



BEEYONDERS

Document title: System Requirements

D2.1: System Requirements WP2, T2.1

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1. Technical references

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Executive Summary

BEEYONDERS is a R&D project funded by the European Union's Horizon Europe research and innovation programme to fulfil the requirements of the topic: HORIZON-CL4-2021-TWIN-TRANSITION 01-12: Breakthrough technologies supporting technological sovereignty in construction (RIA). Its objective is to face the main challenges in construction that have been defined as: 1.-Labour shortage and lack of digital skills in some countries, 2.-Lack of motivation or young people to work in this sector and gender equality, 3.-Improvement in the safety and well-being of any age and gender workers, 4.- Resource efficiency and reduction of embodied and wasted CO₂ based on a circular economy, and 5.- Increasing the productivity while improving quality, cost efficiency and project delivery.

In the Introduction (section 1), an analogy between 'Inputs' = Challenges/Requirements; 'Outputs' = Outcomes/Results; and 'System' = BEEYONDERS project is indicated to establish a framework and common understanding of the project.

In section 2: 'System Requirements and Objectives', all general ten objectives and sub-objectives are indicated including the deliverables where the reader can verify the work related with them and its fulfilment.

Section 3 deals with the Methodology that BEEYONDERS will follow to achieve its objectives. Essentially, the project will follow the next phases: 1) Development and 2) Validation-demonstration, going from TRL4 to TRL6. The demonstration phase will be carried out in 6 real demonstrators (use-cases) of construction in Spain, Italy, The Netherlands, and Finland.

Section 4 deals with project's Impacts using two approaches:

- On the one hand, impacts are divided in Outcomes (specific) including several proposed Key Performance Indicators; Long-term Outcomes (as they are required by the EU), justifying how BEEYONDERS will help to fulfil them; and ten potential foreseen Key Exploitable Results, that can be increased during the life of the project.
- On the other hand, the results of a big survey performed using Google Forms, related to the general objectives of the project and their impacts, with the aim to retrieve the opinion and indications of the consortium's members, is shown. Twelve key questions are asked, retrieving a mean of 16 complete answers per each one.

Finally, section 5 deals with the conclusions of D2.1, showing the good knowledge of the consortium regarding the project.



1. Introduction to system requirements

Introduction

BEEYONDERS is a R&D project funded by the European Union's Horizon Europe research and innovation programme to fulfil the requirements of the topic: HORIZON-CL4-2021-TWIN-TRANSITION 01-12: Breakthrough technologies supporting technological sovereignty in construction (RIA)

The core ambition of BEEYONDERS is to provide and demonstrate the capabilities of European stakeholders to be able to competitively design, develop, integrate, and implement a set of critical Breakthrough Technologies in real construction scenarios without the need to import them from outside Europe. This implies that BEEYONDERS must contribute to achieve the European technological sovereignty by pushing an industrial development and implementation capacity to address the main **challenges** of the construction sector. These are:

1. Labour shortage and lack of digital skills in some countries
2. Lack of motivation or young people to work in this sector and gender equality
3. Improvement in the safety and well-being of any age and gender workers
4. Resource efficiency and reduction of embodied and wasted CO₂ based on a circular economy
5. Increasing the productivity while improving quality, cost efficiency and project delivery

In BEEYONDERS, both in the task T2.1 and in the current deliverable, it has been defined the concept: "System Requirements" doing the analogy between "System" and "Project", understanding that the last one is a system composed by several stakeholders, human resources, technologies, interactions and in general, a fluid communication. The analogy that is taken consist of the model of a "black box" taken from the classical theory of signals and systems where we have some inputs entering this box, which in fact, represents the system that transforms those inputs in some outputs.



Figure 1: BEEYONDERS SYSTEM

We consider that 'Inputs' are the challenges that Europe in general, and European Construction sector, have to face.

We consider that 'System' is BEEYONDERS' project and its consortium, as it was described in D1.1 and D1.2, which will develop solutions to help to solve the previous challenges (inputs).



Finally, we consider that 'Outputs' are the results, solutions, and the outcomes that BEEYONDERS will provide. These outputs will also take into account the Impact of the project to provide answers at research level to start solving the previous challenges, to positively impact in the European society.

This deliverable has been conceived to establish the general requirements, outcomes and impacts expected from BEEYONDERS to generate a common framework, challenges and understanding of the general objectives of the project.



2. System Requirements and Objectives

This chapter is intended to review the general objectives of BEEYONDERS, in order to indicate the ambitious framework of inputs foreseen in the GA. We have defined:

O1: Set up performance requirements for BEEYONDERS

O1 sets the requirements for technologies and solutions, their expected impact for the users, technology and solutions developers, testers, workers, and future professionals:

- O1.1: Framework scheme of BEEYONDERS BT: Requirements, Methodology, and Impacts.
- O1.2: Technical objectives and performance requirements of each project's solution.
- O1.3: LCA/LCC and cost objectives: resources efficiency and reduction embodied CO₂ emissions.
- O1.4: Technology sovereignty.
- O1.5: Workforce wellbeing monitoring, accidents prevention, gender, and the intersectional perspective.
- O1.6: Standardization (identification of existing standards, regulation, and gaps).

The verification of this objective O1 is going to be carried out through D2.1 (current deliverable), D2.2 (which deals on specific technical requirements), and D8.7 (which will deal with contributions of the project to standardization)

O2: Define and set up testing protocols at TRL 4 and 5, and demonstration plan at TRL6

O2 is focused on testing and demonstration protocols that will be set up regarding the technologies and solutions at TRL4 (validated at lab scale), at TRL5 (validated at relevant environment) and at TRL6 (in construction site):

- O2.1: Testing facilities definition and 6 demonstration case-studies in which technologies will be validated.
- O2.2: Methodology for each BT performance analysis and deployment and demonstration in use cases.
- O2.3: Methodology for assessing the performance (technical, social, environmental LCA/LCC, economic).
- O2.4: Workforce wellbeing monitoring and safety testing methodologies and protocols.

The verification of this objective O2 is going to be carried out through D2.1 (current deliverable), D2.2 (technical requirements), D2.3 (LCA/LCC KPIs), D2.4 (Workers KPIs), D2.5 (Testing Plan and Report), D7.1 (which deals with the methodology and specifications for case studies development and technology integration), and D7.8 (which will retrieve all the conclusions regarding the implementation in real use cases).

O3: Develop, test, and demonstrate Autonomous & Collaborative Robotics solutions

The O3 of BEEYONDERS will develop advanced solutions for Tunnel, Road and Building construction, and Road maintenance use-cases, demonstrating that is possible to implement unmanned machinery to work in



real harsh construction scenarios with autonomous/tele-operated ground and aerial robotic and industrial-machinery vehicles.

O3.1: An autonomous and tele-operated robotic solution (wheel loader machine and drones) to improve challenges in construction of conventional tunnels with explosives developed, tested, and demonstrated.

O3.2: A coordinated ground-aerial autonomous and tele-operated solution to improve wheel loader fuel consumption in earthworks activities for road construction developed, tested and demonstrated.

O3.3: An advanced drone system with non-GPS navigation solution to improve building construction performance developed, tested and demonstrated.

O3.4: A solution based on autonomous robot to solve production and H&S challenges in a road maintenance scenario developed, tested and demonstrated.

