Development of dynamic test methods to evaluate offside technology accuracy

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Introduction

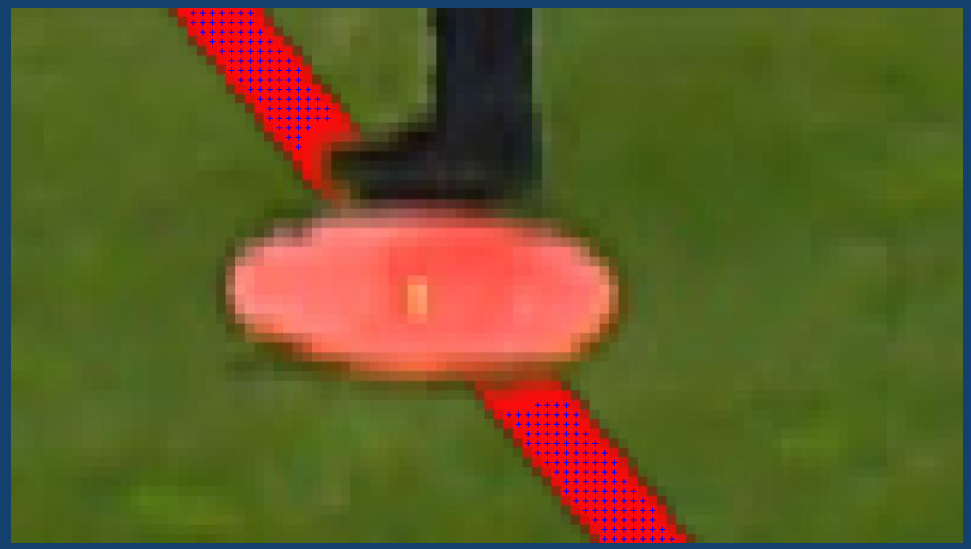
- The Video Assistant Referee (VAR) team supports the decision-making process of the referee in four game-changing situations: goals, penalties, red cards and mistaken identity.

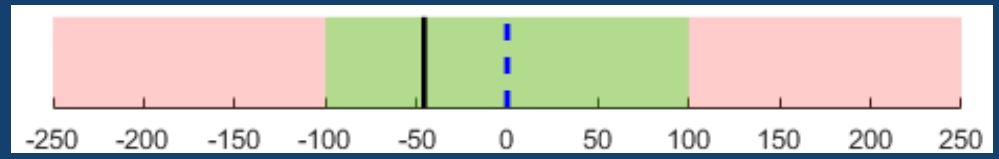
- FIFA called for technology providers to present a solution for the creation of a virtual offside line (VOL), to assist referees determine whether an offside incident had occurred.

- The accuracy of offside incident identification, and whether offside lines were parallel to corresponding goal lines, was assessed using broadcast footage, at a special test event:

Introduction

- 2017 test event at Sandhausen FC, Germany.





Summary metrics:

	Incident (A)	Near side (B)	Far side (C)	Angle (α)
Measurement	-45.8	-49.1	-21.6	0.0
Pass / fail	✓	✓	✓	✓

Introduction

- In addition to two-dimensional (e.g. pitch-level) offside assessments, static three-dimensional assessments (e.g. elevated boot) have been introduced since 2018.

- However, and whilst useful, initial assessments were limited from a number of perspectives:

