

Review Article

A Review Paper on Goal-Line Technology

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Abstract

The goal-line technology is a method used to determine when the ball has slightly crossed the goal line with the assistance of electronic devices and at the same time assisting the referee in awarding a goal or not. Aim of goal-line technology is to assist the match officials in decision-making rather than replacing them. GLT must provide a evident indication that the ball has crossed the line so as to award or cancel the goal.

Keywords: GLT, football, FIFA, GoalRef, Hawk-eye, GoalRef, Cairros

1. Introduction

The topic that we have chosen to discuss in our research paper is the emergence of the use of video technology in sports in recent years. During our lifetimes, information and computer technologies have significantly changed the world. The major technological revolution has had a very profound effect on contemporary sports over the last twenty years. Therefore, the use of different types of technology has become important in recent years due to the fact that sports contain moments in which there are mistakes made by referees and officials. The introduction of technology regarding these sports in recent years has helped to eradicate a number of these errors. The specific type of technology that is going to be discussed in this research paper is the use of video technology in relation to the potential introduction of goal line technology in football.



Fig 1 The Adidas Teamgeist – II with implanted chip, part of proposed Cairros-Adidas system for Goal-line technology

On 5 July 2012, the International Football Association Board (IFAB) officially approved the use of goal line

technology. The two systems approved in principle were involved in test phase 2: GoalRef and Hawk-Eye. In December 2012, FIFA announced it would introduce goal-line technology in a competitive match for the first time at the 2014 FIFA World Cup in Brazil.

2. Review

At its Annual Business Meeting on 20 October 2010, the IFAB discussed the implications of measurement systems that are capable of automatically detecting the scoring of a goal during a football match (so-called goal-line technology or GLT). Consequently, the IFAB laid down a set of four basic requirements a GLT system has to fulfill:

- The goal-line technology applies solely to the goal line and
- Test at the Home of FIFA in Zurich only to determine whether a goal has been scored or not.



Fig 2 Test at the Home of FIFA in Zurich

- The GLT system must be accurate;
- The indication of whether a goal has been scored must be immediate and automatically confirmed within one second.
- The indication of whether a goal has been scored will be communicated only to the match officials (via the referee's watch, by vibration and visual signal).

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2.1 Role of IFAB

As with all changes to the Laws of the Game, IFAB must sanction the use of goal-line technology. Six votes are required to make any changes. FIFA holds four votes and each of the world's first four football associations carries one vote. These are England's The Football Association, the Scottish Football Association, the Football Association of Wales and Northern Ireland's Irish Football Association.

2.2 Challenges for the referee

One of the challenges for referees is that the human eye can handle only approximately 16 images per second, which means the ball needs to be behind the line for at least 60 milliseconds. However, in some cases the ball is only behind the line for a few milliseconds before a player kicks it back or it rebounds back into the field of play, with the result that the human eye cannot see whether the ball has crossed the line.

Another challenge is the vantage point. When viewed from certain angles, it is easy to misjudge the ball's position. Cameras placed at different angles can mislead viewers when showing images "proving" whether or not the ball has crossed the line, which is why only technology dedicated to evaluating such incidents can support the referee in the decision-making process and contribute to a fair game.

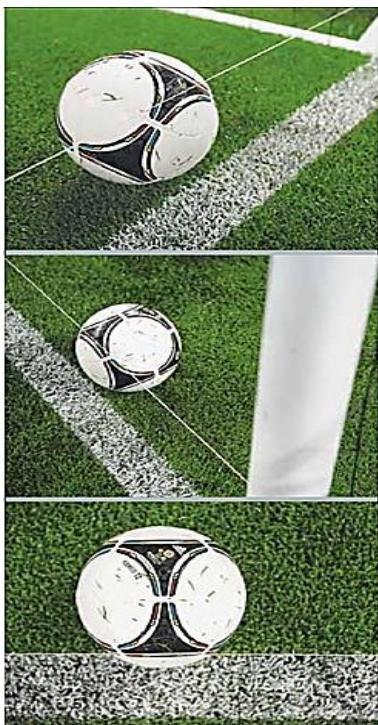


Fig 3 One situation, different perceptions

3. Pre-Planning

As a first step, the competition organizer should discuss the needs and opinions of the competition members concerning goal-line technology. After performing a cost-benefit analysis for this project, it is recommended that the

organiser discusses and answers basic questions on the implementation of GLT for the competition in question.