The verification of this objective O3 is going to be carried out through D2.5 (Testing Plan and report), D4.4, D4.5 (Autonomous Mobile Robot for Infrastructure Maintenance), D4.6 (Autonomous Wheel Loader Machine), D4.7 (HRC Assessment through Agent-based Modelling), D7.2 (Results of Implementation of WP3&4 Technologies in Tunnels Construction), D7.3 (Results of Implementation of WP3&4 Technologies in Road Construction), D7.4 (Results and Analysis of the Implementation of WP3&4&5 Technologies in Building Construction and Increased Wellbeing in Workers), and D7.7 (Results of the Implementation of WP3&4 Technologies in Road Maintenance).

O4: To develop, test and demonstrate new environmental-friendly Additive Manufacturing (AM) solutions

Additive Manufacturing solutions are developed to introduce several benefits to the environment, acting directly on resource optimisation and promoting biodiversity in maritime construction work sites.

O4.1: An AM solution for printing new types of maritime caissons developed, tested, and demonstrated.

O4.2: A pilot plant or small factory to chemically/physically optimize mortars to print in any environmental/geographical situation to maintain a robust control of rheological conditions, to ensure quality in structural elements developed, tested, and demonstrated.

O4.3: A subsea mortar AM element that foster reef biodiversity developed, tested, and demonstrated.

O4.4: A technology to integrate mortar organic shapes using AM printing in vertical on existing caissons walls, to improve the biodiversity in future maritime works developed, tested, and demonstrated.

The verification of this objective O4 is going carried out through the deliverables: D2.5, D6.2, D6.3, D6.4, D6.5 and D7.5.

O5: To develop, test and demonstrate a Digital Twin with Data Fusion from breakthrough (BT) technologies and Artificial Intelligence (AI) modules

A Digital Twin (DT) platform will bring together data acquisition during the case studies to manage the information of BT developed and demonstrated, with a set of layers and applications based on AI for decision-making and improvement of wellbeing & safety of workers.



O5.1: DT design, architecture, interfaces, common data formats and communication protocols defined, developed, tested, and demonstrated

O5.2: AI-capabilities integrated with DT developed, tested, and demonstrated to assess the H&S of workers in collaborative environment with the BT

O5.3: AI-capabilities integrated with DT developed, tested, and demonstrated to assess the productivity & planning of the construction site with the BT

O5.4: Integrate LCA&LCC KPIs for analysing all project developments based on BT design and defined

The verification of this objective O5 is going to carry out through the deliverables: D.2.5, D3.2, D3.3, D3.4, D3.5, D3.6, D3.7, D7.2, D7.3, D7.4, D7.5, and D7.6

O6: Development, implementation, and evaluation of BT around worker's needs

O6 deals with the implementation of previous BTs in workforce, evaluating their impact and consequences for any type of worker, analysing the advantages it can bring considering gender, how it can benefit older construction workers and generating strategies to attract younger ones to construction sector to face the problem of labour shortage. For that, exoskeletons for workers, advanced wearables PPEs and extended reality devices are developed and tested in different scenarios.

O6.1: BT considering different gender characteristics developed, implemented, and evaluated.

O6.2: BT for prevention of accidents and well-being for workers developed, implemented, and evaluated.

O6.3: Effect of BT to attract younger people to construction evaluated.

O6.4: BT solutions evaluated by users thanks to specific programs and surveys developed in the project.

O6.5: Advisory groups of construction workers to provide continuous feedback on BTs.

The verification of this objective O6 is going to carry out through the deliverables: D.2.5, D5.1, D5.2, D5.3 and D7.4

O7: Development of training & learning resources

O7 will develop learning & training resources for current and future employees in view of integration in curricula and modules for undergraduate and lifelong learning programmes:

O7.1: Develop active users learning Virtual Reality modules with sensorial immersive experience

O7.2: Different types of Training activities in technology to improve skills and curricula of workers developed and integrate the BT to the day by day of construction workers.

The verification of this objective O7 is going to carry out through the deliverables: D5.3 and D5.4

O8: Perform standardization activities

O8 will develop a standardization analysis of the technologies and solutions and will produce a roadmap for integration in current (update) and/or future (new) relevant standards.

O8.1: Standards in all BT technologies prior to develop new systems and solutions analysed

O8.2: New results to be reflected in contributions to new standards or update the existing ones analysed



The verification of this objective O6 is going to carry out through the deliverables: D8.7

O9: To develop an international cooperation with Japan

O9 will foster a fruitful technological collaboration with Japan by means of a solid plan of technological missions to strengthen professional relations with technological entities of this country. A specific collaboration with a Japanese entity for using BT in a specific maritime construction case study in the project implemented.

O9.1: Advisory boards and groups of Japanese entities (universities, technological centres and companies) generated

O9.2: 3 face-to-face technological missions to Japan and 6 virtual ones (virtual workshops) carried out

O9.3: Cooperation with Japanese entity Giken on Digital technology for maritime construction carried out

The verification of this objective O6 is going to carry out through the deliverables: D1.5 and D7.6.

O10: To design and implement Market analysis, Dissemination and Exploitation Plans

This objective will cover the entire life of the project and beyond, due to the relevance of exploiting and communicating the developments of BEEYONDERS.

O10.1: Technology trend in BT continuously monitored (Market watch)

O10.2: Dissemination and Communication Plan designed and implemented

O10.3: Exploitation strategy Plan to be adopted by BEEYONDERS developed

O10.4: IPR activities for different business models and partners' agreements considered

The verification of this objective O6 is going to carry out through the deliverables: D7.8, D8.2, D8.3, D8.4, D8.5, D8.6 and D8.7.



3. Methodology

As we have considered in the GA, the R&D methodology designed for BEEYONDERS is a continuous feedback loop between **design, development, and validation-demonstration** where design is at the beginning of the whole process.

Design is understood as a set of principles that will be breakdown in requirements, objectives and, Key Performance Indicators (KPIs) referring to: **Human-centric** principles, **Automation** of the construction site, **Technology integration** (from other industries) in construction, **Resources efficiency**, reduction of **waste**, reduction of embodied **CO₂** emissions, **Safety, wellbeing**, and prevention, **technical performance, non-technical performance** (legal, standards, etc.), **Economic performance** and **Competitiveness** with non-EU competing solutions.

KPIs are set at the beginning of BEEYONDERS (WP2: Specifications & testing) to guide technological and non-technological performance targets for development of the individual solutions and for their integration, and to blueprint the test and validation program to iteratively validate the results at different stages and TRLs of the project. Design is set at the beginning of the project, but, while the main principles and KPIs will remain untouched, they will be revisited, nurtured, and enhanced with new relevant information, to keep pace with the progress of reality, which will affect all parameters as they evolve in time (e.g., change in external requirements and conditions of any type: markets, legal, technological, etc.). Market and technology watch performed in WP8 (Communication, Standardization, Dissemination and Exploitation) will be key to support this evolution and transmit results to the society.

