Chapter 7

# Technological Advances in Football ⚬

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**Abstract**

In this section, the technologies recently used in football are analysed. Football is seen as the most popular branch of the world in terms of spectatorship. Technology is used at the highest level in order to improve the performance in football and not to decrease the interest of the audience. Technology is used from the structure of the stadiums to the clothes worn by the athletes. Wearable technologies have made it easy for coaches to provide feedback by providing information about instant performance monitoring of athletes. In this section, a literature review has been made about the technologies used in football. The proposition "Football, which has become a giant industry since the beginning of the 21st century, is obliged to use technology in order to maintain its economic value" has been tried to be explained.

## 1. Introduction

Starting from ancient times and continuing with the establishment of modern football, football continues to be a sports branch that continues to maintain its popularity without losing its popularity until today due to the fact that it is played, followed and loved by all age groups as well as its interest, excitement, cooperation, competition, socio-cultural, communication and economic value of people and societies.

The popularization of football due to the fact that it is watched and dealt with by a large mass of people coincides with industrialization and its aftermath (Şentürk, 2007). Depending on industrialization and post-industrial transformations, football has become the most talked about sport among other sports branches and its fans are constantly increasing (Kıvanç, 2001). Today, based on the interest in football and the astronomical figures spent on it, it can be stated that the interest in football is constantly increasing

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with the technological, sociological, economic and cultural developments that go one step forward with each passing moment and that it has taken its place in the group of professions as a rent. Known as the branch with the highest popularity, soccer has become a situation that is equated with sports in the minds. So much so that football constitutes one out of every three academic studies in the field of sports sciences. The issue of football popularity, which is open to evaluation from many angles, needs to be looked at from different angles (Öntürk et al., 2019).

## Technology and Football

With the advancing technological developments, human life is equipped with electronic devices. Depending on these developments, individuals can easily follow whatever they are interested in through social media, internet websites, blog sites and web media. Football is a popular sport that has been followed, watched and played by millions of people for many years. In some countries, it is not seen as a sport but as a separate reality and a completely different world (Solmaz & Baritci, 2019).

As digitalization resulting from developments in communication and information technologies has transformed people's habits, football has taken its share of this transformation. The fact that this interest continues to increase day by day has caused the game to take on a commercial structure and has turned football into a giant industry. This giant industry, which has actors such as football clubs, media, fans, referees, coaches and players, has undergone a significant transformation with the digital age, which we encounter in every aspect of daily life and changes all habits of humanity. Of course, it is inevitable that this period, which eliminates the distinction between time and space and in which digitalization is intertwined with human life, has manifested itself in a field like football, which attracts millions of people and earns millions. This transformation in football has taken place within many different parameters of the digital age. Technological developments have enabled football to be played on more favorable fields, with better-equipped equipment and presented to the masses through better quality broadcasts (Çırak, 2020).

Technology has historically always found a place in football in one way or another. Shoes, soccer balls, jerseys, stadiums, training techniques, soccer broadcasting and almost everything related to soccer has been changing and developing with technology. These changes have become somewhat visible in recent years with the active use of football statistics and new training techniques in football. Today, one of the biggest factors in the success of

many coaches is recognized as the presence of technological support teams behind them (Çobanoğulları, 2020).

Various laboratories have been established and R&D studies are carried out to create products with sports technology. These technologies, which are not limited to sports products, have shown their effects on many irons such as flags, whistles, headphones used by referees who are the decision makers in sports. Wi-fi, satellite broadcasts, fiber systems used in sports competitions are also examples. In addition, sports facilities have been transformed into smart facilities and turned into new camera systems, scoreboards, computer-aided facilities. With the technological tools and equipment used in training science, future athletes have started to be created in laboratories and analyzes have started to be made in virtual environment (Devecioğlu & Altungül, 2011).

