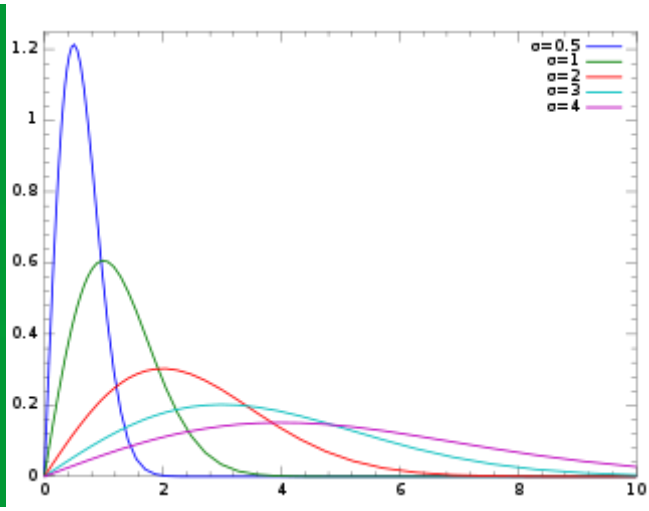


RECURVE ARCHERY

Training and Tournament
Two sides of the same medal

Part 2
WA-1440
Probability for Hits and Misses – Men

F. Wegrostek, co B. Kolmanz

April 2019

Miss and Hit Probability in Training and Tournament

Misses (= missed scoring area) in training are often viewed even by experienced shooters as a mishap, as a stupid mistake away from the actual skills, at least as something that may not occur in full concentration in a competition.

Well, there are real mishaps, such as a slipped down arrow rest, the shot on the neighboring target. They do not really have anything to do with the actual skill of the archer. Such things happen like elementary events and are incalculable. They are therefore excluded from the performance consideration and definition of miss subsequently.

In the following, misses mean, when arrows miss the scoring area in the "normal" shooting course during archery. They are so to speak, loners and the arrows usually end far away from the main arrow group. Thus, there is a comprehensible tendency with the archer to settle them away from their own shooting ability and ultimately to exclude those misses from consideration of their own shooting performance.

This approach to judge misses not as a part of actual shooting performance and to think that misses can be avoided in a competition, would certainly be wrong. Because misses represent the lower score end of the personal performance spectrum and belongs therefore to the personal performance level as every hit on the disc do.

Misses are not an issue for the 1300-scoring archer in a WA 1440 round. There are (almost) no misses with him. But an **1100 scoring archer** (WA 1440 Round, Men) will have to expect on an average about **1-2 misses** on the 50m shooting distance and 80z target. More precisely, he has a 4% chance of missing the target (5-10) at 50m. This necessarily results from the size of his error variance strongly associated with the given skill level. And the arrow variation of an 1100 scoring archer exceeds just a little bit the end of the 80z target face at the 50m range.

Misses cannot be influenced or avoided per se. They are the result of individual error variation. They can only be reduced when the archer increases his skill level himself. The number of misses is thus an important (negative) indicator for the performance level of an archer. That is also why, as an archer and trainer, one should observe the misses and by no means exclude it.

