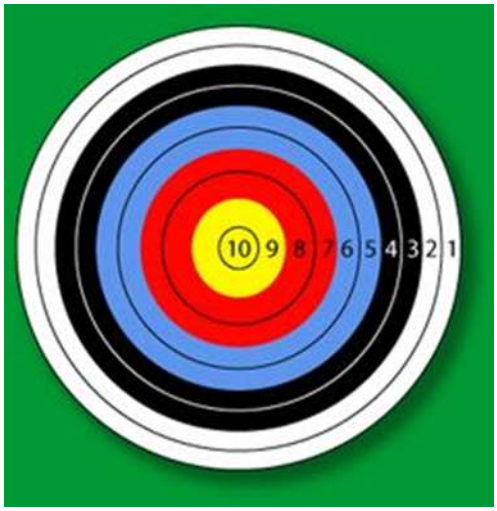

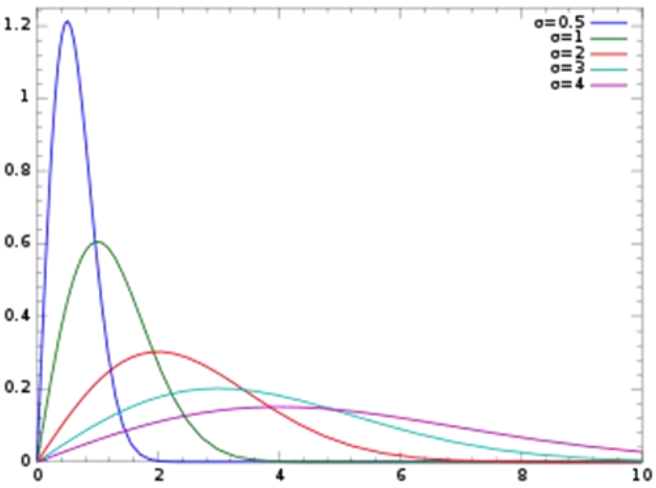

RECURVE ARCHERY

Training and Tournament
Two sides of the same medal

Part 1
WA-1440 Performance Forecast – Men

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Training and Tournament

How often does the following happen: You practice at a shooting distance, in the winter perhaps at 18m indoor, you have increased in performance - at least that's what you think - and then in the spring you enter full of expectations in the new outdoor season. The first tournament, a WA 1440 Round comes and then the disillusionment. You have expected a much higher Score result!

Why are the expectations raised in training often not met in the competition? Many reasons are repeatedly cited: On the day of the tournament you were not in a physical and mental normal form, the competition conditions were bad, nervousness, maybe you suffer from competition-weakness, etc.

Much may be true, but the key questions are:

1.) Can one predict WA 1440–Scores from the archery training result of only one shooting distance at all?

2.) Did you record the training performance in the right way?

3.) Did you correctly apply the Scores achieved in training on the Score result in the WA 1440 Round?

The following article series deals with this topic:

Correct performance recording in the training phase and which performance forecasts can be compiled for a WA 1440 Round. Because: ***Training and tournament are just two different sides of the same medal!***

WA 1440 Performance Forecast

Men (90m, 70m, 50m, and 30m)

An illustrative story

The Maier family, father and son, are passionate archers. In addition to the club's own archery range, shooting is also possible in the private garden at a shooting distance of 18m on the 40cm target face (10-6). Even in winter and in bad weather, the Maier family wants to stay in training and have therefore set up a small shooting range at 10m shooting distance in the basement of their house. As a target face they use a paper discs with 8cm diameter.

The choice of 8cm diameter slices is no coincidence! Father Maier is a tinkerer and remembers his math lesson. He noted: The 8cm slices at 10m shooting distance correspond visually exactly a circle of 24 cm diameter on the 80cm disc support (Math: Intercept Theorem!). And this corresponds to the disc diameter over the rings 10, 9 and 8.

Father Maier continues to think and asks himself: Can the achieved performance on the 10m shooting distance or the 18m shooting distance with certain restrictions, more precisely exclusion of shooting distance factors, be transferred to other shooting distances? So, would it be possible to predict WA 1440 competition results based on training results?

This contradicted Maier Junior!