Technology has completely changed the way soccer is played and experienced. With multiple HD cameras allowing us to see every move from every conceivable angle, we now know almost everything that happens on the pitch. For example, we can see which part of the pitch a player spends most of his time on, how many passes he makes, where he makes them and to whom. Technology allows spectators to experience soccer on a whole new level. New technologies on the pitch will make games more enjoyable, especially when they enable the right decisions to be made, which in turn will lead to fewer interruptions and less frustration (Vanhooijdonk, 2021).

With the continued development of microtechnology, player tracking has become one of the most important components of game monitoring in team sports. The 3 main goals of player tracking are; better understanding of training, optimization of training load models at the team level, helping players to decide on their training programs to improve athlete performance and prevent potential injuries (Akenhead & Nassis, 2016).

Football is one of the most followed sports branches in the world, and this interest allows football to be constantly developed and renewed. For this reason, especially the athletes, technical team and all other stakeholders in the football sector want the matches to be managed fairly and impartially. Nowadays, due to technological developments, the development of digital media technology in the field of sports and sporting competitions is a normal situation. Since referees have the potential to change the final result, their chances of making the right decision during the competition have increased by utilizing technological developments (Caz et al. 2021).

The transformation of football into an industrial business has necessitated the transformation of green fields, which are seen as investment areas, into

a fair and transparent area by removing errors as much as possible. In order to ensure a standardized management approach, the use of technology in football has become increasingly important in recent years. The most striking example of this is the Video Assistant Referee System (Engin & Çelik, 2019).

The most important criterion for the future of football is to decide how much technology should be included in football and how much it should be included. Since it does not seem possible to try to ignore mistakes and bear the consequences in industrial football where billions of dollars are spent, technology has been allowed to enter football. In this context; developed countries in football have switched to VAR technology with the belief that technology will encourage players to behave in a more disciplined manner and bring more justice to matches (Orta, 2020).

Hawkeye system works with 7 cameras for each goal. This system combines images from different angles to track the ball in 3D. If the software of this technology decides that the ball has crossed the line, the watch on the referee's wrist notifies the goal with vibration and image alerts. With this technological development, the question "did the ball cross the line?", which is one of the biggest debates in football, is answered (Demir, 2017).

Recently, football has become a field where millions of dollars are spent on issues such as player buying and selling, the renovation and construction of infrastructure facilities, stadiums, uniforms, team name sponsorships, and this industry is growing day by day. In this huge field, mistakes need to be minimized as each sector tries to get its own piece of the pie. In order to minimize errors, we need to take advantage of the opportunities that technology offers us. Therefore, training scientists should produce information for athletes by using technology at a good level and improve their systems by analyzing the information they produce (Sajadi & Rahmani, 2007).

Competition analysis and performance evaluation in football is extremely important for coaches, analysts and teams. Analysis provides useful information for coaches in evaluating the competitions they have played and will play. In the light of this information, it enables both player and team performance to be monitored, minimizing mistakes and increasing strengths (Hughes & Franks, 2004).

Competition analysis in soccer is an important tool that helps teams to evaluate their performance, improve their tactics and gain superiority over their opponents. The performance of soccer players, who are the main

protagonists of the game, indirectly affects the success of coaches. Coaches need objective data in addition to their subjective comments when evaluating their athletes. At this point, competition analysis comes into play, allowing teams to examine their games in a deeper way. It reveals not only the team performance but also the individual performances of the players. Today, soccer now examines even very fine details. The technical teams of the teams reach up to 15 people (Yavuz et al., 2023).

Nowadays, investments in analysis programs are quite large and limited in terms of data transfer. In addition to this information, different analysis programs also provide information about parameters such as passing, shooting, intermediate numbers, number and rates of winning duels (Bal, 2011). In line with the information obtained with the data provided by these systems, coaches can get to know their team and opponents better, observe them objectively and organize the training program (Tokul, 2017). Competition analysis systems, which provide objective information about the team and players, can provide comparative positive and negative data not only daily or weekly but also throughout the season (Araslı, 2010).

