establishing

research, development and innovation department

2021 annual report

BUILTCOLAB
DIGITAL BUILT ENVIRONMENT

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BUILTCOLAB

DIGITAL BUILT ENVIRONMENT

The Collaborative Laboratory for the Built Environment of the Future

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Foreword

Global challenges such as circularity and sustainability require a consolidated construction industry transformation. Buildings and infrastructures need to be adaptable and designed for disassembly. Life cycle concerns must be brought to the initial designs and simulations. The use of natural resources must be reduced and optimised.

Industrialisation will play an essential role in this changing paradigm, and the digital transition will trigger the long-term win. Digital technologies and artificial intelligence will catalyse the hidden value of data, democratising new forms of intelligence and processes optimisation. The progressive digital transition will show the full potential of the interconnected systems of systems that constitute the built environment.

This transformation is inevitable.

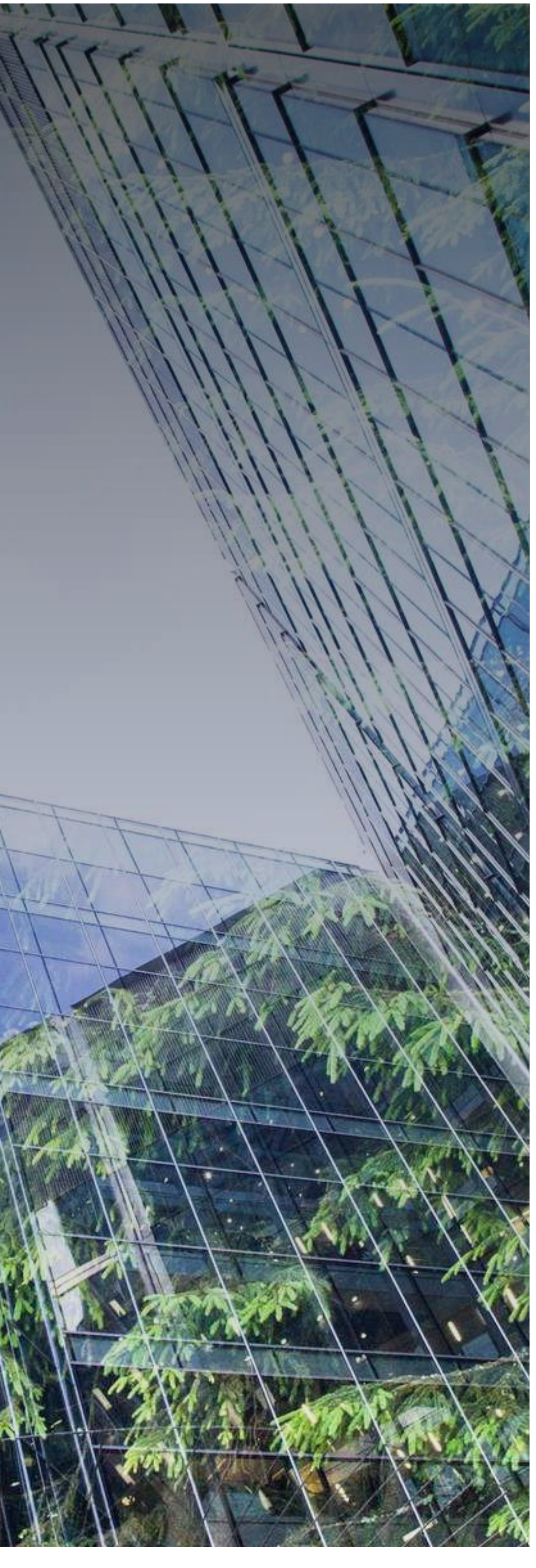
Design support systems are increasingly supporting advanced simulations and parametric optimisations. Modular and prefabricated construction is becoming more advanced, increasing productivity and efficiency.

Innovative technologies and robots are being implemented to help offsite and onsite construction, creating synergies with human professionals. Buildings and infrastructures are progressively more intelligent and interactive, providing comfortable, adaptable and sustainable spaces.

The RDI department of BUILT CoLAB has a clear strategy to support this transition, focusing on priority innovation areas and a "technology-to-market" approach, actively working on the development, testing, demonstration, standardisation, consultancy, and all the complementary activities needed to support the industry towards a more sustainable and innovative future.

The industry needs to absorb new competencies and innovative tools, to be prepared for a smooth transition. BUILT CoLAB, pushed by the ambition of the entire team, assumes the responsibility of getting these tools and competencies to the industry. This report aims to present the dynamics of the RDI department to put forward several projects aligned with the industry needs.

(António Aguiar Costa)
RDI Director



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BUILT CoLAB

The Collaborative Laboratory for the Built Environment of the Future.

BUILT CoLAB aims to develop research, innovation, and knowledge activities in the AEC sector's ecosystem, increasing its productivity, competitiveness, and sustainable growth. It further aims to promote the digital and climatic transformation of buildings and infrastructures, making them adaptable, intelligent, resilient and sustainable.

We are guided by a "technology-to-market" approach, raising maturity levels for technologies, products and services. BUILT brings together knowledge centres, industry and end-users in a collaborative environment, promoting a shared creative model that will contribute to the transformation of the built environment of the future.

The scope of BUILT CoLAB's operation is the built environment as a whole, considering its distinctive types of buildings and infrastructure, from habitation and transportation to energy production and water treatment. Our R&D agenda covers the complete life cycle of the built environment, including design and construction, management and maintenance, and ultimately deconstruction and recycling. This agenda promotes the digitisation of the ecosystem based on data-driven BIM methodologies that encourage the use of digital twins, prefabrication, and much more.

We promote the digital and environmental transition of buildings and infrastructures, making them adaptable, intelligent, resilient and sustainable.

Our Team

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Twin Transition Specialist

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Data Science Specialist

Research Areas

Smart Transport Infrastructures

- Infrastructures Intelligence
- Decision Support Systems
- Geomatics

IoT and Smart Technologies

- Sensors and IoT
- IT Development

BIM Intelligence

- BIM and Digital Twin
- Smart Digital Design
- Tools Development
- Machine Learning
- Blockchain

Green Transition

- Sustainability Methodologies
- Sustainability Optimisation
- Constructive Systems

Standards and Digital Transition

- Digital Transition
- Standardisation
- Certification

Intensive Innovation Groups

The Research, Development and Innovation team has a challenging mission: **to generate impact in the industry in the shortest time**. We know that RDI activities are time-consuming, so capitalising on existing developments and focusing on quick wins is critical.

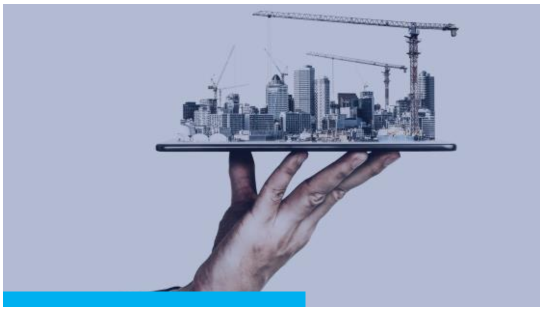
In this sense, priority development areas, as well as partnerships and collaborations to be strengthened, have been identified, giving rise to what we call as **Intensive Innovation Groups**, **IIGs** for short. **These groups are agile, with few collaborators, but with a well-defined scope and action plan**.

Each IIG has a highly qualified team dedicated to generating innovative results, creating, and implementing new products and services in the market. New IIGs can be established if high potential opportunities are identified, with existing developments promoting collaborations with dedicated partners.

As the number of IIGs grow and the complexity of the developments increases, the RDI department adapted and created an action framework supported by several **research areas**.

Intensive Innovation Groups

Currently, the work of the RDI team is divided into 14 IIGs. In the following, the diverse IIGs will be presented in more detail.

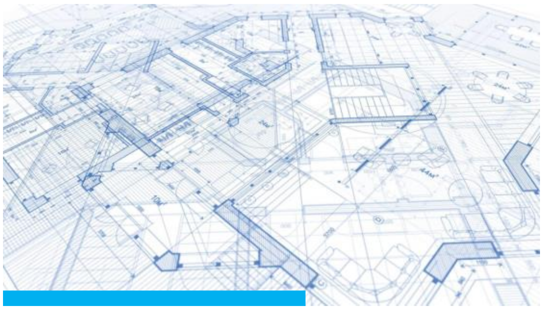


AUTOMATION
Digital Production Optimisation

DigiTT
Digital Twin Operations

IoTASK
Converting "dumb" equipment into smart, digital and connected systems

POSITIV
Smart Modular Design



SIMPLIFY
E-licensing and E-procurement Platform

SMILE
Smart Energy and Management Optimisation for Buildings

BIMCLOUD4ALL
Collaborative Platform

BUILDING PASSPORT
BIM-based Building Logbook

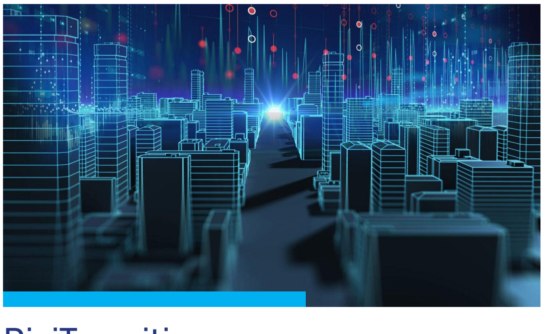
HIVE
High Interactive Virtual Environment for the Built Environment

DIGITAL EYE
Laser Scanning Technologies to Support Construction Control

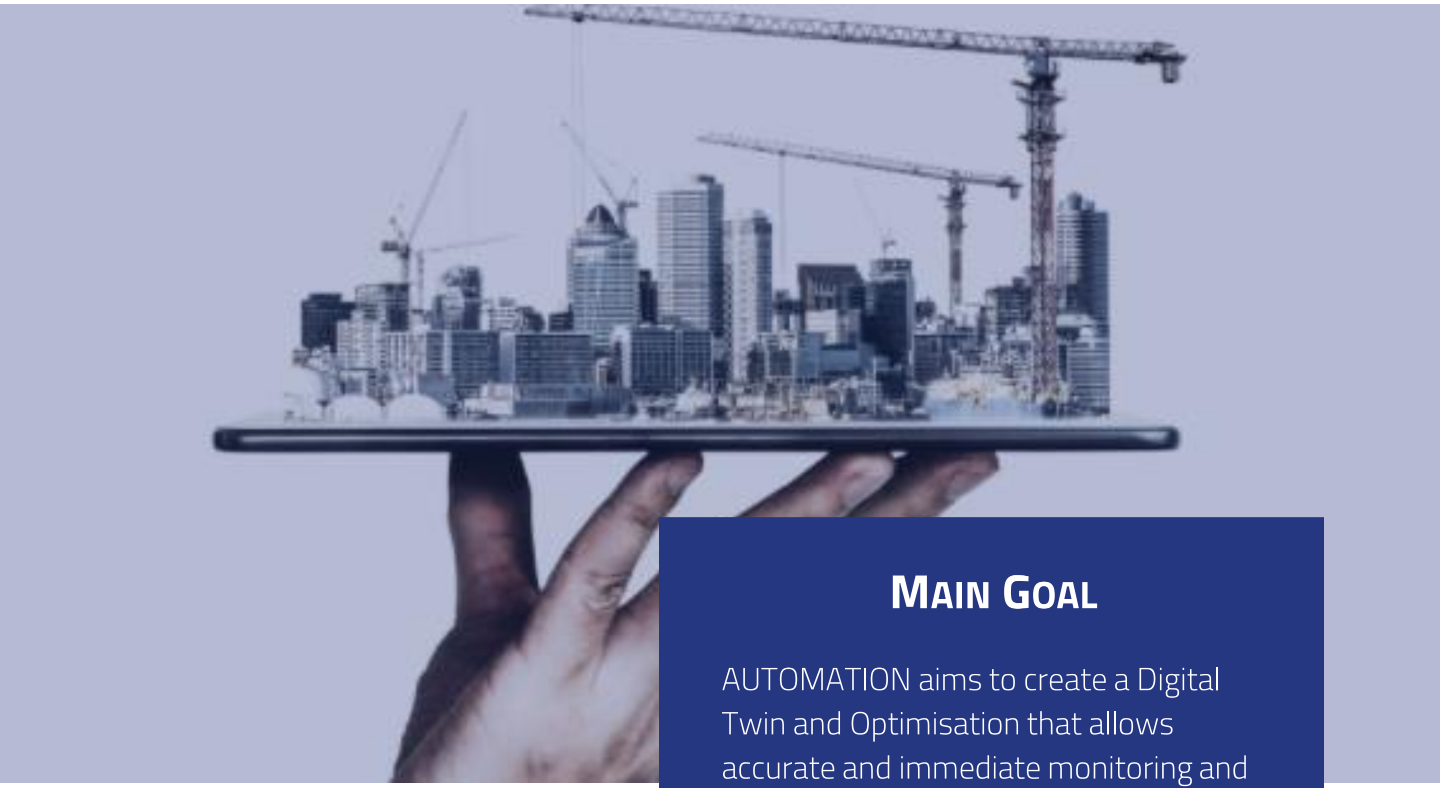
BUILDING LIFE
Life cycle and Circular BIM-based Design

CircularDynamics
Implementation of circular economy models in the construction sector

CertBIM
BIM Process Standardisation



DigiTransition
Accelerating SMEs’ Digital Transition



AUTOMATION

Digital Production Optimisation

Main Goal

AUTOMATION aims to create a Digital Twin and Optimisation that allows accurate and immediate monitoring and control over ongoing construction tasks using any handheld device and provides several alternatives for the optimal distribution of resources for a construction project.

The output solutions optimise several factors simultaneously- multi-objective optimisation, which can be customisable depending on user preferences and/or project specifications, among which one can highlight construction costs, construction durations, or carbon emissions.

Main Activities

- Optimisation model to support decision
- GIS integration
- Interactive interface

Several processes in construction are characterised by high uncertainty and variability that significantly affect the productivity of construction operations. With the increasing competition within the construction sector, companies and designers are looking to take advantage of new technologies to support the design and planning of more complex projects. Yet, currently, most managers still rely on intuition and experience to plan and manage construction processes, together with rudimentary and human-based productivity estimation tools and methodologies.

On the verge of a new revolution of the construction industry, commonly known as Construction 4.0, the BUILT CoLAB offers the possibility to take a step further into the digitalisation and automation of the construction sector by providing a **system to support decision making during both design and construction phases of a project.**

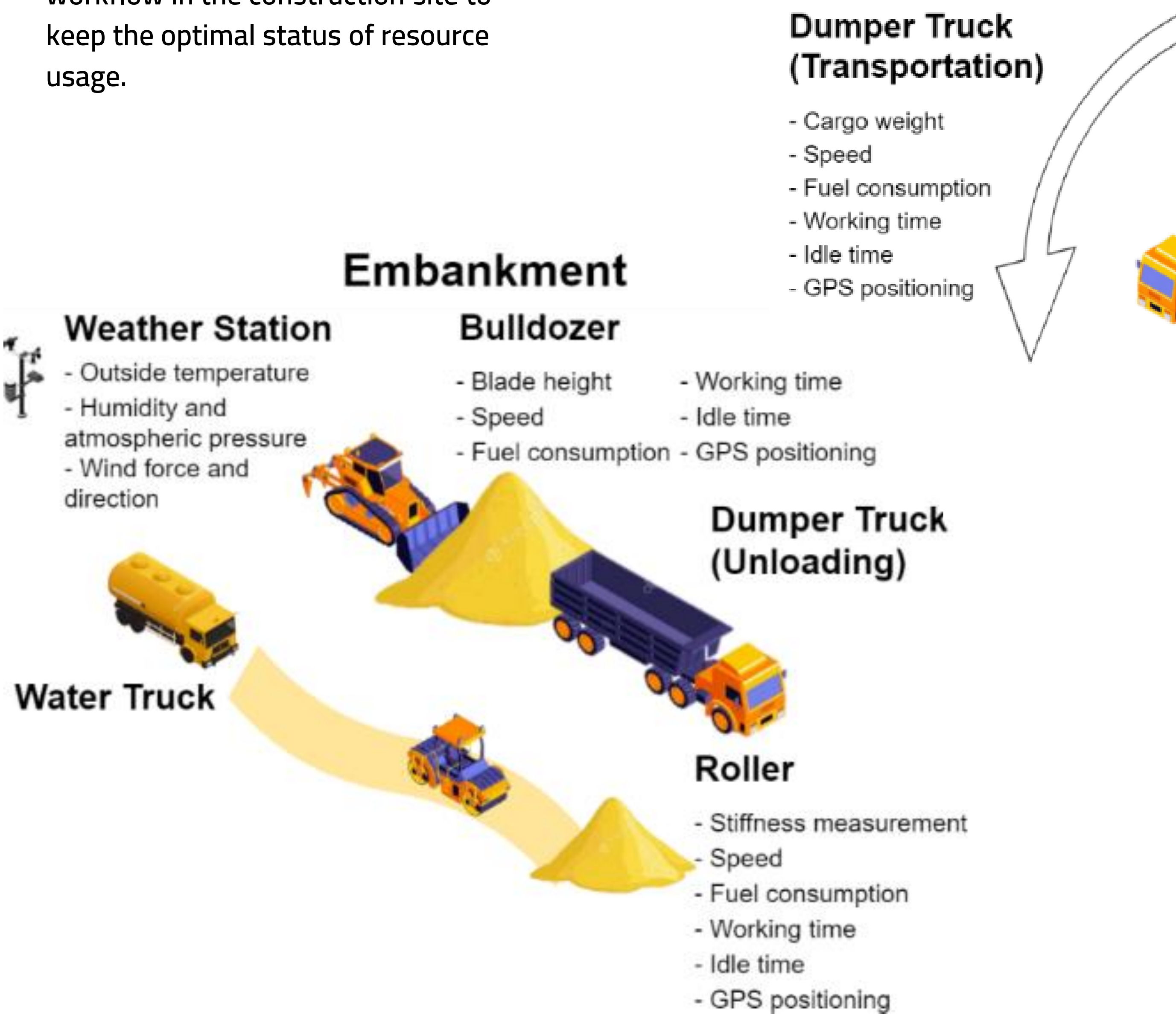
Artificial intelligence techniques such as machine learning algorithms can provide accurate estimates concerning the productivity of construction equipment that have been shown to outperform conventional estimation methods, such as those provided in manufacturer's handbooks. Combined with remote monitoring and dynamic optimisation technologies, these feature the potential to tackle the uncertainty and volatility inherent to construction worksite environments, preventing exclusive reliance on engineers' intuition and experience.

