

# Electronic Line-Calling Systems: Evaluation Procedures

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by the Electronic Line Calling  
Authorisation Body



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## Definitions

Terms defined in the singular shall have the same meaning when used in the plural, and terms defined in the plural shall have the same meaning when used in the singular.

Advanced Notification of Strike (ANS)	The formal written notification that the ELC Authorisation Body intends to impose a Strike upon a System within a certain time period, subject to any response from the Vendor within the relevant time period.
Appeal Panel	A group of four (4) members consisting of one representative from each of the ITF, ATP, WTA and GST (excluding any members that are also members of the JEC) which shall be appointed to hear an appeal in relation to an ELC Classification decision made by the ELC Authorisation Body and in accordance with these Procedures.
Applicant Company	Either the Vendor or any person/company applying for ELC Classification on behalf of the Vendor.
CAS	The Court of Arbitration for Sport in Lausanne, Switzerland.
Chair Umpire	As described in the <i>ITF Duties &amp; Procedures for Officials</i> .
Classification Fee	The annual fee payable by the Vendor for ELC Classification at a particular ELC Classification Level as set out in section 9 (Fees).
Cooling-Off Period	The period of time in which the Vendor is unable to apply for further System Evaluation on account of a failure to progress in a previous System Evaluation.
ELC Authorisation Body	Either: (i) the JEC for “Gold” level ELC Classification decisions; or (ii) the ITF for “Silver” level and “Bronze” level ELC Classification decisions.
ELC Classification	The allocation of an ELC Classification Level to a particular System in accordance with these Procedures.
ELC Classification Level	The level of “Bronze”, “Silver” or “Gold” for ELC Classification as described in these Procedures.
ELC System or System	The collective hardware and software used to make electronic line calls and provide feedback.
Electronic Line-Calling (ELC)	A method of determining the impact location between a ball and court surface, normally with respect to service lines and court boundaries without assistance from umpire or line judge.
Evaluation Fee	The fee payable by the Vendor for an evaluation in accordance with the table in section 9 (Fees).
Evaluation Process	The steps taken to evaluate a System for ELC Classification (comprising System Application, System Evaluation and System Monitoring).
GST	“Grand Slam Tennis” being an unincorporated body comprising the following entities each responsible for organising and staging the respective grand slam tennis tournaments in Australia, France, the United Kingdom and the United States of America: (i) Tennis Australia Limited; (ii) the French Tennis Federation; (iii) The All England Lawn Tennis Club (Championships) Limited; and (iv) United States Tennis Association Incorporated.

Joint ELC Committee (JEC)	Representatives from the International Tennis Federation (ITF), ATP, WTA and constituent bodies of GST, responsible for evaluating a “Gold” level System.
Losses	All liabilities, damages, losses (including loss of profits, loss of business, loss of reputation, loss of savings and loss of opportunity), fines, expenses and costs (including all interest, penalties, legal costs (calculated on a full indemnity basis) and reasonable professional costs and expenses).
Notice of Appeal	The formal notification provided by a Vendor that it is making an appeal against a decision made by the ELC Authorisation Body in accordance with these Procedures.
PAT	Player Analysis Technology as defined in the <i>Rules of Tennis</i> .
PAT Application	The application for PAT approval via the ITF Technical Centre.
Post-Evaluation Assessments	The assessment of a System carried out during System Monitoring to ensure that the System Requirements in respect of the relevant ELC Classification Level continue to be met.
Real-time System	A system output providing near instantaneous line calls for all ‘out’ calls using audio and/or visual feedback. Also known as a ‘live system’.
Reliability Audit	A method of assessing the System Requirements as part of the System Evaluation and System Monitoring stages of the Evaluation Process.
Review Officials (ROs)	As described in the <i>ITF Duties &amp; Procedures for Officials</i> .
Review System	A system output providing an in/out decision for a selected ball impact after a point has ended. This may be supported by visualisation of ball trajectory and impact mark relative to the court lines. Also known as a ‘challenge system’.
Sanctioning Body	Body responsible for organising and running and/or sanctioning a tournament e.g. Governing Body or National Association.
Strike	A record of a System failure imposed on the records of a System in the event of failing to meet the System Requirements during the System Monitoring stage of the Evaluation Process.
System Application	The first stage of the Evaluation Process for a System in which the Vendor makes an application for ELC Classification at a certain ELC Classification Level.
System Evaluation	The second stage of the Evaluation Process in which an assessment is made of whether a System meets the System Requirements for an ELC Classification Level.
System Monitoring	The final (and ongoing) part of the Evaluation Process for a System which takes place after an ELC Classification Level has been awarded.
System Principles	Characteristics required for a System to be effectively used for ELC.
System Requirements	The specific standards a System must meet in order to satisfy the System Principles.
Governing Body (together the Governing Bodies)	The constituent bodies of the GST, the ATP, the WTA and the International Tennis Federation (ITF).
Tournament Fault Log	A method of assessing the System Requirements as part of the System Evaluation and System Monitoring stages of the Evaluation Process.

Vendor	The company or individual(s) responsible for the manufacture, installation and running of a System.
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# ELECTRONIC LINE-CALLING SYSTEMS: EVALUATION PROCEDURES

## 1. Introduction

- 1.1. Traditionally, tennis was adjudicated by humans. The decisions as to whether the ball bounced 'in' or 'out' were made exclusively by line umpires, chair umpires or (at the lower levels of the game) players. However, the human information-processing system has limited capacity and there are often occasions when there is uncertainty or dispute over a close call. This is largely because the impact between a ball and surface (a) lasts for a short time (less than 0.01 seconds), and (b) occurs at high speed, with rapid changes in ball position, direction and speed.
- 1.2. Advances in technology have resulted in the development of several methods of automatically determining whether a ball is in or out via "**Electronic Line-Calling**" or "**ELC**". The ITF, as the world governing body of tennis, is the focal point for the collation, evaluation and dissemination of information relating to systems with ELC capability (the "**ELC Systems**").
- 1.3. As major stakeholders in tennis, the ITF, ATP, WTA and GST are also collaborating on the evaluation of certain ELC Systems. ELC Systems offer the potential for more accurate and consistent decision-making than humans, but their suitability for this purpose must be established before they can be considered for use in professional tennis. Consequently, the ITF, ATP, WTA and constituent bodies of GST formed the Joint ELC Committee (the "**JEC**") to evaluate certain ELC Systems. Other ELC Systems shall be evaluated by the ITF.
- 1.4. The purpose of these *Electronic Line-Calling Systems: Evaluation Procedures* (the "**Procedures**") is to (i) set out the standards that an ELC System must meet in order to obtain, and maintain, classification at certain levels and (ii) describe the process by which these standards will be assessed and monitored.
- 1.5. Any updates or changes to these Procedures must be approved by the ELC Authorisation Body (or Bodies) to which the changes relate (see section 4 below for details in respect of the ELC Authorisation Body). Periodic reviews of the Procedures will be undertaken, on at least an annual basis. Revised versions of the Procedures will be published on the ITF website.

## 2. Theory of ball-surface impacts

- 2.1. The impact between a tennis ball and a court surface is complex. The contact area between a ball resting on a court surface is relatively small. If a ball is dropped vertically, the contact area tends to increase as the bottom of the ball deforms (i.e. it flattens out). In general, the greater its velocity in the vertical direction when it hits the surface (up to a point), the more it deforms and the bigger the maximum contact area (see Figure 1 for an extreme example). Thus, whether a ball touches a line may be determined by the speed at which it hits the ground, as a faster-moving ball has a greater area of contact with the court surface. For the majority of impacts in tennis, the ball is moving horizontally as well as vertically, which increases the complexity of the determination of the true impact location. Due to the horizontal motion, the ball slides and/or rolls along the ground, and thus leaves the surface at a different position from that at which it first made contact. The amount of sliding changes from shot to

shot, and depends on approach angle, speed, spin, and the court surface type, making it difficult to accurately identify the true initial impact point.



Figure 1. The compression of a tennis ball during an impact at 90° to the surface.

2.2. Humans may use ‘clues’ to the impact location. For example, the ball disturbs the surface particles on a clay court, leaving a mark on the surface, while on grass, the presence or absence of chalk dust is sometimes used as evidence of the bounce location. Marks can also be seen on hard courts. In all cases, however, such evidence may be misleading. For example, it is possible that clay particles not directly touched by the ball may be disturbed by those particles moving due to the ball impact, which will result in a larger mark than the true contact area. On a hard court, however, the threshold pressure required between the ball and surface to leave a mark may not be generated until sometime after initial contact, thus leaving a smaller mark than the true contact area.

### 3. System Principles

3.1. To be acceptable for use, an ELC System (the “**System**”) must be:

- a) **Accurate.** The System must repeatedly identify the true impact location of the ball within a specified tolerance.
- b) **Reliable.** The System must continue to function without fault or breakdown for extended periods.
- c) **Practical.** The System must be easy to use by the designated operator(s) and not interfere with other aspects of their role.
- d) **Suitable.** The System must operate over the full range of conditions experienced in tennis, while not exposing players to health or safety risks.

Together these form the “**System Principles**”.

