BIM applications for the management of road infrastructure assets. Practical experience of Intelligent Safety Management in Road Maintenance: BIMSAFETY - ROADS

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ABSTRACT:

The article presents the results of an experimental study in which the BIM model of a road infrastructure was used as a case study for the development of a tool for intelligent safety management of road maintenance.

Initially, a general review is made of the state of the art and the main challenges that arise in BIM applications for road infrastructure, followed by a discussion of the innovative contribution of the implementation of BIM methodology and its associated technologies to asset management in general, the problems associated with it and the particularities of its use in road maintenance.

The problem of road safety management and the potential contribution of BIM to it, whose use would enable an *"Intelligent Management of Safety in Road Maintenance"*, is also analyzed.

The BIMSAFETY - ROADS platform is described, which is not a commercial software tool but a specific development resulting from a research carried out within the framework of an R&D&I initiative, where the BIM methodology is used for the collection and analysis of data related to road safety, occupational risk prevention and service quality indicators during the management of road maintenance and preservation operations. A general description is given and the basic lines of action on which the implementation evolved are pointed out. The BIM management modules developed and the control and data analysis panels incorporated are also detailed. All this is completed with Virtual Reality applications that fit in with the experience carried out.

As a final conclusion, it is expressed the point of view of the authors about the scope and achievements of the presented development and also the challenges for the future in the application of the BIM methodology and its associated technologies to road maintenance.

KEYWORDS:

BIM, Asset Management, Road Maintenance, Road Safety, Occupational Risk Prevention, Intelligent Information Management.

1. BIM APPLICATIONS IN ROAD INFRASTRUCTURE

1.1. State of the art.

In recent years, the evolution of the use of BIM in construction projects has been experiencing a significant increase that has been consolidated over time. This explosion, which is undoubtedly due to the multiple benefits provided by the use of this methodology, is very evident in the construction of buildings, both residential and industrial, but it should be noted that the phenomenon is not so clear in the case of road infrastructure works.

It is also true that efforts are increasingly evident at the European level to streamline and increase the speed of the process of implementation and adoption of BIM in the construction market through government policies and initiatives to promote it in a growing number of EU Member States. However, this effort must be spearheaded by the construction companies themselves, which must perceive the use of new technologies as a crucial opportunity to improve productivity, quality, safety conditions at work and environmental care. BIM can be a fundamental tool, since, combined with other technologies, it can be a lever for development in a very low-tech sector. Thus, according to the European Commission's March 2019 report by *European Construction Sector Observatory*, if this type of implementation were carried out, savings of between 13 and 21% could be achieved in the construction phase, and between 10 and 17% in the maintenance and operations phase. The digitization of construction in the EU is considered a fundamental tool for achieving climate neutrality and economic recovery. **[1]**

On the other hand, from an economic point of view, the forecast is that the valuation of the European BIM market (according to ECSO TP BIM 2019 report), will be 2,100 million euros, mainly due to the development of public infrastructures. **[2]**

However, at the moment it is not perceived that public decision makers are giving the necessary importance to the digitization of all phases of the life cycle, as they seem more focused on the Project and Construction phase and to a lesser extent on the maintenance and operation phase.

It should also be noted that there is some reluctance to use BIM, largely due to the difficult quantification of the benefits it brings. However, its costs are more easily quantifiable: it is estimated that the cost of training, licenses and computer equipment is between €15,000 and €20,000 per worker to be able to adopt BIM correctly, according to the *Methodology Handbook Calculating Costs and Benefits for the use of BIM in Public Tenders, published by the European Innovation Council and SMEs Executive Agency (EISMEA)*. This handbook offers a cost-benefit calculator, but the benefit depends on multiple factors, the main one being the maturity level, with the benefit/cost ratio varying between 1.69 and 5.31 depending on the BIM maturity level and the life cycle to which it applies. **[3]**

Regarding the use of BIM in operation and maintenance of road infrastructures, the current vision for its most obvious application is framed in the following points:

- Information support for maintenance and renewal

- Data monitoring and predictive maintenance platform
- Facilities and asset management data repository
- Platform for virtual delivery and commissioning.

1.2. Main challenges in the adoption of BIM in road infrastructures

The following are the main challenges currently posed by the implementation of BIM in road infrastructures:

- The industry continues to prioritize the design phase, as opposed to the construction phase and even more so over the operation and maintenance phase.

- There is a clear consensus that one of the obstacles is the interoperability between the different software. In this respect, the implementation of the IFC5 standard is eagerly awaited. *(IFC files, or Industry Foundation Classes, are data models that function as a standardized file format for the exchange of different BIM software whose main objective is to promote interoperability between different programs. In particular, the IFC5 standard will be a development of the currently most used specifications, IFC 2x3 and IFC4, which will allow better representation of point and linear infrastructures)*. **[4]**

- It is also a challenge to deal with the emergence of new roles, work processes, or legal issues.

- There is a great difference in the size of the companies in the sector, so the availability of economic and human resources to be able to implement BIM is very unequal. This requires greater coordination efforts.

- One of the main barriers, although it may seem paradoxical, is the lack of appreciation of the benefits of BIM.

- Bringing together other technologies such as augmented or virtual reality, 3D printing, digital twin, artificial intelligence, etc., with BIM in a way that produces synergies that enhance the digitization of the sector.