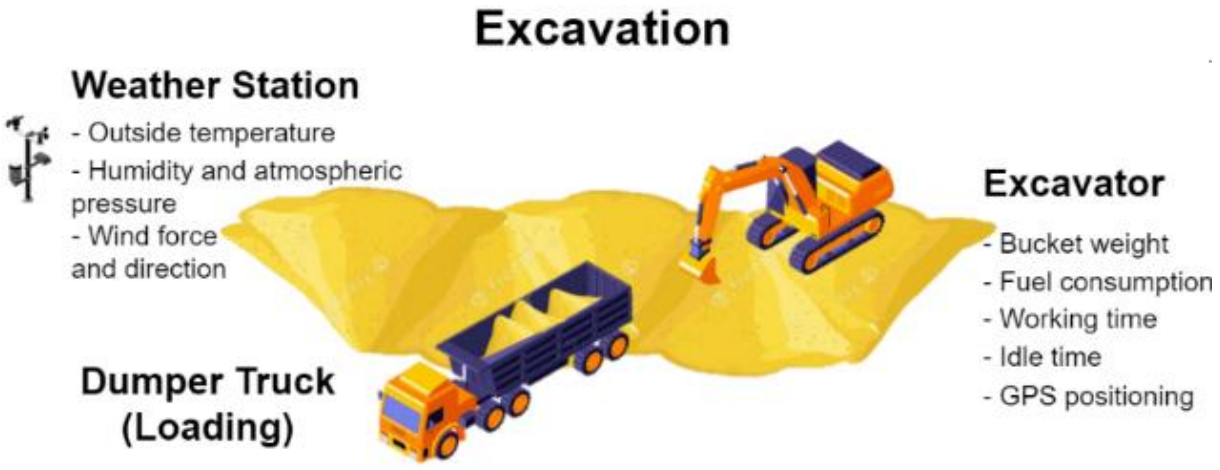
The system is specifically tailored for constructions that strongly rely on heavy mechanical equipment, among which one can highlight road and railway construction, pavement maintenance and rehabilitation, dam construction, tunnels and subway construction, or any other construction project in which the constant and accurate assessment of the productivity teams/resources can be achieved.

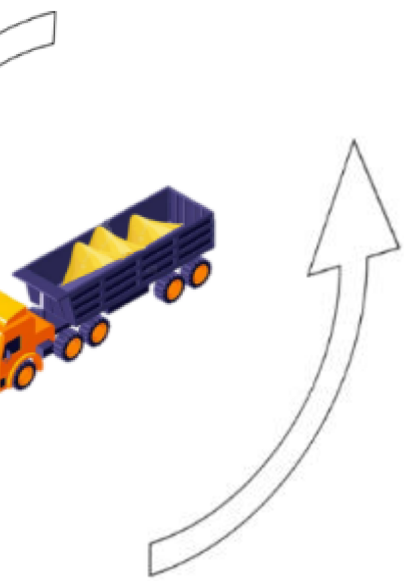
AUTOMATION@EARTHWORKS

Since any construction is **typically susceptible to unpredictable occurrences** (i.e., equipment malfunction, unfavorable atmospheric conditions, inaccurate estimations of team productivities), they constantly require an **adjustment or reorganisation of the workflow in the construction site to keep the optimal status of resource usage.**

In order to tackle this issue, mechanical equipment can be retrofitted with sensors capable of (near) real-time monitoring of operations, providing insight on the actual productivity and/or cost associated with the equipment's activity.







When combined with an Internet of Things (IoT) framework, the resulting data can be fed into an optimisation system, which constantly monitors activities and outputs suggestions concerning the optimal allocation of resources, thus **promoting the full digitalisation of the construction process.**

Hence, the system is tailored to **support decision-making throughout all project phases**, including not only bidding, design, and planning phases by providing the user with resource usage solutions (from project budget to planning, including the corresponding costs and durations), but also during the construction phase, in which the constant monitoring of resources and reassessment of their allocation to tasks is paramount in the context of **increasing productivity and company competitiveness.**

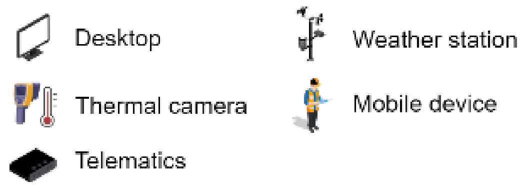
Check our latest article focusing the work on AUTOMATION @Earthworks

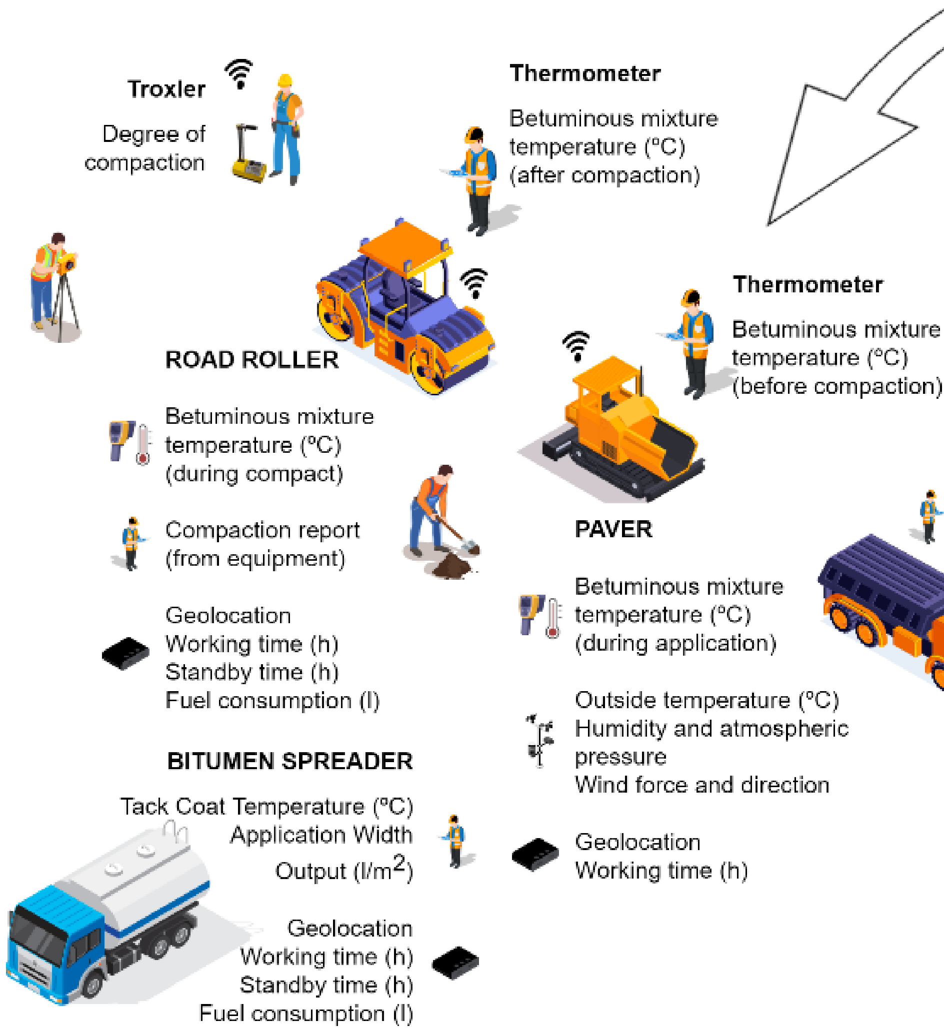
PAV 4.0 & BET 4.0

Decision support applications leveraging on concepts such as artificial intelligence, optimisation, sensorisation, digitalisation, Industry 4.0 and **Digital Twin to support road construction and rehabilitation projects - PAV4.0**, and vertical construction projects involving concrete structural elements, as is the case of **buildings - BET4.0.**

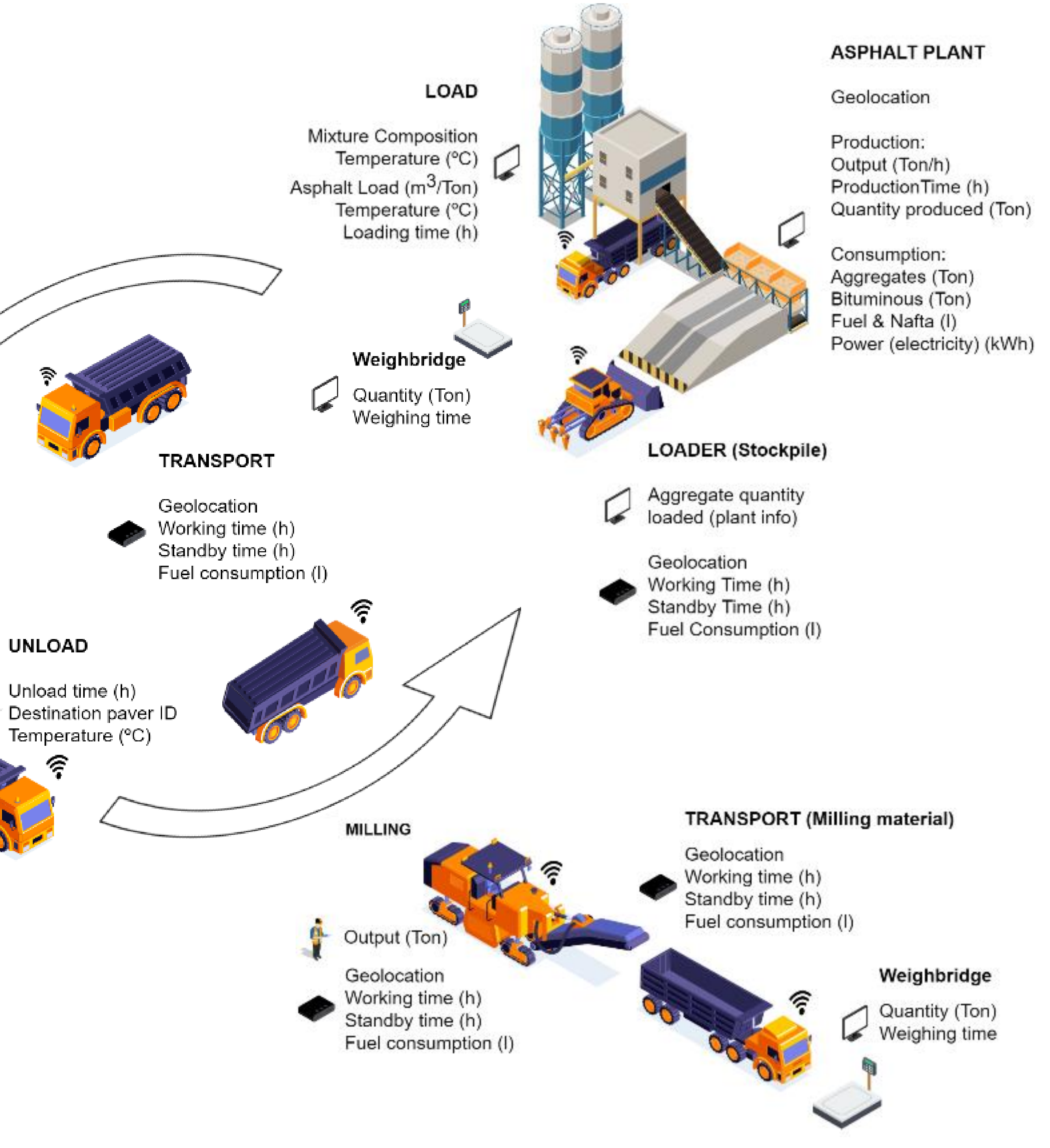
The goal is to promote industry digitalisation by producing an application including a use graphical interface with **GIS viewer for real-time monitoring of progress in addition to an optimisation module**.

The optimisation leverages on smart sensor technologies, which allows the system to respond to variations in productivity or work rate of construction equipment and production teams, providing suggestions for minor alterations in the allocation of these resources when necessary, so as to continuously guarantee optimal work conditions.





Finally, this project also includes the **integration of a quality control monitoring module of georeferenced elements (pavement sections or concrete elements).**



DigiTT

Digital Twin Operations

Main Goal

DigiTT focuses on the improvement of conventional operations in the context of construction and the built environment. The approach adopts the combination of the implementation of novel technologies together with the experience of experts in the field to improve the processes by which companies generate profit.

The main goal is to support the decision-making processes concerning the management of resources in ways that reduce waste and improve operational efficiency and efficacy.

Main Activities

- Create digital twin for infrastructure
- Optimise decision support system for infrastructure operation

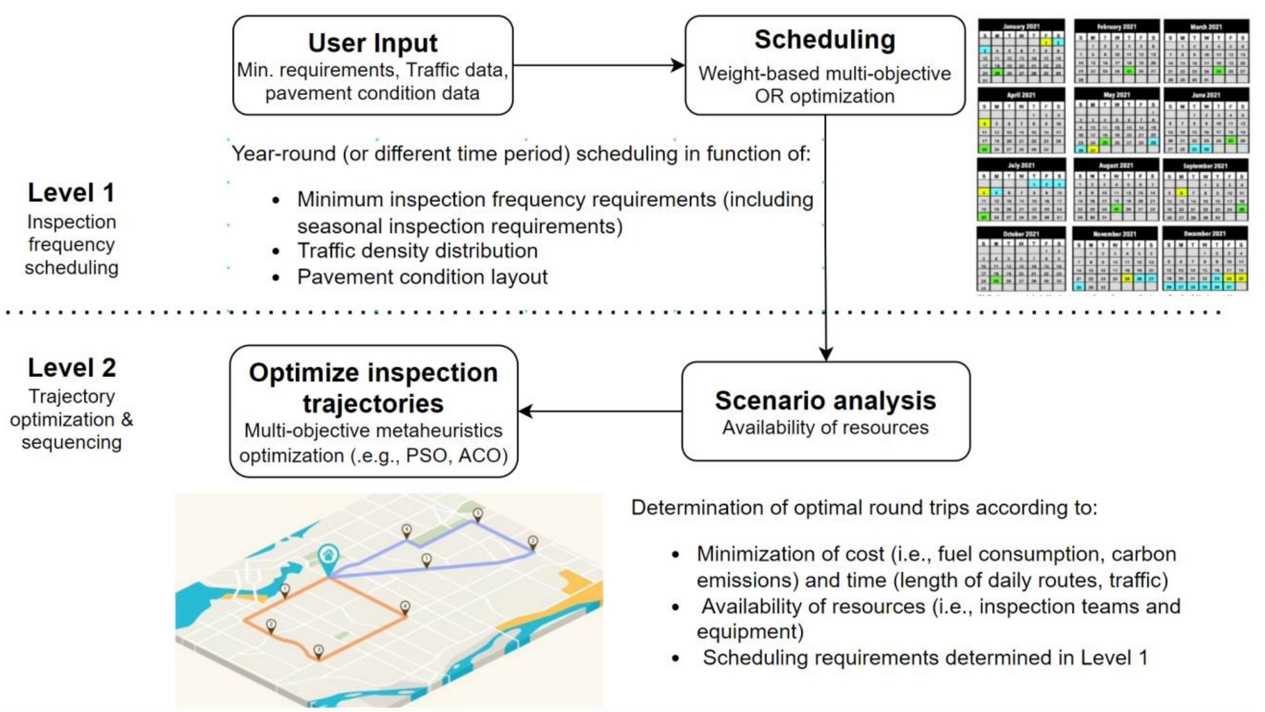
Audit

This project addresses the support of scheduling and optimisation of road pavement inspection operations. The approach is divided into two phases:

- Phase 1: Scheduling - **Scheduling** the frequency of inspection along the network depending on applicable restrictions;
- Phase 2: Routing - Determination of optimal **daily routes** considering cost minimisation and inspection area maximisation.

The proposed system supports year-round scheduling for inspection teams to travel through all company assets (i.e., roads, bridges).

The routing optimisation considers aspects such as minimum inspection frequency requirements, traffic density distribution, and pavement condition layout, to minimise the time and cost of inspection operations (i.e., travelled distance vs. inspected area). This leverages the integration of artificial intelligence and routing optimisation algorithms to develop a **decision support system for optimising the activity of road asset inspection teams**.



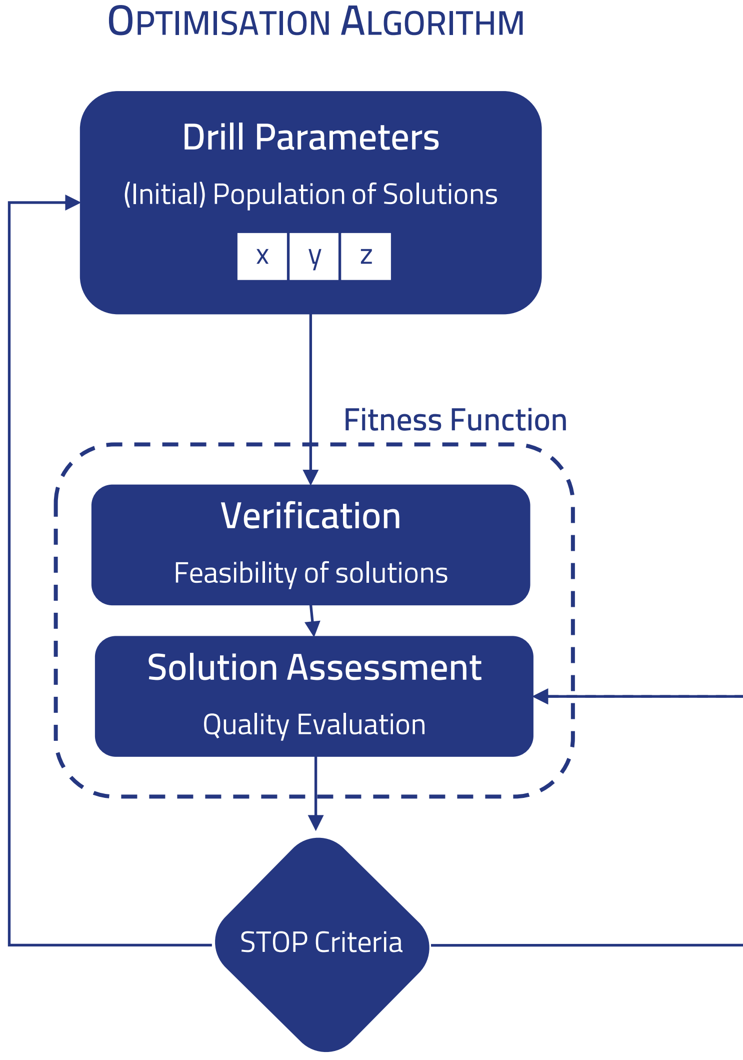
Drilling

This project aims to support the **optimisation of drilling processes through historical data, comprising a first approach to developing a Digital Twin for drilling operations**. This leverages the broader construction trends concerning the development of Digital Twins for construction and logistic operations, resorting to sensorisation and artificial intelligence to monitor and/or optimise specific construction operations.