#### 4. Classification Levels and the ELC Authorisation Body

- 4.1. The “**Governing Bodies**” have recognised the growing demand from players for ELC Systems to be utilised and the increasing number of Vendors available to provide ELC Systems at the lower levels of the tennis pyramid. To support consumer confidence and assist with System selection, Systems will be classified into one of three levels (“Bronze”, “Silver” or “Gold” – the “**ELC Classification Levels**”), from January 2024 onwards (the “**ELC Classification**”).
- 4.2. ELC Classification for any System will be determined by the “**ELC Authorisation Body**”. The relevant ELC Authorisation Body for each of the ELC Classification Levels shall be as follows:
  - a) For “Gold” level ELC Classification decisions the relevant ELC Authorisation Body shall be the JEC; and
  - b) For “Silver” level and “Bronze” level ELC Classification decisions the relevant ELC Authorisation Body shall be the ITF.
- 4.3. ELC Classification demonstrates the ability of the Systems to meet the System Principles described in section 3 (System Principles) above. For a System to be awarded ELC Classification, it must meet all of the System Requirements at the level concerned as determined by the relevant ELC Authorisation Body at its sole discretion. The System Requirements for each of the ELC Classification Levels are described in more detail in Appendix 2 (System Requirements). In meeting these System Requirements, the System will be satisfying the System Principles to the extent required for that ELC Classification Level. It is understood that each tournament organiser may request further testing from the Vendors outside of the procedures outlined in this document in order to meet their tournament specific requirements.
- 4.4. If a Vendor wishes to re-test a System to gain ELC Classification in a different ELC Classification Level, the Vendor must demonstrate the ability of the System to meet the additional System Requirements of that ELC Classification Level. This may require the System to undergo further evaluations. For the avoidance of doubt, if a System ‘fails’ to obtain a ‘new’ ELC Classification Level following System Evaluation, the System shall retain any existing ELC Classification Level previously obtained unless determined otherwise by the ELC Authorisation Body.

## 5. Evaluation Process

- 5.1. The “**Evaluation Process**” describes the steps taken to evaluate the Systems for ELC Classification (Table 1-3). The Evaluation Process is comprised of three distinct stages: (i) “**System Application**”; (ii) “**System Evaluation**”; and (iii) “**System Monitoring**”.
- 5.2. A fundamental aspect of the Evaluation Process is that it is ‘Vendor driven’. Vendors are expected to lead the Evaluation Process in terms of submitting an application and arranging for testing. A System will only progress to the next stage of the Evaluation Process once agreed by the ELC Authorisation Body.
- 5.3. Vendors must specify the System’s intended ELC Classification Level as part of the application. Evaluations will typically follow the stages set out in Tables 1-3 below unless prior agreement is received from the ELC Authorisation Body and notified to the Vendor.
- 5.4. The Vendor must notify the ELC Authorisation Body via email to [elc@itftennis.com](mailto:elc@itftennis.com) of any change(s), upgrades or modifications to the System during the System Evaluation and at any time after the System obtains ELC Classification, which might impact upon the performance of the System or its ability to meet with the System Requirements (e.g. changes to the number of cameras/other hardware, their placement on/off court or specification, or major revisions to the software). The Vendor must provide details in respect of such change(s), including evidence of their impact on performance, as soon as reasonably practicable and in any event at least two (2) weeks before the change(s) is implemented as part of a live tournament System, unless an immediate change is required to meet the System Requirements. A Vendor’s failure to provide sufficient (or any) information in respect of change(s) to the configuration of the System may result in the immediate suspension of the System’s ELC Classification whilst the ELC Authorisation Body verifies whether the System continues to meet the System Requirements. The ELC Authorisation Body reserves the right to repeat all (or part(s) of) the Evaluation Process on Systems that have undergone change(s) which the ELC Authorisation Body considers may be significant. This shall be done at the Vendor’s expense.

<b>“GOLD” LEVEL – FOR USE OF THE JEC AS THE ELC AUTHORISATION BODY</b>	
Stage 1	1.1 PAT Application review <sup>a</sup>
	1.2 PAT test/demo
	1.3 PAT report
Stage 2	2.1 System Application review <sup>a, b</sup>
Stage 3	3.1 1st evaluation: Accuracy <sup>c</sup> + Choreographed testing <sup>d</sup>
	3.2 Evaluation report <sup>e</sup>
Stage 4	4.1 2nd evaluation: Accuracy <sup>c</sup> + Match play testing <sup>f</sup> (2-3 days of matches, inc. doubles)
	4.2 Evaluation report <sup>e</sup>
Stage 5	5.1 3rd evaluation: Accuracy <sup>c</sup> + Shadow tournament <sup>g</sup> (3-4 days of tournament matches, inc. doubles)
	5.2 Evaluation report <sup>e</sup>
Stage 6	6.1 Reliability Audit <sup>h</sup> (4-5 matches per event from 2 events, inc. doubles)
	6.2 4 <sup>th</sup> Evaluation: Live tournament (with Line Umpires & Review System back-up if testing a Real-time System)
	6.3 Evaluation report <sup>e</sup>
CLASSIFIED <sup>i</sup> FOR HARD COURT (Review System, Real-time System or both)	
ENTER SYSTEM MONITORING PROCESS	
Stage 7	7.1 Grass evaluation: Accuracy <sup>c</sup>
	7.2 Evaluation report <sup>e</sup>
CLASSIFIED <sup>i</sup> FOR GRASS	
Stage 8	8.1 Clay evaluation 1: Accuracy <sup>c</sup> + Match play testing (minimum 2 days, inc. doubles)
	8.2 Evaluation report <sup>e</sup>
CLASSIFIED <sup>i</sup> FOR REVIEW SYSTEM ON CLAY	
Stage 9	9.1 Clay Reliability Audit <sup>h</sup> (4-5 matches per event from 2 red-clay events, inc. doubles)
	9.2 Clay evaluation 2: Live Review System tournament + shadow Real-time System
	9.3 Clay evaluation 3: Live Real-time System tournament (with Line Umpires & Review System back-up)
	9.4 Evaluation report <sup>e</sup>
CLASSIFIED <sup>i</sup> FOR REAL-TIME SYSTEM ON CLAY	

Table 1. Stages of the Evaluation Process for Gold-level ELC Classification. Stages 7-9 are only required if the System is to be used on these surfaces. See below for related notes.

<b>“SILVER” LEVEL – FOR USE OF THE ITF AS THE ELC AUTHORISATION BODY</b>	
Stage 1	1.1 PAT Application review <sup>a</sup>
	1.2 PAT test/demo
	1.3 PAT report
Stage 2	2.1 System Application review <sup>ab</sup>
Stage 3	3.1 1st evaluation: Accuracy <sup>c</sup> + Choreographed testing <sup>d</sup>
	3.2 Evaluation report <sup>e</sup>
Stage 4	4.1 2nd evaluation: Accuracy <sup>c</sup> + Match play testing <sup>f</sup> (1-2 days of matches, inc. doubles)
	4.2 Evaluation report <sup>e</sup>
Stage 5	5.1 3rd evaluation: Shadow tournament <sup>g</sup> + Live tournament (minimum 3 days of tournament matches, inc. doubles)
	5.2 Real-time systems only - Reliability Audit <sup>h</sup> (2 matches per event from 2 events, inc. doubles)
	5.3 Evaluation report <sup>e</sup>
CLASSIFIED <sup>i</sup> FOR HARD COURT (Review System, Real-time System or both) ENTER SYSTEM MONITORING PROCESS	

Table 2. Stages of the Evaluation Process for Silver-level ELC Classification. See below for related notes.

<b>“BRONZE” LEVEL – FOR USE OF THE ITF AS THE ELC AUTHORISATION BODY</b>	
Stage 1	1.1 PAT Application review <sup>a</sup>
	1.2 PAT test/demo
	1.3 PAT report
Stage 2	2.1 System Application review <sup>ab</sup>
Stage 3	3.1 1st evaluation: Accuracy <sup>c</sup> + Choreographed testing <sup>d</sup> + Match play testing <sup>f</sup> (1-2 days of matches, inc. doubles)
	3.2 Evaluation report <sup>e</sup>
Stage 4	4.1 2nd evaluation: Accuracy <sup>c</sup> + Shadow tournament <sup>g</sup> + Live tournament (minimum 2 days of tournament matches, inc. doubles)
	4.2 Real-time systems only - Reliability Audit <sup>h</sup> (2 matches per event from 2 events, inc. doubles)
	4.3 Evaluation report <sup>e</sup>
CLASSIFIED <sup>i</sup> FOR HARD COURT (Review System, Real-time System or both) ENTER SYSTEM MONITORING PROCESS	

Table 3. Stages of the Evaluation Process for Bronze-level ELC Classification. See below for related notes.