In order to solve these challenges, the EU in its analytical report on digitization in the construction sector **[1]**, points to the specific need for three types of intervention:

- Regulatory framework at EU level, ensuring better data quality and better data management, as well as addressing challenges related to intellectual property rights and cybersecurity.

- Raising awareness and convincing construction SMEs of the need to implement digital technologies, as they need to be aware of the opportunities that exist, adapted to their capabilities and resources.

- Increase financial support to companies to invest in digital technologies, such as Horizon Europe or Digital Europe initiatives that support investments such as the deployment of digital technologies, research and innovation.

In order for BIM to be applied in the coming years in the maintenance and operation of road infrastructures, and to overcome all the challenges mentioned above, the quantitative and qualitative evidence of the contribution of the BIM methodology from the early stages of the life cycle to the operation and maintenance phase must be transferred to the construction industry.

2. INNOVATIVE CONTRIBUTION OF THE APPLICATION OF THE BIM METHODOLOGY AND ITS ASSOCIATED TECNOLOGIES TO ASSET MANAGEMENT

2.1. Overview

BIM methodology has been implemented unevenly around the world for more than 20 years. Some countries have developed standards and guidelines to facilitate its use and homogenize software development and information production and have achieved a greater number of strategic objectives than others who simply follow the path of what has already been discovered.

However, the natural evolution has always been to start with the use of BIM models for coordination and 3D visualization and gradually, as the maturity of the market and of the various players in the construction sector increases, to look for new benefits. Chronologically, it is necessary for this BIM development to take place in the design and construction phases so that asset management activities can benefit from all the information created and shared during this development phase.

Technological approaches to the world of asset management are already taking place in different areas. Thanks to the fact that the Internet is now almost ubiquitous, cheaper components and connection fees, devices are multiplying that, however simple their operation, are capable of sending data or reacting to external requests. The Internet of Things (IoT) makes available to any user the ability to control or be informed by sensors installed in a building or infrastructure.

If we want to make all this data accessible to the average user or want it to be useful for the management of a given asset, we will need at least two things:

- Apply intelligence to that data to filter and select it so that it becomes interpretable information, and…

- A BIM Model that allows the visualization of that information and facilitates decision making in a more intuitive way.

2.2. Problems associated with implantation

The use of BIM methodology in the development phase (project and construction) is beginning to consolidate in such a way that a large part of the contracts currently tendered require, in a more or less precise way, the use of BIM methodology and the delivery of three-dimensional models containing the "as built" information at the end of the works. It will be in the next few years when, as a result of the completion of an increasing number of constructions using this methodology, we will start to see BIM models whose information will theoretically be used in the near future for the management of these assets.

It should be remembered that the methodology is much more developed in the building field than in the civil engineering field. Infrastructure design programs have started importing/exporting BIM formats only 3 or 4 years ago when building programs have been in use for more than 12 years. This means that these formats are now adapting to include in their semantics construction elements that are specific to linear infrastructures and do not exist in building.

There is still a lack of imagination, software development and criteria so that the data and documents used for construction can be used to conserve and manage these assets. This is mainly due to the absence of these agents in the decision-making process in the initial phases, but also because of the lack of software to make all this effort profitable. It is therefore necessary to adapt the software and adapt the processes with asset management in mind, since a model created for budgeting a project or planning its construction will be useful for preparing the model for the maintenance phase, but it will have to be modified. To the extent that maintenance is limited to the execution of new extensions or renovations, BIM can be used again as in the development phase, but if we are talking about a use to manage, operate and maintain an asset, the built reality is no longer so important and needs appear that have to do with spaces, equipment, installation networks, consumption, conditions of use and maintenance... therefore it is necessary to "rethink" BIM.

A new problem also arises: computer formats become obsolete very quickly, and so do the media on which this information is stored. The CD or DVD storage revolution has become obsolete in just 10 years. Information stored in formats that are 5 years old cannot be opened in another 5 years. But maintenance contracts or operating concessions are for 25, 30 or even 50 years. We do not have today any support or format that guarantees that we will be able to use it in 20 years' time.

Finally, it is worth mentioning the scarce bibliography available today on this subject. Although, in this regard, the publication in the second half of 2020 of the third part of ISO 19650: *Organization and digitization of information in building and civil engineering works using BIM and Information Management when using BIM*, which comes to complete the first two parts published in 2018, has been a major breakthrough. This ISO 19650:3, entitled: *"Part 3: Operational phase of the assets"*, focuses on asset management with a focus on increasing the efficiency and effectiveness of information management processes. **[5]**

2.3. BIM implantation in roadway maintenance

Based on the above, it seems that the use of BIM in infrastructure management or maintenance is at the tail end of the development of this methodology.

The challenges of BIM implementation in road maintenance are mainly two:

- The management (control, visualization...) of the information generated.
- The housing of this information throughout the entire period of operation.

To face them, it will be necessary to reinterpret the uses that are currently being given to the models and the information contained in them.

Waiting until the use of BIM is more consolidated in the development phase to make models available for use in maintenance, apart from being unambitious, would absurdly delay the exploitation of its advantages. Understanding the whole process as a circular economy system in which the maintenance of an infrastructure is the state prior to a state of development of a new project, and that the information of the work not only serves to build, but is generated to inform the next link in that chain, the role of the operator takes on more relevance, having to be included in the decision making from the first conceptual meetings.

