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Chapter 13
Major Events, Big Facilities: From FM for a Football Stadium – Tools for Augmented Experiences and Fan Engagement

Maurizio Marco Bocconcino
Politecnico di Torino, Italy

Fabio Manzone
Politecnico di Torino, Italy

ABSTRACT

Let us imagine a large sports facility and an integrated system to control its maintenance (structures, facilities, furnishings, communication systems), pre-configure temporary set-ups, procurement of goods and materials, check compliance with technical regulations concerning the safety and regularity of sports and recreational events, contracts with sponsors and suppliers, and the work of technical staff. Then, let's imagine that this mass of data is supplemented by tracking the flows of people attending events, recording their behaviour through the looks they make, the stops they make, the actions they take. This is the theme of the contribution proposed, an experimental application involving a sports facility of international importance and integrating BIM processes for design and maintenance, social and commercial information systems open to the public, marketing and usage analyses based on sensors and big data, and artificial intelligence capable of prefiguring the safest and most comfortable solutions.

INTRODUCTION

The subject of knowledge through automatic data collection requires reflection on the synthesis models that such actions produce and the construction of an analytical method for validating the qualities of metadata and its synthesis actions. In particular, a study of data concerning the interaction between humans and the environment and data more specifically involving technological infrastructures. The themes of Big Data, the Internet of things (IoT) and the smart city converge in a project that aims to bring these

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aspects together through the innovative point of view of representation. Through models, it is possible to orient and promote the understanding of complex structures by making explicit apparently concealed relationships and mechanisms (Bocconcino, 2018). With regard to the possibility of expressing the city of tomorrow, models simulate and design the project in a dimension of physicality. In recent years, a number of instrumental and technological supports appear to have matured; they can make the design process more efficient, in particular for one relevant aspect: the integration in the cognitive framework of a series of attitudinal and behavioural data, both those concerning the individual and those relating to groups of people who move, live and use urban space.

Over time, the methods of investigation of the physical and social context in which the urban regeneration and redevelopment project is born and developed, for different reasons, have seen a progressive difficulty in the field of data collection and its processing to produce information (Lo Turco et al., 2021). The different disciplines involved in the study and the design need to search for fields of confrontation where they can express, in a language common to all, their instances, their methods, the articulation of their outcomes. This field of recomposition can be facilitated by two relevant guidelines: the integration of knowledge in the professionals in training with components that are exogenous with respect to their own field of application; the possibility of access to resources and tools for analysis and representation that are interactive, dynamic and customisable according to the user's interest (Bocconcino&Manzone, 2019).

Digital technologies have radically transformed our interaction with the built environment. Mobile devices provide tools to quickly access and share information. In the context of large event facilities, these technologies impact both capital projects and day-to-day operations. Computer-aided facilities management (CAFM) systems that support the full range of facilities management (FM) activities, both physical and IT, have become ubiquitous: information technologies that are easy to access and use open up integrated knowledge containers to professionals and workers and allow structured, organised and interrogable controls with the appropriate levels of adaptation, both in the construction and management phases. (D'Urso, 2011).

Thanks to sensor networks and IoT devices, FM teams have access to a wide range of real-time building information (Valinejadshoubi, 2022). Mobile apps and cloud-hosted file systems further enhance this functionality, providing service engineers with field access to building and equipment information and building occupants with a limited range of self-service activities, such as real-time room scheduling and problem reporting (Villa et al., 2021).

The digital information model set up in the feasibility and design phases of complex artefacts increasingly supports site monitoring and ongoing maintenance activities (Lo Turco, 2015, Lo Turco et al., 2015). From design to construction site to management, this chapter aims to define an operative frontier by illustrating a method of automatic processing and graphic representation of data that multiplies the possibilities of the construction and management model set up within information and computer systems dedicated to the maintenance process (Bocconcino, 2021).

One particular common ground is neuroarchitecture/neurourbanism; although it appears to be a new discipline, for decades its function has been to create spaces capable of arousing and ensuring well-being and improving the quality of life. A meeting point between neuroscience, architecture and urban planning, architects, engineers and neuroscientists work hand in hand within this discipline. This interdisciplinary synergy aims to design spaces and buildings focused on the functioning of the brain of those who will then live or work in them.

In this spontaneous challenge, a great influence has been directed by two main objectives in the conceptualisation of building space design: 'visual perception' and 'spatial perception'. It has been shown that the professional capacity of intervention teams cannot fully meet the needs arising from a wide range of users, who experience large performance buildings on a daily basis and develop a long-term perception that influences their habits. Therefore, there is an emerging opportunity to collect and transform citizens' perceptions into a supporting intelligence, operating as artificial intelligence, which can guide the decision and skills of professionals both by educating them at multiple levels and by producing more suitable results on building design and project transformation.

Imagine we enter a stadium to watch our favourite football team play. The mobile phone shows us a map, guides us inside the structure, shows us additional content with respect to the event we are about to attend, statistics, historical footage, interviews of past and present protagonists, and even during the match provides content that increases the sensory experience, multiplies points of view, amplifies listening, the interpretation of what is happening, allows us to interact with the facility's services, catering, gadgets, booking of present and future experiences for leisure and recreation, with the functions attached to the facility. A pocket-sized maxi-screen at our fingertips and which, if we want it, addresses only us. That recognises us and offers us routes and experiences that make us feel welcome and cared for.

Now let us imagine that all this stems from an integrated system that allows in that same stadium to control ordinary and extraordinary maintenance on structures, facilities, furnishings, communication systems, pre-configure temporary set-ups, procure goods and materials, verify compliance with technical regulations relating to safety and the regularity of the conduct of sporting and recreational events, contracts with sponsors and suppliers, and the work of technical personnel.

And finally, let us imagine that this mass of data is supplemented by tracking the flow of people, recording their behaviour through the looks, the stops, the actions they take. And that a trace of all this remains for future redesigns of spaces that take into account the ergonomic aspects that derive from reading and interpreting the recordings made.

The chapter illustrates integrated applications for the monitoring and management of a sports facility - the name of which cannot be stated at the moment - as an information base for the involvement of spectators by recording their behaviour, movements and preferences through sensors, big data, and artificial intelligence capable of prefiguring personalised and engaging solutions. The considerations that follow, after an initial definition of the state of the art, describe a meta-project and a prototype realised on an experimental basis involving a sports facility of international importance and integrating BIM and GIS processes for design and maintenance, social and commercial information systems open to the public, marketing and usage analyses based on sensors and big data, and artificial intelligences capable of prefiguring the safest and most comfortable solutions.