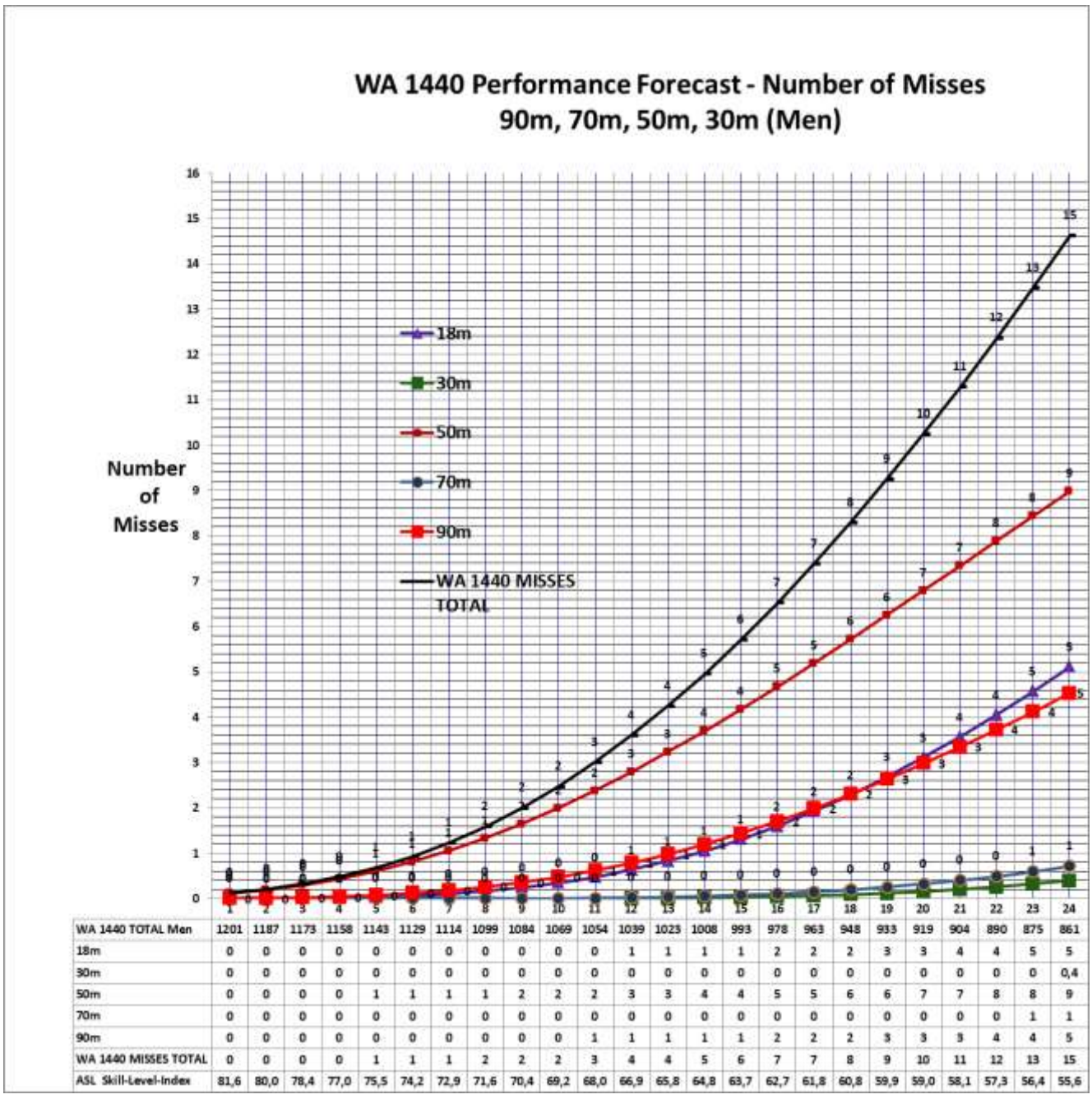
The tables below show the probabilities and the number of misses and hits for the rings separated by individual skill levels. The mathematical-statistical background is briefly explained on page 6.

The tables are intended for performance orientation for archers and coaches. In particular, the frequency of gold hits is already a reasonable measure to determine your own shooting level and to estimate the performance for a WA 1440 round. The procedure is very simple and will be explained by examples.

Misses in the WA 1440-Round
Men

The following graph and table shows the number of misses for the various WA 1440 shooting distances and the WA 1440 total at different skill levels.

