

# Impact of Track Official Positions When Using Fully Automatic Timing

## A Scientific Approach

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### The Impact of Fully Automatic Timing on Competition

Everyone wants fair racing. Starting lines are staggered to yield equal lengths. A competitor leaving the line early recalls the race. The ideal of no one getting an unfair advantage has not changed with the introduction of fully automatic timing (FAT). What has changed is the precision of times officials now use.

In the era of eyes on the gun and finger on a stop watch, times and errors in timing were measured in *tenths* of seconds. With FAT, places and advancement of competitors hinge on times measured in *hundredths* of seconds, occasionally in as little as *ten-thousandths* of seconds. In the world of racing small differences suddenly matter for fairness. For this reason we need to apply the science of sound to starter positioning.

Ideally the signal to start should occur at each starting position at the same instant. To accomplish that, the organizers of the 1995 World Championships used a "silent gun", so named because the pistol generated a sound only in speakers positioned two meters behind each lane's starting line. Lennart Julin (Sweden) examined starts in several international competitions, comparing the start of the FAT clock to the maximum pressure on starting blocks. His work revealed more uniform reaction times among athletes with "silent gun" starts compared to traditional "loud gun" starts.

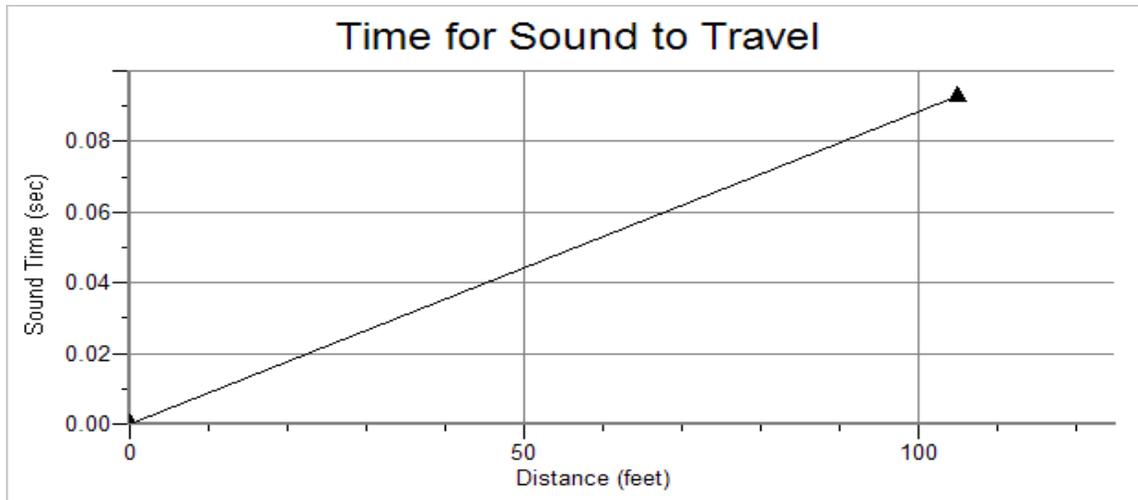
All FAT time measurements at the Illinois High School Association (IHSA) State Meet begin with a "loud gun" from a starter positioned various distances from the runners at the line. Julin's investigation of racing at the Sydney Olympics, where a "loud gun" start was used, shows that starter position denied Maurice Greene a world record in the 100 meters. Starter position altered reaction times across the starting line by 0.050 seconds!

### Factors in Athlete Reaction Times

Many factors go into determining the difference between the start of the FAT clock and a competitor's response to the starting signal.

(D) = Time for sound to cross the distance between the starter and the competitor.

"D" is calculated from a distance using an average speed of 1,125 feet/second for sound (Figure 1). Atmospheric conditions can affect this value. The narrow range of temperatures and wind speeds in track conditions render their effect negligible.



Figure

1

**(A) = Auditory Potential**

"A" is determined by the auditory signal traveling from inner ear to brain stem to auditory cortex where it must be processed (recognized) versus background noise. A second signal must then pass to the motor cortex and to the muscles before they can react.

A study released in June, 2008, by the University of Alberta in Edmonton (Canada), indicates the loudness of a sound has an effect on reaction time. Individuals hearing a 120 decibel sound react on average 0.018 seconds sooner than ones hearing an 80 decibel signal. A 1998 study by Frei Universitat Berlin (Germany) determined nearly all weapons used to start races in track generate a 160 decibel sound one meter from the gun.

Using the German 160 dB value for the sound intensity of a starting pistol, my calculations show that the University of Alberta study investigated sound levels well below that normally heard by runners (see Figure 2). For this reason the effect of loudness in calculating "A" is questionable and likely can be ignored as negligible.

With distances ranging from 20 feet on straight starts to 100 feet on staggered starts, runners actually hear only a 14 dB difference in loudness compared to the 40 dB difference used in the Canadian study. Since the decibel is a logarithmic unit, the weakest sound heard by an athlete (at 100 feet from the gun) is still *six times louder* than the loudest tone used in the study. If louder means quicker response, all competitors get good start signals regardless of lane position.

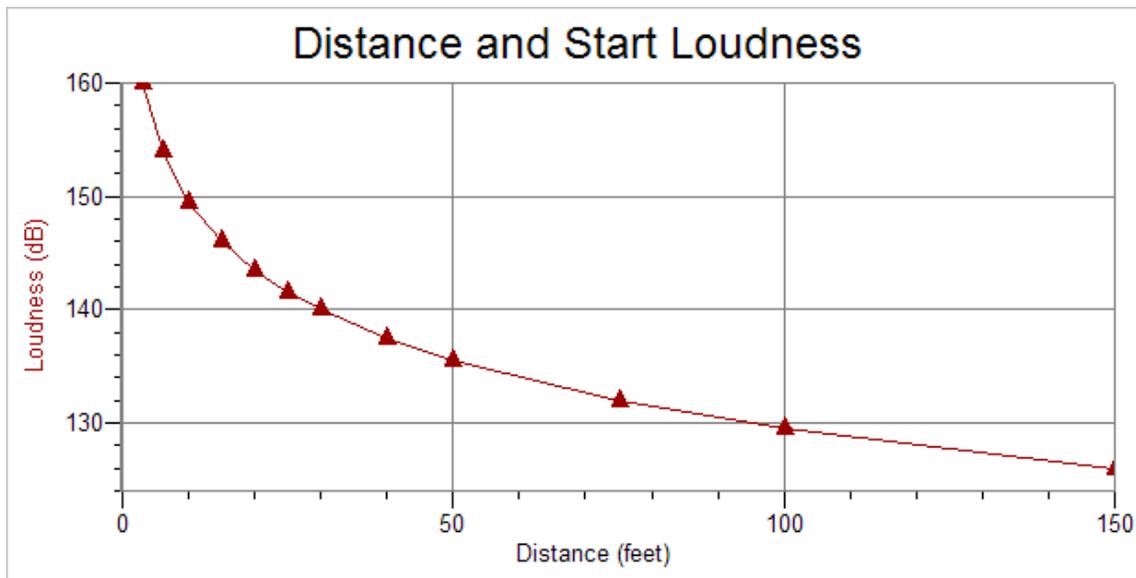


Figure 2

**(G) = Competitor guessing**

The purpose of the starter intentionally varying the interval between the “set” command and the gun is to discourage timing or guessing the start. An ideal start is one where everyone simply reacts to the sound. The continuing incidents of false starts are evidence that guessing is still in the minds of a few competitors, though the high school false start disqualification rule has ended the coached strategy of purposely false starting.

