

# Experience with ReactTime



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## Contents

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<b>INTRODUCTION</b>	<b>2</b>
<b>REACTIME SYSTEM OVERVIEW</b>	<b>2</b>
Block Sensors and Block Mounts	3
Command Center	3
ReactTime Software	4
<b>NCAA DIVISION I NATIONAL CHAMPIONSHIPS</b>	<b>5</b>
Spectrum of Athletes	8
<b>US OLYMPIC TRIALS</b>	<b>9</b>
First Mover	10
Consistency and Repeatability	12
<b>CONCLUSION</b>	<b>13</b>

## Introduction

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This document describes our internal experiences using the ReactTime Reaction Time and False Start Detection system during the 2000 athletics season. The system was used at the following competitions:

Competition	Location	Date
NCAA Division I National Championships	Durham, NC	May 31 – June 3
IAAF Grand Prix II	Seville, Spain	June 9
IAAF Grand Prix I	Eugene, OR, USA	June 24
Oregon Track Classic	Portland, OR, USA	June 25
US Olympic Trials	Sacramento, CA, USA	July 13-23

With the exception of the IAAF Grand Prix II event in Seville, all the events were done with the wireless version of ReactTime and personally operated by Doug DeAngelis. The Seville event used a wired system operated by our Spanish distributor MONDO Iberica.

## ReactTime System Overview

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ReactTime is the trade name for a reaction time and false start detection system manufactured by Lynx System Developers, Inc. of Woburn, Massachusetts in the United States of America.

ReactTime can be used in two different ways: competition mode or training mode. When used as a competition system, the following components may be present (terms in italics will be used throughout this document):

- Wireless *Block Sensors* for each lane (attached via *Block Mounts*)
- *Speakers* for each lane
- ReactTime *Command Center*
- Paper Tape *Printer*
- Starter's *Headset* (bi-directional audio)
- Recall Starter's Headset (listen only)
- Central Charging System
- Notebook PC with *ReactTime Software*

When used as a training system, the following components may be present:

- Block Sensor (attached via a Block Mount)
- Speaker
- Start Button or Gun Sensor (depending on whether the start sequence is generated by ReactTime or a human starter)
- Photocell(s) (for time-to-distance readings)
- Notebook PC with ReactTime Training Software (not required; used to save and analyze data)

Please reference the attached product literature and user manuals for more details.

## Block Sensors and Block Mounts

Block Sensors are devices which can be attached to any starting block using a Block Mount. Block Mounts are designed to be mounted on all known brands of starting block, so special starting blocks are not required. Block Sensors are made as separate components so that it is possible to leave the Block Mount on the starting block and easily remove the sensor (either for safekeeping, charging, or moving to another block). The Block Mount assures a direct physical connection between the block itself and the Block Sensor. This connection has no slack, assuring that all movement in the block is transmitted to the sensor. This is central to the proper operation of the detection algorithm which samples movement in the block 1000 times per second in order to make a determination on when the athlete first *intentionally* moves.

The Block Sensor is extremely sensitive, which is what allows it to detect the slight movements of the starting block relative to the track surface. Although it is very sensitive, various signal processing filters are used to normalize for aspects which may change from event to event and athlete to athlete, and this assures that unintentional movements are not detected. Fortunately, our experience has shown that intentional movements such as the start or the kind of twitch that is typically called by an experienced starter have a very distinct “signature” compared to the kind of movement that is normally associated with an athlete simply being in the set position (we shall see this later in this discussion). Make no mistake: there is no such thing as a perfectly still athlete – the goal is therefore to detect when an athlete has “commenced his starting motion” as per IAAF Rule 162.6, and report this back to the Command Center, and then to the starter.

## Command Center

The Command Center is a small, custom computer operated by the starter or their assistant which serves the following functions:

- 1) Distributes the audio from the Starter’s Headset to the Speakers in all the blocks;
- 2) Emits a tone in the Starter’s Headset if any of the Block Sensors detected movement before 100/1000ths of a second after the gun was fired;
- 3) Prints the reaction times for each athlete on the Paper Tape Printer;
- 4) Retrieves all movement trace data from the Block Sensors for transmission to the ReactTime Software.

If a false start is detected by the Command Center, the tone will be emitted in the Starter’s Headset within 200/1000ths of a second after the gun was fired. As a result, any delay in firing of the recall gun is generally due to indecision on the part of the starter (or often, mechanical failure of the gun itself).

There are a number of software settings in the Command Center which allow the operator to control its function. These allow the operator to set, for example:

- 1) the number of lanes in the system;
- 2) the volume of the audio in the Speakers;
- 3) the volume of the audio in the Starter’s Headset;
- 4) the *Active Detection Period*.

The Active Detection Period is the period during which the Block Sensors are actually detecting motion. This is used to mask, for example, movement related to the athlete actually entering the set position.

This period can be defined as either a fixed amount of time *after* the starter has given the set command or as a fixed amount of time *before* the gun was fired. The second mode, where the system waits until the gun has fired and then looks back in time, is a key feature allowing the ReacTime system to avoid incorrect detections which might otherwise occur during a long hold by a starter. This has become our preferred mode of operation.