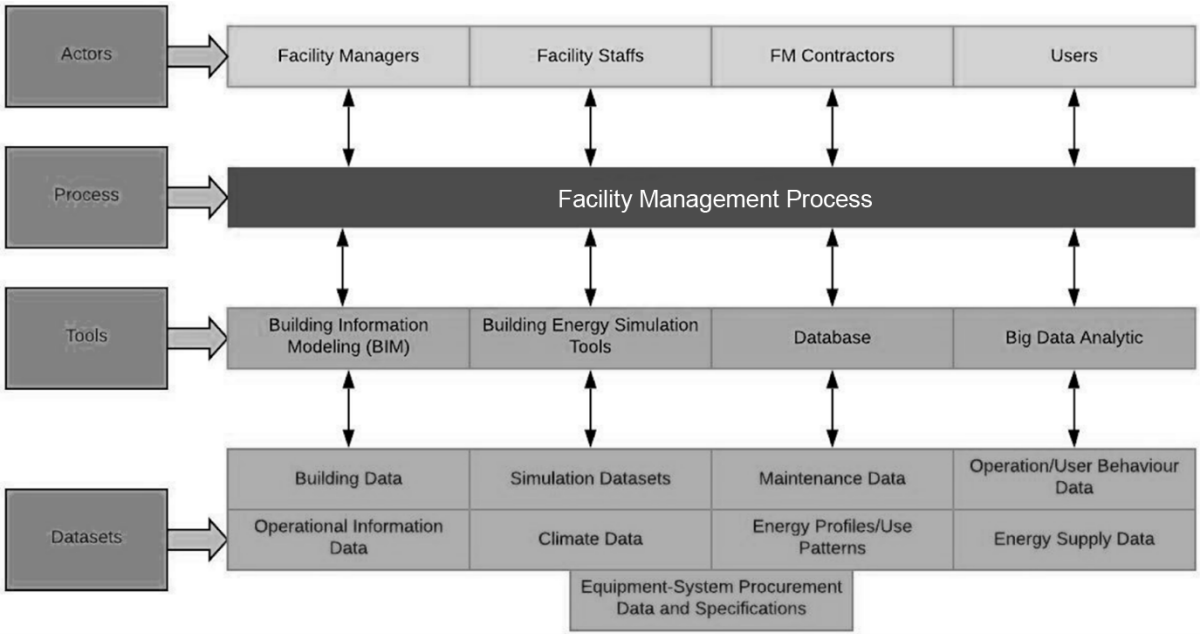
BACKGROUND

New high-tech systems are finding more and more areas of application in structures. Complex facilities require learning and automated systems (Roper, 2017). To achieve this, FM systems need to be more expandable and offer opportunities for data analysis (Demirdogen et al., 2020). In the literature, building automation systems (BAS) and computerised maintenance management systems (CMMS), have been used as FM systems. However, there are some problems with the use of these systems. Some of them are highly dependent on:

- sensors, implementations of new scenarios and technological extensions (Asensio et al., 2019);
- collection and recording of information in proprietary systems (Bhatt&Verma, 2015);
- predefined operational strategies, by the amount of data (Macarulla et al., 2017);
- low monitoring capacity due to dependence on process control and automation;
- missing or incorrect data due to problems with sensors;
- lack of data analysis or limited data analysis in CMMS and BAS systems, security systems and Computer-Aided Facility Management (CAFM) (Gunay et al., 2019);
- some organisational and management expectations of these technologies.

The above-mentioned restrictions for FM systems, the need for utilisation data from the design and construction phase, heterogeneous data, IoT issues and storage problems in BIM lead to the consideration of the integration of BIM, web databases, augmented reality and artificial intelligence (Fig. 1).

Figure 1. Facility Management (FM) data management vision (source: Arayici et al., 2018).



The increasing automation of site processes through BIM and AR technologies can improve decision-making and provide real-time access to information (Barbero et al., 2021). However, software products based on BIM and lean management have not yet integrated AR technology for visualising activities and related information, as well as work progress and performance. On the other hand, BIM- and AR-based applications do not manage construction processes according to lean management practices. On the contrary, they only focus on providing interactive 3D models and documents on site to assist inspections and report problems (Fig. 2). These aspects will be considered in the meta-design proposal that will be described in the following sections.

In the following, the discussion focuses on the aspects more properly related to the management of the facility in terms of user involvement. These aspects should be read in continuity with the brief framework outlined above.

The Sale, Promotion and Marketing of Sport and The Role of the Fan

The new digital technologies with their potential for dissemination and interactivity change the rules of the game, the timing, schedules, dos and don'ts of sports information, transforming sport into entertainment (Previati, 2020). At the same time, sport is considered a privileged content by the new media and also an effective promotional vehicle for industrial and service companies. For their part, sports clubs have considerable difficulty in harmonising the technical and sporting values and the passion of the public and practitioners with the different demands of businesses and communication channels. While the new media constitute an important opportunity for the dissemination and promotion of the sport seen and practised, there is a risk that sport will be overwhelmed by pure business logic, the same from which fans and sportsmen and women are fleeing in search of expression, participation, wellbeing, recreation and entertainment.

Marketing is a business function that can be expressed in the business of companies in every sector. A type of marketing is therefore also intended for the sports sector: sports marketing. Sport and therefore sports marketing must be considered as unique phenomena, given the complexity and distinctiveness of the sporting element: authors John Beech and Simon Chadwick define sports marketing as: 'an ongoing process where events with an uncertain outcome are exploited for the direct or indirect fulfilment of the needs of sporting customers, sport-related businesses and other sport-related individuals or organisations' (Beech&Chadwick, 2013).

What has transformed sport into a 'business-intensive' sector is first and foremost the new role assumed by the spectator, primarily the 'television viewer'. It is the demand of those who attend sporting events that plays a fundamental role, especially if the event is enjoyed via television. We are now in the 2000s, in which sport marketing has reached a remarkable development, and in Italy alone it turns over several billion lire a year, especially in the area of football.

The years 2010-2015, are the years in which the company is called a brand, close collaborations are called partnerships, and in which sponsorships are increasingly 'people oriented' (Kang, 2020).

Sports marketing invests in any sport, from the most popular to the minor sports, thanks to an ever-increasing number of thematic channels, magazines and media dedicated to sport, thanks to the development of increasingly advanced technologies, and thanks to the total globalisation of sport, which has reached the entire world through its most prestigious leagues, enabling investors to take advantage of communication platforms with planetary reach (Rosenthal&Eliane, 2017).

Professional football clubs have become, to all intents and purposes, businesses and their goal is no longer to achieve sporting success alone. Talking about brands is not so simple, since a univocal definition does not exist and because the brand itself dwells in the minds of customers and consumers and is identified in the global idea that customers have of that particular company or product.

Figure 2. Differences between functionalities of commercial software products for the construction management (source: Ratajczak et al., 2019, pag. 4).