- *Number of arrows: 90,70,50,30m: 36 arrows; 18m: 60 arrows*
- *Target face: 90m, 70m: 122cm; 50m, 30m: 80z;18m,10m: 40cm [10-6]*
- *All values are rounded to one's digit!*



WA 1440 TOTAL Men	1201	1187	1173	1158	1143	1129	1114	1099	1084	1069	1054	1039	1023	1008	993	978	963	948	933	919	904	890	875	861
18m	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	3	3	4	4	5	5
30m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,4
50m	0	0	0	0	1	1	1	1	2	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9
70m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
90m	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	3	3	3	4	4	5
WA 1440 MISSES TOTAL	0	0	0	0	1	1	1	2	2	2	3	4	4	5	6	7	7	8	9	10	11	12	13	15
ASL Skill-Level-Index	81,6	80,0	78,4	77,0	75,5	74,2	72,9	71,6	70,4	69,2	68,0	66,9	65,8	64,8	63,7	62,7	61,8	60,8	59,9	59,0	58,1	57,3	56,4	55,6

Comments

Misses occur in the Men Class at a shooting performance below 1200 in a WA 1440 Round, primarily on the 80z target of the 50m range. This is followed by misses at 90m (and 18m Indoor). Misses at the 70m and 30m shooting distance occur below a WA 1440 total score of 875 points.

Number of Misses in a WA 1440 Round (and 18m Indoor)

Number of Misses - Men								
WA 1440 TOTAL	10m	18m	30m	50m	70m	90m	WA 1440 MISSES TOTAL	ASL Skill-Index
1427	0	0	0	0	0	0	0	133,1
1417	0	0	0	0	0	0	0	127,1
1406	0	0	0	0	0	0	0	121,9
1394	0	0	0	0	0	0	0	117,3
1381	0	0	0	0	0	0	0	113,2
1368	0	0	0	0	0	0	0	109,6
1355	0	0	0	0	0	0	0	106,2
1341	0	0	0	0	0	0	0	103,2
1327	0	0	0	0	0	0	0	100,4
1313	0	0	0	0	0	0	0	97,7
1299	0	0	0	0	0	0	0	95,3
1286	0	0	0	0	0	0	0	93,0
1272	0	0	0	0	0	0	0	90,8
1258	0	0	0	0	0	0	0	88,8
1244	0	0	0	0	0	0	0	86,8
1230	0	0	0	0	0	0	0	85,0
1215	0	0	0	0	0	0	0	83,2
1201	0	0	0	0	0	0	0	81,6
1187	0	0	0	0	0	0	0	80,0
1173	0	0	0	0	0	0	0	78,4
1158	0	0	0	0	0	0	0	77,0
1143	0	0	0	1	0	0	1	75,5
1129	0	0	0	1	0	0	1	74,2
1114	0	0	0	1	0	0	1	72,9
1099	0	0	0	1	0	0	2	71,6
1084	0	0	0	2	0	0	2	70,4
1069	0	0	0	2	0	0	2	69,2
1054	0	0	0	2	0	1	3	68,0
1039	0	1	0	3	0	1	4	66,9
1023	0	1	0	3	0	1	4	65,8
1008	0	1	0	4	0	1	5	64,8
993	0	1	0	4	0	1	6	63,7
978	0	2	0	5	0	2	7	62,7
963	0	2	0	5	0	2	7	61,8
948	0	2	0	6	0	2	8	60,8
933	0	3	0	6	0	3	9	59,9
919	0	3	0	7	0	3	10	59,0
904	0	4	0	7	0	3	11	58,1
890	0	4	0	8	0	4	12	57,3
875	0	5	0	8	1	4	13	56,4
861	0	5	0,4	9	1	5	15	55,6

Appearances of Miss from 1 onwards are highlighted in orange!

The number of misses gives already a rough first indications about the skill level of an archer: 1 miss on 50m distance corresponds with a score of 1100 in a WA 1440 round, 4 misses on 50m distance indicates a total WA 1440 score of around 1000, etc.

Cut here

Hit Probability in the WA 1440 Round - Men

The hit probability (= frequency of hits in%) can be calculated for each hit ring at each shooting distance in a WA 1440 round, dependent on various archer's skill level.

The tables below show the probabilities (in percentage) and the number of hits for each of the 10 rings.