The optimisation system for drilling operations includes **global project and fleet management, both concerning the global allocation of resources and the local optimisation of drilling processes.**

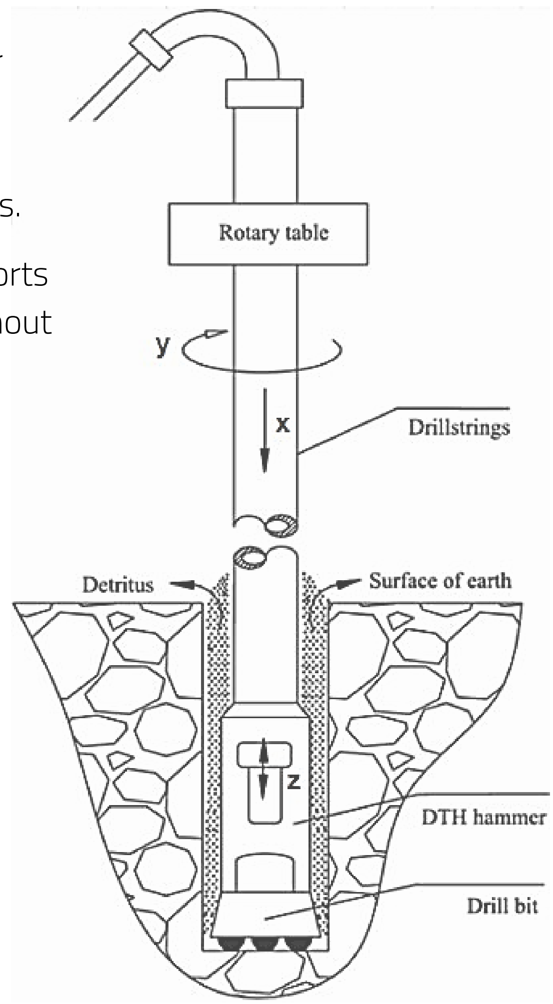
On the global scale, the system addresses the geographical layout and distribution of available resources, namely drilling equipment, throughout all active construction sites, scheduling their allocation, use, and transportation from site to site.

Conversely, on the local scale, the drilling process itself is addressed as an **optimisation process in which the system constantly monitors and outputs suggestions on the best drilling parameters to maximise productivity**.



This holistic optimisation on both scales aims to maximise the productivity of the company, rather than limiting the optimisation to local drilling operations, which may not necessarily correspond to the best overall usage of resources.

Finally, ensuring the automatic generation of reports for each construction process carried out throughout construction, these are compiled into a single global report that **supports decision-making and acts as historical records for future auditing**.



Data-driven Prediction Model

Drilling Database
Past Projects

Supervised ML Models
Prediction of Performance

Prediction of drilling rate
(cm/min)

Prediction Costs
Maintenance and Fuel Consuption

OUTPUT

Optimal drilling parameters for:

1. Minimisation of drilling time (max. productivity)
2. Minimisation of drilling time vs cost (pareto optimisation)

IoTASK

Smart, Digital and Connected Systems

Main Goal

IoTASK aims to create agnostic IoT solutions to create, retrofit, or adapt cyber-physical systems in order to be capable of capturing physical variables and making the data available in a way that allows interconnection and interoperability, with intelligent decision support systems or data science platforms.

This IIG aims to develop high TRL experimental versions of the devices and their platforms. To do so, it explores themes such as sensors, communication technologies, electrical autonomy, reliability, redundancy, security, and data platforms

Main Activities

- Develop smart sensor networks
- Retrofit existing equipment and infrastructures
- Design innovative IoT architectures
- Digitise machines, infrastructures, or processes

The built environment needs to actively be part of the change that arises with **IoT possibilities**. With just one phone, it becomes possible to remotely open a window or control and manage a construction site, all based on a Wi-Fi or 5G cellular connection on the other side of the world.

Recent studies, by the International Data Corporation, indicate that the world will have about 40 billion connected devices by 2025. This entire connection system reflects positively on the world economy, and the construction sector, often seen as old-fashioned or primitive, needs to grab this opportunity. If it is possible to model, plan, and project while not connected, all these actions increase in efficiency and possibilities if a cyber-physical connection to the world is accomplished.

With IoT, construction becomes more manageable, efficient, agile, and safe, either in its processes (e.g., construction, renovation, management) or in its buildings' usage (e.g., monitoring, analysis, optimisation). Yet, it also poses several challenges in terms of:

- **security** – connecting something to a network exposes it to the world and to hacking. It is therefore critical to assure cyber-security and data privacy;
- **interoperability** – different manufacturers, languages, standards, etc., pose a serious threat to systems' operability. Open standards, protocols, and technology may mitigate this risk;
- **connectivity** – is almost everywhere, yet it assumes different forms and architectures. Choosing the best can be challenging, as it affects software requirements and/or costs;
- **environmental sustainability** – is probably the most impacting subject for the next years. New technologies should not imply manufacturing new equipment, consuming additional natural resources, or even more electricity demands. Instead, it should mean that everything was considered regarding suitability;
- **acceptability** – not all technology is accepted immediately. Pricing, usability, user experience, practicality, or even the design, can be factors that may decide if technology is accepted.

Smart Office

We are focused on developing a low-power **smart building system, which increases efficiency and comfort by automatically or semi-automatically managing the office according to its use and occupancy.**

Currently, the work is centered in BUILT CoLAB's Head Office for demonstration and test bed purposes. The developments are to be explored in the optics of a Smart Building by extrapolation. The technical choices and the design of the solution bares in mind situations where this type of solution is implemented in new buildings, a simpler scenario in terms of integration, or in existing buildings, where the challenges are vaster as it becomes necessary to consider aspects such as retrofitting.

The objectives are to demonstrate Smart Building technologies in a close, efficient to use and challenging environment; to **implement low power sensor networks; to increase energy efficiency and reduce environmental footprint**; and to develop automatic or semiautomatic control systems that may use AI to control or support building management in order to provide comfort, energy efficiency, and monitoring to support digital twins.

The market is currently flooded with IoT devices, which use a plethora of different protocols and message formats, making interoperability very complex and often not possible. To solve this, architecture is being developed that will be able to control each device individually and coordinate them.

The first node was already developed, and it controls the main door lock allowing the creation of digital control access to all the Porto collaborators of BUILT CoLAB. Other nodes are being developed and will result in an automated, efficient, monitored smart office. These results can later be extrapolated to a Smart Building of any type.

Retrofitting

The goal is to **convert existing machines** (households or heavy machinery, for instance), that are still functional, into smart devices that are connected and that can be controlled and monitored remotely.

This is being done by **installing sensors to existing equipment and infrastructures**, which were not initially designed with digital capabilities to provide control, decision support, or real-time sensor data.

One of the objectives is to develop a common framework (using the SmartCommNode, for instance) that may be customised for each specific situation. This will provide access to:

- Digital technologies on existing systems;
- Digital systems;
- Cost-efficient and open systems;
- New and custom digital capabilities in the context of their use.

> [...] retrofitting equipment is a building block of BUILT CoLABs strategy for all the Smart Buildings and Smart Construction initiatives.

In a time where waste production, energy consumption or raw materials exploration are important variables in the sustainability equation, it is essential to keep (working) equipment and infrastructures and not replacing them by newer ones just because they are "smarter". This would have a high environmental (and economical) cost that is not desirable.

In buildings, heating and cooling systems are an example of possible retrofits. In construction, excavators are another. In both situations, it is possible to retrofit the equipment to make them connected, controllable, or able to be monitored. Every machine poses a different challenge.

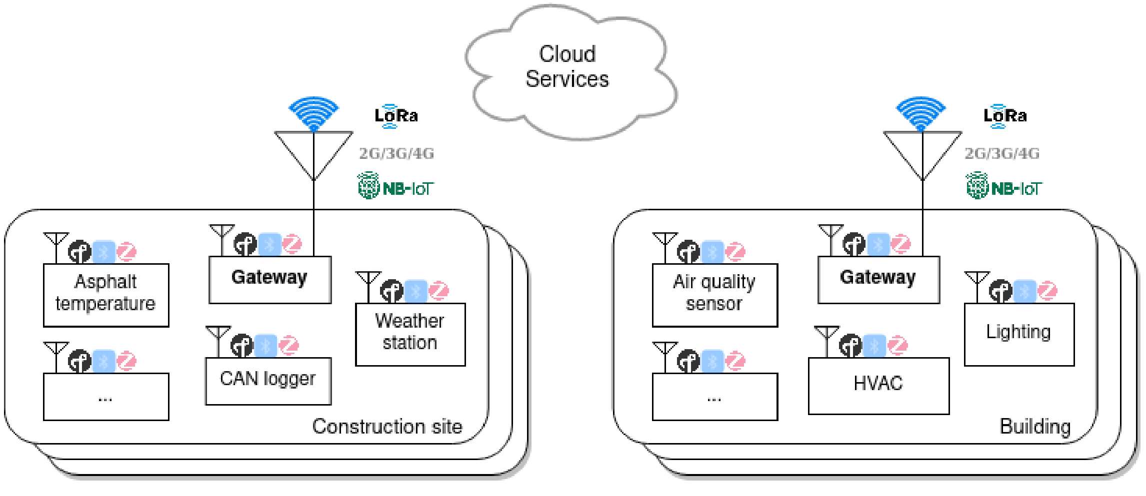
SmartCommNode

The construction industry's digital shift has mostly been based on vendor-locked solutions, favoring vertical silos which lead users to acquire and use equipment from the same ecosystem. Such designs are common as they favor other solutions from the same practitioner (same solution ecosystem), potentially leading to increased vendor revenues and user retention rates.

Alongside this aspect, the maturity stage of the digital solutions leveraged by the practitioners (e.g,. IoT) has been creating a constant need for renewal of software stacks and hardware counterparts (e.g., devices being deprecated, protocol specifications being changed), which has several drawbacks, including costs increase and e-waste creation.

These issues have an increased impact on heavy machinery and equipment like the ones used in the construction sector since the cost barrier is higher and has a direct impact on the feasibility of keeping upgrading the existing equipment.

These factors create the need for a solution that bridges existing equipment and enables them to be integrated with current technological solutions, without depending on vendor-specific solutions while optimising costs.



SmartCommNode proposes an interconnectivity solution with sensing and human-interaction capabilities, which can be installed in existing equipment and infrastructure bridging with already in-place communication interfaces, while having a little-to-no impact on the equipment and infrastructures where the nodes are deployed. Such a system enables further expandability both in terms of features and integration (e.g., third parties).

The solution modularity also enables fine-tuning to each concrete use case, e.g., adapting the data transfer method and rate depending on the range coverage required and sensor density. It also enables the optimisation of certain non-functional requirements (e.g., range, latency, energy usage).

This modularity is achieved by: (1) making the device's hardware and software compliant with different protocols and radios; (2) making their substitution as plug-and-play as possible; and (3) having multi-protocol gateways that can be configured on the fly to communicate with the devices on-site.

Fuel Estimator

Decision support and optimisation tools to be used in construction often require an accurate estimation of cost variables to maximise its benefit. Heavy machinery is typically one of the greatest costs to consider mainly due to fuel consumption. These, typically, diesel-powered machines have a great variability of fuel consumption depending on the scenario of use.

The work in progress intends to provide a **better fuel consumption estimation, from the creation of a tool that can estimate fuel consumption of construction trucks** (and later other machines) depending on the carried load, the slope, the distance, and the pavement type.

Having a more accurate estimation will increase the benefit of these optimisation tools. The fuel consumption estimation model is being developed using Machine Learning algorithms, which are supported by data gathered through several sensors, particularly designed datalogger with wireless communication and opportunistic synchronisation, in a real context experiment.

An IoT hardware platform is currently being upgraded to allow real-time data transmission, more sensor data, and ground truth user input. **More trucks, more drivers, and more data, in general, will contribute to a better estimation model and consequently with better fuel estimations**.

Results demonstrate the viability of the method, providing important insight into the advantages associated with the combination of sensorisation and machine learning models in a real-world construction setting. **A public web service is being developed to make available this tool to all construction stakeholders**.

With an IoT approach, construction becomes more sustainable, more efficient, more competitive, more agile, and safer.

POSITIV

Smart Modular Design

Main Goal

POSITIV is a new approach to building design. It bases itself on new concepts and innovative technological instruments, aiming to create an original design methodology that increases the overall productivity and quality of the AEC industry.

More specifically, this methodology focuses on the development of modular and integrated construction systems, as well as a ground-breaking digital platform that helps stakeholders work in modular construction and enables the development of a collaboration network that covers the entire supply chain.

Main Activities

- Modular methodology and processes development;
- Modular systems parametrisation and analysis;
- BIM Module Library;
- Design and supply support platform.

In the last decades, the AEC sector has been lagging behind other industrial sectors in terms of productivity, with unique product types, unstable demand, and a specialised, labour-intensive work impeding the implementation of leaner production systems.

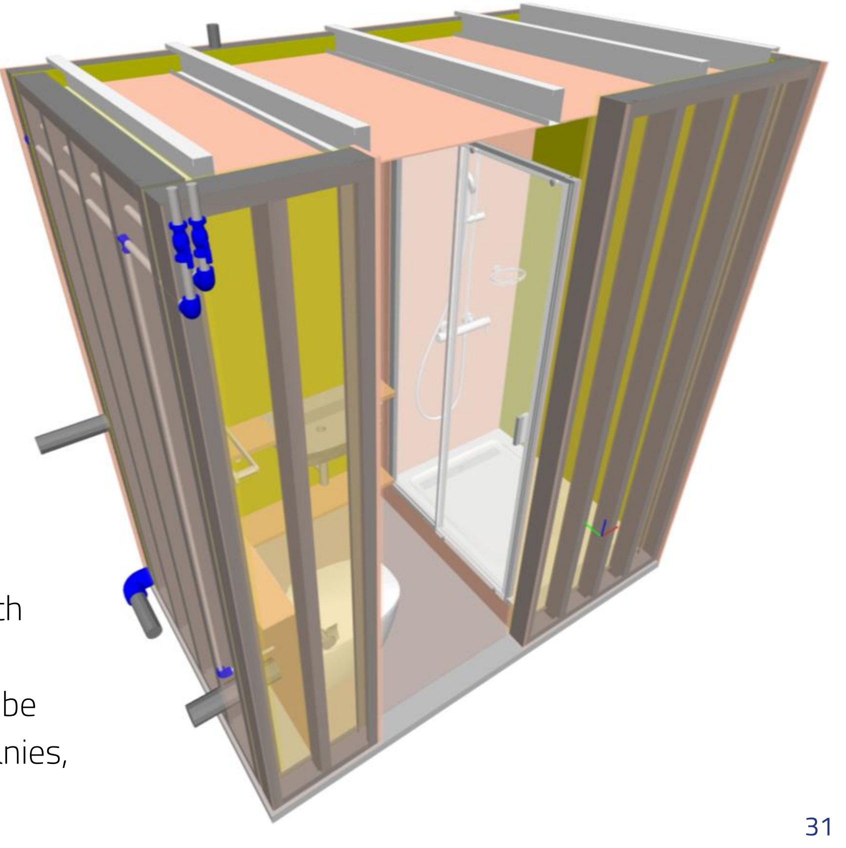
To address this issue, **the AEC sector is increasingly shifting from traditional onsite methods towards modular construction, prefabricating building components in controlled offsite factory conditions and subsequently transporting and assembling these components onsite**.

Modular construction's benefits have been well-documented and include faster, safer, more sustainable, and more productive processes, as well as higher-quality products.

Nevertheless, despite these established advantages, modular construction is still unpopular among clients, due to the high degree of standardisation and repetition that is often required and associated with this methodology.
Thus, this concept is left to be driven by contractor companies, who gain from the increased productivity.

However, since these entities are frequently brought into a project at the end of the design process, contractors have the complex task of adapting modular strategies to an existing design, decomposing the building into standardised units for offsite prefabrication, while preserving the essence and unique vision of the original design.

POSITIV's action lines focus on supporting this modularisation effort, establishing a pipeline of tools that ease this process' implementation in the AEC industry.



ModuLAB

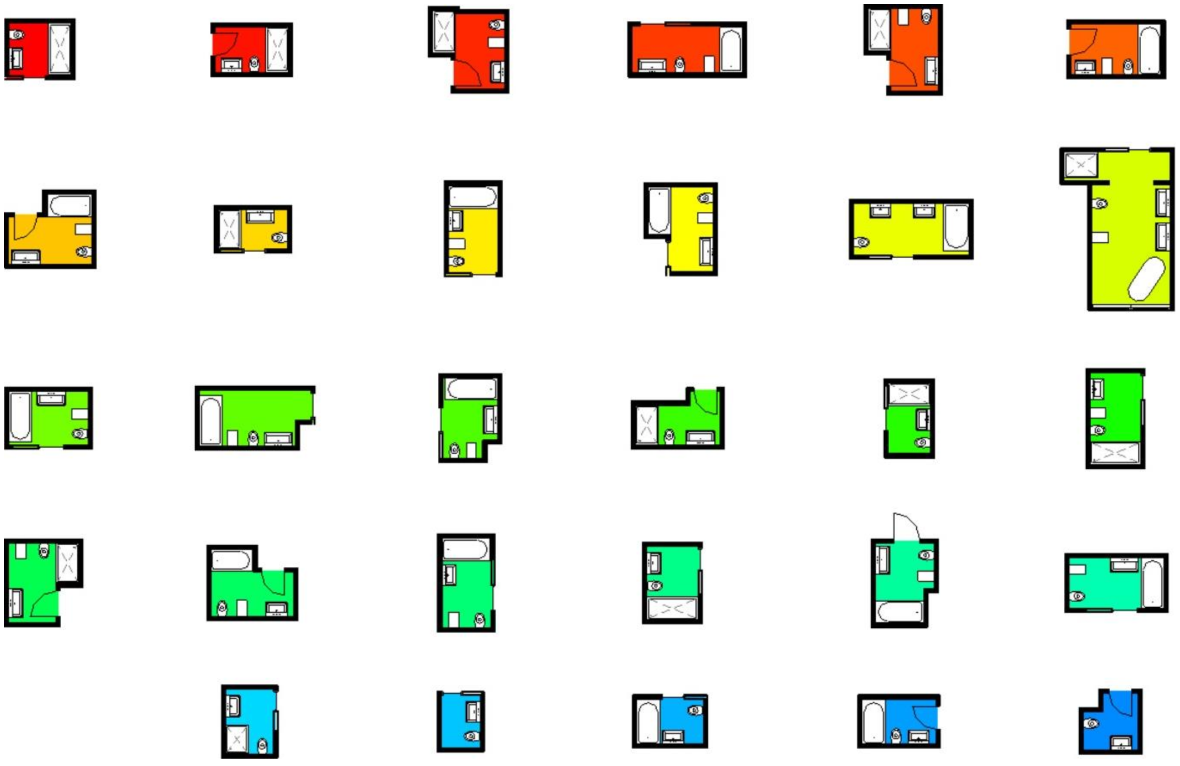
ModuLAB was the first development to be integrated in our modularisation pipeline.