## Notes related to Tables 1-3

- a) The Vendor applies for evaluation of the System by the ELC Authorisation Body (using the forms provided in Appendix 1 (ELC System Application)) and ITF approval of Player Analysis Technology (“PAT”). A video file, or link to a video file, of the System shall also be supplied, showing all equipment, preferably in operation, and all visual devices (e.g. software output, and all information sent to Chair Umpire). An audio commentary is preferable. System Application materials will be circulated to the members of the ELC Authorisation Body for review. Any application for approval of PAT will be reviewed by the ITF Technical Centre (the “PAT Application”).
- b) If the application is deemed to be suitable to proceed to the System Evaluation stage of the Evaluation Process by the ELC Authorisation Body, a time and location for the first stage of the System Evaluation will be agreed. For each stage of the System Evaluation a backup date should be suggested in case the original date is (or becomes) unsuitable.
- c) Accuracy testing will usually be performed before any gameplay testing during each stage of the System Evaluation. However, the ELC Authorisation Body reserves the right to conduct accuracy testing at any stage of a System test. The System should be capable of testing accuracy under natural, artificial, and changing illumination.
- d) The Vendor is required to provide a minimum of two players for the choreographed play testing. Players should be of a sufficient standard to aid the System Evaluation (such as to hit the ball close to the lines on request) and must be available to play as required by the ELC Authorisation Body. Players will be used at the ELC Authorisation Body’s discretion and may be used during accuracy testing, in addition to demonstration of the System operation.
- e) A report is produced by the ELC Authorisation Body. Issues identified in the report must be resolved to the satisfaction of the ELC Authorisation Body before proceeding with another stage of the System Evaluation. This must include a written description by the Vendor of the problem, identification of the root cause, how it was rectified and evidence that the corrective action was successful (and will prevent recurrence of the problem). The ELC Authorisation Body will take the overall performance of a System into account when deciding whether a System passes each part of the System Evaluation. The ELC Authorisation Body may, at its discretion, decide to allow a System to move to the next stage of the System Evaluation whilst problems identified are being addressed and on the condition that these will be addressed to the satisfaction of the ELC Authorisation Body at a later stage in the process.
- f) The Vendor is responsible for organising players for 2-3 days of matches (unless otherwise stated) on one court. As a minimum, this should include at least two singles and two doubles matches.
- g) Shadow and live testing requires the System to be installed at a suitable tournament venue (Appendix 2), which the Vendor is responsible for arranging. Gold level Real-time Systems must also demonstrate their ability to provide Review System ELC in accordance with the requirements set out in A2.2 of Appendix 2 (System Requirements). Shadow and live testing tournaments must have adequate video with audio, sufficient to hear ‘out’ calls, from one end of the court which can be accessed by the ELC Authorisation Body after the event. A method of determining timestamps from match score is preferred.
- h) As a minimum, the Vendor must provide bounce mark coordinate data on a point-by-point basis for at least five matches selected by the ELC Authorisation Body or

their designee. Broadcast footage of the matches selected must be publicly accessible or provided to the ELC Authorisation Body by the Vendor. Data for Reliability Audits may be collected concurrently with step 6.2 (for hard court audits) or 9.2 (for clay court audits) for Gold-level Real-time Systems. For Silver and Bronze Systems, data for Reliability Audits can only be collected from matches not assessed as part of shadow or live testing.

- i) In the event a System meets all of the System Requirements during System Evaluation to the satisfaction of the ELC Authorisation Body, it shall be allocated ELC Classification at the relevant ELC Classification Level. ELC Classification is only valid for Systems that are assessed under the configuration used during System Evaluation.

## **6. System Application**

- 6.1. Before any formal testing by the ELC Authorisation Body takes place, an initial review is undertaken to establish whether there is any reason to believe that the inherent characteristics of the System would render it unsuitable for use in tennis. This is conducted via two separate and distinct measures: a review of the Vendor's System Application by the ELC Authorisation Body and a review of the Vendor's PAT Application by the ITF.
- 6.2. The System Application requires the Vendor to describe the System and demonstrate its capability to provide accurate ELC. Vendors are encouraged to provide as much detail as possible to support the System Application, including photos and videos. The Vendor may subsequently be requested to supply additional supporting material such as self-conducted accuracy testing to demonstrate the System's ability to meet the System Requirements during the Evaluation Process.
- 6.3. The review of the PAT Application and subsequent testing of the PAT product by the ITF determines whether the System conforms to the Rules of Tennis. The System Application and the PAT Application can be submitted consecutively or concurrently; however, the System must have PAT approval from the ITF and the System Application must have been approved by the ELC Authorisation Body before proceeding to System Evaluation stage. In the instance further information is required in relation to either application, feedback will be provided to the Vendor who may be asked to provide additional supplementary material rather than full resubmission of an application.
- 6.4. Documentation for the Evaluation Process application can be found in Appendix 1 (ELC System Application). PAT Application documentation can be found separately on the [ITF website](#).

## **7. System Evaluation**

- 7.1. Each System requires multiple evaluations during the course of the System Evaluation stage. During each evaluation, combinations of System accuracy, choreographed play, match play, shadow testing and live testing will be used to assess the performance of the System against the System Requirements (see Appendix 2 (System Requirements)). A minimum of two different venues must be used in Stages 3-6 for Gold-level Systems (to validate that the performance of the System is independent of the installation environment).
- 7.2. For a System to obtain ELC Classification as a Review System and Real-time System, line-calling, choreographed play, shadow and live testing must be completed for both the Review System and the Real-time System. Systems will typically undergo

evaluation as a Review System first. Evaluation of Review System and Real-time System line-calling may be completed simultaneously only with the agreement of the ELC Authorisation Body. Real-time Systems are required to pass an additional test to assess the reliability of the System (the Reliability Audit – see below).

- 7.3. The Vendor is responsible for selecting a suitable tournament venue when required for a System Evaluation. Suitable venues must allow for the testing of the System Requirements for the target Classification Level as detailed in A2.2 of Appendix 2 (System Requirements). The final decision on whether a venue is suitable is at the discretion of the ELC Authorisation Body.
- 7.4. Systems are required to complete separate tests for indoor and outdoor courts. Systems that meet the System Requirements based solely on indoor testing will only gain ELC Classification for indoor use. Systems that meet the evaluation criteria based (at least in part) on outdoor testing under artificial lighting, will gain ELC Classification for indoor and outdoor use. Real-time Systems and Review Systems must both be tested outdoors in order to gain ELC Classification for outdoor use.
- 7.5. The following types of testing will be used to evaluate whether the relevant System Requirements have been met, such that ELC Classification should be awarded:

### **7.5.1. Accuracy test**

- 7.5.1.1. A key element of the System Evaluation is the extent to which the System can identify the true ball impact location. This will be evaluated based on ball trajectories that are in the range possible during normal play and will normally include various impact locations and conditions. A System's performance will be assessed in terms of:
- 7.5.1.2. Reliability of tracking/detection – the percentage of times that the System successfully tracks/detects the ball.
- 7.5.1.3. Decision-making success rate – the percentage of correct in/out calls within the stated tolerance.
- 7.5.1.4. Gold-level Systems only:
- Average accuracy per test location – the average of the absolute discrepancies for a test location.
  - Single impact accuracy – the maximum single discrepancy for all impacts.
  - True ball impact location is measured to the nearest millimetre through use of calibrated high-speed video footage. Distances reported for the ball impacts should be from the point furthest in or, if landing out, the point closest to the outside edge of the line. The Vendor is responsible for ensuring lighting at the venue is appropriate to perform accuracy testing. The ELC Authorisation Body bears no responsibility for failure to perform accuracy testing due to inadequate lighting.
- 7.5.1.5. A single accuracy test will consist of several impacts located across at least five court locations. A minimum of 10 impacts within the acceptable range (within 100 mm of the 'out-side edge' of the line) are required at each location. For Silver-level and Bronze-level Systems, at least three shots per location must be within 25 mm of the 'out'-side edge of the line. To maintain high repeatability, ball impacts within this range are typically achieved via use of a ball cannon located 3-5 m from the impact location. More information regarding specific requirements for accuracy testing can be found in Appendix 2 (System Requirements).
- 7.5.1.6. Systems are required to complete separate accuracy tests for hard, grass and clay court surfaces. Typically, Systems will complete the Evaluation Process on hard court before grass or clay court surfaces.

### **7.5.2. Choreographed play test**

- 7.5.2.1. Choreographed play testing requires the System to be installed on a court. A combination of standard gameplay and choreographed play may be conducted. Players provided by the Vendor should be prepared to play a match up to three sets long. The players should be of a sufficient standard to be able to play out specific gameplay scenarios on demand. Before play commences, the Vendor is required to provide a tour of the System's characteristics such as hardware, software, operator duties and user interface.

### **7.5.3. Match play test**

- 7.5.3.1. Match play testing simulates the System operation as it would be used in a tournament environment. The suitability and reliability of the System will be assessed over the course of successive matches. It is not essential for the match play test to take place at an organised event, although enough players and officials must be provided to allow 2-3 days of continuous play, including both singles and doubles matches. Players must be of a suitable standard to effectively test System capability.

### **7.5.4. Shadow test**

- 7.5.4.1. Shadow testing demonstrates the System operation during tournament play. The System is operated in the background in parallel with the on-court officials (if applicable). Where applicable, courtside requirements must be demonstrated in the operations booth (see Appendix 2 (System Requirements)).

### **7.5.5. Live test**

- 7.5.5.1. If a System's performance in previous evaluations is deemed suitable by the ELC Authorisation Body, the System Evaluation proceeds to a live test, in which the System is used by officials to make (and review) on-court decisions. The practicality of the System for use by the umpire, officials and players will be assessed. A Tournament Fault Log will be conducted to assess the System against the System Requirements. Further details on the Tournament Fault Log can be found in A3.2 of Appendix 3 (System Monitoring).