  - No movement between attacking and defending players,

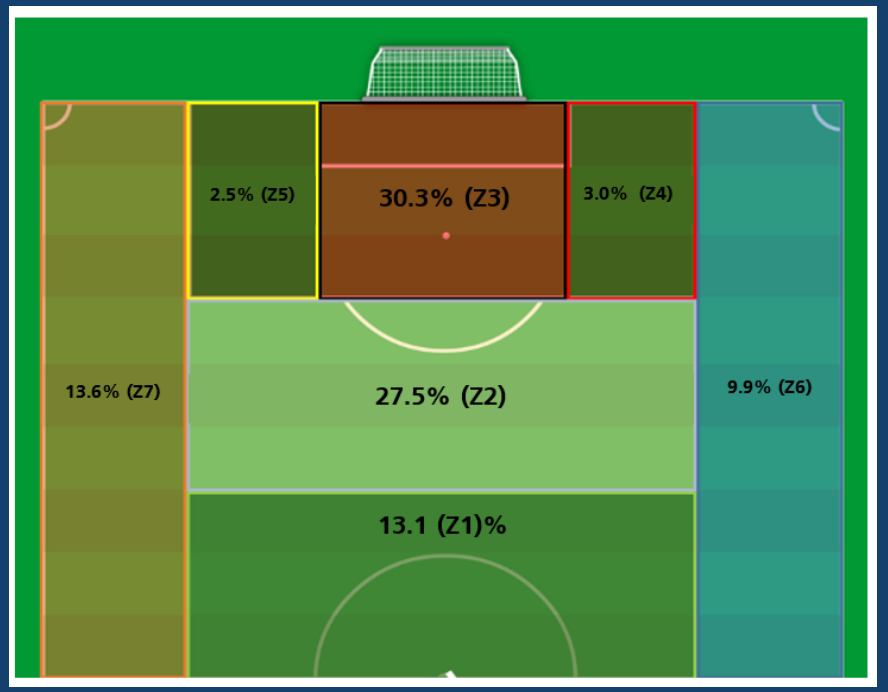
  - Uncertainty surrounding the time instant of the forward kick,

  - Use of static broadcast camera footage, and representativeness of three-dimensional locations assessed.

- FIFA, Sheffield Hallam University (SHU) and Manchester Metropolitan University (MMU) are working collaboratively to address these concerns.

Review of problem

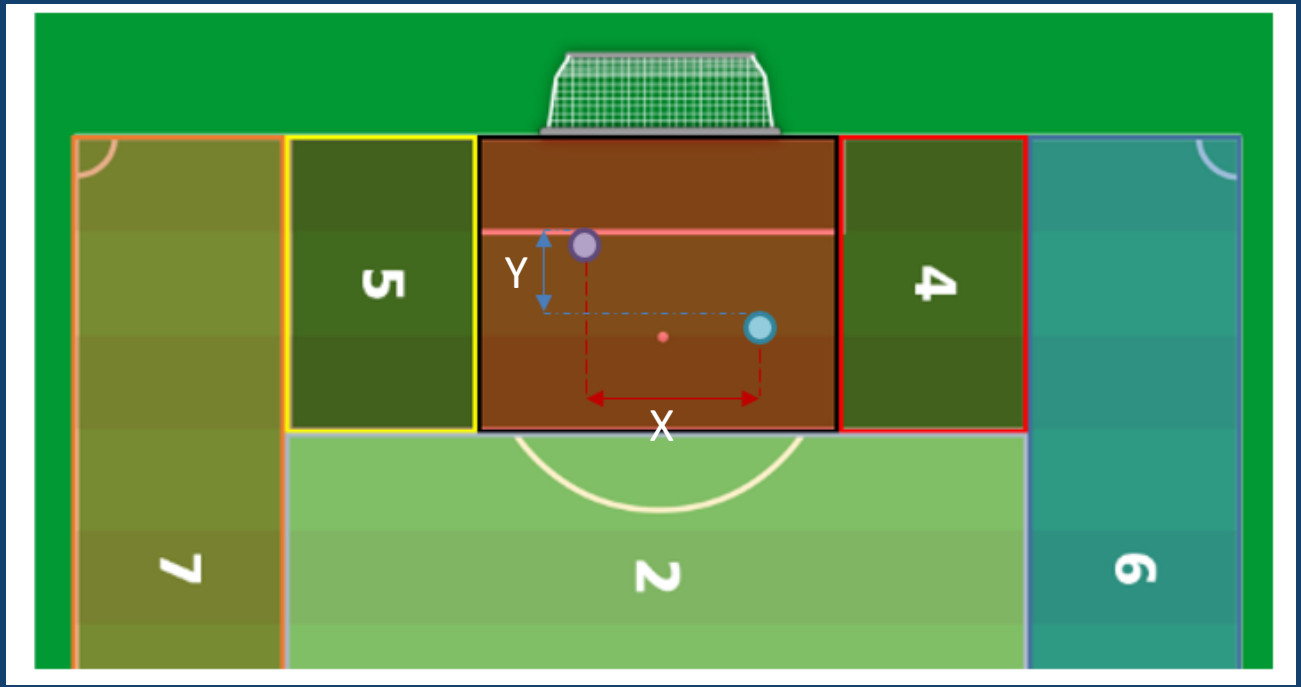
- Understanding of offside incidents is important. Recent analysis by FIFA* highlights that ~58% of all offside incidents occurs in central, penalty area regions (Z2 and Z3).