On the other hand, the much more extended use over time that operators will make of the model compared to the development phase should lead the Public Administrations that own the assets to make an effort to analyze how to demand the delivery of information at the end of the infrastructure works. In this regard, it is worth noting that certain properties have already begun to take steps to implement BIM in the inventory of their infrastructures, including it in their requirements and recommendations. For example, in Spain, two of the latest BIM guides published by entities such as State Ports of Spain or the General Directorate of Mobility and Road Infrastructures of the Regional Government of Extremadura take this aspect into account. **[6], [7].**

In any case, the information generated in the project phase is much more controlled: we know what it must be like and what information it must contain so that the construction company can execute the work... while the information in the maintenance phase is much more dispersed: we can talk about data provided by sensors, information obtained from public web services, even from navigators used by drivers, etc. The representation of this information is a real challenge and even more so if we add the need for it to last over time and be flexible to accept new technologies in the following years.

In addition, we must take into account that the design and construction teams are familiar with the BIM language and environment for construction. They are professionals for whom the incorporation of BIM processes has meant a change, but the objective remains the same: "Construct a building or infrastructure on time and on budget". The problem is that, in the case of road maintenance, although the objective also remains constant: "To maintain the infrastructure in adequate condition", less specialized agents are involved, as well as road users, and decision making is marked by increasingly large amounts of data and information.

For example, in the application of BIM in road maintenance, we encounter such basic problems as how to generate 3D models with a sufficient level of detail to use them in a practical way, depending both on the initial information available and on the specific BIM software tools for linear infrastructures.

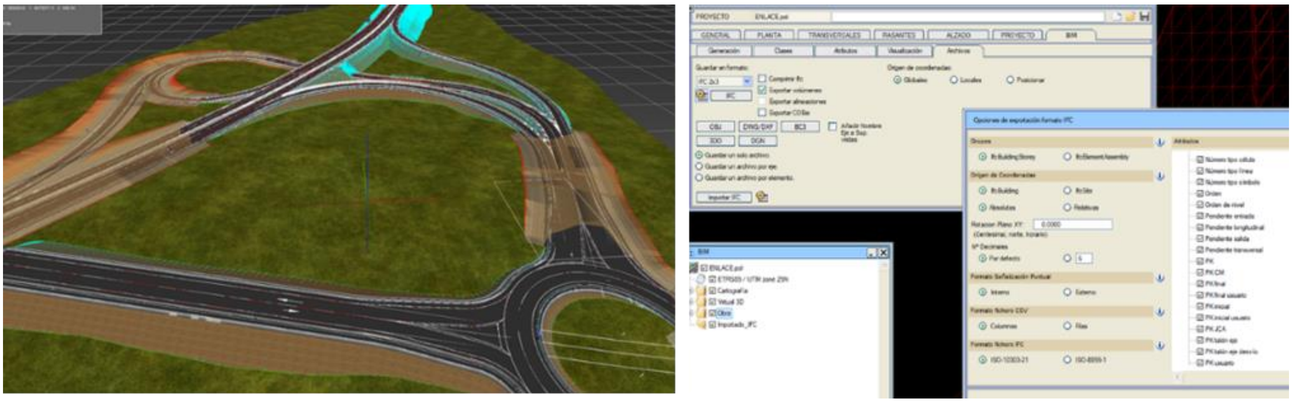

Figure 1 - BIM modeling and implementation for roadway maintenance

In this sense, the experience of implementing the BIMSAFETY - ROADS platform has allowed us to reach interesting conclusions such as the need for the configuration of specific parameters of the modeled elements or the incorporation to the models of elements that facilitate screen navigation and drop-down menus, a key aspect in the development of the tool since, due to the difficulty of handling the linear models by the current BIM viewers, it provided an important added value in the different modules of the digital platform.

3. INTELLIGENT SAFETY MANAGEMENT IN ROAD MAINTENANCE

3.1. Road safety management

The road is the transport infrastructure that provides the greatest mobility to society, being that, at European level, around 90% of personal trips and over 70% of overland goods use this mode of transport (in the case of Spain, the latter percentage is also in the order of 90%). **[8]**

If we analyze road transport from the perspective of safety, we find two aspects that are certainly complex: on the one hand, road safety, i.e., everything related to traffic accidents, and on the other hand, risk prevention for the infrastructure maintenance workers themselves. In some cases, both may be directly related (traffic accidents affecting maintenance workers in the course of their work) and, in general, they may be related, either directly or indirectly, to the quality of the maintenance service offered to users.

Therefore, in the development of the maintenance and operation of the different sections of the road networks, it is necessary to record, handle and manage information related to these aspects. The organization and analysis of all this information in a practical, fast and flexible way using new technologies associated with Industry 4.0 is, from our point of view, a disruptive phenomenon in the way of approaching its problems.

3.2. Potential contribution of BIM to road safety management

BIM (Building Information Modeling) as a collaborative work methodology for the creation and management of infrastructure assets, allows centralizing the information in a digital model operated by all the agents related to them throughout their life cycle, which is obviously fully applicable to Road Maintenance Safety, especially understanding its management, in a broad and general way, associated to the set of digital tools for the development of the BIM methodology during, in this case, the operation of a road.