Functionalities	Autodesk ® BIM 360 Plan™	Autodesk® BIM 360 Docs™	Oracle Aconex Connected BIM	Oracle Latista	Dalux TwinBIM	Trimble Vico Office *(not mobile app)*	VisiLean
• 3D model visualization	✓	✓	✓	✓	✓	✓	✓
• 3D object filtering	✓	✓	✓	✓	✓	✓	✓
• Visualization of 3D model in Augmented Reality (AR)	X	✓	X	X	✓	X	X[1]
• 3D model superimposed on real world in AR	X	✓	X	X	✓	X	X
• 3D interactive models (data displaying of each Building Information Modeling (BIM) object)	X	✓	✓	✓	✓	✓	✓
• Visualization of attached documents to BIM objects	X	✓	✓	X	✓	X	✓
• Notes attachment to BIM objects	✓	✓	✓	✓	✓	X	✓
• Task list related to locations	✓	X	X	X	X	✓	✓
• Instructions for the execution of construction works linked to task list	X	X	X	X	X	X	✓
• Quality Checklists linked to tasks	X	X	X	✓	X	X	✓
• Construction progress and performance tracking	✓	X	X	X	X	X	✓
• Construction progress and performance reporting (dashboard)	✓	X	X	X	X	X	✓
• Reporting of performance and progress Key Performance Indicators on BIM model in each location	X	X	X	X	X	X	X

Virtual Reality and In Store Experience

The concept of Virtual Reality is not new. What is new, rather, is its massive introduction into everyday life: a phenomenon that has been growing steadily in recent years. It now appears everywhere, in different contexts, from workplace simulations to marketing activities, from tourism to sports grounds (Fan, 2017). It has had a disruptive impact in all areas and the sports industry, in particular, has reciprocated by welcoming it with open arms. Virtual reality allows brands to generate experiences that connect them even more directly with individuals: leagues, clubs and sponsors are looking for more and more innovative ways through which to connect with audiences in a fan-engagement function (Wu et al., 2022). At first, virtual reality was one of the many 'techno fashions' of the moment, but - as times matured - it became the key to the entertainment development of the near future. Major technology brands have worked to evolve the technology to offer devices for all budgets, but also to develop sophisticated devices for professional training - just think of the race simulators used by Formula 1 drivers - or live events.

Emotional experience, and the exploration of the environment, are not simply triggered by external stimuli, but that the brain regulates emotional experience and exploratory behaviour itself, based on the perception of one's own body, and of the spatial context, put in a reciprocal relationship: we are not mere machines that merely respond to stimuli, our emotions and our behaviour are both based on the interdependent perception of ourselves and the world.

For this reason, the sensation of crossing one's physical limits, communicated by VR, has an exhilarating, entertaining and immersive effect (Kerski, 2022). Just imagine being comfortably seated at the stadium - but the same applies if we are sitting on the couch at home, in front of the TV - perhaps next to a friend, and at the same time experiencing the thrill of being close to the field or enjoying a 360° view, if desired even from above, or seeing several environments at the same time. As technology advances, experiences - both live and TV - are set to become increasingly immersive and affect the engagement generated.

Virtual shopping could soon become one of the most widely used methods of online shopping, even by clubs, especially taking advantage of highly emotional moments, such as the matches themselves: it is a much more immersive experience than usual shopping, on which companies can focus to create an emotional connection between the customer and the brand (Fathy, 2022). Here's why:

- a greater sense of ownership. People feel more comfortable with things they have established a personal connection with, they feel they own them. It is like a sense of intimacy that makes them more secure and involved. Although they do not yet own the object, they have come to relate to it as if it were already their own;
- the fan, or customer, feels at the centre of a story and, the sense of a story, is built as they go along. VR, in this sense, can be a powerful storytelling medium, telling not only the product, but also the brand, its story and its message, as well as associating them with the immense emotional imagery that a club possesses. Virtual reality allows the spectator to be in the middle of a game, it is true, but it will enable him to feel part of the story of his colours, day by day, and to choose how to become the protagonist and/or how to hear it told;
- a feeling of security and control. Everyone likes to have things under control, to decide how to live an experience, what to see and from what point of view. Conversely, the customer is inclined to distrust the brand that tries to forcibly direct him towards a service or product;

- the customer can build a personalised experience and use it at any time. Which, in reality, is not possible;
- the amount of data that the company acquires improves the knowledge of the customer and, consequently, the relationship itself, as it allows it to offer services and products tailored to the customer and increases, most importantly, the chances of monetisation.

Sport feeds on its own myths: every victory, every record, every athlete, marks the history of a team. Fans love to relive the past and virtual reality, in this respect, opens up scenarios with which other technologies cannot compete.

Augmented Experiences and Fan Involvement in Football

Often, the size and visual impact of a football stadium are the features that excite a child the first time they attend a game. Although, as one grows up, one tends to appreciate other things as well, such as the very pleasure of seeing new venues. More than eight thousand stadiums and over three hundred leagues to choose from are the best that any football fan could wish for. This is the Groundhopper App database (Futbology App, from December 2019), a very simple and intuitive mobile app that allows you to register your attendance at the stadium every time you go to watch a match. The dream of every football and travel fan, defined by the English neologism 'groundhopper', which represents a passion, but also a lifestyle. Born around the 1970s in England as a hobby, it has spread particularly in northern Europe since the 1980s, and now almost everywhere: it means travelling around the world from stadium to stadium during matches, precisely in order to see and visit as many places, teams and stadiums as possible. The database of the Futbology app is huge, with continually updated calendars in combination with the GPS function, which offers the possibility of finding a match nearby, wherever you are (even when travelling). In addition, thanks to the archive provided by the app, you can add all the matches you have seen in the past, even in stadiums that no longer exist, automatically creating your own 'history', which you can also later download in list format to your PC, and statistics broken down by stadium, team and country.

Mobile applications are becoming more and more prevalent in the lives of everyone in various fields, and football clubs could obviously not be excluded from this scenario either. In fact, more and more top clubs are deciding to make apps to allow their fans to keep up to date with the latest news or to enable personalised experiences when in or outside the stadium.

An interesting example is what Paris Saint Germain recently did, launching the 'Stadium App', an application for mobile devices that can be used both by fans in the stadium and those who decide to watch the match from home. Thanks to this service, it is possible, for example, to see the most important actions of the game in a slowed-down version, as well as to view some live content and dedicated services for fans.

Real Madrid, on the other hand, decided some time ago to offer an app for fans. Since a little over a year ago, thanks to this tool and the collaboration of Mediapro and Microsoft, it is possible to watch the matches played by the 'blancos' (Real Madrid team players) in the Champions League on mobile devices. Thanks to this initiative, the European champion club has confirmed its desire to be at the forefront of technology by offering the possibility for fans to feel close to the team even when they cannot be present at the stadium or in front of the TV. Real believes particularly in this project; the system acts as a real social network, where users can discuss the match in groups, share audio from inside the stadium or compete in virtual games for prizes such as exclusive access to content.

Barcelona has also decided to focus on digital by launching an app dedicated to its fans. This is an initiative dedicated to the fans of the blaugrana (Barcelona supporter) around the world to make them feel closer to the team. The Catalan club has thus created a multi-lingual platform to allow supporters from all over the world to get to know each other and get in touch. The service, called FCB App Studio, can also be seen as a further opportunity to increase the visibility of the club's sponsors on social networks. In fact, each user has the possibility to upload online a photo montage of him/herself in which he/she appears with some blaugrana players wearing the official uniform.

Even another top club like Manchester City did not want to be left out of this scenario. In fact, the English club recently launched a new virtual reality mobile application, where it will be possible to watch matches with specific glasses.

