RATIONALE FOR TIMING SYSTEM ADJUSTMENT

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Just imagine the perfect automatic timing system: the same signal that starts the swimmers, also instantaneously starts the absolutely accurate timing system and the backup watch timers start the watches with incredible accuracy. At the end of the race, each swimmer's first touch immediately stops the automatic timing system for the appropriate lane and both the secondary system button pushers and the watch timers are completely accurate….primary, secondary, and watch times all agree to the hundredth of a second! WOW!!!! So…. who needs a secondary or watch time anyway? Those of us who officiate in the real, somewhat less-than-perfect world…. that's who! In the real world a time recorded for a swimmer may be not only correct or incorrect, but also "relatively correct", and it's up to the referee to figure it all out and be sure each swimmer gets fair treatment and an accurate time. So let's consider some possibilities with a typical system.

The primary system starts automatically with the starting signal and finishes with the swimmer's touch of the pad at the end of the race. The secondary system also starts automatically with the starting signal and finishes with the manual push of one, two or three buttons operated by lane officials in each lane. For the sake of convenience in this paper, we'll talk about "the button" whatever the number of buttons in use in each lane. The watch backup is based on one to three manually operated watches per lane (but we'll refer to "the watch" in each lane). If all systems work properly, three different system measures of each swimmer's time are produced (and, in the real world, the three usually are different from each other):

> **P** = an apparently correct Primary (**P**ad) time with automatic start and automatic stop.
> **B** = an apparently correct Secondary (**B**utton) time with automatic start and manual stop
> **W** = an apparently correct backup **W**atch time with manual start and manual stop

The decision about whether a time is "apparently correct" depends on its agreement with other information. A primary time within two or (perhaps) three tenths of a second of both the corresponding secondary and watch times is usually considered accurate. For convenience in describing different situations in this paper and exercise, we will use "P", "B", and "W" as defined above, and also define the following:

> **R** = a "Relatively correct" primary time (described later)

R' = a "Relatively correct" secondary time (see below)
X = a missing or incorrect time

Thus, "**P**-**B**-**W**" is shorthand to represent a situation in which all three times were good and "**X**-**R'**-**W**" indicates a missing or incorrect primary time with a "relatively correct" button secondary time and a good watch time.

Since the primary time from a properly functioning system is considered most accurate and is the official time whenever it is considered to be correct, there is no problem when a good primary time is available. Under current (2004) USAS (USA Swimming) rules, the objective when a primary time is either missing or considered incorrect is to estimate what the primary time would have been if it had been measured correctly. THE BEST POSSIBLE ESTIMATE OF THE CORRECT PRIMARY TIME IS THE FAIREST TIME TO GIVE A SWIMMER FOR WHOM AN ACCURATE PRIMARY TIME IS NOT AVAILABLE. Sometimes calculation of the "best possible estimate" appears impractical because of the amount of work involved, but that extra work is the only fair way to resolve a problem.

SYSTEM ERROR CORRECTIONS

Before considering specific situations, let's grapple with two somewhat similar concepts that a referee must understand in order to decide what the "best possible estimate" of a missing primary time may be. Neither of these concepts involves equipment that measures time inaccurately, and it is always wise to be aware of the possibility that equipment might be miscalibrated or set up incorrectly. From a beat-up old watch to the fanciest new automatic timing system, if a mechanical/electronic problem is causing the device to measure time either too quickly or too slowly, there's a basic problem needing correction or some alternate timing device should be used until expert recalibration is completed. Identifying an equipment calibration problem can be difficult if the error is quite small. A bad watch will usually give bad times regardless of who is operating it (and usually a suspect watch can be fairly easily replaced). An out-of-calibration or incorrectly set up automatic timing system is suggested when there are continually "unusual" differences between primary times and watch backups. Knowing that "correct" watch times tend to be a fraction <u>faster</u> than primary times in most cases, particularly if there is not a good visual starting signal and/or the starting signal is far away from the timers, can help.