Recently, with the development of technology, the methods of analysis in football have moved away from subjective interpretations to objective interpretations. In this way, the system has become more valid and reliable. Interpretation of seasonal data allows us to follow team and individual developments. This data changes every year as the identity of the players changes. Even in player sales, this data has started to be presented to rival teams (Ocakbaşı, 2018).

Professional soccer is a global spectator sport and its players have always been in the public eye. Today, however, new digital technologies, from devices that can track every movement and switch to artificial intelligence tools that can predict a player's behavior, have exposed athletes to more scrutiny than ever before (Ronco, 2022).

Player health monitoring and performance tracking have changed significantly in recent years. Smart clothing technologies are used in player monitoring systems. The use of wearable electronic measurement devices was approved by FIFA in 2015 (Dunn et al., 2018). Smart clothing products such as gloves, socks, swimsuits, shorts, T-shirts, pants, leggings and bras are typically made of advanced textiles that contain interwoven circuits, sensors and additional hardware. Smart clothing and wearables connect to smartphone apps or laptops via bluetooth or wi-fi. Depending on its purpose, smart clothing and wearables can collect all kinds of data such as running speed, muscle activity, breathing rate, heart rate, perspiration

and temperature, step counting, calories consumed, altitude. Distance tracking, step count, anaerobic threshold, fitness and stress levels and many other measurements. Wearable technologies provide objective data that helps maximize training, monitor player performance, determine fitness levels and reduce injury risks in soccer. Coaches, trainers and medical staff analyze and use the data collected from these devices to make data-driven choices, improve player development and enhance performance on the field (Vanhooijdonk, 2021).

Considering the importance of success in sports, the desire of athletes and sports supporters for development is as valuable and high as success. For this reason, investment in nanotechnology in sports is extremely high. Competition and the desire to succeed have driven athletes and teams to this development. Sports equipment produced with nanotechnology is an important factor for athletes and teams to gain advantage. For example, products produced with nanotechnology are used in tennis, swimming, golf, cycling, athletics, winter sports such as ice skating, skiing, sledding, bowling, hockey, baseball, badminton, motor sports, speed sports, sailing, racing boats and football (Şentürk & Özer, 2022).

Another technological development is the leggings used by athletes. The "Smart Legging" leggings prepared by AiQ Smart Clothing, supported by Qualcomm, can measure posture and position with a total of 5 sensors located in the center of the knees, ankles and spine of the clothing. The technology that collects data on pulse and respiration can send the data to the phone via bluetooth. In this way, body analysis of football players can be done more easily (Şentürk & Özer, 2022).

Technological developments have also occurred for the soccer ball, one of the basic tools of football. Adidas has developed balls called "Beau Jeu", which means "beautiful game", developed with the latest technology and provides more grip (Demir, 2017).

## Technologies Used in Football

When technological developments in football are examined; it is seen in the literature reviews that it has made significant progress especially in areas such as training and performance analysis, athlete performance monitoring and tracking, athlete health monitoring and tracking, athlete training (talent, technique, etc.), wearable technologies and stadium and field technologies. In this context, the technologies used in football will be mentioned in the light of the reviewed literatures.

- **Kinexon ONE Athlete Monitoring System**

Kinexon ONE Athlete Monitoring System analyzes and measures football players and team performance, tactics, games and training, and provides the right training exercises to achieve specific goals. It includes a variety of exercises developed and recommended by leading sports scientists, coaches and sports associations to ensure that players reach their full potential (Çelebi, 2017).