The application of these principles in a given section of road or highway focused on the management of both road safety and occupational risk prevention of operators has great potential with the added value of the visualization of the distribution of accidents on the model of the infrastructure that facilitates both the rapid recognition of those places where they are concentrated and the detailed analysis of the three-dimensional model (such as the elements of signaling, beaconing and defenses that are available in the area and all the information collected at the time of the accident). The potential of the possibility of reproducing an accident in a virtual environment to analyze its causes and singularities is also evident.

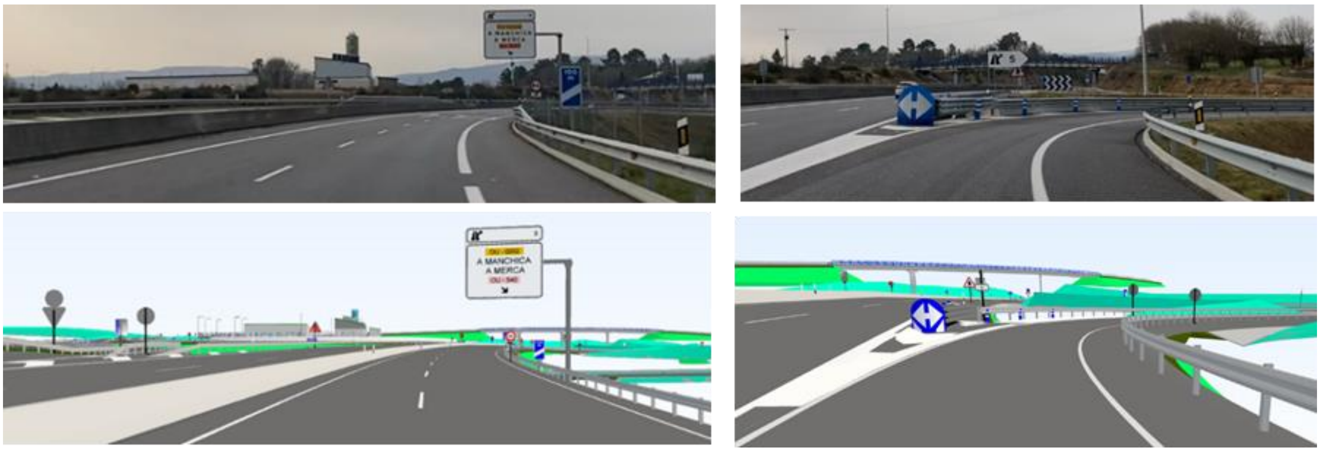

Figure 2 - Comparison between images taken "in situ" and images extracted from a 3D road model

Therefore, we can conclude that the processing and analysis of data and information in a fluid way through digital management modules and 3D visualization tools can facilitate the early detection of problems, risks and hazards and an improvement in the quality of service and working conditions that will indirectly have an impact on the reduction of accidents and, by extension, on the saving of economic, personal and social costs.

4. EXPERIENCE OF PRACTICAL APPLICATION OF BIM IN THE INTELLIGENT MANAGEMENT OF ROAD MAINTENANCE SAFETY: BIMSAFETY - ROADS

4.1. General description

This R+D+i project developed by COPASA **[9]** with the aim of improving safety in conservation globally implements a platform that integrates BIM methodology, data processing through artificial intelligence and virtual reality applications so that all these digital technologies are used for the effective management of road safety, occupational risk prevention and quality of service provided to the user in the operations of conservation, maintenance and operation of roads.

The idea consisted in the generation of an intelligent information management tool taking advantage of the potential of both interactive data analysis and visual representation in three dimensions, facilitating safety assessment from multiple perspectives practically in real time. It should be noted that this implementation has not been carried out with the intention of generating a commercial software but as an implementation of the specific research mentioned above.

