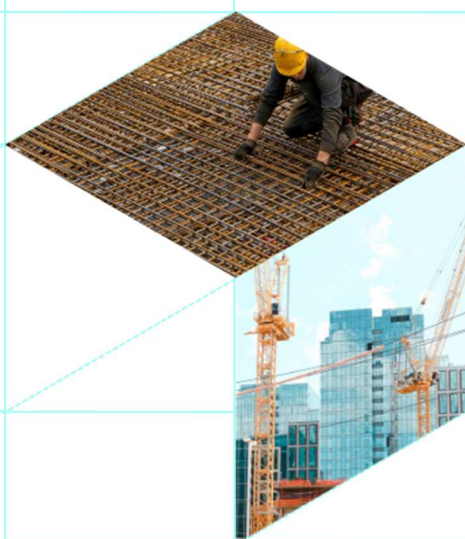




**BEEYONDERS**

# **Document title: Technology Market Outlook Report**

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## **D8.3: Technology Market Outlook Report WP 8, T 8.3**

**Authors: Edgar Valverde (PNO); María Jiménez (PNO)**



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# Technical references

|                            |                                                                                                                   |
|----------------------------|-------------------------------------------------------------------------------------------------------------------|
| <b>PROJECT ACRONYM</b>     | BEEYONDERS                                                                                                        |
| <b>PROJECT TITLE</b>       | Breakthrough European tEchnologies Yielding cOnstruction sOvereignty, Diversity & Efficiency of ResourceS         |
| <b>PROJECT COORDINATOR</b> | Antonio Alonso Cepeda<br><a href="mailto:antonio.alonso.cepeda@acciona.com">antonio.alonso.cepeda@acciona.com</a> |
| <b>PROJECT DURATION</b>    | June 2022 – November 2025 (42 months)                                                                             |

|                                     |                                                      |
|-------------------------------------|------------------------------------------------------|
| <b>DELIVERABLE NO.</b>              | D8.3                                                 |
| <b>DISSEMINATION LEVEL*</b>         | PU                                                   |
| <b>WORK PACKAGE</b>                 | WP 8 - Dissemination, Communication and Exploitation |
| <b>TASK</b>                         | T8.3 – Technology trends and Market watch            |
| <b>LEAD BENEFICIARY</b>             | PNO                                                  |
| <b>CONTRIBUTING BENEFICIARY/IES</b> | All partners                                         |
| <b>DUE DATE OF DELIVERABLE</b>      | 30 November 2023                                     |
| <b>ACTUAL SUBMISSION DATE</b>       | 30 November 2023                                     |

\* PU = PUBLIC

PP = RESTRICTED TO OTHER PROGRAMME PARTICIPANTS (INCLUDING THE COMMISSION SERVICES)

RE = RESTRICTED TO A GROUP SPECIFIED BY THE CONSORTIUM (INCLUDING THE COMMISSION SERVICES)

CO = CONFIDENTIAL, ONLY FOR MEMBERS OF THE CONSORTIUM (INCLUDING THE COMMISSION SERVICES)

| V   | DATE       | BENEFICIARY | AUTHOR                        |
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## List of Abbreviations

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| Abbreviations | Definition                               |
|---------------|------------------------------------------|
| AI            | Artificial Intelligence                  |
| AR            | Augmented Reality                        |
| BAS           | Building Automation Systems              |
| BIM           | Building Information Modelling           |
| CAD           | Computer-Aided Design                    |
| CAGR          | Compound Annual Growth Rate              |
| CDW           | Construction and Demolition Waste        |
| CEN           | European Committee for Standardisation   |
| DESI          | Digital Economy and Society Index        |
| DIH(s)        | Digital Innovation Hub(s)                |
| EC            | European Commission                      |
| ECB           | European Central Bank                    |
| EIB           | European Investment Bank                 |
| EU            | European Union                           |
| FTE(s)        | Full Time Equivalent(s)                  |
| GDP           | Gross Domestic Product                   |
| GDPR          | General Data Protection Regulation       |
| GIS           | Geographic Information System            |
| ICT           | Information and Communication Technology |
| IoT           | Internet of Things                       |
| IPO           | Initial Public Offering                  |
| IT            | Information Technology                   |
| MS(s)         | Member State(s)                          |
| PE            | Private Equity                           |
| R&D           | Research & Development                   |
| R&D&I         | Research, Development and Innovation     |
| RoI           | Return of Investment                     |
| SMEs          | Small and Medium-sized Enterprises       |
| TEF(s)        | Testing and Experimenting Facility(ies)  |
| VC            | Venture Capital                          |



# Executive Summary

---

BEEYONDERS offers a distinctive prospect for the European construction sector to leverage the extensive employment of AI, automation, and digitalisation. These innovations will seamlessly integrate into the current technology available in the market to enhance construction processes, fostering efficiency and sustainability. Simultaneously, integrating these initiatives will create a work environment that prioritises the health and safety of sectorial workers.

This report aims to foster a shared understanding of the business potential of each of the BEEYONDERS' Use Cases. This information will be reported via:

- Thorough analysis of the current situation of the related construction markets.
- Studies of the construction market's projection related to the chosen Use Cases.
- The advantage of BEEYONDERS' technology to fulfil the market demand.
- The R&D&I trend recorded from the innovation formulation to the market solutions.
- The already available alternative technologies in the current market and their players.

The analysis has been performed using the methodologies and approach part of the Intellectual Property the PNO Group R&D Advisory Services presented in this document and combined the usage of dedicated tools and desktop research.



# 1. Content of the report

## 1.1. Scope of the report and relation to the other task

The primary objective of this report is to enhance the joint understanding of the strengths and weaknesses of the project's business cases. In doing so, we will provide a comprehensive overview of the current state of the selected and relevant markets compared to the technological development of the project.

Also, leveraging on previous insights and efforts to classify and identify the key players and the associated value-chains (as reported in the Deliverable D8.2 - Innovation Ecosystem and Stakeholders Map), further data will be collected to provide valuable information to shedding light on the criteria for partners seeking to enter the associated market successfully in the following part of the project.

## 1.2. General methodology outline and connection to other tasks

**Bottom-up Data Driven approach:** PNO has looked at the innovation landscape holistically, looking at a mixed scoreboard of different drivers defining private and public investments in R&D and on the project-specific markets, forming our insights' foundation. A mix of proprietary (i.e. Wheesbee<sup>1</sup>) and trusted private data sources have been used in addition to necessary public sources for data mining.

**Top-down validation:** PNO will seek input and insights from our esteemed project partners. This will finally lead to preparing and executing interviews from selected external stakeholders to enrich the insights interpretation and understanding, which will be performed later in the project during Task 8.3.

This collaborative effort ensures that market insights are comprehensive and informed in the end, giving PNO and the consortium the knowledge to make strategic business decisions and tap into new opportunities.

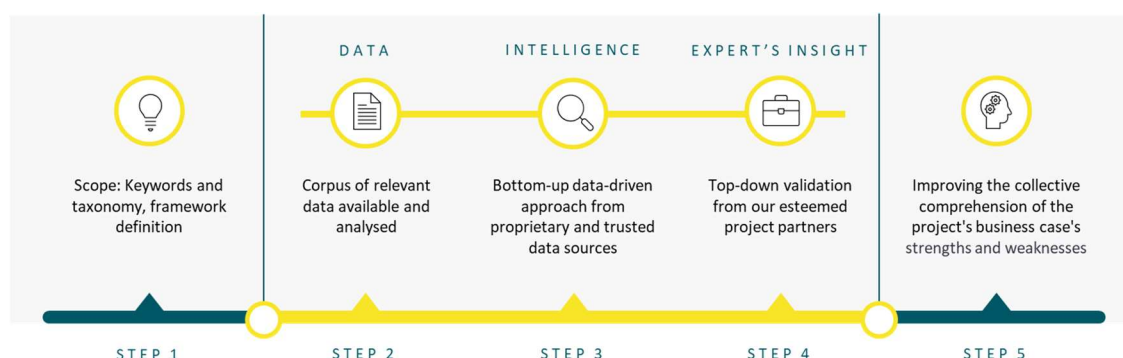


Figure 1: Methodology Concept

<sup>1</sup> Wheesbee, <https://app.wheesbee.eu/>



## 2. BEEYONDERS Business Potential

According to the study performed by Oxford Economics in 2021, *the global construction industry is predicted to contribute to economic growth and recovery after the COVID-19 pandemic*, with an expected output of €12.56 trillion<sup>2</sup> by 2025<sup>3</sup>. An updated study by the same entity suggests an increasing value of over €3.96 trillion<sup>4</sup> compared to the result in 2022, and over the next 15 years, it will reach up to €13.12 trillion<sup>5</sup> by 2037<sup>6</sup>.

While the mentioned observation keeps the prediction moderate, several other sources suggest *a more optimistic growth of CAGR from 5.5 to 6.6% for a shorter forecasting period up to 2032*. The research performed by Expert Market Research with 2023 as its base year, for example, predicted a growth of up to €22.57 trillion<sup>7</sup> by 2032<sup>8</sup>. The disparity between these research studies arises due to the differences in their data collection methodologies: the initial study covers forecasts for all major construction and engineering markets globally, while the other calculates the market for all sizes of construction contracts, inclusive of all kinds of end-use sectors, both public and private.

Maintaining an inclusive perspective, both observations from The Business Research Company<sup>9</sup> and Research and Markets<sup>10</sup> agree on the prediction of a 5.5% CAGR from 2022 to 2027. Furthermore, they anticipate a subsequent boost in growth from 2028 to 2032, projecting a 6.6% CAGR, offering a monetary market value of up to €24.44 trillion<sup>11</sup> at the end of the forecast period. Another additional analysis conducted by PR

<sup>2</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023. (1 USD = 0.9437 EUR)

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>3</sup> Oxford Economics. (2021). *Future of Construction: A Global Forecast for Construction to 2030*. Retrieved 2023.

[https://resources.oxfordeconomics.com/hubfs/Future%20of%20Construction\\_Full%20Report\\_FINAL.pdf](https://resources.oxfordeconomics.com/hubfs/Future%20of%20Construction_Full%20Report_FINAL.pdf)

<sup>4</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023. (1 USD = 0.9437 EUR)

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>5</sup> Ibid.

<sup>6</sup> Oxford Economics. (2023). *Global Construction Futures*. Retrieved 2023.

<https://www.oxfordeconomics.com/resource/global-construction-futures/>

<sup>7</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023. (1 USD = 0.9437 EUR)

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>8</sup> Expert Market Research. (2023). *Global Construction Market Growth, Size, Outlook, Forecast: By End Use: Commercial, Residential, Industrial, Education and Research, Medical and Healthcare, Others; Regional Analysis; Market Dynamics: SWOT Analysis, Porter's Five Forces Analysis; Competitive Landscape; Key Trends and Developments in the Market; 2024-2032*. Retrieved 2023.

<https://www.expertmarketresearch.com/reports/construction-market>

<sup>9</sup> The Business Research Company. (2023). *Construction Market 2023 – By Type of Construction (Buildings Construction, Heavy and Civil Engineering Construction, Specialty Trade Contractors, Land Planning and Development), By End-Use Sector (Public, Private), By Type of Contractor (Large Contractor, Small Contractor), and by Region, Opportunities, and Strategies – Global Forecast to 2032*. Retrieved 2023.

<https://www.thebusinessresearchcompany.com/report/construction-market>

<sup>10</sup> Research and Markets. (2023). *Construction Global Market Opportunities and Strategies To 2032*. Retrieved 2023.

<https://www.researchandmarkets.com/reports/5895047/construction-global-market-opportunities>

<sup>11</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023. (1 USD = 0.9437 EUR)

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)



Newswire aligns with a CAGR of 6.1%<sup>12</sup> throughout the observation period, culminating in an anticipated total of €24.56 trillion<sup>13</sup> after the forecast. The last three studies use the same year as their base prediction year, showing **the global construction market value of €13.58 trillion, which equals 14.2% of the worldwide GDP in 2022.**

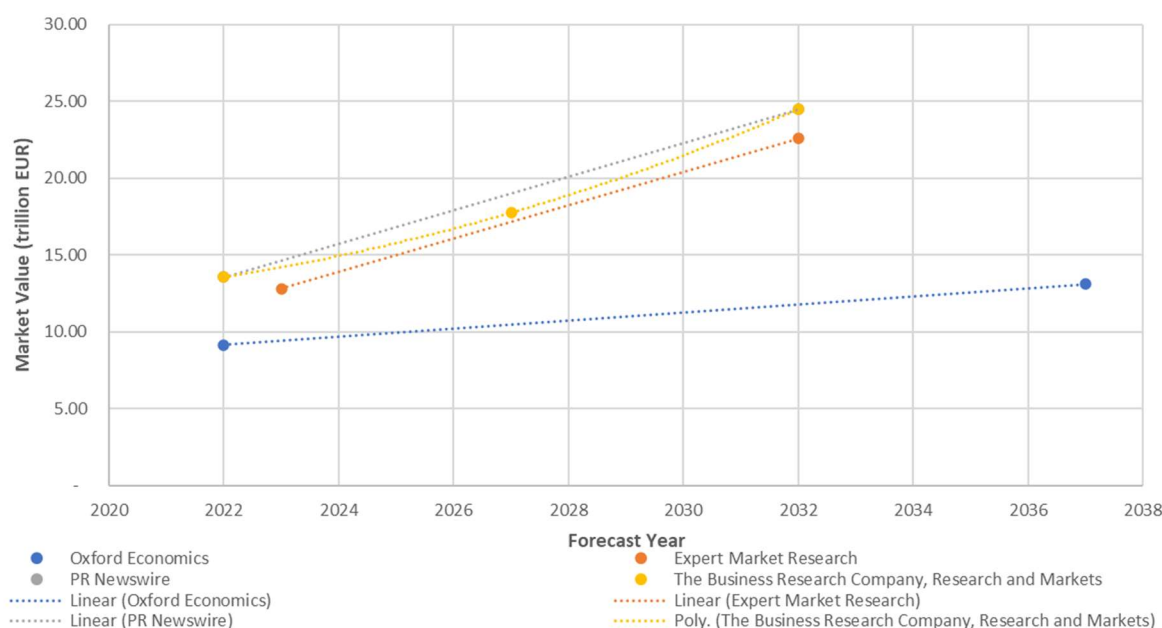


Figure 2: Global Construction Sector Forecasts (references integrated in text above).