**(RT) = The Reaction Time Equation**

The sum of these factors is a true measure of the effect of starter position on FAT marks. “A” is flexible due to inconsistent auditory cortex recognition of gun versus background noise, but on average is 0.120 seconds. Louder guns may produce slightly smaller values. “G” is totally unpredictable, but ideally should be zero for competitors reacting to the gun and not guessing. The ideal equation for determining the reaction time “RT” to the start as it appears on the FAT clock is:

$$\begin{aligned}
 \text{RT} &= \text{D} + \text{A} - \text{G} \\
 &= \text{D} + (0.120 \text{ seconds}) - (0.000 \text{ seconds})
 \end{aligned}$$

The only factor within control of race officials is “D” and the uneven delay it produces for the start of any “loud gun” race. It is this factor on which we will focus.

**Worth Worrying About**

We must acknowledge that a “loud gun” start will always generate a ripple in starting impulses for the competitive field. Has the starter’s position been a factor in meets outside of the Games in Sydney? Quite likely yes!

Look at the potential impact of starter position on qualifying race results at the IHSA State Championships (see Table 1). Nearly 300 entries in the past six years may have had their fates determined by where the starter stood for their race. The same uncertainty exists for the recorded time of any place. How many medals have been determined by the starter's impact on FAT results? Officials must minimize the range of "D" values when FAT is used.

**IHSA Boys Qualifying Heats  
2003 – 2008 State Meets**

**IHSA Girls Qualifying Heats  
2003 – 2008 State Meets**

Event	Avg. Time to 1st Non-Qualifier (seconds)	Range in "D" from Starter (seconds)	Entries Potentially Effected	Event	Avg. Time to 1st Non-Qualifier (seconds)	Range in "D" from Starter (seconds)	Entries Potentially Effected
4x800	0.36	0.03	3	4x800	1.13	0.03	4
4x100	0.07	0.06	20	4x100	0.08	0.06	16
3200	NQ	0.03	-	3200	NQ	0.03	-
110 Hurdles	0.07	0.02	12	100 Hurdles	0.06	0.02	17
100	0.01	0.02	37	100	0.03	0.02	26
800	0.18	0.03	9	800	0.29	0.03	6
4x200	0.14	0.06	11	4x200	0.27	0.06	7
400	0.07	0.06	22	400	0.23	0.06	10
300 Hurdles	0.11	0.03	8	300 Hurdles	0.22	0.03	11
1600	0.37	0.03	3	1600	0.80	0.03	2
200	0.03	0.03	23	200	0.06	0.03	18
4x400	0.24	0.05	6	4x400	0.62	0.05	5

Table 1

**The Science of Seeing**

We all are familiar with imperfect sight when it comes to the ability to focus on objects. An entire industry of lens making serves this need to correct near and far sightedness. We are less aware of how the acuity of our seeing changes in our field of vision.

The angle of peripheral vision originates with light falling on the retina (Figure 3) and for most people is 160°. In this peripheral vision region we see motion but little detail. You probably have had the experience of thinking you saw something move in

the corner of your eye and turning to see what it was. Peripheral vision is useless in good officiating since specifics are missing. Was that movement or not? If so, was it a spectator or a competitor? Which competitor?

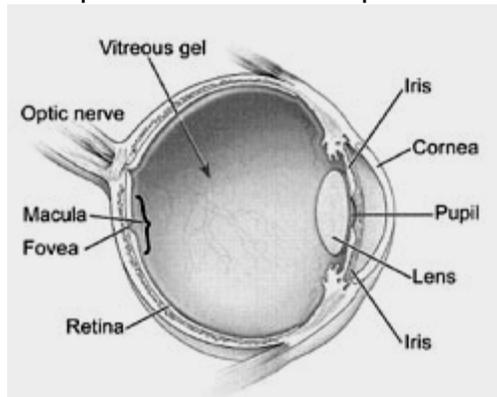


Figure 3

Central vision originates with light falling on the eye's macula and is used to read, drive, and recognize pictures or faces. It spans only 30° horizontally, even less vertically, and is where we see detail and depth (Figure 4). Both hands held side by side with thumbs overlapping at arms length cover approximately 30° of arc. It is central vision that allows us to see small movements and identify with absolute certainty the competitor(s) involved. Officials must be placed so that there are no gaps in their collective central vision of the start.

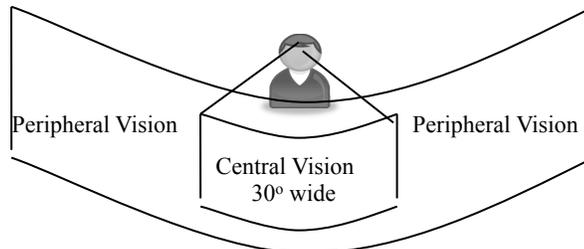


Figure 4

We need a consistent philosophy in the placement of all officials, the duties we expect of them, and the central vision angles they are afforded. Several priorities should be used regarding placement of officials.

**1<sup>st</sup> Priority - Officials make calls on violations in their 30° central vision field.**

**2<sup>nd</sup> Priority - The optimal view of a competitor's start is an unobstructed profile or frontal oblique view.**

**3<sup>rd</sup> Priority - If a profile view is not practical, a straight on frontal view of a competitor is preferable to any view from behind.**

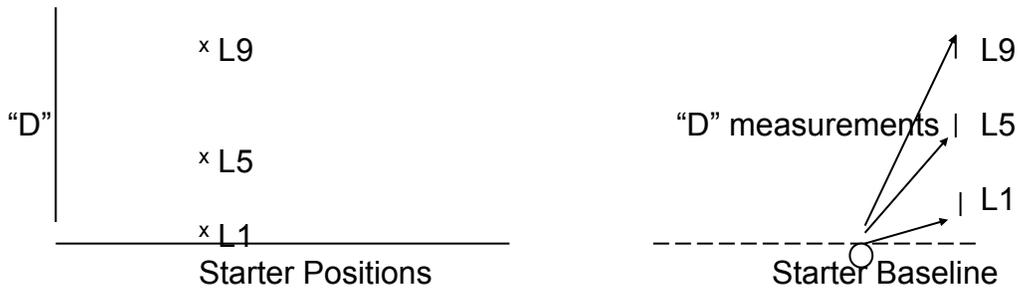
**4<sup>th</sup> Priority - No panning of central vision is necessary for any official to observe their assigned competitors.**

This priority sequence was used in establishing advised positions for officials at the start of a race. The end result was a chain of readiness signals from one assistant to a second, and finally from that assistant to the starter.

**Data Collection**

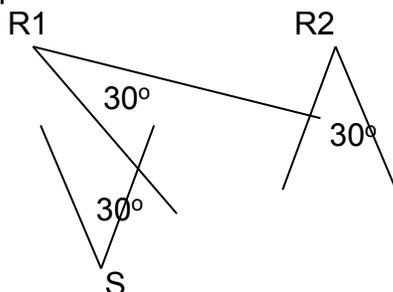
The track facility at Wheaton Warrenville South High School is very similar to that of O'Brien Field on the campus of Eastern Illinois University. Both tracks have nine 42" lanes. Both tracks have their common finish line set back a significant distance from the start of the first curve. The inside curve radii are nearly identical. Data taken from Wheaton should be extremely close to any dimensions in Charleston.

Distance measurements were made from various positions along the starter baseline and the center of the starting lines of Lanes 1, 5, and 9 using fiberglass tape measures. These distances were used to calculate the "D" values for each starter position. Lines on the delay time graphs show how arrival times of the sound wave vary at each starter position along the baseline for all three lanes.



The starter baseline for the straight starting line runs parallel to Lane 1 approximately 2 feet inside the track. The starter's position for this no-stagger start is measured from the starting line extended across the baseline. The starter baseline for the stagger start along a straightaway is the extension of Lane 7's starting line inside the track. The starter baseline for the staggered start on a curve is the extension of Lane 5's starting line along the curve's radius. The starter's position on a staggered start is the distance inside the track along the baseline.