Visor line and arrow line are different, one straight line, the other a parable flight. The trajectory depends on many influencing factors, which have different effects on the shooting distances, such as various bow and arrow parameters (i.e. bow weight, arrow weight), external influences (egg different wind speed between ground and higher layers), biometric and psychological effects Components (i.e. different inclination of the archers upper body at the shooting distances, with the shooting distance decreasing visual performance). In a word, the shooting process is just too complex to transfer score results from one shooting distance to another, or even predict the WA 1440 score.

The experienced coach involved in the discussion states that the skill level of an archer is expressed in both training and tournament score. A good training result can thus expect a good tournament result. In the meantime, there are not only empirical values for the expected benefits on the WA shooting distances, but also calculation values, which take into account important shooting distance-related factors. The individual skill level determined at a shooting distance can be mathematically transferred to all other shooting distances and expressed in corresponding ring scores. Thus, forecasts made out of a training shooting sample - just from one shooting distance - have an objective background. They make sense for a better controlling of the own shooting performance level.

Graphic: WA 1440 Performance Forecast Men

The graphic "WA 1440 Score Forecast Men"
offers the scores of each distance of the WA 1440 Round and the total WA 1440 score (plus 10m shooting distance) as the skill level decreases (from left to right).

Target faces: 122cm for 90m and 70m; 80z for 50m and 30m

All data in the graphic are shown again in the table later below (chapter “How to determine archer’s Skill-Level in the Training - Performance table"). In addition the so-called **confidence intervals** were added. The meaning and benefits of these confidence intervals are explained there.

Data Background:

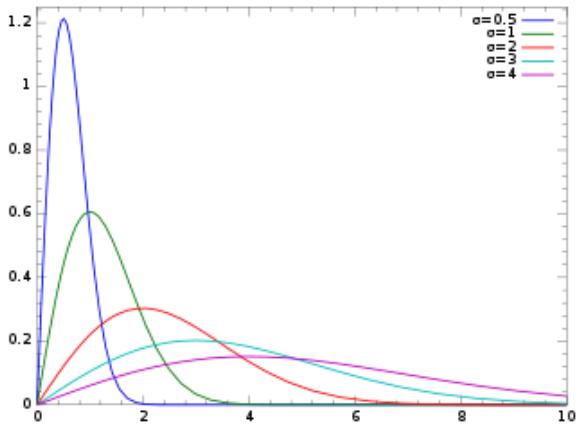
The scores in the graphic and in the table stem from a complex computer application. The algorithmic approach for the forecasting model is based on Rayleigh's probability distribution (see graph below, https://en.wikipedia.org/wiki/Rayleigh distribution). The performance forecast (prognosis) for various 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).