As shown in the graph above, the forecast studies vote for optimistic linear growth in the global construction sector, whether in the big players' playground or the collective of all players. As for more detailed information about the geographic contributions, China, the United States, and India are the superpowers in construction markets that will mainly drive this growth<sup>14</sup>. Up to 70% of the construction work completed in the next 15 years will be performed by the world's top 10 construction markets, while the top-growing construction markets in prediction are the Philippines, Vietnam, Malaysia, and Indonesia<sup>15</sup>. This rise in demand is the result of the increase in the government's infrastructure development expenditure globally, the expanding global

<sup>12</sup> PR Newswire. (2023). Global Construction Industry Forecast - Market Size, Growth Rate and Leading Region, By the Global Market Model. Retrieved 2023.  
<https://www.prnewswire.com/news-releases/global-construction-industry-forecast---market-size-growth-rate-and-leading-region-by-the-global-market-model-301875304.html>

<sup>13</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.  
[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>14</sup> Oxford Economics. (2023). Global Construction Futures. Retrieved 2023.  
<https://www.oxfordeconomics.com/resource/global-construction-futures/>

<sup>15</sup> Ibid.



popularity of green construction and green economy<sup>16</sup>, the rise of industrialisation<sup>17</sup>, the growing numbers of smart cities, and the ascending flow of urbanisation<sup>18</sup>.

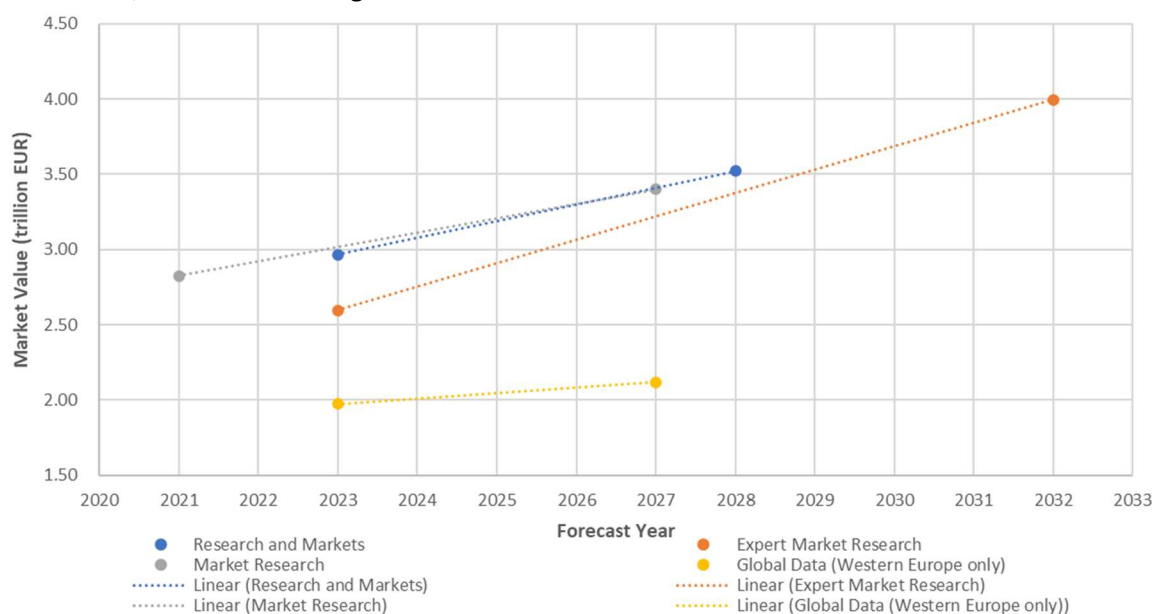


Figure 3: European Construction Sector Forecasts

Focusing on Europe, an in-depth study conducted by Research and Markets<sup>19</sup> has foreseen a robust growth trajectory of 3.5% CAGR between 2023 and 2028, resulting in €3.52 trillion<sup>20</sup> after the projection year. The report attributes this substantial growth to be driven by advancements in construction technology, such as BIM, 3D printing, and drone surveying for top-notch, sustainable, and budget-friendly infrastructure projects, further elevating the European construction market's expansion. This outlook aligns with a prior study conducted in the preceding year by Market Research for the projection period concluding in 2027. The analysis gives a slightly more positive CAGR of 3.6%<sup>21</sup>, with the market value of the end of the projection worth €3.49 trillion<sup>22</sup>. Additionally, a more extended projection span analytics was undertaken by Expert

<sup>16</sup> Ibid.

<sup>17</sup> PR Newswire. (2023). Global Construction Industry Forecast - Market Size, Growth Rate and Leading Region, By the Global Market Model. Retrieved 2023.

<https://www.prnewswire.com/news-releases/global-construction-industry-forecast---market-size-growth-rate-and-leading-region-by-the-global-market-model-301875304.html>

<sup>18</sup> The Business Research Company. (2023). Construction Market 2023 – By Type of Construction (Buildings Construction, Heavy and Civil Engineering Construction, Specialty Trade Contractors, Land Planning and Development), By End-Use Sector (Public, Private), By Type of Contractor (Large Contractor, Small Contractor), and by Region, Opportunities, and Strategies – Global Forecast to 2032. Retrieved 2023.

<https://www.thebusinessresearchcompany.com/report/construction-market>

<sup>19</sup> Research and Markets. (2023). Europe Construction Market Report and Forecast 2023-2028. Retrieved 2023.

<https://www.researchandmarkets.com/reports/5775269/europe-construction-market-report-forecast>

<sup>20</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>21</sup> Market Research. (2022). Europe Construction Market Report and Forecast 2022-2027. Retrieved 2023.

<https://chat.openai.com/c/31d11988-0aaf-4db4-b5ea-e8d4151ccb9c>

<sup>22</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)



Market Research, which evaluated the 2023 to 2032 period. With an even brighter picture CAGR of 4.9%<sup>23</sup>, the study expects the market value to be worth €4 trillion<sup>24</sup> after the forecast period. The comparison among these studies is shown above.

A regional review in Western Europe by GlobalData expects the construction market to reach €2.09 trillion<sup>25</sup> for the 2023 to 2027 forecast period with a CAGR of 1.40%. While the study noted the possible shrinkage in 2023 due to the impact of elevated costs for materials, energy, and labour and the tightening monetary policy that continues to happen, the forecast-period growth is still confident of growing from various sectors. One is the demand for solar plants as the green alternatives to reduce fossil fuel dependency in the energy and utilities sector<sup>26</sup>. Another noteworthy factor to consider is the anticipated rush of growth across Eastern Europe for the next 15 years, predicted to be worth €0.94 trillion<sup>27</sup>, underpinned by a foreseen reconstruction poised to kickstart once the Russia-Ukraine conflict resolves. This growth will receive further momentum from reconstructing the post-earthquake solutions in Turkey<sup>28</sup>.

## 2.1. Building Construction Use Case

The market review for the Building Construction Use Case covers all processes from the design and planning, creation, modification, repair, enhancement, and installations of fixtures, facilities, and equipment that are integral to the buildings to dismantling residential and non-residential buildings. The players on the game field are engaged in various structures, including but not limited to hotels, residential properties, apartments, restaurants, schools and universities, sports facilities, office complexes, hospitals, governmental buildings, and other edifices. The market value of this sector encapsulates the construction services and the associated goods integrated within the service package offered by the construction service providers. **As of 2022, Asia-Pacific was the leading region of the world's building construction market. The runner-up of the market was North America**<sup>29</sup>. The global building construction market registered €6.68 trillion last year and grew to €7.13 trillion in 2023. Report Linker expected a steady growth of CAGR 6.2% to reach €9.07 trillion in 2027<sup>30</sup>. A study with a more positive outlook was done by Allied Market Research, which shows that €1.05 trillion is

<sup>23</sup> Expert Market Research. (2023). Europe Construction Market Share, Size, Analysis, Trends: By End Use: Residential, Healthcare, Hospitality, Others; By Residential Buildings and Single Units: Apartments/Flats, Detached Houses, Semi-Detached, Terraced Houses, Others; Regional Analysis; Competitive Landscape; Key Trends and Developments in the Market; 2024-2032. Retrieved 2023.

<sup>24</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>25</sup> Ibid.

<sup>26</sup> Global Data. (2023). Western Europe Construction Market Size, Trend Analysis by Sector, Competitive Landscape and Forecast to 2027. Retrieved 2023.

<https://www.globaldata.com/store/report/western-europe-construction-market-analysis/>

<sup>27</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>28</sup> Oxford Economics. (2023). Global Construction Futures. Retrieved 2023.

<https://www.oxfordeconomics.com/resource/global-construction-futures/>

<sup>29</sup> ReportLinker. (2023). Buildings Construction Global Market Report 2023. Retrieved 2023.

<https://www.reportlinker.com/p06193657/Buildings-Construction-Global-Market-Report.html>

<sup>30</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)



expected to be gained from the 7.4% CAGR<sup>31</sup> along the forecast period of 2022 to 2031, reaching €10.43 trillion<sup>32</sup> at the end of the observation period.

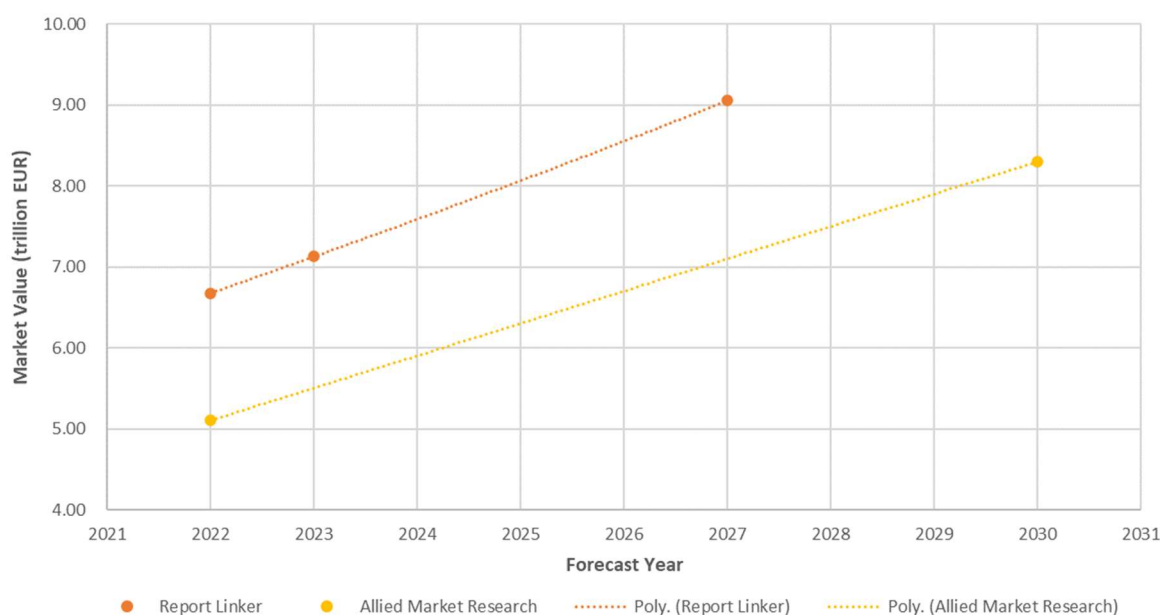


Figure 4: Global Building Construction Sector Forecasts

Multiple factors, such as population expansion, urbanisation trends, government regulations, technological advancements, and environmental considerations, influence the market dynamics and growth in the Building Construction world. Some market trends emerged to cater to users' demands. One is **the tendency to maximise prefabrication and modular construction** to speed up production, minimise production costs by taking advantage of economies of scale, waste less material (more environmentally friendly), and shorten project timelines by mitigating weather-related delays and enhancing quality control<sup>33</sup>. The second trend is **the more inclusive use of BIM both in the creation and maintenance process of a building**. By integrating BIM with other emerging technologies like artificial intelligence (AI), Internet of Things (IoT), and augmented reality (AR), it is becoming more effective in enhancing project management, automating tasks, and fostering immersive experiences, resulting in an improvement in project outcomes and more efficient operational procedures<sup>34</sup>.

<sup>31</sup> Allied Market Research. (2022). Building Construction Market by Type (Residential, Non-residential), by Construction Type (New Construction, Renovation), by Application (Owned, Rental), by End User (Private, Public): Global Opportunity Analysis and Industry Forecast, 2021-2031. Retrieved 2023.

<https://www.alliedmarketresearch.com/building-construction-market-A17012>

<sup>32</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>33</sup> CDI. (2022). Buildings Construction Market Size, Share & Trends Estimation Report By Type Outlook (Nonresidential Building Construction, Residential Building Construction, Other), By Application (Private Sectors, Public Sectors, Other Sectors), By Construction Type Outlook (Residential Building Construction, Nonresidential Building Construction, Infrastructure Construction), By Region, And Segment Forecasts, 2023 - 2030. Retrieved 2023.