The track facility at Wheaton was put into digital form using a CAD program. Distances as measured on the electronic image of the track agreed to within 1 foot of distances measured at the track with a fiberglass tape. The primary function of the CAD image was to generate accurate central vision angles for officials. Thirty degree angles are constructed from each official's position to display how central vision fields align and overlap.



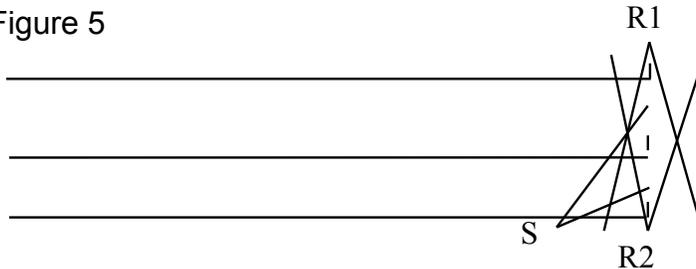
Finally, it is my hope that this data as offered will prove useful in evaluating present practice and modifying placement of officials as deemed necessary.

### Starter Position and Placement of Assistants

Current Practices and Advised Changes

100 meter, 100 meter Hurdles, and 110 meter Hurdles Starts

Figure 5



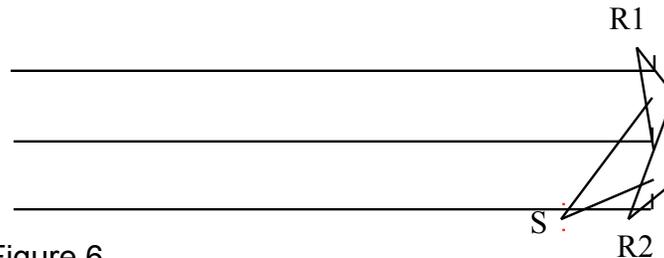
**Current Position (Figure 5):**

“(The starter will) take a position, 8-20 feet from the starting line, on the inside of the track. Make sure you have a line of vision that includes the entire starting line.... The second assistant will signal the first assistant (when) ready and then the first assistant will signal the starter to give the set command.”

“The first assistant should be in a position on the opposite side of the track from the starter... (and) should be in a position on the line.... The first assistant will be responsible for the outside lanes (5-8).”

“The second assistant should be on the infield positioned on the line, opposite the first assistant. The second assistant will be responsible for the inside lanes.”

Figure 6



**Current Position Shifted (Figure 6):**

The assistant starters frequently move one meter ahead of the starting line to see the front of the competitive field and the starting line. Closest runners are in peripheral vision for R1 and R2.

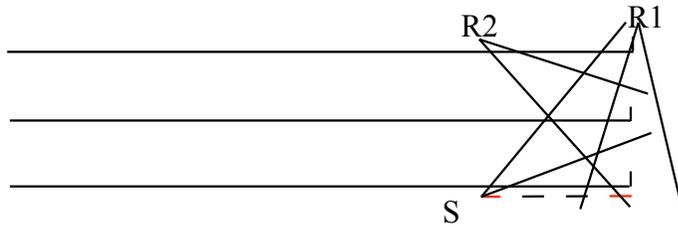


Figure 7

**Advised Position (Figure 7):**

“The starter takes a position, 12 meters from the starting line, on the inside of the track. The starter will be responsible for Lanes 4-9. The second assistant will signal the first assistant when ready and then the first assistant will signal the starter to give the set command.”

“The second assistant should be in a position on the opposite side of the track from the starter. The second assistant will be responsible for Lanes 1-6.”

“The first assistant should be positioned on the line outside the track. The first assistant will be responsible for the viewing all lanes from behind.”

**Rationale for Modification:**

Moving the starter farther down the track reduces the FAT difference for the field from 0.026 seconds to 0.013 seconds. All competitors cannot fit into the starter’s central vision. Assistant starter 2 is moved outside and the two officials split the field. Assistant starter 1 is away from the track and in line with the back of the field to see early motion/slippage for all lanes. Assistant starter 1 is also located in the starter’s central vision.

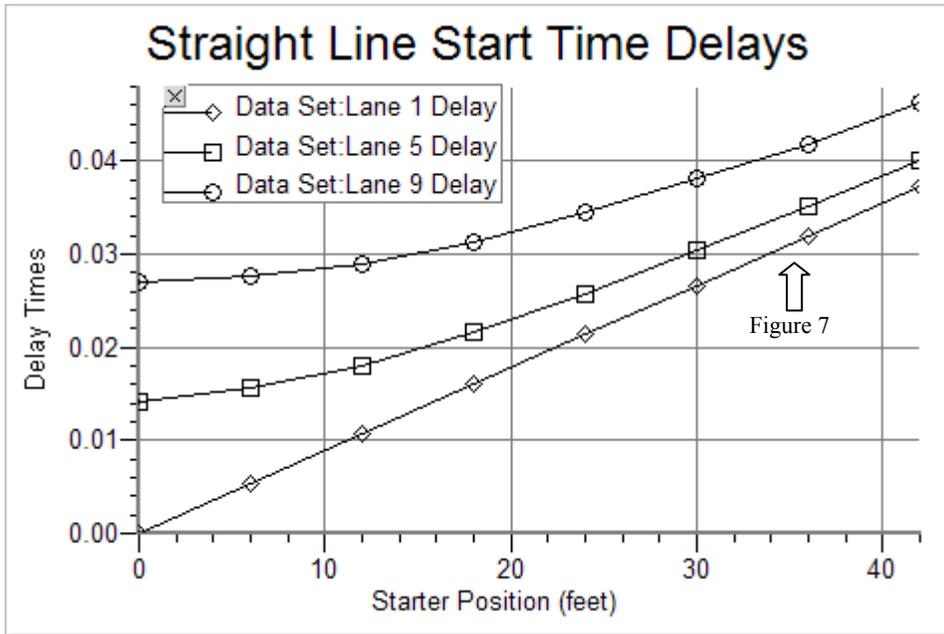


Figure 8

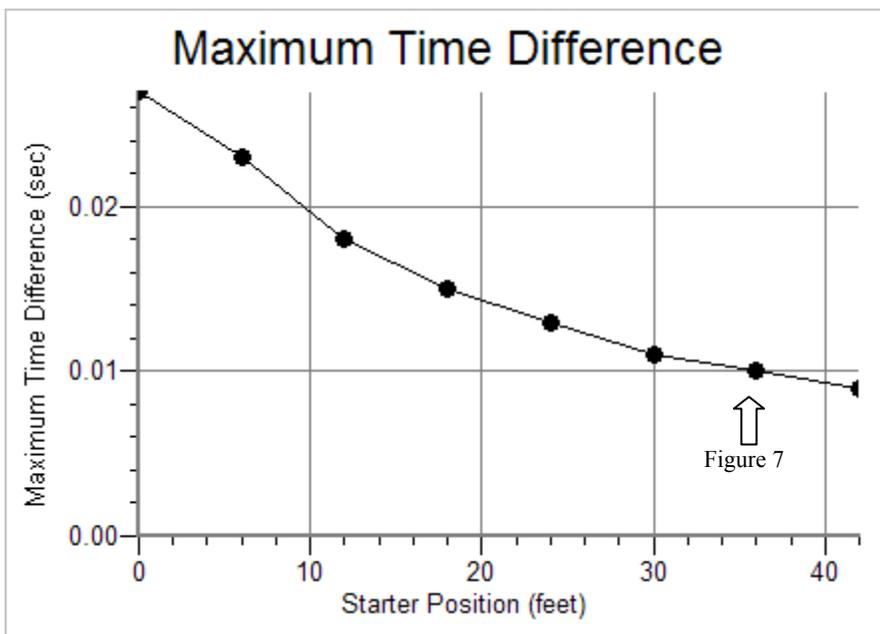


Figure 9

At a distance of 36 feet from the starter no competitor hears the gun by more than 0.01 seconds before any other competitor. The arrow is the time difference for the proposed starter position.