But let's suppose that there is no reason to question the mechanical/electronic accuracy of the equipment. How could there still be a "system error". A system error exists when "correct" times obtained by one system regularly differ by a fairly constant amount from "correct" times measured by another system. We just touched on a common example of system error: because people have reaction times and cannot start watches at exactly the same instant that the starting signal is given, manual watches are usually started a fraction of a second after the automatic timing system starts. Because people can anticipate a swimmer's

finishing touch, they are often closer in stopping their watches at the same instant that the swimmer's touch stops the automatic timing system. When both of these things happen, the manual watch will have been running for a slightly shorter time than the automatic timing system, and usually the manual watch time will be slightly faster than the primary time. Finding that most watch times are regularly a few hundredths of a second faster than the corresponding primary times is neither unusual nor an indication of problems with either system; it is simply an indication of a rather common "system error". And, since primary times are regarded as the correct (most accurate) times, a backup watch time may have to have a system error correction added to it to get the best estimate of what the primary time would have been and make it directly comparable to other primary times. In this paper let's call the error the "correction factor". A secondary system error with a manual-electronic (button) secondary system is also possible. Although modern timing systems often include a timing delay to approximate human reaction time on the secondary system, it's best to check to see whether there is a regular difference between pad and button times. Examine the data to determine whether or not there is a system error in any secondary or backup system. Remembering that it's mathematically possible for a system error to be positive or negative, these two system errors are:

Watch system error = Average (P-W)

Secondary system error = Average (P-B)

Sometimes just by "eyeballing" the data from a number of heats, a referee can feel pretty sure about whether or not a system error exists. In the real world, practical considerations are also involved. With limited time to make calculations, a system error affecting one lane in the slow heat of a distance event can often be corrected by using a previously calculated "correction factor', while a system error affecting a lane in the fast heat of a sprint event may require several calculations to assure that the correct adjustment is made.

In cases where the referee decides calculation of a system error is necessary, the next question is how to calculate "Average (P-W)" or "Average (P-B)". For situations in which only one or two lanes are missing valid primary times, the 2004 USAS Rules 102.16 shows the method for estimating a system error. The primary method in the rulebook estimates the system error in the lane(s) with missing/bad primary time(s) from observed system errors in other lanes for the same heat. This method assumes that the performance of the timer(s), or button pusher(s) in the lane(s) lacking primary time(s) is neither better nor worse than the average performance of the timer(s) in the other lanes. This assumption is probably reasonable in most cases, but it can be tested by looking at results for the lane(s) in question for adjacent heats of the same event (if the timer/s in that lane has/have not changed during those heats). If examination of adjacent heats indicates that the timer in question consistently produces a system error (P-B or P-W for that particular lane) that differs from the average system error for other

lanes, it may be better to calculate “Average (P-B) or (P-W)” from data in that lane only for about half a dozen heats of the same distance/stroke from heats adjacent to the heat in question. The primary rulebook method (estimate based on data across lanes in the same heat) is commonly called a “horizontal” correction and the method in which the average is based on data from only the lane in question over several adjacent heats, a “vertical” correction. In most cases, the “horizontal” and “vertical” estimates of system error should be very similar. The referee should consider all available evidence and use what he or she judges to be the best possible estimate.

It is often not practical for the referee to do all the calculations involved in getting the “best” estimate. This function is usually performed by a Chief Timing Judge or Administrative Referee, but all referees should understand the principles and purposes well enough to determine if an adjustment has been made correctly before authorizing its use. As a quick example of calculating system error for a six-lane pool with automatic primary and only watch backup, consider the following possible results:

		Lane 1	Lane 2	Lane 3	Lane 4	Lane 5	Lane 6
“Horizontal”							
(Heat 8 only)	(P)	27.44	27.52	?	27.12	27.42	27.48
	(W)	27.30	27.39	27.05	27.06	27.24	27.38