<https://www.contrivedatuminights.com/product-report/buildings-construction-market-9993/>

<sup>34</sup> Ibid.



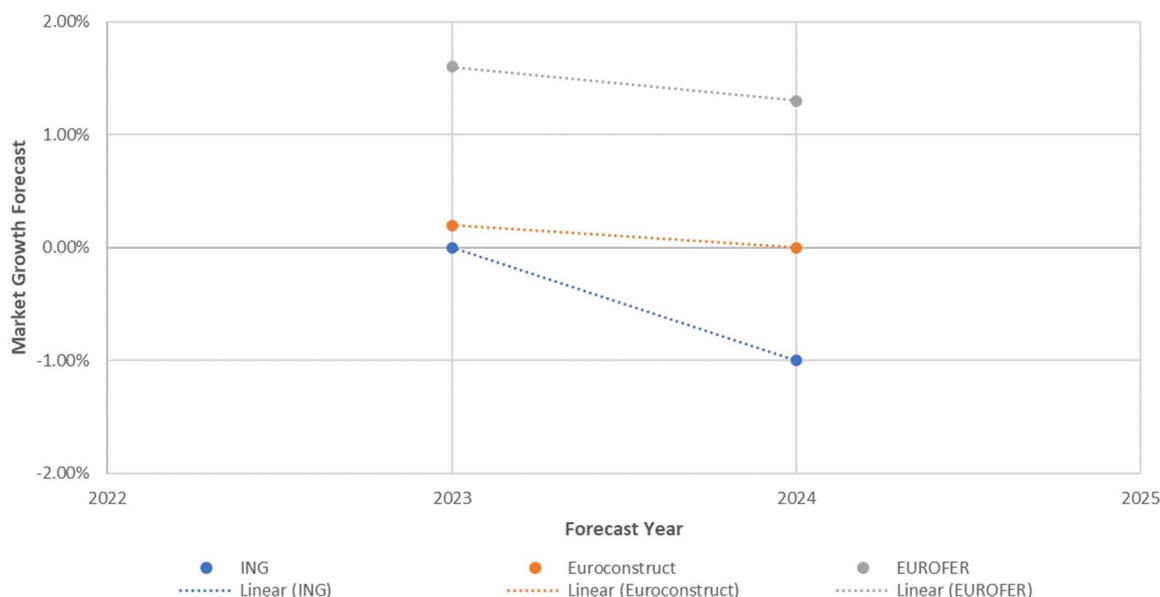


Figure 5: European Building Construction Forecast

However, *looking at the regional market, this development is quite challenging*. Fitch Solutions predicted a subtle growth of 1.5% YoY during 2023, considered underperforming compared to the same timestamp for the global market version<sup>35</sup>. ING reported a *stagnancy in June 2023 compared to last year's record*<sup>36</sup>. Like ING, Euroconstruct estimated a fall of 0.2% in 2023 and 0% growth in 2024. On the other hand, EUROFER calculated a more enthusiastic prediction of 1.6% growth for 2023 and a moderate 1.3% in 2024<sup>37</sup>.

<sup>35</sup> Fitch Solutions. (2023). Europe Construction Forecast Update: Economic Backdrop Continues to Cloud Outlook. Retrieved 2023. <https://www.fitchsolutions.com/infrastructure/europe-construction-forecast-update-economic-backdrop-continues-cloud-outlook-07-08-2023>

<sup>36</sup> ING. (2023). Europe's construction sector set to slow as demand plummets. Retrieved 2023.

<https://think.ing.com/articles/european-construction-sector-slows-as-demand-plummets/>

<sup>37</sup> GMK Center (2023). EU construction industry outlook and its impact on the steel market. Retrieved 2023.

<https://gmk.center/en/posts/overview-of-the-situation-in-the-eu-construction-industry-implications-for-the-steel-market>



## EU construction forecast

Volume output construction sector, % YoY

|                                                                                   |                | 2021  | 2022* | 2023* | 2024* |
|-----------------------------------------------------------------------------------|----------------|-------|-------|-------|-------|
|  | Austria        | 7.7%  | 3.0%  | 0.0%  | -1.5% |
|  | Belgium        | 4.2%  | 1.5%  | 0.5%  | 1.0%  |
|  | France         | 13.8% | 2.5%  | 0.0%  | -0.5% |
|  | Germany        | -1.6% | -1.6% | -1.0% | -1.5% |
|  | Netherlands    | 3.5%  | 2.7%  | 0.5%  | -2.5% |
|  | Poland         | 1.5%  | 8.2%  | 0.5%  | 0.0%  |
|  | Spain          | -6.2% | -7.4% | 3.0%  | 2.0%  |
|  | European Union | 5.5%  | 2.7%  | 0.0%  | -1.0% |
|  | Turkey         | -0.6% | -3.0% | -1.0% | 3.0%  |

Source: Eurostat & ING Research \*Estimates & Forecasts

Figure 6: EU Construction Forecast, Volume Output Construction Sector

While ongoing projects and a growing emphasis on sustainability have been working as a buffer to prevent the reduction in volumes, there is a forecasted emergence that the drop will start next year. The **elevated interest rate and surging building costs** have also clipped European demand for new construction projects<sup>38</sup>. This unfavourable development is affected mainly by the decline in building permits and the sales of building material sectors, creating a modest decrease of -1 % for EU construction in 2024. On the other hand, the demand for renovation and maintenance, which account for over 50% of the total construction output, is less affected by economic cycles. **This demand for renovation and maintenance and the lack of drop in the non-residential sector counterbalance the decline in the new building sector and create resilience for the industry**, as projected for selected countries<sup>39</sup>.

*There is an inclination to use prefabricated and modular construction and BIM both in the creation and maintenance process of a building. These trends, combined with the demand for renovation and maintenance and more construction for the non-residential sector, drive the building construction industry. However, challenges such as regional stagnancy, rising building costs, and higher interest rates are acting as constraints, impeding the sector's overall growth.*

Despite these technological advancements, challenges persist in the day-to-day execution of the sector, where real-life sites exhibit a higher density of workers and construction elements than civil work projects. Here, the operational focus often relies on the physical capacity of the worker rather than extensive machinery use.

<sup>38</sup> Construction Europe. (2023). *Why European Construction Could Be Set for A Downturn in 2024?* Retrieved 2023. <https://www.construction-europe.com/news/why-european-construction-could-be-set-for-a-downturn-in-2024/8031406.article>

<sup>39</sup> ING. (2023). *Europe's construction sector set to slow as demand plummets*. Retrieved 2023. <https://think.ing.com/articles/european-construction-sector-slows-as-demand-plummets/>



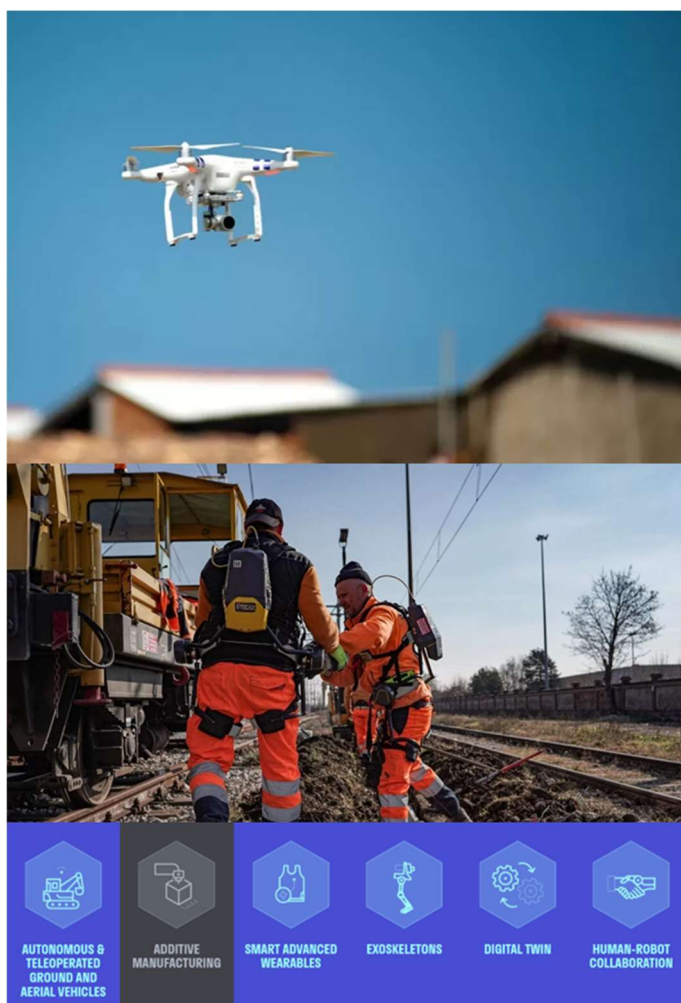


Figure 7: BEEYONDERS' Innovation for the Building Construction Use Case.

Image Credit: BEEYONDERS, Italian Institute of Technology—IIT

Delving into how the innovation developed in the BEEYONDERS project can be exploited in the Building Use Case, the idea to emphasise the use of autonomous devices, robotics, and **wearables** at the forefront, helping the efficiency of the construction process while **promoting the safety of the construction workers by monitoring workers' biometric and kinematic parameters**, is relatively sound. The ageing workforce can be protected using **exoskeletons and wearables, which are pivotal in collecting data to prevent workplace injuries and accidents. Autonomous drones implemented in the projects can be used in collaboration with autonomous or teleoperated wheel loaders to load and unload materials and navigate safely in complex construction environments.** Additionally, autonomous drones deployed with real-time information reporting can be swarmed around the building to compare the construction progress, checking for any possible deviation from the original plans. Once the data is collected, it will be uploaded into a Digital Twin to analyse it and allow the rescheduling of work if needed.

## 2.2. Transportation Infrastructure Construction Use Case (Covering Road Construction Use Case, Road Maintenance Use Case, and Tunnel Construction Use Case).

The global Transportation Infrastructure Construction Use Case covers the Road Construction, Road Maintenance and Tunnel Construction Use Case. Overall, the global transportation infrastructure has experienced substantial expansion in recent years. This encompasses the key components of physical structures, facilities, and systems that build roads, railways, airports, seaports, bridges, and more. These



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infrastructural components work as the footing for the seamless movements of people, services, and goods across places and, in the bigger view, play a pivotal role in the development of the economy<sup>40</sup>.

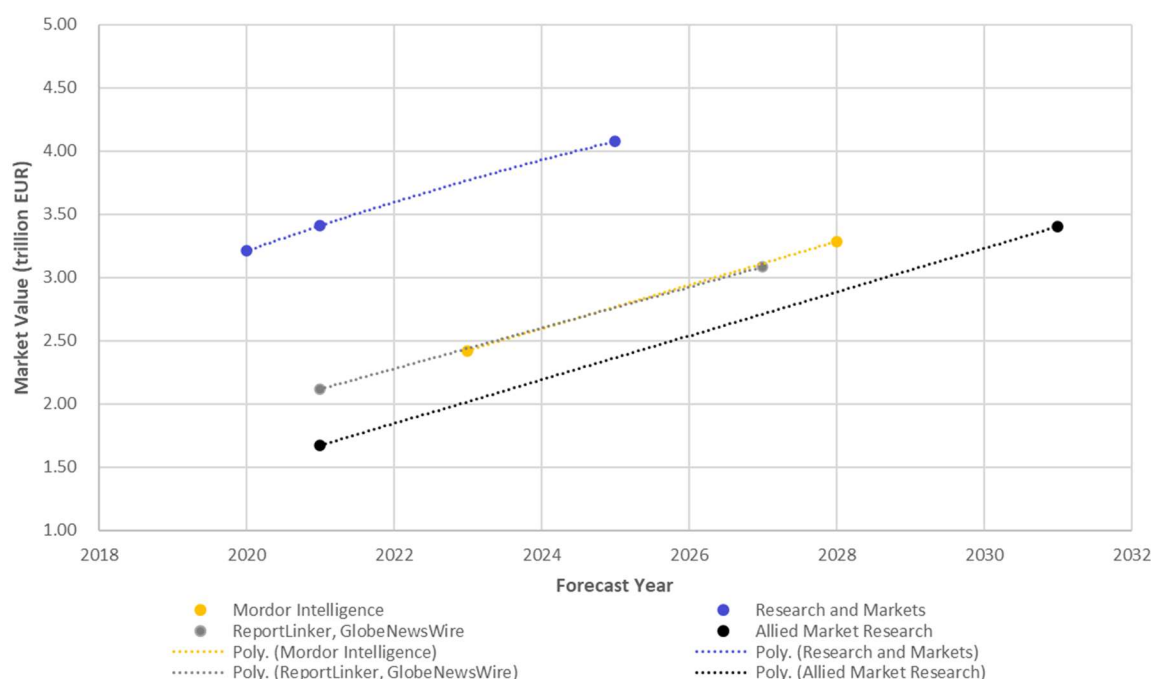


Figure 8: Global Transportation Infrastructure Construction Market Forecast

As shown in the graph above, several selected studies proved that the direction of growth for the transportation infrastructure is favourable. Several studies examine the growth trajectory and point to a positive outlook for transportation infrastructure. Mordor Intelligence offers a conservative prediction, projecting a CAGR of 6.27% from 2023 to 2028<sup>41</sup>, expecting to grab €3.28 trillion<sup>42</sup>, followed by the study from Research and Markets, with a fluctuating CAGR of 6.2% to 4.9% scattered in the different phases of the forecast from 2020 to 2025<sup>43</sup>, anticipating €4.08 trillion<sup>44</sup>. Meanwhile, both studies from Globe Newswire<sup>45</sup> and ReportLinker<sup>46</sup> align on the possibility of a slightly more optimistic CAGR of 6.48% from 2021 to 2027,

<sup>40</sup> Markwide Research. (2023). Global Transportation Infrastructure Market Analysis: Industry Size, Share, Research Report, Insights, Covid-19 Impact, Statistics, Trends, Growth, and Forecast 2023-2030. Retrieved 2023.