	OPTION 1	OPTION 2
General System	Allow GLT use All stadiums must have the same system	Do not allow GLT use All stadiums must have the same system
Ownership/ finance	System is purchased by stadium owner	System is financed (lease/purchase) by competition organiser
Maintenance	Centrally organised and administered by competition organiser	Individual organised for each installation
Application in Competition	All competition matches to use GLT	GLT need not be used in all games (possible introduction during competition)
Replays of goal-line Incidents	No replays allowed	Replays accepted only on TV

Fig 4 Initial questions to be answered by the competition organizer

Steps included in pre-planning are:

- 1 – Cost Calculation
- 2 - Pre-planning checklist
- 3 - Recommended content of tender for GLT
- 4 – Recommended agenda for site inspection
- 5 – Bidding procedure checklist
- 6 – Project agreement – consideration of legal points

3.1 Hawk-Eye

The Hawk-Eye system was first developed in 1999. It is based on the principle of triangulation using the visual images and timing data provided by high-speed video cameras at different locations around the area of play. The system uses high frame rate cameras to triangulate and track the ball in flight. The software calculates the ball's location in each frame by identifying the pixels that correspond to the ball. The software can track the ball and predict the flight path, even if several cameras are being blocked. The system also records the ball's flight path and stores it in a database that is used to create a graphic image of the flight path, so the images can be shown to commentators, coaches and audiences. The data from the system can also be used to determine statistics for players and analyse trends. The proposal involves placing seven cameras for each goal mouth around the stadium



Fig 5 Hawk-eye System

3.2 GoalRef Attachment

GoalRef features a passive electronic circuit embedded in the ball and a low-frequency magnetic field around the goal. Any change in the field on or behind the goalline is detected by coils embedded in the goal frame, which determine the scoring of a goal. By producing low magnetic fields around the goals, GoalRef creates the radio equivalent of a light curtain. As soon as the ball has wholly crossed the goal line between the posts, a change in the magnetic field is detected. A goal alert is then instantaneously transmitted to the game officials using an encrypted radio signal, with a message displayed on their wristwatches.



Fig 6 GoalRef Attachment

3.3 Cairo's GLT system

It uses four major components

- 1-Magnetic Field
- 2- Sensors
- 3- Receivers

4- Referee

There are few pros and cons of using this technology

The advantages are:-

Returns the signal in $1/10^{\text{th}}$ of a second

Ball doesn't have to be visible

99.9% accurate

The only disadvantage here is that it is compatible only with Adidas balls



Fig 7 Cairo's GLT system

4. Installation Period

One of the most sensitive points during this phase of the project is determining a joint schedule for the installation and final test of the goal-line technology systems. All parties in this process (competition organiser, GLT provider, stadium management) should therefore agree on the dates when the company will be allowed access to the stadium(s) to install its system(s), especially those dates when it is allowed to enter the field of play.

4.1 FIFA Club World Cup 2012

Between October and November 2012, the GLT providers began the installation of their systems in the two stadiums used for the FIFA Club World Cup in Japan. In close cooperation with the Japan Football Association (JFA), the Local Organising Committee and the local stadium management, Hawk-Eye installed its system in the Toyota Stadium (15th October – 28th November) and GoalRef in the Yokohama International Stadium (19th November – 2nd December).



Fig 8 GoalRef Antenna behind the goal

5. Final Installation test and acceptance of the installation

Checklist for final installation test and acceptance of the installation

Select an independent test institute for the final installation test (contract needed)
 Determine a schedule for final installation test
 Prepare the competition stadiums (stadium management) for the final test
 Approve the final installation based on positive test results
 Submit the signed FIFA acceptance and acknowledgement form to the GLT provider
 Check whether the installation appears on fifa.com before the start of the competition



Fig 9 Final installation test – dropping a plumb to define the goal line

Once the requirements for final installation test and Acceptance of the installation are fulfilled then the FIFA Quality Programme for Goal Line Technology (GLT) hands out an acknowledgement to the association. This is known as the FIFA acceptance and acknowledgement form.

6 . Education of referees

Training session on Goal-Line Technology

Explain why goal-line technology supports referees (vantage points!)

Present the installed GLT system

Demonstrate the accuracy of the system

Explain the referee's watch in detail

Hand over a referee checklist for the obligatory referee check

Provide training in the referee check for all participating referees

Explain the procedure should the watch malfunction during a match

Ask for feedback on the functionality of the GLT system after each match

Questions and answers after the training session

"It was important that we had the training session before the tournament to show the referees the accuracy of the system and that they could rely on the new technology."
(FIFA Head of Refereeing Massimo Busacca, 16 December 2012)



Fig 10 Goal-line technology training session

Conclusion

First implemented at FIFA Club world cup 2012, and since then it has been implemented at multiple tournaments, like English Premier League, Liga BBVA, Bundesliga, etc and internationally it has been implemented at FIFA Confederations Cup 2013 and the FIFA world cup 2014, both in Brazil. GLT has been a success, since it has ameliorated the sport and given a helping hand to the match officials. Goal Line Technology makes use of GoalMinder, Cairos , GoalRef and the Hawk-eye system to assist in decision making. It has eliminated the missed events affecting the game as well as it uses magnetic fields and cameras to enhance the decision making ability of the referees.

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