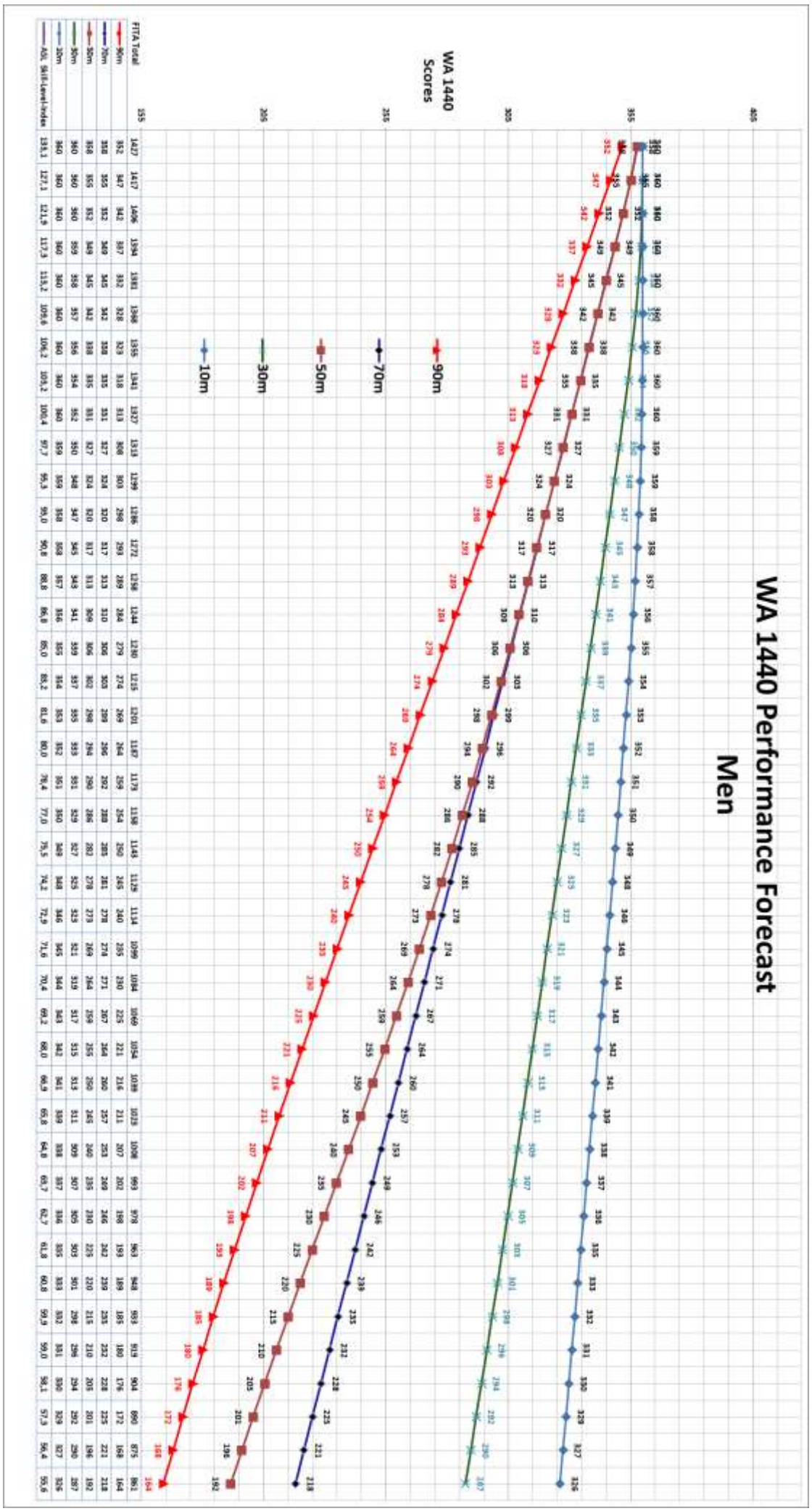
Also included for the different shooting distances are the different target faces/sizes and the WA rule for touched rings, and a 0.5 cm arrow shaft diameter.

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


WA 1440 Performance Forecast
Men
WA 1440
Scores
90m
70m
50m
30m
10m

Cut here

For reading,
one looks for the value on the graph, which corresponds with the training result on the shooting distance. All vertical values above and below are the performance levels and expected score results for the WA 1440.

For the individual transmission of the training results to the forecast values it is recommended to use the Shooting-Performance Table which includes the confidence intervals (page 7)!

Comments on the graphic

The scores corresponding between the shooting distances represent the same skill level of an archer (see ASL, bottom data line). Individual score deviations from an archer at a shooting distance (so-called “shooting distance-strengths" and "shooting distance-weaknesses") have individual specific reasons that the archer should, of course, pursue.

The score curves for each shooting distance proceeds at different level and have a different gradient between the high-performed and low-performed archers (see example in the table below).

The different height of the ring-scores between the shooting distances shows how "easy or difficult" one and the same score with 36 arrows is achieved. The curves of the "difficult" shooting distances are thus below the "easy" shooting distances. The main reason for the score level differences of the shooting distances is that the target faces do not correspond in size to the given skill of Archer alike. Only the 122cm overlay at 70m shooting distance corresponds (approximately) with the 80z target face at 50m and thus both curves are congruent above the performance level of 1200 total rings. From 1200 rings downwards, however, the score results of the 50m shot shooting distance fall below the score results of the 70m shooting distance. This is caused by the increase of Misses on the 50m shooting distance, which is particularly difficult for lower-performance archers, and on the 80z target.

The example below illustrates the different Score point differences on each shooting distance between 2 archers with different performance standards (skill levels):

WA-1440 Range	**Archer A**	**Archer B**	**Score Difference**
	Score		
WA-1440 total	**1299**	**1272**	**-27**
90m	303	293	-10
70m	324	317	-7
50m	324	317	-7
30m	348	345	-3
10m	359	358	-1

Archer A and B separate a score of 27 points in total, 10 score points of which account for the 90m shooting distance! At the 30m shooting distance, the two archers separate only 3 score points, at 10m only 1 score-point.

The 90m score differs best between different performing archers, followed by 70m and 50m equally. These 3 shooting distances are therefore particularly suitable as training distances in

order to detect any performance change/progress or to forecast the score for a WA 1440 Round.

