## TIMING ACCURACY RESEARCH UPDATE (DECEMBER, 2010)

## INTRODUCTION

Timing lights are a commonly used field testing tool for the measurement of running performance in athletic development and research. At present a range of these systems exist, either commercially or in-house developed. Despite the typical claims of "accurate to 1/100$^{th}$ of a second", this is actually a technical spec which does not hold true in the real world.

Many athletes will train for weeks, months or even years to improve their performance by 5-10%, especially in the areas of speed and agility. The question is, can your measurement tools/methods accurately track this change in performance and lead you to the right conclusions? Unfortunately the answer is often NO.

There are currently 3 main types of sports timing light on the global market -

- Basic single beam systems (e.g. Brower, Microgate)
- Single beam systems with microprocessor functionality (SMARTSPEED, Fitness Technology); and
- Dual and triple beam systems (e.g. Swift Performance)

While most basic and home-made timing systems claim to have good accuracy, the reliability of their measurements is questionable. Research by the *Australian Institute of Sport* has shown that basic single beam systems DO NOT satisfy the requirements of reliability for sprint timing, with a typical error between sprints of well **over 5%**. What is the implication of this? It means that even if an athlete improves by 5%, your timing test might say they haven't improved at all! Worse still, the test may say they have improved or deteriorated by 5%, and they haven't changed at all. If an athlete trains for a whole year to improve by 5%, what benefits will such a test have?

For this reason the use of single beam uncorrected systems is not accepted by the Australian Institute of Sport network, and cannot be purchased in Australia as a result. If you are serious about measurement, these are systems are not acceptable.

Timing athletes with a stopwatch is even worse, with **typical errors of around 7-10%** to be expected. There's a good chance you tell an athlete they've got faster, when they've actually got slower!

As an athlete passes through a photo-beam, a number of "breaks" can occur, corresponding to leading/trialing hands or feet, and the torso. Single beam systems will be triggered by the first event at both start and split/stop gates, and hence the source of the unreliability. For example, the start gate may be triggered by a hand instead of the body, therefore producing a significantly worse result.

Several manufacturers of simple timing systems have attempted to improve reliability by adding extra beams (usually dual or triple beam). The theory behind this is that if two beams have to be broken concurrently, an object such as the hand cannot trigger the gate, as it will only break one of the beams. For many years this method has been standard practice throughout the Australian Institute of Sport Network, one of the world's leading sport science organizations.

Despite the popularity of dual beam gates and their improved reliability of measurement, several manufacturers (including Fusion Sport) chose to produce single beam gates with microprocessor technology and achieve in software the elimination of false objects such as hands and feet. There are a number of reasons for this which we will discuss later.

Systems such as SMARTSPEED are programmed to interpret all events as an athlete passes through the light beam, and take the start of the largest event, which is always the torso. This technology is known as **Error Correction Processing** (also known as *False Signal Processing*). Using this correction method, there can be any number of hand breaks, trailing foot breaks etc – the microprocessor will simply take the largest event, and take the start of this event as the time point, as illustrated in figure 1.