*Data from FIFA U20 World Cup Poland 2019, FIFA Women's World Cup France 2019, FIFA U17 World Cup Brazil 2019, FIFA Club world Cup Qatar, 2019.

Review of problem

- Inter-player distances (Z2 and Z3) were 7.1 m and 1.3 m (X and Y directions respectively)*, reflecting a high number of 'difficult' offside decisions within analysed incidents.



*Data from FIFA U20 World Cup Poland 2019, FIFA Women's World Cup France 2019, FIFA U17 World Cup Brazil 2019, FIFA Club world Cup Qatar, 2019.

Review of problem

- Current test methods do not account for moving players and moving cameras, and they do not assess offside lines for both attacking and defending players.

- Analysis indicates that ‘difficult’, high-velocity incidents occur in central, penalty area regions.

- Accurate and high-speed three-dimensional photogrammetry is therefore essential to minimise uncertainty associated with the time and location of a player’s limb(s).

- Further, the instant of forward kick must be accurately determined, to assess accuracy margins for offside incidents assessed using different frame rate video.

Concept

- To address this problem, our collaborative research will address;

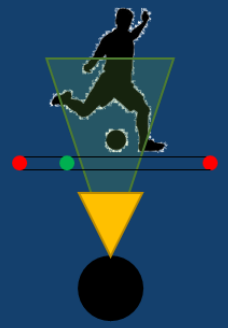
    1. Three-dimensional position of body locations – for a moving attacker and defender – in relevant pitch regions,
    2. Time instant of the forward kick,
    3. Agreement with offside technology providers, using moving broadcast camera footage.

Method

- Six calibrated high-speed (1,000 Hz) cameras will be used to accurately assess the three-dimensional position of goal-scoring body locations (markers) for an attacker and defender.
    - Cameras provide two ~74 m^3 motion capture volumes for attacker and defender. Measures resolved into a common coordinate system, aligned to the corresponding goal line.
- Seventh high-speed camera (1,000 Hz) identify instant football is kicked, and instant offside technology provider assesses incident, using a timing system visible in both image sets.
    - Allows measurement of relevant perpendicular distances between VOLs, and offside decision.