### **7.5.6. Reliability Audit (Real-time Systems only)**

- 7.5.6.1. Real-time Systems will be required to submit additional data for multiple matches to enable the ELC Authorisation Body to analyse the data and conduct a Reliability Audit. A Reliability Audit typically consists of providing a data file listing the time and location (co-ordinates) of all ball bounces detected in each match, the System decision ('in' or 'out'), and video, synchronised with the times in the file, showing the match from one end of the court. Reliability will be assessed by recording the number of missed or incorrect calls. A missed call is a bounce the System does not measure/detect, including those that land 'in'. An incorrect call is a bounce that is captured by the System but is given incorrectly as 'in' or 'out'. All bounces, including those in-between points, that trigger an audible 'out' call, must be included in the data. Incorrect calls will only be recorded when the call was clearly wrong. Further details on the Reliability Audit requirements can be found in A3.3 of Appendix 3 (System Monitoring).

### 7.5.7. Failure to progress

7.5.7.1. At any stage of the System Evaluation the ELC Authorisation Body has the discretion to decide that a System is not meeting, or close enough to meeting, the System Requirements and should not progress to the next stage of the System Evaluation. If the ELC Authorisation Body reaches this decision it will notify the Vendor of this and provide its reasons for deciding that the System shall not progress to the next stage. A record will be made of any stages/System Requirements that the System has met at the date of the ELC Authorisation Body's decision. If the Vendor then wishes to reinitiate the System Evaluation at a later point with the same System, the ELC Authorisation Body can decide to allow the System Evaluation to proceed from the point at which it was stopped if it is satisfied that a) the System has not been changed such that any previously met Requirements need to be re-assessed and b) the System Requirements have not changed such that re-assessment is required to assess whether the revised System Requirements are met.

### 7.5.8. Cooling-Off Period

- 7.5.8.1. If a System fails to progress at any stage of the System Evaluation, the Vendor will be unable to apply for further System Evaluation for that particular System for a defined period of time (the "**Cooling-Off Period**"). The standard duration of the Cooling-Off Period shall be three (3) calendar months from the date of the ELC Authorisation Body's decision that the System cannot progress to the next stage. During the Cooling-Off Period, a Vendor may provide supporting documentation to demonstrate System improvement, however, no further evaluations will be held. Consecutive evaluations where there is a failure to progress to the next stage will result in the Cooling-Off Period being doubled in duration from the point of the lattermost failed evaluation (up to a maximum Cooling-Off Period of one (1) year).
- 7.5.8.2. The ELC Authorisation Body may opt to waive the Cooling-Off Period so that its restrictions shall not apply for a particular System. Such decision will be made by the ELC Authorisation Body at its sole discretion.

## 8. System Classification and System Monitoring

8.1. When, following the completion of the System Evaluation, the ELC Authorisation Body is satisfied that all of the System Requirements for a particular ELC Classification Level have been met, the ELC Authorisation Body shall award the System that ELC Classification Level. The Vendor will be notified of this decision in writing. The System will be added to the public register of classified Systems, with the name of the System, the Vendor and the ELC Classification Level published. The System will then enter the System Monitoring stage.

- 8.2. Post-evaluation monitoring and assessment is carried out during the System Monitoring stage to evaluate the System to ensure the System Requirements for the applicable ELC Classification Level continue to be met. This is done via “**Post-Evaluation Assessments**”, “**Tournament Fault Logs**” and “**Reliability Audits**”, as set out in Appendix 3 (System Monitoring). A Post-Evaluation Assessment, Tournament Fault Log and/or Reliability Audit may be requested by the tournament organiser, the “**Sanctioning Body**” or the ELC Authorisation Body. Post-Evaluation Assessments are generally conducted on-site prior to the commencement of play. However, the ELC Authorisation Body reserves the right to evaluate any of the System Requirements (see Appendix 2 (System Requirements)) at any time during System Monitoring (either with or without notice). Evidence for use in System Monitoring will typically be collected by officials, e.g. “**Chair Umpires**” and “**Review Officials**” (as both described in the *ITF Duties & Procedures for Officials*) and reported to the ELC Authorisation Body for review. However, System Monitoring may also be carried out by the ELC Authorisation Body, its designated representatives, ITF accredited laboratories, or by Vendor self-assessment. Vendors are expected to lead the set-up, measurement and reporting of results under the supervision of a Review Official (RO).
- 8.3. Where a Vendor becomes aware that one or more of the System Requirements may not be met by its System, the Vendor is required to notify the ELC Authorisation Body via email to [elc@itftennis.com](mailto:elc@itftennis.com) of this as soon as reasonably practicable and in any event within seven (7) business days of becoming aware of the same. The ELC Classification Level is applicable to the ELC System as presented and evaluated during the Evaluation Period. Any modification of the ELC System after ELC Classification has been granted must be notified to the ELC Authorisation Body, which reserves the right to repeat the Evaluation Process for the modified ELC System.

#### 8.4. **Strikes and suspension of ELC Classification**

- 8.4.1. If a System fails to meet the System Requirements following a Post-Evaluation Assessment, review of a Tournament Fault Log or Reliability Audit (see Appendix 3 (System Monitoring)) as determined by the ELC Authorisation Body, the Vendor will be notified in writing that the ELC Authorisation Body intends to impose a “**Strike**” on the System (the “**Advanced Notification of Strike**”, or “**ANS**”). The ANS will set out the System Requirement(s) that appear to not have been met by the System. In the two (2) week period immediately following the ANS, the Vendor is entitled to submit evidence to the ELC Authorisation Body to demonstrate that the failure to meet System Requirements was not as a result of the System but instead was due to circumstances or causes outside of the Vendor’s control.
- 8.4.2. If, following receipt of any such evidence the ELC Authorisation Body determines that the failure to meet System Requirements was not due to the System itself, the Strike shall not be imposed on the records for that System.
- 8.4.3. If no evidence is received from the Vendor or the ELC Authorisation Body determines that the Strike should remain despite any evidence provided, the Strike shall be imposed on the records for that System.
- 8.4.4. Strikes are capped at a maximum of one (1) Strike imposed per System per tournament.

- 8.4.5. Once a Strike has been imposed, it will be recorded on the ELC Authorisation Body's records for that System. It will stay 'active' on these records unless the ELC Authorisation Body decides that the Strike should be removed, in which case the Strike will remain on the records for that System but will not be 'active'. The record of 'active' and 'inactive' Strikes that have been imposed on a System will be available to the Governing Bodies.
- 8.4.6. The Vendor can apply to the ELC Authorisation Body to have a Strike removed at any time. If such an application is being made the Vendor must provide the ELC Authorisation Body with evidence of:
- What has been done to address the issue(s) that caused the Strike to be imposed, including preventative measures to avoid recurrence of the issue(s);
  - How the System Requirements that were not being met (and in relation to which the Strike was imposed) are now being satisfied.
- 8.4.7. The ELC Authorisation Body may request further information from the Vendor or for tests to be undertaken on the System before reaching a decision as to whether the Strike should be removed. Once the ELC Authorisation Body has received the information that it requires, the ELC Authorisation Body will consider the application and decide whether to remove the Strike. It will inform the Vendor of its decision in writing and provide reasons for the decision. If the application is successful, the Strike will be removed. If a Strike is removed, it is no longer included in the active total of Strikes for that System but will remain on the records for that System. If the ELC Authorisation Body is satisfied during the two weeks following provision of an ANS that the issue causing the failure to meet System Requirements has already been rectified, the Strike shall be imposed but then immediately removed.
- 8.4.8. The accumulation of three (3) active (i.e. unremoved) Strikes by any System will result in the immediate suspension of its ELC Classification. The ELC Authorisation Body will write to the Vendor with notice of the immediate suspension and the name of the System/Vendor shall be removed from the ITF website list of Systems with ELC Classification.
- 8.4.9. The final decision on the issue and/or removal of any Strikes will be made by the ELC Authorisation Body at its sole discretion.
- 8.4.10. In circumstances where a System is found to be wholly unfit for purpose in relation to the System Principles or for any other reason found to be wholly unfit for ELC Classification in the view of the ELC Authorisation Body, this may result in the immediate suspension of ELC Classification for a particular System. Such immediate suspension of a System's ELC Classification may be made without the provision of (i) an ANS; (ii) any informal warning(s) to the relevant Vendor; or (iii) any Strike(s) against the System concerned. The decision immediately to suspend ELC Classification will be made by the ELC Authorisation Body at its sole discretion, acting reasonably, and will be communicated by the ELC Authorisation Body to the relevant Vendor, together with the reasons for the decision.
- 8.4.11. If a System does not undertake any System Monitoring assessments during a period of 18 months, Classification can be immediately suspended. In these circumstances, Systems must demonstrate their ability to meet the System Requirements for the suspension to be lifted. This may include repeating some or all the assessments as described in section 7 as deemed appropriate by the ELC Authorisation Body.

- 8.4.12. Suspension of ELC Classification may result in the System/Vendor becoming ineligible for use in certain tournaments, subject to the respective tournament organiser's eligibility requirements.
- 8.4.13. A Vendor can apply to the ELC Authorisation Body to have the suspension of its System's ELC Classification lifted by following the steps outlined in section 8.4.6, in relation to the failures that resulted in the immediate suspension.