## 300 meter Hurdle Start

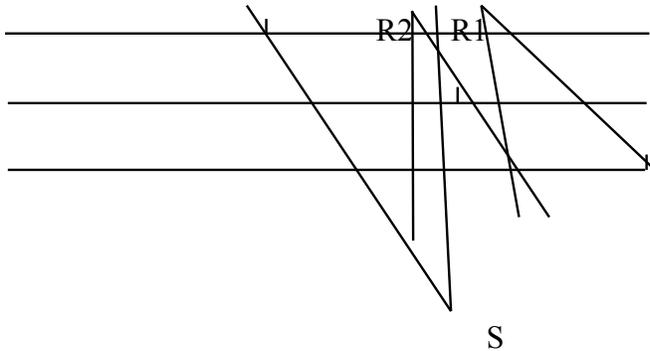


Figure 10

### Current Positioning (Figure 10):

“The starter will take a position on the infield midway between the inside and outside runner.”

“The assistants will be in a position opposite the starter in or near the outside lane and within the starter’s line of vision.”

“...the first assistant will watch the inside three lanes, the second assistant will watch the middle three lanes, and the starter will watch the outside three lanes...”

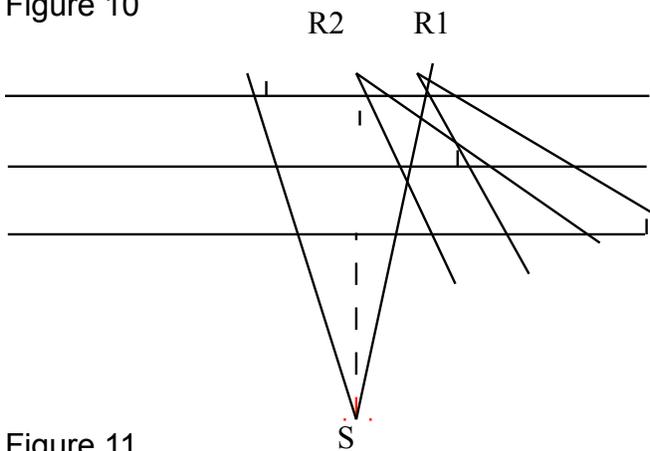


Figure 11

### Advised Positioning (Figure 11):

“The starter will take a position on the infield in line with the Lane 7 start and 15 meters from the track.”

“The first assistant will stand in Lane 9 in line with the Lane 6 start and watch the inside three lanes. The second assistant will stand in line with the Lane 7 start and watch the middle three lanes. The starter will watch the outside three lanes.”

### Rationale for Modification:

Moving the starter farther from the track and across from Lane 7 start instead of the current Lane 5 reduces the FAT difference for the field from 0.028 seconds to 0.012 seconds. The FAT difference between Lanes 1 and 9 falls to 0.003 seconds. The assistants essentially remain in the same positions as the current configuration since it offers frontal oblique views of their assigned runners while remaining in the starter’s central vision field.

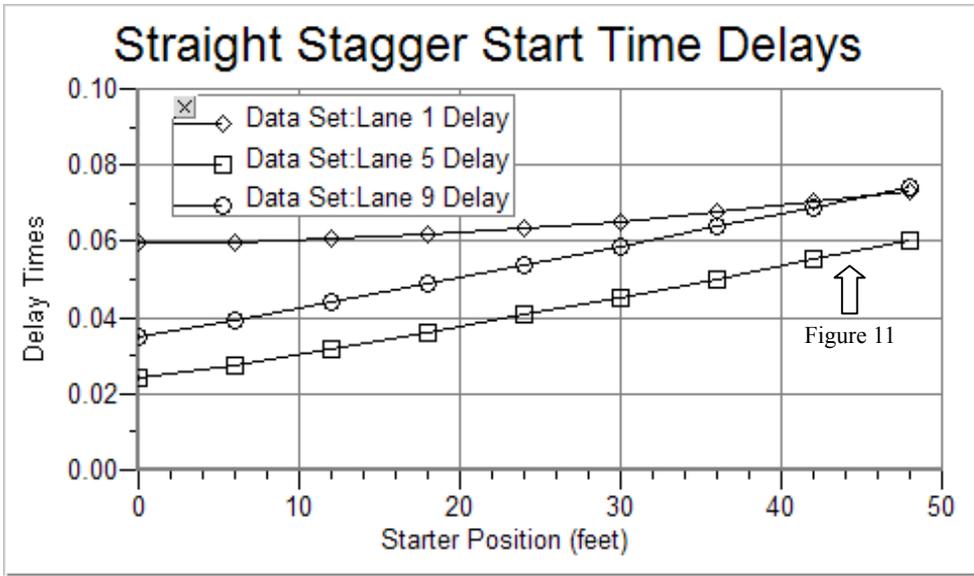


Figure 12

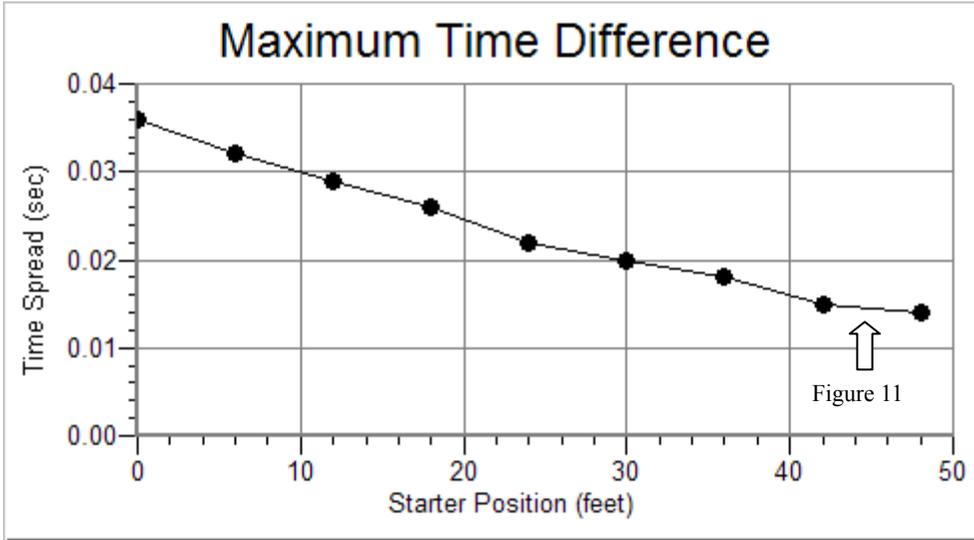


Figure 13

## 200 meter Start

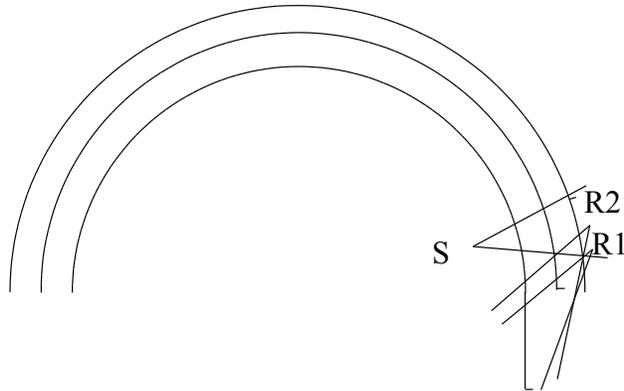


Figure 14

### Current Positioning (Figure 14):

“The starter will take a position on the infield midway between the inside and outside runner.”