Method

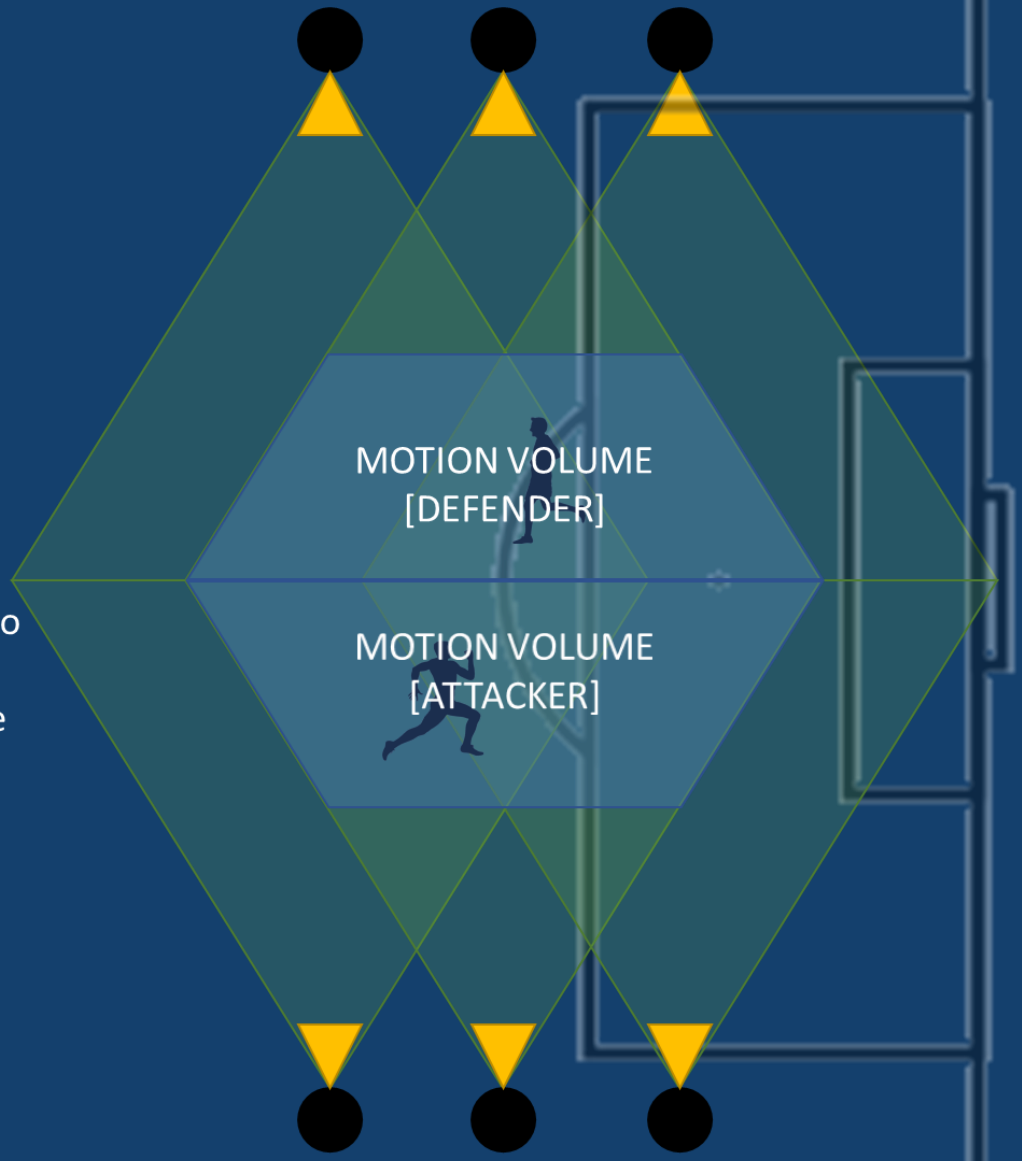
TIMER		
17	55	01
		02



Seven synchronised, high-speed video cameras provide a large three-dimensional motion capture volume and football kick identification area