## 9. Fees

- 9.1. All costs incurred in relation to the Evaluation Process for a particular System shall be covered by the Vendor of the System concerned. This includes (without limitation): travel, accommodation and subsistence of all ELC Authorisation Body members and ROs; transport and hire of equipment (as necessary). In addition to expenses, fees in respect of the Evaluation Process will be charged (the "**Evaluation Fees**").
- 9.2. The Evaluation Fees (all in US\$ in addition to expenses) are set out in Table 4 below. For System Evaluations consisting of multiple assessment components, the highest Evaluation Fee will be charged (e.g. a Shadow test including accuracy at the Gold level would be \$6,600).
- 9.3. Evaluation Fees should be paid to the ITF before an evaluation commences and are non-refundable. For the avoidance of doubt this means that if an evaluation commences and is not completed for any reason(s) which is outside of the ELC Authorisation Body's control (including but not limited to the weather, the functioning of the System, the court conditions, technical failures), the Evaluation Fee shall be retained by the ITF. If a System fails to progress at a particular stage and therefore the same evaluation is subsequently repeated, a fresh Evaluation Fee needs to be paid for each evaluation that is required.
- 9.4. Vendors who have obtained ELC Classification are required to pay an annual fee to the ITF for ongoing System Monitoring to maintain the System's ELC Classification (the "**Classification Fee**"). The Classification Fee is determined by the ELC Classification Level and the number of Systems provided by the Vendor. The Vendor is required to pay the Classification Fee for each level at which its System is classified. A System that has been classified as both a Review System and a Real-time System is subject to a single Classification Fee. For example, if a Vendor has one System classified at Gold level and two Systems at Bronze level, they would need to pay \$11,000 + \$3,300 + \$3,300 (\$17,600 in total). The Classification Fee is due from the date on which the ELC Authorisation Body confirms that the System has obtained ELC Classification at the relevant ELC Classification Level.

- 9.5. The current annual Classification Fee for each System (all in US\$) is as follows:
- Gold: \$11,000;
  - Silver: \$5,500;
  - Bronze: \$3,300.
- 9.6. Evaluation Fees and Classification Fees will be reviewed by the ELC Authorisation Body on an annual basis. The ELC Authorisation Body reserves the right to amend the Evaluation Fees and/or Classification Fees at its sole discretion. Any changes to Evaluation Fees and/or Classification Fees shall be notified to Vendors in a timely manner.
- 9.7. All applications for ELC Classification must be accompanied by written acceptance of the liability for costs, including Evaluation Fees and Classification Fees. In addition, the applicant must apply and pay for ITF approval as a PAT product.
- 9.8. Failure to pay Classification Fees for any System will result in the suspension of Classification for that System.

	Accuracy only	Choreographed	Match play	Shadow	Live	Reliability Audit
Gold	\$3,300	\$4,400	\$5,500	\$6,600	\$8,800	\$2,200
Silver	\$2,200	\$3,300	\$4,400	\$5,500	\$7,700	\$1,100
Bronze	\$2,200	\$3,300	\$4,400	\$5,500	\$5,500	\$1,100

Table 4. Evaluation Fees.

## 10. Terms and conditions

- 10.1. Any Vendor making a System Application and/or whose System is part of the Evaluation Process (including System Monitoring) and/or whose System has obtained ELC Classification agrees to follow, and be bound by, these Procedures.
- 10.2. A System will not obtain ELC Classification until it has met the relevant System Requirements in the view of the ELC Authorisation Body. The ELC Authorisation Body reserves the right to consider the performance over all evaluations in its deliberations on whether that System is deemed successfully to have met the System Requirements.
- 10.3. The processes for (i) System Application; (ii) System Evaluation; and (iii) System Monitoring are subject to ongoing review by the ELC Authorisation Body and may be amended by the ELC Authorisation Body as and when necessary and without prior notice.
- 10.4. Neither participation in (or completion of) System Evaluation nor attainment of ELC Classification forms or provides any guarantee that a System will be adopted for tournament play or used for any tournament in particular.
- 10.5. ELC Classification is based upon the System Requirements being met at the location(s) (including facility and storage) and under the prevailing ambient conditions on the days of testing. It is not possible to test every scenario as part of the Evaluation Process. It is strongly recommended, therefore, that end users establish that the System performs to the required standard in the location (and, if possible, under the ambient conditions) in which the end user intends the System to be used.
- 10.6. Neither the JEC (including each constituent body connected with it) nor the ITF provides any representation, warranty, guarantee or any other form of assurance to the end user or any other third party in respect of the performance, quality or reliability of a System, or the suitability of a System for use by the end user or any other third party.
- 10.7. The Vendor shall indemnify the JEC (and each constituent body connected with it) and the ITF against all "**Losses**" incurred by them as a result of any claim by a third party: (i) arising out of or in connection with any defective System; (ii) concerning the performance, quality, safety, reliability or suitability of a System; and/or (iii) that the supply, receipt or use of a System infringes the intellectual property rights of any third party.
- 10.8. Subject to sections 10.9 and 10.10 below, the maximum aggregate liability of the JEC (and any bodies connected with it) in contract, tort (including negligence), breach of statutory duty or otherwise, howsoever arising and even if foreseeable, under or in connection with the Evaluation Process (including, without limitation, System Application, System Evaluation and System Monitoring) shall, in respect of any Vendor, be limited to the aggregate amount of the Evaluation Fee and/or Classification Fee (as applicable) paid by that Vendor pursuant to these Procedures during the twelve (12) months preceding the event for which such liability is found; and

10.9. Subject to section 10.10 below, neither the JEC nor any bodies connected with it shall have any liability in contract, tort (including negligence), breach of statutory duty or otherwise, howsoever arising and even if foreseeable, arising under or in connection with: (i) a scenario whereby a certain System fails to meet the requisite System Requirements for ELC Classification or loses its ELC Classification following a decision of the ELC Authorisation Body and the Vendor has already incurred costs or suffers financial (or other) consequences as a result; (ii) the ELC Authorisation Body's decisions at any stage(s) of the Evaluation Process (including, without limitation, System Evaluation); (iii) any evaluations aborted for reasons beyond the ELC Authorisation Body's control; (iv) any decisions taken to suspend ELC Classification for any reason whatsoever; or (v) any indirect or consequential losses flowing in any way whatsoever from the application and/or performance of these Procedures.

10.10. Nothing in these Procedures excludes or limits any liability:

10.10.1. arising under the indemnity set out in section 10.7 above;

10.10.2. for death or personal injury caused by negligence;

10.10.3. for fraud or fraudulent misrepresentation; or

10.10.4. for any other liability that cannot legally be limited.

10.11. The law of England and Wales will govern the performance and interpretation of these Procedures.

10.12. For any matter in dispute arising out of these Procedures for which a distinct process or route of appeal is not set out in these Procedures, the parties to the dispute will be deemed to have agreed to submit the dispute to the Court of Arbitration for Sport in Lausanne, Switzerland ("**CAS**"), for resolution by arbitration in accordance with the CAS Code of Sports-Related Arbitration, they shall not bring any action or claim that conflicts with that submission to the jurisdiction of the CAS, and they shall be bound by the decisions of the CAS.

## **11. Appeals**

11.1. The decisions of the ELC Authorisation Body are final other than the following decisions of the ELC Authorisation Body only which may be appealed by a Vendor in relation to decisions made about their own System:

11.1.1. A decision not to approve a System Application to progress to System Evaluation (section 6);

11.1.2. A decision not to progress a System to the next stage of System Evaluation (section 7);

11.1.3. A decision not to grant an ELC Classification at the conclusion of the System Evaluation (section 8);

11.1.4. A decision to impose a Strike on a System (section 8);

11.1.5. A decision not to remove a Strike following an application to do so by the Vendor (section 8);

11.1.6. A decision to suspend the ELC Classification of a System (section 8).

- 11.2. The appeal shall be heard by a panel of four (4) members consisting of one representative from each of the ITF, ATP, WTA and a representative of GST (and which shall exclude any members of the JEC and any other individuals involved in the decision being appealed) appointed for the purposes of hearing the appeal (the “**Appeal Panel**”). The Appeal Panel will make decisions by majority, such that if an appeal is to be upheld then the majority of the Appeal Panel must vote to uphold the appeal. The Appeal Panel shall exercise a supervisory jurisdiction, meaning that the appeal shall not take the form of a *de novo* review, but instead shall be limited to a consideration of whether the decision being challenged:
  - 11.2.1. was irrational (i.e. it falls outside the range of what a reasonable decision-maker might decide), arbitrary or capricious;
  - 11.2.2. was based on an error of law (i.e. it is contrary to these Procedures, properly construed, or to applicable law); or
  - 11.2.3. followed a procedure in reaching the decision that was so unfair as to be contrary to natural justice.
- 11.3. A Vendor must notify the ELC Authorisation Body of the appeal via email to [elc@itftennis.com](mailto:elc@itftennis.com) by no later than twenty-one (21) days after receipt of the ELC Authorisation Body’s decision (the “**Notice of Appeal**”). The Notice of Appeal should include the decision being appealed, the grounds upon which the Vendor wishes to challenge the decision and documentation that the Vendor wishes to rely on in support of their challenge.
- 11.4. The Appeal Panel shall consider any such appeal on the papers, unless the Appeal Panel determines that a full oral hearing is necessary in order for it fairly to determine the appeal.
- 11.5. In the event an appeal is successful, the Appeal Panel shall remit the decision back to the ELC Authorisation Body. The ELC Authorisation Body shall re-consider the ELC Classification decision in view of the Appeal Panel’s findings but the ELC Authorisation Body shall be entitled to make any fresh decision it deems to be appropriate.
- 11.6. The Appeal Panel cannot under any circumstances make its own ELC Classification decisions for the System concerned. The right to make any decision in respect of ELC Classification is reserved exclusively for the ELC Authorisation Body.