*Figure 1: Kinexon ONE Athlete Monitoring System (Çelebi, 2017).*

- **Sentio Sports Analytics Sistem**

Sentio is a cloud-based software platform that collects and organizes data invisible to the naked eye in real time on sports fields, develops predictive analyses about the game based on this data, and presents these outputs to coaches and fans in real time in web, mobile application, television and printed report formats. Sentio processes data from optical sensors during matches, and from chips developed by Eksa Teknoloji during friendly matches and training sessions where athletes are allowed to be implanted with chips, in real time, and extracts the distances traveled by athletes, the locations and duration of their high intensity runs, the difficulty levels of their passes, shots and crosses, and their success rates to support coaches' decisions such as tactics and substitutions during the match. Sentio also allows coaches to instantly revisit desired positions, analyze team placement, inter-block

distances, team width and height, and shape training programs. With Sentio, which removes the human factor in data collection and analysis, coaches' valuable time can be redirected from routine tasks such as data collection to high value-added tasks such as making sense of data and winning matches or tournaments. In Turkey, the system is used in Super League and Turkish National Football Team's home matches (TUBITAK, 2013).



*Figure 2. Sentio Sports Analytics Sistem (https://sentiosports.com/2023).*

• **TRACAB Gen5 Optical Monitoring System**

The TRACAB Optical Tracking System developed by ChyronHego is an optical tracking system approved by FIFA and achieves high performance under the EPTS program. All the physical, positional and tactical data collected allows for a wide range of applications to enhance fan engagement and the use of a brand new data analysis platform provided by SciSports. This wealth of data provides coaches, managers and image analysts with a single platform and interface for monitoring and analysis. Thus, they can more effectively evaluate their own team's performance to compare with other teams and identify areas for tactical improvement (Linke et al. 2020).

ChyronHego also provides football teams with the Coach Paint image analysis and presentation tool, which has become standard in most of world football. This powerful software allows high-quality graphics to be overlaid on match footage very quickly, helping the soccer technical team to more easily explain the key elements of a match in a visual way. The whole team

and each individual player can thus learn more effectively and improve their tactical awareness and skills (www.sportsvideo.org/2020).



*Figure 3. TRACAB Optical Monitoring System (www.digitalmediaworld.tv /2017).*

- **Video Assistant Referee (VAR) System**

This system will be used in controversial situations as a joint decision made by IFAB and FIFA to determine whether a goal, penalty, red card, or incorrect player punishment has been given. The "Video Assistant Referee (VAR)" system was developed to assist referees in football matches and has been subject to trials approved by the International Football Association Board (IFAB) responsible for regulating football game rules and sanctioned by FIFA. If the referee requests assistance for a decision, the system will intervene and investigate the incident in question via video footage. This information will then be communicated to the referee through a communication set, and the referee will make a decision based on the conveyed information (IFAB, 2023; FIFA, 2023).

*Figure 4. Video Assistant Referee (VAR) System (IFAB, 2023).*

- **Semi-Automatic Offside Technology (SAOT)**

Semi-Automatic Offside Technology (SAOT) is a support tool that helps video match officials and pitch officials make faster, more repeatable, and more accurate offside decisions.

While VAR uses video replay technology to deal with various aspects of decision-making in football, semi-automatic offside technology is specialized only in one area. Two technologies work together to enhance consistency when making offside decisions. The new technology consists of 12 specialised tracking cameras mounted beneath the roof of the stadium, which calculate the exact position of each player on the field 50 times per second using up to 29 data points. These 29 data points encompass all limbs and extremities relevant to making offside calls (FIFA, 2023). Semi-automatic offside technology (SAOT) is the latest technological development in football. Since VAR has been implemented at the professional level across the sport since 2018, SAOT has been developed to further enhance the accuracy of refereeing decisions. Rather than reviewing video footage, SAOT uses tracking data to calculate offsides. When technology identifies an offside violation, an automatic warning is sent to the video operations unit, which the VAR team can use to check the validity of the offside line while the game is still in progress. After the VAR team manually verifies the offside lines and determines whether the offside player has intervened in the game, they inform the on-field referee of their decision, and the match proceeds accordingly. SAOT also utilizes a specially designed ball to aid in offside detection. VAR officials track the ball's location and contact 500 times per second by placing a motion sensor inside a specially designed ball. The technology helps identify potential offsides.