		Heat 5	Heat 6	Heat 7	Heat 9	Heat 10	Heat 11
“Vertical”							
(Lane 3)	(P)	28.23	28.01	27.60	27.20	27.68	27.11
	(W)	28.13	27.86	27.49	27.04	27.59	26.98

“Horizontal” estimate calculation -- .14+.13+.06+.18+.10 =.61 $\frac{.61}{5}$ = .12

If we name the “correction factor” delta (**Δ**), then:

Δ= .12

“Vertical” estimate calculation -- .10+.15+.11+.16+.09+.13 =.74 $\frac{.74}{6}$ = .12

Δ = .12

Official time for heat 8, Lane 3 …. W + **Δ** = Official time, or 27.05 +.12 = 27.17

Remember, when calculating averages we drop the thousandths without rounding off to the hundredths. Another important point would be to check the resulting times against an ‘order of finish’ or ‘across the board judging’ as it is called in some LSC’s.

CORRECTING A LATE SYSTEM START

A bit earlier we mentioned “relatively correct” times and that probably sounded confusing. Perhaps you can suggest a better term for describing such things, but all referees need to understand the concept, no matter what we call it. Suppose for some reason the starting signal starts the swimmers but fails to start the automatic timing system and the swimmers are not recalled. Whenever this situation occurs, **THE TIMING SYSTEM SHOULD BE STARTED MANUALLY ASAP** (and any qualified timing console operator must be aware of the vital importance of manually starting the system whenever it fails to start automatically). Since the automatic timing system was started manually, at some point in time after the actual start of the race, the times registered by both the primary system (pads) and secondary (buttons) for the heat will be faster than they should be. Nevertheless, if all swimmers touch the pads properly and there are no pad malfunctions, both the order of finish and the differences in times between any two swimmers are shown correctly by the primary system. All one needs to do to determine correct primary times is know exactly how late the automatic system started and add that correction factor to the “relative correct” pad times registered by the manually started automatic system. Adding an appropriate correction to “relatively correct” pad times results in times that are more accurate than any other times except for the completely automatic times available when the primary system functions completely correctly. Thus, it is essential for all referees to know how to determine an appropriate correction.

The 2004 USA Swimming Rules 102.16 demonstrates part of an appropriate procedure using all lanes that have both a good watch time and a “relatively correct” pad time, by finding the average difference between watch and pad [average (W-R)] and adding that average difference to each ”relatively correct” pad time. The result of this procedure is to correct the “relatively correct” pad times so that, on the average, they will agree with the watch times. The 2004 USAS Rule book gives an example of a correction for a “Heat Malfunction” in Table 2. What the example fails to take into account is that the watch times may suffer from a system error that can be estimated from adjacent heat data. The USAS procedure is fine as far as it goes, but it may not go far enough. If there is no watch system error, the USAS procedure is correct, but if there is a watch system error (and there usually is to some degree), that error must be estimated and included in the correction for any late system start to get the best estimate. Let’s consider an example, in which heat 3 had a late start of the primary system:

		Lane 1	Lane 2	Lane 3	Lane 4	Lane 5	Lane 6
Heat 2	(P)	59.35	58.20	58.07	58.38	59.14	59.23
	(W)	59.20	58.07	58.01	58.21	58.95	59.09
Heat 3	(R)	(53.83)	(53.22)	(52.92)	(53.05)	(53.99)	(53.93)
(Late start)	(W)	58.93	58.21	57.78	57.95	58.88	58.84
Heat 4	(P)	58.79	58.10	57.91	58.03	58.41	59.18

(W) 58.67 57.96 57.87 57.92 58.28 58.98

First, according to the watches, how late was the start?

Average (W-R) = 5.10+4.99+4.86+4.90+4.89+4.91 = $\frac{29.65}{6}$ = 4.94

The value of "Relative Correct" Average (**ΔR**) is 4.94

Now, determine the watch system error (**ΔW**) if adjacent heat data indicate that there is any watch system error.