The Lane 360°, released by Tottenham Hotspur, is a web experience that allowed fans to explore their historic White Hart Lane stadium: for the first time ever, fans could immerse themselves in the history of a major sporting venue through 360-degree videos. The stadium - now disused - comes back to life and opens up to the fans. The pitch, the stands, the halls, the dressing rooms and familiar areas rarely accessible to supporters: everything is now part of the club's historical heritage and is shared with the fans, who are also given back the unique atmosphere of the past through a combination of 360° footage, extraordinary archive photographs and video memories of fans, players who have become Tottenham legends and players of the present. The Lane 360° is the only way to visit White Hart Lane again and, from an emotional point of view, for the fan it has a value that goes far beyond the archival one: it reminds him of his identity, reinforces his sense of belonging and links him to the positive values of the team.

But the evocative power with which virtual reality can re-present the past can also be used to show the future, to build it before the fans' very eyes: this is the case with SPVRS, another official Tottenham Hotspur app, launched last May. Back in 2018, fans of English football club Tottenham were able to take an exciting virtual tour of the new stadium, still under construction, to see what it would look like once it was finished, during a match with 60,000 spectators. SPVRS - an acronym that stands for Stadium Project Virtual Reality Suite - performs a similar function for fans as The Lane 360°, however, taking fans inside the new stadium before it is even built. As the general excitement builds, fans can follow the progress of the work as the app provides easy access to the Stadium News feed - on Tottenham's official website - ensuring up to date 'construction news'. But most importantly, fans can enjoy an extraordinary experience: thanks to a printable tracker image that can be brought to life via a smartphone or tablet, users can be transported to the centre of the pitch and, from there, enjoy a full view of the structure as it will be once completed. Not only that: the entire virtual structure is interactive, so fans can discover interesting facts and information - the number of seats, the materials used, even how many bricks will be used - about the construction of the sports facility. Premium users also have access to a special virtual area, as well as an overview from their chosen venue.

The two apps created by Tottenham are an example of how Virtual Reality - especially in its most recent developments - can push the boundaries of marketing in the quest for greater fan involvement.

In Italy, something similar, beyond apps with the latest news, is being tried by Genoa Calcio and Juventus F.C.: Genoa Virtual Reality is an engaging tool that 'dematerialises' the classic Fan Village, adapting perfectly to the characteristics of many Italian stadiums. Inside the stadium, the Rossoblù (Genoa) supporters were able to test this new technology free of charge before the match by being transported inside the pitch and experiencing the game like a footballer. Juventus F. C. focused on the Stadium, a facility that is also appreciated abroad. Before arriving at the stadium, it is in fact possible to

download the 'Sosta facile' application on one's mobile device or send a simple sms to pay for parking in a simple, safe and innovative way.

PROTOTYPE STADIUM MANAGEMENT AND MAINTENANCE THROUGH WEB APPLICATION

As an information basis for fan engagement implementations, a maintenance-oriented web application is illustrated below.

Maintenance Web Management Prototype

The activity of management and maintenance of the elements present in the Stadium can be articulated in consequential phases each related to specific data organisation procedures and supporting IT products. These procedures and products must respect standards and compatibility with the most widespread technologies and, in particular, with those already adopted or being adopted by the hypothetical Customer. Furthermore, the procedures and tools must also be easily valid for future implementations on the Customer's entire estate. Below are the main development phases (Figs. 3-7).

Phase Zero: Current Status / Census and Mapping

This first phase involves the survey of all the signage elements and the corresponding location on plans of the different levels of the Stadium. The supporting computer tools consist of a series of spreadsheets that record the individual elements, univocally coded (according to criteria already in use by the Customer), with their relative types, and vector drawings of the plans with the punctual location of the signs, identified with a label bearing a unique code.

Phase One: Setting up the mySQL relational database

The set of alphanumeric data collected must be organised within a relational database so as to allow:

- insertion and updating of the data collected in phase 1 (through interfaces that can be compiled by electronic devices);
- data interrogation according to different reading filters (again through interfaces);
- production of extended or summary reports for digital or hardcopy printing.

The tool chosen for this phase, due to its compatibility characteristics and the possibility of interaction with other production environments, including future ones, is mySQL. Queries and reports are to be agreed in order to design the application to the customer's needs.

Phase One bis: DBWEB (independent of Phase 1, but co-operating with it) / Preparation of web environment interface for timely management and maintenance records

The operation and maintenance data need to be updated periodically, even at the individual sign level. This phase involves the preparation of an "agile" IT tool for recording field data that can be recorded directly (light devices) or in the back office (desktop). Recording is done by means of cards associated

with each element via QRcode, or from a drop-down list to identify the code, or from Map, or from filters by category.

The records thus collected, related and linked with the permanent data referred to in the previous phases, form the history of the interventions and can allow queries regarding the planned obsolescence of the materials or the verification (check list) of the preparation of the various configurations of the Stadium or planned activities.

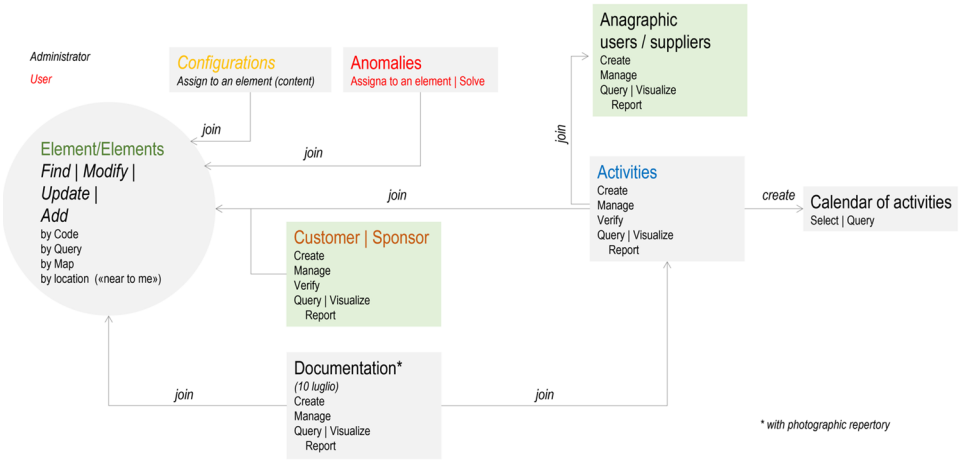
Phase Two: GIS / Geographical Information System Setup for Location and Signal Control

The plans set up in phase 1 must be implemented on a geographical database in order to be able to relate to the data organised in phase 2. This development of the geometric component of the data (point location) allows the relational connection with the alphanumeric attributes of the signals and thus enables:

- spatial interrogation of the data;
- production of thematic floor plans related to the queries;
- further implementation towards web management of the data.

The tool identified is OpenStreetMap, a free licence software.

Figure 3. Stadio App: Conceptual Scheme | List of areas and functionalities.