The ReacTime system can be either wireless and battery powered or wired and AC powered. When AC powered, only the Command Center needs to be plugged in to an outlet since the power for the Block Sensors is sent down the data wires. In either case, the individual Block Sensors constantly report their status back to the Command Center so that the operator is aware of a loss of power or connectivity in advance of the start of any race.

## ReacTime Software

The ReacTime Software, and the computer that it runs on, are not required for proper operation of the system. In competition, the software is used for the following purposes:

- 1) to retrieve, display, print and keep a permanent record of the Movement Trace for every athlete in every race, so that these may be consulted in the case of a question or protest;
- 2) to communicate the reaction times for each athlete to the primary FinishLynx system, so that this data may be integrated with the official results and passed on to the appropriate places (scoreboard, printed results, Internet, etc.)

It is very easy for the operator of the Command Center to also operate the ReacTime Software if it is in use. The system literally requires only one button push to arm it for each race (two if you want the set times indicated on graphs).

## NCAA Division I National Championships

The only official function of ReacTime at this competition was to provide a wireless system for distributing audio from the starter to the individual starting blocks. Because of this, the recall tone was turned off in the Starter's Headset for the entire competition. Unofficially, we used this event to test several versions of the software and detection algorithm before determining which we would select for the final production system.

In order to give a basic understanding of the data generated by the ReacTime system, we will first look at a "normal" 100m race. Figure 1 shows all the reaction times for each athlete as well as the power traces. Each graph shows a 5 second period in time across the X-axis, starting three seconds before the gun and going until two seconds after the gun. The vertical dimension, which we call "power", is a relative measure of the amount of energy absorbed by the starting block. There are also a number of vertical lines on the graph. From the left, the first line represents when the starter gave the set command, the next is when the gun went off, and the last is the "legal limit" of 100/1000ths of a second after the gun. You will note that in every case in this race, there was no significant movement in any lane until after the legal limit, and therefore this was a fair start.

