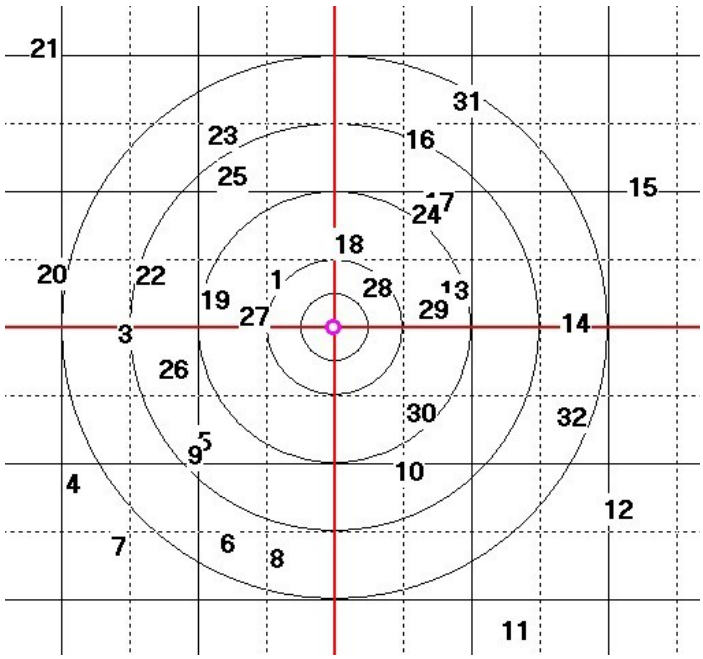
TMRC1

32 SHOTS at 880 Yards
X SPAN 1022.20 mm
Y SPAN 1002.60 mm
CENTRE FITTED REPORT
X CENTRE SHIFT -2.73 mm
Y CENTRE SHIFT -15.12 mm
Shown Further from Centre 19
Shown Closer to Centre 13

308 WIN MV 2960 f/s 155 grain projectiles
Estimated Velocity at target 1500 f/s
Air Temperature 32.5 deg C . Humidity 65 %
Test Sheet Stability < 1 mm movement over 800 mm.