Phase Three: Integrated management environment via webGIS

The development envisages the preparation, in an environment that is fully accessible via the web and thus with common mobile devices, of all the information apparatuses (data and geolocations), so as to allow queries, updates and new entries using the plans of the various plant levels as an interface. In essence, this involves transferring the functions up to phases 2 and 3 reserved for the desktop environment also to lightweight portable devices (smartphones and tablets) (Ratajczak, 2019).

Figure 4. Stadio App: Logic Scheme| Data and relationship Model.

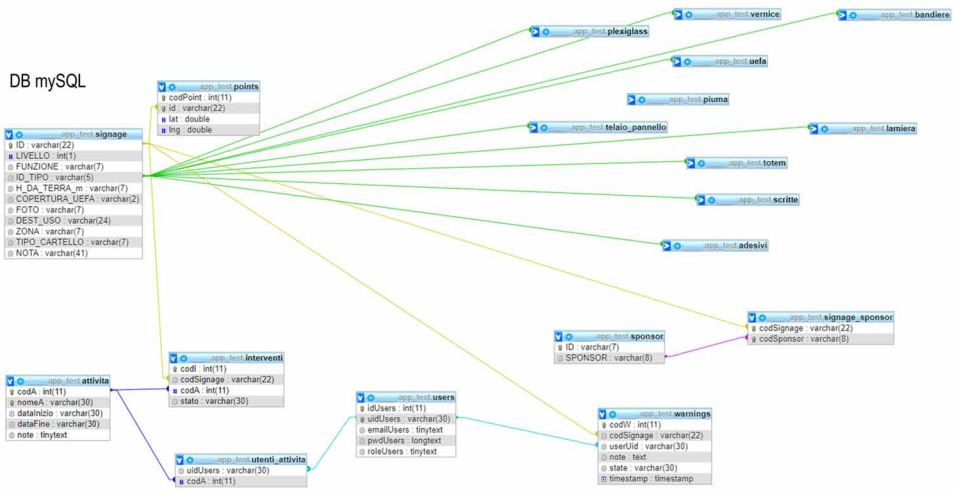
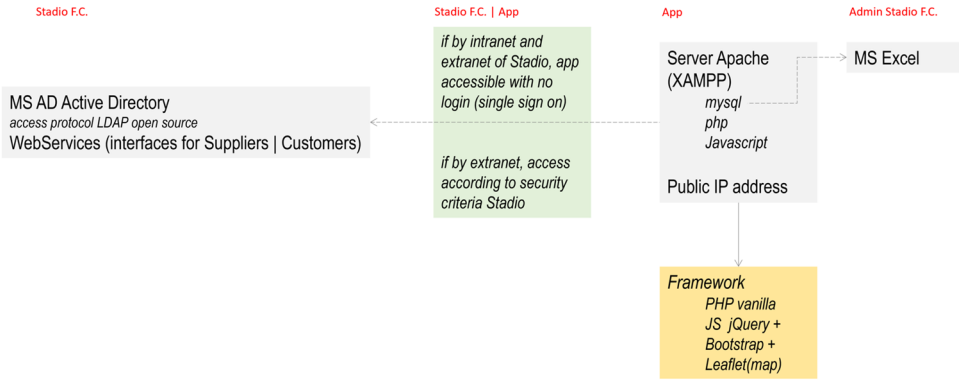


Figure 5. Stadio App: Physical Schema | Installing functions and access.



Phase Four: Coordination with existing BIM model

The previous phases are preparatory and compatible with implementation of the previously organised alphanumeric and geometric data into the existing BIM model. This phase involves the connection of the different environments developed (database, gis and web) with the stadium information model. This integration is also compatible with the maintenance system that the client is activating.

METAPROJECT SURVEY AND SHARING FOR AUGMENTED EXPERIENCES AND ENGAGEMENT

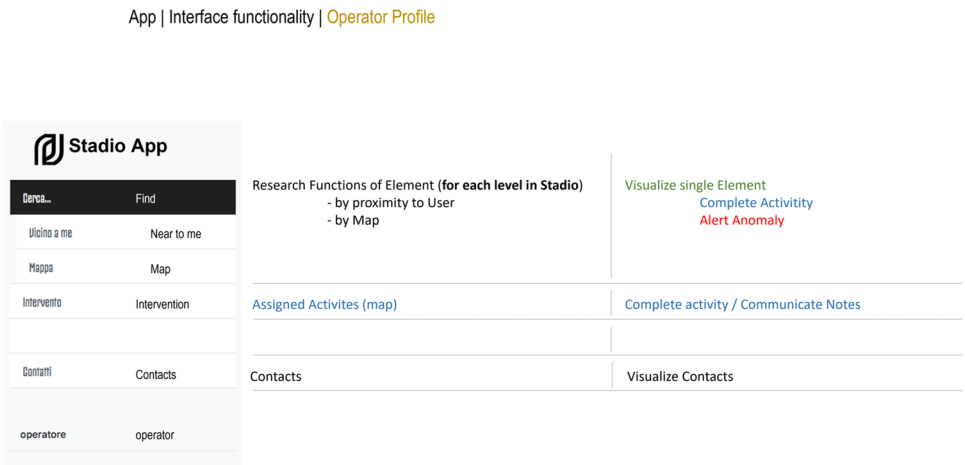
A built space valued as an environment of high perceptual quality contributes to the social and psychological health of the people and communities that inhabit it (Mehta, 2013, p. 56). Urban spaces are closely

linked to the way people live and work in cities. The liveability of cities is an important issue that has an impact on the quality of life; the relief of urban form originates in the reading and interpretation of historical structuring as a consequence of a process of mutation and design in the urban, architectural, political and social spheres (Cavallari Murat, 1968). The introduction of an effective method of evaluating the emotional responses of people living in urban spaces represents a relevant step for the actions of urban design and regeneration of cities and also for those of training future professionals through the instilling of the culture of data and information. Introducing integrated support based on information systems at the urban scale and techniques for tracking behaviour, habits, and participation in social life contributes to critically assessing the relationship between public space and people's behavioural responses.

Figure 6. Stadio App: Interface functionality | Admin Profile.



Figure 7. Stadio App: Interface functionality | Operator Profile.



Considerations on Perceptual Aspects Related to Meta-Design

Those who learn to design spaces and places for man and society base their knowledge process on behavioural models, demand frameworks, functional requirements, but do not in fact employ 'profiling' tools such as those used in the field of commerce and consumption, not with the same capillarity and intensity of data collection and analysis to take in information, not with the same incisiveness and not with the same level of updating and in-depth analysis (Bocconcino, 2022). It therefore seems relevant to transfer some models of analysis dedicated to profiling potential 'poor consumers' to the urban survey from its most vital component, the citizens. In some of these studies, digital urban simulation represents the starting point for the planning, design and regeneration of the built city: the use of computational methods that analyse and generate spatial configurations with iterative computational methods represents the new support tool for the definition of 'citizen journeys', a noble derivation that we could give to the concept of customer journey, here declined as citizen journey, a sort of urban marketing or neuromarketing applied to the vision (to the gaze, to observation) and to the use of the city.