## Appendix 1 – ELC System Application

### Contact Information

Product name:	
Applicant Company:	
Contact person(s):	
Address:	
Telephone:	
Mobile phone:	
Email:	

### Application Checklist

ITF PAT Approval	
Written confirmation of acceptance of responsibility for the costs of System Evaluations and Post-Evaluation Assessments where relevant (including Evaluation Fees and Classification Fees and expenses)	

### Declaration

<p>I, being a duly authorised representative of the Applicant Company, confirm that I have read and understood, and that the Applicant Company hereby agrees to, the contents of this document “Electronic Line-Calling Systems: Evaluation Procedures” (Revision 28.1). In particular but without limitation, the Applicant Company acknowledges, accepts and agrees to the provisions regarding indemnification, limitation of liability, exclusion of liability and the other terms set out in section 10 (Terms and Conditions) of such document.</p> <p>Signed on behalf of Applicant Company:</p>		
Name (please print):		Electronic Signature:
Date:		

Completed application to be submitted to:

ITF Technical Centre, ITF Licensing UK Ltd,  
 Bank Lane, Roehampton, London, SW15 5XZ, UK  
 Tel: +44 (0) 208 878 6464  
 Fax: +44 (0) 208 392 4773  
 Email: [elc@itftennis.com](mailto:elc@itftennis.com)

If you have previously made an application, please highlight the items that have changed since the last application, by adding the text “[change]” at the end of the relevant section(s).

**A1.1 General description**

System type ('Real-time System', i.e. designed to make line calls immediately, or 'Review System', i.e. designed to provide a replay as an aid for the Chair Umpire or other user).
Target ELC Classification Level(s), i.e. Gold, Silver or Bronze. This should be the level(s) the Vendor hopes to achieve to help the ELC Authorisation Body assess the suitability of test venues/tournaments.
System coverage (singles only or singles and doubles).
Is the System claimed to work on all surfaces (if 'no', please specify surfaces for which the System is <u>not</u> designed).
Impact detection method (e.g. light beam interruption, pixel recognition, court marking).
Description of the major System components.
Cost (to buy outright and to rent) and technical support provided.
Portability (dimensions, weight).
Claimed advantages of the System (compared to other Systems).
How long does the System take to set up (please divide into installation time and calibration/verification, and state whether these can be done in parallel)?

Minimum/preferred number of people required to operate the System.
Number of courts on which the System has been installed, and period(s) of installation.
Has the System been used by players?

### A1.2 Hardware

Type (manufacturer and model), number (minimum and optimum) and size of detection devices.
Local requirements of detection device(s).
Number of PCs required and location(s) with respect to detection devices, court surface and operators.
Installation requirements (including power requirements, any modifications to court, connections between components).
Are detection devices or hardware exposed to interference by spectators, officials, etc.?
Is a backup System available in case the main System fails (e.g. through power loss or hardware malfunction)?
Number of access points to hardware during normal use (i.e. by spectators, officials, etc.).

Number of failure points (i.e. hardware locations where the normal System function may be disrupted).
Is any part of the System laid <u>under</u> the court surface (please specify)? If so, please state how many times a court can be resurfaced before the System's performance (e.g. accuracy) is affected.

### A1.3 Software

General description.
If camera-based, frame rate and shutter speed of camera.
If camera-based, please describe software algorithm used for reconstruction of ball trajectory.
If camera-based, how many images of a trajectory are needed to maximise tracking accuracy (specify pre- and post-impact separately)?
Does the System use post-bounce data to establish ball/surface contact locations?
Information provided to Chair Umpire / user (including time delay between ball contact and signal to Chair Umpire / user).
(How) does the System deal with obstruction of ball by player(s)?
(How) does the System deal with the non-circularity of ball-surface contact area?

(How) does the System deal with sliding/rolling of ball during impact?

(How) does the System transfer data into other electronic systems (e.g. statistical databases and web-based 'live' scoring transmissions)?

#### A1.4 Performance

Please note that any performance characteristics supplied below will only be accepted in lieu of testing in exceptional circumstances. Where performance is not known, specify 'not known'.

Accuracy (average difference between true contact point and that recorded). Specify number of test impacts and inbound ball conditions.

Can the System accuracy be displayed by the software and how is it determined?

Resolution (i.e. smallest determinable change in ball position).

Precision (for a constant input, System makes the same decision).

How long does the System take to produce a result (i.e. provide a replay for a Review System or "out" call for a Real-time System)?

What is the longest period the System has operated uninterrupted by faults?

Range of temperature and humidity within the System operates at maximum accuracy.

Does the System produce the same accuracy under natural light and floodlights? What is the minimum lighting (in lux) the System requires to operate accurately?

Does the System function with the same accuracy at all venues?

Can the System perform a self-diagnosis of accuracy during use?

Has performance specified above been established by Vendor or independently (if independently, provide contact details of testing body, and supply a copy of any test reports)?

### **A1.5 Safety and security**

Does the System generate any emissions that are above ambient levels (such as electrical or magnetic fields)? If so, please specify type and intensity.

Does the software contain security features to (a) prevent hacking, and (b) ensure that data are not manipulated, either accidentally or deliberately? If so, please describe.

### **A1.6 On-court layout**

Please indicate the preferred location of all equipment (including connecting wires) by drawing on, and labelling, the diagram at the end of this section.

### **A1.7 Other information**

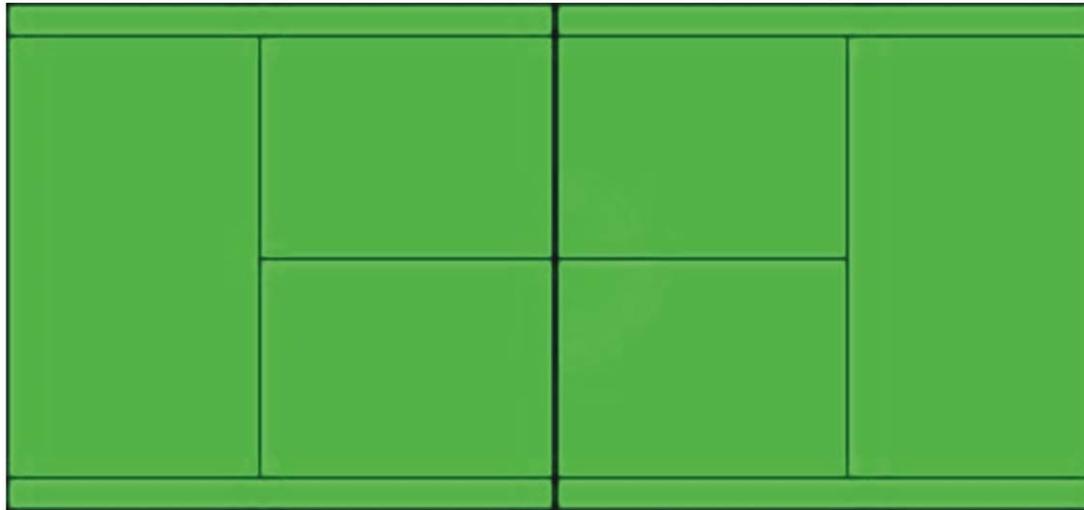
Please list any collaborations and/or partnerships with companies other than that named. Please specify the aspects of the System for which the companies specified are responsible.

Please provide any further information that you feel is of relevance here.

Note: Information provided in Appendix 1 may be used in the evaluation report. Photographic information/evidence for any aspect of the System information is welcomed.

# Seating Area

● Chair Umpire



## **Appendix 2 – System Requirements**

To satisfy the System Principles, Systems need to meet the requirements specified in sections A2.1 - A2.2.5 below (the “**System Requirements**”). The extent to which these System Requirements can be evaluated in this process may vary due to the characteristics of the System, time, and geographical constraints. The System Requirements are split into two sections: requirements all Systems must meet and level-specific requirements.

### **A2.1 System Requirements (all Systems)**

Requirements for all Systems, regardless of Classification Level are listed below. For objective requirements, measurement methods can be found in section 7 (System Evaluation). The suitability of the System to meet subjective requirements is at the discretion of the ELC Authorisation Body.

#### **A2.1.1 General**

- The System must provide full performance under common conditions that can be expected in a tennis match.
- The System must be unobtrusive when installed in its operating environment. At a minimum, it must not adversely affect the players or the officials.
- The System must not occupy so much space courtside as to interfere with the court layout, infrastructure or operation in comparison with currently accepted practice. It must not draw undue or excessive attention and must not detract from the enjoyment of spectators.
- The System must not adversely affect activities related to television or other communication media.