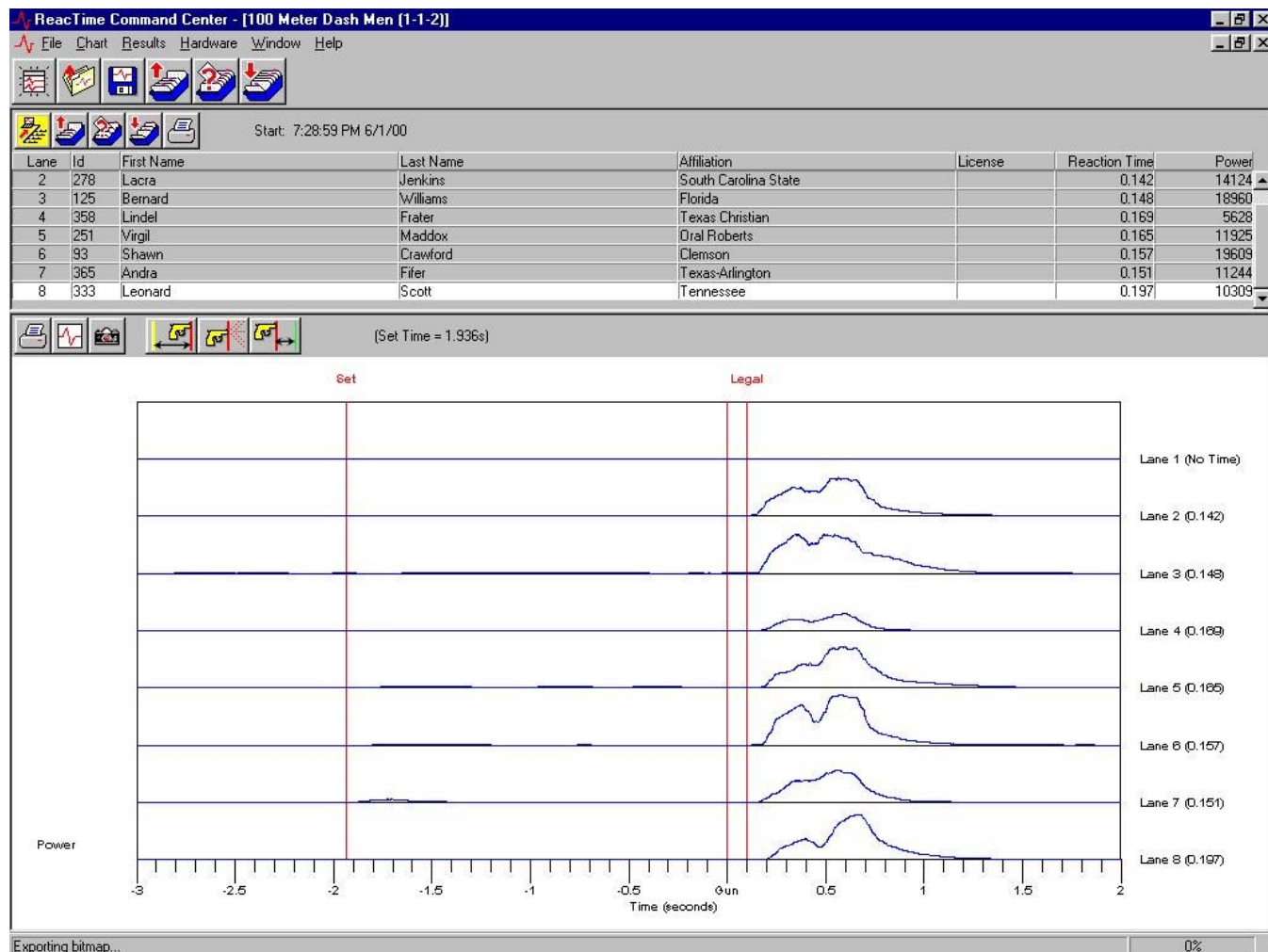
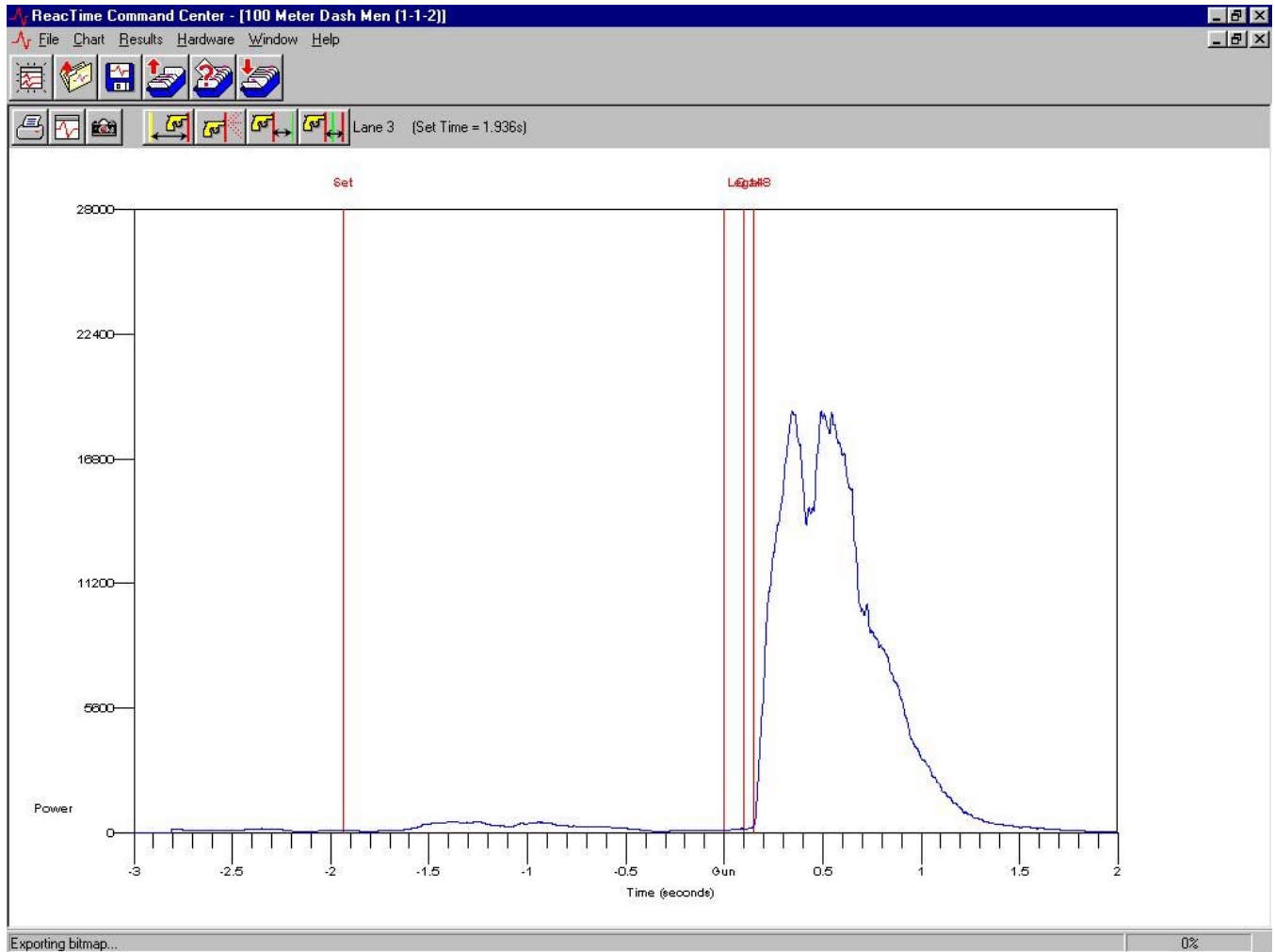