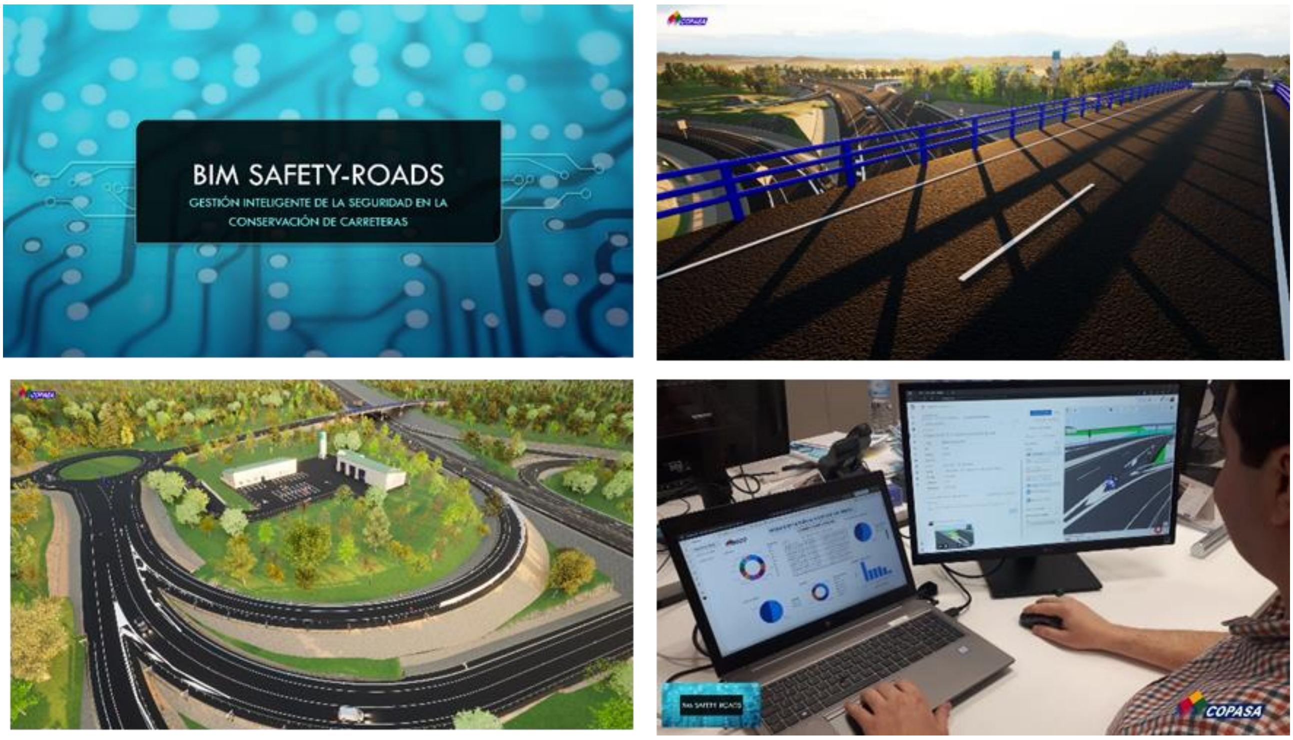

Figure 3 - BIMSAFETY - ROADS, Intelligent Management of Road Maintenance Safety

4.2. Basic lines of action

For the development of this digital tool, the following basic lines of action were established, according to which the implementation was built:

- Research and practical experimentation for BIM implementation in road maintenance.

- Development of an accident management module, which includes two aspects: a sub-module related to road safety and another one related to occupational risk prevention.

- Development of a service quality indicator management module.

- Implementation of data processing and artificial intelligence tools for the development of control panels to analyze the information contained in the accident management and service quality modules.

- Application of BIM methodology for the study of specific prototype accidents using virtual reality.

4.3. BIM management modules

4.3.1. *BIM module for accident management*

This module was developed using the BIM model of the maintenance of the Ourense to Celanova highway (Galicia, Spain) as a repository of accident information (both occupational safety and road safety).

For the development of the modules, we used the BIM platform engine, BIMSYNC Arena, from the specialized software company, CATENDA **[10]**, which allows to visualize BIM models and collaboratively manage the evolution and improvements in the modeling of projects. Based on its issue generator, different specific templates were programmed for each module. These implementations, designed for each type of accident or incident considered, allow the data and information of each of the accidents or incidents to be stored as they occur.