#### **A2.1.2 Performance**

- The System should provide coverage of all court lines. Doubles lines are not required during singles matches.
- The System’s performance must be unaffected by rain or moisture on the court surface, or surface temperatures in the range of 0-70°C (0-40°C for Systems being evaluated for indoor only usage).
- The System must be operational under all weather conditions that are deemed suitable for play by the Referee (not applicable for Systems being evaluated for indoor only usage).
- The System must meet the required performance standards under all combinations of normal playing conditions, including variation in bounce location, ball speed, spin and trajectory angle.
- The System’s performance will not be affected by any objects worn or carried by players or officials, including rackets.

### **A2.1.3 Court and Balls**

- If the court must be modified in any way, the modified court must not be materially different from a standard court in appearance and/or all playing characteristics.
- The playing characteristics of the court must be the same whether or not the System is in operation.
- If the ball must be modified in any way, all such modifications must be applicable to all ball types in current use. Modified balls must be ITF Approved.
- The sensing characteristics of the System/ball combination must not deteriorate over the ambient temperature range of 0-50°C, or by the appearance of moisture in the cloth cover (or clay if used on clay courts).

### **A2.1.4 Reliability and Maintenance**

- The mean time between any breakdown should be not less than 80 hours of operation.
- All parts of the System should be modularised to facilitate failure repair.
- The System should have multiple (at least double) redundancies built into its design.
- Following initial (pre-event) calibration, the System should be capable of re-calibration at that event during the course of normal play (i.e. between successive matches) without people or objects on the court surface.
- The System should have embedded test diagnostics.
- For Systems using impact-sensing elements under the court surface, a failure in one of those line elements must not affect the performance of other elements or any other part of the System.
- The System must have a high level of discrimination capability against non-ball in play signals. This would include background rejection, and interference effects due to magnetic, optical, infrared or other sources.
- There must be an adequate level of protection against deliberate or inadvertent actions by spectators, or players, to either produce a false or incorrect signal (such as an audible “out” beep) or otherwise interfere with the System.

### **A2.1.5 Safety and Interference**

- The System must not present a risk to players due to collision with equipment, electric shock, etc.
- Systems using energy sources such as electromagnetic radiation, infrared beams or optical methods should not pose any risk to the players, officials or spectators.
- The System must not have any significant adverse effects on other nearby electrical equipment, such as TV cameras, data transmission lines or microphones.

- Systems must be capable of operating satisfactorily in the electromagnetic environments normally found at major tennis venues.

## **A2.2 Classification Level specific System Requirements**

The following System Requirements vary depending on the level of System. For a System to be assigned a level it must meet all System Requirements (A2.1) alongside all the System Requirements for any single level.

### **A2.2.1 General**

Gold:

- The System should be controllable by the Chair Umpire, whether directly or indirectly.

Silver:

- The System should be directly controllable by the Chair Umpire or players.

Bronze:

- The System should be directly controllable by the Chair Umpire or players.

### **A2.2.2 Performance**

Gold:

- The System must be operational under natural, artificial and variable-light conditions that are suitable for play.
- The System will not be affected by the presence or movements of players (in singles and doubles play), including stepping/sliding or standing on the lines.
- A Review System should provide a replay of the ball trajectory and footprint relative to the lines on the court (using virtual or real images). The image quality and accuracy will be sufficient to visually confirm the System's (automated) decision. This image will be available to the Chair Umpire and players, and, upon approval by the tournament Sanctioning Body, to others such as spectators or television viewers. The average time interval between the ball bounce and availability of the replay should not exceed 10 seconds. The maximum time should not exceed 30 seconds.
- A Real-time System should provide "out" calls automatically and simultaneously to umpires, players and spectators in a clear and unambiguous way with an audible signal. A number of choices of types and volumes of audible signals (including synthetic voice) must be available for use by the Chair Umpire or tournament management. The time interval between ball bounce and the audible signal must not be significantly longer than that normally required for a Line Umpire's call. An appropriate response time is  $0.15 \pm 0.05$  seconds.
- There must be a sufficiently wide 'sensed zone', where the ball impact location is detected, either side of the line. The minimum size of such zone is from 50 cm 'in' to 100 cm 'out'.
- There must be a sufficiently wide 'call zone' where "out" calls are provided. The minimum distance for such zone is 2.0 m from the lines.

#### Silver:

- The System must be operational under natural or artificial light conditions typical of tennis venues. The System must remain operable at lux levels equal to or above 500 lux.
- The System will not be affected by the presence or movements of players (in singles and, optionally, doubles play), including stepping/sliding or standing on the lines.
- A Review System should provide a visual image of the ball trajectory or footprint relative to the lines on the court. The image quality and accuracy will be sufficient to visually confirm the System's (automated) decision. This image will be available to the Chair Umpire and players (as required).
- A Real-time System should have the ability to provide "out" calls automatically and simultaneously to umpires, players and spectators in a clear and unambiguous way with an audible and visual signal. The time interval between ball bounce and the signal must not be significantly longer than that normally required for the ball to travel from near the baseline to the net. An appropriate response time is  $0.3 \pm 0.2$  seconds.
- There must be a sufficiently wide 'sensed zone', where the ball impact location is detected, either side of the line. The minimum size of such zone is from 30 cm 'in' to 60 cm 'out'.
- There must be a sufficiently wide 'call zone' where "out" calls are provided. The minimum distance for such zone is 1.0 m from the lines.

#### Bronze:

- The System must be operational under natural or artificial light conditions typical of tennis venues.
- The System will not be affected by the presence or movements of players (in singles and, optionally, doubles play), including stepping/sliding or standing on the lines.
- A Review System should provide an in/out call for any selected shot.
- A Real-time System should have the ability to provide "out" calls automatically and simultaneously to umpires, players and spectators in a clear and unambiguous way with an audible and visual signal. The time interval between ball bounce and the signal must not be significantly longer than that normally required for the ball to travel from near the baseline to the net. An appropriate response time is  $0.3 \pm 0.2$  seconds.
- There must be a sufficiently wide 'sensed zone', where the ball impact location is detected, either side of the line. The minimum size of such zone is from 30 cm 'in' to 60 cm 'out'.
- There must be a sufficiently wide 'call zone' where "out" calls are provided. The minimum distance for such zone is 1.0 m from the lines.

### **A2.2.3 Control/Replay Equipment**

Gold:

- The System must include equipment to enable a Chair Umpire to control and/or monitor (or be aware of) its status, and that of the match.
- The control functions of any handset used by the Chair Umpire must be compatible with existing scoring handset systems used in professional tennis and must have suitable interface characteristics.
- When used as a replacement for on-court Line Umpires, the System status monitoring must be provided to the Chair Umpire in an unobtrusive manner, without affecting the task of officiating.
- When used as a replacement for on-court Line Umpires, the control equipment must have the capability to allow the use of special purpose software (e.g. for visual confirmation of all decisions or actions taken).
- When used as a replacement for on-court Line Umpires, equipment must be available for the RO to make, and communicate to court, near instantaneous foot fault decisions.

Silver:

- The System must include equipment to enable the operator (Chair Umpire or player) to control and/or monitor (or be aware of) its status, and that of the match.
- When used as a Review System the user interface should allow for easy and quick selection of ball impacts by the Chair Umpire or players.
- Ball trajectory and impact print relative to the court lines must be visualised within 5 seconds of shot selection.

Bronze:

- The System must include equipment to enable the operator (Chair Umpire or player) to control and/or monitor (or be aware of) its status, and that of the match.
- When used as a Review System the user interface should allow for easy and quick selection of ball impacts by the Chair Umpire or players.
- Ball trajectory and impact print relative to the court lines must be visualised within 10 seconds of shot selection.

### **A2.2.4 Reliability and Maintenance**

Gold:

- A Real-time System must have a proven back-up System capable of restoring/maintaining its line-calling service within 5 minutes of any loss of service provided by its primary System (e.g. in case of a power outage/surge at the venue).
- The majority of failures of the System should be easily correctable by the Chair Umpire or a trained technician within 5 minutes.

- The System should reliably provide accurate calls. The frequency of missed or incorrect calls should not exceed 1 call per 120 hours of operation for a Review System or 1 call per 12 hours for a Real-time System for a minimum of 120 hours of operation.

Silver:

- A Real-time System must be able to be reset within 10 minutes of any loss of service (e.g. in case of a power outage or System disturbance from player or equipment collisions).
- The System should have a built-in capability for automatic self-test, which should be carried out at frequent intervals during standby conditions.
- The majority of failures of the System should be easily correctable by the Chair Umpire or players with minimal training within 5 minutes.
- The System should reliably provide accurate calls. The frequency of missed or incorrect calls should not exceed 1 call per 12 hours of operation for a Review System or 1 call per 6 hours for a Real-time System for a minimum of 120 hours of operation.

Bronze:

- The System should have a built-in capability for automatic self-test, which should be carried out before play commences.
- The majority of failures of the System should be easily correctable by the Chair Umpire or players with minimal training within 10 minutes.
- The System should reliably provide accurate calls. The frequency of missed or incorrect calls should not exceed 1 call per 9 hours of operation for a Review System or 1 call per 4 hours for a Real-time System for a minimum of 120 hours of operation.