How to determine the Archer’s Skill-Level in the Training

Back to the history of the Maier family!

As already described, the Maier family has set up a target butt in their own garden at 18m shooting distance and for the winter and in bad weather in the basement of their house at 10m shooting distance.

The total training consists mainly of a part of the exercise in which individual biomechanical and psychomotor processes of archery are practiced. The achieved scores have no or only impact-controlling meaning. They are not recorded on a scorecard. The entire training program is completed by 5 to 10 passes of 6 arrows, the results of which are recorded on a scorecard. Since the number of arrows shot in training varies according to the time available, the average ring value per arrow is used for comparison purposes. The last training results are compared with the results before. Once the last results of the training are under the penultimate, another time they are over. It is difficult to interpret the ups and downs of the training performances. Also, the assignment of the training result to other shooting distances, be it a WA70m or WA1440, does not seem easy.

Soon there will be discussions about this and about how to proceed between father and son. How many arrows must be shot and counted in training to capture your own performance level? Is it possible to record your own skill (performance level) in training passes? And how can you change the training result to WA rounds

The experienced coach comments on this as follows:

The starting point for the performance recording and for a prediction of the score in a WA 1440 or WA 70m round is always first a certain number of training arrows ("sample") on any selected standard shooting distance, but preferably outdoor at 90m, or at 70m or on 50m. This sample of training arrows depicts the possible skill level of the archer, which is transferred by forecast to other shooting distances or to the overall result of the WA 1440. However, the performance score determined from the naturally limited sample is only an approximation to the actual skill of the archer. To more accurately grasp the skill of an archer, the archer would have to shoot thousands upon thousands (infinitely many) arrows, which of course cannot be the purpose of a training-sample.

The way out of the dilemma is as follows: From a (limited) sample a **confidence interval** can be calculated within which the unknown true performance parameter (number of rings) with a defined probability lies. The larger the training sample, the smaller the confidence interval. From the confidence intervals it is also clear how big the ring difference of two training samples must be, so that one can assume an increase in performance instead of random skill fluctuation.

The following shooting performance table shows the scores of the graphic in table format and additionally the confidence intervals. This score-table is intended for use for archers and coaches!

Shooting-Performance Table

Shooting Scores for each WA 1440-Shooting Range including Confidence-Intervals

- *Number of arrows: 90,70,50,30m: 36 arrows; 18m: 60 arrows*
- *Probability for the confidence interval: P=68%*
- *Target face: 90m, 70m: 122cm; 50m, 30m: 80z;18m,10m: 40cm [10-6]*