Figure 1 Fair Start NCAA Div 1 National Championships

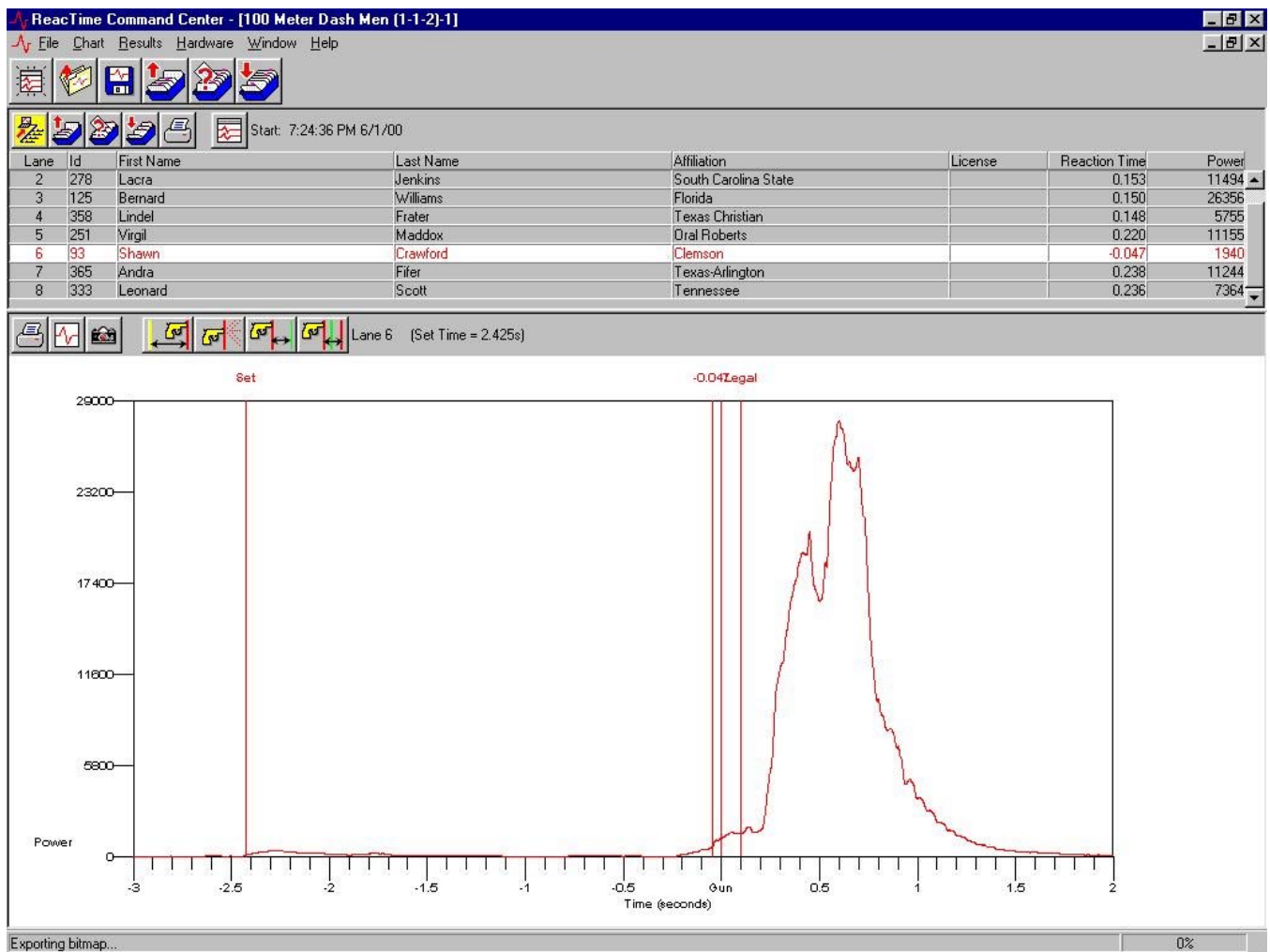
Individual lanes can also be “zoomed in” on using the software. An example of this can be seen in Figure 2, which is a zoomed in view of the trace for Lane 3. Note how much steeper the trace is on the zoomed in version. It is the same data being displayed, it is just that there is now only one graph consuming the vertical screen space instead of eight. For this reason, it is generally best to zoom in on a lane which may be in question so that the subtleties of motion can be examined in greater detail.



**Figure 2 Trace for Lane 3 NCAA Championships**

Because of the “one false start and you’re out” rule in the NCAAs, it is not surprising that we did not see very many false starts at this competition. We will discuss here, however, one particular heat of the 100m in which an athlete “twitched”; he began his starting motion but did not fully leave the blocks. The starter called the race back, but did not issue a false start.

Figure 3 below shows what the trace data for the offending athlete looked like in the ReactTime Software. As you can see, the trace and the athlete’s name are in red, indicating a false start. Compare this trace to the previous one, for example, and you will see the difference between a hard twitch and a powerful exit from the blocks. It is also useful to note in both these traces the relative amount of motion detected after the set command was given (i.e., while the athlete was entering the set position). From this, one can see that in the case of this false start, the athlete showed intent to start, even though they did not fully exit the blocks.