Development phase starts at TRL 4 with WP3: Digital Twin & Diagnostics, WP4: Autonomous vehicles and collaborative robotics, WP5: Worker-centric technologies to improve health, safety and well-being, and WP6: Additive manufacturing, and brings solutions and their integration to TRL5, evolving to prototypes, under the guiding KPIs, and with the feedback of testing at the level of TRLs 4 (lab) and 5 (relevant DT-integration environment). Prototypes and the whole BEEYONDERS' integrated solutions will be applied to the different use cases in WP7 (Case Studies) at the final stage, reaching TRL6, further fine-tuned and adjusted with the inputs from the validation campaign in the case studies. As a mean of assuring the successful achievement of target TRL6, the WPs time distribution (Gantt) has been designed in order to permit an overlap between the beginning of the technical developments with the testing stage in the lab scale and starting the case studies approximately at the midterm of the technological work packages in order to allow a further iteration of tuning these technologies while these are initially deployed on the case studies.

Validation-demonstration is organised in two main segments. The **1st segment** will occur within WP2 and begin with the definition of a **Testing Plan** (T2.2) for the solutions and their integration, according to the KPIs resulting from the design, i.e., the detailed planning and configuration of the tests needed to evaluate the performance of the solutions at two stages of development: **a) lab scale validation** of the individual solutions and of their conceptual integration at TRLs 4, and **b) validation of their solutions and their integration in relevant environment** (TRL5), this is, at a scale where the actual prototypes are working together in an integrated manner, being the Digital Twin the container of such integration, leaving the lab to work in test facilities and real interconnection at a level prior to field case studies. The **2nd segment** of validation will follow the same main scheme in WP7, beginning with the **planning of the validation campaigns in each of the case studies** and performing the validation at real scale to reach TRL6. This segment will test and implement in real environments all technologies developed, demonstrating they are feasible in big use cases of construction. In this segment, will be essential to have a very common, detailed and carefully methodology to follow in each use-case. This methodology will be defined at the beginning of the WP7. On the other hand,



a final assessment of results and the retrieving of added-value information will be performed at the end of this WP.

This information is represented in the next figure:

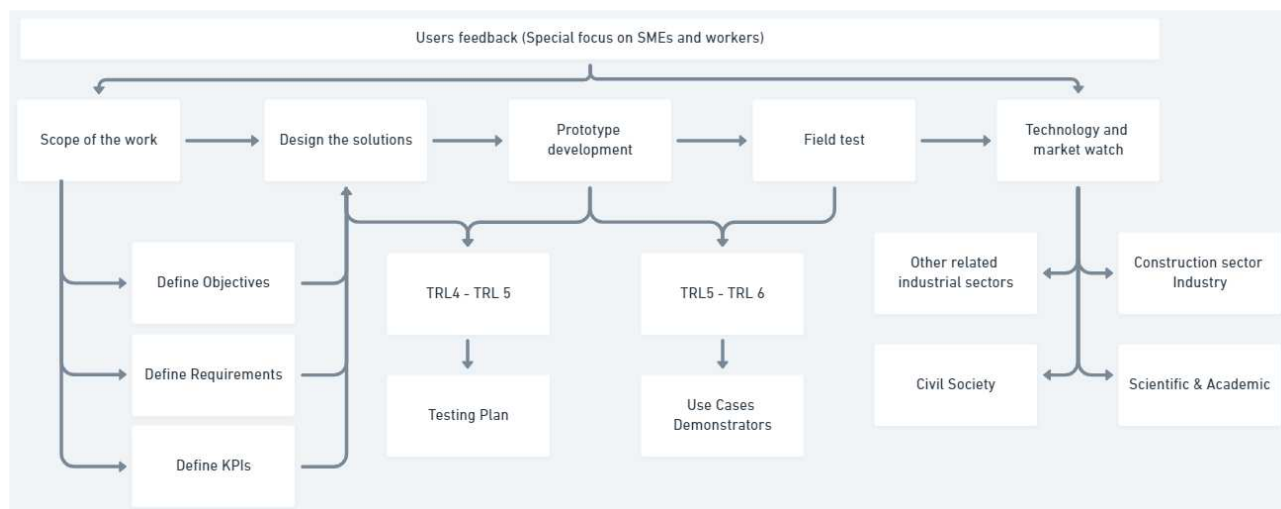


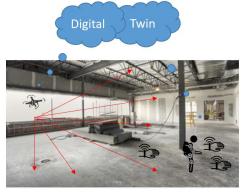
Figure 2: BEEYONDERS' Methodology

Use cases will be the final demonstrators of the breakthrough technologies after having been developed during the first half part of the project and will consist of 6 high-impact worksite typologies in construction. In this deliverable D2.1, we just indicate their description, because they will be described deeply in D2.2 and essentially, in WP7.

Table 1: BEEYONDERS' use-cases

BEEYONDERS' Use Cases			
TUNNEL CONSTRUCTION	Spain		
ROAD CONSTRUCTION	Italy		
MARITIME CONSTRUCTION	Spain	 	



MARITIME CONSTRUCTION – EU & JAPAN COLLABORATION	The Nederland's	
BUILDING CONSTRUCTION	Finland	
ROAD MAINTENANCE	Italy	



4. Impacts

Outcomes

As it was defined in the first chapter, Outcomes will be part of the results of the system BEEYONDERS. According to the GA, five specific outcomes with some potential and indicative Key Performance Indicators (KPIs) were proposed to monitor the success of the result. We consider them ‘potential’ because during the project, these can be modified if the technology development and implementation of the pace of the project considers it.

Outcome 1: Successful integration of the next breakthrough technologies: autonomous vehicles and human robot collaboration, additive manufacturing, diagnostics and monitoring and autonomous maintenance; derived from other industries in the construction sector.

This outcome will materialize in the previous 6 case studies integrating various breakthrough technologies in real construction sites.

Some KPIs proposed for:

- Autonomous vehicles: number of activities done per resources used, and operating time of machinery.
- Human Robot collaboration: average time to complete a task, failure rate completing a task, or accident rate completing a task.
- Additive Manufacturing: material utilization ratio, and number of workers for the same task.
- Diagnostics and monitoring: location and biometric parameters, range of communication, and number of optimized strategies.

Outcome 2: Demonstrate the impact of the use of these new breakthrough technologies on the efficiency of resources (raw materials, water etc.), the reduction of waste and embodied CO₂ emissions

Some KPIs proposed for:

- Autonomous vehicles: duration of the activity, energy consumption, environmental pollution, or reduction of congestions.
- Digital Twin: energy consumption, waste avoidance, relocations of material, or reduction of congestions
- Collaborative robotic devices: energy consumption, duration of the activity, and work-related failures
- Additive Manufacturing: LCA analysis, cost benefit analysis, and increased biodiversity of the marine life

Outcome 3: Demonstration of the safety of BT on a construction environment in cooperation with workers

Some KPIs proposed for:

- Autonomous vehicles: confined area avoidance, and pedestrian workers to equipment near-miss exposures



- Agent-based modelling (ABM): ABM risk indexes, and pedestrian workers to equipment near-miss exposures
- Additive Manufacturing: labor-intensive reduction, and formwork operations reduced

Outcome 4: Demonstrate a reduction of dependency for importing breakthrough technologies related to additive manufacturing, human robot collaboration or autonomous vehicles.

Some KPIs proposed are: New PhDs, scientific publications, patents, and new start-ups

Outcome 5: Increase the wellbeing of the construction workforce concerned.