	Training		Indoor		WA 1440 WA 1440 - 90m, 70m, 50m, 30m (Men)									
ASL Skill-Level-Index	10m	Confidence-Interval ±	18m	Confidence-Interval ±	30m	Confidence-Interval ±	50m	Confidence-Interval ±	70m	Confidence-Interval ±	90m	Confidence-Interval ±	WA 1440 TOTAL	Confidence-Interval ±
133,1	360	0	600	0	360	0	358	1	358	1	352	3	1427	3
127,1	360	0	600	0	360	0	355	2	355	2	347	3	1417	4
121,9	360	0	599	1	360	1	352	3	352	3	342	4	1406	5
117,3	360	0	598	1	359	1	349	3	349	3	337	4	1394	6
113,2	360	0	596	2	358	1	345	3	345	3	332	4	1381	7
109,6	360	0	593	2	357	2	342	4	342	4	328	5	1368	8
106,2	360	0	590	3	356	2	338	4	338	4	323	5	1355	9
103,2	360	0	587	3	354	2	335	4	335	4	318	6	1341	9
100,4	360	1	584	4	352	3	331	5	331	4	313	6	1327	10
97,7	359	1	580	4	350	3	327	5	327	5	308	6	1313	11
95,3	359	1	577	4	348	3	324	5	324	5	303	7	1299	12
93,0	358	1	573	4	347	3	320	5	320	5	298	7	1286	12
90,8	358	1	569	5	345	3	317	6	317	6	293	8	1272	13
88,8	357	2	566	5	343	4	313	6	313	6	289	8	1258	14
86,8	356	2	562	5	341	4	309	6	310	6	284	8	1244	14
85,0	355	2	558	6	339	4	306	7	306	7	279	9	1230	15
83,2	354	2	554	6	337	4	302	7	303	7	274	9	1215	16
81,6	353	2	551	6	335	4	298	8	299	7	269	10	1201	16
80,0	352	3	547	6	333	4	294	8	296	7	264	10	1187	17
78,4	351	3	543	7	331	5	290	9	292	8	259	11	1173	18
77,0	350	3	539	7	329	5	286	9	288	8	254	11	1158	19
75,5	349	3	535	7	327	5	282	10	285	8	250	11	1143	19
74,2	348	3	531	8	325	5	278	11	281	9	245	12	1129	20
72,9	346	3	527	8	323	5	273	11	278	9	240	12	1114	21
71,6	345	3	523	8	321	5	269	12	274	9	235	13	1099	21
70,4	344	3	519	9	319	6	264	13	271	10	230	13	1084	22
69,2	343	4	515	9	317	6	259	13	267	10	225	13	1069	23
68,0	342	4	511	10	315	6	255	14	264	10	221	14	1054	23
66,9	341	4	506	11	313	6	250	15	260	11	216	14	1039	24
65,8	339	4	501	11	311	6	245	15	257	11	211	14	1023	25
64,8	338	4	496	12	309	6	240	16	253	11	207	15	1008	25
63,7	337	4	491	13	307	7	235	16	249	11	202	15	993	26
62,7	336	4	486	14	305	7	230	17	246	12	198	15	978	27
61,8	335	4	481	14	303	7	225	17	242	12	193	16	963	27
60,8	333	4	476	15	301	7	220	18	239	12	189	16	948	28
59,9	332	5	470	16	298	8	215	18	235	13	185	16	933	28
59,0	331	5	464	17	296	8	210	19	232	13	180	16	919	29
58,1	330	5	458	17	294	8	205	19	228	13	176	16	904	29
57,3	329	5	453	18	292	9	201	19	225	13	172	17	890	30
56,4	327	5	446	19	290	9	196	20	221	14	168	17	875	30
55,6	326	5	440	19	287	9	192	20	218	14	164	17	861	31

All values are rounded to onces digit!

Cut here

Explanations to the table with a readout example

An archer, **for example**, achieves a score of **294** in training with 36 arrows on 50m. Now we have to keep in mind that is the result of a relatively small sample. If the archer repeatedly fired 36 arrows, he would achieve ring results that differ, perhaps even significantly, from the first training sample. Where is his actual score-based performance at 50m? The answer is: Probably close to the mean of all training samples. But where is it really? Mathematicians like C. Friedrich Gauss have dealt with it.

No one can tell where the true 50m score of the archer is. To find out, you would have to shoot infinitely many training arrows. But you can make predictions about the range in which the archer's true, unknown parameter (50m score) is a defined probability.

In our example, according to the table, the true archer's 50m performance score is 68% probability within a range (called the confidence interval) of 294 ± 8, or between 286 and 302 rings. Probability is equivalent to percentage frequency of appearance of the ring values.

ATTENTION: If the archer - as recommended - shot 144 arrows instead of 36 arrows, so if his training sample is 4 times larger than the sample on which the table is based, the confidence interval of the table is reduced to half! (See also below "The size of the training sample").

How to calculate WA-Scores with Confidence Interval out of Training Values:

There is a training sample of 144 arrows (4x36) on the 50m shooting distance. Average score for this shooting distance is assumed to be **294** (average value for 36 arrows). The corresponding scores of the other shooting distances can first be read from the table for the first orientation: 264, 296, 333, and 1187.

If, however, you want to know more, namely within which range the 68% probability is the real skill value, the **confidence interval** has to be read. The confidence interval for 36 arrows is according to Table 8 rings. But the training sample is 4 times bigger. This reduces the confidence interval to half (8/2), namely 4. The confidence interval is now subtracted once from the training sample value and added once (294 ± 4). Finally, the corresponding shooting distance values are read from the table for the two confidence interval limits. This yields the forecast values for the lower and upper interval limits for all shooting distances.

WA-1440 Shooting-Range	Archer "Example"	Confidence Intervall (144 Arrows)	Confidence Interval Limits	
	Score	±	Lower End	Upper End
90m	264		259	269
70m	296		292	299
50m - Training-Sample(144 arrows)	**294**	8 /2 = 4	**290**	**298**
30m	333		331	335
WA 1440 total	**1187**		**1172**	**1201**

Result - Interpretation: The archer with the score of 294 at 50m distance will score with a 100-fold repetition of the training sample about 68 times between 290 and 298. And his WA 1440 total ring value will be between 1172 and 1201.