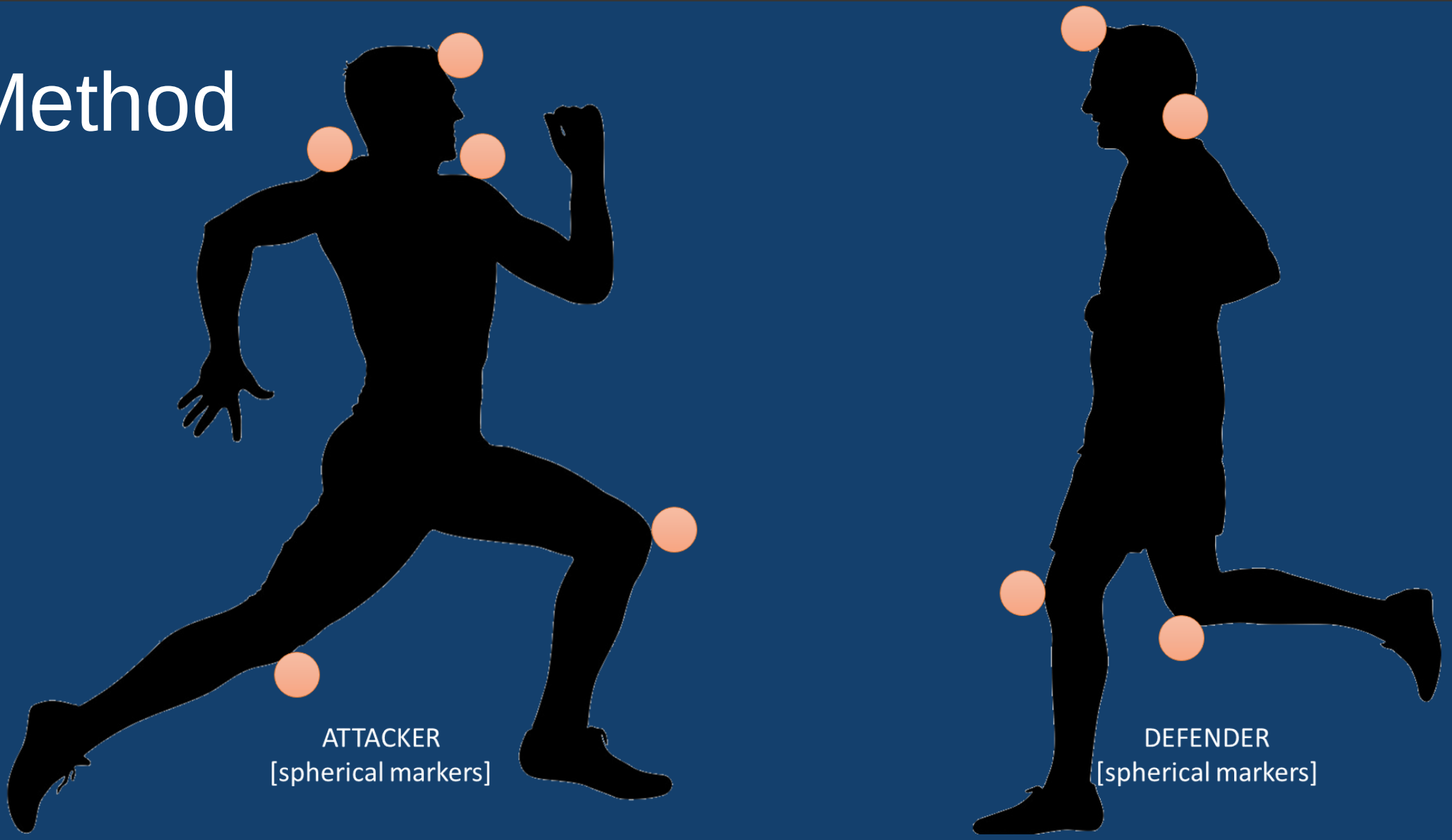
KEY

High-speed video camera



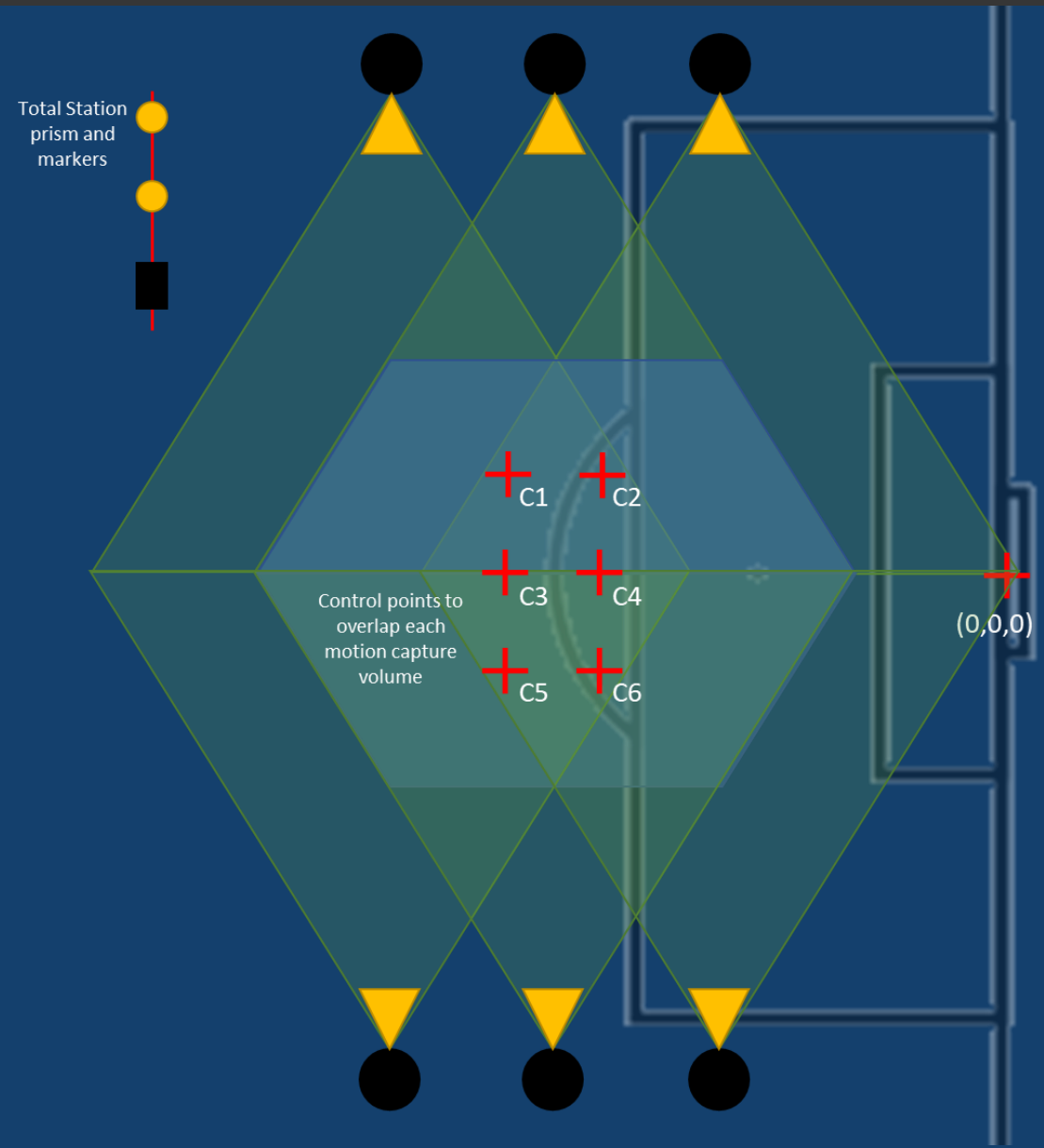
Experimental setup (not to scale). Setup illustrates attacker and defender motion volumes and the synchronised capture of football kick and timing system, to identify corresponding broadcast video images.