**Figure 3 Athlete Movement Prior to Start at NCAA Championships**

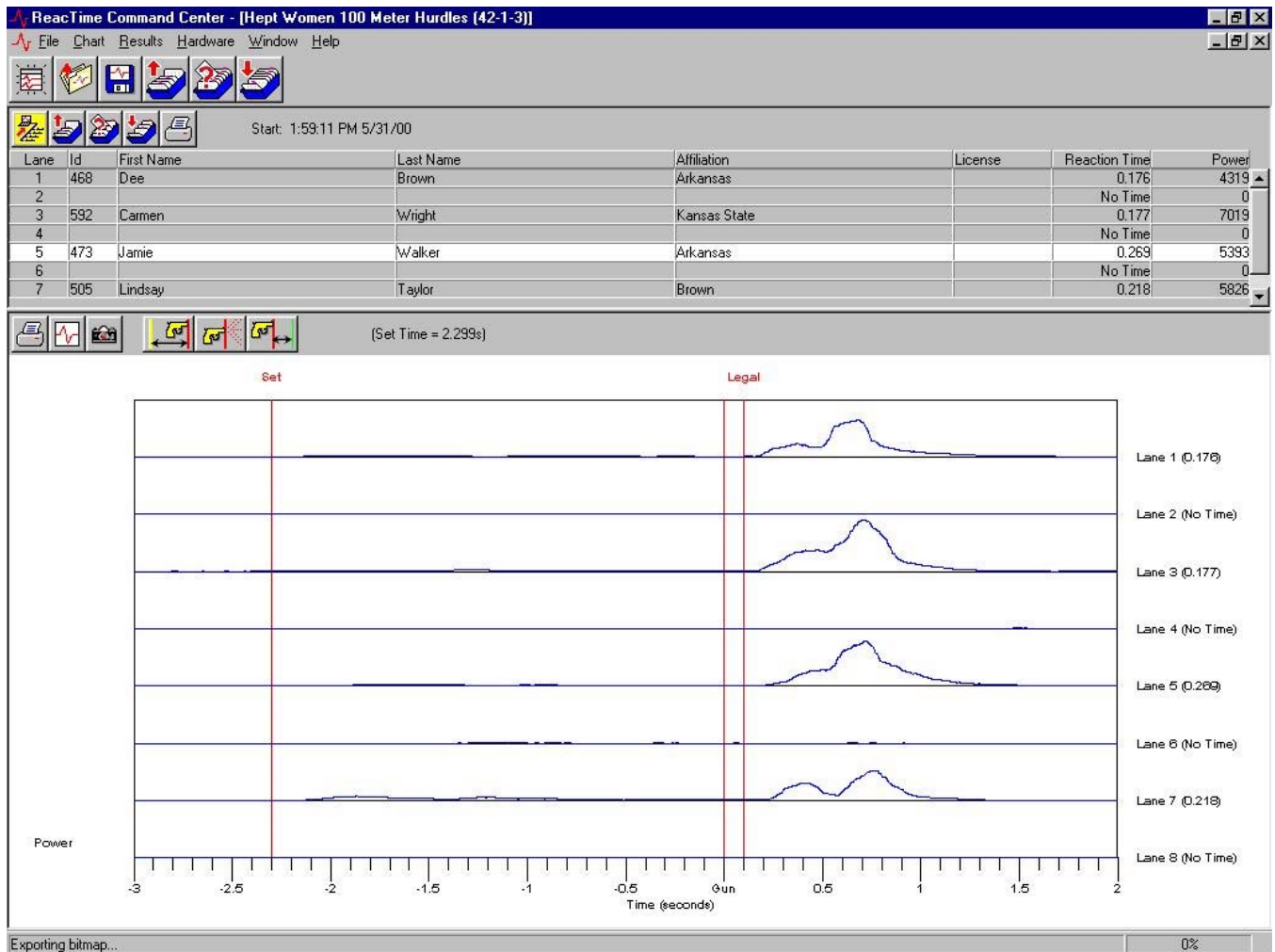
Video footage taken simultaneously with all the races, as well as discussions with the starters of the races, confirmed that the ReactTime system was indeed triggering on the kind of motion that they would consider to be illegal, and not triggering on the kind of motion they would consider to be legal. Since this distinction is a difficult one to make definitively, our goal was to make the ReactTime system conservative. That is to say, if a ReactTime system detects what it determines to be illegal motion, there was almost certainly significant illegal motion. If it is ever going to err, it is going to be in not calling a race back that had some motion that may or may not have been significant. It should also be clear that in these discussions, what we are really talking about is a distinction in the relative size of “twitches” in the set position; it would be virtually impossible for an athlete to actually fully leave the blocks with any force and not have that motion be considered significant.

What we were surprised by at the NAAs, however, was the amount of motion in the set position that was allowed by the starters. They seemed to prefer holding slightly longer until all athletes were still rather than calling the race up and starting over, or calling a false start. In order to deal with this, we modified the system software so that it would only detect motion that occurred near the gun; specifically in the period 300/1000ths before the gun and 100/1000ths after the gun (the actual period is selectable by the operator – this is simply what we chose). We then explained to the starter that motion well in advance of the gun was to be called at their discretion, leaving the system to call the “close ones”. Although the

settings allow for a more aggressive use of the system, we feel that this is the proper use of this kind of equipment in competition. This method strikes a fair balance between the responsibility of the starter to commence a fair race while not causing endless restarts of a race as a result of inconsequential movement in the set position.

## Spectrum of Athletes

In order to show ability of the system to “normalize” for athletes of varying strength and power, we include Figure 4, a sample trace from the Women’s Heptathlon Hurdles. These athletes are, on average, likely to have the least powerful starts relative to the Men’s 100m athletes.