As the starting point, **ModuLAB can recognise the modularisation potential of a BIM model, identifying design patterns that enable the generation of preliminary modules.** These modules can be used to replace rooms/compartments in the existing building design, without loosing the overall architecture and design of the building.

To do so, ModuLAB works as a plugin for Autodesk Revit, directly extracting and pre-processing the BIM models' geometrical and alphanumerical information to feed it into an innovative semi-supervised clustering algorithm that calculates the similarity between rooms, grouping them into distinct clusters.

The extracted information includes features that the RDI team identified as relevant to the modularisation process, ranging from the overall room architecture to the typology and position of the contained objects.

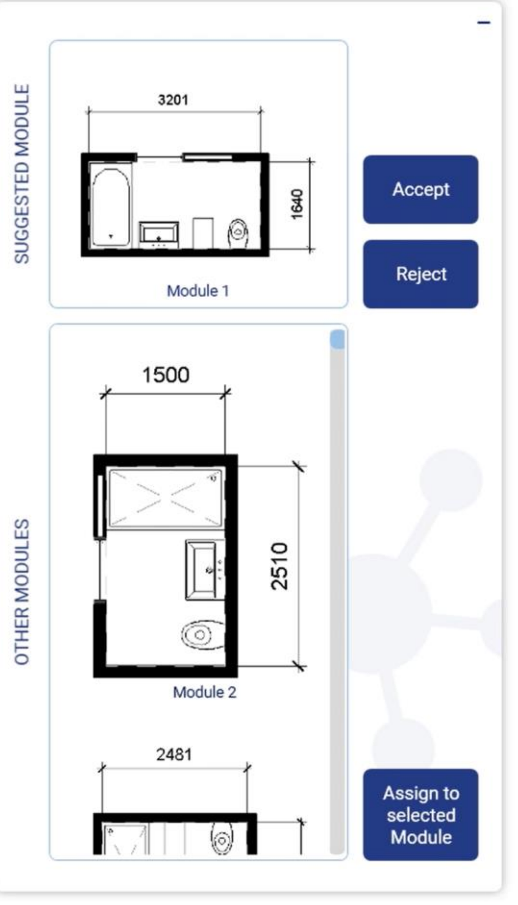
The semi-supervised clustering itself can be seen as an iterative process with two phases: the clustering analysis; and the user validation.



The first calculates the clusters using the extracted data while the second relies on the user to validate the results of the output clusters. **This user feedback is then integrated in a new iteration, resulting in new clusters – a feature that makes the software easily adaptable to distinct building designs and architectures**. This iterative process is repeated until a satisfactory solution is acquired.

Afterwards, ModuLAB selects, for each cluster, a single module that can be industrialised for construction.

To ease the validation process, an intuitive GUI was designed, enabling users to quickly accept or reject cluster attributions, even allowing for the direct assignment of rooms to different clusters. So not to overload the user, only rooms with a high degree of uncertainty are shown during the validation process.



Additionally, ModuLAB has two visualisation tools in its features, allowing the user to check modularisation results in a grid, sorted by cluster, or directly over the floor plans. Rooms are coloured distinctively by cluster to offer a better understanding of the results.

Check our most recent international article regarding the development and assessment of ModuLAB with the collaboration of CASAIS – Engenharia e Construção.

ModuLAB

ModuGEN

After using ModuLAB to divide the building's rooms into similar groups and select a representative module for each cluster, the selected modules are optimised in ModuGEN. Thus, ModuGEN is the second software in our modularisation pipeline.

ModuGEN optimises modules in regards to material waste, while taking into account prefabrication requirements. It also generates the required detail and parametrisation that production factories require, exporting the modules' BIM models to specialised 3D mechanical software (i.e., Autodesk Inventor).

To meet all these objectives, ModuGEN requires a preliminary customisation of its optimisation engine to each individual company, to be able to adapt and take into account each companies' machinery requisites (e.g., maximum frame length, maximum profile thichness) and working materials (e.g., standard dimensions of gypsum boards).

> BUILT CoLAB is working closely with several companies to enhance modular construction processes, focusing on assessing ModuLIB's progress, as well as developing early iterations of ModuGEN.

IMAGE BY MOTA-ENGIL

ModuLIB

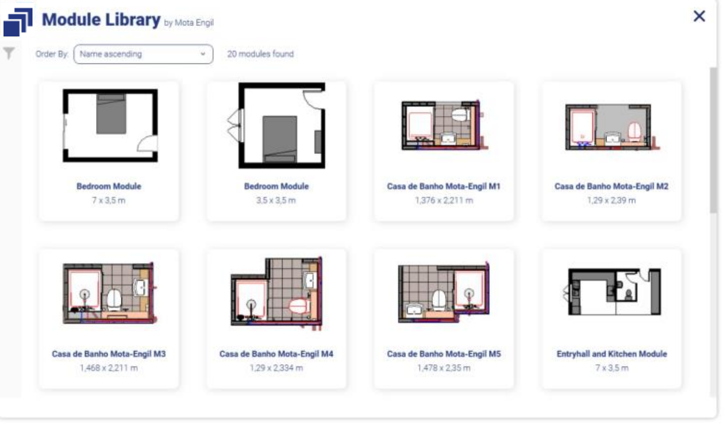
As the third software in our modularisation pipeline, ModuLIB serves as a BIM module library. Similarly to the previous plugins, **ModuLIB is fully integrated within Autodesk Revit, allowing for the visualisation, selection, comparison, customisation, and insertion (within Revit's BIM environment) of previously stored BIM modules.** These modules can either originate directly from ModuGEN or be simply imported by the user.

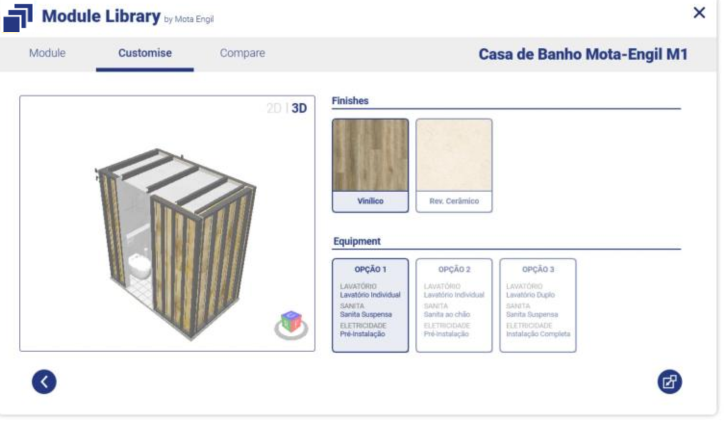
Since **ModuLIB is meant as a national level tool**, to be adopted and applied by multiple and distinct stakeholders, it is equipped with several tools that ease the identification of suitable modules.

Namely, this tool includes a filtering and sorting option; a comprehensive model description; a 2D and 3D visualisation window; and a comparison tool, that enables the direct comparison between modules.

Finally, before directly importing the module to Revit's modelling canvas, ModuLIB allows for the module to be customised according to the options provided by the supplier.

Contact us to try ModuLIB!





SIMPLIFY

Digital Platform for Buildings' Processes

Main Goal

Simplify aims to answer the increasing national demand for a semi- or even fully-automated e-licensing and e-permitting platform, to be employed by municipalities and design companies.

This platform will be integrated with BIM to automate regulation checking and provide a collaborative environment to support the stakeholders' engagement.

This scope will further be expanded to include personalised rule checks, enabling companies to create their own sets of rules and requirements for their BIM projects.

Main Activities

- E-licensing and e-permitting framework;
- BIM-based rule-checking platform;
- Pilot case studies with key municipalities and associates.

Building and infrastructure design and engineering demand the consideration for multiple codes and regulations. These requirements cover multi-disciplinary areas from urban planning, fire safety, accessibility, environmental impact, to cite a few. Non-compliance can lead to far-reaching consequences, including user safety.

Currently, these codes and regulations are characterised by high geographic disparities (both at the national and local scale), as well as some ambiguity, being mostly checked manually – both by planning consultants and the building permission authorities – based primarily on construction plans and additional textual documents.

Given the lack of integrated digital support tools, the checking procedure is laborious, inefficient, expensive, and error-prone, leading to massive permit request queues, that negatively affect construction projects, with delays and budget overruns.

Recognising this problem, **our objective is to increase the efficiency of checking code and regulation compliance by developing an e-permitting and e-licensing platform to be employed by both municipalities and design companies.**

This platform will be fully integrated with BIM, allowing for:

- the automation of checking procedures;
- an increased efficiency and transparency of the administrative process;
- an easier access to the building and requirements information;
- the overall de-risking of the project.

By supporting this platform with a completely parametrised and flexible core engine, we further plan to develop a customisable section of the platform, where companies can create simple rule checks, based on arithmetic and logical operators, effectively establishing their own BIM project requirements.

For more intricate rules, BUILT CoLAB will work in tandem with platform users to developed personalised checks according to their needs.

The following action lines represent our first developments to create the aforementioned platform's core engine.

BIM Classification

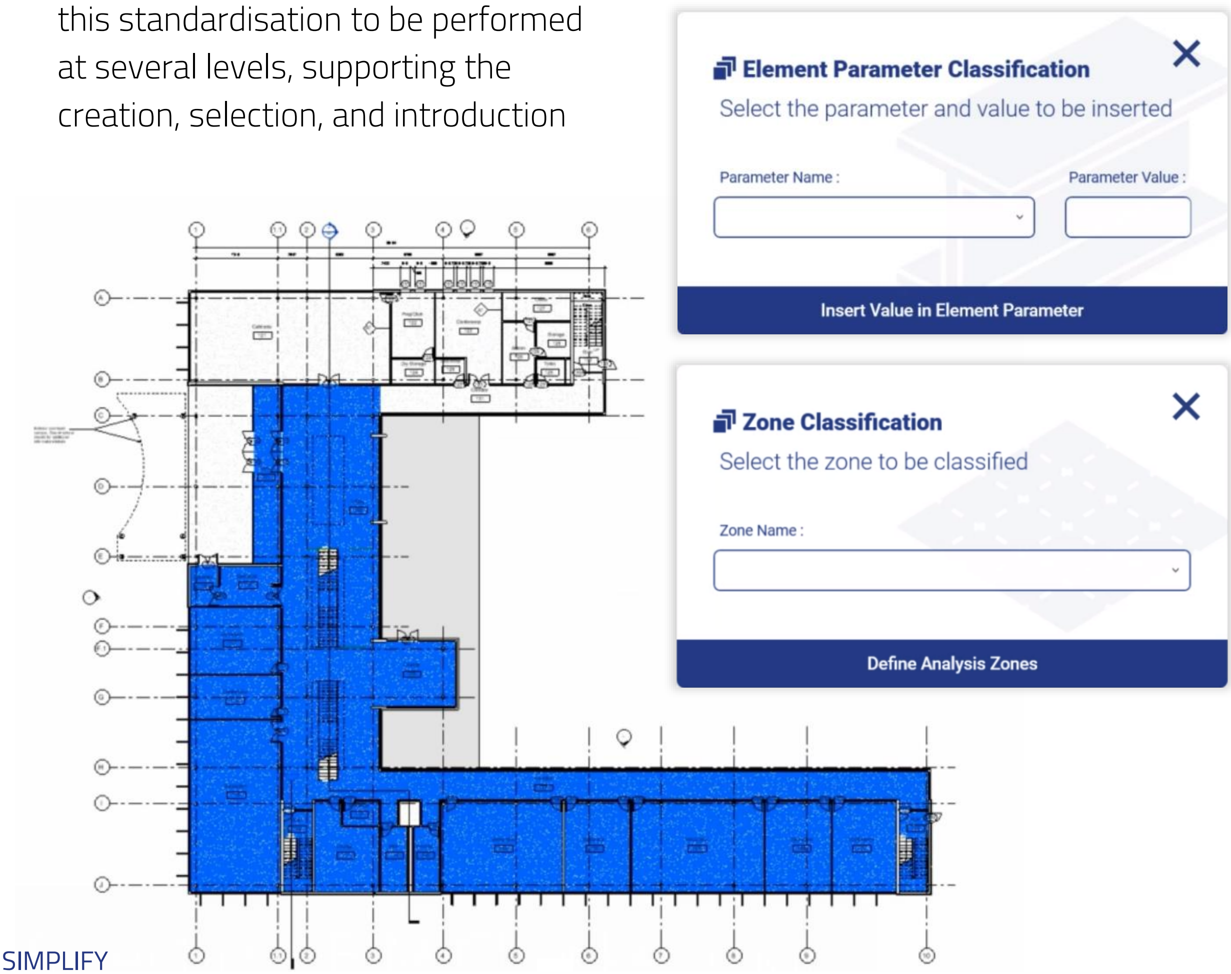
BIM Classification allows for a swift standardisation of BIM models.

BIM Classification does this by simplifying the adoption and implementation of pre-established BIM modelling rules, supporting its users during the modelling process.

This allows for an intuitive collaboration between project stakeholders, as well as an easier deployment of rule-checking systems, reliant on this standardisation.

Currently, BIM Classification allows this standardisation to be performed at several levels, supporting the creation, selection, and introduction of BIM parameters and zones in the BIM model, whose nomenclature and typology can be easily shared between users.

These parameters and zones can be assigned to multiple elements simultaneously, either through the manual selection of multiple elements (i.e., using the cursor) or by filtering objects according to their category and type. For a more detailed process, parameters and zones can also be introduced element-by-element.



BIM Checker

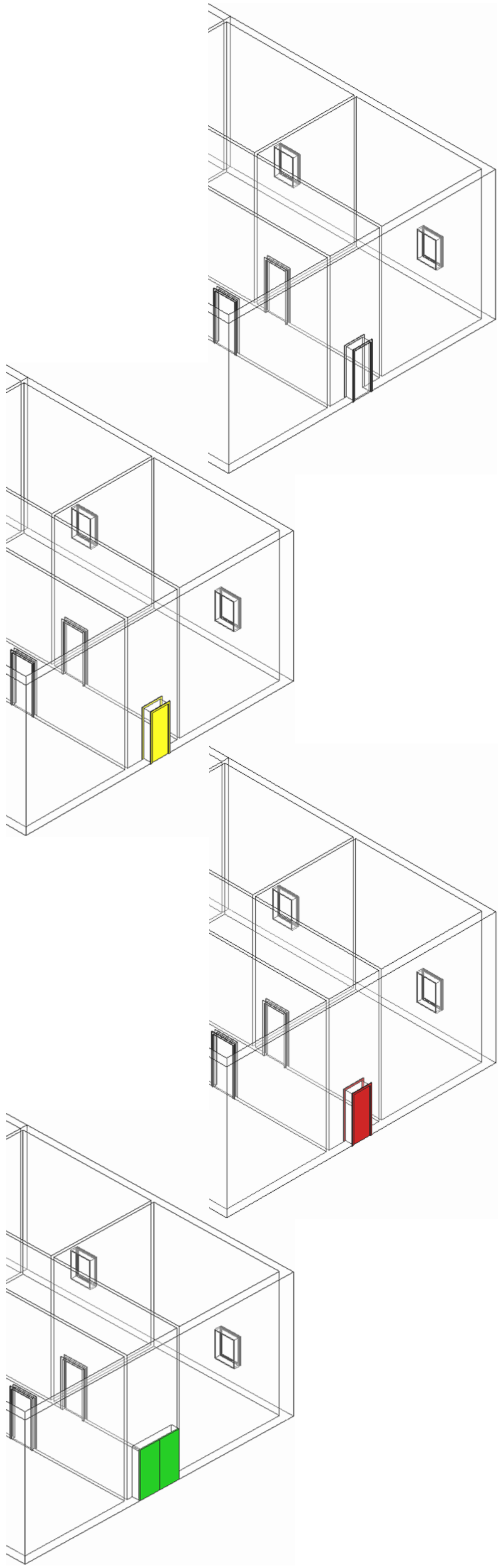
BIM Checker allows for the automatic and simultaneous validation of various rules within a BIM environment. These rules can be linked to existing national codes and regulations or custom checks that translate each companies' BIM requirements. These rules are stored within the BIM Checker's database and can be easily selected for checking using the software GUI.

After the rules are checked, **the software can present the acquired results directly within the BIM environment, by creating a new 3D View, with the BIM elements coloured according to a pre-established colour** scheme:

- Yellow, if an element cannot be validated from the lack of parameters;
- Red, if an element fails validation;
- Green, if an element succeeds validation.

This allows the user to quickly locate non-compliant BIM elements.

Alternatively, **the results can be presented in a textual log, which can be exported as a PDF report**, easing information sharing among project stakeholders. This log can also have its font coloured according to the pre-established colour scheme.



SMILE

Smart Energy and Management Optimisation

Main Goal

The SMILE project aims to exploit BIM and IoT to develop a real-time digital replica of the building.

At the core of this digital environment resides an intelligence engine that automatically learns the building's usage and dynamic patterns, enabling the optimisation of its operation and resource allocation.

To offer further insight into the building behavior and support user management decisions, a web-based platform, connected to the building's BIM model and sensors database, will display the building's 3D geometry and sensor data.

Main Activities

- Development of a methodology for the creation of an as-is BIM model and the integration of BIM and IoT;
- Platform development;
- Intelligence engine design and implementation.