Method



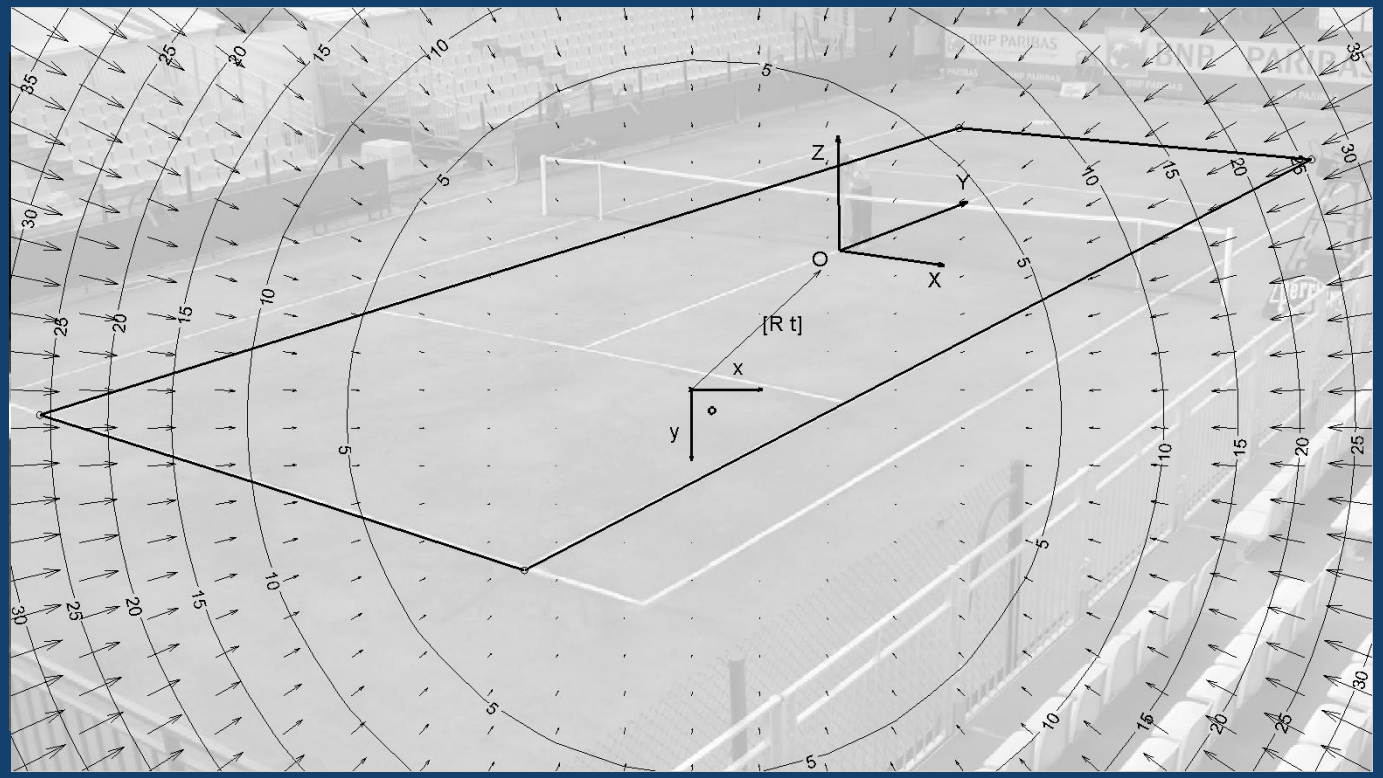
Large spherical markers attached to wearable garments (e.g. vest top, knee support and hat) provide reference points (incl. boot heel or toe) for high-speed camera and offside technology provider assessment (not to scale).

Method



Definition of a common coordinate system (not to scale). Defining three-dimensional control points, using a Total Station surveying tool, will allow the alignment of high-speed camera and offside technology provider information, relative to the corresponding goal line.