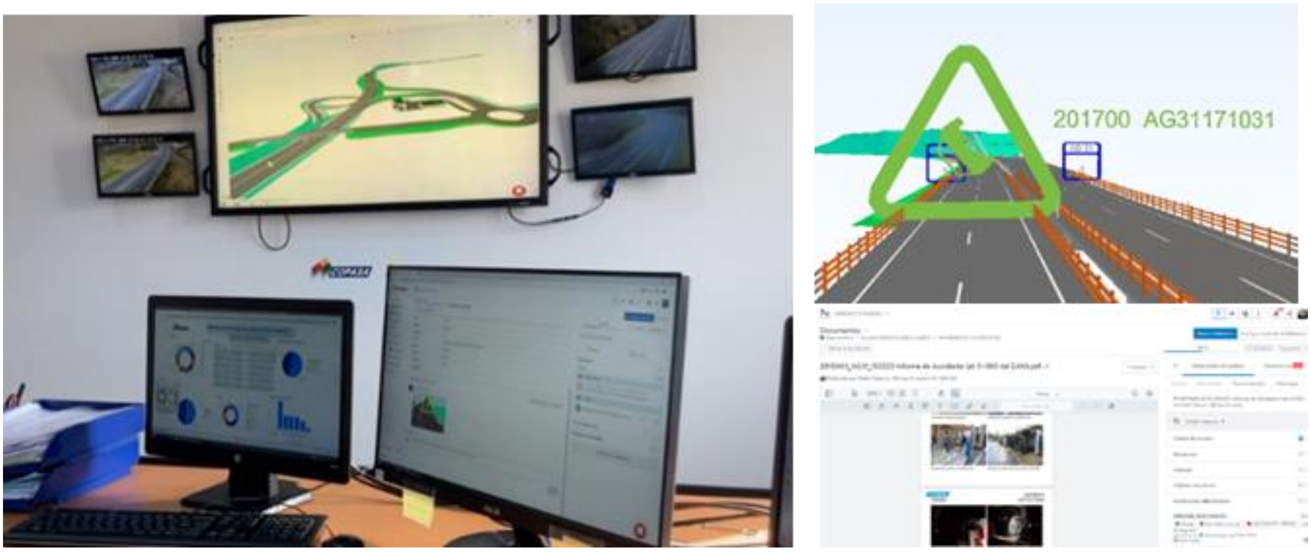

Figure 4 - Accident management BIM module

Two accident sections or sub-modules are established within the platform. On the one hand, traffic accidents are collected: each time an accident occurs, an incident is generated within the platform with the accident data, assigning a unique identification number which, in turn, is modeled together with a warning sign serving as a reference point located at the kilometer point and direction of traffic where the accident occurred. All generated cards can be exported in CSV format *(special type of text file that allows storing data in a table structure with values separated by commas)*. This file is filtered and those data that are necessary are segregated with Power Query *(data preparation and transformation engine that allows connecting, combining and refining data sources with various programs)* and imported into Microsoft Power BI *(unified and scalable business intelligence platform)* in order to make connections between data sources and create dashboards. By adapting the potential offered by the collaborative platform in terms of communication and data processing, we were able to link the reference point, the documentation and the generated incident allowing telematic access to all the information related to the accident in a quick and easy way. The attached documentation includes all the relevant data, such as the description of the facts, the state of the road, the possible causes, the work of the maintenance resources mobilized, as well as their reaction times, the damage caused both to the people involved and to the infrastructure itself, and various graphic material such as photographs, location plans and sketches of what happened.

On the other hand, there is the occupational accidents sub-module, which generates the incidents produced by the conservation center's service personnel. Each incident file contains data on the accident, location, damaged area of the body, etc., and the time of sick leave is tracked.

The generation of these modules is a very valuable tool not only from the point of view of the contractor but also from the point of view of the road owner or those responsible for road safety.

The possibility of visualizing the distribution of all accidents on a model of the infrastructure facilitates the quick recognition of those places where they are concentrated. From there and analyzing the details of the three-dimensional model, the signaling elements, beacons and defenses that are available in the area and all the information collected at the time of the accident, it is possible to obtain preliminary conclusions about their possible causes and immediately propose improvements aimed at reducing the likelihood of accidents occurring or their serious consequences. In the event that no immediate conclusions can be drawn, all the information gathered can be cross-checked with the infrastructure quality indicators.

With regard to accidents at work, once the history of accidents on the road under study has been analyzed and those that took place on the trunk road have been represented, it has been found that, although in principle their relationship with the characteristics of the road provided by the 3D model is less evident, it is really useful, especially in the case of accidents involving the road user (collisions with signaling vehicles, running over operators, etc.). The possibility of being able to reproduce the accident in a virtual environment and analyze its causes has an unquestionable potential to which is added the ease of access to information and relevant data.

4.3.2. *BIM module for management of service quality indicators*

The concept of "service quality indicators" is widely used, especially in connection with state-of-the-art concession contracts, but it is also beginning to appear in road maintenance and operation service contracts. These indicators are used to quantify the quality of the service offered to road users in such a way that they can also be used to establish mechanisms for bonuses or penalties for the service provider to charge for the contract. These indicators are usually related to parameters indicative of the state of maintenance of the infrastructure (condition of the road surface, signaling, etc.) or to aspects such as reaction times for attending to incidents, periods of partial or total occupation of the road for maintenance operations, accident rates, etc...

The platform has focused on a series of indicators oriented to the attention of the incidents that could occur on the road, understanding that they are related, although indirectly, both to road safety and occupational safety, although it is interesting to note that the technology and operations developed for this case are extrapolated to other types of indicators that would like to implement.

On the other hand, it is also noteworthy that the indicative parameters of the road condition have been taken into account in the accident module by using them as one of the possible perspectives of analysis of the possible causes of accidents.

The collaborative platform provides the recording of indicator control tables and the association of incidents/accidents with their spatial location in the 3D model. It includes a specific section focused solely on the management of indicators.

This indicator management module is absolutely new in the market, integrating applications that allow an automatic and real-time monitoring of the quality of the service provided by the maintenance company and that is adaptable to the different indicators that can be established in the different contracts by the administrations.

4.4. Control panels and data analysis

The linking of the BIM modules for accident and indicator management with data processing and artificial intelligence tools such as Power BI, Microsoft's data analysis service designed to provide interactive visualizations and business intelligence (BI) capabilities, is done by generating a series of control panels within the platform. **[11]**

Five dashboards have been generated where the available data for each of the aspects considered are integrated in such a way that all the information is organized in such a way that situation analysis and conclusions can be made in real time.

The control panels generated are the following:

- Traffic accidents, in relation to their causes and consequences.
- Traffic accidents, in relation to the state of the road.
- Traffic accidents, in relation to weather conditions.
- Occupational accidents.
- Service quality indicators.