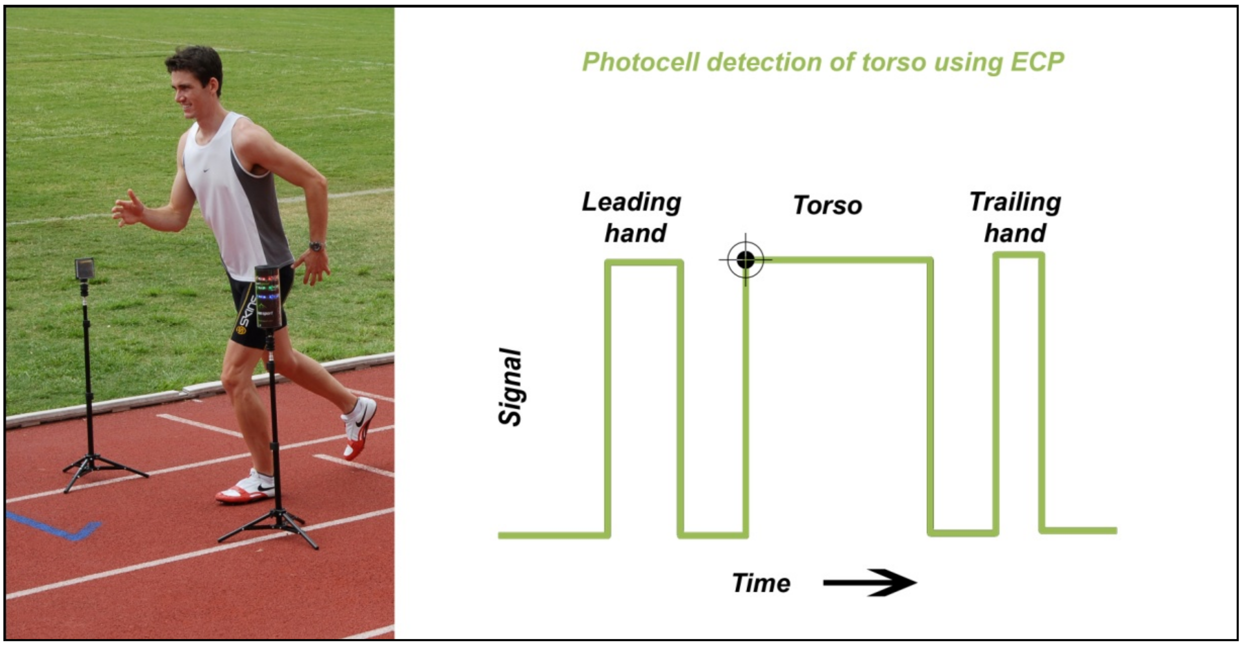


**Figure 1** – Detection of torso using Error Correction Processing (ECP)

## WHY USE A SINGLE BEAM WITH ERROR CORRECTION?

The advantages of single corrected beams are numerous -

- **Real event measurement** - timing is based on actual events - the torso crossing a single point in space, rather than an average of a number of events, such as that produced by multi-beam hardware solutions.
- **Flexibility and Configurability** - as ECP is a software innovation, it can be configured simply from software. For applications involving racquets, balls, sticks, bicycle or wheelchair wheels, ECP can be simply turned off and the first event is taken.
- **Easy to use:** One beam to line-up means less set-up time, better battery life and greater lane width
- **Cost and Power Saving:** extra beams means increased production cost, and higher battery load
- **Common sense:** why use hardware to do what can be done perfectly well in software?

## DOES ERROR CORRECTION WORK?

Several **independent** studies have now been presented on this topic. Firstly, D'Auria et al. (1996) set out to compare the reliability of SMARTSPEED to that of standard dual beam gates, with athletes performing 6 trials over split distances of 5, 10, 20 and 30 meters. The following data has been reproduced with permission.

Figure 2 illustrates the Typical Error of Measurement (TEM) for the two systems. Measured in seconds, this variable indicates the "typical error" that we might expect due to variations in the accuracy of measurement.