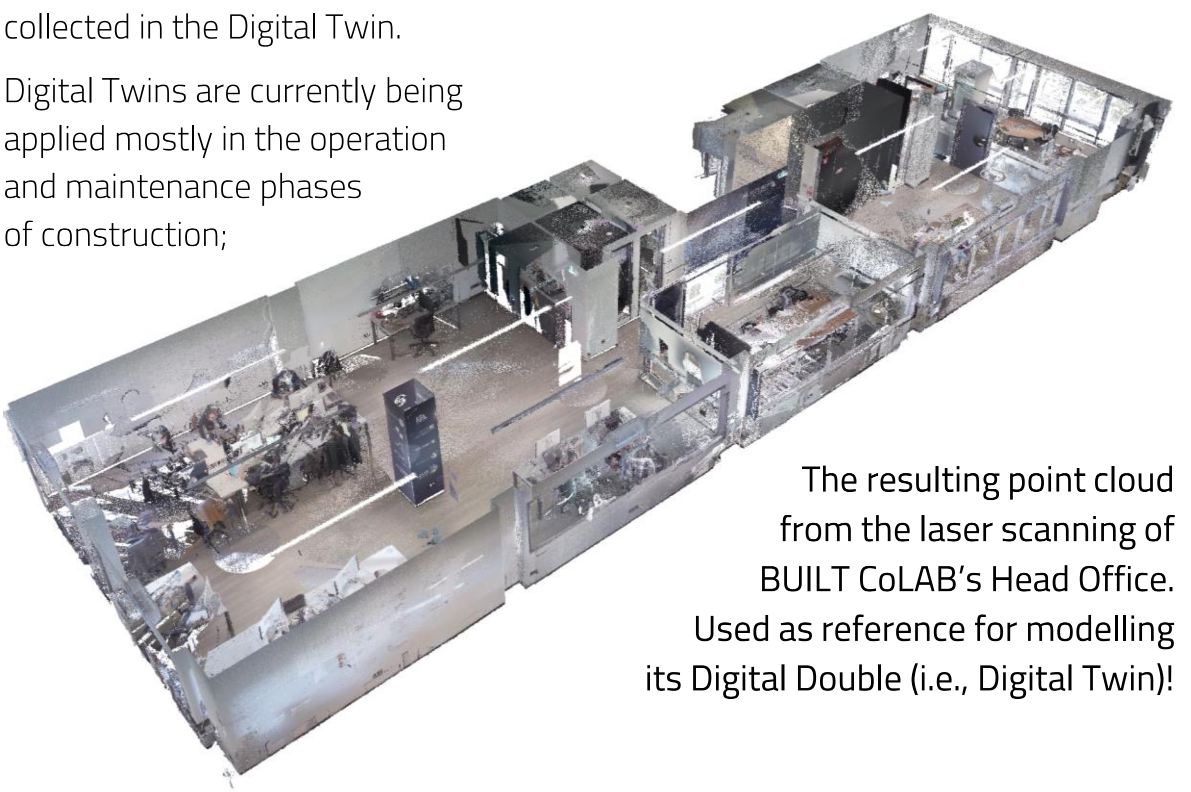
The monitoring of a building in real-time through BIM has long been an objective of the industry. This objective has recently been gaining increased traction in both academic and industry discussions, supported by the integration of IoT technology and the culmination in a Digital Twin – a digital double of its physical counterpart which, in the construction industry, tends to be a building, infrastructure or even city.

The Digital Twin provides a real-time connection to these physical environments, enabling the collection, generation, visualisation, and analysis of their data; which in turn allows for better management, monitoring, and optimised processes. This optimisation is frequently performed using AI models that are trained and tested using the data collected in the Digital Twin.

Digital Twins are currently being applied mostly in the operation and maintenance phases of construction; however, overall, all phases are being explored within this topic. Namely:

- Monitoring and management of construction tasks through the sensorisation of the construction site. Allowing for a safer working environment, progress tracking, team management, and automatic reporting;
- Predictive maintenance and anomaly detection;
- Analysis and simulation of a building using the collected and stored data, either for energy efficiency, thermal comfort, structural behaviour, or even city planning.

At BUILT CoLAB we are currently working on Double, a web-based platform reliant on BIM, IoT and Digital Twins.



The resulting point cloud from the laser scanning of BUILT CoLAB's Head Office. Used as reference for modelling its Digital Double (i.e., Digital Twin)!

Double

Double is the BIM counterpart to IoTASK, most prominently the Smart Office action line.

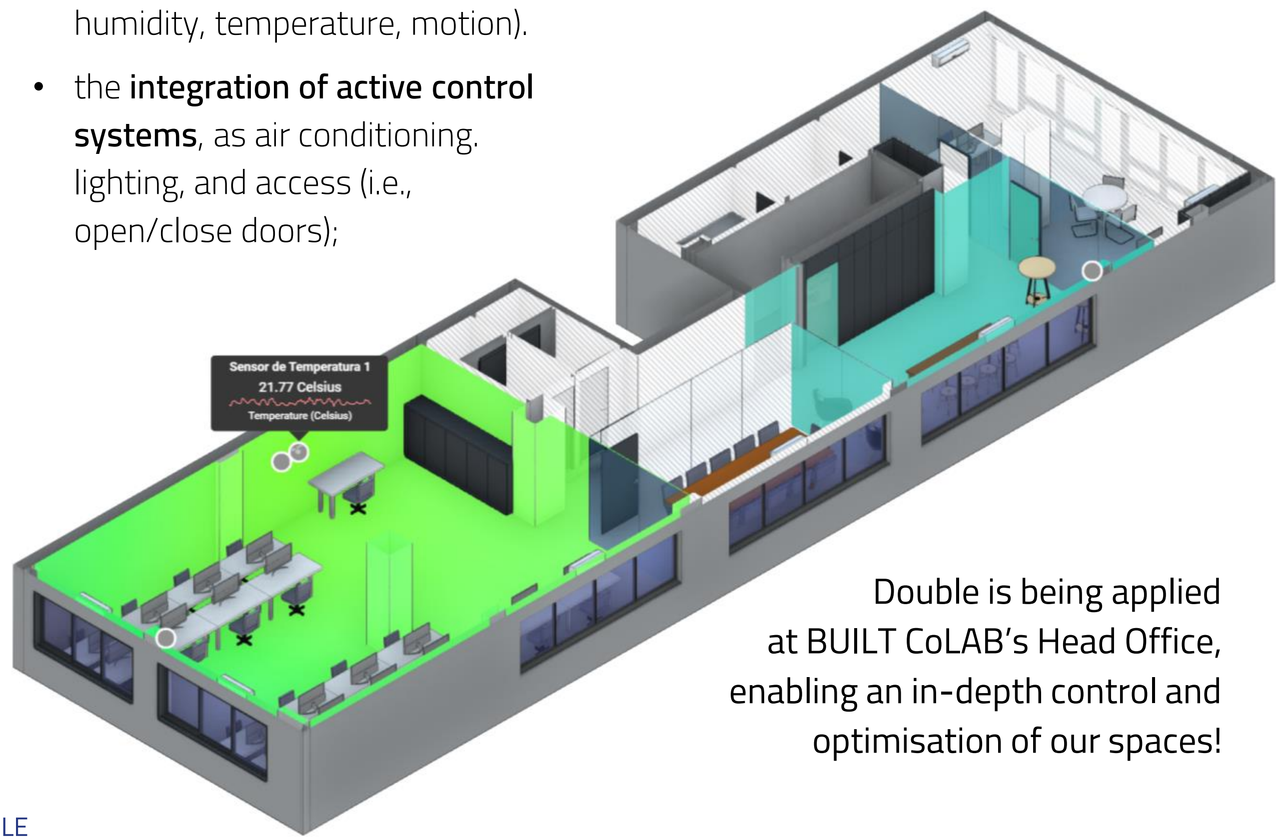
By allying the BIM methodology with the IoT technology, Double enables the acquisition of a real-time digital representation of the built environment, otherwise known as a Digital Twin.

This philosophy allows for the collection, storing and analysis of the buildings' data, enabling dynamic simulations and analyses that enable:

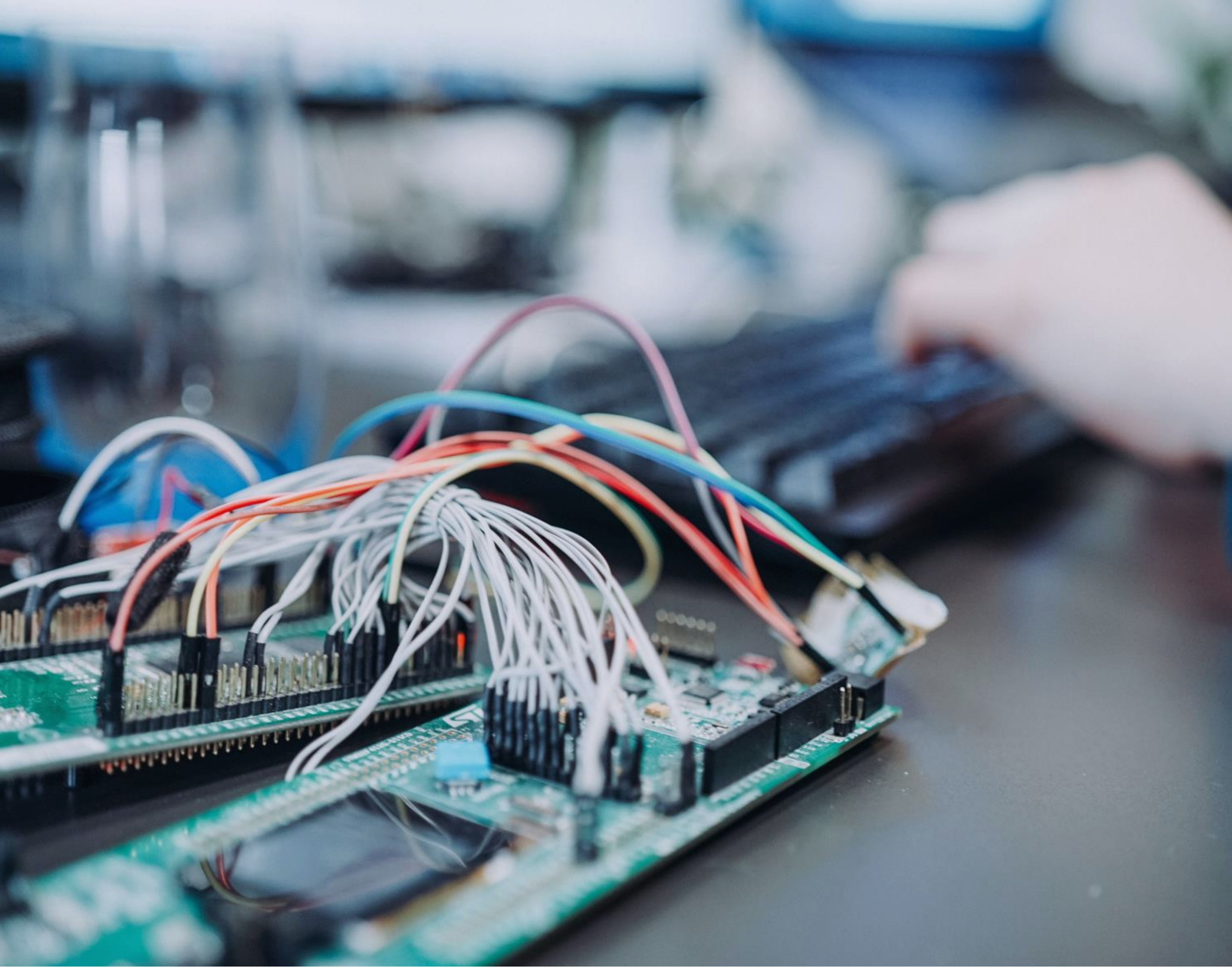
- a better **decision making and extended monitoring of the built environment**, through multiple and diverse sensors (e.g., CO_2, humidity, temperature, motion).
- the **integration of active control systems**, as air conditioning. lighting, and access (i.e., open/close doors);
- and the **development of an intelligent optimisation system** based on AI, to improve the building's energy efficiency and thermal comfort.

Current efforts centre on developing a Digital Twin of BUILT CoLAB's Head Office, to function as a living lab in which to explore this technology.

This Digital Twin creation required the office's laser scanning and the installation of multiple sensors that also had to be digitally represented in the model. **The sensors' data is displayed interactively in a custom-made 3D web-based digital platform – Double**.



Double is being applied at BUILT CoLAB's Head Office, enabling an in-depth control and optimisation of our spaces!



Double web-based platform supports Autodesk Forge, easing its integration with BIM modelling software and allowing users to swiftly access and share their Digital Twins from multiple locations and devices.
Check out Double's presentation video!

DOUBLE

BIMCloud4All

Collaborative Platform

Main Goal

This initiative will focus on the development of a collaboration platform for the construction industry.

BUILT CoLAB will implement an interactive and usable frontend, as well as develop detailed templates to adapt the collaboration platform to existing standards and guidelines.

The platform will be available for the industry to promote digital collaboration and innovative document and/or model management practices.

Main Activities

- BUILT CoLAB frontend development
- Platform templates development
- Platform implementation

The proposed platform aims to provide the basis for several modules that leverage the capability to gather and process data in an interoperable and interactive environment. These modules integrate several advanced technologies and dynamic optimisation tools, which tackle the high uncertainty inherent to construction environments by providing flexibility and adaptability to the system and integrating teams, equipment, and processes in a real-time decision support approach.

This platform can integrate and optimise the planning and execution of construction projects, supporting decision-making throughout both design and construction phases. On the one hand, it supports the definition of the project information requirements, establishes a common data environment for the entire project, and enhances communication and collaboration. On the other hand, it provides a digital twin cockpit that integrates multiple data sources, potentiating efficiency and increased project performance.

In this digital, intelligent and information-based environment, the planning and scheduling capabilities can be based on predictive data; the design can potentiate simulation-based approaches, and construction can be monitored and controlled more closely, allowing for automatic re-configuration and re-optimisation of the system according to the monitored status of the available resources.

In practice, this platform is expected to have an indirect but significant impact on **economic** (e.g., cost and time minimisation), **environmental** (e.g., decrease in carbon emissions and optimisation of resources), and **social** (e.g., higher quality of structures and services, improving life cycle and user comfort and safety) aspects, which correspond to the three pillars of **sustainability in construction**.

This platform can integrate and optimise the planning and execution of construction projects, supporting decision-making throughout both design and construction phases.

idBIM – National Object Library

BUILT CoLAB is working on developing a national library for BIM objects. This is part of a major initiative called REV@CONSTRUCTION, which aims to digitalise the construction industry and promote supply chains integration.

The objective is to develop a common framework for information classification systems and product data templates (PDTs), a complete guide for modelling BIM objects, and an open platform for BIM objects and their respective data management. BUILT CoLAB is currently developing this platform, under the scope of a BIM object library. This library will emphasise the current collaboration and interoperability in the construction sector, providing integration with multiple existing tools.

Regarding PDTs, there are several synergies around their development alongside the guidelines for BIM objects modelling, particularly with the national committee for BIM standardisation, CT197. This collaboration is crucial and elevates the role of standardisation.

Digi4Construction

This project aims to develop and democratise the access to a digital platform for the built environment, which will provide a common data environment for the national construction industry and related processes.

This ambitious goal requires a detailed analysis of the best international practices and a deep understanding of the construction industry dynamics. The platform will follow a BIM execution plan logic, providing support to all the steps needed to define and manage information throughout the project. It will provide the industry with a standardised way to communicate, assuring maximum systematisation and organisation.

This project will be developed within the REV@CONSTRUCTION initiative, which is a major project for the digitalisation of the construction industry, bringing different stakeholders together to provide adequate solutions to the industry of the future.

Integrated platform for the built environment, which provides a common data environment for the construction industry.

HIVE

Highly Interactive Virtual Environment for the AEC industry

Main Goal

Virtual and Augmented Reality have been progressively adopted in a multiple industries, showcasing numerous advantages and potential. At BUILT CoLAB, we aim to explore this technology within the AEC industry, developing several innovative solutions to support collaborative digital design, virtual construction, and augmented management of the built environment.

In this sense, an IIG is proposed to create an interactive virtual environment that supports VR/AR developments, in a go-to-market approach that is strongly supported by consolidated research and innovation.

Main Activities

- Define appropriate use cases
- Identify suitable VR/AR tools that can be adapted to the AEC industry
- Develop a realistic, immersive and interactive virtual built environment

VR and AR have shown encouraging results in a variety of fields related to the AEC industry, easing stakeholders' communication and collaboration, supporting design review and decision making, enabling a safer construction environment, improving spatial perception, or serving as an intuitive pedagogic and/or training tool; with different applications pushing the technology forward, in a daily basis.

We believe that the full potential of this technology has not being fully grasped and strive to identify key solutions to improve traditional AEC industry workflows through VR/AR, in a non-disruptive manner.

To do so, we aim to integrate our VR/AR developments with BIM, using this methodology's increasing maturity and progressively technically-intensive software, to reinforce our developments' impact and adoption.

However, we recognise that **solutions based on this technology are far from being a one-fits-all approach** and should be carefully developed to answer each stakeholder's unique needs.

We look forward to continuing the development of VR/AR solutions to solve existing problems hindering the AEC community.

> [...] we strive to identify key solutions to improve the AEC industry workflow through VR and AR , in a non-disruptive approach.

BIM Exporter

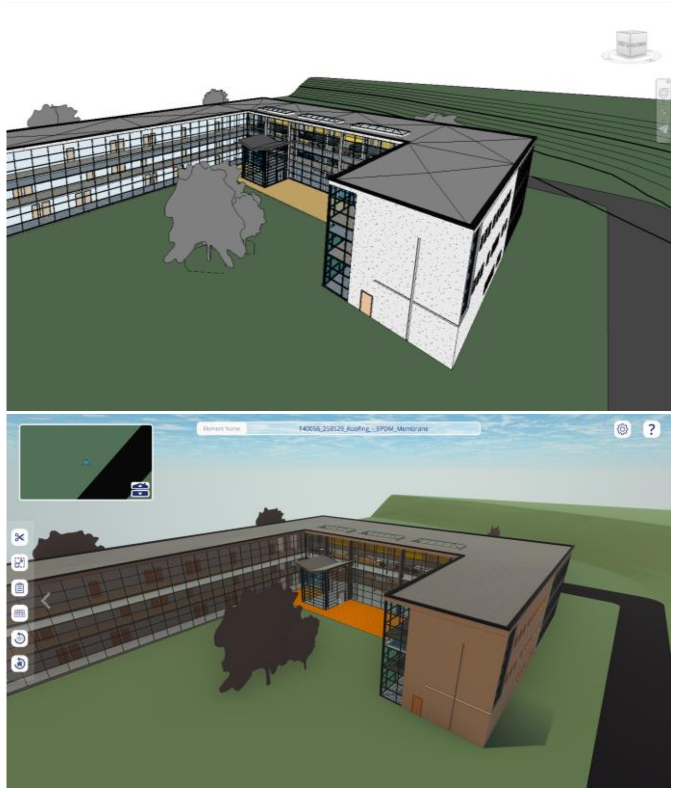
Having a mostly supportive role in the HIVE IIG, developments within the BIM Exporter action line enable the exportation of BIM models to different formats and configurations.

Current efforts focus primarily on the integration of VR/AR technologies with the BIM methodology, allowing for the exportation of BIM models to formats that are accepted by VR/AR-enabled game engines, in which these technologies are developed.

More specifically, the RDI team has developed **.obj Exporter, a plugin for Autodesk Revit that generates .OBJ, .MTL, and .JSON files that contain the BIM model geometrical and alphanumerical information**.

These files can be fully integrated with Unity, to enable a fully immersive, realistic, and interactive environment, in which project teams may work and collaborate.