### **A2.2.5 Accuracy**

Gold:

- The decision-making success rate (i.e. “in” or “out” decisions) for all impacts in the range 100 mm ‘in’ to 100 mm ‘out’ (as measured by the ITF) should be 100% with a tolerance of  $\pm 5$  mm.
- The average absolute discrepancy between the System and the ITF for all impacts on a single line on court should not exceed 5 mm.
- The maximum discrepancy between the System and the ITF for all impacts should not exceed 10 mm.

Silver:

- The decision-making success rate (i.e. “in” or “out” decisions) for all impacts in the range 25 mm ‘in’ to 25 mm ‘out’ (as measured by the ITF) should be 80%.
- The decision-making success rate (i.e. “in” or “out” decisions) for all impacts from 25-100 mm ‘in’ or ‘out’ (as measured by the ITF) should be 95%.

Bronze:

- The decision-making success rate (i.e. “in” or “out” decisions) for long-line impacts in the range 25 mm ‘in’ to 25 mm ‘out’ (as measured by the ITF) should be 75%.
- The decision-making success rate (i.e. “in” or “out” decisions) for cross-line impacts in the range 25 mm ‘in’ to 25 mm ‘out’ (as measured by the ITF) should be 65%.
- The decision-making success rate (i.e. “in” or “out” decisions) for all impacts from 25-100 mm ‘in’ or ‘out’ (as measured by the ITF) should be 85%.

## Appendix 3 – System Monitoring

### A3.1 Post-Evaluation Assessment

#### Method

The Vendor is responsible for running the Post-Evaluation Assessment under the supervision of the RO. The RO is responsible for selecting testing locations across the court, ensuring the shots are valid, and the results are reported accurately. Instruction manuals and documentation to record results can be requested from the ITF ([elc@itftennis.com](mailto:elc@itftennis.com)). Four locations, including at least one cross-court line (service lines and baselines) on each side of the court and a long line (parallel to the length of the court), are selected. The Vendor will then set up the high-speed camera at the first location and take 10 valid shots. During this process, the high-speed camera operator should not have direct contact with the System operator. Acceptable shots typically meet the following criteria as measured by the System unless measured otherwise using the high-speed cameras (Figure A1):

- Inbound shot speed 80-120 km/h (slower speeds are also permitted at the discretion of the RO)
- Inbound angle 15-20° (higher angles are also permitted at the discretion of the RO)
- Ball bounce location within 100 mm 'in' or 'out' (measured by the high-speed cameras)
- Ball bounce location within 300 mm of the calibration point along the length of the line.

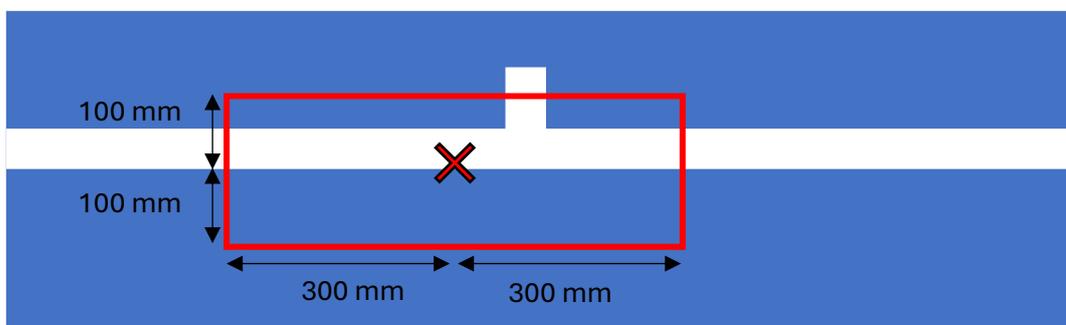


Figure A1. Area of acceptance for ball bounces. Red cross indicates target location on the baseline as selected by the RO. Red box indicates acceptable limits for ball landing location.

Performance of the System is measured using the Accuracy Score which reflects how the System performs against the System Requirements for accuracy (Appendix 2.2.5: Accuracy). After three locations have been tested (30 shots total), the Accuracy Score is calculated using the results template provided to the Review Official by the ELC Authorisation Body. For Gold-level Systems, if the Accuracy Score is below 10, the assessment is finished, and the results are sent to the tournament Referee/Supervisor and the ELC Authorisation Body. If the Accuracy Score is 10 or above, the assessment continues to the fourth location. At this location 10-15 valid shots are taken. If, after the additional shots, the Accuracy Score remains at 10 or above, the accuracy assessment

is failed, and the results are sent to the tournament Referee/Supervisor and the ELC Authorisation Body. Following confirmation from the ELC Authorisation Body, an ANS is issued by the ELC Authorisation Body.

**Calculation of Accuracy Score for Gold-level Systems**

The Accuracy Score can be calculated via:

$$\left( \frac{\textit{Average}}{\sqrt{n}} + \frac{\textit{Over ten}}{\sqrt{n}} + \frac{\textit{Wrong}}{\sqrt{n}} \right) \times 10$$

Where:

- n* Total number of shots
- Average* Average discrepancy between Systems (mm)
- Over ten* Number of shots with a discrepancy above 10 mm
- Wrong* Number of wrong decisions (outside of 5-mm tolerance)

**A3.2 Tournament Fault Log**

During a tournament, the RO will monitor the System and record any malfunctions in a Fault Log. Faults are categorised by severity with Level A faults indicating a malfunction resulting in play being stopped or a point replayed (Table A1). Level B faults indicate System malfunctions where the result of the point can be correctly assigned but where there is a deviation from the standard operating procedure (Table A1). If any faults are recorded during a tournament, the Fault Log is sent to the Sanctioning Body for review. If the Sanctioning Body believes the System has broken the points threshold for the given tournament, the report is sent to the ELC Authorisation Body for review. Following confirmation from the ELC Authorisation Body, an ANS is issued by the ELC Authorisation Body. The Vendor will receive a summary of the fault log to comment on any faults.

**Calculation of results**

Where faults have been logged during a tournament, Systems are assigned points based upon the severity and duration of the fault. Point totals for each tournament are assessed against the allowable limit which is dependent on the number of matches for the System has been used during the course of the Tournament.

The points threshold for Gold-level Systems is calculated by doubling the number of complete matches for which the System was used during the tournament. For example, a tournament at which the System was used for 64 matches would have a limit of 128 points.

The points threshold for Silver-level Systems is calculated by multiplying the number of complete matches for which the System was used by five. For example, a tournament at which the System was used for 64 matches would have a limit of 320 points.

Fault	Issue	Description	Points allocation			
			Each time	≤15 min	≤30 min	Every 15 min over 30 min
A+	Wrong point awarded	Any fault resulting in the point being awarded to the incorrect player	50			
A1	System down	ELC System down resulting in play being stopped	-	20	30	100
A2	System malfunctions	No tracking or bounce on main and spare System, no result	20			
A3	Wrong setup	Wrong set up of singles/doubles or wrong service box selected, play stopped	10			
A4	Other issues affecting play	Random or clearly erroneous FAULT or OUT calls	10			
A5	All cameras 1 feed loss	TV camera down as well as Vendor camera 1 feed down, play stopped	10			
A6	No system call	No or late on court System call within call zone – Chair umpire intervenes	10			
B1	Software issues	Frozen main or spare System or other software issues	2.5			
B2	Partial camera 1 feed loss	Loss of TV camera 1 or ELC Vendor camera 1 view, play continues	2.5			
B3	Wrong set up	Wrong set up of singles/doubles or wrong service box selected, play continues	2.5			
B4	Loss of light signal	Loss of light on Chair Umpire or Review Official panel	2.5			
B5	Late System call	Late on-court System call within call zone – No chair umpire intervention	2.5			
B6	Court sound loss	Court sound loss in the booth or no audio calls on court. CU uses light to make the call	2.5			
B7	Unable to send signal	Unable to send Cancel, STOP STOP or foot fault signals. Wrong set up of RO controls	2.5			
B8	Foot fault camera loss	Total foot fault camera loss	-	1	2.5	
B9	No show on board	No visualisation available on court board due to vendor issue	2.5			
B10	Other moderate failures	Partial foot fault camera loss, double call, other issues. Play continues	1			

Table A1. Description of points and associated point allocation.

### **A3.3 Reliability Audit**

Vendors will be asked by the ELC Authorisation Body to provide a minimum of five matches of data selected by the ELC Authorisation Body from a tournament. This will include both singles and doubles matches where appropriate. The vendor must state any matches for which data is unavailable or unsuitable for audit before the ELC Authorisation Body selects matches. If data for more than 50% of matches at a tournament is unsuitable, this tournament cannot be used for reliability audit purposes. The Reliability Audit shall take place as set out in section 7.5.6. If the Reliability Audit is failed, the matter is referred to the ELC Authorisation Body for an ANS to be issued.

For Gold-level systems the data for two matches will be analysed. If all bounce coordinates are present and accurate, the audit is complete. If two, or more, missing bounce coordinates or incorrect calls are identified, the audit is failed. If there is one missing bounce or incorrect call, two additional matches will be assessed. If any additional missing bounces or incorrect calls are present, the audit is failed.

For Silver- and Bronze-level systems the data for two matches will be analysed. If there are two or fewer missing or incorrect bounce points, the audit is complete. If three, or more, missing bounce coordinates or incorrect calls are identified, the audit is failed.