<https://markwideresearch.com/global-transportation-infrastructure-market/>

<sup>41</sup> Mordor Intelligence. (2022). Infrastructure Sector Market Size & Share Analysis: Growth Trends & Forecasts (2023 - 2028). Retrieved 2023.

<https://www.mordorintelligence.com/industry-reports/infrastructure-sector>

<sup>42</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>43</sup> Research and Markets. (2021). Global Infrastructure Outlook to 2025. Retrieved 2023.

<https://www.researchandmarkets.com/reports/5457096/global-infrastructure-outlook-to-2025>

<sup>44</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>45</sup> GlobeNewswire. (2023). Global Infrastructure Construction Market Size & Share Analysis: Growth Trends & Forecasts (2023 - 2028). Retrieved 2023.

<https://www.globenewswire.com/news-release/2023/07/17/2705872/0/en/Global-Infrastructure-Construction-Market-Size-Share-Analysis-Growth-Trends-Forecasts-2023-2028.html>

<sup>46</sup> ReportLinker. (2023). Global Infrastructure Construction Market Size & Share Analysis: Growth Trends & Forecasts (2023 - 2028). Retrieved 2023.



hoping to reach €3.08 trillion<sup>47</sup> at the forecast's end. The most positive perspective arises from the study from Allied Market Research, with a CAGR of 7.20%<sup>48</sup> from 2021 to 2031, anticipating a total value of €3.40 trillion waiting at the end of the period.

This positive trajectory is particularly noteworthy given the challenges, such as the *increasing population and the rate of urbanisation* that demand quality mobility. At the same time, the *obtainable land for transportation construction steadily diminishes*<sup>49</sup>. The *ageing existing transport infrastructure*, exacerbated by natural or artificial disasters, could compromise safety requirements if operated longer than expected. Remarkably, amidst the significant disruptions brought about by the COVID-19 pandemic, there was still growth in global infrastructure construction output in 2020<sup>50</sup>.

The forces of *globalisation and economic growth* prompt governments worldwide to invest in infrastructure projects that will stimulate connectivity and enhance the overall quality of life<sup>51</sup>. Simultaneously, environmental considerations and technological advancements advocate for *greener and smarter infrastructure construction*.<sup>52</sup>

*The growing population, urbanisation rate, the influence of globalisation, and economic progress collectively highlight the urgency to adopt new technologies that address the necessity for safe, environmentally friendly, and efficient transportation methods on equally secure and rejuvenated infrastructure. The intersection of economic, environmental, and technological imperatives emphasises the imperative for innovation and strategic investment in the global transportation infrastructure sector.*

While these market drivers propel growth and innovation, it is imperative to acknowledge the challenges and constraints that could impact the industry's trajectory. One notable challenge lies in the *substantial capital requirements for building transportation infrastructure* that can pose significant challenges, particularly for emerging economies with limited financial resources. This financial strain extends beyond initial construction to budget constraints for maintenance and operational costs. Additionally, from a legal and bureaucratic perspective, *the complexity of navigating regulations and obtaining permits*, including land acquisition and

<https://www.reportlinker.com/p06459646/Global-Infrastructure-Construction-Market-Size-Share-Analysis-Growth-Trends-Forecasts.html>

<sup>47</sup> European Central Bank. (2023). *USD to EUR exchange rate on October 23, 2023*.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>48</sup> Allied Market Research. (2022). *Global Transportation Infrastructure Market by Type (Railway, Airport, Roads and Bridges, Ports), by Application (Urban, Rural), by Construction Type (New Construction, Renovation): Global Opportunity Analysis and Industry Forecast, 2022-2031*. Retrieved 2023.

<https://www.alliedmarketresearch.com/transportation-infrastructure-market>

<sup>49</sup> Allied Market Research. (2022). *Global Transportation Infrastructure Market by Type (Railway, Airport, Roads and Bridges, Ports), by Application (Urban, Rural), by Construction Type (New Construction, Renovation): Global Opportunity Analysis and Industry Forecast, 2022-2031*. Retrieved 2023.

<https://www.alliedmarketresearch.com/transportation-infrastructure-market>

<sup>50</sup> PR Newswire. (2021). *Global Infrastructure Construction Outlook Report 2021-2025: Focus on Roads, Railways, Power and Electricity, Water and Sewerage, and Airports and Other Infrastructure Sectors*. Retrieved 2023.

<https://www.prnewswire.com/news-releases/global-infrastructure-construction-outlook-report-2021-2025-focus-on-roads-railways-power-and-electricity-water-and-sewerage-and-airports-and-other-infrastructure-sectors-301403714.html>

<sup>51</sup> Markwide Research. (2023). *Global Transportation Infrastructure Market Analysis: Industry Size, Share, Research Report, Insights, Covid-19 Impact, Statistics, Trends, Growth, and Forecast 2023-2030*. Retrieved 2023.

<https://markwideresearch.com/global-transportation-infrastructure-market/>

<sup>52</sup> International Transport Forum. (2023). *Comparing Transport Infrastructure Investment Policies around the Globe*. Retrieved 2023



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securing rights-of-way for infrastructure projects, may impede development and project execution. Navigating these multifaceted challenges requires a strategic approach to ensure sustainable and resilient infrastructure growth<sup>53</sup>.

*The substantial upfront capital needed for initiating projects, alongside the ongoing challenge of budgeting for maintenance and operational costs, is compounded by the intricate process of obtaining permits, navigating regulatory frameworks, acquiring land, and securing rights-of-way for infrastructure projects. These complexities collectively pose potential hindrances to the growth of the transportation infrastructure market.*

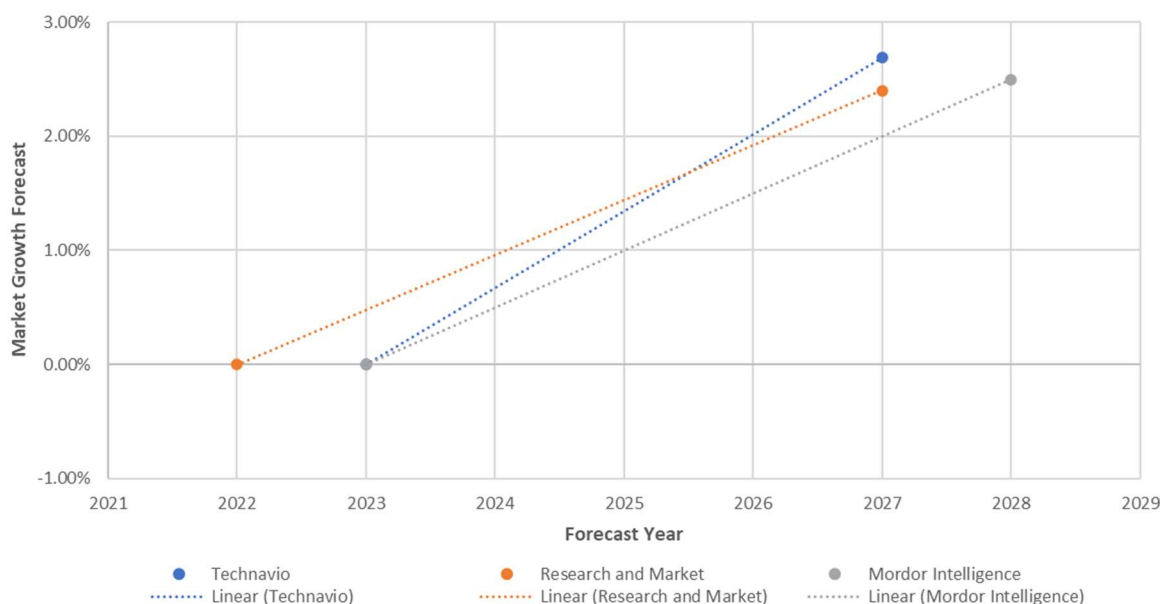


Figure 9: European Transportation Infrastructure Construction Market Forecast

Stepping into the European context, we observe **a significant upswing in the growth of the transportation infrastructure market across the region**. This finding is supported by several studies, as shown in the graph above. First, the survey from Technavio predicted the growth of a CAGR of 2.69%<sup>54</sup> between 2022 and 2027, worth €0.04 trillion<sup>55</sup>. The analysis from Research and Markets reported a 2.40% CAGR growth for the forecast period of 2022 to 2027<sup>56</sup>. Mordor Intelligence reported a slightly higher CAGR of 2.50% starting in

<sup>53</sup> Markwide Research. (2023). Global Transportation Infrastructure Market Analysis: Industry Size, Share, Research Report, Insights, Covid-19 Impact, Statistics, Trends, Growth, and Forecast 2023-2030. Retrieved 2023.

<https://markwideresearch.com/global-transportation-infrastructure-market/>

<sup>54</sup> Technavio. (2023). Europe - Road Freight Transportation Market by Product, and Vehicle Type - Forecast and Analysis 2023-2027. Retrieved 2023.

<https://www.technavio.com/report/road-freight-transportation-market-in-europe-industry-analysis>

<sup>55</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>56</sup> Research and Markets. (2022). Europe Transportation Infrastructure Construction Market - Growth, Trends, COVID-19 Impact, and Forecasts (2022 - 2027). Retrieved 2023.

<https://www.researchandmarkets.com/reports/5572863/europe-transportation-infrastructure>



2023 and ending in 2028<sup>57</sup>. From the environmental point of view, we also expect that Europe will transform its green energy sector and the broader economy through green infrastructure investment<sup>58</sup>.

This positive trajectory in Europe is driven by a merging of influential factors, including *the burgeoning urban population*, which has seen a rise from 75% in 2020 to a projected 80% by 2035. Notably, *the allocation of public spaces within Europe's city centres*, comprising between 2 and 15% of the total land area,<sup>59</sup> plays a crucial role in alleviating the pressures of the increasing urban population. This surge forces a substantial expansion of transportation infrastructure in developing countries, facilitating the migration of populations from rural to urban areas. Projections indicate a steady rise in public transportation users, with an anticipated reach of 569.6 million by 2026, a significant increase from 60% in 2022 to an estimated 67.1%<sup>60</sup>. This underscores *the growing reliance on public transportation solutions, further propelling the demand for robust and efficient transportation infrastructure across Europe*. For this, Europe is strong in hosting one of the world's most diverse transportation sectors<sup>61</sup>, facilitating the movement of goods and passengers across over 50 land borders through air, road, sea, and rail networks<sup>62</sup>. *However, as construction material costs in Europe consistently experience disinflation, the industry faces an ongoing risk of potential disruptions in energy supply, compounded with constrained labour availability*<sup>63</sup>.

### 2.2.1. Road Construction Use Case

As we navigate through the intricacies of specific use cases within the expansive global transportation infrastructure market, the road construction sector emerges as a pivotal player, significantly influencing regional connectivity and shaping the terrain of sustainable mobility. In this context, the road construction market refers to the construction data of a network of interconnected roadways, highways, and bridges<sup>64</sup> unless specified otherwise. Understanding the trajectory of the road construction market is obligatory to apply BEEYONDERS' technology in this Use Case.

<sup>57</sup> Mordor Intelligence. (2022). *Europe Transportation Infrastructure Construction Market Size & Share Analysis - Growth Trends & Forecasts (2023 - 2028)*. Retrieved 2023.

<https://www.mordorintelligence.com/industry-reports/europe-transportation-infrastructure-construction-market>

<sup>58</sup> DWS. (2023). *Infrastructure Strategic Outlook 2023*. Retrieved 2023.

<https://www.dws.com/AssetDownload/Index?assetGuid=05916931-052a-4d8a-8337-318aa2bf7553&consumer=E-Library>

<sup>59</sup> Research and Markets. (2022). *Europe Transportation Infrastructure Construction Market - Growth, Trends, COVID-19 Impact, and Forecasts (2022 - 2027)*. Retrieved 2023.

<https://www.researchandmarkets.com/reports/5572863/europe-transportation-infrastructure>

<sup>60</sup> Ibid.

<sup>61</sup> Statista. (2023). *Transport Industry in Europe - Statistics & Facts*. Retrieved 2023.

<https://www.statista.com/topics/3671/transportation-industry-in-europe/#topicOverview>

<sup>62</sup> Statista. (2023). *Europe Mobility Services Industry Revenue by Mode 2017-2026*. Retrieved 2023.

<https://www.statista.com/statistics/1131408/revenue-of-european-mobility-services-industry/>

<sup>63</sup> Fitch Solutions. (2023). *Europe Infrastructure Report*. Retrieved 2023.

<https://store.fitchsolutions.com/infrastructure/europe-infrastructure-report>

<sup>64</sup> The Business Research Company. (2023). *Highway, Street, And Bridge Construction Global Market Report 2023 - By Type (Highway, Street, Bridge), By Construction Type (New Construction, Reconstruction And Repair), By Funding (Government Funding, Private Funding) - Market Size, Trends, And Global Forecast 2023-2032*. Retrieved 2023.