.obj Exporter



By taking advantage of the generated files, a link can be established between the BIM authoring software and Unity, allowing for changes that are made in the VR/AR environment to be automatically replicated in the BIM environment.

This allows for the establishment of complex interoperability features between both software, enabling:

- the relay of information from the VR/AR environment to BIM;
- the modification of the building design within the VR/AR environment;
- and much more!

Construction Simulation

Construction is an intertwining flow of complex variables, from construction tasks and deadlines to project deliverables and communication.

Frequently, parties with distinct levels of experience and knowledge need to collaborate within this intricate environment, working together to identify solutions to pressing problems.

However, the sheer amount of complexity increases the level of abstraction workers need to achieve to access a solution's viability.

To this end, **Construction Simulation translates our efforts in developing a virtual, VR-ready environment, where multiple parties may deploy, simulate, and examine solutions in a cooperative approach**, assessing their viability within the constraints of a realistic construction site.

Additionally, by translating the construction workflow from 2D to 3D and animating all the existing steps, workers can gain further insight into the construction process, improving their technical knowledge and readying themselves for the tasks at hand.

VR enables workers to gain new technical knowledge into innovative workflow – in less time, with less costs, and within a safer environment.

HIVE App

HIVE App, or simply HIVE, is the culmination of the RDI team's work on the IIG of the same name. **As one of our most encompassing tools, HIVE displays a multitude of purposes**, from allowing simple visualisation of BIM projects to creating an immersive and interactive environment tailored to project design and management.

Currently, HIVE has two versions: Lite and Pro; with the Pro version displaying extra features, with many more being in development.

By being fully integrated with .obj Exporter, HIVE enables access not only the BIM model's geometrical and appearance data, but also its alphanumerical information, which may be edited within the HIVE software. This editing is translated onto the BIM model through the established live link between HIVE and Revit – a unique feature of the Pro version.

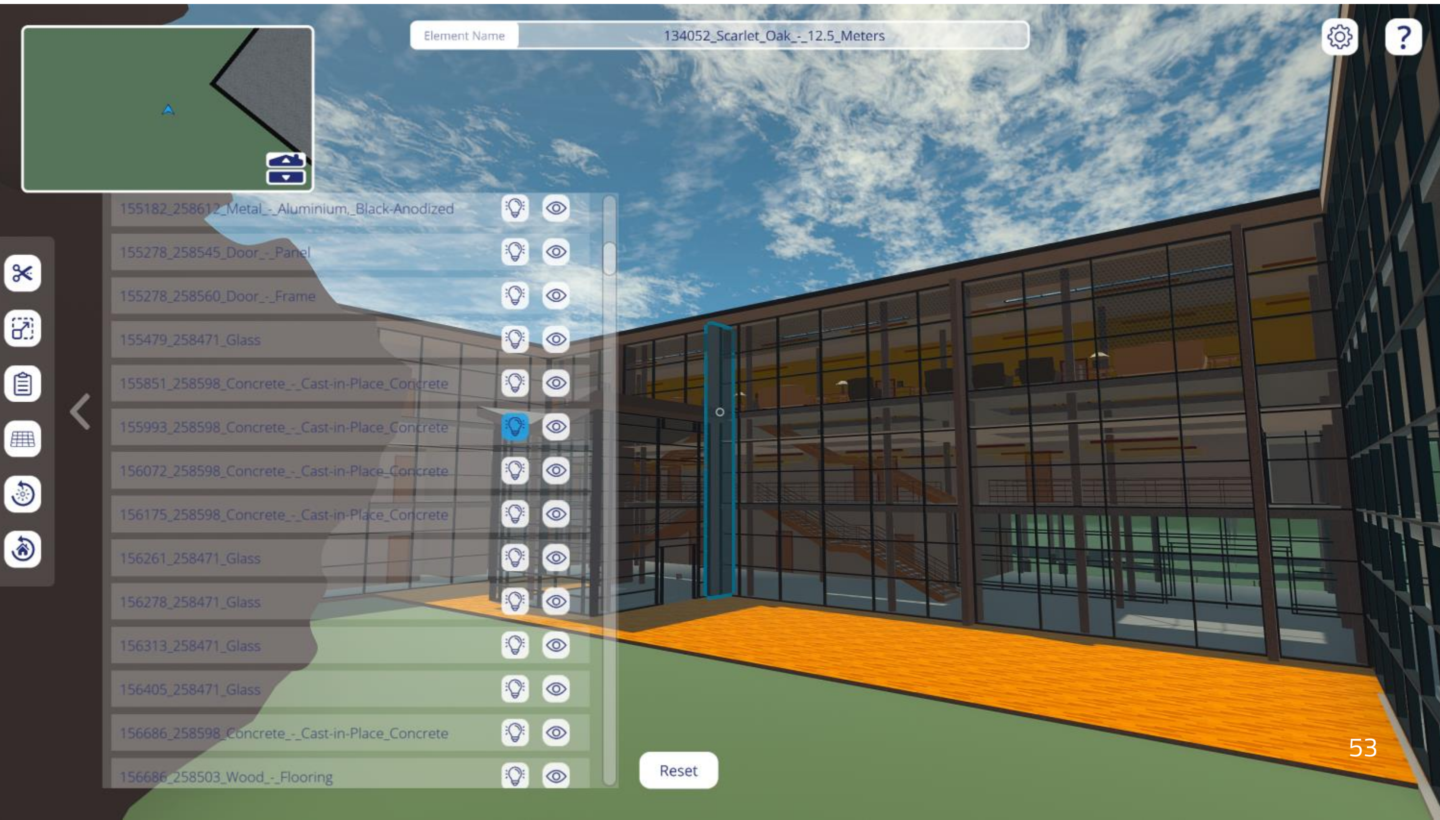
As a tool based on Unity, HIVE explores this game engine's ability to develop a more realistic render of the built environment, adding value to an otherwise schematic BIM model.

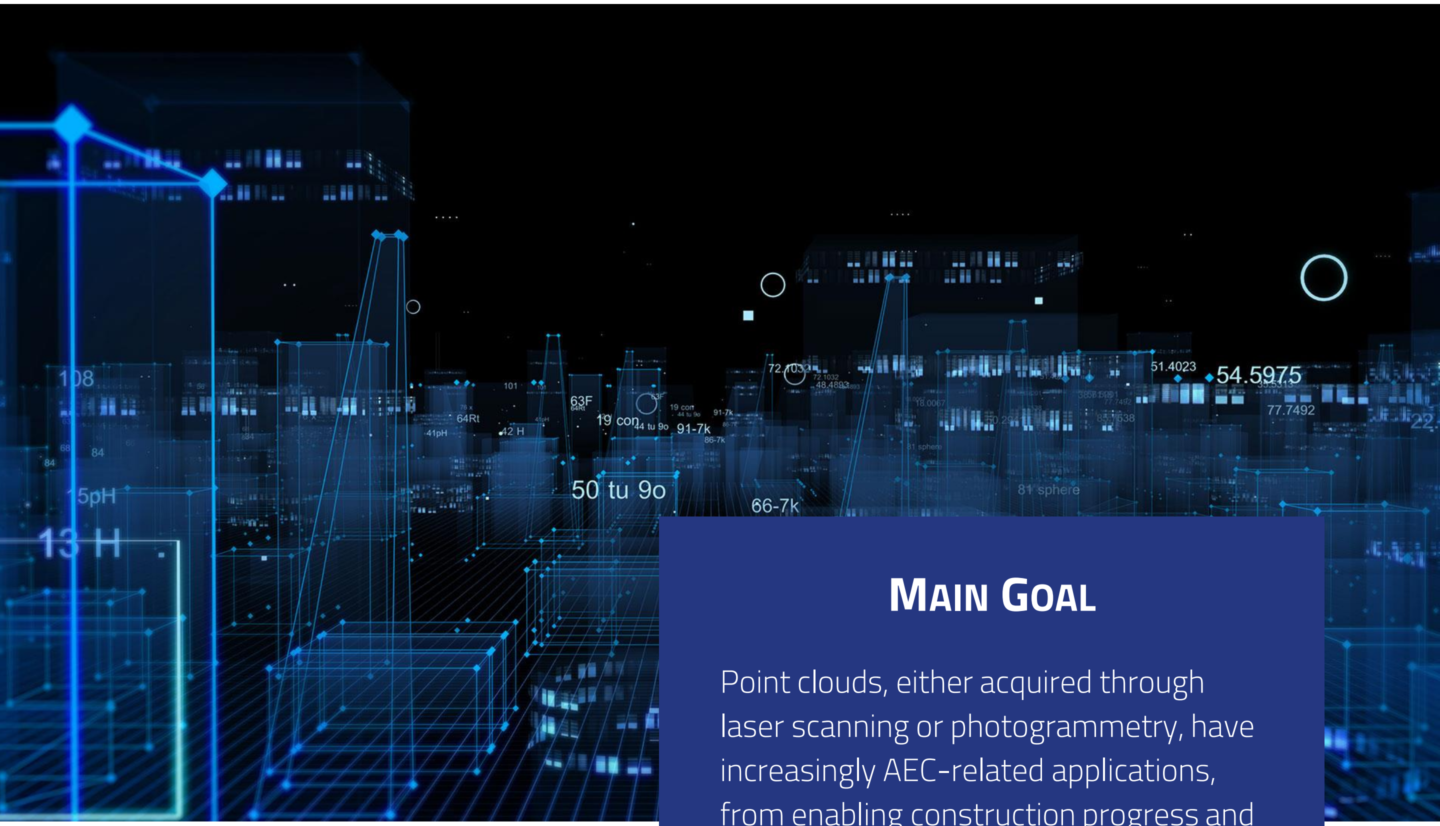
There are several tools and features associated with HIVE, as such, check our HIVE video for a glimpse of the ones already developed!

HIVE

HIVE allows for easy visualisation of BIM models, enabling a realistic immersion and interaction with the built environment, while requiring little to no technical knowledge regarding BIM software

HIVE





Main Goal

Point clouds, either acquired through laser scanning or photogrammetry, have increasingly AEC-related applications, from enabling construction progress and quality monitoring, to serving as detailed geometrical references during the BIM modelling of existing buildings and infrastructures.

To this end, Digital Eye aims to develop and implement fully-automated solutions based on these increasingly popular assets, with the objective of creating a platform that reduces construction errors and improves existing AEC workflows' efficiency.

DIGITAL EYE

Laser Scanning Technologies

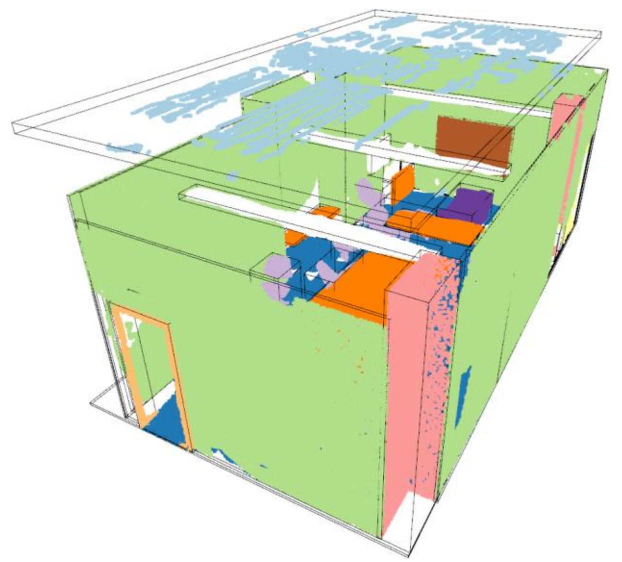
Main Activities

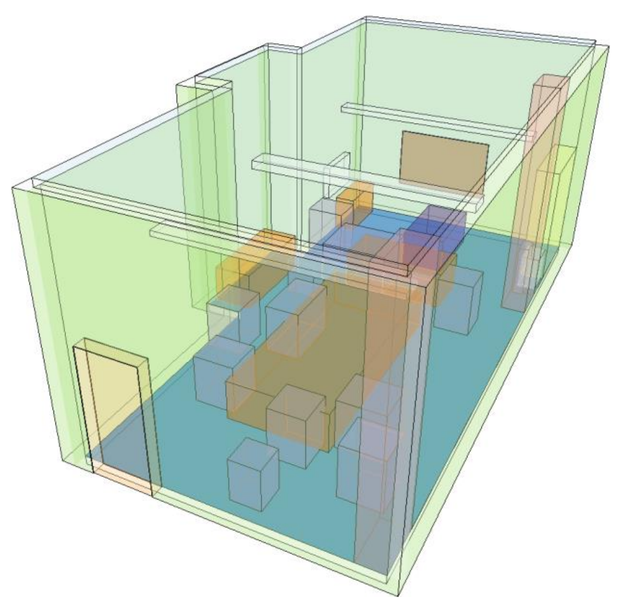
- Develop a digital platform to support DIGITAL EYE implementations in the construction site
- Develop AI solutions to automate point cloud: processing; comparison with 4D BIM models; and generation of BIM models (scan-to-BIM)

Recent technological developments, coupled with the rise in popularity of non-invasive imaging tools and long-range methods, enabled the performance of highly accurate and precise geometric surveys, allowing for the creation of detailed, easily visualised and understood, representations of existing buildings and infrastructure.

In the last decades, various survey technologies were successfully implemented in the Construction industry, with recent developments focusing, particularly, on photogrammetry and laser scanning. Both methods generate point clouds as their output, being considered mass data collection techniques suitable for a wide variety of applications, scales and object complexity levels. These technologies have been applied in multiple facets of the AEC industry, including: construction monitoring and tracking, project communication, quality assurance and control, and BIM modelling.

Taking into account the importance of these technologies, we at BUILT CoLAB have been focusing point clouds with the purpose of streamlining engineering and aiding Construction operators to perform their tasks swiftly, with a higher degree of quality.





PointLAB

PointLAB is THE web-based platform for point cloud processing.

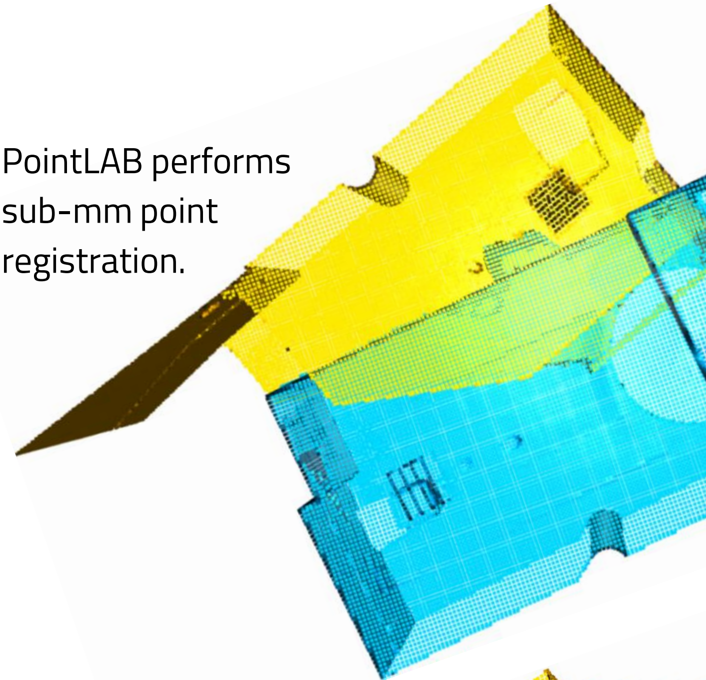
We at BUILT CoLAB identified the need to democratise point cloud processing software, allowing SMEs to gain access to a technology that has been long implemented in the industry, but which lacks a general adoption given its cost and technical knowledge.

In fact, although point cloud hardware cost has decreased over the last decade, software subscriptions have stabilised or, in some cases, even steadily increased.

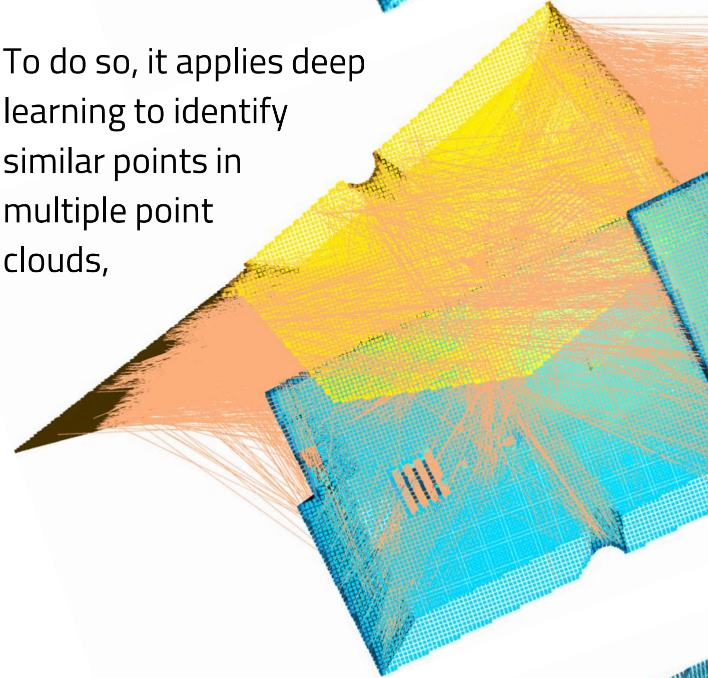
As such, the entry cost to this technology remains high, limiting the companies access to its advantages, to projects that require its application, and even to important collaborations with other stakeholders who, given the lack of point cloud software from the remaining project entities, cannot share their findings and point cloud assets.

To this end, **BUILT CoLAB designed PointLAB as a pay-per-use service**, instead of a software with an associated monthly/annual subscription.