The size of the training sample

The confidence intervals reported in the table are based on a (minimum) number of 36 arrows per distance (60 arrows at the 18m distance) and 68% probability. However, a larger number of arrows are recommended for the WA training sample, namely 4 series of 36 arrows per distance. Then the confidence interval shown in the table can be halved - as we said before.

Example: In the table with (only) 36 arrows at 50m and an achieved score of 269 the (unknown) true performance score (skill) will be with 68% probability in the range 269 **± 12** (= confidence interval, see table), so between 257 and 281. The confidence interval, in which the true skill of the archer is lying with a probability of 68%, is quite large.

In a sample of 4 x 36 arrows at 50m, the confidence interval is reduced to half, which is 269 ± 6, i.e. between 263 and 275. The prognosis becomes more accurate.

Performance Level and Confidence Interval

It can also be seen from the table that the confidence interval of the prognosis values decreases with increasing skill (ASL index). Increasing skill means smaller arrow grouping (less standard deviation). The smaller the score spread of an archer, the more accurate the score forecasts for individual distances. An archer with a WA 1440 result of 1300 (skill index 95.4) will achieve values between 1288 and 1312 (confidence interval ± 12) in about 7 out of 10 tournaments. A WA1000-Score archer has more than twice the variance; its confidence interval is ± 25.

Methodical Advices for the Recruitment of the Training Sample

The recommended 144 arrows should be shot in 4 series with 6 passes of 6 arrows each. Before the start, as usual in tournaments, 6-12 non-scoring test shots are allowed for warm-up and adjustment of the sight. Short breaks of around 5-10 minutes can be made between the 4 series. The 4 series can also be split over 2 days. For each day the shooting with trial arrows applies.

If you have started with the training sample, the arrows are picked up after every pass of 6 arrows. Of course, every arrow counts, including the Miss (0). The ring value of each arrow is recorded (shot list). The ring values are added together and divided by the number of arrows (i.e. 144) (count on 3 comma digits!). This gives the mean ring value. Multiplied by 36, it results in the training WA 1440 score of the corresponding distance. The corresponding ring values of the other WA-1440 distances can then be read from the table or graphic!

The training sample should preferably be taken at a distance of 90m, 70m and 50m, as it leads to more reliable prognosis values. If the training values are taken from shorter distances (18m, 30m), it is recommended to increase the training sample to 360 arrows. The confidence interval then reduces to about 1/3 of the table values.

Using the Confidence Intervals to detect an Increase in Performance

Recognizing performance progress with some assurance is not easy for the archer. The obtained scores in training rounds vary due to the given "natural" error variance of the archer.

The question is: how big must the score difference of two training outcomes be in order to be able to accept a performance progress?

The confidence intervals shown in the table are helpful!

And that goes like this:

An archer, for example, in training 3 months ago at 50m with 4 x 36 arrows on average got a score of 306 for 36 arrows. Now he achieves after intensive training and repetition of 4 x 36 training arrows a Score value of 313, so 7 score points more than 3 months earlier. Is this difference to be seen as a real performance improvement or is it just a variation within the given skill level?

We read a confidence interval of ± 7 for the score 306 at 50m for 36 arrows. As 144 arrows were shot in training, 4 times more, we can halve the confidence interval; this results in ± 3.5 points (see "The size of the training sample"). We do the same for the 313 rings; this gives ± 3. Both confidence intervals together give 6.5. The score difference of 7 points between the two training samples is slightly larger than the two confidence intervals together. It is therefore likely to be 2 samples of different levels of performance, which means an improvement in performance.

The Benefit from the Performance Table (Summary)

Finally, the main benefits from the performance table for archers and coaches are briefly summarized:

- The Performance Chart assigns the personal skill level of the Archer to the internationally regulated WA 1440 Round without the archer himself taking part in a WA 1440 tournament.
- A larger deviation between predicted and actually achieved scores at a certain shooting distance is an indication for a possible archery problem at that shooting distance. It is then will be necessary to find the reason (psychological, biometric, etc.).
- Confidence intervals make it easier and more objective to decide whether a higher training score than in the past is more likely to be a performance increase or just a possible random performance variation.

THE END