“The assistants will be in a position opposite the starter in or near the outside lane and within the starter’s line of vision.”

“...the first assistant will watch the inside three lanes, the second assistant will watch the middle three lanes, and the starter will watch the outside three lanes...”

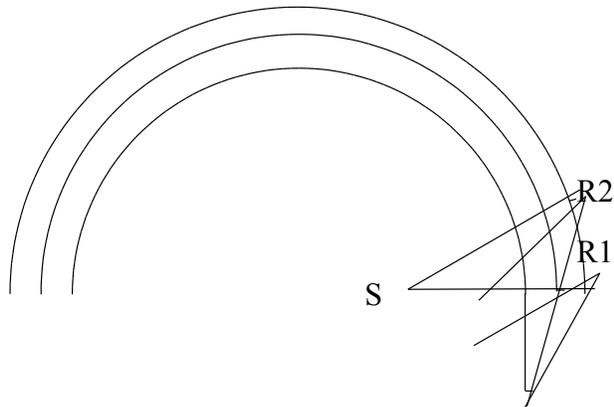


Figure 15

### Advised Positioning (Figure 15):

“The starter will take a position on the infield in line with the Lane 5 start and 18 meters from the track.”

“The first assistant will stand in Lane 9 in line with the Lane 5 start and watch the inside three lanes. The second assistant will stand in line with the Lane 8 start and watch the middle three lanes. The starter will watch the outside three lanes.”

### Rationale for Modification:

Moving the starter farther from the track and across from Lane 5 instead of the current Lane 7 reduces the FAT difference for the field from 0.029 seconds to 0.016 seconds. It also gives the starter two more lanes of central vision. Moving the assistants reduces the issue of forward runners blocking the central vision view of other runners directly down the starting field.

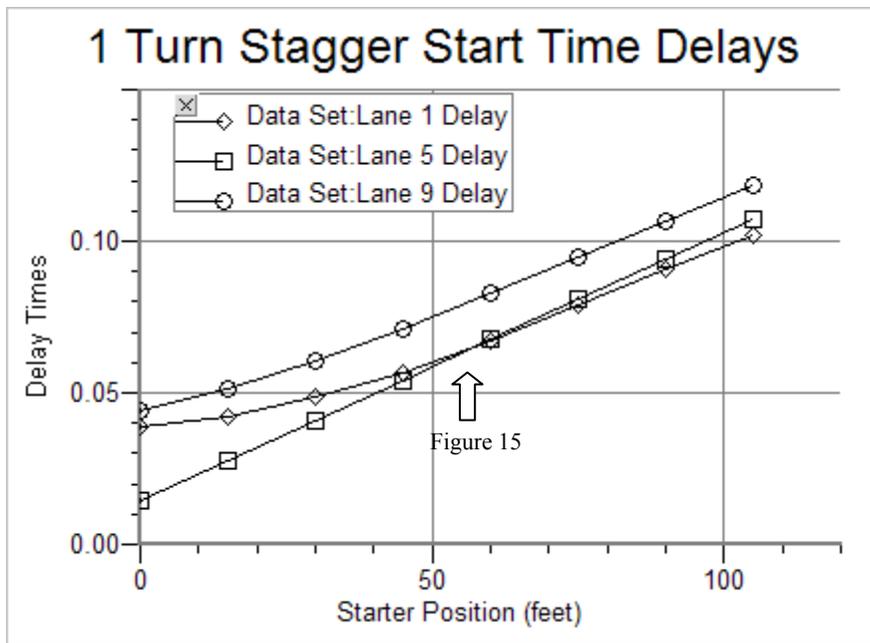


Figure 16

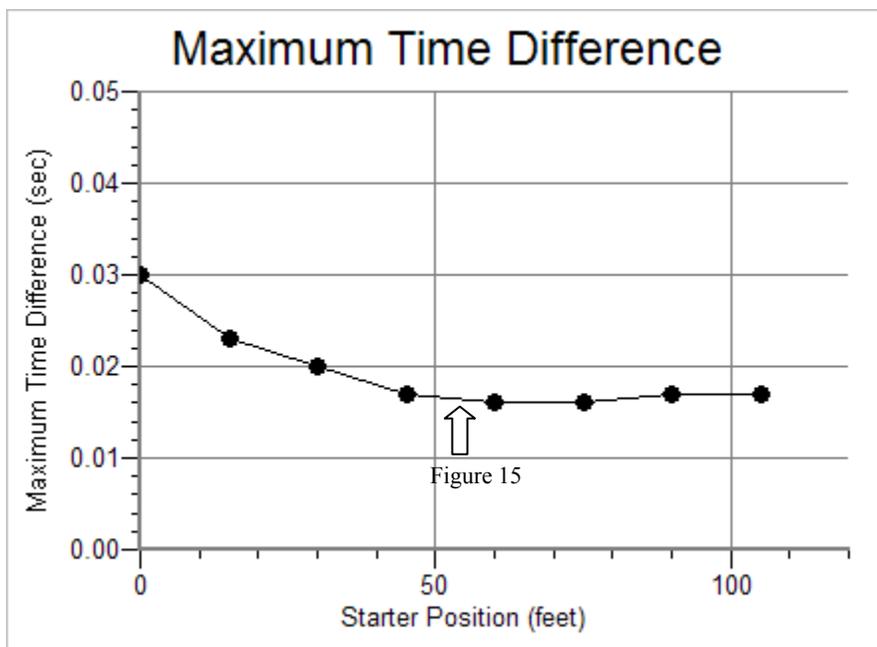
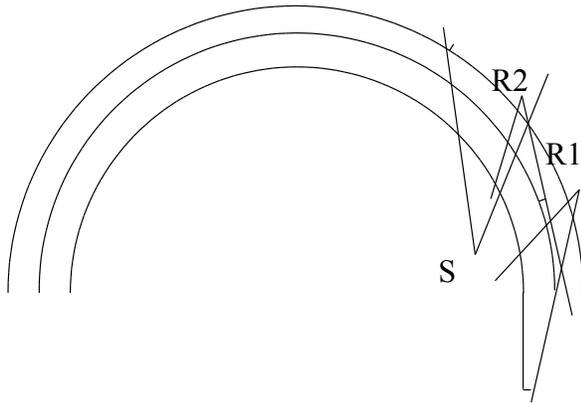


Figure 17

## 4x100 meter Relay, and 400 meter Start



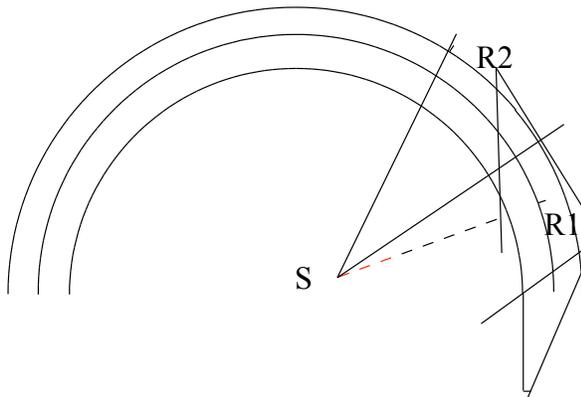
### Current Positioning (Figure 18):

“The starter will take a position on the infield midway between the inside and outside runner.”

“The assistants will be in a position opposite the starter in or near the outside lane and within the starter’s line of vision.”

“...the first assistant will watch the inside three lanes, the second assistant will watch the middle three lanes, and the starter will watch the outside three lanes...”

Figure 18



### Advised Positioning (Figure 19):

“The starter will take a position on the infield in line with the Lane 5 start and 28 meters from the track.”