**Figure 4 NCAA Heptathlon Trace**

As you can see, although the power for these athletes is somewhat lower (in the range of 4000-7000 as compared to 5000 to 20000 for the Men’s 100m), the look of the data and the significance of the motion relative to the motion in the set position is still sufficient to make a determination of motion that is consistent with reality.

One thing we learned was that at a major competition which may switch between 100m, 200m and 400m events often on the schedule, it is useful to have two separate systems so that one can be dedicated to the 100m start, and another to the 200m/400m. We addressed this issue at the Olympic Trials.

## ***US Olympic Trials***

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At the US Olympic Trials, the ReactTime system was used for both audio distribution and in its complete capacity in detecting false starts. Also, due to the fact that one false start was allowed, there were many more opportunities for it to come into play. The following summarizes the system performance over the eight days of competition:

- There were no situations in which the system called a false start that it shouldn't have;
- There were no situations in which the system did not call a false start when it should have;
- There was one situation in which the system did not give a tone to the starter to recall (even though the false start had been detected). This was attributable to operator error; the operator had turned off the headset tone for one race (an amputee 100m) and forgot to turn it back on for the next race. As Murphy's Law would have it, of course, this happened in the final of the Men's 100m. It is the case, of course, that the starter hears other tones in advance of firing the gun that let them know that the system is "ready"; and they weren't hearing those either. Unfortunately, the starters had not had enough experience with the system to realize that this was a problem, and so did not inform the operator. In the future, this will be handled by giving both the starter and the recall starter a headset, and by explaining better to all starters what they should expect to hear when the system is properly configured.
- Over the 8 days of competition, there was just one situation (200m on the last day) in which we received some interference from NBC's high-energy wireless "head shot" cameras. Since we hadn't had any problems all week, we didn't realize the cause until it was too late, or we could have solved it. As a result, there were a few races at the end of the day where we had to turn detection off to assure that the interference would not adversely effect the outcome.
- We were able to integrate the reaction times into the official results which can be seen, for example, at:

<http://www.cyberscoreboard.com/results.php?id=27341>

<http://www.cyberscoreboard.com/images/27341/27341-1-1-rt.jpg>

## First Mover

One of the more common problems for a starter is not always identifying that a false start has occurred, but identifying who the “first mover” was. ReactTime assists in this by offering the following indications to the starter and the operator of the system:

- 1) The starter not only hears a tone, but hears a number of tones corresponding to the offending lane;
- 2) The LCD readout on the ReactTime Command Center immediately shows the offending lane;
- 3) The Paper Tape Printer will show “FS” beside the lane of the offender;
- 4) The ReactTime software will highlight the offender in red, and allows visual verification that others moved after him or her.

Figure 5 shows an example of a race from the Olympic Trials in which multiple athletes moved before the legal limit, and in which the starters were able to consult the system to assure that the correct athlete was charged.