- *Shown are 4 score levels of the WA 1440 Round: 1000, 1100, 1200, and 1300.*
- *Target faces are framed.*
- *Hit values from 1% (rounded) respectively 1 hit (rounded) onward are highlighted in color.*
- *The difference to 100% or 36 arrows at the score levels 1000 and 1100 at the 90m distance are due to misses outside the target.*

Reading examples:

- An archer with a skill level of 1000 in a WA 1440 round can expect about 9% hits in the gold tens (see first top table); that's 13 gold tens out of 144 arrows (table below). Approximately 20% (28 arrows) are gold-nine. Overall, this shooting-level is expected to be about 29% gold hits (or 41 gold shots out from 144 arrows).

  The number of gold hits should be given special attention! It is easy to keep them in mind during practice and then well-suited to use it for a rough prognosis of the WA-1440 results via the tables!

- At the 90m distance, the 1000-score archer is about 96% on the target face. About 4%, i.e. (at least) 1 arrow of 36, are outside of the target face.

- At the 50m distance, the arrows of the 1000 score archer spreads over the 5-ring, i.e. beyond the target face and they are therefore misses:
  4-ring: 6%
  3-ring: 3%
  2 ring: 1%
  1 ring: 0% (more precisely: below 0.5%)
  Total Miss: around 10%

  Thus it results in the stately number of about 10% Misses, i.e. 3 - 4 arrows out of 36 arrows.
  The lower table shows the 3 arrows as Miss (4-ring: 2, 3-ring 1).
  The "incorrectness" is due to the individual rounding!

Hit Probability and Number of Hits in the WA 1440 Round at various Score Levels

1000 Score-Level

Hit Probability							WA 1440 TOTAL	ASL (Skill)
Ring	10m	18m	30m	50m	70m	90m	1.000	64,2
10s	48%	17%	20%	7%	6%	3%	9%	Gold
9s	42%	32%	37%	16%	16%	9%	20%	29%
8s	9%	28%	28%	21%	21%	13%	21%	
7s	1%	15%	12%	20%	20%	15%	17%	
6s	0%	6%	3%	16%	16%	15%	12%	
5s	0%	2%	1%	10%	10%	13%	9%	
4s	0%	0%	0%	6%	6%	11%	6%	
3s	0%	0%	0%	3%	3%	8%	3%	
2s	0%	0%	0%	1%	1%	5%	2%	
1s	0%	0%	0%	0%	0%	3%	1%	
	100%	100%	100%	100%	100%	96%	99%	

Numbs of Hits							WA 1440 TOTAL	ASL (Skill)
Ring	10m	18m	30m	50m	70m	90m	1.000	64,2
10s	17	10	7	2	2	1	13	Gold
9s	15	19	13	6	6	3	28	41
8s	3	17	10	7	8	5	30	
7s	0	9	4	7	7	6	24	
6s	0	4	1	6	6	5	18	
5s	0	1	0	4	4	5	12	
4s	0	0	0	2	2	4	8	
3s	0	0	0	1	1	3	5	
2s	0	0	0	0	0	2	3	
1s	0	0	0	0	0	1	1	
	36	60	36	36	36	35	143	

1100 Score-Level

Hit Probability							WA 1440 TOTAL	ASL (Skill)
Ring	10m	18m	30m	50m	70m	90m	1.100	71,6
10s	63%	25%	28%	10%	10%	5%	13%	Gold
9s	34%	39%	43%	22%	22%	13%	25%	38%
8s	3%	25%	22%	25%	26%	18%	23%	
7s	0%	9%	6%	20%	20%	19%	16%	
6s	0%	2%	1%	13%	13%	16%	11%	
5s	0%	0%	0%	6%	6%	12%	6%	
4s	0%	0%	0%	3%	2%	8%	3%	
3s	0%	0%	0%	1%	1%	5%	2%	
2s	0%	0%	0%	0%	0%	2%	1%	
1s	0%	0%	0%	0%	0%	1%	0%	
	100%	100%	100%	100%	100%	99%	100%	