Some KPIs proposed for:

- Exoskeletons: Musculoskeletal injuries, biomechanical loading support, and absenteeism reduction
- A wearable sensor platform: Real-time warnings, fatalities avoided, muscular strains, and training impact.

Apart from the previous Outcomes, BEEYONDERS will take into account other long-term outcomes regarding the specific destination of the Work Programme. Under the topic Twin Transition 01-12, we consider the next ones:

- **Accelerate the twin green and digital transition of the manufacturing and construction sectors.**
 - Reducing CO₂ in each technology and demonstrator. In a global way in the project, we have initially estimated an 11% reduction of CO₂
 - BEEYONDERS is fully focused on the construction sector to introduce BT to generate a positive transition to a more advanced and efficient construction sector.
- **Create a new green, flexible and digital way to build and produce goods [...]**
 - Construction sector produces several goods (types of infrastructure) for the use of citizens. BEEYONDERS will research on building in a more sustainable way, reducing the CO₂ emitted or embedded (using the right amount of material and resources, thanks to the optimization and automation of tasks).
- **Make the jobs of the humans working in the manufacturing and construction sectors more attractive and safer and point the way to opportunities for upskilling.**
 - BEEYONDERS will make construction jobs more attractive to construction workers by:
 - Introducing advanced technology that makes the sector more attractive to the youngest.
 - Developing advanced technology that allows machines to carry out the most dangerous and harsh jobs.
 - Generating learning materials and training courses of the new technologies developed, so that construction workers can increase their skills.
 - Achieving automatization in a highly dynamic environment as construction sites.



KERs

Regarding the Exploitation process, BEEYONDERS has defined some initial candidates to be Key Exploitable Results (KERs). These are:

1. A methodology to measure the impact of digital and new technologies in construction processes.
2. An autonomous / teleoperated wheel loader.
3. An autonomous drone tailored to flight in non-GPS areas and adapted to underground works.
4. An autonomous ground mobile platform for inspection and maintenance tasks of large areas.
5. Optimized and bio-compatible mortars adapted to 3D-printing for maritime ecosystems.
6. 3D printing equipment capable of working in vertical walls of caisson formworks for maritime construction.
7. An exoskeleton capable of assisting both the lower-back and the arms in a unique device.
8. Wearables integrated in Personal Protective Equipment for worker H&S and monitoring.
9. Construction Digital Twin platform and added value services.
10. Learning and training platforms incorporating virtual reality and connection with digital solutions.

Specific tasks and deliverables in the WP8 are going to be developed to identify the characteristics of these potential exploitable results, their Intellectual Property Rights (IPR), and business plans.

Even having defined these ones, it is possible that new KERs can be increased during the course of the project.

Results retrieved from the SYSTEM REQUIREMENTS survey

Entities and participants

To prepare this deliverable (D2.1) and the D2.2, the consortium has been involved in the realization of a survey which has focused on the expectations each member has, regarding the general objectives defined in chapter 2, the impacts of the project, and how to achieve them in a successful way.

The survey has been carried out through the tool 'Google Forms', sending a link to all members for retrieving their answers.

A high participation of the consortium in this exercise has been achieved, and this deliverable has been enriched with very valuable information. The next table shows the details of participation:

Table 2: Participants in survey

Entities and participants in the Survey			
ACCIONA	Carlos Martín-Portugués	José Luis Burón	Antonio Alonso
TECNALIA	Diego Zamora	Iván Villaverde	Nerea Tárrago
CAIDIO	Aku Willenius		
COBOD	1 person		



EBC	Fernando Sigchos Jiménez, Fernando Vespa, Elena Petrich
HIDROMEK	Ferhan Fiçici
FADA CATEC	Francisco Javier Pérez Grau
ICONS	1 person
SEABOOST	Matthieu Lapinski
PNO	1 person
HOLCIM	Qing Zhang
VTT	1 person

We can notice that in some fields is written “1 person” instead of a name, this means that he/she did not register his/her name due to the form included the option to add or not the identity of the respondent.

SYSTEM REQUIREMENTS survey results

Next, we show, general objective by general objective, several key questions related to each of them, asking for the opinion of partners, to support in the orientation of facing that objective.

O1: Set up the performance requirements for BEEYONDERS.

Table 3: Answers to Question O1.1

<i>Question O1.1: From the point of view of your role/activity as a partner of BEEYONDERS, how do you expect your contribution can impact positively in the reduction of wasted materials and the reduction of CO2 embodied in the processes of the Construction sector?</i>	
Answer 1.1.1	need to develop solutions with an at least equal CO2 impact or lower
A 1.1.2	N/A
A 1.1.3	In WP6 on additive manufacturing, we are leveraging caisson construction with 3D printing technology and ecological design, which allows us to save material use by putting the material at the right place, to reduce construction time, construction labor and to have more positive environmental impact by boosting biodiversity. Major contribution of Holcim will be on material scale, greener material, and fictionized material that bring biodiversity.
A 1.1.4	Using more energy efficient vehicles for the inspection/maintenance tasks.
A 1.1.5	Our contribution in this project is to build up an autonomous/tele-operated wheel loader. By autonomous systems, operator/human will be out of operation cycles. By this



	way, it will be possible to optimize the machine behavior during its work. This will help to reduce the CO2 emissions during the operation of the machine.
A 1.1.6	3D-printed technology allows to limit use of materials and concrete, especially in order to create marine habitats and eco-design of maritime infrastructures.
A 1.1.7	The use of aerial robots can help reduce waste by providing quick and frequent data to assess the state of the construction
A 1.1.8	3D printing construction only applies printed materials where needed. Freedom of design allows for optimised structures.
A 1.1.9	The tunnel use case foresees the cooperation between drones and autonomous/teleoperated machinery and platforms, with the support of the digital twin, in order to coordinate debris removal activities following the detonation. This cooperation can lead to a more efficient operation of the machinery the reduces its energy consumption and the CO2 emissions associated.
A 1.1.10	Definition of tailored business models and a thoughtful exploitation plan to facilitate the adoption and sustainability of the project results.
A 1.1.11	Icons activities under WP2 will not have a direct impact on the reduction of wasted materials and CO2 emissions.
A 1.1.12	Our contribution will enable making the concrete used in 3D printing of maritime infrastructure more homogeneous in quality, which reduces wasted concrete and unnecessary usage of cement in the material.
A 1.1.13	The management through Digital Twins allows a real-time control of the construction sites, which also results in a better knowledge of the elements manufactured, replaced and even of the waste generated or when the waste generating actions are executed. Likewise, construction automation reduces the labor force and consequently the transportation of workers to the site and the waste they produce on site. It also allows tasks to be performed in an optimized manner (through the DATA collected), i.e., faster, with fewer errors and without non-productive time, which reduces emissions in general.
A 1.1.14	EBC will contribute to this area in particular in the context of the two tasks we lead: • T8.5 - Liaison activities, raising awareness on the urgency of reducing material waste and CO2 emissions, targeting not only internally our national members, representing construction SMEs and crafts, but also a wide range of external stakeholders from the whole construction value chain, both at national and European level. • T5.4 - Training activities, coordinating the development of learning material addressing circularity, waste management, etc. The upskilling and reskilling of the construction workforce and attracting new talent are key to gather the number of competences needed in order to achieve the European ambitions in terms of environment, digitalization and health and safety.
A 1.1.15	As end user in BEEYONDERS with background in the field of 3 of the case studies proposed (Roads and buildings), my contribution will be focused on granting that the solutions proposed are realistic and compatible with low impact on current production processes but effective to reduce waste generation and CO2 emissions.