Method


Z
Y
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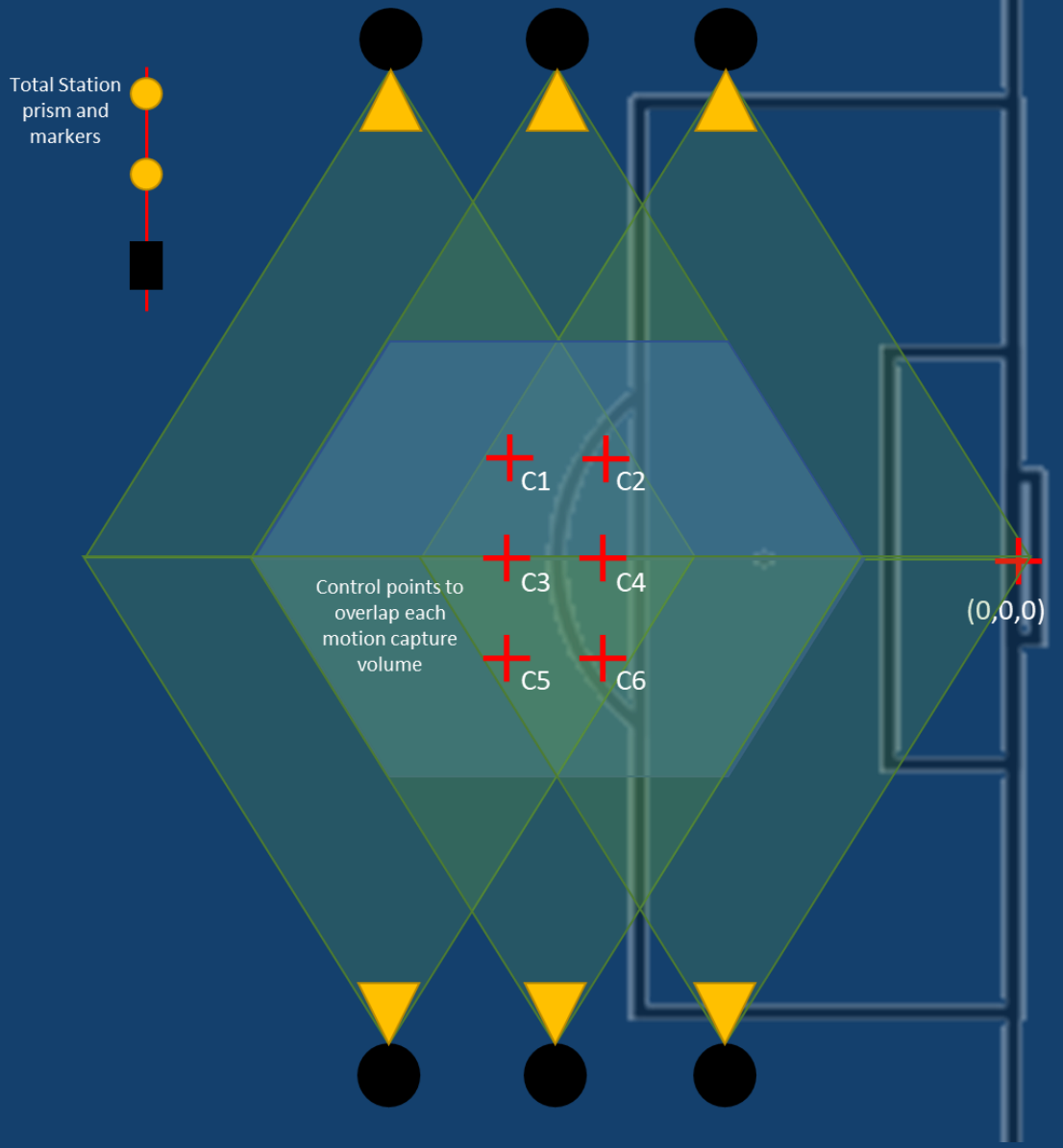
y


Total Station prism and markers
C1
C2
C3
C4
C5
C6
Control points to overlap each motion capture volume
(0,0,0)

Summary

- To summarise, collaborative research will provide high-speed, three-dimensional measurements for clearly definable body locations (markers).
    - This is necessary to minimise player movement between images and uncertainty when defining VOLs.
- Specifically, research will assess:
    - Accuracy of body marker locations identified by offside technology providers, in three-dimensions.
    - Perpendicular distances of attacking and defending player VOLs, based on body marker locations.
    - Confirmation of onside or offside decision.
    - Measures provided for instant football is played upfield, and instant identified by offside technology providers.

Status

- Timeline for collaborative research has been impacted by ongoing COVID-19 pandemic restrictions. However, research is planned to be implemented in three phases;
    - Phase 1: Laboratory-based validation of high-speed camera measures (Advanced Wellbeing Research Centre, UK),
    - Phase 2: Field-based pilot of dynamic VOL test block (UK stadium),
    - Phase 3: Field-based offside technology provider assessment, using dynamic VOL test block (international stadium).

Advanced Wellbeing Research Centre

- Sheffield Hallam University's Advanced Wellbeing Research Centre (AWRC) is a £14 m Department of Health and Social Care funded facility, it was launched in February 2020.
    - AWRC houses a wide range of state-of-the-art research facilities, including a 500 m^2 Movement Analysis laboratory, and is also home to the Sports Engineering Research Group.

Sheffield Hallam University

Sheffield Hallam University | Sports Engineering Research

Manchester Metropolitan University

FIFA

Thank you for your attention.

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