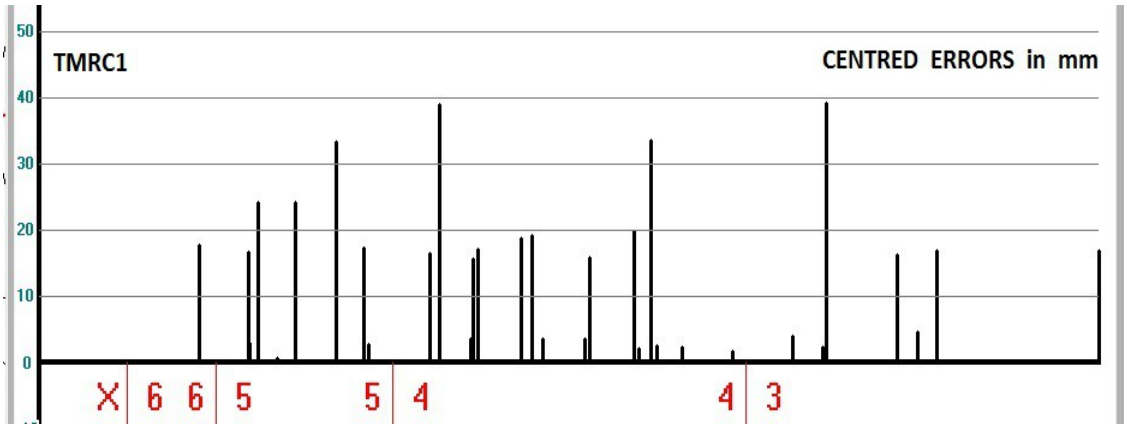
RAW MEASUREMENTS

No	Impact X	Impact Y	Monitor X	Monitor Y
1	-103.2	80.5	-111.2	108.4
2	-138.8	15.8	-133.3	31.9
3	-363.5	-13.4	-357.4	3.0
4	-454.2	-270.7	-449.8	-253.8
5	-227.9	-198.4	-237.2	-195.5
6	-188.0	-375.3	-208.4	-384.6
7	-376.2	-378.5	-400.9	-391.3
8	-104.4	-399.0	-100.8	-381.8
9	-244.8	-222.6	-255.3	-220.8
10	119.7	-250.0	149.8	-262.4
11	303.8	-524.5	318.2	-521.6
12	479.4	-315.5	494.0	-311.5
13	198.6	61.8	212.6	90.0
14	406.4	5.3	406.9	21.7
15	521.0	238.6	523.6	249.1
16	138.8	321.2	152.0	348.3
17	172.9	213.1	186.4	239.5
18	18.4	141.1	21.5	155.6
19	-212.2	45.6	-207.0	61.8
20	-490.2	89.3	-483.8	105.9
21	-501.2	478.1	-508.6	506.9
22	-320.9	85.7	-314.6	101.8
23	-197.2	327.4	-206.8	357.9
24	151.7	192.7	166.0	219.5
25	-180.9	258.1	-190.5	288.1
26	-282.5	-74.0	-276.3	-57.4
27	-143.8	16.6	-157.1	49.8
28	66.9	64.9	81.7	93.0
29	161.5	28.2	180.5	61.2
30	141.2	-149.3	141.0	-167.4
31	221.1	386.3	222.3	400.5
32	399.6	-156.2	400.7	-139.2



SHOT POSITIONS

Grid in minutes and half minutes (880 yards)



X, 6, 5, 4, 3 indicate Score or how far shot is from the centre.

BARS ARE REAL ERROR SIZE

CENTRED ERRORS

No	X	Y	Rad	Lin
1	-10.7	12.8	16.7	16.7
2	2.7	1.0	-2.4	2.9
3	3.4	1.3	-3.4	3.7
4	1.7	1.8	-2.4	2.5
5	-12.1	-12.3	17.2	17.2
6	-23.1	-24.4	31.7	33.6
7	-27.4	-28.0	39.1	39.2
8	0.9	2.1	-2.2	2.2
9	-13.2	-13.3	18.7	18.7
10	27.4	-27.6	38.0	38.9
11	11.7	-12.2	16.6	16.9
12	11.9	-11.1	15.9	16.2
13	11.3	13.1	14.8	17.3
14	-2.2	1.3	-2.2	2.6
15	-0.1	-4.6	-2.0	4.6
16	10.5	12.0	15.5	16.0
17	10.8	11.3	15.6	15.6
18	0.4	-0.6	-0.5	0.7
19	2.5	1.1	-2.1	2.7
20	3.7	1.5	-3.3	4.0
21	-10.1	13.7	16.9	17.0
22	3.6	1.0	-3.1	3.7
23	-12.4	15.4	19.3	19.8
24	11.5	11.7	16.4	16.4
25	-12.3	14.9	19.0	19.3
26	3.5	1.4	-3.7	3.7
27	-16.0	18.1	20.3	24.1
28	12.1	13.0	17.5	17.8
29	16.3	17.9	19.8	24.2
30	-2.9	-33.2	20.2	33.3
31	-1.5	-1.0	-1.6	1.8
32	-1.6	1.9	-2.2	2.5