Numbs of Hits							WA 1440 TOTAL	ASL (Skill)
Ring	10m	18m	30m	50m	70m	90m	1.100	71,6
10s	23	15	10	3	3	2	19	Gold
9s	12	23	15	8	8	5	36	55
8s	1	15	8	9	9	6	33	
7s	0	5	2	7	7	7	23	
6s	0	1	0	5	5	6	15	
5s	0	0	0	2	2	4	9	
4s	0	0	0	1	1	3	5	
3s	0	0	0	0	0	2	2	
2s	0	0	0	0	0	1	1	
1s	0	0	0	0	0	0	0	
	36	60	36	36	36	36	144	

1200 Score-Level

Hit Probability							WA 1440 TOTAL	ASL (Skill)
Ring	10m	18m	30m	50m	70m	90m	1.200	81,6
10s	81%	38%	43%	16%	16%	9%	21%	Gold
9s	19%	44%	45%	32%	32%	21%	32%	53%
8s	0%	16%	11%	28%	29%	24%	23%	
7s	0%	2%	1%	16%	16%	21%	13%	
6s	0%	0%	0%	6%	6%	14%	6%	
5s	0%	0%	0%	2%	2%	7%	3%	
4s	0%	0%	0%	0%	0%	3%	1%	
3s	0%	0%	0%	0%	0%	1%	0%	
2s	0%	0%	0%	0%	0%	0%	0%	
1s	0%	0%	0%	0%	0%	0%	0%	
	100%	100%	100%	100%	100%	100%	100%	

Numbs of Hits							WA 1440 TOTAL	ASL (Skill)
Ring	10m	18m	30m	50m	70m	90m	1.200	81,6
10s	29	23	15	6	6	3	30	Gold
9s	7	26	16	11	12	7	47	76
8s	0	9	4	10	10	9	33	
7s	0	1	0	6	6	7	19	
6s	0	0	0	2	2	5	9	
5s	0	0	0	1	1	3	4	
4s	0	0	0	0	0	1	1	
3s	0	0	0	0	0	0	0	
2s	0	0	0	0	0	0	0	
1s	0	0	0	0	0	0	0	
	36	60	36	36	36	36	144	

1300 Score-Level

Hit Probability							WA 1440 TOTAL	ASL (Skill)
Ring	10m	18m	30m	50m	70m	90m	1.300	95,3
10s	97%	64%	69%	30%	30%	17%	37%	Gold
9s	3%	34%	30%	44%	45%	35%	38%	75%
8s	0%	3%	1%	21%	20%	28%	18%	
7s	0%	0%	0%	4%	4%	14%	6%	
6s	0%	0%	0%	0%	0%	5%	1%	
5s	0%	0%	0%	0%	0%	1%	0%	
4s	0%	0%	0%	0%	0%	0%	0%	
3s	0%	0%	0%	0%	0%	0%	0%	
2s	0%	0%	0%	0%	0%	0%	0%	
1s	0%	0%	0%	0%	0%	0%	0%	
	100%	100%	100%	100%	100%	100%	100%	

Numbs of Hits							WA 1440 TOTAL	ASL (Skill)
Ring	10m	18m	30m	50m	70m	90m	1.300	95,3
10s	35	38	25	11	11	6	53	Gold
9s	1	20	11	16	16	12	55	108
8s	0	2	0	7	7	10	25	
7s	0	0	0	2	2	5	8	
6s	0	0	0	0	0	2	2	
5s	0	0	0	0	0	0	0	
4s	0	0	0	0	0	0	0	
3s	0	0	0	0	0	0	0	
2s	0	0	0	0	0	0	0	
1s	0	0	0	0	0	0	0	
	36	60	36	36	36	36	144	

All values are rounded to onces digit!.