“The first assistant will stand in Lane 9 in line with the Lane 4 start and watch the inside three lanes. The second assistant will stand in line with the Lane 8 start and watch the middle three lanes. The starter will watch the outside three lanes.”

“The first assistant signals the second when the inside lanes are ready. When the second sees the inside lanes are ready and has their own middle lanes ready, the starter is signaled. When the starter sees the outer lanes ready and the second assistant ready, the race can begin.”

Figure 19

### Rationale for Modification:

Moving the starter farther from the track and across from Lane 5 start instead of the current Lane 7 reduces the FAT difference for the field from 0.059 seconds to 0.016 seconds. It also gives the starter two more lanes of central vision. Moving the assistants reduces the issue of runners blocking the central vision view of other runners directly down the starting field. The first assistant starter cannot stand in the central vision of the starter as described with the current positioning format anyway. The advantage gained with the proposed positioning is more direct angles to the lanes each official is responsible to observe.

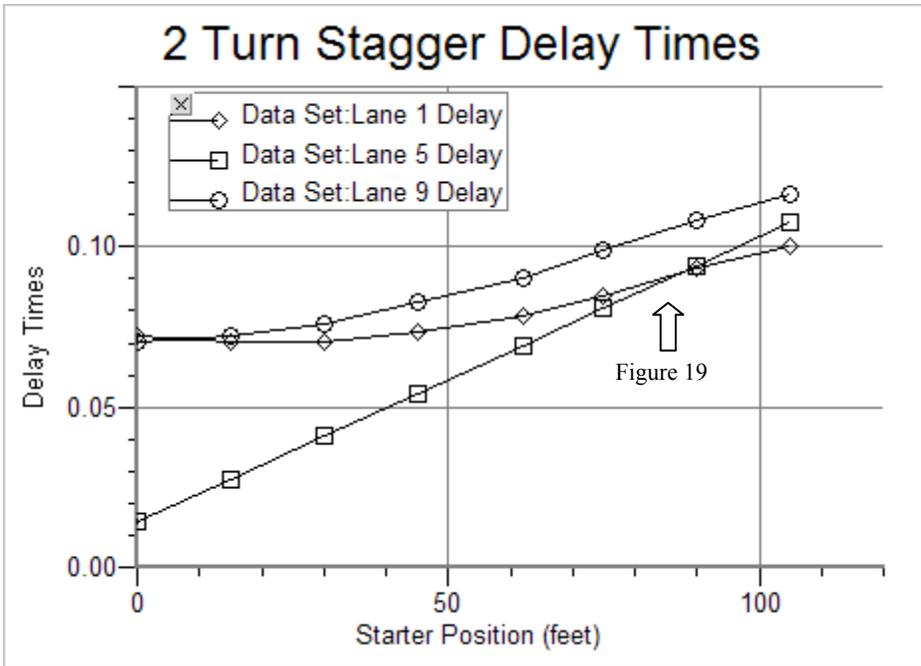


Figure 20

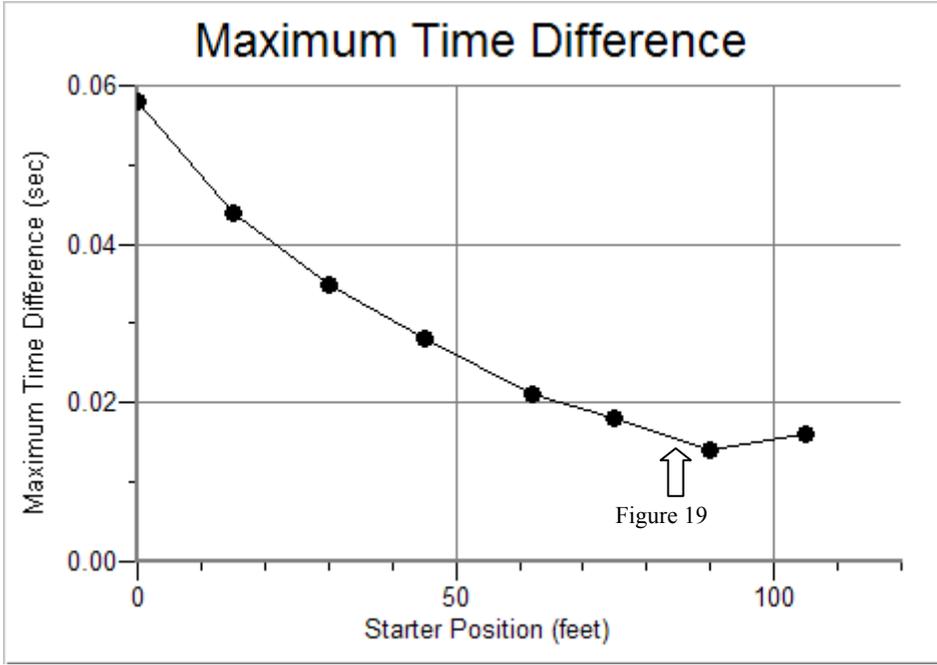


Figure 21

## 4x400 meter Relay Start

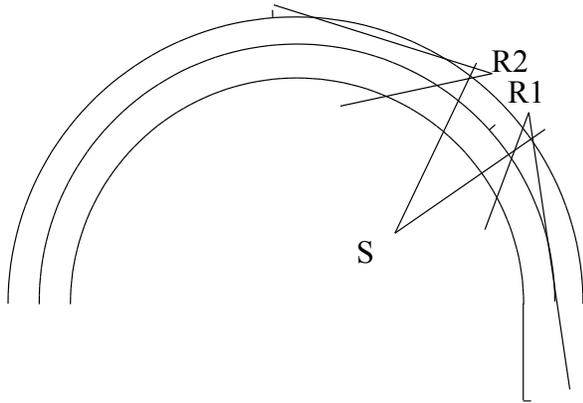


Figure 22

### Current Positioning (Figure 22):

"The starter will take a position on the infield midway between the inside and outside runner."

"The assistants will be in a position opposite the starter in or near the outside lane and within the starter's line of vision."

"...the first assistant will watch the inside three lanes, the starter will watch the middle three lanes, and the second assistant will watch the outside three lanes..."

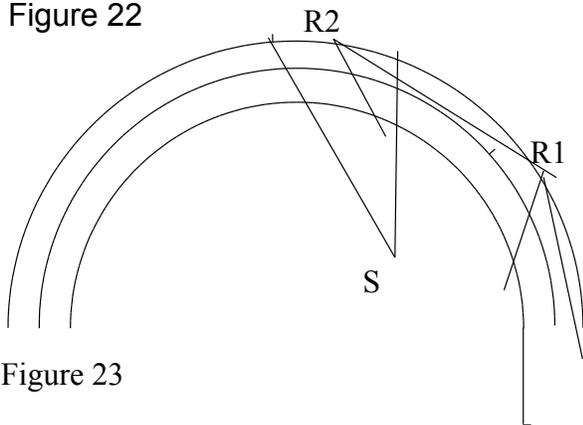


Figure 23

### Advised Positioning (Figures 23 & 24):

"The starter will take a position on the infield midway between the inside and outside runner." (Figure 23)

"The starter will stand on the infield in line with the Lane 5 start and 18 meters from the track." (Figure 24)

"The first assistant will stand in Lane 9 in line with the Lane 5 start and watch the inside three lanes. The second assistant will stand in line with the Lane 8 start and watch Lane 4 through 7. The starter will watch the outside two lanes."

"The first assistant signals the second when the inside lanes are ready. When the second sees the inside lanes are ready and has their own middle lanes ready, the starter is signaled. When the starter sees the outer lanes ready and the second assistant ready, the race can begin."