A 1.1.16	The use of digital twins allows to optimize the management of the information of a project so that coordination errors are avoided. The usual corrections of this type of deviations involve great waste of energy and materials.
A 1.1.17	I can contribute fostering the understanding of the objectives of the project and helping to propose good requirements aligned with the needs of the production in construction work sites but including those breakthrough technologies and improvements of methodologies in construction that have to prove the reduction of CO2 embodied.

Table 4: Answers to Question O1.2

<i>Question O1.2: How do you think your contributions to BEEYONDERS are going to impact in a higher efficiency of resources for construction?</i>	
Answer 1.2.1	This would be the main expected impact (to be monitored), targeting savings up to 50% of time
A 1.2.2	VTT's contributions support the wellbeing of the workers and thus improves overall efficacy and potentially reducing sick leaves.
A 1.2.3	By developing performing material for 3D printed caisson.
A 1.2.4	N/A
A 1.2.5	For construction industry, lots of earth moving machineries are used including wheel loaders and those construction areas (most of them) are dangerous sites. By autonomous systems, it will decrease the operation times, keep the operator away from those danger areas, increase the efficiency compared with the systems operated by humans.
A 1.2.6	Our contributions concerned more specifically the ecological design of future maritime infrastructures. Large scale 3D printers can allow to limit resources for eco-designed maritime constructions.
A 1.2.7	The use of aerial robots can help optimize resources in every aspect, by providing tools to take decisions actively based on real data
A 1.2.8	3D printing construction requires less labour than standard construction and the construction speed is greater.
A 1.2.9	The tunnel use case aims to reduce idle times between detonation of explosives and removal of debris. This shall have a direct impact on the global productivity of tunnel construction, and thus increase the efficiency of the resources (machinery, workers) involved in the process.
A 1.2.10	Creating a wide impact together with a suitable exploitation strategy and a realistic roadmap for enabling the commercialization of the project results.
A 1.2.11	Activities concerning the workers KPI (Task 2.4) will provide a measurement framework to assess the impact of the technologies on the workforce, considering technology acceptance and user experience. This will support the uptake of such technologies, therefore contributing to higher efficiency of resources in the sector.



A 1.2.12	Our contribution will enable the automated quality assurance and thermal control of concrete. The automation makes the process higher in efficiency requiring less resources in production.
A 1.2.13	As mentioned above, collecting meaningful construction site DATA in a centralized and usable form allows for better use of resources.
A 1.2.14	Aware of its environmental and social responsibilities, our network will provide input so as to bridge the gap between innovation and small construction companies. By testing and potentially adopting innovative tools and methods, activities on construction sites could be improved regarding time and energy consumption as well as safety, de facto leading to a better use of resources in construction.
A 1.2.15	Setting up (together with the partners involved) actual and detailed workflows for the different processes involved in the different case studies, to identify activities/tasks and processes that have real potential to reduce the consumption of resources.
A 1.2.16	We are going to rethink processes to carry out them in a more efficient way trying to reduce idle times, fuel or even materials. We are experts in construction and know where some bottle necks are.

Table 5: Answers to Question O1.3

Question O1.3: <i>How do you plan to contribute to the reduction of dependency for importing breakthrough technologies from outside Europe at the end of the project?</i>	
Answer 1.3.1	positively, by developing the right ecosystem of partnerships to address the whole value chain
A 1.3.2	By developing novel wellbeing and safety solutions for European level.
A 1.3.3	Materials are produced in Europe.
A 1.3.4	Developing local technologies on remote and autonomous operation of mobile robotic platforms.
A 1.3.5	It will not be an individual contribution according to our company. The success will belong to the project, BEEYONDERS. With that project, the solution for the requirements of the construction industry will be found internally (in Europe).
A 1.3.6	The large-scale 3D-printer used for the project is from EU and is one of most innovative in the world.
A 1.3.7	By the development, integration and refinement of novel algorithms and technologies, especially those related to indoor navigation of autonomous aerial robots
A 1.3.8	COBOD technology is developed and manufactured in Denmark.
A 1.3.9	The tunnel use case integrates technologies (drones, autonomous platforms, autonomous/teleoperated machinery, digital twin) provided by European partners. However, a more detailed analysis of the supply chain involved in the delivery of the different technology components of the use case (both hardware and software) is



	needed in order to evaluate more accurately the dependency on imports from outside Europe.
A 1.3.10	Boosting innovation activities within the EU and fostering the collaboration of European actors in key technological areas.
A 1.3.11	Our role in the development of these technologies, validating social well-being, health and safety of workers, will contribute to better product development and user experience, supporting the uptake of these technologies, increasing also the competitiveness of the technologies.
A 1.3.12	By implementing modern breakthrough technologies for automated quality assurance of concrete in Europe.
A 1.3.13	The establishment of a functional architecture or framework for the organized collection of data from robots, drones and other technologically disruptive devices on construction sites that are tested in the project, will allow to know and control their real performance and consequently improve them, as well as to make them understandable, accessible and manageable to the end-users through digital twin visualizations.
A 1.3.14	This technical point falls outside the expertise of EBC; however, by contributing to the validation and testing of innovation developed by European stakeholders that is SME-friendly, our network could help reducing the dependency from non-EU technology.
A 1.3.15	Participating in the required benchmarking of technologies, prioritizing those with developed and manufactures in Europe.
A 1.3.16	Many of the most breakthrough technologies are in Europe. One of the main problems is to put them together (to generate a real integration and deployment for construction use-cases), solve specific problems of this integration and testing the real impact of solving successfully different challenges in construction. In our case it is very important to define precisely the needs and requirements as an end user, and after that, to define how to measure the results based on hybrid methods like monitoring of productivity-savings variables and workers-managers surveys.

Table 6: Answers to Question O1.4

Question O1.4: Which KPIs do you consider and how do you plan to get them?	
Answer 1.4.1	defining the baselines in a fair mode, and monitoring the exact performance of our prototypes and the roadmap of improvement after this first experience, which is not always the most optimized one
A 1.4.2	Objective 6: KPIs: Worker's profiles (gender, age, country) / acceptance level / safety / productivity / feedback. O1.5: KPIs: Worker, user and value chain needs / Environmental - Social constraints / Technical constraints.
A 1.4.3	durability, CO2 emission, and biodiversity
A 1.4.4	Mainly the ones related to Outcomes 3 and 4.