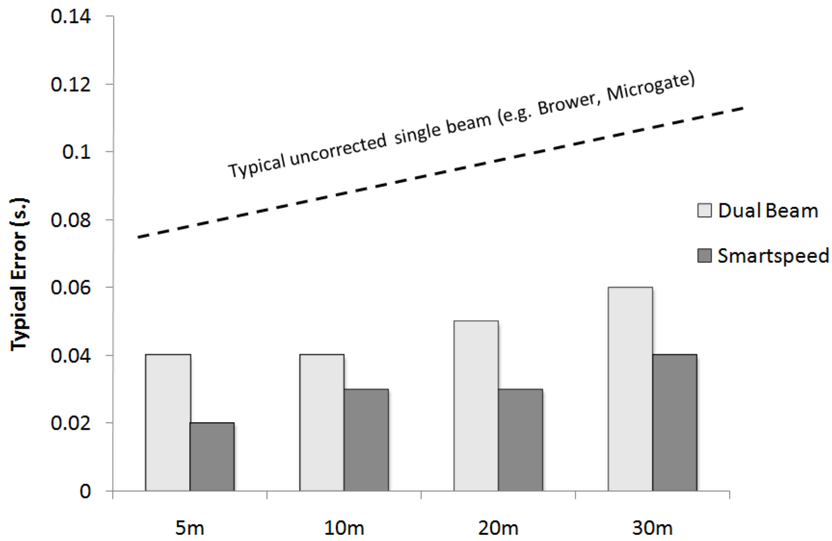


***Figure 2*** *- TEM (s.) for dual and single beam (corrected) timing gates over various split distances.*

As indicated by Figure 2, typical error increases as distance increases, due to a greater absolute time and potential for variation between trials. Figure 2 also indicates that SMARTSPEED gates typically had a lower typical error at all distances. A second measure of reliability, Coefficient of Variation (CV%) is illustrated in Figure 3.

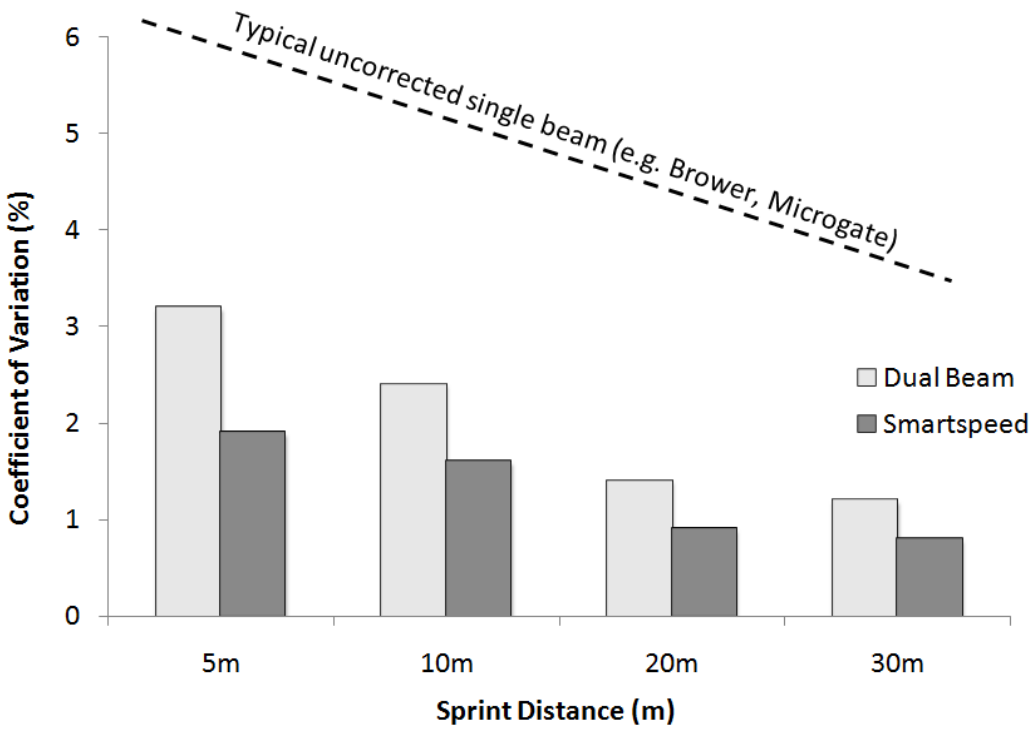


***Figure 3*** *- CV (%) values for dual and single beam (corrected) gates over various split distances.*

The results of this independent investigation demonstrate that single beam gates (with error correction) are **considerably more reliable** than traditional dual beam gates, at all distances. This was particularly evident at the 5m distance, where error measures for SMARTSPEED were *almost half* those of the dual beam system, and where timing accuracy is especially important given the amount of improvement an athlete can expect over such a short distance.

One potentially interesting finding of this investigation was that the authors reported possible differences between the results of the two systems, and cautioned the use of the two systems for collecting comparative data. The degree of difference was on average 0.03 seconds, and was all attributed to the start gate. One limitation of the study recognised by the authors was that it was logistically impossible to overlap the timing gates (see picture, right), so this was recognised as a likely cause of at least some if not all of the difference.