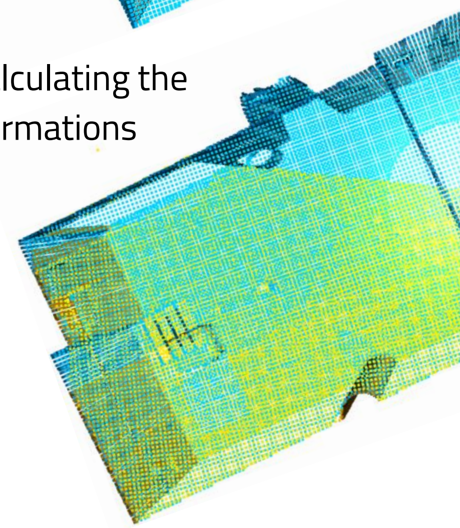
By leveraging current web-based technologies and state-of-the-art



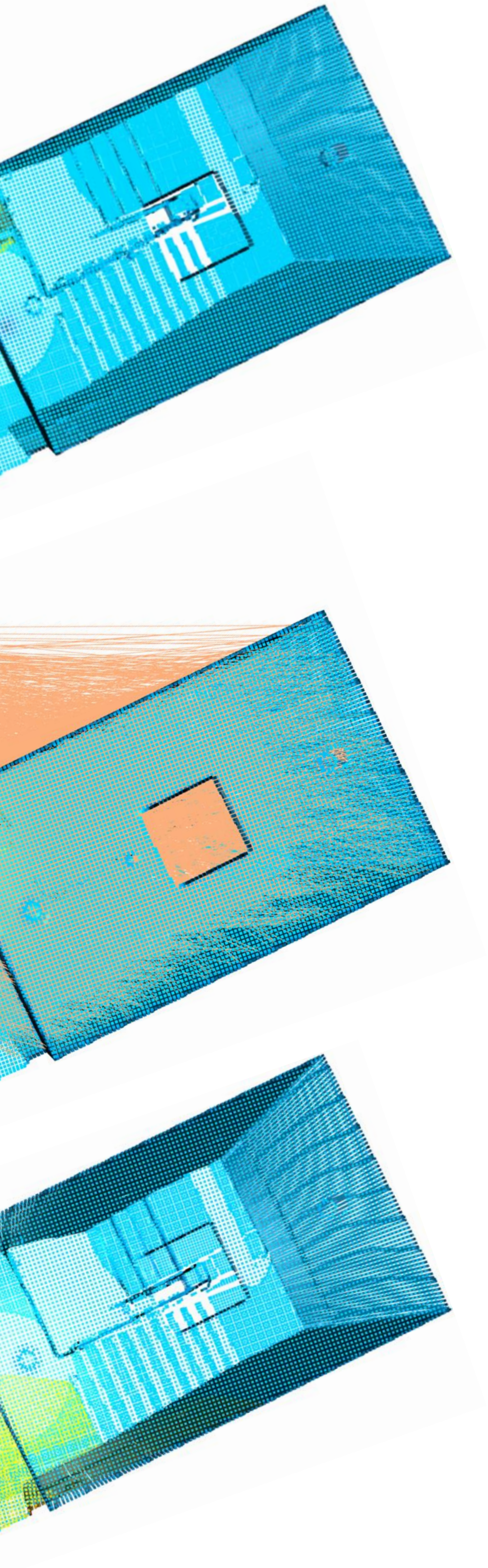
PointLAB performs sub-mm point registration.



To do so, it applies deep learning to identify similar points in multiple point clouds,



subsequently calculating the required transformations to overlap the identified points.



frameworks, **PointLAB is able to supply a service far and above the current available tools provided by offline software**.

In fact, by applying in-house knowledge on AI and deep learning networks for point cloud processing, PointLAB is able to perform multiple point cloud processing tasks fully-automatically, with higher levels of accuracy and precision than the current tools provided by offline software.

This is because the computational price which limits the deployment of such approaches in the user side is fully bore by BUILT CoLAB, by performing the bulk of the processing on our existing servers.

We hope to rollout PointLAB soon for world-wide alpha and beta testing.

Currently developed features, which will be integrated in both these testings, include: login system for access to user-owned point clouds; point cloud upload, storage, and download; point cloud processing (i.e., resolution modification, noise removal, registration, unification, and format conversion); point cloud handling (i.e., visualisation, navigation, clipping, measurement, and annotation); point cloud sharing; and even SIG integration.

On development processes include fully automatic Scan-to-BIM and construction monitoring. These are intricate processes which require their own developments as seen in the following pages.

Scan2BIM

Scan2BIM is BUILT CoLAB's approach to the **automation of the increasingly popular scan-to-BIM process**.

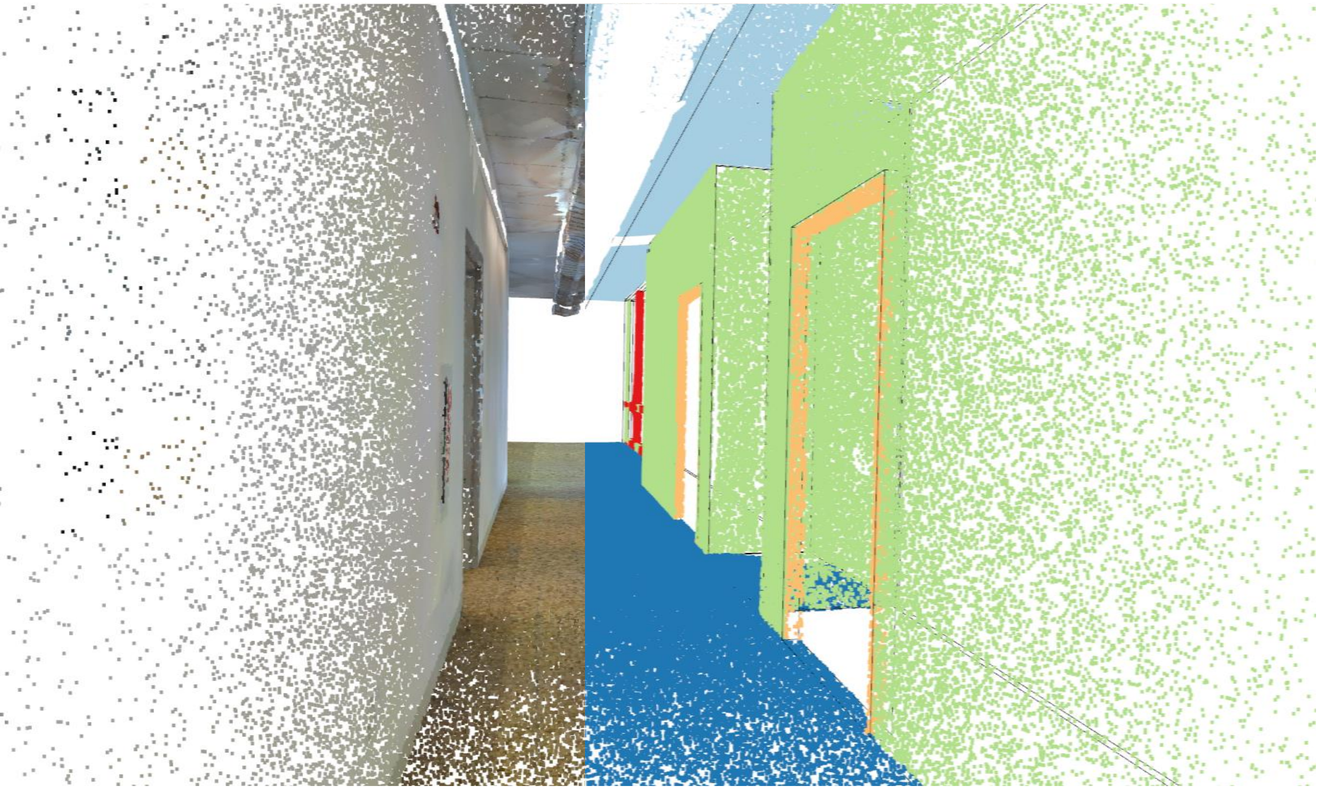
To do so, as in PointLAB, we rely on deep learning networks to completely segment point clouds into building elements, classifying them according to pre-established classes (e.g., walls, columns, floors, stairs, doors, windows, chairs, lamps, boards), even detailing its constituent parts.

The elements are then geometrically characterised using a tried-and-true pipeline which extracts all required data to allow for the automatic generation of semantically and topologically enriched BIM models of the surveyed point cloud.

Scan2BIM can be fully integrated in PointLAB, being envisioned as an addon for our platform.

Successful tests have already been performed, with key industry partnerships helping us test our developments in this field. **If you want to contribute, let us know!**

Scan2BIM performs the automatic segmentation and classification of point clouds.



ConstructionScan

Recognising the increasing need to automatically monitor the construction progress and quality, the RDI team at BUILT CoLAB started developing ConstructionScan in the late stages of 2021.

Contrary to the semi-automatically approach proposed in HIVE, **ConstructionScan is a fully-automatic approach to this problem, reliant on the performance of scheduled laser scanning surveys**.

By comparing the acquired point clouds with the existing timeline stored within the BIM model, ConstructionScan can identify existing overdue, on time and ahead of scheduled tasks, while also enabling the preemptively user-warning of high-risk of delay tasks.

Furthermore, by connecting this information with the BIM model, ConstructionScan is able to export comprehensive reports and bills of quantities, streamlining construction management tasks and allowing for the automated payment of personalised tranches, in accordance with the current construction progress.

We are looking for early partners to be part of the development and testing of ConstructionScan!

BUILDING LIFE

Life Cycle and Circular BIM-based Design

Main Goal

This IIG reflects the current need that the AEC sector has to reduce its environmental impacts, contributing, among other environmental impact indicators, to the overall reduction of greenhouse gases (GHG). According to the European Green Deal, and for all sectors, a 55 % reduction of GHG emissions must be achieved in 2030 (with the year 1990 as reference) and carbon neutrality in 2050.

The work is focused on developing digital tools that potentiate the minimisation of several environmental impact indicators using the LCA methodology and since the project's inception.

Main Activities

- Compile an EPD database
- Development and/or application of multi-objective LCA optimisation algorithms
- Improve existing BIM plugin, available EPDs database and chosen solution's LCA optimisation

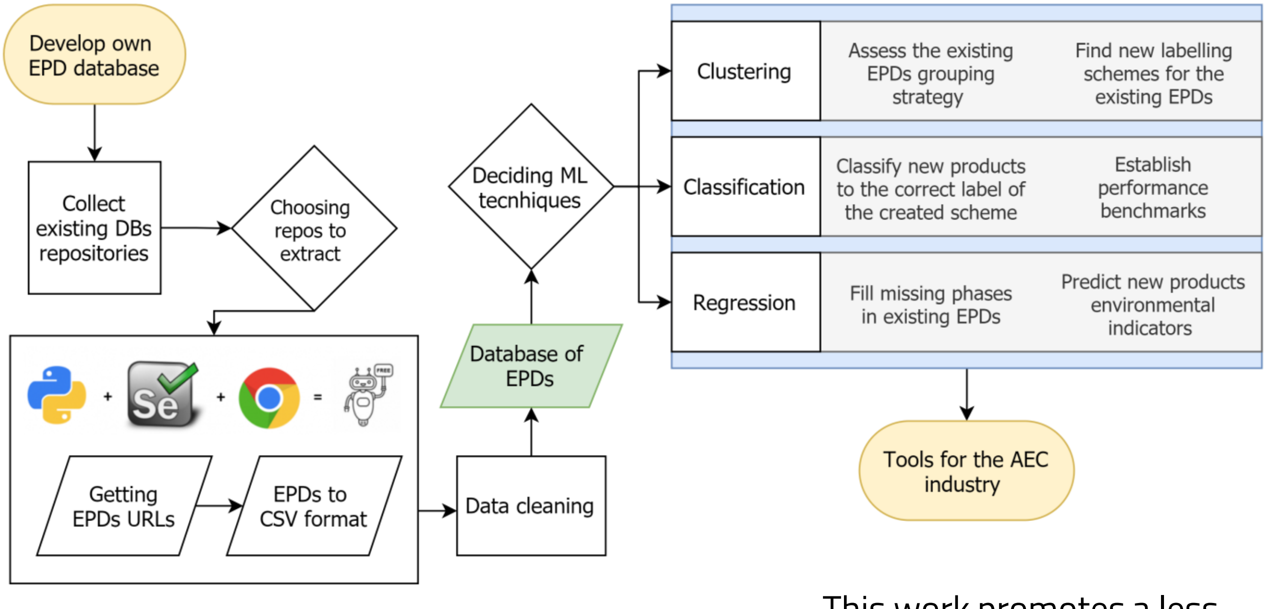
EPD Database

This research intends to gather available data from construction materials, products, and constructive systems that are already published in **Environmental Product Declarations (EPD)**, where their different environmental impact indicators are quantified for the different life cycle stages.

With such intensive data collection, it should be possible to obtain a broad spectrum of EPDs that can then be evaluated using statistical and machine learning techniques. Such techniques focus on clustering, classification, and regressions.

With clustering, the objective is to assess the existing EPDs grouping propensity; with classification, the objective is to classify new products to the correct label of the created scheme; and, finally, the regression objective is to fill missing stages in the existing EPDs.

The final objective for all these evaluations is to obtain an EPD database that allows **supporting the choice between distinct materials and develop tools that enable the extraction of structured knowledge and patterns from the existing database**.



This work promotes a less environmentally impactful use of materials, products, and constructive systems in the AEC sector.

LCA Optimisation

The research is being carried out between the BUILT CoLAB team and the academia – Instituto Superior Técnico – with the PhD student Teresa Ferreira, which is developing her works under the supervision of Prof António Aguiar Costa (BUILT CoLAB and IST) and Prof José Dinis Silvestre (IST).

This research is supported on the previously gathered, treated (statistically and using machine learning techniques), and compiled Environmental Product Declaration (EPD) database.

The main goal is to incorporate the developed algorithm(s) into the BIM plugin to support designers and their decision process on using varied materials, products, and constructive systems, and their possible environmental and economic impacts optimisation as a function of the project needs.

However, its focus is on evaluating the potential and the **development/application of multi-objective algorithm(s) that can promote the choice of distinct materials, products, and constructive systems, depending on the designer's requirements, emphasising the minimisation of environmental impact indicators**. With the support of the EPD database and while being evaluated in different performance aspects (e.g., environmental, economic) and on the designer's priorities, different optimum solutions can be obtained.

Moreover, one of the other objectives of this research is to develop at least one algorithm that can be potentially integrated into a BIM plugin (see BIM LCA plugin research), promoting this optimisation since the construction conception.

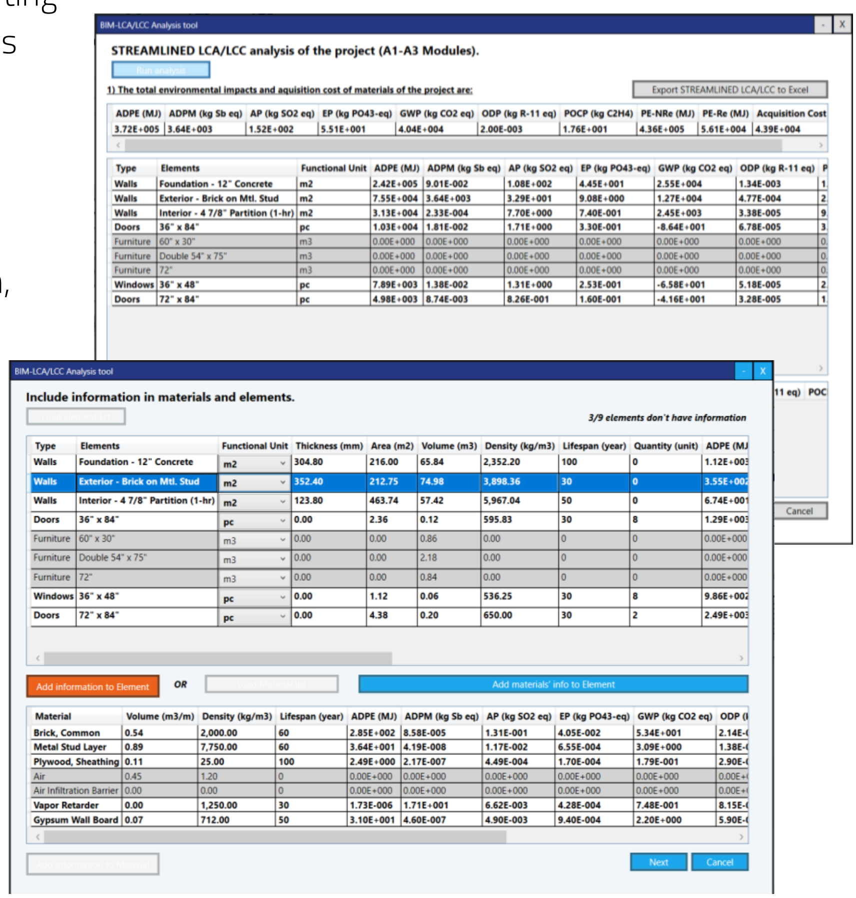
Therefore, its primary goal is to incorporate the developed algorithm(s) into the BIM plugin to **support designers and their decision process on using varied materials, products, and constructive systems, and their possible environmental and economic impacts optimisation as a function of the project needs.**

BIM LCA Plugin

This research focuses on previous research initiated by Dr Ruben Santos on his PhD thesis works. The original work created a plugin for Revit to quantify the different environmental impact indicators associated with the construction of a whole building, based on the individual component's impacts, using **a Life Cycle Assessment (LCA)** methodology. As a result, several scientific articles were written and published in international peer-reviewed journals on this subject.

With such a complete starting point, this research intends to: improve the user experience and the user interface; Improve the current database associated with the plugin, offering a new and more complete one; and incorporate optimisation algorithms that can allow designers to make real-time choices in terms of multi-criteria options, such as environmental and economic aspects.

Therefore, this research's primary goal is to develop an updated and revised version of the existing BIM plugin with the best possible user experience and interface while incorporating the newly created EPDs database and the multi-criteria optimisation algorithms, allowing designers to make real-time choices based on their priorities. Since the conception stages, such a **tool is expected to significantly contribute to a more sustainable AEC sector**.



Circular Dynamics

Circular Economy Models

Main Goal

The Circular Dynamics IIG reflects the urgency to reduce the high demand and use of raw materials and natural resources to mitigate such negative impacts on Earth. This unsustainable demand and use lead to natural raw materials scarcity and significantly contributes to the emissions of GHG, which severely contribute to the drastic climate change seen nowadays.

Therefore, the need of reducing the consumption of raw materials and residues production led to the creation of this IIG, with its primary goal being to contribute to the transition from a linear to a circular economy in the AEC sector.

Main Activities

- Development of the Portuguese Circularity Action Plan for the Construction Sector
- Support the optimisation of natural resources use, minimising the CDW

Circularity

This research is currently being carried out as a project under the **management of the BUILT CoLAB team, after the signature of a Protocol with the Fundo Ambiental - Portuguese Ministry of Environment and Climatic Action -, AICCOPN, AECOPS, APA, CIP, CPCI, IMPIC, and PTPC**, due to the European environmental goals but also to the National ones (Plano de Ação para a Economia Circular em Portugal – Portuguese Action Plan for a Circular Economy). This Protocol's main objective is to produce an Action Plan for the Circularity of the Portuguese Construction Sector, promoting this sector's transition from a linear to a circular economy.

Due to several actors and implications, the **Action Plan for the Circularity of the Portuguese Construction Sector** is built around a state-of-the-art report that receives several inputs: four workshops that promote discussion between actors; three capacitation actions that promote knowledge-gathering; and one support task related to residues management.