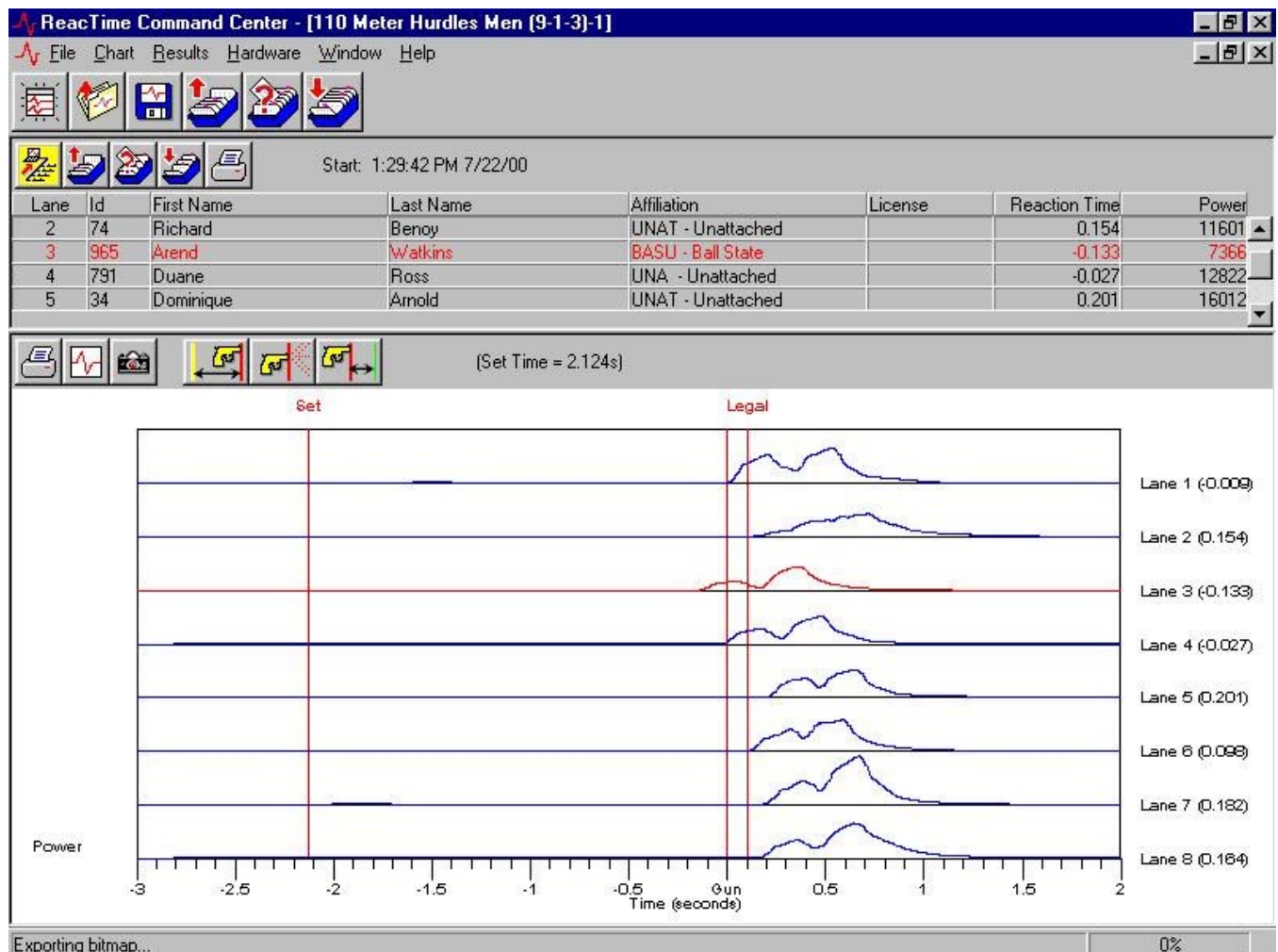


Figure 5 US Olympic Trials - Multiple Athlete Movement

A similar situation can be seen in Figure 6 below. This one is more subtle, however, since the first mover (Lane 4) started his motion first, but was not the first athlete to fully come out of the blocks.