*Figure 5. Semi-automatic offside technology (Tripathi, (2022).*

- **Goal Line Technologies**

Goal-line technology is a technical tool that instantly determines whether the entire ball has crossed the goal line. Goal-line technology has been indispensable in the football world since 2014, when it was first introduced. The technology clearly indicates whether the ball has completely crossed the line. This information helps the referee to make a final decision. The information is transmitted within a split second, allowing the referee to respond instantly. The technology is based on the principles of the magnetic field, which has a sensor inside that sends data to the main server after measuring the magnetic field deviations in case a ball crosses the goal line. Within a very short time the signal is transmitted to the referee's clock and then the referee declares the goal. The main purpose of goal-line technology is to provide more accurate information, i.e. to determine whether the ball has completely crossed the goal line. The system utilises 14 high-speed cameras mounted on the podium/under the roof of the stadium. The data from the cameras is used to create a 3D animation to visualise the decision to fans on television and on a giant screen inside the stadium (FIFA, 2022; https://sportsmatik.com/2021). Four systems (GoalControl, GoalRef, Hawk-Eye and Cairos) have been approved by the International Football Association Board (IFAB) for use in the professional game (IFAB, 2023).

➢ **Goal Control-4D System**

The Goal Control-4D goal-line technology system works with 14 high-speed cameras (7 per goal) installed in the stadium and around the pitch. The cameras track the movements of the players and the ball with a powerful image processor. The system, which distinguishes between players, referees and other objects, places the three-dimensional positions of everything on

the pitch in the coordinate system of the pitch with an accuracy of a few millimetres; when the ball crosses the goal line, it sends a vibration and optical signal to the smartwatches of the officials. Thus, all images of the goal can be replayed (Çelebi, 2017).



*Figure 6: Goal Control-4D (Invasion, 2014).*

> **GoalRef**

The GoalRef target detection system was developed by Fraunhofer IIS. It is a radio-based system that uses low-frequency magnetic fields to determine whether the entire ball has crossed the goal line. There are two magnetic fields. One is generated in the goal area (using coils attached to the goal), the other in and around the ball (using a passive electronic circuit embedded in the ball). The working principle is basically based on an electronic circuit embedded in the ball and a low-frequency magnetic field around the goal. The data is processed and then wirelessly transmitted to the referee's wristwatch and a message is displayed in real time in addition to a vibrating warning (Wood, 2023; Özeren, 2022).
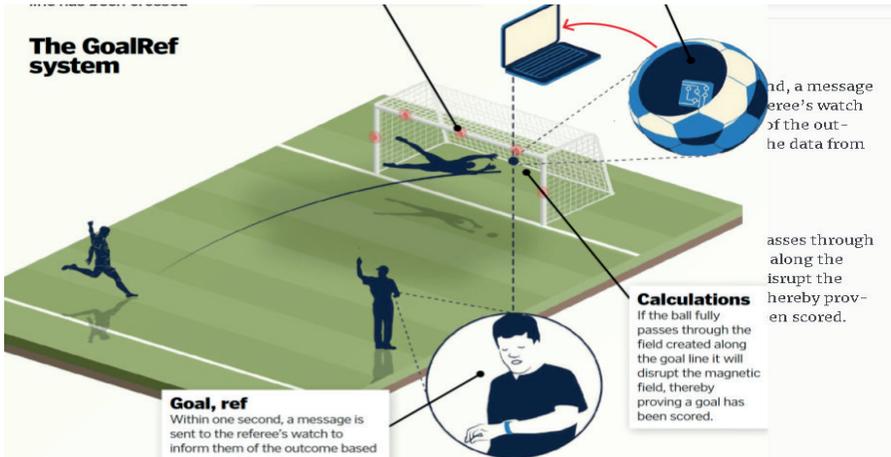
*Resim 7: GoalRef System (www.pressreader.com/2018).*