<https://www.thebusinessresearchcompany.com/report/highway-street-and-bridge-construction-global-market-report>



According to Fortune Business Insights, the market is anticipated to witness a steady growth of CAGR 2.06% from 2023 to 2030, with the expected market share of €1.26 trillion<sup>65</sup> by the conclusion of this period<sup>66</sup>. The optimism surrounding the market is further supported by the study from The Business Research Company, with a CAGR of 5.3% between 2023 and 2027, culminating in an end worth of €1.06 trillion<sup>67</sup> market share<sup>68</sup>. These predictions align seamlessly with the insights provided by GM Insight, indicating a robust growth trajectory with a CAGR exceeding 6% between 2022 and 2032, ending the extensive period with an astounding €3.67 trillion<sup>69</sup> market share<sup>70</sup>. The comparison between these selected studies is explained in the graph below.

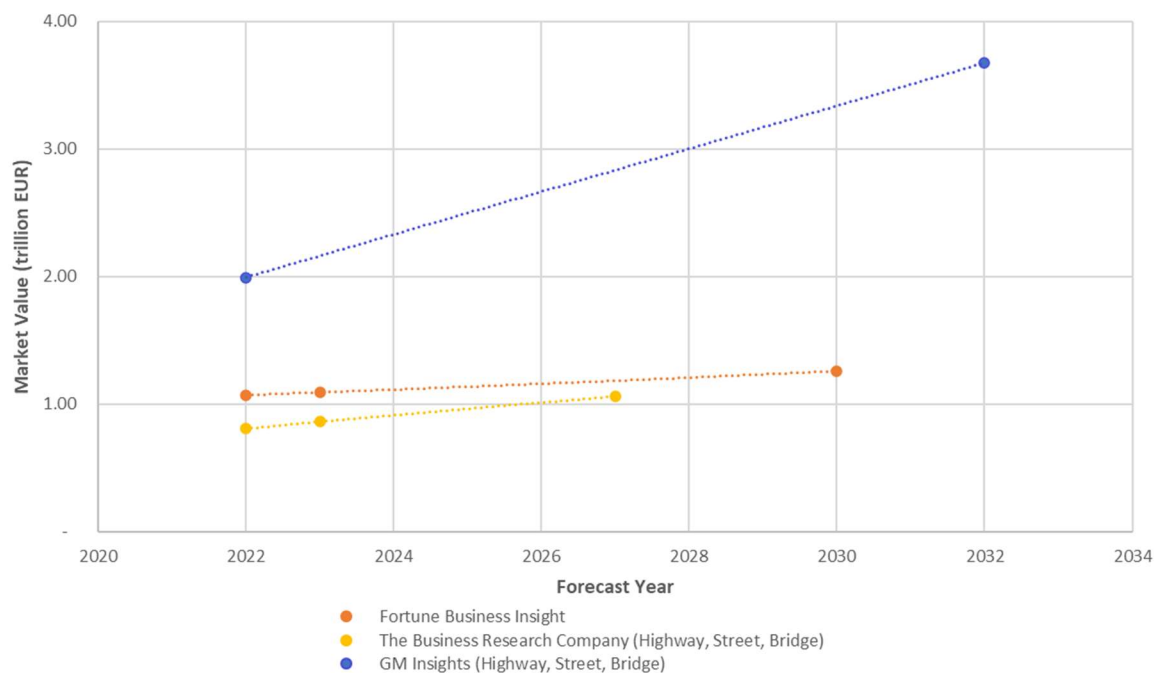


Figure 10: Global Road Construction Market Forecast

<sup>65</sup> European Central Bank. (2023). *USD to EUR exchange rate on October 23, 2023*.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>66</sup> Fortune Business Insights. (2023). *Road & Highway Infrastructure Market Size, Share & COVID-19 Impact Analysis, By Road Type (National/Interstate highways, State Highways, and Other Roads), By Components (Road, Bridges/ Tunnels/ Culverts, Marking & Signage, Safety Equipment, Traffic Management System, and Others), By Process (Maintenance & Expansion), and Regional Forecast, 2022-2030*. Retrieved 2023.

<https://www.fortunebusinessinsights.com/road-highway-infrastructure-market-107930>

<sup>67</sup> European Central Bank. (2023). *USD to EUR exchange rate on October 23, 2023*.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>68</sup> The Business Research Company. (2023). *Highway, Street, And Bridge Construction Global Market Report 2023 - By Type (Highway, Street, Bridge), By Construction Type (New Construction, Reconstruction And Repair), By Funding (Government Funding, Private Funding) - Market Size, Trends, And Global Forecast 2023-2032*. Retrieved 2023.

<https://www.thebusinessresearchcompany.com/report/highway-street-and-bridge-construction-global-market-report>

<sup>69</sup> European Central Bank. (2023). *USD to EUR exchange rate on October 23, 2023*.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>70</sup> Global Market Insights. (2023). *Highway, Street, and Bridge Construction Market Size - By Type (Highway, Street, Bridge), By Construction Type (New Construction, Reconstruction, Repair) & Global Forecast 2023-2032*. Retrieved 2023.

<https://www.gminsights.com/industry-analysis/highway-street-and-bridge-construction-market>



The first point that drives the global road construction market is that an enhanced transportation network is urgently needed to foster international connectivity and support the **increasing tourism industry**. Governments globally recognise this need, leading to a surge in investments to modernise and expand transportation infrastructure<sup>71</sup>. The parallel growth in **population and urbanisation** simultaneously raises the **number of automobiles** available in the market, which would need adequate land to run on<sup>72</sup>. As a response, the industry has to accommodate the quantity and quality of the road in terms of efficiency and safety in transportation systems<sup>73</sup>. These collective drivers underscore a dynamic landscape where the need for improved connectivity, investment, and safety converge to shape the future of the transportation infrastructure market.

*Several key drivers that propel the road construction market are the demand for an enhanced transportation network, government investments, and the growing number of automobiles due to the rising population and urbanisation. At the same time, budget limitations hinder the growth of the global road construction market.*

Despite the promising trajectory, certain constraints loom over the transportation infrastructure market. Chief among these challenges is **the issue of limited funding**<sup>74</sup>. The ambitious projects necessitated by the growing demands often face financial constraints, impeding their timely execution. Furthermore, the **high maintenance costs associated with modern infrastructure** pose a considerable restraint<sup>75</sup>. Balancing the need for continual maintenance and improvements within the constraints of available funds becomes a delicate challenge. As the industry strives for innovation and efficiency, addressing these financial and maintenance hurdles is crucial to sustaining the momentum of growth in the transportation infrastructure market.

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<sup>71</sup> Research and Market. (2023). *Global Highway and Road Construction Market*. Retrieved 2023.

<https://www.researchandmarkets.com/reports/5860755/global-highway-road-construction-market>

<sup>72</sup> Construction Business Review. (2022). *Key Market Drivers And Trends For The Road Construction And Maintenance Market*. Retrieved 2023.

<https://www.constructionbusinessreview.com/news/key-market-drivers-and-trends-for-the-road-construction-and-maintenance-market-nwid-792.html>

<sup>73</sup> Global Research Consulting. (2023). *Highway and Road Construction Market Size, Share & Trends Analysis Report by Type (Highway, Street, Bridge, and Others), By Construction Type (New Construction, Reconstruction, Pavement Construction, and Others), Forecast Period (2023-2030)*. Retrieved 2023.

<https://www.omrglobal.com/industry-reports/highway-and-road-construction-market>

<sup>74</sup> Technavio. (2022). *Road Construction and Maintenance Market - North America, Europe, EMEA, APAC: US, Canada, China, Germany, UK - Forecast 2023-2027*. Retrieved 2023.

<https://www.technavio.com/report/road-construction-and-maintenance-industry-analysis>

<sup>75</sup> Fortune Business Insights. (2023). *Road & Highway Infrastructure Market Size, Share & COVID-19 Impact Analysis, By Road Type (National/Interstate highways, State Highways, and Other Roads), By Components (Road, Bridges/ Tunnels/ Culverts, Marking & Signage, Safety Equipment, Traffic Management System, and Others), By Process (Maintenance & Expansion), and Regional Forecast, 2022-2030*. Retrieved 2023.

<https://www.fortunebusinessinsights.com/road-highway-infrastructure-market-107930>





Figure 11: BEEYONDERS' Innovation for the Road Construction Use Case

Image Credit: BEEYONDERS,  
Australian Road Research Board

These demands are coupled with the high CO<sub>2</sub> emissions generated during road construction, given that earthworks constitute one of the most resource-intensive facets of the process. Meticulous and efficient planning and routing are essential to curb excess CO<sub>2</sub>, avoid operational overlaps, and enable significant fuel savings to reduce CO<sub>2</sub> emissions caused by this sector.

To address these challenges and enhance operational efficiency, **BEEYONDERS technology employs ground and air autonomous and teleoperated navigation integrated into vehicles**, encompassing terrestrial construction machinery and aerial drones. All the terrain **data collected are then uploaded into Digital Twins, where the Artificial Intelligence functionalities will analyse and prioritise tasks on hand**, issuing precise instructions to earthwork machinery for autonomous execution. Once the tasks are completed, the drones will reassess the updated situation, initiating the next work cycle. **This synchronised approach reduces ineffective project execution on the terrain, minimising excess time, fuel consumption, and CO<sub>2</sub> emissions within the construction process**, making BEEYONDERS' innovation a significant contribution to environmental control in the road construction sector.

### 2.2.2. Road Maintenance Use Case

The second part of the transportation infrastructure construction is the Road Maintenance Use Case, which takes centre stage in ensuring both traffic safety and the overall condition and aesthetic of the road<sup>76</sup>. This facet of the market encompasses a variety of activities, ranging from routine maintenance tasks on more minor scales like pothole repairs and crack sealing to addressing emergency repairs due to severe weather events or damaged roadways impacted by unexpected accidents<sup>77</sup>. Additionally, the road maintenance market extends its responsibility to the level of significant rehabilitation or rejuvenation projects. These

<sup>76</sup> 360 Research Reports. (2022). *Global Road Maintenance Industry Research Report, Competitive Landscape, Market Size, Regional Status, and Prospect*. Retrieved 2023.

<https://www.360researchreports.com/global-road-maintenance-industry-research-report-competitive-landscape-market-21438888>

<sup>77</sup> MarketResearch.com (2023). *Road Maintenance Market Size – By Road Type (Highway and Expressway, Urban Road, Rural Road), By Service Type (Routine maintenance, Emergency maintenance, Reactive maintenance), Forecast 2023 – 2032*. Retrieved 2023.

<https://www.marketresearch.com/One-Off-Global-Market-Insights-v4130/Road-Maintenance-Size-Type-Highway-35244648/>



comprise extensive initiatives such as repaving, widening, or restructuring roads and highways to enhance their durability, functionality, and visual appeal performance<sup>78</sup>.

As we delve into the global road maintenance market, it becomes evident that the significance of this sector is not to be kept lightly. The escalating demand for heightened safety measures to reduce fatalities is substantiated by comprehensive studies, as illustrated in the graph below. The survey from Verified Market Research anticipates a steady trajectory of a CAGR of 3.80% for 2022-2030<sup>79</sup>, culminating in a market share of €0.19 trillion<sup>80</sup>. Concurrently, 360 Research Reports and Market Research Guru present a slightly more optimistic outlook, forecasting CAGR rates of 4.12% for 2021-2027<sup>81</sup> and 4.14% for 2022-2028<sup>82</sup>, respectively. Spherical Insights adopts an even more optimistic stance with a CAGR of 5.10% for 2022-2032, aiming to attain €0.02 trillion market share<sup>83</sup>. Meanwhile, Global Information reports substantial growth with a CAGR of 6.20% for 2022-2030<sup>84</sup>, aspiring to achieve an equivalent market share by the conclusion of the forecasted period. These diverse perspectives collectively emphasise the dynamic nature of the global road maintenance market and the multifaceted considerations that shape its trajectory.

<sup>78</sup> Verified Market Research. (2022). Global Road Maintenance Market Size By Roadways (Highways, Lower Traffic Volume Roadways, and Local streets), By Type (Pavement Management and Road Fixtures), By Pavement (Asphalt and Concrete), By Managing Agencies (Federal, State, and Municipal), By Geographic Scope And Forecast. Retrieved 2023.

<https://www.verifiedmarketresearch.com/product/road-maintenance-market/>

<sup>79</sup> Ibid.

<sup>80</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>81</sup> 360 Research Reports. (2022). Global Road Maintenance Industry Research Report, Competitive Landscape, Market Size, Regional Status, and Prospect. Retrieved 2023.

<https://www.360researchreports.com/global-road-maintenance-industry-research-report-competitive-landscape-market-21438888>

<sup>82</sup> Market Research Guru (2023). Global Road Maintenance Industry Research Report, Competitive Landscape, Market Size, Regional Status, and Prospect. Retrieved 2023.

<https://marketresearchguru.com/global-road-maintenance-industry-research-report-2023-competitive-landscape-market-22379557>

<sup>83</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>84</sup> Global Information (2023). Road Maintenance Market, By Product Type, By Application, By Country, and By Region - Industry Analysis, Market Size, Market Share & Forecast from 2023-2030. Retrieved 2023.