From Heat 2 -- .15+.13+.06+.17+.19+.14 = $\frac{.84}{6}$ = .14

From Heat 4 -- .12+.14+.04+.11+.13+.20 = $\frac{.74}{6}$ = .12

$\frac{.14 + .12}{2}$ = .13

The watch system error factor (**ΔW**) is…… **ΔW** = .13

Combining the two corrections, what is the total correction?

Official time = (**ΔR +ΔW**) or …. 4.94 + .13 = 5.07

The total correction factor **Δ** is 5.07.

Adding this correction to the "relatively correct" pad times gets official times of:

Lane 1	Lane 2	Lane 3	Lane 4	Lane 5	Lane 6
53.83	53.22	52.92	53.05	53.99	53.93
5.07	5.07	5.07	5.07	5.07	5.07
58.90	58.29	57.99	58.12	59.06	59.00

Should a referee go beyond the procedures given in the USAS Rules? That's up to each referee, but we believe that each referee should do his or her best to understand the principles and procedures involved and to give each swimmer the

fairest result he or she is able to determine. If one believes that there is a fairly constant watch system error of about .13 seconds in the above example, it seems only fair to use that information in calculating an appropriate correction for the late system start. If one wants to look at more than two heats to decide about a watch system error, that's certainly a possibility. But…. **MAKE AN *INFORMED* DECISION.**

SOME SITUATIONS AND SUGGESTED SOLUTIONS

1. **P-B-W** Primary (Pad), Secondary (Button), and Watch time are all good.
   P-?-? The Primary (Pad) time is good, but the button and watch may or may not be good.

   As they say, "If it ain't broke, don't fix it"! When you believe the primary time is correct, the primary time is official regardless of whether or not the buttons and watches were good.

2. **R-R'-W** The automatic timing system got a late start (manually, after the starting signal started the swimmers) but, except for the late system start, everything is believed to have worked properly (first touch registered at finish, buttons were pushed at proper time, etc.). The R-R'-W case applies to all lanes in any heat where the automatic system started late.

   When you believe the primary time is correct except for a late system start (i.e. the primary time is "relatively" correct), get the best estimate of just how late the late system start was and add this correction factor to each "relatively" correct pad time. The correction is based on the mean difference between W and R for each lane in the problem heat and the estimated watch system error (if any), which is determined from adjacent heats. Best estimate of P = R + Average (W-R) + Average (P-W).

3. **X-B-W** The Primary (pad) time is believed to be bad, but both the Button secondary and the Watch backup are believed to be correct. (This most often occurs in a single lane due to a missed touch at the finish or a malfunctioning pad in that lane, but it can occur in several lanes in one heat.)

   The Secondary (Button) time can usually be used as a good estimate of the missing/incorrect primary time, but especially in close races, one should check adjacent heats to see whether there is evidence of a secondary system error for that lane's button.

4. **X-X-W** Both the Primary and Secondary times are missing, but the Watch backup is believed to be correct. (This should be extremely rare, but can happen in all lanes if the system doesn't start and is not started manually, or in one or several lanes at the end of a bad connecting cable.)

Use the Watch backup to estimate the missing primary time after determining whether or not there is any watch system error. The best estimate of any watch system error, if the lane watch timers have not been changed, probably comes from adjacent heats of the same stroke and distance where both watch and primary time appear to be correct for the lane in question. If the watch system error appears to be constant across lanes, one overall estimate of the watch system error may suffice. If the error appears to vary across lanes (regularly larger in some lanes than in others) separate lane estimates may be needed. Best estimate of P = W + Average (P-W).

5. **X-X-X** Somehow (????) all three systems fail and there is no good time registered for one or more lanes. (This should never happen.)

   DON'T LET IT HAPPEN!! But if it does happen in a low-key age group meet, you might consider using coach/spectator watch times, plus place judge data, plus whatever else you can find (or allow a re-swim).

6. **Additional Reminder** – Individual watch and/or button times that are 'way out,' should not be used for determining average correction factors. For example, if button (or watch) differences in all lanes with good pad times except one are between .02 and .06 and one lane is .29, one should not use that lane in the computations.