

## LINE CALLING

The introduction of Cyclops at the Wimbledon Championships in 1980 marked the advent of electronic aids to assist officials in tennis. The subsequent growth of the game and simultaneous improvement in computer processing power has driven the development of systems to track and detect balls, which has resulted in the potential to automate line-calling.

In 2003 at the second International ITF Tennis Science and Technology congress in London, the governing bodies, players, equipment manufacturers and television commentators joined in a panel discussion on the future of electronic line-calling.



In November 2003, the ITF, in collaboration with the WTA and ATP, produced a protocol for the evaluation of electronic line-calling systems, and in August 2004 at Flushing Meadows during US Open qualifying, Auto-Ref became the first system to be evaluated.

Evaluations consist of three phases:

1. Assessment of the accuracy of the system under 'laboratory' conditions, and practicality/usability in a demonstration under controlled conditions.
2. A further accuracy and 'shadow' test under tournament conditions, in which the system is set up at a tournament, but the calls made are not used by on-court officials.
3. If the system performance in accuracy and shadow testing is deemed suitable, evaluation proceeds to an accuracy and 'live' test, in which the system is used by officials to make/review on-court decisions.

## Hawk-Eye Officiating

Hawk-Eye became the second electronic line-calling system to be evaluated under laboratory conditions in December 2004, in Hampshire (UK).

A Phantom high-speed camera was used to collect digital video images of ball impacts at four different locations around a court. At each site, the camera was mounted approximately 1 cm above the court surface and operated at 2,000 Hz (pictures per second), with a shutter opening of 50 microseconds to ensure still images.

Each camera image consisted of a matrix of  $512 \times 512$  pixels. A field of view in the plane of ball movement of  $0.5 \times 0.5$  m was calibrated, giving a resolution of approximately 1 mm. The videos were digitised, with an overall uncertainty in the ITF readings of  $\pm 0.9$  mm, and the results were compared with those from Hawk-Eye.

In each test, a standard tennis ball was projected onto the surface close to the line. Various impact angles and speeds were used. At two locations, a compressed-air ball cannon was used, which was angled at approximately  $30^\circ$  to the horizontal and which fired balls at the line with zero spin at 30 to 40 ms<sup>-1</sup> (67-90 mph). At a further two locations, a dual-wheel ball projector (BOLA) was used, which projected balls at 40 or 50 m/s (90-125 mph) from a height of approximately 2 m from the opposite side of the net.

On 14 October 2005, the ITF announced that Hawk-Eye Officiating had met the standards set by the committee comprising representatives of the ITF, ATP and WTA Tour for use in reviewing decisions made by on-court officials.

In January 2006, the ITF's Official Mixed Teams Championships, Hopman Cup, became the first tournament to use an Electronic Line-Calling System in an officially sanctioned event. This system, Hawk-Eye Officiating, worked extremely well and was a very popular addition with players, officials, the media and the general public.

## Hawk-Eye Live

Hawk-Eye Live became the first electronic line-calling system to complete the evaluation process for use as a live (real-time) system in June 2020.

---

## FOXTENN Top Real Precision System

FOXTENN became the second electronic line-calling system to complete the evaluation process in December 2016. In 2017, the ATP Moselle Open in Metz became the first professional tournament to use FOXTENN.



## FOXTENN Live

FOXTENN Live became the second electronic line-calling system to complete the evaluation process for use as a live system in November 2021.

### FlightScope Line Calling System

FlightScope became the third line-calling system to complete the evaluation process in January 2020.



### Serve Speed Systems

In parallel with the evaluation of line-calling systems, the ITF Technical Centre also launched a scheme to validate the accuracy of systems used for measuring the speed of serves. To date, one system has completed evaluation – FlightScope RacquetRadar.