<https://www.giiresearch.com/report/anvi1358231-road-maintenance-market-by-product-type-by.html>



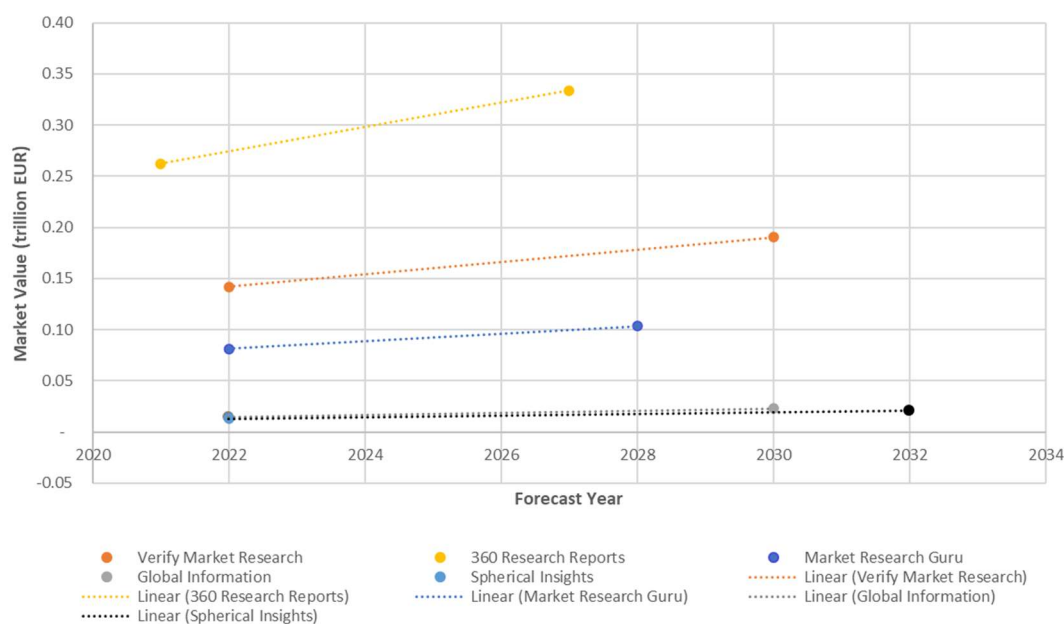


Figure 12: Global Road Maintenance Market Forecast

Several factors manoeuvre the growth of the global road maintenance market. The growing forces of **urbanisation, population expansion, and rising road safety concerns** further propel the momentum for proactive maintenance practices, promising long-term cost savings, enhanced connectivity, and improved trade relations. Along with the flow of mobility, the increasing **number of road accidents** and a heightened demand to reduce fatalities<sup>85</sup> underscore the critical importance of robust maintenance operations, creating pressure on the governments to be held accountable to increase the quality of the infrastructure<sup>86</sup>.

*The growing population, urbanisation, and increasing road-related accidents push governments to invest more in the road maintenance sector. This initiative is at risk of being slowed down by the lack of public funding, bureaucratic speed, shortage of skilled workers, and disruptions by severe weather.*

However, while the road maintenance market is poised to fulfil the users' needs, like its counterparts, it faces several constraints that warrant careful consideration. One of the primary challenges is the **need for more public funding or budget**<sup>87</sup> for infrastructure projects<sup>88</sup>. Another challenge that slows infrastructure

<sup>85</sup> Construction Business Review. (2022). *Key Market Drivers And Trends For The Road Construction And Maintenance Market*. Retrieved 2023.

<https://www.constructionbusinessreview.com/news/key-market-drivers-and-trends-for-the-road-construction-and-maintenance-market-nwid-792.html>

<sup>86</sup> MarkWideResearch (2023). *Global Road Maintenance Market Analysis – Industry Size, Share, Research Report, Insights, Covid-19 Impact, Statistics, Trends, Growth and Forecast 2023-2030*. Retrieved 2023.

<https://markwideresearch.com/global-road-maintenance-market/>

<sup>87</sup> Global Market Insights (2023). *Road Maintenance Market Size - By Road Type (Highway and Expressway, Urban Road, Rural Road), By Service Type (Routine maintenance, Emergency maintenance, Reactive maintenance), Forecast 2023 – 2032*. Retrieved 2023.

<https://www.gminsights.com/industry-analysis/road-maintenance-market>

<sup>88</sup> Spherical Insights (2023). *Global Road Maintenance Market Size, Share, and COVID-19 Impact Analysis, By Type (Highway & Expressway, Urban Road, Rural Road, Local Street), By Service Type (Routine maintenance, Emergency maintenance, Reactive maintenance), By Pavement (Asphalt, Concrete), By Managing Agency (Federal, State, Municipal), and By Region (North America, Europe, Asia-Pacific, Latin America, Middle East, and Africa), Analysis and Forecast 2022 – 2032*. Retrieved 2023.

<https://www.sphericalinsights.com/reports/road-maintenance-market>



development is **bureaucratic delays**, roadblocks, and other regulatory issues. Additionally, the need for more skilled workers and **unexpected adverse weather** can disrupt maintenance schedules and impact the efficiency of ongoing projects.

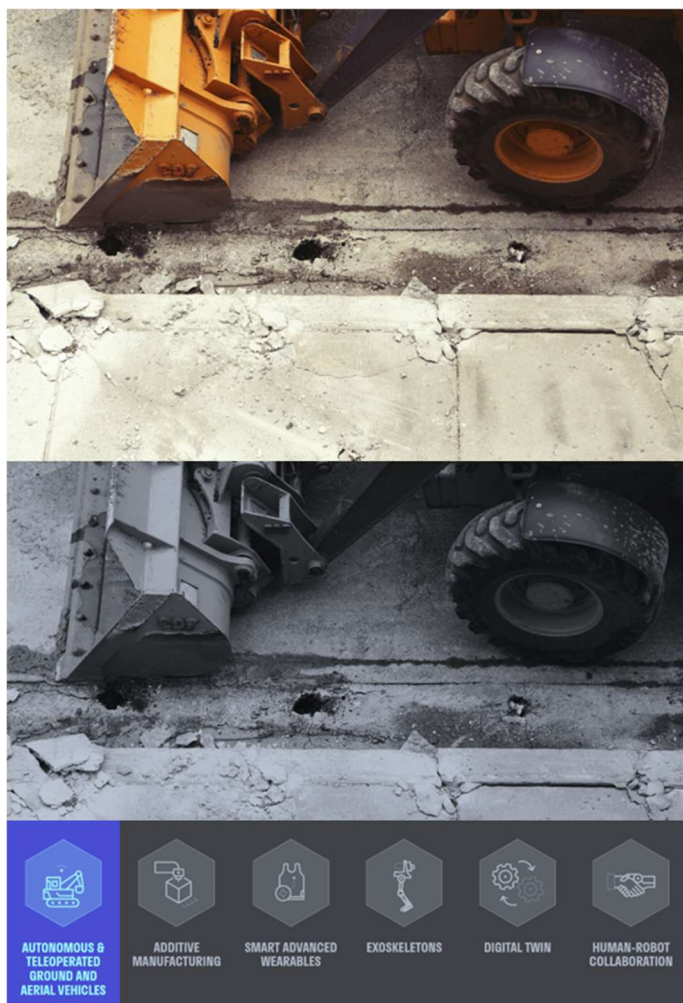


Figure 13: BEEYONDERS' Innovation for the Road Maintenance Use Case  
Image Credit: BEEYONDERS

vehicles, the robotic platform demonstrates the ability to perform these tasks seamlessly during the operational service of roads without disrupting infrastructure users. This solution from BEEYONDERS addresses the current road maintenance use case situation. It paves the way for a more efficient and technologically advanced approach to infrastructure inspection and upkeep.

In response to the growing population, urbanisation, and increased road-related accidents, governments are investing more in the safety of the transportation infrastructure. An integral component of this strategy is the road maintenance sector, which is crucial for sustaining modern mobility. This pivotal aspect of modern mobility needs to be conserved periodically in normal conditions<sup>89</sup>. However, on special occasions such as road accidents, severe weather, or another mistreatment that can threaten the safety and mobility of the road user, more attention is needed to execute the imperative treatment<sup>90</sup>.

Until now, most of the current methods to execute road inspections require personnel driving along them, including in adverse conditions, which means a relatively high risk to workers' safety. This condition works as an invitation for BEEYONDERS' innovation to jump in by introducing **autonomous robotic solutions, both aerial and ground-based**. **Autonomous drones** equipped with specialised perception and analysis software could be deployed to **check the retro-reflectivity level of vertical traffic signals and assess the status of horizontal ones**. At the same time, the robotic platform could be employed to **inspect roadside vegetation, measuring growth and type through predictive analysis using drones and 3D maps**. By maximising the use of aerial autonomous

<sup>89</sup> MarketResearch.com (2023). Road Maintenance Market Size – By Road Type (Highway and Expressway, Urban Road, Rural Road), By Service Type (Routine maintenance, Emergency maintenance, Reactive maintenance), Forecast 2023 – 2032. Retrieved 2023.

<https://www.marketresearch.com/One-Off-Global-Market-Insights-v4130/Road-Maintenance-Size-Type-Highway-35244648/>

<sup>90</sup> Verified Market Research. (2022). Global Road Maintenance Market Size By Roadways (Highways, Lower Traffic Volume Roadways, and Local streets), By Type (Pavement Management and Road Fixtures), By Pavement (Asphalt and Concrete), By Managing Agencies (Federal, State, and Municipal), By Geographic Scope And Forecast. Retrieved 2023.

<https://www.verifiedmarketresearch.com/product/road-maintenance-market/>



### 2.2.3. Tunnel Construction Use Case

The Tunnel Construction Use Case is the third part of the transportation infrastructure use case. The infrastructure is characterised by having a fully enclosed structure within the soil, with entry and exit points at each end. Tunnels are crucial in the modern world, catering to various modes of transportation, such as rail, vehicular, or pedestrian traffic, but mostly in facilitating rapid transit systems, serving as indispensable links in highway and railway networks<sup>91</sup>. Tunnels also strategically enhance connectivity across diverse geographical landscapes, navigating through natural boundaries like mountains<sup>92</sup>.

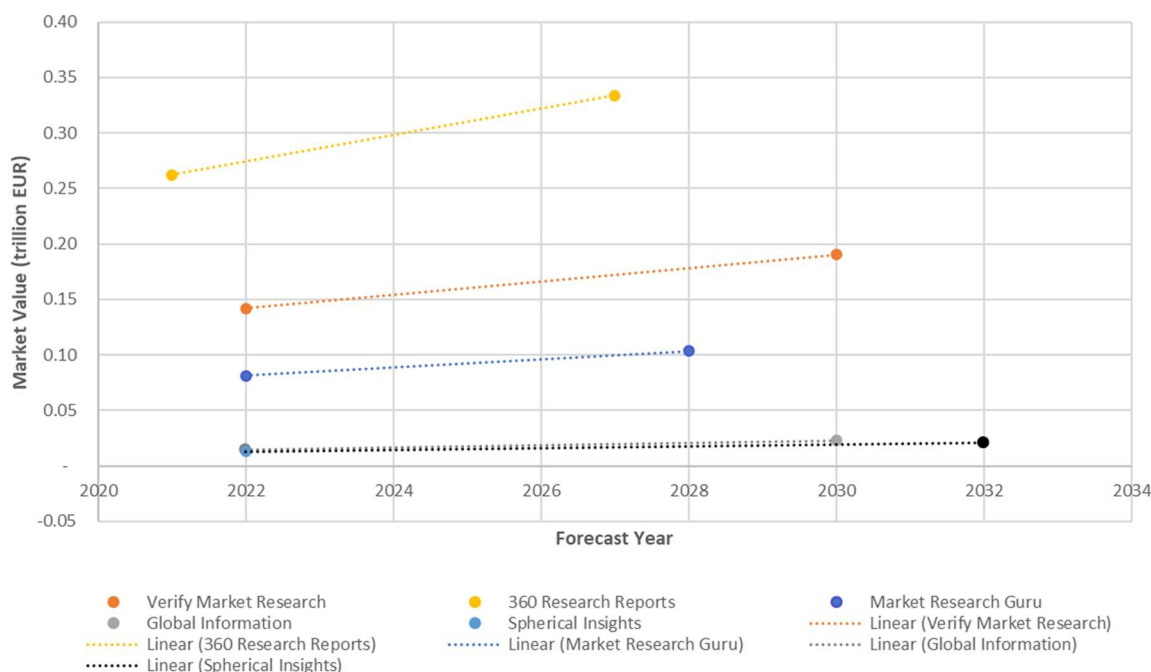


Figure 14: Global Tunnel Construction Market Forecast

To assess the feasibility of entering the global tunnel construction market, we have collected comprehensive studies of the sector, where the market's growth and trajectory are predicted in various ways. The graph above illustrates insights from reputable sources such as Research and Markets, CISION PR Newswire, Report Linker, Market Growth Reports, Business Research Insights, MarketResearch, and Absolute Reports. The consensus among these studies predicts a notable growth trajectory for the sector. Overall, the prediction can be categorised into three groups. The first group consists of the studies from Research and Markets<sup>93</sup>,

<sup>91</sup> ReportLinker (2023). *Tunnel Global Market Report 2023*. Retrieved 2023.

<https://www.reportlinker.com/p06464172/Tunnel-Global-Market-Report.html>

<sup>92</sup> Research and Markets (2023). Global Tunnel Market Set to Expand at 5.4% CAGR, Reaching \$30.7 Billion by 2027, Driven by Technological Advancements and Rising Demand for Tunnel Construction. Retrieved 2023.

<https://www.prnewswire.com/news-releases/global-tunnel-market-set-to-expand-at-5-4-cagr-reaching-30-7-billion-by-2027--driven-by-technological-advancements-and-rising-demand-for-tunnel-construction-301932318.html>

<sup>93</sup> Research and Markets (2023). Tunnel Construction Market – Global Industry Analysis, Size, Share, Growth, Trends, and Forecast 2023-2030 – By Product, Technology, Grade, Application, End-user and Region (North America, Europe, Asia Pacific, Latin America and Middle East and Africa). Retrieved 2023.