The state of the art of research on human perception of the built environment is based both on questionnaires, interviews and field observations of people interacting with the environment under study, and on the use of more frontier methods, which make it possible to investigate the relationship between spatial characteristics and the senses, through the use of tools that collect and process significant masses of data, including from sensors of various kinds and from social media, often to investigate which types of places people find most comfortable (Girardin et al, 2009 and Resch et al, 2015).

The study of the city is not new to the introduction of advanced science and research fronts. Following the increasing availability of these kinds of resources, in the last decade the social sciences have introduced quantitative parameters and indicators, often labelled computational social science (Lazer et al. 2009), related to environmental perception, feeling, emotion, social connectedness, previously limited to qualitative modes of enquiry (Moretti, 2016). In particular, the emerging network science that studies complex networks has made a significant contribution to field research (Borner et al., 2007).

Network science takes an exclusively spatial perspective on urban data, focusing on the relationships and interactions between people, places, and institutions, at different scales. Manuel Castells (1996) introduced to urban studies the notion that by abstracting cities as social spatial networks of interaction, network science helps to uncover structural commonalities shared by most human systems, allowing for the construction of cognitive and predictive models of development (Batty 2013). The infrastructure of the built fabric with sensor networks has opened up real-time representations of the state and condition of places. The growth of social media is leading to new forms of participation and activism, alongside traditional forms of participation in the design of places; citizens voluntarily take on roles of monitoring and reporting, a phenomenon that has been described as the rise of the 'expert amateur' (Kuznetsov&Paulos 2010).

In recent years, more incisive approaches have been developed to understand how people perceive and feel the space and environment they experience. The analysis of the flows of citizens (human mobility), the tracking of the eye that collects the scene in glances (eye tracking), the automatic study of the movement of groups of people, who move in different physical places (body tracking), represent new scenarios - real and virtual - made available to the actors involved in the processes of management and maintenance of the real estate heritage.

In this context, the management of urban space and buildings becomes the tool for the relationship between use and wise administration of assets to adapt buildings to people's needs. Asset management

as a discipline has three different and integrated purposes: i) to achieve organisational goals by balancing risks, opportunities and costs through the integration of different digital technologies; ii) to produce value through the management of the built environment; iii) to support sustainability strategies. Regarding the first objective, 'integration' is probably the most relevant topic, as a key factor of the whole process, and involves not only integration between technologies, but also between technologies and users, and between users and buildings. The second objective is closely related to the concept of heritage enhancement, and consequently to the topic of sustainable reuse, in addition to the economic dimension of the building process itself. In this challenge, two main educational objectives in the conceptualisation of building planning can have a major influence: the 'visual perception' and the 'spatial perception' of places and volumes.

Through typing on devices, we leave and collect traces. This is how our digital identity is formed, with this we can predict our behaviour or even influence it. The data market is all of us.

To expound on the objectives of the proposal, let us use a few questions: how can artificial intelligence technologies used on a commercial and consumer level be brought into the field of training and education for the design of the city? And to design spaces that are liveable and give well-being? Is it unrealistic to think of a design of the city (and of public space) that stems from the orderly and constant observation of those who breathe it, those who live it, those who see/look/observe it, those who use it, those who walk through it?

The answer to these questions should tend towards the constitution of a consultable atlas of experiences in urban space, stratified in two reading planes, lines of development of the project: perception and observation; the flow of people, behaviour, habits, use and fruition of space, production of contents, events. It must be expressed through multi-dimensional maps, digital public spaces, dynamic and interactive containers of experiences and visual stimuli that provide scenarios for the interpretations of scholars and designers.

The critical intervention of the operator in the process is required as an initial contribution to the modelling pipeline, to assess the quality of the extraction of the building form, but the process declines towards the possibility of an AI (Machine Learning) learning automatism, where a considerable support of calculation functions is provided for the adherence (fitting) of the extracted surfaces and the correspondence (compactness) of the structure of the three-dimensional entities, controlled in terms of vertices, components and parameters.

Semanticisation and Integration of the Digital Space for Digital Asset Management Responsiveness

As the databases of acquired and processed information will be composed of a large and complex extension of data, it is necessary to impose a semantic labelling approach for Repository elements, identifying 'instances' and 'annotations' in relation to parameters and query indicators that define them (Pavan et al., 2017). The methodologies adopted refer to the reading of the state of affairs in relation to heritage management, aimed at knowing:

- technological systems and management methods (type and quality of data available);
- social dimension environments (habits, movements, attendance);
- user profiling;

- methodological approach and critical review (modelling, instrumentation, environmental simulations);
- identification of representative cases and selection criteria (preliminary to measurements);
- identification of data periodicity character
- definition of supports (models from expeditious survey, to have surface models, and sensor set-up) and information system distributing info (simplified gis/bim)
- installation project, installation and data collection (automatic and questionnaires/interviews), identification of anomaly indicators that will be used for testing and verification of the practice
- identification of graphic modes and codes for representing and understanding phenomena;
- comparison with users and administrators (management savings, user education, virtuous behaviour);
- real time or asynchronous graphics and definition of minimum representation.

The main lines of development to be utilised and implemented concern the aspects highlighted below.

Visual and Perceptual Mapping for Behavioural Tracking

Eye and movement tracker systems will be applied to the case study, making it possible to obtain information on the user's behaviour in the scene, both at the level of gaze observation and movement in the scene, with measurement of dwell times and distribution trajectories. In contrast to applications focused on defined screens/frames, free and unconstrained scenes will be considered, which are functional for preliminary cognitive-behavioural considerations. Precise information will be obtained on the users' perception of architectural and building scene characterisation elements, motor sequence of scene exploration, with the potential to provide hints on the logical connections perceived by people in the building container.

Wearable eye-tracking devices, equipped with infrared cameras (to detect eye movements, gaze samples, fixations, pupil size, blinks) and an ordinary front-facing camera (to record the observed scene), record the gaze path in a totally free scene. In this case, subjects can move freely, without limiting the ocular data collected to a specific view and obtain information on how the built environment is perceived and explored, the distribution of users' visual attention, the static-dynamic elements of fixation-visual tracking, potential 'emotional states' and the cognitive load associated with performing specific functions.

Tracking Paths and Flows within the Structure

By means of head-tracking or body-tracking devices, consisting of fixed cameras installed in the scene, physical movements and pauses during the experience of the environments will be monitored, evaluating more complex behaviours, such as common exploration patterns, the permanence and distribution of users in the premises according to environmental factors, comfort, crowding, occupation of infrastructures.

In the laboratory environment, it will be possible to conduct similar experiments and investigations with virtual reality simulations, both in the non-immersive case (using a screen and a remote eye tracker) and in the immersive situation (e.g., using a wearable device such as Oculus Rift enhanced for eye tracking).

3D Modelling of the Building/Urban Container

Dynamic 3D spatial survey and scan-to-BIM modelling solutions will be applied to develop simultaneous global localisation and mapping of physical spaces with collected sensory data translated into a virtual scenario arranged for spatial machine intelligence (SMIS). Greater automation and self-management of spatial data will be investigated, for the acquisition of scene geometry and the transposition of spatial semantics. The representation of building and urban containers belonging to the study areas will define a digital background of observation and declination of models and data analysis at multiple Levels of Detail of the spatial scene, applied for the documentation of paths, volumes, open spaces and architectural/technological details (Zaker&Coloma, 2018).