Here, the goal is to gather information from the different actors and, at the same time, to provide the skills and knowledge that promote the transition towards a circular economy.

The main goal of this research is to develop an Action Plan for the Circularity of the Portuguese Construction Sector, but also to support the SMEs and Public Administration connected to the AEC sector **to promote decarbonisation and efficient use of resources, supporting the sector transition to a circular economy**.

CIRCULARIDADE NA CONSTRUÇÃO

circularidade.builtcolab.pt

GreenSpecs

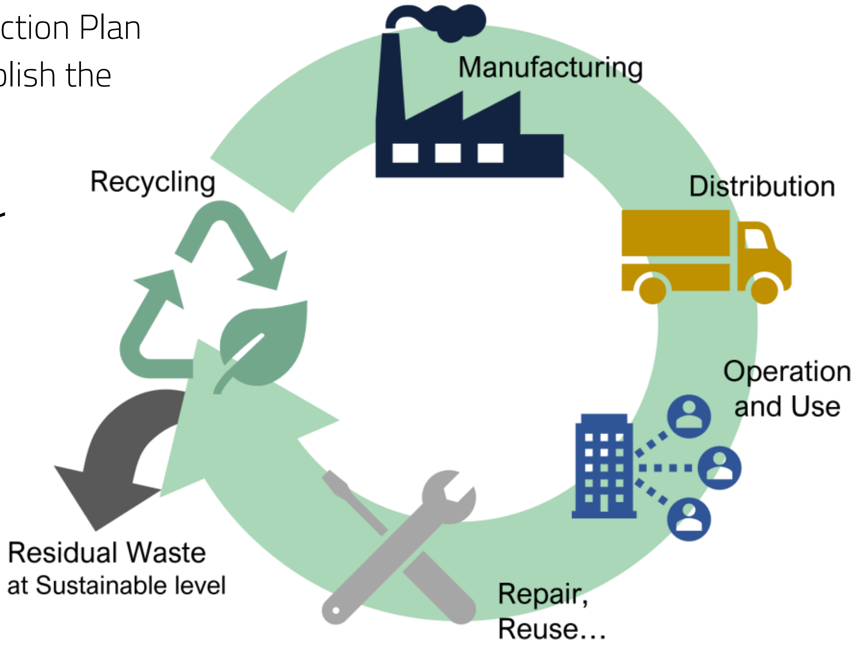
The significance of applying the Action Plan for the Circularity of the Portuguese Construction Sector is strongly connected to the need to achieve several **European and National goals**.

This fact justifies the need to establish different layers of support to the AEC sector. As in any other transition, this transition to a circular economy in the AEC sector presents a challenge to the multitude of actors involved due to the need of creating awareness while also gathering new knowledge and promoting the correct application and enforcement of such Action Plan.

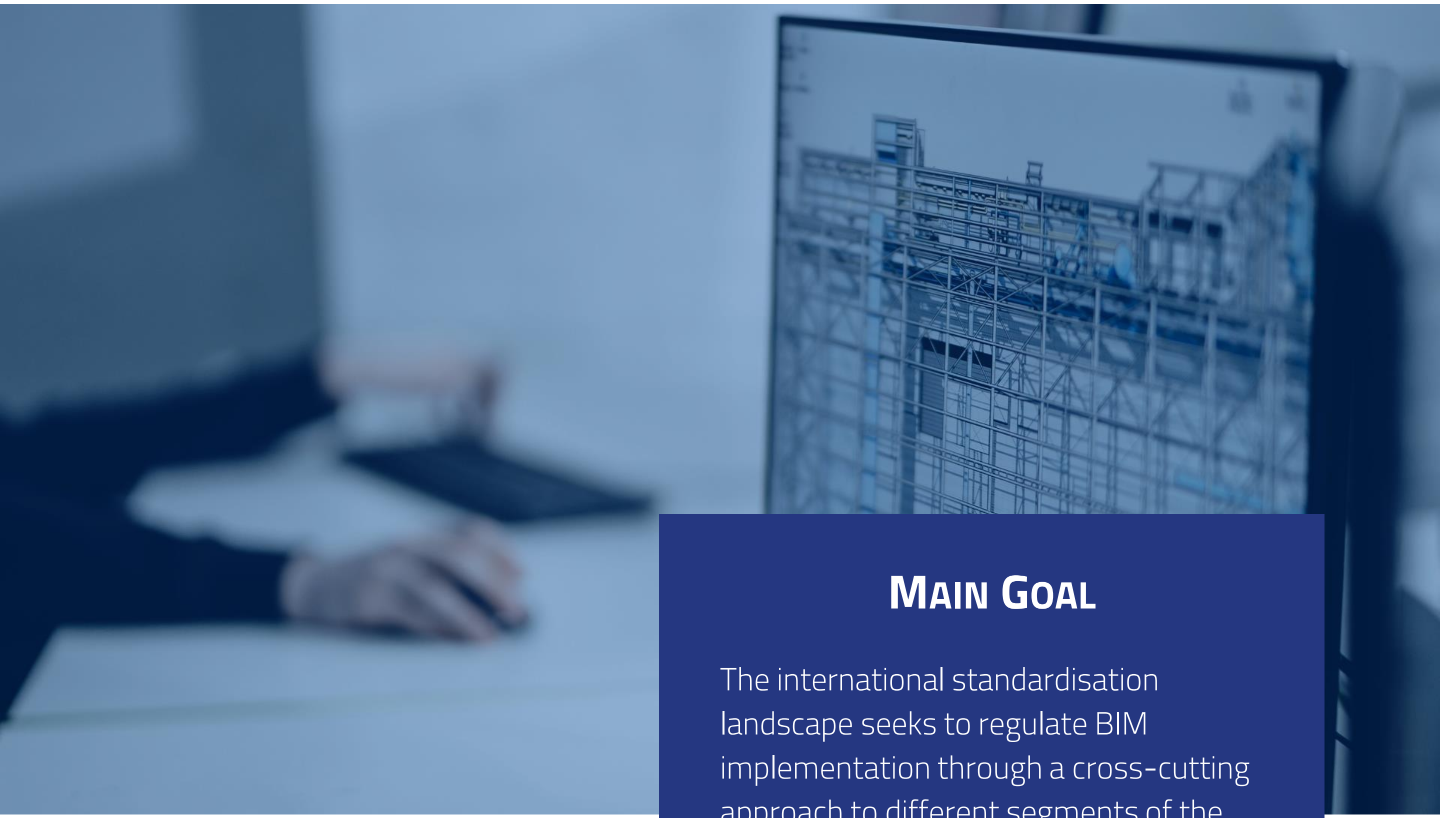
This research is crystallised from a broader project that intends to support the developing Action Plan (see Circularity) and establish the foundations for further **support of direct actions related to the AEC sector and green procurement**.

Here, the research is strongly connected to the action lines described in the previous project (see Circularity) that are related, among others, with technical guidelines for **Construction and Demolition Waste (CDW), Design for Disassembly, Materials Passports, and other topics relevant for future integration in BIM tools**.

Therefore, this project's main objective is connected to the development of new digital tools that are interconnected between the digital and green transition (designated as twin transition) and circular economy principles to be applied in the Portuguese Construction Sector while **helping SMEs to be competitive in applying the principles of sustainability and circularity**.



Action Plan for the Circularity of the Portuguese Construction Sector to promote decarbonisation and efficient use of resources, supporting the sector transition to a circular economy



CertBIM

BIM Process Standardisation

Main Goal

The international standardisation landscape seeks to regulate BIM implementation through a cross-cutting approach to different segments of the AEC sector. The development of European standards related to BIM is growing and requires close monitoring of regulatory documentation that focuses on both good practice and fundamental rules of application.

Thus, CertBIM aims to support the structuring of contents, specific for each segment, oriented towards the standardisation of processes related to BIM methodology.

Main Activities

- Manage the standardisation activities of Portuguese BIM Technical Committee (CT 197-BIM)
- Promote learning and training activities, contributing to the national adoption of BIM

Undertaking a coherent transition towards a more digitised world might be one of the greatest leaps in the human's evolutionary path. Society's future is closely connected to its digital future, which shall result from inclusive strategies while opening new opportunities in a very technical environment. With all the foreseen opportunities there will come unforeseen challenges to be addressed by nations, specially to promote a faster and safer transition.

Within regulated markets such as the European, standards play a vital role by creating a structured framework capable of promoting efficiency from all agents involved in the transition to a more digital future.

BIM Certification will ensure the structured framework will become a reality by merging the **standardisation role within the national technical committee for the BIM implementation with the promotion of certification schemes for the industry**.

Standards will also contribute to a global response towards a better environment by reaching climate neutrality with the help of digital technologies. Tackling such demanding challenges at the core of significant economic sectors, as it is the construction industry, can only be possible with a highly structured approach.

Empowering citizens with the correct tools to make them start, grow, innovate and compete on fair terms is mandatory to make them a key driver of the digital transition. Amongst the construction sector exists a great diversity of services thus it is important to avoid exclusions of white-collar and blue-collar professionals along the digitisation process.

BIM Certification

BIM Certification aims to help AEC professionals get more familiarised with digitisation concepts while achieving **global BIM recognition to work in a collaborative environment**.

By promoting certification schemes for products, systems and services it will be possible for professionals to choose the correct certification which might help them tackle their specific needs. These referred schemes will be based on **international specifications and guidelines to promote additional trust and interoperability within the BIM ecosystem.**

The compliance with international standards will also contribute to the implementation of public policy objectives hence improving social and economic development. Well-prepared companies will be confident to work overseas in foreign markets that might also follow the same regulatory framework.

BIM
PRÉMIO EXCELÊNCIA 2021

BIM Excellence Award was created by CT197-BIM, the BIM National Technical Commission for Standardisation. In 2021, BUILT CoLAB, Cluster AEC and PTPC – Portuguese Technology Platform of Construction were added to this initiative.

In May **2021**, **three awards** were attributed: "Simulation and Project" Award; "Planning and Construction" Award; and "Built Environment Management" Award. In addition, **four honorable mentions** were also attributed.

BIM Empowerment

To work in a highly digitised environment means it is necessary to follow a cross-cutting approach to **empower professionals that are not already familiar with digital processes**.

Within the construction industry there are specific segments that have special needs even though they might interact with each other under a common framework.

BIM Empowerment focuses on providing new skills to both blue and white-collar professionals with the help of existing digital platforms.

The creation of content to be digitally shared is not only a way of reaching a broader audience but also a way of allowing **trainees to engage with individual education plans where specific requirements are set based on assessed digital maturity level.**

Strengthening existing and future workforce within the construction sector shall follow a harmonised structure in different European countries while keeping the agility to support bespoke empowerment strategies.

DigiTransition

Digital Transition of SMEs

Main Goal

DigiTransition's main goal is to accelerate the digital transition of companies linked to the built environment, strongly marked by SMEs. This acceleration will be promoted through the implementation of a Digital Transition Plan, at a national level, which will range from the assessment of the digital maturity level up to the definition of implementation strategies in national and international contexts.

The evolutionary record of business digitalisation will be reported through an online platform from which will be possible to map the real needs of the AEC sector and, consequently, adjust the operability of the Digital Transition Plan.

Main Activities

- Support the definition of a nationwide Digital Transition Plan
- Develop a digital platform to support digital transition of SMEs

Contributing to the sharing of knowledge amongst the Portuguese construction sector is our key goal in order to upskill the sector's professionals in a structured way while being compliant with similar international markets.

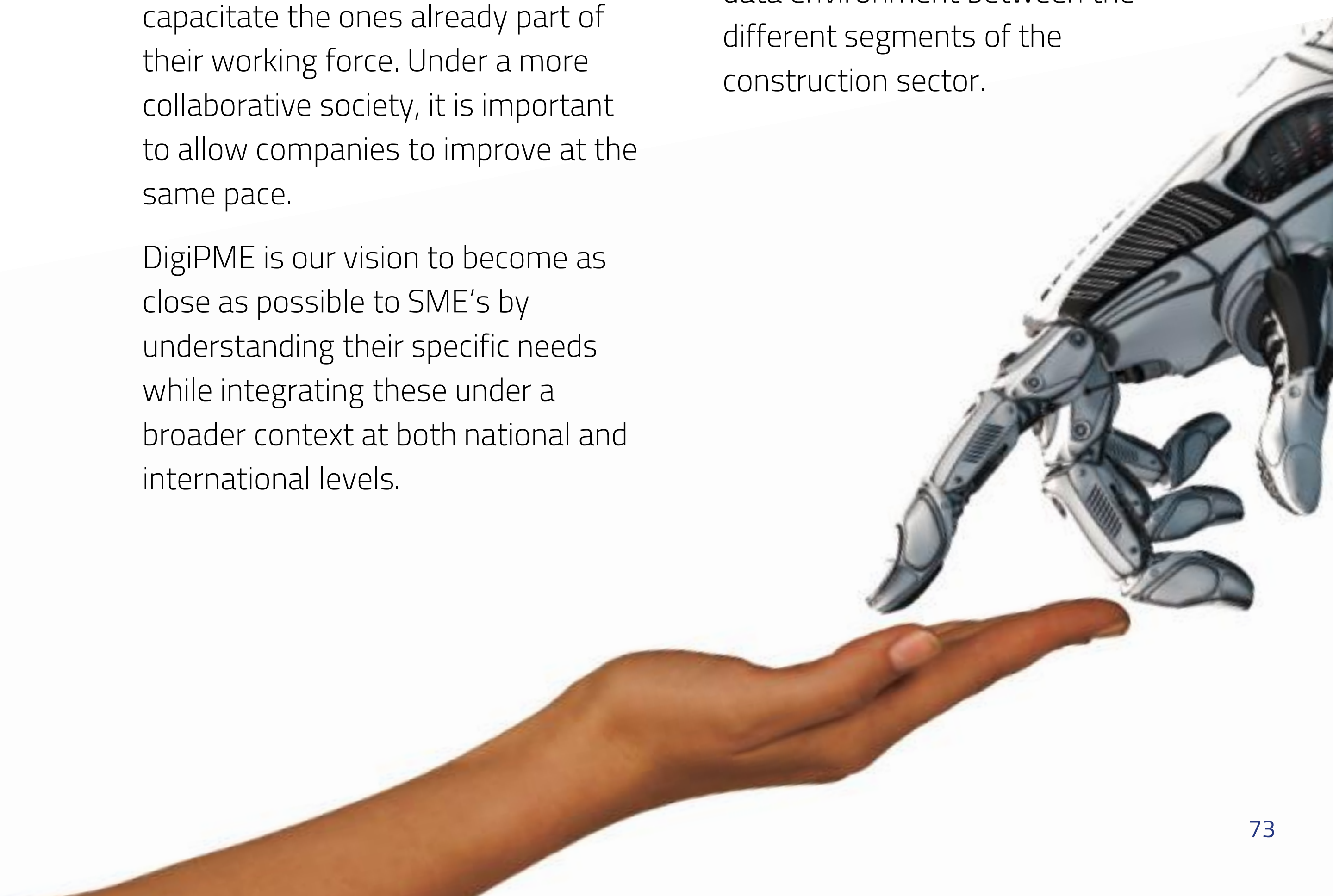
Small and Medium Enterprises represent the majority of the national entrepreneurial ecosystem which makes them crucial to help undertaking the required digital transition. Despite SME's agile approach towards the embedment of digital solutions as a problem solver, it is known that those companies struggle not only to find highly capable professionals but also capacitate the ones already part of their working force. Under a more collaborative society, it is important to allow companies to improve at the same pace.

DigiPME is our vision to become as close as possible to SME's by understanding their specific needs while integrating these under a broader context at both national and international levels.

The collection of data through focused surveys is a key procedure to develop a scorecard of SMEs ' maturity level and provide targeted recommendations capable of levelling their digital skills.

Aiming to reach a broader knowledge transfer, the digital transition process must be achieved by providing not only benchmark results but also specific tools that can narrow existing gaps within companies' internal resources.

BIMSpecs will provide such tools which will guide the implementation of strategic plans as well as guarantee the creation of a common data environment between the different segments of the construction sector.



DigiPME

Before implementing an action plan, it is important for **SMEs to assess their maturity level and find the correct measures to contribute to their digital level improvement**. The creation of an observatory to monitor the digitisation of the construction sector must be complemented by an advisory strategy with a focused approach.

A regular report must be publicly shared to generally inform the improvement of the construction industry regarding digitisation.

The assessment of the company's digital skills will become a valuable instrument to develop a scorecard in terms of digital maturity as well as an important data source to continuously feed the observatory database and create more accurate benchmark reports.

These more concise results will contribute to the development of implementation guidelines based on **real requirements and consequently contribute to the definition of a national action plan for the digital transition**.

BIMSpecs

We work to actively contribute to the creation of a **national BIM mandate, supporting public procurement procedures, and facilitating the relationship between governmental and private stakeholders**, through the creation of sets of BIM requirements and specifications.

The development of specific tools able to facilitate the implementation of BIM will leverage the adoption of internationally certified methods and procedures by SMEs within a common work-frame. At a global scale, these tools will contribute to a **faster and more structured implementation of a digital ecosystem.**

It is important for SMEs to assess their maturity level and find the correct measures to contribute to their digital level improvement.

Future Strategy

The initial RDI strategy focused on establishing a solid portfolio of digital tools and methodologies, which secured BUILT CoLAB position as a crucial player in the construction industry innovation panorama.

The created Intensive Innovation Groups enabled a challenging, but well-succeeded, vision that delivered multiple innovative solutions, placing our RDI team as a protagonist on the most important RDI national initiatives.

During 2021, the RDI department doubled in size, being tailored to face increasing development challenges. To this end, we took an important step towards a more rigorous and business-oriented management structure, which motivated an accelerated development. Several Research Areas were constituted to coordinate the different IIGs and their distinct scopes of research.

We understand that as projects turn increasingly bigger and more complex, additional energy must be allocated to their development. Simultaneously, we need to internationalise and establish international partnerships while sustaining our national growth and focus.

As such, BUILT CoLAB faces a critical moment in which it needs to open its

BUILT CoLAB needs to internationalise and create international partnerships.

We are aiming at challenging times. The team must focus on winner projects while maintaining a diverse portfolio of products and services.

existing portfolio of products and services to the industry while investing and focusing on a limited number of research and innovation initiatives.

Thus, moving forward, in 2022, we aim to maintain the current developments and available portfolio, with our future strategy focusing on:

- Digital Twins and smart buildings technology;
- A Common Data Environment for the construction industry;
- Virtual Reality for design and worker instruction;
- Augmented Reality applied to the construction site;
- Digital tools for Modularisation;
- PointLAB and Scan-to-BIM;
- BIM-based LCA software;
- Decision support tools for green procurement;
- And the optimisation of Smart Infrastructures.

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