A 1.4.5	The most important KPI is to build up a autonomous/tele-operated wheel loader.
A 1.4.6	Capacity to print large scale concrete units including ecological designs. Biocompatibility of 3D concrete allowing a standard colonization by marine life
A 1.4.7	Time to acquire data from the construction site, and make it available for the appropriate workers
A 1.4.8	Cost, Sustainability, Commercial viability
A 1.4.9	For the tunnel use case, the following KPIs could be defined: a) % reduction of idle time after detonation, associated to the use of drones, autonomous/teleoperated machinery and digital twin b) % reduction of energy consumption and embodied CO2 emissions associated to more efficient operation o autonomous/teleoperated machinery supported by drones and the digital twin.
A 1.4.10	For each of the BEEYONDERS results: - Market potential - Innovation readiness - Innovation management capacity - Exploitation/commercialization readability - Partners' availability, capacity, and willingness - Stakeholders, early adopters, and end users (potential customers) interest - Replicability capacity - Sustainability interest/capacity (maintenance, updates, compatibility, support, etc.) - Economic viability - IPR management
A 1.4.11	ICONS is involved in the development of worker KPIs. We consider that the economical, environmental, and technological KPIs are interlinked and therefore will be relevant for the development of workers KPIs.
A 1.4.12	Mainly have to be defined KPIs related to: O1.1: Framework scheme of BEEYONDERS BT: Requirements, Methodology and Impacts O1.2: Technical objectives and performance requirements of each project's solution O1.6: Standardization (identification of existing standards, regulation, and gaps) O2.1: Testing facilities definition and 6 demonstration case-studies in which technologies will be validated O2.2: Methodology for each BT performance analysis and deployment and demonstration in use cases O5.1: DT design, architecture, interfaces, common data formats and communication protocols defined, developed, tested, and demonstrated O5.2: AI-capabilities integrated with DT developed, tested, and demonstrated to assess the H&S of workers in collaborative environment with the BT O5.3: AI-capabilities integrated with DT developed, tested, and demonstrated to assess the productivity & planning of the construction site with the BT O5.4: Integrate LCA&LCC KPIs for analyzing all project developments based on BT design and defined
A 1.4.13	- The KPIs on the acceptance level of Beeyonders technologies by construction workers and companies (especially SMEs) and on the needs of the value chain - The KPIs on the audiences reached by training activities and material, with feedback from users on the challenges and competences acquired.
A 1.4.14	Real-time warnings and fatalities avoided
A 1.4.15	(1) GWP; (2) Energy demand; 1 and 2 measured following LCA principles. (3) Increase of productivity (Productivity in the building case study using exoskeletons verified if feasible by MTM (Motion Time Measurement as world standard for industry shopfloor



analysis and optimization and that could be suitable for on-site construction activities). In the other case studies, it will be measured and compared with traditional production volume, cost per unit and times indicators. (4) Safety aspects: Incidents and accidents rate etc. Psychosocial and ergonomic risk decrease, and perception should be also considered, gathering information through devoted surveys in order to get measurable results. (This will be mostly relevant to the tunnels and buildings case studies). (5) Financing costs measured following LCC principles. Planning and investment should be proportioned compared to the expected benefit. For this and all indicators in BEEYONDERS, system boundaries must be defined accordingly to reach the promised impact.

O2: Define and set up testing protocols at TRL 4 and 5, and demonstration plan at TRL6

Table 7: Answers to Question O2.1

<i>Question O2.1: Design-Science and Human-Centered design are applied to the developments proposed in BEEYONDERS. Did you know these methodologies before this project? Do you think these are the adequate? Is there any methodology would you propose apart from these mentioned?</i>	
Answer 2.1.1	No
A 2.1.2	Methodologies are known and adequate.
A 2.1.3	no
A 2.1.4	I'm not familiar with those methodologies.
A 2.1.5	We are aware and have already used these methodologies, we thought that this knowledge will be enough.
A 2.1.6	Biomimicry / Bioinspiration could be interesting to study / mentioned in BEEYONDERS.
A 2.1.7	I was not familiar with human-centered design
A 2.1.8	I have heard about these methodologies before, and I have seen them applied to some extent in a couple of previous European projects. In principle both methodologies seem adequate for the project, but it is important that all partners get familiar with them so that their implementation is effective. Agile methodologies could also be assessed for development of all or part of the BEEYONDERS technologies (specially software components)
A 2.1.9	Co-design and co-creation approaches involving stakeholders from the whole BEEYONDERS value chain could also bring benefits to the project in terms of creating solutions attractive for the end users.
A 2.1.10	We are aware of such approaches, and we believe they are appropriate for achieving the project's goals. Task 2.4 will also adopt a user-centered approach to assess the technologies developed.



A 2.1.11	No, I don't know these methods before the project.
A 2.1.12	Yes, but design thinking must prevail in such technical domains, as it combines user needs with the feasibility of having a product for those needs. Human-centered design incorporates user needs and feedback to guide the developments but does not by itself guarantee a viable solution.
A 2.1.13	Although this technical point is traditionally outside the EBC's expertise, we were aware of these methodologies prior to this project and are glad to have now the opportunity to expand our knowledge in this area, with a view to possibly transferring it also to our national members and construction SMEs.
A 2.1.14	No, I didn't know about these methodologies
A 2.1.15	Yes, as part of the related ISO standard. Yes, they are adequate as users will be involved throughout design, development and refinement (thank you to the demonstration activities planned) of the different solutions proposed.
A 2.1.16	No, I didn't know these methods before the project.
A 2.1.17	I heard about Human-Centered design. I understand the main focus of these methodologies and I think it is important to use them with balance to improve the comfortability in services and products improving the experience and efficiency of people while perform their job. Regarding other methodologies, I think that "Project Management Professional" (PMP) is very generic for any type of project including construction, giving very good results, and SCRUM is very useful for enhancing productivity in other sectors like programing, but it could be adapted to the characteristics of construction.

Table 8: Answers to Question O2.2

Question O2.2: Do you consider that to apply an iterative approach during the project (2 or 3 iterations) is a good strategy to face BEEYONDERS?	
Answer 2.2.1	yes
A 2.2.2	Yes.
A 2.2.3	Yes
A 2.2.4	The strategy is adequate.
A 2.2.5	Ecological studies are long, and it seems difficult to readapt the strategy if the first one show negative results. But in others cases, the strategy looks adequate.
A 2.2.6	Sure, I think an iterative and incremental development approach is very appropriate in a project like BEEYONDERS, so we can adapt to potentially unforeseen needs.



A 2.2.7	The strategy is adequate, but it is important to define how this monitoring will be implemented, it may require periodic technology watch, interviews with stakeholders, etc. in order to get early feedback for adaptation of BEEYONDERS technologies.
A 2.2.8	Yes, it is important to have an eye on related technologies and approaches, as well as on competitors and other breakthrough solutions to be able to provide at the end of the project market attractive solutions which are competitive and sustainable.
A 2.2.9	The proposed strategy is adequate, because it allows for a faster and cost-effective development, incorporating a continuous feedback loop between technology developers and end-users.
A 2.2.10	Yes. The only way to understand, which is the basis for improving, the operation and performance of complex systems, such as robots, etc., operating in demanding environments, such as construction sites, is by collecting operational data continuously and centrally to be properly analyzed and visualized.
A 2.2.11	We believe that constant monitoring of technologies will be crucial in order to adapt all that is necessary, especially in view of their acceptance by construction companies and workers. Technologies uptake will only happen if construction SMEs see a pragmatic added value for their daily construction activities.
A 2.2.12	Yes, I think it is important to keep the technologies monitored in order to better understand the possible limitations and trying to overcome them
A 2.2.13	Yes, refinement would be crucial during the whole project to reach the desired and ambitious impacts

03: Perform standardization activities

Table 9: Answers to Question O3.1

Question O3.1: Are you aware about any restriction / challenge related to any technology regarding the current standards, both in your country or European domain?	
Answer 3.1.1	No
A 3.1.2	yes
A 3.1.3	GDPR issues should be noted.
A 3.1.4	no
A 3.1.5	There are currently very few technology standards, as it is a still developing sector.
A 3.1.6	For construction sites, there are not too many standards to describe the use of the construction machineries. In order to create new standards and road map, the data, produced in this project or from the machine, should be shared. The new regulation is being produced with the name of "Data Act" and it will be directly related to the data produced on the machine. Definitions and rules will be challenge for this project.