The translation of different data on (sensory and visual) perception of functional space, from the building scale to the urban context of location, validates an essential methodological aspect of cognitive classification between volumes, infrastructure and open spaces within their possible building transformations (Fig. 8).

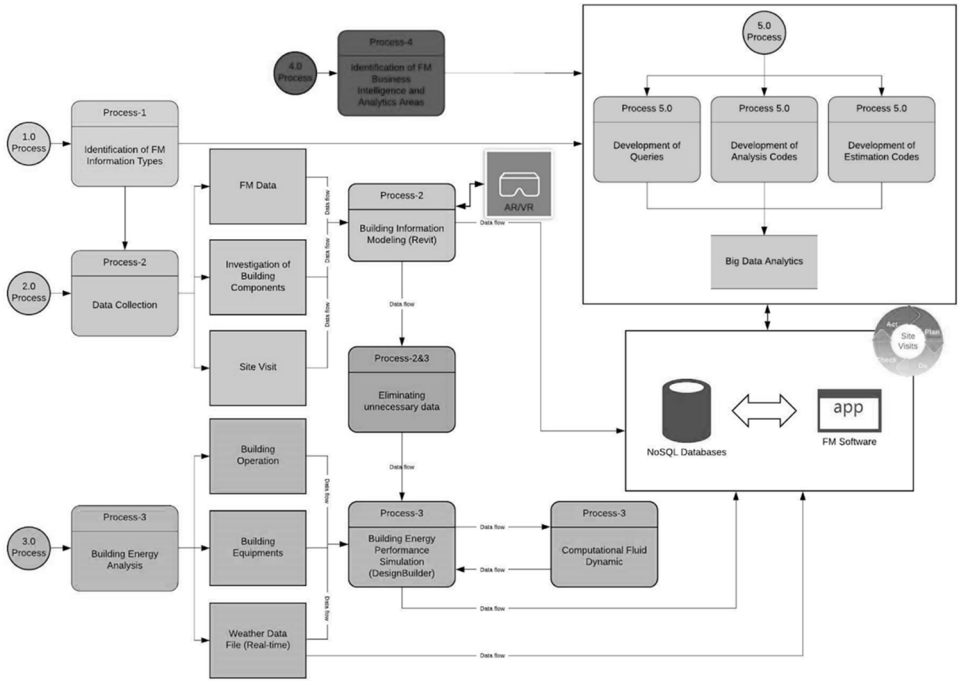
DISCUSSION

The urban and territorial relevance of large sports facilities imposes the assumption of a design and mainly recovery approach, oriented both to structural verification and to modernisation of large facilities, in relation to the performance field, which requires the use of new techniques and materials to improve their life cycle. The innovations guaranteed by the progressive development of the regulatory framework constitute the reference for design recovery and technological innovation. Integrated recovery and valorisation strategies applied to sports facilities therefore represent a new technological frontier to be explored in the light of recent developments in the field of cultural heritage and activities.

The last decade has been characterised by a progressive increase in synergy in every relational sphere. The interdependence between global and local has encouraged local cultures to rediscover the territory as a place with an identity.

The functions of human activity, such as living, producing, leisure, are linked in time and space, leading to a radical increase in the traditional representation of the urban place. The future of the urban market thus depends on the ability of cities to condition functions and forms of planning, so as to optimise their competitiveness and capacity for interaction in the context of global space. which highlights the need for sustainable and competitive economic strategies for the metropolitan context. Today, the new guidelines assume the valid principle that a sports facility can only be active if it produces a fair profit for an operator. This is to be interpreted as an incentive and stimulus aimed at a managerial nature of a sports facility and in particular of a football stadium. Otherwise, sports facilities run the risk of becoming expensive due to the degradation resulting from inactivity or the confrontation with design and safety regulations, characterised by architectural adaptation, due to facilities built with a design conception that differs from today's requirements.

Figure 8. A Framework for Integration of BIM, BEPS and Big Data Analytics in View of Lean



Management Philosophy (source: Demirdögen et al., 2020, pag. 20).

Richard Rogers in his autobiography states "Consistency is change (...) my goal is to adapt buildings to people's needs" (2018).

It is useful to dwell on some considerations that draw on the existing availability in terms of real-time recording of different factors. The spread and development of ICTs make possible the pervasive and ubiquitous transmission of information about people's movements and flows, fostering an interrelationship between information, humans and the environment. The traditionally static approach centred on infrastructural networks, the core of the traditional idea of smart buildings, is shifting towards a cultural vision of the smart building, where ICTs can promote the transition from "smart buildings" to "smart places", in particular through participatory applications. A new and important role is played by artificial intelligence, through which data can be collected, selected and analysed, in order to gather useful information on the behaviour of the users of spaces, and consequently be able to deduce new levels of knowledge capable of triggering the acquisition of higher level skills (critical reflection, awareness, problem solving skills). The methods of cataloguing and utilising the analysed data, through GIS and BIM information systems, dedicated to the urban environment, are important. The 2D and 3D visualisation of data processed by AI promotes the processes of 'visual computing', i.e. the analysis technique based on the visual representation of data, which favours the study of large amounts of data.

In the field of construction, the difficulty of managing large functional structures highlights the demand for tools to support the technological design and management of spaces, taking into account the activities used, behavioural practices and response mechanisms desired by users (Bocconcino, 2019). The contextual loss of quality of the common space derives from the rapid and disorderly use that is

experienced, often far from the expected logical patterns of frequency, path and concentration of gaze. Through the recent limitations and alterations of the ways in which limited spaces and public compartments are experienced, the analysis of these phenomena must constantly update the knowledge behind building management, monitoring the dynamics of interaction between man and building, deciphering changes and providing solutions just as quickly.

By increasing the understanding of how individuals perceive the built environment, both inside and outside the built enclosures that make up the urban fabric, it is possible to assess which characteristics of the built space are interpreted as positive or negative on the quality of use (Donato et al., 2017).

The aim is to apply quantitative data, certified by sensory measurements of behavioural dynamics and translated with appropriate graphic codes for the representation and understanding of phenomena, to find correlations between the characteristics of the observed framework and the perception of individuals and groups of individuals within the built space. This involves defining a supervisory tool (an "explorer" database, a collector of building sensory data) as an enhanced Digital Asset Management competence.

For this requirement, the same space must be traced in parallel in its two real-digital counterparts: the real space must be the object of measurement and observation of human cognitive phenomena, and of analysis of the building containers that house them; the digital space, as a validated replica of both the spatial and technological properties reproduced, must collect and adopt such data to endow itself with responsive qualities. The direction must be twofold: management practitioners (such as energy managers, technicians) must promote analysis to develop cyclical interventions, conservation and planned management agendas; marketing practitioners will use behavioural mechanism analysis frameworks to confront users on their 'digital paradigm' and drive awareness on behavioural mechanisms of interaction with the sports facility and its functions.