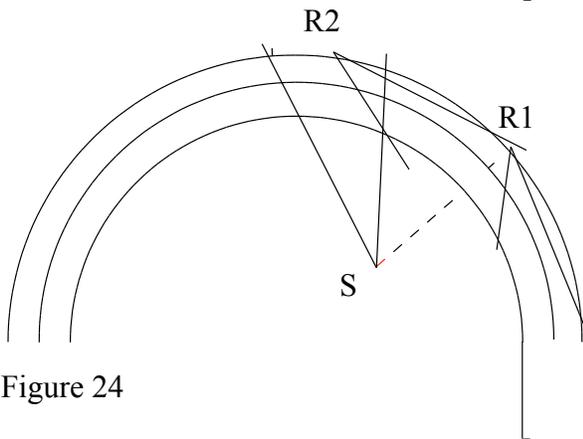


Figure 24

**Rationale:**

The optimal position for producing the smallest FAT difference (0.016 seconds) is unfortunately in the center of the High Jump venue. The first advised position keeps the original starting position where the second advised position decreases the FAT difference from 0.052 sec to 0.035 sec. All officials have either profile or frontal views of their assigned lanes, eliminating the least preferred view from the rear for assistant two.

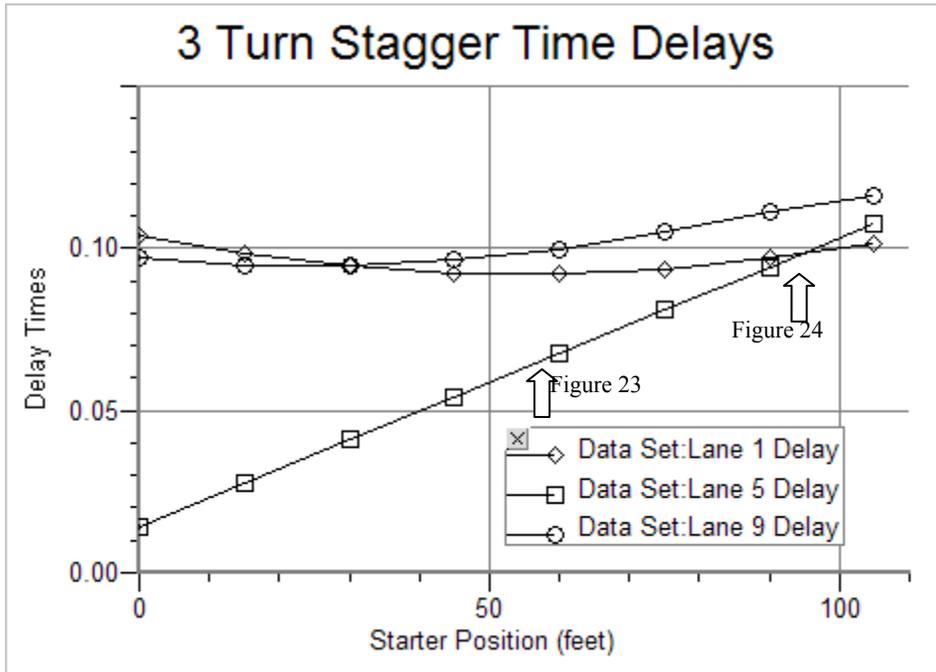


Figure 25

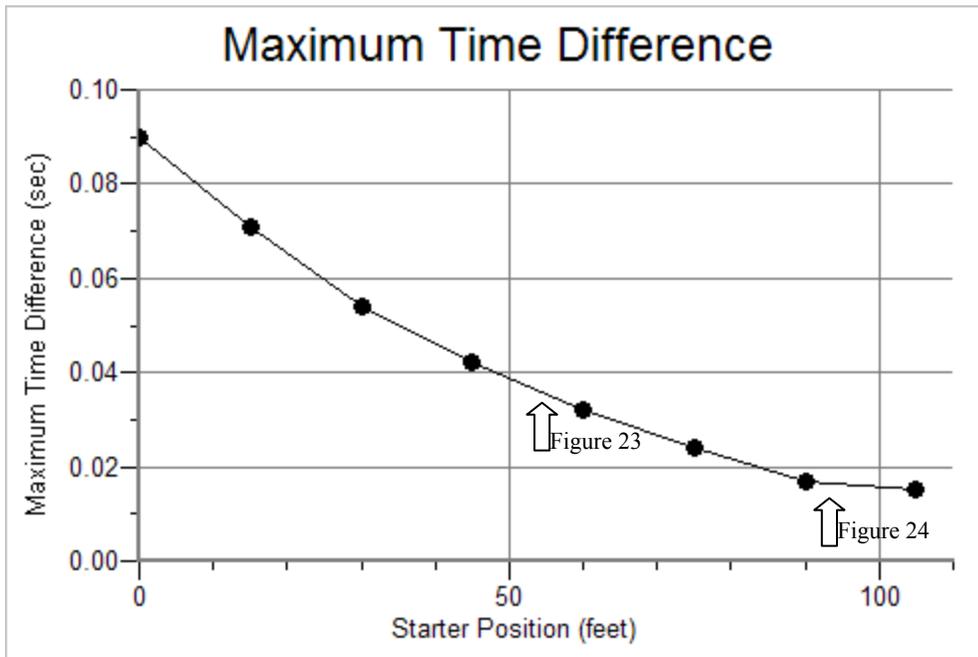


Figure 26

## 4x200 meter Relay

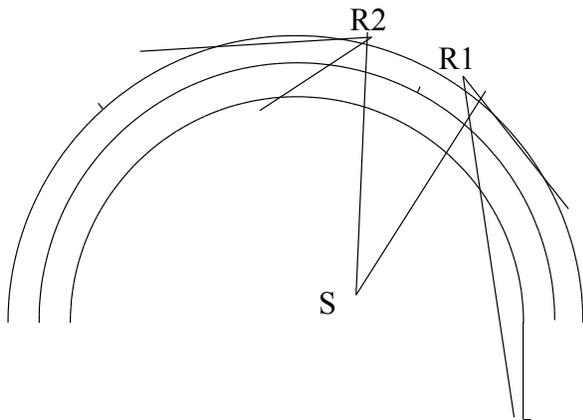


Figure 27

### Current Positioning (Figure 27):

“The starter will take a position on the infield midway between the inside and outside runner.”

“The assistants will be in a position opposite the starter in or near the outside lane and within the starter’s line of vision.”

“...the first assistant will watch the inside three lanes, the starter will watch the middle three lanes, and the second assistant will watch the outside three lanes...”

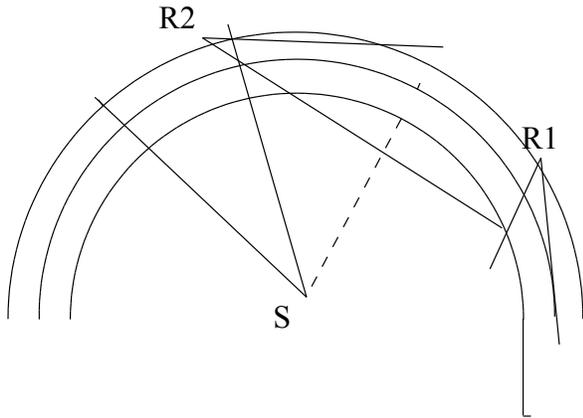


Figure 28

### Advised Positioning (Figure 28):

“The starter will stand on the infield in line with the Lane 5 start and 33 meters from the track.”

“The first assistant will stand in Lane 9 in line with the Lane 4 start and watch the inside three lanes. The second assistant will stand in line with the Lane 8 start and watch Lane 4 through 7. The starter will watch the outside two lanes.”

“The first assistant signals the second when the inside lanes are ready. When the second sees the inside lanes are ready and has their own middle lanes ready, the starter is signaled. When the starter sees the outer lanes ready and the second assistant ready, the race can begin.”