Cut here

The distribution of hits

The distribution of the hits on the 10s ring target face (and on 0) have left-asymmetric frequency profiles (Rayleigh distribution). The hits are more frequent around the center than towards the end of the target face. This picture is common with all archers whereby the width of the distribution depends on the individual skill of the archer. The arrows scatter in vertical and horizontal direction as a mathematically described “normal distribution”.
With regard to the origin of the data, reference is made to the description below.

Data Background:

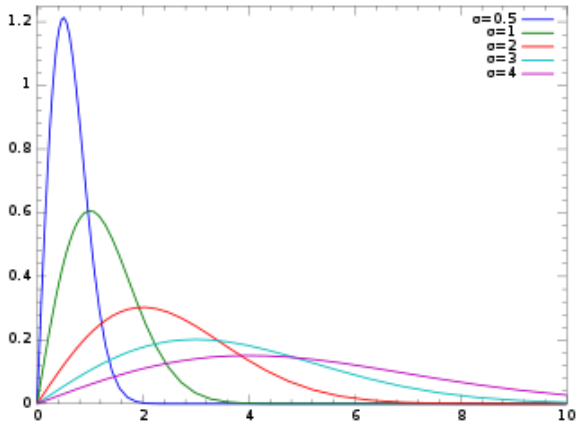
The scores in the graphic and in the table stem from a complex computer application. The algorithmic approach for the forecasting model is based on Rayleigh's probability distribution (see graph below, https://en.wikipedia.org/wiki/Rayleigh distribution). The performance forecast (prognosis) for various shooting distances is done via sigma following the intercept theorem. According to J. L. Park studies the standard deviation is divided into a linear and quadratic error proportion based on the shooting distance (James L. Park, Modeling Archer's scores at different shooting distances to quantify score loss due to equipment selection and technique, Formula 7, Journal of Sports Engineering and Technology).

The Skill Level Index was also calculated according to James L. Park (James L. Parks, James E. Larven, Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology, Vol. 228, 2: pp. 86-94., First Published January 28, 2014; Source: ArtemisLite).

Also included for the different shooting distances are the different target faces/sizes and the WA rule for touched rings, and a 0.5 cm arrow shaft diameter.

Rayleigh probability density function as a function of σ

Different standard deviations result in different probability distributions. They represent different skill levels of the archers. The narrower the curve of the distribution is the higher is the skill level.



Graph: StefanPohl [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], from Wikimedia Commons

How can the Tables be used by Archers and Coaches to Estimate the Performance in a WA 1440 Round

When using these tables, keep in mind that the table values are applied to a (limited) training sample that is unlikely to accurately reflect the skill level of the archer (see confidence interval). But they do allow an approximate performance estimate.

1.) By observing the misses

Number of misses outlines already the performance level of an archer.
For example, an archer having steadily 2-3 misses on the 50m-distance can barely reach 1100 rings in the WA 1440. His error variance is still too big for that.

2.) By observing the gold hits

It is highly recommended to count and observe respectively the number and percentage of the gold hits for a first orientation on own performance! It is simple and well practicable. That is especially recommended for archers who shy away from written records for convenience or other reasons.

Examples:

An archer would like to achieve a score of 1200 in a WA 1440 round. He practices usually at 50m or 70m distance. From the corresponding table he reads for these distances 48% gold hits (16% 10-rings + 32% 9-rings). He knows that he should hit the gold with almost every second shot in a long run.

For achieving an 1100-score in a WA1440 round it is necessary, according to the table, to hit the gold in around 1/3 (10% + 22% = 32%) cases of all shots at the 50m or 70m ranges.

That's the simplest performance orientation! The performance control can be done without written record, simply by tracking the gold hits alone.

Performance targets that lie between the performance tables are to be determined by interpolating (e.g. averaging) the values.

For example, if you plan to achieve an 1050 score in a WA 1440 round and you are just shooting on the 50m distance, you can read the values for the 50m distance from the 1000 score-level table and from the 1100 score-level table and then average the values (7%+16%+10%+22%)/2 = 37,5% gold.

THE END