Resource management is also relevant by considering the adaptive reuse approach and strategies (Lo Turco&Bocconcino, 2017). These are usually based on the assumption that buildings, areas, neighbourhoods and sites are not static entities, designed for a single use during their life cycle. On the contrary, it consists of the practice of introducing new content into an existing site, paying special attention to the needs of society and following the principle of maximum conservation and minimum transformation. Within this perspective, an integrated digital asset management strategy can integrate different tools and means related to predictive impact assessment and decision support strategies, taking real advantage of integrated and interactive models and the increase of huge amounts of data

The construction industry is rapidly pushing forward the so-called 'servitisation' process, moving from selling the physical good (the product) to the end user to selling the physical good within a set of services that can be activated after purchase. This has an enormous impact on the organisational core business, shifts much of the value generation to the utilisation phase and can be further developed through an integrated and interconnected digital approach.

It is interesting to focus on the type of interactions that can be assessed between these functions and some innovative ICT technologies, in order to evaluate the impact of the digital revolution from an asset management perspective. A short list of these disruptive ICT technologies may include: Internet of Things (IoT), communication technologies, data acquisition, Blockchain, BIM and HBIM, augmented and virtual reality (A/V R), artificial intelligence (AI), and additive manufacturing.

From a comprehensive analysis of these mutual interactions, it is possible to foresee at least two foreseeable evolutionary scenarios: i) a rapid forward shift from BIM/HBIM, IoT and AI to a widespread implementation of interactive Digital Twins; ii) an increasing integration of IoT networks with

AI techniques in order to improve connectivity and interoperability between users, digital models and buildings, with a real-time self-updating BIM/HBIM.

In the end, this scenario may configure a true 'Digital Asset Management revolution' based on two pillars: an incoming ontological mutation generated by the multidimensional and multiplatform integration and interaction between humans, things and models, both in a real and virtual context; the rise of a new 'digi-real' paradigm and ecosystem based on intelligent and self-adaptive buildings and models in the so-called 'everything everywhere' paradigm.

It will assist in design activities through data collection with quali-quantitative methodology, in order to outline and propose the profile of users interacting in specific architectural environments, their identity profiling as users of collective spaces and their ethical characterisation with respect to value systems and collective behaviour patterns. It will define the ethical-moral criteria of applications and interactions with the aim of preparing protocols and practices that outline active processes both in their latent and manifest representation, considering the environment as a characterising element for the formation and education of the subject, trying to delineate, should they emerge, counter spaces of action.

CONCLUSION

The world of sport was one of the first early adopters of VR (after the military), think of F1 drivers and simulators, now so advanced in terms of technology that they not only digitally reproduce a physical circuit but also allow athletes to train body and mind - as if they were really driving on a circuit - and engineers to acquire new data for car design or engine engineering. Other interesting examples come from cycling, golf and football. Here, too, the beginning of the use of simulators based on Virtual Reality goes back several years.

In a copy of the digital world, the sporting event itself has crossed the dimension of the real to pass - at least partially - into that of the virtual with eSports. Consumers' expectations regarding experiences - increasingly personalised, increasingly immersive - put brands under pressure, but a healthy pressure because it pushes them to find new solutions, and, new solutions mean new lifeblood for sports marketing, both for entertainment and engagement. In this context, the value of VR is invaluable because it represents a comprehensive and immersive way to communicate what the brand can offer, especially for its potential as:

- has the power to show what is not visible, 'purpose-built' situations or environments that would otherwise be impossible for a fan to reach;
- the experiences are highly customisable and not pre-set and monotonous, because they can be set and varied according to the needs, tastes and inputs of the user. This makes them even more engaging;
- the use of gamification makes the VR experience highly active and interactive. And more easily memorable;
- each user experience can be analysed to collect data and information: how much time a user has spent online, what they have seen, which products they have marked as their favourites, from which area they connect;
- millennials, and younger generations in general, were born and grow up using digital technologies as their preferred vehicle of communication.

Investing in the integration of management systems and promotion and involvement of supporters therefore means looking at the customers of today and those of the future.

Mixed Reality is making it possible to raise the quality of both virtual reality and augmented reality: much more technologically advanced than VR (because it combines the use of different technologies, sensors, wearable devices, highly advanced optics, and ever greater computing power for data analysis), Mixed Reality makes it possible to raise AR to a superior experience by allowing people to experience ever larger realistic scenarios within spaces and time that are no longer confined to the real visual experience.

It is a horizon that still needs to be deciphered but which may appear clearer if we imagine the interesting frontiers that can open up in medicine, wellness, education (training/teaching), entertainment, communication, industrial design or building construction, art and everything else. All the way to sport.

360° videos have already introduced a new way of viewing a game or a sporting event (but also a concert or a show) by allowing people to have a full view, as if they were physically present, even while sitting on the sofa in front of the TV or holding their smartphone or tablet. Soon, the experience will be live 360° and will allow fans not only to have a full view of the stadium, the dressing room, the pitch, but even to immerse themselves in the game action with a view similar to that of the athlete on the pitch.

Compared to what we are already able to touch today, therefore, and imagining what we will be able to do in the near future, the future will increasingly be a mixture of AR/VR, which, intertwined with other technologies such as IoT and wearable devices, will make Mixed Reality increasingly pervasive and allow us to experience sport at a higher level.

Mixed Reality in fan engagement represents an evolution in how existing technologies can be adapted to provide tremendous opportunities for teams to engage and entertain crowds and television audiences. The technology exists, it fits directly into existing technical and commercial structures. Most importantly, it demonstrates that with a fan-focused approach to technology implementation, we can build customised experiences from the information assets that facility management already provides.

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KEY TERMS AND DEFINITIONS

Fan Engagement: Fan engagement is the watchword for any sports club. This concept is based on the consideration that real fan engagement only occurs when the team is able to build an intense and special bond with them. It represents the new frontier of the relationship between fans, brand and athletes, and the individual experience of each fan is the beating heart of this relationship. If a brand improves the way it reaches out to its fans and succeeds in providing them with memorable moments, as a direct consequence the same fans will want to experience it again and this will lead to a tangible increase in performance for the brand.

Sports Venue Management: Sports venue management is the practice of operating an establishment in which people participate in or watch sports. Football stadiums, bowling alleys, golf clubs and sports-focused entertainment establishments are examples of sports venues.

Sustainable Facility Management: Sustainable facility management seeks to ensure that each building has a greatly reduced, or even neutral, impact on the environment. Generally, this implies several changes in the daily operations, as well as changes to the structure of the building itself. One of the possible alternatives to architectural changes is to use smart sustainable technology. However, it has been shown that sustainable facility management is not just about minimising the impact of buildings. Sustainable facility management has repercussions for buildings, people, and organisations.

Venue Management Software: Venue management software can help market avenue as a major selling point for events. This can help to book more attendees, increase sales and spend less time on admin. Venue management software eliminates the busy work behind planning an event and lets users get straight to increasing awareness and sales for their company.