ACOUSTIC CENTRE SHIFT

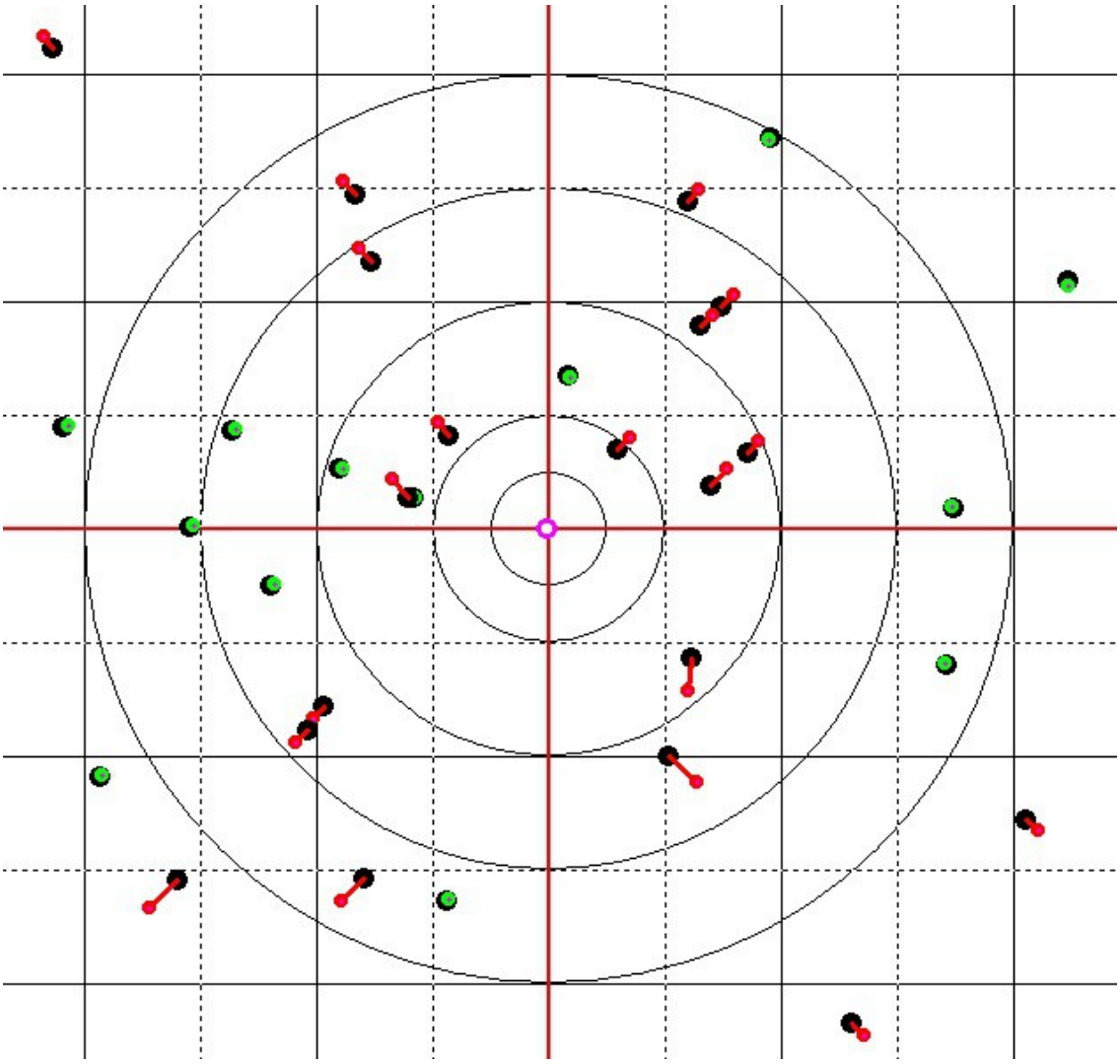
Depends on how accurately Aiming Marks are fixed to target.

X - 2.73 mm Y - 15.12 mm

Target Errors have been broken into an X (Horizontal) and Y (Vertical) component. Shooters instinctively think this way, we have measured the target this way, and it is a very convenient way to simplify calculations.

	AVERAGE mm (880 Yards)	SD (880 Yards)
X component	Zero (because group is centred)	11.72 mm 0.05 minute
Y component	Zero (because group is centred)	13.79 mm 0.06 minute
Actual Direct (Lin)	14.23 mm [1] 0.06 minute	10.47 mm [2] 0.05 minute

SD values may be used to predict the probability of future errors which is left to another document. NOTE however, that maximum predicted errors in a number of shots is a multiple of the SD value.



RED is expansion, GREEN contraction of reported shot positions.

AVERAGE RADIAL SHIFT is 11.2 mm OUTWARDS

Errors are usually too small to show with a very good target on a map of this type. See previous Graphic.

1 Being a direct distance , this error is always positive. The SD if often greater than the Average. See Footnote 2.

2 When it is impossible for an error distribution close to zero to spill into the negative region, the distribution is not a Normal Distribution. This is usually the case with Actual Direct Errors which are always positive. It now becomes a FOLDED NORMAL DISTRIBUTION. Calculation and use of SD now becomes complex. Many have wrongly applied the rules for a Normal Distribution to this case. Often the results only differ slightly but it really should be avoided. Applying this to make predictions is complex and best avoided.