➢ **Hawk-Eye**

Hawk-Eye is a computer vision system used to visually track the trajectory of the ball and display its statistically most probable profile in numerous sports such as football, cricket, tennis, badminton, rugby and volleyball. The Hawk-Eye system, owned by Sony, was developed by Paul Hawkins in the United Kingdom. The Hawke-Eye system uses three cameras focussed on each goal line, each shooting at 600 frames per second. Hawk-Eye can make an accurate judgement as to whether the ball has completely crossed the line or not, and transmit this information to the centre referee in the form of an audible beep within half a second (Wood, 2023; Özeren, 2022).



*Figure 8. Hawk-Eye System (YouTube, 2012).*

- **aiScout Artificial Intelligence Programme**

aiScout, an artificial intelligence programme, is a mobile technology platform for football clubs and scouts to generate reliable, comparative data that can assist in amateur talent identification, talent analysis and development. The programme analyses the physical, technical, psychometric and cognitive performance of young athletes during specific drills in exercise and training and allows the athlete to upload their own images. Thus, this mobile application ensures that talented amateur players are seen by professional teams from all over the world and have a higher chance of being discovered (https://ai.io/2023).



*Figure 9. aiScout Artificial Intelligence Programme (https://ai.io/2023).*

- **Zone7 Artificial Intelligence Programme**

To keep athletes healthy and performing at a high level, the Zone7 programme determines daily injury risk predictions from an artificial intelligence engine and transfers the data to mobile devices. The system inputs data from medical profiles, fitness assessments and wearable devices to determine which players may be at risk of injury. The system provides green, yellow and red indicators for players' daily risk levels, allowing coaches to decide whether to reduce the intensity of a particular player's training sessions to minimise injury risk (https://zone7.ai/2023).

*Figure 10. Zone7 Artificial Intelligence Programme ( https://zone7.ai/2023).*

- **Playertek Pod**

The Playertek Pod consists of a wearable GPS tracker and sensor package that is paired with a compatible smartphone via a dedicated app. The Playertek Pod device is used by attaching it to vests specially designed by Catapult Sports, an Australian company. The Playertek platform utilises a variety of different sensor techniques to track every possible variable during both game performance and training to create a comprehensive high-level picture of the way a player moves, how far they cover, their top speed, average sprint distance and total number of sprints. It is based on the Playertek Pod, which houses all the necessary sensors and technology fitted to the Playertek vest. The pod is extremely small and lightweight, able to withstand the rigours of a professional game while remaining robust and robust. All data collected by the Playertek Pod can be viewed and interpreted in the Playertek app, which is provided free of charge with the earth Playertek platform (Scavuzzo, 2016). If players want to analyse their own game, they can use the Playertek Pod to get basic information such as who ran how much, how many correct passes, how many incorrect passes, as well as advanced data such as heat maps showing the weight of the game. A GPS device is built into this velcro garment, which looks like a small tank top worn over the upper body. After wearing the Playertek Pod and completing your match, it is necessary to pair the device. After pairing, the data is displayed on the screen. In addition to the web application, there are also mobile applications compatible with Android and iOS devices (Çelebi, 2017).

*Figure 11. Playertek Pod (Scavuzzo, 2016).*

- **Viper Pod Athlete Monitoring Device**

The Viper Pod is a performance monitoring tool used by some of the best teams in the world in many sports such as the Premier League, NFL or NBA. The vest and the viper pod for the pod were developed by STATSports, an Irish company. All relevant metrics including running distance, pace, acceleration or heart rate are monitored by this device. The Viper pod transfers all data in real time using the Viper Live Streaming software and makes all collected data downloadable after each session. There is also the option to see the location and movement in real time from a bird's eye view (Ostsieker, 2016). Another difference of Viper Pod is that it can track collisions and score the instantaneous fatigue of footballers. This makes it easier to make the right decision for substitution, as well as to understand who the fittest players are in the long run (Çelebi, 2017). The device helps to collect large amounts of data such as running speed, stress load, distance travelled, which can be easily displayed. It helps to provide important information to coaches so that they can evaluate the performance of each player. Viper Pod helps to provide a detailed analysis of a player from one session to another in real time. The device can be conveniently worn on the player's body with the help of a belt (https://sportsmatik.com/2022).