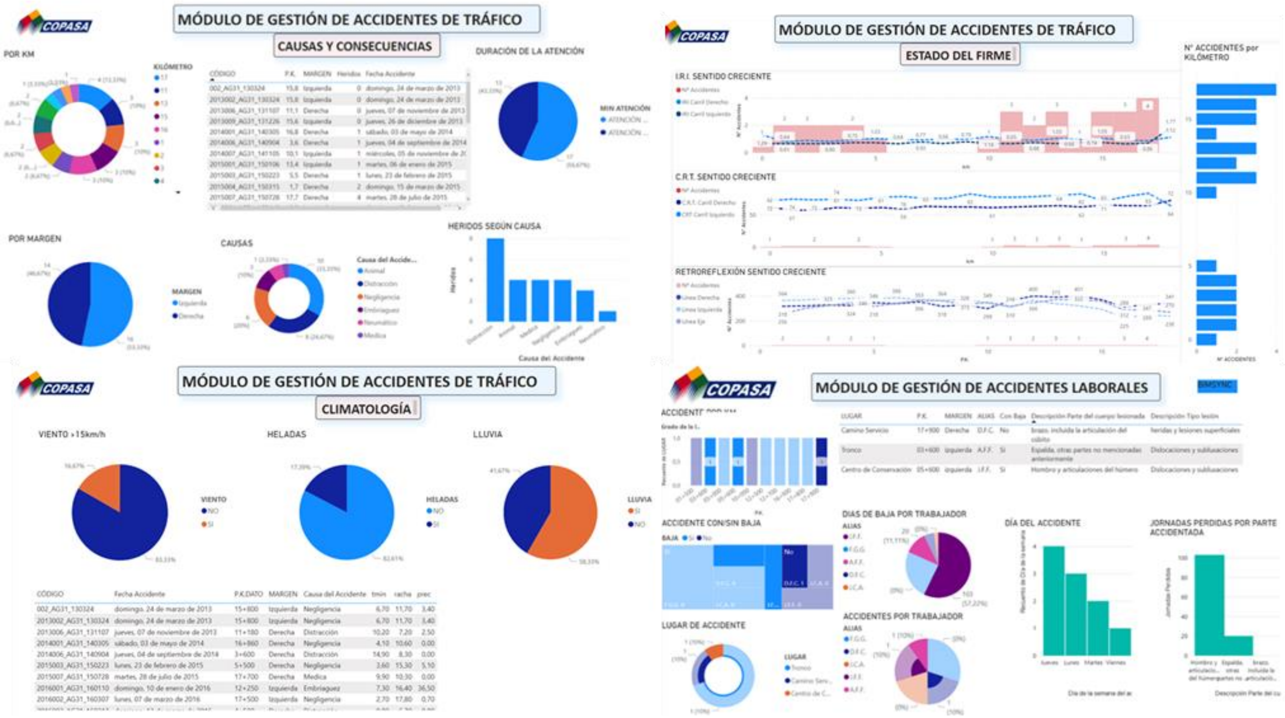

Figure 5 - Traffic and Occupational accident control panels

The occupational accident control panel has proven to be particularly effective in analyzing the interrelationship between accidents, possible causes and other aspects such as the place or situation and the time of the accident (aspects that can be subsequently studied using Virtual Reality applications).

The control panel for indicator management is intended to provide a more specific control of the fulfillment of quality objectives, relating the personnel involved, both at the control room and the emergency assistance unit level, with reaction, attention and damage repair times, as well as the causes alleged in the justification of non-compliance with the objective.

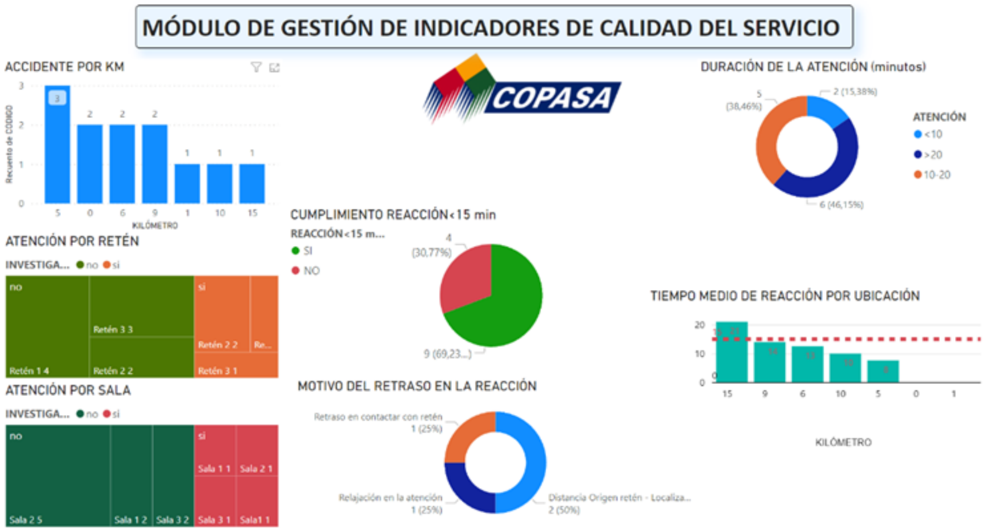

Figure 6 - Indicator management module control panel

This type of panel makes it possible to focus on a specific moment within the immensity of data produced by various sources, bringing them together in a series of graphs that offer a clear view of the facts for an objective analysis of the causes. Decision-making is facilitated in order to minimize future recurrences of the causes that generated the accident or incident. Therefore, the disruptive aspect, from the point of view of the conservator, is the clarity in the presentation and analysis of data, and the immediacy in the possible decision making.

4.5. Application of Virtual Reality

The project also included a series of virtual reality applications for the study of specific accidents as a source of visual information for the improvement of action processes by the emergency services that intervene when an accident occurs and in order to prepare the means, signaling and repair equipment for the damaged elements.

For this type of recreation, the Twinmotion program **[12]** is used, in which the layout modeling is imported and the accident vehicle is located. The program allows the recreation of the weather, lighting and position of the sun at the date and time of the accident.