<https://www.researchandmarkets.com/report/tunnel>



CISION PR Newswire<sup>94</sup>, Report Linker<sup>95</sup>, and the Business Research Company<sup>96</sup> that voted to align on a CAGR of 4.3% for the forecast period of 2023-2027, concluding the prediction with €0.03 trillion market share<sup>97</sup>. Notably, the outlook becomes more optimistic in the second group, involving the studies from Market Growth Reports<sup>98</sup> and Business Research Insights<sup>99</sup>, indicating a higher CAGR of 7.38% for 2021-2027, with an expected market share of €0.13 trillion<sup>100</sup>. The last group is a collection of MarketResearch.com<sup>101</sup> and Absolute Reports<sup>102</sup> studies that present an even more positive perspective, projecting the highest CAGR of 7.56%, hoping to conclude the forecast period with a market share of €0.14 trillion<sup>103</sup>.

*The changing urbanisation and industrialisation push the government to fulfil the economy's need for safe and quality mobility with minimum traffic congestion via tunnel construction. Several drawbacks for the sector are classic challenges in high capital cost, the low availability of skilled labour, challenges in bureaucracy and regulation, and the interruption in the supply chain of construction materials.*

Navigating the complex global tunnel construction market requires a nuanced understanding of the fundamental forces driving its growth. These market drivers, among others, come from the changing landscape of **urbanisation and industrialisation**<sup>104</sup>. As cities expand and industries flourish, there's a

<sup>94</sup> CISION PR Newswire (2023). Global Tunnel Market Set to Expand at 5.4% CAGR, Reaching \$30.7 Billion by 2027, Driven by Technological Advancements and Rising Demand for Tunnel Construction. Retrieved 2023.

<https://www.prnewswire.com/news-releases/global-tunnel-market-set-to-expand-at-5-4-cagr-reaching-30-7-billion-by-2027--driven-by-technological-advancements-and-rising-demand-for-tunnel-construction-301932318.html>

<sup>95</sup> ReportLinker (2023). Tunnel Global Market Report 2023. Retrieved 2023.

<https://www.reportlinker.com/p06464172/Tunnel-Global-Market-Report.html>

<sup>96</sup> The Business Research Company (2023). Tunnel Global Market Report 2023 – By Tunnel Type (Railway Tunnel, Highway, And Roadway Tunnel), By Material (Steel, Concrete, Composite Material), By Application (Commercial Construction, Government Construction) – Market Size, Trends, And Global Forecast 2023-2032. Retrieved 2023.

<https://www.thebusinessresearchcompany.com/report/tunnel-global-market-report>

<sup>97</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>98</sup> Market Growth Reports (2022). Global Tunnel Construction Industry Research Report, Competitive Landscape, Market Size, Regional Status and Prospect. Retrieved 2023.

<https://www.marketgrowthreports.com/global-tunnel-construction-industry-research-report-competitive-landscape-market-21739480>

<sup>99</sup> Business Research Insights (2023). Tunnel Construction Market Size, Share, Growth, and Industry Analysis, By Type (New Work, Reconstruction, Repairs), By Application (Transportation Tunnel, Utility Tunnel) and Regional Insights and Forecast to 2031. Retrieved 2023.

<https://www.businessresearchinsights.com/market-reports/tunnel-construction-market-109337>

<sup>100</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>101</sup> Market Research.com (2023). Global Tunnel Construction Market Research Report 2023-Competitive Analysis, Status and Outlook by Type, Downstream Industry, and Geography, Forecast to 2029. Retrieved 2023.

<https://www.marketresearch.com/Maia-Research-v4212/Global-Tunnel-Construction-Research-Competitive-33760650/>

<sup>102</sup> Absolute Reports (2023). Global Tunnel Construction Market Research Report 2023 – Competitive Analysis, Status, and Outlook by Type, Downstream Industry, and Geography, Forecast to 2029. Retrieved 2023.

<https://www.absolutereports.com/global-tunnel-construction-market-22709684>

<sup>103</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>104</sup> Research and Markets (2023). Tunnel Construction Market – Global Industry Analysis, Size, Share, Growth, Trends, and Forecast 2023-2030 – By Product, Technology, Grade, Application, End-user and Region (North America, Europe, Asia Pacific, Latin America and Middle East and Africa). Retrieved 2023.

<https://www.researchandmarkets.com/report/tunnel>



heightened demand for constructing roads and railway tunnels, providing crucial connectivity for transportation networks. **Governments, especially in leading economies, proactively invest in infrastructure construction to cater to mobility demand with heightened safety and minimum traffic congestion<sup>105</sup>.**

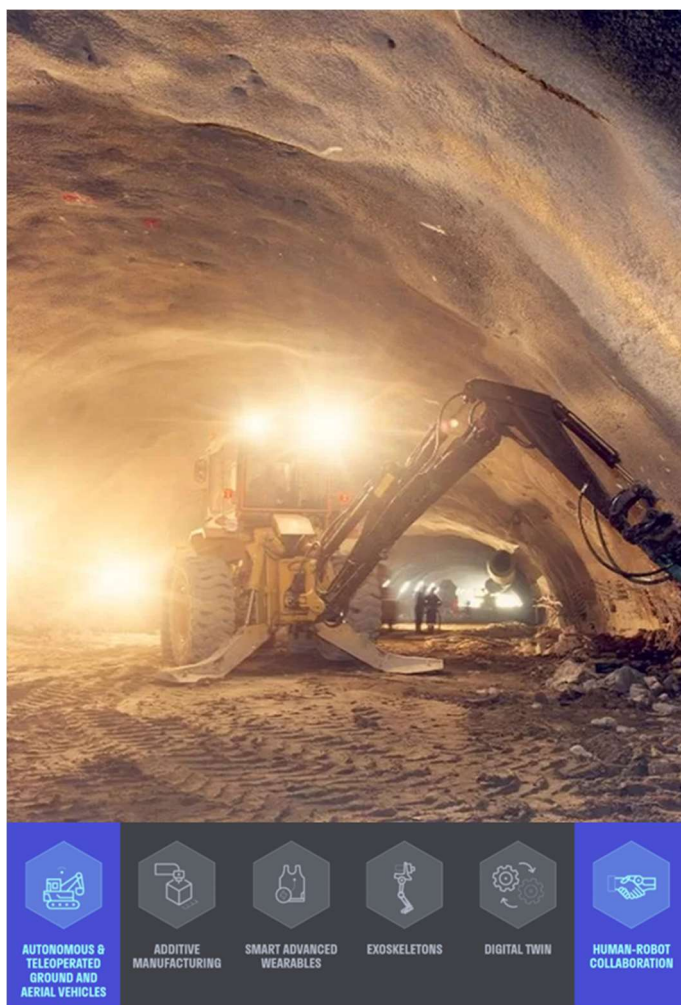


Figure 15: BEEYONDERS' Innovation for the Tunnel Construction Use Case  
Image Credit: Acciona

However, this promising trajectory must compromise to face several challenges that can influence the growth of the sector negatively, such as the **high capital cost<sup>106</sup>** of tunnel construction and maintenance, the **shortage of skilled labour, regulatory hurdles** around standards and permits, and the **interruption in the supply chain of construction materials**. Addressing these challenges is crucial to sustaining the positive momentum of the tunnel construction market.

The growing demand for seamless, safe, and efficient mobility with little to no traffic congestion requires alternative paths, as viable ground transportation routes are becoming scarce<sup>107</sup>. Here, the tunnel construction sector flourishes as an immediate alternative to fulfil the necessity. However, the industry faces formidable challenges, including bureaucratic hurdles and high capital requirements. Tunnel construction is also listed as one of the most hazardous activities in the construction sector, necessitating stringent safety measures, including periods when no workers are present.

In challenging hard or rocky terrains, the traditional tunnel construction involves using explosives and jumbo to drill the excavation front and then cleansing the tunnel atmosphere using an air extraction system. Not only is this process unsuitable for tunnel construction workers' safety, as it is beyond the human

survival rate, but it is also very time-consuming and creates unproductive downtime.

<sup>105</sup> Absolute Reports (2023). Global Tunnel Construction Market Research Report 2023 – Competitive Analysis, Status, and Outlook by Type, Downstream Industry, and Geography, Forecast to 2029. Retrieved 2023.

<https://www.absolutereports.com/global-tunnel-construction-market-22709684>

<sup>106</sup> Business Research Insights (2023). Tunnel Construction Market Size, Share, Growth, and Industry Analysis, By Type (New Work, Reconstruction, Repairs), By Application (Transportation Tunnel, Utility Tunnel) and Regional Insights and Forecast to 2031. Retrieved 2023.

<https://www.businessresearchinsights.com/market-reports/tunnel-construction-market-109337>

<sup>107</sup> Research and Markets (2023). Tunnel Construction Market – Global Industry Analysis, Size, Share, Growth, Trends, and Forecast 2023-2030 – By Product, Technology, Grade, Application, End-user and Region (North America, Europe, Asia Pacific, Latin America and Middle East and Africa). Retrieved 2023.

<https://www.researchandmarkets.com/report/tunnel>



Hence, the idea of employing BEEYONDERS' developed autonomous and teleoperated ground and air robotic solutions can ensure the safety of the tunnel construction workers while keeping productivity on track since these innovative solutions can enter the tunnel immediately after the explosion. The solution works with the drones collecting pivotal information about the tunnel conditions, where the data sent will be used to aid the combination of autonomous and remote-controlled machinery within the tunnel to clear explosion debris from the excavation front when the project site is still considered unsafe for human workers. Human workers then *monitor this procedure using Digital Twin*, ensuring the alignment between the progress and the initial plan while keeping the safety level and downtime low.

## 2.3. Maritime Construction Use Case

In the innovative landscape of the maritime use case, our focus is on leveraging additive manufacturing and 3D print automation to create environmentally friendly caisson structures. This forward-thinking approach aligns with the broader industry trend of integrating advanced technologies to enhance construction processes while ensuring sustainability.

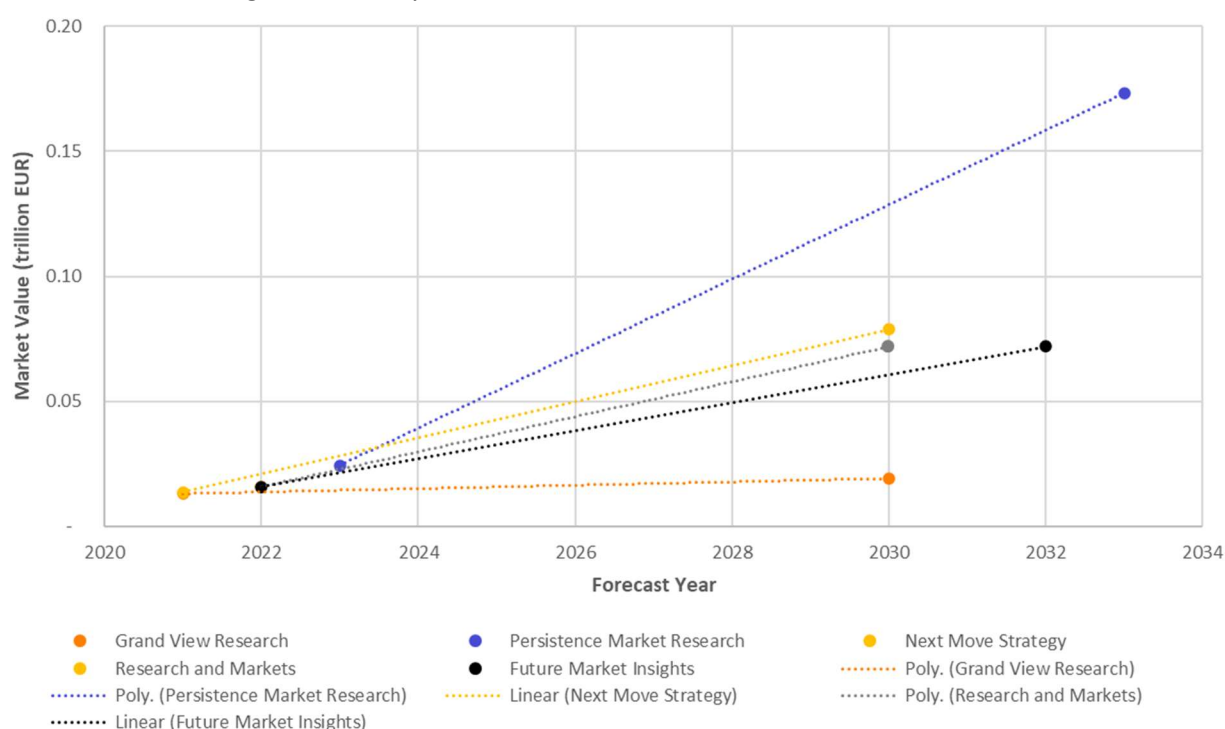


Figure 16: Global Additive Manufacturing Forecast

Within the growing global additive manufacturing sector, diverse perspectives on the direction of the growth emerge from several reputable studies. One of them comes from Grand View Research, where, in their study, the global additive manufacturing sector will witness a substantial growth of a CAGR of 20.8% from 2022 to



2030<sup>108</sup>, growing from €0.013 trillion to €0.019 trillion<sup>109</sup>. In parallel, Persistence Market Research<sup>110</sup> estimates the market's value to reach €0.173 trillion<sup>111</sup> by the end of 2033, exhibiting a robust CAGR of 21.6%. The contrasting point of view comes from the shift in defining the industry's use cases. Other studies confirm similar forecast numbers. Next Move Strategy Consulting<sup>112</sup> estimates the market value to reach €0.079 trillion<sup>113</sup> by the end of 2030 due to the growth in 2021-2030 with a notable CAGR of 21.20%. Their study is similar to the one created by Future Market Insights<sup>114</sup> and foresees the same CAGR but for the forecast of 2022 to 2030, with an expected ending share of €0.072 trillion<sup>115</sup>. Another study collected by Research and Markets projects a remarkable trajectory that will reveal a valuation of €0.072 trillion<sup>116</sup> due to a CAGR of 21.20% from 2022 to 2030<sup>117</sup>. These diverse forecasts underscore the promising outlook and immense growth potential within the additive manufacturing sector, reflecting the innovation and flexibility of the material to be employed in various use cases.