*Figure 12. Viper Pod (https://sportsmatik.com/2022).*

- **Apex Tracking Athlete Monitoring Device**

It is a wearable athlete tracking device developed by STATSports. Apex tracking is a black compression vest worn under the regular jersey. The vest has a tracking device built into a pouch between the shoulder blades that contains a number of sensors. These include GPS to track position, accelerometers to measure speed, gyroscopes to measure direction in three dimensions and magnetometers to record direction of travel The device also contains an embedded processor that synthesises raw data and calculates performance metrics such as distance travelled and number of sprints completed in real time (https://statsports.com/2023).



*Figure 13. Apex Tracking (https://statsports.com/2023).*

- **f50 Adizero miCoac Crampon**

"miCoach compatible adizero f50" is produced by Adidas Company for football players. It has a speed sensor and performance tracking system (Speed_Cell chip) placed on the sole of the boot. In addition to capturing the movements at a 360-degree angle, the system is able to measure the main performance values, including average speed recorded every second, maximum speed recorded every 5 seconds, number of slaloms and sprint time, distance, short stride and long stride. In addition, the built-in memory can store all of the user's measurements for seven hours. This data can then be easily transferred wirelessly to iPhone, PC and MAC. Players have the chance to compare their performance data with each other and increase intra-team competition (https://hypebeast.com/2012).
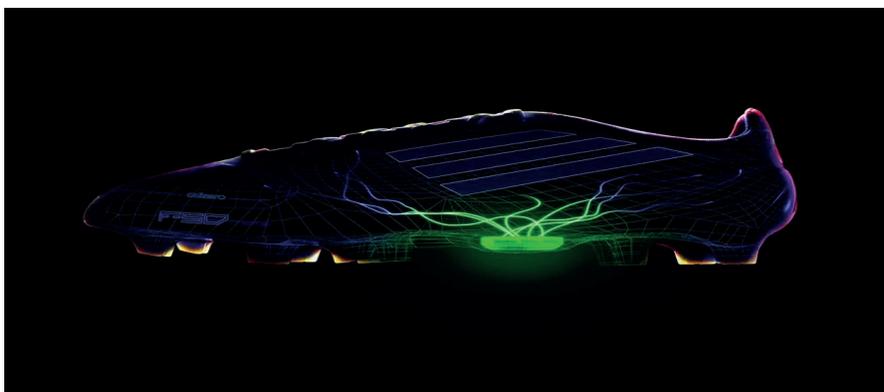


*Figure 14: Adidas f50 Adizero miCoac Crampon ( https://newatlas.com/2023).*

- **Adidas GMR (Shoe Insoles with Chip)**

Adidas GMR technology is a wearable technology developed by adidas in collaboration with EA Sports FIFA Mobile and Jacquard and Google. The Jacquard Chip, developed by Google, is a sophisticated piece of hardware that houses tiny sensors. The data from these sensors is read by Jacquard's advanced machine learning algorithms to identify football movements and wirelessly transmit them to the GMR mobile app. To use the Adidas GMR, it is enough to put the insoles inside the boots or trainers and install the GMR App on a smartphone, tablet, etc. GMR is a smart insole application system that automatically measures data on different types of kicks such as running distance, dribbling, passing and penalty. Thanks to the GMR App application, your football performance can be followed in detail. In addition, GMR not only allows you to track the football matches or sports activities

you physically play, but also transfers your experience to the virtual world by transferring it to the FIFA Mobile version (Vanhooijdonk, 2021).