Once the scenarios have been generated, a presentation is exported that can be consulted on any PC without the need to install specific software, since the scene is visualized from any web browser, with an easy-to-use interface that can be navigated at the will of the operator, changing the location and point of view in first person, even the weather conditions, the season or the date and time, allowing to understand the environment with all the possible variables.

Figure 7 - Recreation of specific accidents in Virtual Reality

To achieve greater immersion in the virtual environment, it is also possible to use devices such as virtual reality glasses that allow a first-person view.

The practical applications of virtual reality provide an important added value to the development carried out, highlighting the following aspects closely related to the day to day of road maintenance:

- Immersion in the scenario of an accident through virtual reality, combined with massive data analysis, allows a descriptive and predictive analysis of the causes that led to the accident, identifying dangerous sections, location of anomalies and possible hidden relationships, which otherwise would not be detectable.

- Training and coaching of accident response personnel to minimize the risk of occupational accidents during the work of signaling, vehicle removal, etc. Also, to analyze complex situations that may arise during the repair of track elements after an accident, such as the lack of space to place machinery or stockpile materials, or the location of lifting equipment.

- Sensitization of workers to real situations, since the freedom of action and first-hand experience allow them to see the consequences of an accident at work, which effectively induces a change of attitude in the worker.

- It also allows to put into practice and interact with what has been learned in conventional training, without the need of a real presence in the field and, on the other hand, it is able to subject the employee to an imminent simulated risk through first-person sensations, and to analyze his reactions in extreme situations.

5. CONCLUSIONS

The development of BIM for its application in the management of road infrastructure assets is an unstoppable trend whose definitive hatching will occur sooner rather than later, since its practical utilities in this field are unquestionable. On the other hand, it is true that, to date, there are still important challenges that will have to be addressed in the coming years in order to achieve a satisfactory evolution in the integration of this methodology.

From the point of view of road safety and risk prevention, the use of this type of technology associated with digital transformation can be a disruptive phenomenon in the way of understanding this problem, since it allows us to anticipate potential risk situations, which will undoubtedly lead to a reduction in accident rates and thus to savings in economic, personal and social costs.

In the case of the platform for intelligent safety management described in this article, BIMSAFETY - ROADS, the fundamental achievement was to outline an integrated tool for the management of information related to safety and prevention that not only functions as a 3D repository but also makes it possible to use the full potential of both data and visuals to perform analyses from multiple perspectives so that conclusions can be drawn and corrective measures or other types of decisions can be taken practically in real time. In this sense, a great success of the implementation was to establish applications really adjusted to the needs of road maintenance and operation contracts from the point of view of road safety, risk prevention and service quality indicators.

The implementation of this methodology from a business point of view is a major challenge, but, at the same time, a great opportunity to take advantage of all the potential it offers along with all the technology associated with it that, as the development of BIMSAFETY - ROADS has allowed us to appreciate in COPASA, can lead, without any doubt, to substantial improvements in safety, productivity, quality and care for the environment.

In any case, making a global analysis of the integration of the BIM methodology in the management of road infrastructure assets, we must conclude that there are still crucial technological aspects to advance in the future related both to the access, control and visualization of the large amount of data and information that are handled in this type of activities as well as to the hosting and operational maintenance of these data throughout the entire life cycle**.**

6. REFERENCES

1. (2019) ***Promoting favorable investment conditions. Analytical report*****.** European construction sector observatory (European Commission).

2. (2019). ***Building Information Modelling in the EU construction sector. Trend Paper Series.*** European Construction Sector Observatory (European Commission).

3. Papadaki, I.; Feustel, M.; Soubra, S.; Marchetti, C.; Bozzolo, A.; Gussoni, M.; Porta, M.; Botto, S.; Ardizzone, E.; Paraboschi, A.; Macciò, C.; Proia, M.; Giodice, M. (2021). ***Calculating Costs and Benefits for the use of Building Information Modelling in Public Tenders. Methodology Handbook.*** RINA, B1P GROUP, EUBIM TASKGROUP. European Innovation Council and SMEs Executive Agency (EISMEA).

4. (2018) ***ISO 16739-1: Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries.*** ISO STANDARS. International Organization for Standardization.

5. (2020). ***ISO 19650-3: Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 3: Operational phase of the assets.*** ISO STANDARS. International Organization for Standardization.

6. (2019). ***BIM GUIDE for the State-owned Port System.*** State Ports. Ministry of Development. Government of Spain.

7. (2022). ***BIM GUIDE of the General Directorate of Mobility and Road Infrastructures.*** Department of Mobility, Transport and Housing. Regional Government of Extremadura.

8. (2022). ***Transport and Logistics Observatory in Spain: Annual Report 2021.*** General Secretariat of Transport and Mobility. Ministry of Transport, Mobility and Urban Agenda. Government of Spain.

9. **S.A. de Obras y Servicios, COPASA:** *Spanish international construction company specializing in civil engineering and building projects.* https://www.copasagroup.com/

10. **Catenda AS:** *Norwegian software company developer of the collaborative project management platform Bimsync*. https://catenda.com/

11. **Microsoft Power BI:** *Unified and scalable business intelligence (BI) software platform developed by Microsoft*. https://powerbi.microsoft.com/

12. **Twinmotion:** *Epic Games' software for real-time visualization or 3D immersion of infrastructure projects*. https://www.twinmotion.com/