Recently another independent investigation was performed by a PhD candidate at Edith Cowan University in Australia Earp and Newton, 2010). This study sought to add to the previous investigation in two ways –

- They used one system which measured signals from single and multiple beams all attached to one timing gate. This eliminated the issue of not being able to line the hardware up together as experience in the D'Auria (1996) study;
- They used video analysis techniques to actually quantify how many false signals were in fact recorded by each system type.

The results showed that UNCORRECTED single beams were certainly prone to errors, as expected. However, the study also showed that False Signal Processing (as used by SMARTSPEED) was COMPLETELY effective at eliminating false triggers. In fact, in 8 out of 49 trials, the dual beam gates did still register false triggers, due to events such as a hand/leg combination activating the gate.

Interestingly, both the Earp & Newton (2010) and D'Auria (2006) studies found that the dual beam and corrected single beam solutions were practically the same.

## OTHER POTENTIAL SOURCES OF ERROR

In addition to the potential errors caused by false signals at the beam break, there are several other potential sources of error which should be recognised –

1. Processing errors – some system use a central PC or PDA to actually record time events. In other words, when a gate is broken, it simply sends a signal to say "I am broken" and the central computer records the time on its own clock, as the time when the gate was broken. This approach can result in errors when the central PC suffers a delay in processing the signal. Whilst PCs are usually very fast to process signals, they can suffer delays when other processes on the PC are drawing on the computers processors at the same time;
2. Latency errors (transmission errors) – in addition to the processing errors, wireless system which use this "central clock" approach are also prone to errors caused by transmission delays from the gates to the computer. This can occur either when the gates are a long way from the computer, or more importantly the signal from the gate does not make it to the PC on the first try. In this case, the gate would wait a set time and send the message again, until the central computer receives it. This can add considerable error, especially when using multiple gates and multiple lanes.

SMARTSPEED completely overcomes these potential errors by using a sophisticated "on board timing" method at each gate. In other words, when a SMARTSPEED gate is broken, is does not say "I have been broken", it says "I was broken at exactly HH:MM:SSS". The advantage of this is that even if there are delays in transmission over a long distance, or of the message doesn't arrive the first time, the accuracy is not affected at all. Furthermore, SMARTSPEED patented network protocol ensures that all gates are kept in exact synchronisation with each other, with regular automatic resynchronisation events throughout the testing session.

## DISCUSSION & IMPLICATIONS

Australia's National Sport Science Quality Assurance (NSSQA) require that sprint testing must comply with a maximum typical error of 0.05 seconds over 30m, however, typical error of < 0.03 seconds is desirable for the testing of elite athletes. The D'Auria (1996) investigation has demonstrated that the SMARTSPEED system satisfied NSQAA standards at all distances, and achieved the desired error of 0.03 seconds. or less at distances of 5, 10 and 20m. The results for reliability measures (TEM and CV%) further demonstrate that the single beam method with correction was superior to the dual beam method at all distances investigated. Dual beam gates did not achieve less than 0.04 seconds of error at any distance, and in fact did not meet NSQAA requirements at the 30m distance.

Accuracy and reliability in speed and agility testing are paramount for providing athletes with valid feedback. Failure to achieve high standards of reliability by using stop-watches or uncorrected single beams compromise the assessment of performance in athletes, and may in fact provide invalid feedback which may prove detrimental to the training program.

Whilst dual beam systems appear to be acceptable as a solution to the uncorrected single beam issue, they are still more prone to false measurements, and this is reflected in the poorer test-retest reliability values reported by D'Auria (2006), and supported by the finding of false signals on occasion by Earp & Newton (2010). Furthermore, the dual beam hardware approach is less flexible in application, harder to align, and places unnecessary demands on production cost, battery requirements and maintenance.

## REFERENCES

D'Auria, S., Tanner, R., Sheppard, J. and Manning, J. (2006) Evaluation of Various Methodologies used to Assess Sprint Performance. Paper presented at the Australian Institute of Sport Applied Physiology Conference, 2006.

Earp & Newton (2010) Analysis of false signals in electronic timing systems: single and double beam gates. Paper presented at the 2010 Australian Strength & Conditioning Association Conference, Gold Coast, Australia.