*Figure 15: Adidas GMR (Shoe Insoles with Chip) (Akbaş, 2020).*

• **SOCKIT Foot Technique Development Device**

Sockit is a device that helps young footballers (5-12 years old) to improve their technique. It is manufactured by the Californian company Sockit. The working principle is that if you touch the ball when passing or shooting, it gives direct feedback on whether the ball is hit with the correct surface of the foot. The one-size-fits-all wearable device is designed to be securely attached to football shoes. The tracking takes place in different positions, such as on the laces or on the sides, in order to record as many passing and shooting techniques as possible for training. The SOCKIT is made of industrial-strength thermal plastic rubber and is designed to withstand shock, impact and other extreme conditions. It includes a light-emitting function supported by 6 LEDs powered by a replaceable lithium battery and is one size fits all (Ostsieker, 2016).

*Figure 16. SOCKIT (https://socalfieldtrips.com/2023).*

• **miCoach Smart Ball Technology**

Smart ball technology, FIFA event miCoach, developed jointly by German Cairos Technologies and Adidas companies, is a bluetooth and application compatible football ball with sensors inside that can detect speed, rotation, kick hardness and flight path. The data from these can be simultaneously transferred to the application on the smartphone. The miCoach smart ball's application contains information on the intensity of the shot, the trajectory of the ball's flight and return, as well as the impact points. The miCoach app offers training programmes for players to improve their hitting skills and reach advanced hitting techniques such as the "knuckle ball" shot. In the "Challenge yourself" section, there are goals such as hitting the ball at a certain speed, curling around the wall or hitting a professional level standing ball. In addition, with the "record book" section, all strokes are recorded and progress can be monitored (Demir, 2020; Çelebi, 2017).

*Figure 17. miCoach Smart Ball (www.jebiga.com/2023).*

- **Grass Field Technology**

Undoubtedly, football pitches have also received their share from the technological developments in football. Today, technological investments are made in order to make football pitches healthy, convenient, equipped and better quality football for players. Natural grass and artificial turf are used in football pitches. Especially natural grass pitches are the most preferred pitches of professional football teams. However, the maintenance and protection of these fields for four seasons is very difficult and costly. Recently, hybrid grass systems have started to be used in football fields.

The GrassMaster hybrid turf system, first developed by the Dutch Desso Sports, has started to be used. Hybrid grass is a type of grass that has started to be used in new generation stadiums and aims to minimise weather opposition. Hybrid grass is used instead of natural grass, which is easily worn out due to insufficient air flow and sunlight. Hybrid grass is a hybrid grass type that is formed by combining both natural and synthetic grass. Since natural grass is integrated with artificial grass, a more robust grass emerges. This solid grass does not lift like natural grass and the ground does not deteriorate. Hybrid turf, which is formed by the integration of nature and technology, is also preferred by many big clubs due to its ease of use, durability and longer life (www.grassmastersolutions.com/2023; https://reformsports.com/2023).

A more robust, long-lasting, durable playground is obtained by passing the natural grass roots through the holes of the special production artificial turf to the soil ground. Hybrid grass offers the chance to play comfortably as it does not lift or slip on the ground. Since it is resistant to wear and tear, it minimises treatment and maintenance costs. Hybrid grass provides the

quality of playing on natural grass ground. It provides a less slippery ground than natural grass even in rainy weather conditions. There is no lifting or ground slipping as in natural grass. It maximises the quality of play by offering standard shock absorption resistance, friction, rotational resistance, slip resistance, drainage properties and underfoot stability. It offers a green and healthy field without mud and grass breaks. Hybrid turf field, which is longer lasting and durable than natural turf, provides the opportunity to play and train on the same surface. Therefore, both playing and training can be done on the same field without the need for a training field (www. grassmastersolutions.com/2023; https://reformsports.com/2023).



*Figure 18: Hybrid Grass Technology (www.bahceye.com/2023).*

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