A 3.1.7	In our case, immersing artificial reefs can be associated to regulations permits depending on the countries, especially outside of marinas and ports.
A 3.1.8	Yes, aerial robots in outdoor environments are subject to regulations at EU level. For indoor environments, they should comply with the health & safety guidelines from the owner of the facilities
A 3.1.9	I am not aware yet of any standard-related restriction that may affect the work that I will carry out in the project
A 3.1.10	Not at this point of the project, but it is important both to respect restrictions/limits due to regulation and commercial licenses, as well as to create solutions that maximize compatibility and reusability (for example, by using existing standards, and/or contributing to them).
A 3.1.11	Unable to provide this information.
A 3.1.12	There is no legal regulation for robots, let alone for their use on site, i.e., who is responsible for the work they perform, their interaction with people, etc.? If they use special materials for their work (mortars for 3D printing, etc.), are they covered by regulation or are they the responsibility of the designer or contractor? There is a lot of work to be done on all of this, which in itself is one of the aspects that makes the construction industry less open to technological innovations.
A 3.1.13	SMEs participation to standardization is very limited, especially in the international level. As such, the standards developed are not adapted to their needs, and as such not widely applied by them. For instance, in the world of Additive Manufacturing, large, international companies are playing an increasingly important role. Smaller companies do not have the capacity to foresee a representation in these organs, so in reality we see that, at this strategic decision-making level, large companies and national bodies are the de facto authors of the new standards. This in contrast with the relative importance of SMEs in this sector, and more specifically the importance of SME's in bringing true innovation to the sector and to other industrial activities. As such, SME access to this market gets restricted, because certain practices are excluded from the standards
A 3.1.14	No
A 3.1.15	No, but attention must be paid to safety and environmental standards to avoid barriers to future implementation
A 3.1.16	No.
A 3.1.17	No, at the moment.



Table 10: Answers to Question O3.2

Question O3.2: Do you agree for each main technology used in BEEYONDERS, an analysis of existing standards should be done to ensure a development of technologies at the end of the project is built in such way that will be possible to integrate it in a future proposal of the updated corresponding standard?	
Answer 3.2.1	Yes
A 3.2.2	yes
A 3.2.3	We agree.
A 3.2.4	yes
A 3.2.5	Yes, we agree. There should be a lot of new standards when we think about the sector and machine working area.
A 3.2.6	Definitely!
A 3.2.7	Yes. It is important though to try to identify as early as possible which technology developments within BEEYONDERS have a higher potential for contributing to new or existing standards.
A 3.2.8	Indeed, just indicated that in the previous question.
A 3.2.9	We believe meeting existing standards is important for the market uptake of technologies beyond the project.
A 3.2.10	Absolutely, otherwise they will never be regulated (i.e., usable) solutions in this type of environment, where worker safety and quality of workmanship are a top priority.
A 3.2.11	In principle, we agree with this approach. However, we should be careful not to limit the possibilities for innovation that the standards offer.
A 3.2.12	Yes, I agree
A 3.2.13	Yes, with continuous monitoring the information obtained from the processes is maximum. This is a key aspect to optimize the designs based on actual needs.
A 3.2.14	Of course, I totally agree.



O4: To develop an international cooperation with Japan

Table 11: Answers to Question O4.1

	Question O4.1: Do you or your entity have any contact with Japanese actors (universities, technological centers or companies) which would be useful to generate a good starting point for developing a EU-JP solutions ecosystem for BEEYONDERS and further initiatives?
Answer 4.1.1	maybe
A 4.1.2	VTT's Beeyonders team doesn't have direct connection to Japan, but we can utilize VTT organisations networks to find out if there's any, if needed.
A 4.1.3	Yes, we are in contact with Prof. Maruyama (Nagoya University and Tokyo University), working on concrete durability and climate change.
A 4.1.4	We have a year's long relationship with some Japanese robot manufacturers (Kawada, Fanuc), but their products are beyond the scope of Beeyonders.
A 4.1.5	Our company has some suppliers located in Japan; we have conducted too many projects with Japanese.
A 4.1.6	There is a "French Institute of Japan" involved in artificial reefs technologies. Japan is a specialized country in large scale artificial reefs and collaborations could be of great interest.
A 4.1.7	Not directly, but through Anibal Ollero from the University of Seville I guess there could be some contacts at academic level
A 4.1.8	Possibly, this question should be directed to our General Manager, Henrik-Lund Nielsen.
A 4.1.9	My company used to have periodical contacts with a Japanese construction company. Maybe this can be explored for the EU-JP collaboration.
A 4.1.10	PNO has contact with the EU-Japan Centre for Industrial Cooperation (https://www.eu-japan.eu/) that may be useful for establishing direct links with Japanese actors.
A 4.1.11	We do not have any Japanese contacts in the sector.
A 4.1.12	No
A 4.1.13	Not beyond those related to the preparation of the proposal.
A 4.1.14	We do not have contacts with Japanese actors yet, but we will be happy to provide support in identifying and collaborating with Japanese stakeholders, focusing in particular on the EU-Japan collaboration strategy.
A 4.1.15	We are not in contact with any Japanese actors
A 4.1.16	Yes, if necessary ACCIONA could support the consortium in the selection of additional Japanese actors to be involved in BEEYONDERS



A 4.1.17	Not related to the subject of the proposal.
A 4.1.18	We had some contact in the past. I can try to recover it.

05: To design and implement Market analysis, Dissemination, and Exploitation Plans

Table 12: Answers to Question 05.1

	<i>Question 05.1: From your perspective and background, could you provide two ideas (examples) of valuable exploitable results you would expect to get from the project?</i>
Answer 5.1.1	Prototype with LCCA analysis vs the reference case
A 5.1.2	1. Increasing the maturity of the VTT's breakthrough technology to enable future exploitation of the BT for European industry. 2. New initiatives for upcoming EU and national projects.
A 5.1.3	economical and technical feasibility of 3d printing caisson structure; construction material to bring biodiversity
A 5.1.4	Outdoor tele-operation and autonomous navigation technologies for mobile robots.
A 5.1.5	First one is to improve our project management methodologies by cooperating with European companies. The other one is to integrate our companies in new projects by means of collaborations in BEEYONDERS.
A 5.1.6	Ecological index calculated from marine colonization of 3D-concrete tiles (%cover, diversity, abundance) Comparison of colonization between different concrete formulae (standard, 3Dprinted), different pilot sites...
A 5.1.7	One would be GNSS-free autonomous navigation for aerial robots in confined spaces, another could be the fast and remote monitoring of road signaling using aerial robots
A 5.1.8	Marine friendly 3D printable construction materials, 3D construction design and process for marine habitat systems
A 5.1.9	A digital platform for management of tunnel construction (coordination of resources, monitoring, etc.), capable of integrating drones and autonomous/teleoperated machinery
A 5.1.10	Not specifically at this point of the project. Our aim is to analyze all the KERs mentioned in the proposal to assess that they are actually "key exploitable results", as well as other results that can be considered as KERs during the project, and for them, go in detail to define suitable business models and a suitable exploitation strategy and sustainability plan.
A 5.1.11	It could be very useful to develop a standardized methodological framework to measure worker's acceptance that could be applied and replicated in future similar projects.