### Rationale:

The optimal position for the starter is behind the center of the High Jump venue where the FAT difference is reduced from 0.058 sec to 0.017 sec. All officials have either profile or frontal views of their assigned lanes, eliminating the least preferred view from the rear for assistant two.

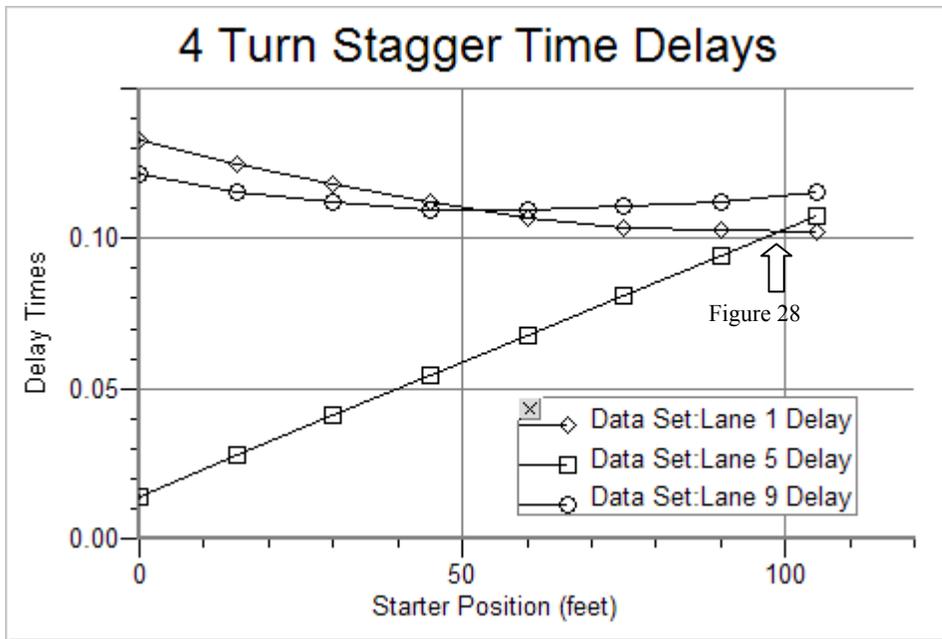


Figure 29

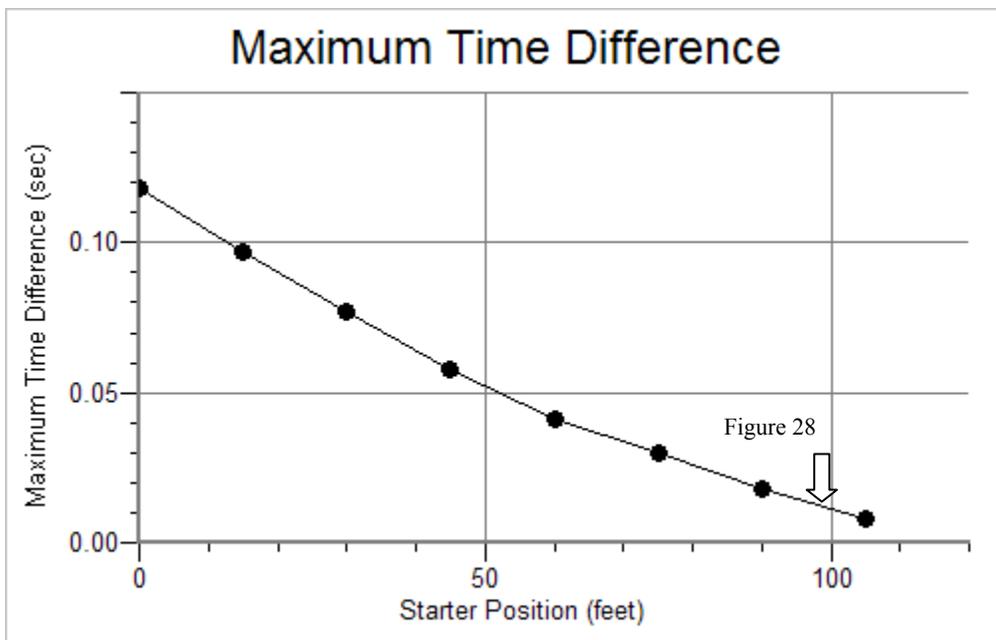


Figure 30

## **Final Comments**

When the results of track competition shifted to fully automatic timing we made a flawed assumption. We assumed that because timing began with a transducer and ended with a camera that it was fair to compare the times in one heat against the times in another. Do not dismiss the significance of the unequal delays in the arrival of the sound of the gun just because they appear to be small. Put their effect in perspective with other things monitored at the start of a race.

No one would knowingly allow a runner in the 400 meter dash to set blocks nearly 19 inches in front of the starting line, but that is precisely the advantage we give a runner in Lane 5 (at 50 second pace) over a runner in Lane 9 using current starter positioning. If a 100 meter competitor in Lane 1 moved forward nearly a foot before the gun went off, it would be easily recognized as an unfair start. Yet this is the advantage we give an 11.0 second 100 meter runner in Lane 1 over a rival in Lane 9 when we stand twenty feet from the starting line. A half miler with a toe covering the alley start line is cause for calling up the field. A heel on the line is the advantage our present positioning gives to center alleys over alleys at the edges.

Only the use of “silent gun” starting will completely erase these inequalities. Nevertheless, we can reduce them with a scientific and reasoned approach to positioning the starting gun (see Table 2). What we can’t eliminate we should make smaller.

<b>Event</b>	<b>“D” Differences Using Present Starter Position</b>	<b>“D” Differences Using Advised Starter Position</b>
4x800	0.03	0.02
4x100	0.06	0.02
3200	0.03	0.02
110 Hurdles	0.03	0.01
100	0.03	0.01
800	0.03	0.02
4x200	0.06	0.02
400	0.06	0.02
300 Hurdles	0.03	0.01
1600	0.03	0.02
200	0.03	0.02
4x400	0.05	0.03

Table 2

In every case the shift from current practices shrinks the inequality in hearing the start. In every case the new position increases the distance between the starter and the racers. At this point we need to ask ourselves which is the greater priority, a few competitors having a better shot at breaking time records or establishing as much equality as possible across the competitive field in hearing the start of the race.

Certainly this repositioning will “slow” the FAT times by amounts measurable in hundredths of seconds since every competitor will have to wait a little longer before the sound wave reaches them. From the outset my contention has been that what everyone *expects* in any footrace is fairness. Most people, if not all, assume electronic timing generates a fair result. Officials in charge of competition must not hold the same misconception.

Similar caution should be in place for locating assistant starters. No matter how the assistants are finally arranged, each should do the “two hand” check as described earlier. If both hands don’t cover every competitor they are supposed to monitor, they are not in position to see using their central vision. The mechanics among officials for signaling readiness can always be adjusted. In my opinion it is high resolution *seeing* of the assigned competitors that should be paramount.

Current practices are the thoughtful product of many highly qualified professionals and in no way am I implying that these techniques are bad. The suggestions I offer are directed toward two goals. One is to improve an official’s ability to make calls with confidence. The other is to establish as much fairness as possible in the timing of every “loud gun” FAT start.

Competitive running has had a long history of innovation. A starting gun replaced dancing toward the line trying to achieve a start by mutual consent. Lanes were set by markings on the surface instead of suspended ropes. Starting blocks replaced trowels. Time was added to order of finish in race results, first with the use of sweep-hand stopwatches with a resolution of 1/5<sup>th</sup> second to more modern electronic versions offering 1/100<sup>th</sup> second precision. With every technical change came an adjustment in how we officiate. I believe in the era of FAT we may need to give more attention to where we stand when we pull the trigger.