



Player Analysis Technology Approval report

Baseline Vision

Test code: PAT-23-029

Serial no: n/a

Software versions:
iOS 12 and later, Android 9.0 and later

Firmware version:
6.013



Issue date: 11 October 2023

Objective: To test and evaluate Baseline Vision Player Analysis Technology according to Rule 31 of the 2023 Rules of Tennis.

Result: Approved

SUMMARY

The Baseline Vision system uses a camera device mounted on the net post to capture and process data. This device includes two video cameras, a processing unit, two speakers and two LED strips. The software on the processing unit allows data such as the 3D trajectory of the ball, ball bounce position and player position to be reconstructed from the camera images.

Players must scan the device QR code using their mobile device on the Baseline app to start data capture. No coaching information is displayed on the camera device. Coaching information, such as match statistics, stroke speeds and ball bounce locations are available on an auxiliary device (e.g. smartphone) via the Baseline app. The LED strips and speakers on both sides of the device provide alerts (e.g. 'in'/ 'out' call, battery status) and are switchable (on/off) through the app settings.

Restrictions on the access by a player to Baseline components during periods when coaching is not and is allowed are as follows:

COMPONENT	NO COACHING	COACHING
Baseline Vision device	Permitted	Permitted
Auxiliary device (e.g. smartphone)	Not permitted	Permitted

NOTE Approval does not attempt to, nor does it in fact, establish the accuracy or reliability of data or fidelity of its transmission, including (but not limited to) the provision of 'in'/ 'out' decisions for the purposes of line-calling.

MAIN COMPONENTS

The main components of the system are described in table 1 and depicted in figure 1.

COMPONENT	FUNCTION(S)
Baseline Vision device	Capture images of play; transmit, store and process data; provide player indications via speakers and LED strips
Baseline net post mount	Allows the Baseline Vision device to be mounted on the net post
Baseline server	Store and transmit data
Baseline app	Communicate data
Auxiliary device (e.g. smartphone)	Communicate data

Table 1. Description of the components of the Baseline system.



Figure 1. Components of the Baseline system (from left to right): Baseline Vision device (with LED strip illuminating white); Baseline net post mount; auxiliary device (smartphone) showing the Baseline app. Not to scale.

DATA CAPTURE AND PROCESSING

The Baseline Vision device is mounted on a net post and contains two video cameras to capture images of play. The device is $23.5 \times 16.5 \times 9.2$ cm in size. The cameras are directed either side of the net (one camera for each side of the court). The cameras contain sensors which capture images and transfer them to the processing unit for image processing and object detection (e.g. the ball, players, rackets, court lines). A light sensor constantly measures the illuminance and automatically adjusts the camera exposure settings.

Software on the device's processing unit uses the location of the ball, player and court lines to calculate ball and player trajectory data. The data calculated includes:

- 3D trajectory of the ball
- 2D bounce position
- Ball speed
- Type of shot (e.g. forehand, backhand)
- 2D position of player
- Rally maximum and average length
- Net clearance of each shot

The only interaction required to start data capture with the Baseline vision device is to press the on/off button once the device is secured above the net post, and launch a session from the Baseline App.

At least one of the players must log in to their Baseline account by scanning the QR code located on the camera device or entering the device's unique four-digit code on their phone. Alternatively, the QR code can be removed from the device and scanned off court (to avoid players bringing their phones onto the court or to avoid unauthorised people logging into the session).

There are two modes available to players using the Baseline Vision device:

1. Free play – users can play a match or rally and the system will collect data and call shots 'in'/'out'.
2. Gamified drills – the system collects data relating to the selected drill and calls shots 'in'/'out' (figure 2 displays an example of one of the drills available).



Figure 2. Introduction to the 'deeper' drill as seen on the Baseline app.

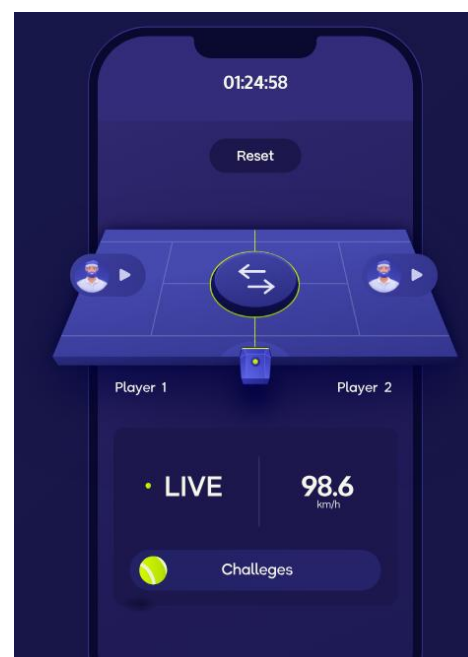


Figure 3. To switch ends, the arrows icon must be clicked (as seen on the Baseline app).

Once a session is in progress, players must use the Baseline App on their phone to change ends (see figure 3). However, if players are not permitted access to their devices while playing (e.g. in a tournament), the Chair Umpire, or other official, can use their device to change the ends of the players by logging into the session.

If a player chooses to end the session, data capture is stopped, and all the data recorded can be obtained from their Baseline App account.

COMMENTS

Start/stopping data capture is player driven. No external internet connection is required to connect to the Baseline Vision device as the camera emits its own Wi-Fi signal. No assistance from human operators is required to run the system, except where players cannot access their phone, e.g. in tournaments, and an official is needed to inform the system that the players have switched sides.

Transmission of data between the Baseline vision device and a mobile device is wireless. Data is securely stored on AWS cloud services and can only be streamed to connected devices. The Wi-Fi connection is authenticated using the QR code scan or the four-digit passkey.

No coaching information is displayed on the Baseline Vision device. Players must end the session before match data are uploaded to their account.

All device configurations and playing modes can be edited on the Baseline App.

The QR code can be removed from the device and scanned off-court if players are not authorised to have devices on-court.

DATA COMMUNICATION

Coaching information is available on an auxiliary device (e.g. smartphone) using the Baseline app. Information includes:

1. Ball placement
2. Player position
3. Ball speed and spin of each shot
4. Match/drill statistics (e.g. serve percentages, points won, rally length)

Additionally, players can download and replay videos of sessions recorded using the Baseline app.

The device will call shots 'in'/'out'. This information is communicated to players via the speakers in the Baseline device and indicated by green/red illumination of the LEDs. There is an option on the Baseline app to challenge any of the last five shots recorded, which shows a close-up 3D visualisation of the ball hitting the court.

Players automatically share data with their opponent (if the opponent is also logged in).

COMMENTS

No coaching information is presented on the device.

Coaching information is available through the Baseline app. Therefore, players must not have access to devices that may have the app installed, such as smartphones or tablets, when coaching is prohibited.

Players automatically share data with their opponent (if logged in). Consequently, a player can have access to data on their opponent at times when play is suspended, e.g. during a rain delay.

Audio and visual (LED) alerts from the device can be switched on/off via the app.

ADDITIONAL INFORMATION

Client:

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Date received: 22 August 2023

Report prepared by: Luke Akroyd

Report authorised by: Jamie Capel-Davies

Revision number: 1

Please note:

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