A 5.1.12	Automated thermal control of concrete in production.
A 5.1.13	- Drones and autonomous machinery developed and tested on the use-cases - Data centralization and visualization in digital twin adaptable to different on-site robotics solutions
A 5.1.14	- All project findings illustrating the positive impact that Beeyonders technologies can have in terms of improving efficiency and safety in the construction sector, in a format that can be easily disseminated at national and European level - Easy-to-use and SME-friendly training material on Beeyonders technologies and emerging green and digital skills needs of construction companies
A 5.1.15	Two exploitable results could be the wearables devices used to monitor the workers and an exoskeleton used to assist the operators during high-load tasks
A 5.1.16	Coordinated ground and aerial vehicles working collaboratively with workers. Exoskeletons and wearables for integrated support for worker H&S monitoring.
A 5.1.17	A robust digital information architecture that includes digital twins and communication protocols with the different systems.
A 5.1.18	1) Measurable results to be shown to the direction demonstrating it is possible to include autonomous machinery in tunnels to improve productivity 2) Demonstration that 3D printing with mortars is possible and good structural and environmental results are obtained.

Table 13: Answers to Question O5.2

Question O5.2: Do you know any related forum, workshops or meeting related to BEEYONDERS' technologies?	
Answer 5.2.1	No
A 5.2.2	yes
A 5.2.3	For now, not known.
A 5.2.4	RILEM International Conference on Digital Fabrication with Concrete, International Conference on 3D Construction Printing
A 5.2.5	Multiple forums related to autonomous driving.
A 5.2.6	Yes, there are some related forums, exhibitions, and workshops in those exhibitions, such as "Advanced Autonomous and Robotics Forum" and "Autonomous Mobility Forum".
A 5.2.7	SER - World Conference on Ecological restoration CARAH - International Conference on Artificial Reef and Related Aquatic Habitats



A 5.2.8	Regarding aerial robotic technologies, conferences, and events such as ICRA, IROS, ICUAS, SSRR, Iberian Robotics Conference, ERF...
A 5.2.9	In Spain: Construmat, Construyes!. In Germany: BAUMA. In UK: Digital Construction Week
A 5.2.10	PNO has connection with different technology, industry, and building associations that may be interesting to contact during the project, and also to organize joint events. For example: European Convention for Structural Steelwork (www.steelconstruct.com), CEMBUREAU - The European Cement Association (https://www.cembureau.eu/).
A 5.2.11	ICONS is currently working on the collection of inputs to feed the communication and dissemination plan. Any information related to forums or sector events will be communicated.
A 5.2.12	Construction Robotics Journal Construction Robotics Forum
A 5.2.13	We can mention for example: • Small Business Standards (SBS) Construction Forum (EBC is founder and member of SBS) • The EU partnership Built4people (EBC sits in the Board) • ECCREDI - EU Council for Construction Research, Development & Innovation – meetings (EBC is a member) • Conferences and events such EUSEW – European Sustainable Energy Week, EVSW – European Vocational Skills Week, Sustainable Places, where EBC presented project findings over the last few years • EU-OSHA agency workshops on health and safety in the digital era
A 5.2.14	SHO International Symposium on Occupational Safety and Hygiene. European Energy Efficiency Conference IoT World Conference Transport Research Arena Transport Research Board (USA)
A 5.2.15	RIMA Network. Robotics for Inspection and Maintenance.
A 5.2.16	ERF 2023

Table 14: Answers to Question O5.3

Question O5.3: <i>Do you think exploitable results from BEEYONDERS can be transferred to the market in a short or medium term?</i>	
Answer 5.3.1	A priori mid to long term transfer, as certification needs to be addressed
A 5.3.2	If GDPR issues and user acceptance can be sorted out on practical exploitation level, then yes. Solutions supporting workflow and wellbeing (efficiency) are closest to exploitation.
A 5.3.3	medium term



A 5.3.4	Yes. We currently have some clients interested in such technologies.
A 5.3.5	Those results will be transferred to the market in medium term.
A 5.3.6	Yes, depending on the ecological results
A 5.3.7	Yes, with the appropriate companies that could offer this kind of services
A 5.3.8	Yes
A 5.3.9	Due to the low TRL targeted by BEEYONDERS, transfer to market in the short/medium term seems difficult, except perhaps for certain technologies (e.g., digital twin) that may reach higher TRL and that have already been adopted to some extent by the construction sector.
A 5.3.10	Considering that the project is a Research and Innovation Action, it should be difficult to take to the market most of the project results in the short term. However, it is surely possible to commercialize some specific results in the short/medium term.
A 5.3.11	The transfer of BEEYONDERS KERs on the short and medium term will depend on the final TRLs achieved in the project, and proven business cases. There is a market need for better technologies addressing worker's safety and wellbeing, as well as increased efficiency in the industry processes. These are strong drivers for innovation in the sector, that could create business opportunities for the companies.
A 5.3.12	Medium term
A 5.3.13	Not in the short term but in the medium term.
A 5.3.14	This technical point falls outside EBC's traditional expertise.
A 5.3.15	In a medium term as they will need lots of tests and maintenance before going to the market
A 5.3.16	Short. Some of the developments included in the project will have in 1-2years a smaller time to market due to the high speed of technology development. Moreover, in my opinion, the TRL by the end of the project will be closer to TRL7 than the expected TRL 6.
A 5.3.17	Medium term.
A 5.3.18	In medium term.



5. Conclusions

BEEYONDERS is going to face the main challenges in construction by developing and integrating breakthrough technologies from other industrial sectors to achieve technological sovereignty in construction.

The most important determining factors of the project, its requirements and results can be defined as a system (the project) with inputs and outputs, which facilitates its simplification. We conclude that the BEEYONDERS' system, through the actions of its members (consortium), will be capable of turning challenges (inputs) into results (outputs).

This deliverable D2.1 has been conceived to establish the general requirements, outcomes and impacts expected from BEEYONDERS to generate a common framework, challenges and understanding of the general objectives of the project.

BEEYONDERS have 10 general objectives with sub-objectives to be achieved at the end of the project.

The Methodology designed to carry out BEEYONDERS allows to begin the project with technologies at TRL4 and reach TRL6, using an iterative process: from Concept/Design to Lab/Test, and from Lab/Test to Use-case/Demonstrator.

The Outcomes of the project and several potential KPIs to measure them are well defined. Similarly, the expected KERs.

The Survey carried out asking for opinions regarding how to face general objectives and how to achieve outcomes has been a success, with an important participation and with very notable contributions to consider. These results will be used during the project to guide developments and implementation in Use-cases, and fundamentally, they will serve to determine the potential impact of the project.

From the results of the Survey, we can conclude that, at this phase, all consortium members have a clear idea about what they have to do, where the potential barriers are, and a good set of suggestions for each questions contributes to anticipate potential risks.