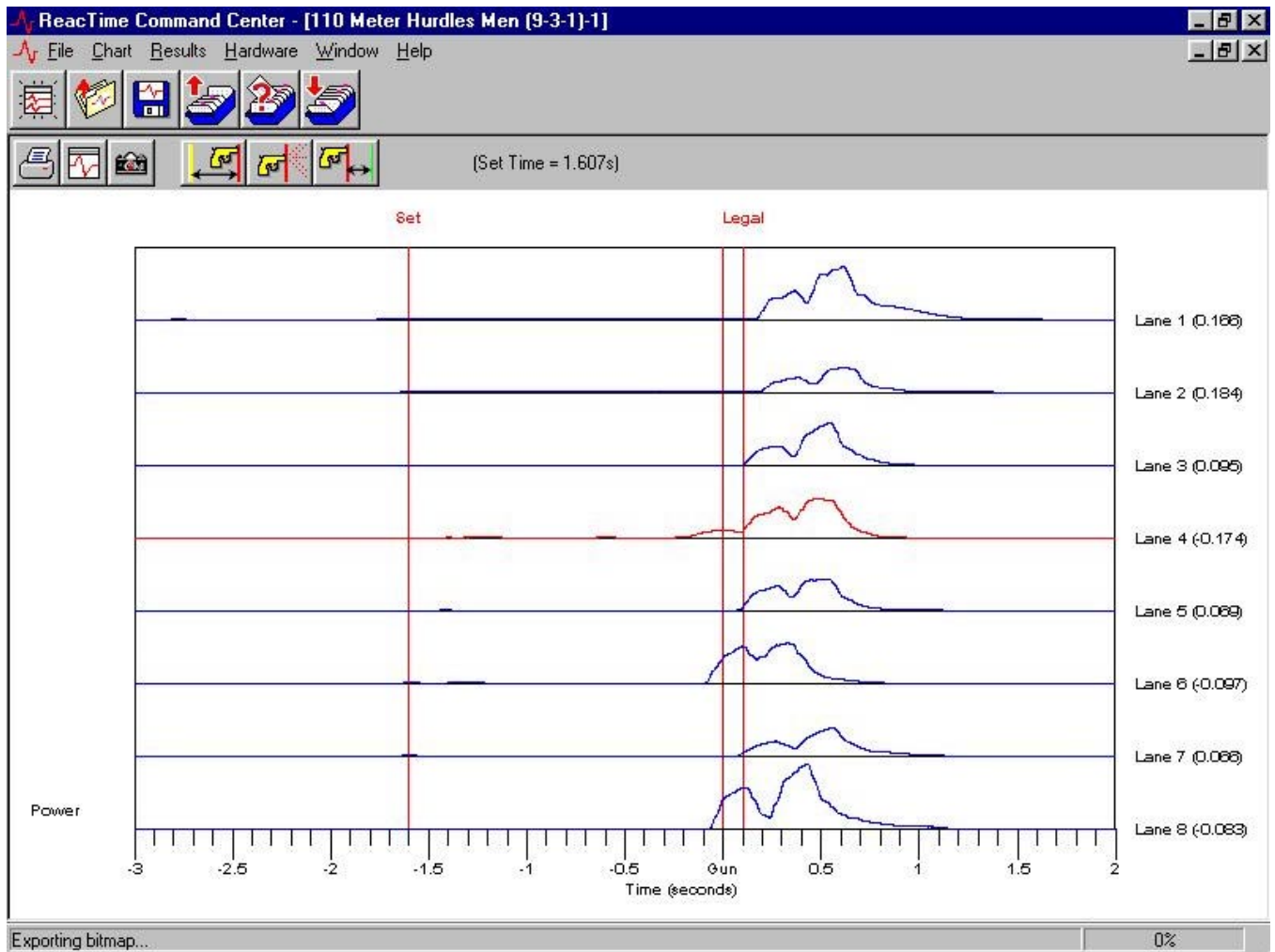
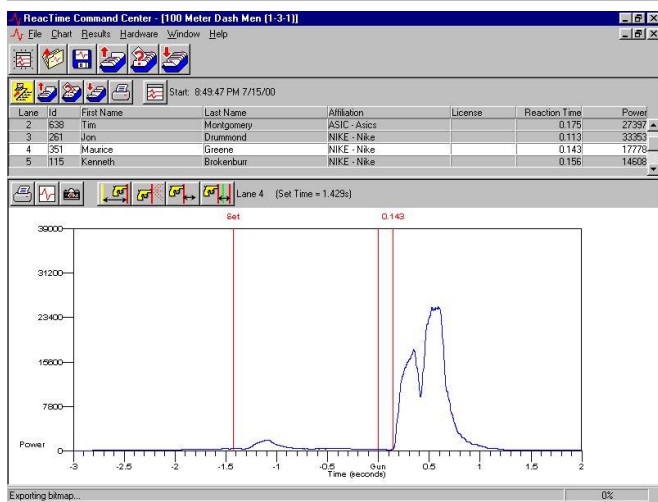
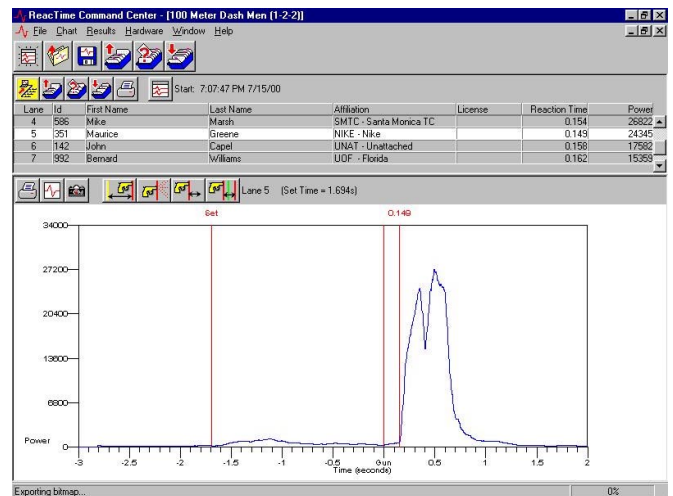
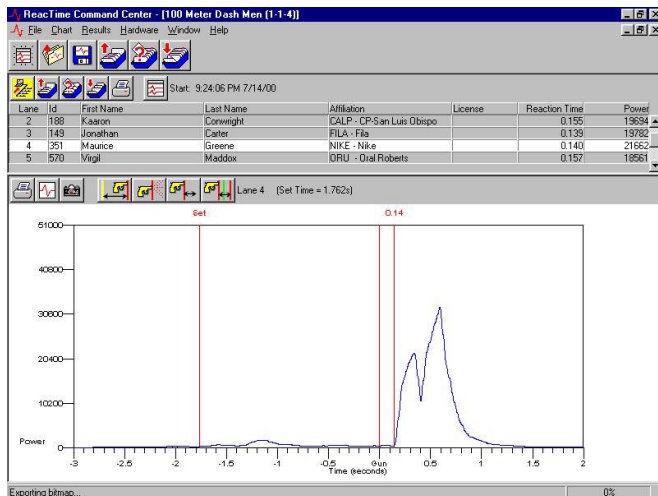


Figure 6 US Olympic Trials - Multiple Athlete Movement (2)

## Consistency and Repeatability

As an example of the consistency and repeatability of the data generated by ReactTime, we will just look at the traces generated by a single athlete in this competition, Mr. Maurice Greene. Below are the individual traces for his lane in the heats, semifinals and final of the 100m. In each case, this athlete exhibits two distinct pushes, the second slightly more powerful than the first. His reaction times in these three races are .140, .149, and .143.

**Table 1 Traces for Maurice Greene at US Olympic Trials**



## **Conclusion**

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The ReactTime Reaction Time and False Start Detection System is a major advance over any previous systems of its type for the following significant reasons:

- 1) It is the first completely wireless false start detection and audio system.
- 2) Individual block sensors can be operated as standalone training devices.
- 3) Enables use on any manufacturer's starting blocks.
- 4) Allows accurate detection in a wide variety of competitions, from youth to professional.
- 5) It is the first affordable system to allow easy integration of reaction times into the data flow.

*Note: ReactTime is protected by US Patent Number 6002336 as well as a number of patents pending worldwide.*