*Several factors that drive the growth of the global additive manufacturing market are the multi-sectorial use of 3D printing technologies, the increased awareness of the benefit of using the technology compared to traditional manufacturing, the advancement of software and 3D printing technologies, and the declining price of additive manufacturing machines and materials due to their popularity.*

Multiple factors propel the escalating growth of the global additive manufacturing market. A notable catalyst is *the widespread use of 3D printing technologies across diverse sectors*, from prototyping for the physical parts of a vehicle in an aerospace industry to smaller semi-finished electrical components like circuit boards,

<sup>108</sup> Grand View Research (2022). Additive Manufacturing Market Size, Share & Trends Analysis Report By Component, By Printer Type, By Technology, By Software, By Application, By Vertical, By Material, By Region, And Segment Forecasts, 2022 – 2030. Retrieved 2023.

<https://www.grandviewresearch.com/industry-analysis/additive-manufacturing-market>

<sup>109</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>110</sup> Persistence Market Research (2022). *Global Market Study on Additive Manufacturing: Commercial Revolution to drive the market*. Retrieved 2023.

<https://www.persistencemarketresearch.com/market-research/additive-manufacturing-market.asp>

<sup>111</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>112</sup> Next Move Strategy Consulting (2023). *Additive Manufacturing Market to Grow at 21.2% CAGR by 2030*. Retrieved 2023.

<https://www.nextmsc.com/news/additive-manufacturing-market>

<sup>113</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>114</sup> Future Market Insights (2023). *Market Survey on Additive Manufacturing and Material Market Covering SaLES Outlook, Up-to-date Key Trends, Market Size and Forecast, Market Statistics, Penetration Analysis, Pricing Analysis and Company Ecosystem*. Retrieved 2023.

<https://www.futuremarketinsights.com/reports/additive-manufacturing-material-market>

<sup>115</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>116</sup> European Central Bank. (2023). USD to EUR exchange rate on October 23, 2023.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>117</sup> Research and Markets (2022). *Additive Manufacturing Market Size, Share & Trends Analysis Report by Component, by Printer Type, by Technology, by Software, by Application, by Vertical, by Material, by Region, and Segment Forecasts, 2022-2030*. Retrieved 2023.

<https://www.researchandmarkets.com/reports/5595864/additive-manufacturing-market-size-share-and>



antennae, capacitors, and sensors to 3D modelling for hobbyists<sup>118</sup>. This surge is further intensified by the *increased awareness of its myriad benefits over traditional manufacturing technologies*. Due to ongoing *advancements in 3D printing technologies and software*, the decreasing *price of additive manufacturing machines and materials* is poised to stimulate sales and push a broader industry focus on reducing production costs and enhancing overall productivity. All of these factors propel the market to reach new heights<sup>119</sup>.

*Meanwhile, the market restraints are the trials and errors in finding the perfect mechanical properties of the additive manufacturing material for the desired products, which create an elevated cost. Another factor is the price of the starting investment of machinery and materials to enter the industry.*

On the other hand, certain factors pose challenges to the rapid development of the additive manufacturing market, particularly concerning the *mechanical properties of the materials used*. Since the material's mechanical properties need to be modified to achieve the desired final products, it might be limiting for smaller players in the industry. This challenge is compounded by *potential financial limitations*, especially for companies that still need to *invest in initial equipment*, further impacting their ability to navigate the evolving additive manufacturing landscape<sup>120</sup>. The interplay of these factors underscores the importance of strategic financial planning and technological adaptation for businesses aiming to thrive in the additive manufacturing sector.

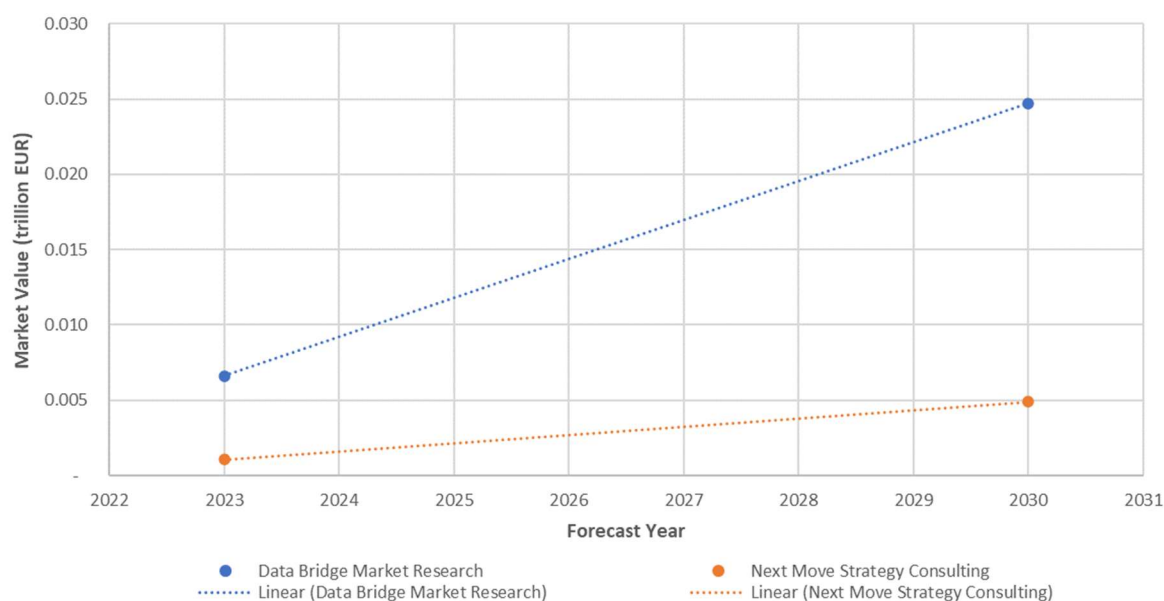


Figure 17: European Additive Manufacturing Forecast

<sup>118</sup> Ibid.

<sup>119</sup> Future Market Insights (2023). *Market Survey on Additive Manufacturing and Material Market Covering SaLES Outlook, Up-to-date Key Trends, Market Size and Foresact, Market Statistics, Penetration Analysis, Pricing Analysis and Company Ecosystem*. Retrieved 2023.

<https://www.futuremarketinsights.com/reports/additive-manufacturing-material-market>

<sup>120</sup> Future Market Insights (2023). *Market Survey on Additive Manufacturing and Material Market Covering SaLES Outlook, Up-to-date Key Trends, Market Size and Foresact, Market Statistics, Penetration Analysis, Pricing Analysis and Company Ecosystem*. Retrieved 2023.

<https://www.futuremarketinsights.com/reports/additive-manufacturing-material-market>



Zooming into the regional market, we have collected the European additive manufacturing forecast studies poised for substantial growth from 2023 to 2030. According to Data Bridge Market Research<sup>121</sup>, the industry's future is bright, with the upward trajectory projected to grow at a CAGR of 20.7% in this period, reaching an estimated value of €0.025 trillion<sup>122</sup> by 2030. In parallel, Next Move Strategy Consulting<sup>123</sup> forecasted that the rest of Europe (Ukraine, Belgium, Switzerland, and others) is anticipated to experience growth up to €0.005 trillion<sup>124</sup>, an impressive CAGR of 24.50% in the same study period. These projections underscore the dynamic nature of the European additive manufacturing landscape, offering a lucrative arena for strategic market penetration and growth initiatives.

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<sup>121</sup> Data Bridge Market Research (2022). *Europe Additive Manufacturing Market – Industry Trends and Forecast to 2030*. Retrieved 2023.

<https://www.databridgemarketresearch.com/reports/europe-additive-manufacturing-market>

<sup>122</sup> European Central Bank. (2023). *USD to EUR exchange rate on October 23, 2023*.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)

<sup>123</sup> Next Move Strategy Consulting (2023). *Rest of Europe Additive Manufacturing (AM) Market is expected to reach USD 5.18 billion by 2030*. Retrieved 2023.

<https://www.nextmsc.com/news/rest-of-europe-additive-manufacturing-market>

<sup>124</sup> European Central Bank. (2023). *USD to EUR exchange rate on October 23, 2023*.

[https://www.ecb.europa.eu/stats/policy\\_and\\_exchange\\_rates/euro\\_reference\\_exchange\\_rates/html/eurofxref-graph-usd.en.html](https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html)



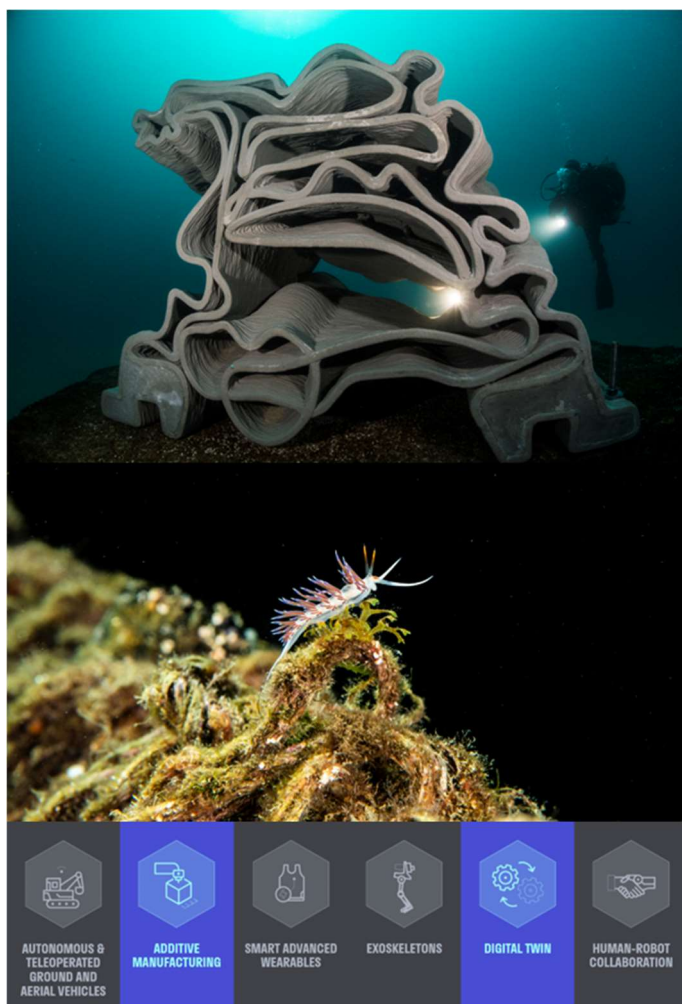


Figure 18: BEEYONDERS' Innovation for Maritime Construction  
Image Credit: Julien Dalle – SEABOOST

When considering additive manufacturing applications for marine infrastructure, the paramount challenge lies in creating **structures that can withstand both the corrosive effects of seawater and dynamic wave loads**. Any innovative solutions in additive manufacturing must meticulously account for these demanding environmental conditions. This application must be **ruggedised, respect biodiversity, and protect the natural marine ecosystem**. In doing so, the BEEYONDERS project is optimising the **structural design of caissons in new geometrical shapes to minimise the use of mortar and waste in construction, thus reducing CO2 emissions**. These newly developed shapes are **bio-inspired and structured to promote reef growth** that will be **monitored using Digital Twin**. The same Digital Twin technology will also monitor and **provide real-time insights into the environmentally friendly push-in pile system**, comparing the installation resistance geotechnical and machine-measured data to the original execution plan.



### 3. Technology and Investment Trend

Based on the extensive review of the market and the analysis of the progress of innovation in digitalisation within the construction sector, PNO has built a holistic view of the innovation flow in digitalisation within the construction sector, providing insights into its trajectory and evolving dynamics.

A comprehensive analysis of BEEYONDERS Innovation Ecosystem was completed in (Deliverable D8.2 - Innovation Ecosystem and Stakeholders Map). Some key outcomes are reported below:

- ✓ ***From a total of 50 top R&D projects worth €114.1 million of total funding over the last seven years (from 2017 to 2023), 87.02% of them have been funded by Europe.***
- ✓ 50 of the most relevant patents have been identified. Within this population, the technology provided is heavily ***concentrated around BIM and 3D Printing technologies, with more than 80% of their use focused on the building construction sector application.***
- ✓ **The early-stage investment portrays the market's willingness to adopt new technology, highlighting the presence of early adopters keen on disrupting the market with their investments in innovative solutions**

The accompanying innovation graph (Figure 16) serves as a visual summary representation, showcasing the evolution from theoretical invention to real-world application and, thus, reflecting a dynamic landscape of technological evolution.

***It has been observed advancing progress for the technology throughout our window of observation period (2017 to 2022)<sup>125</sup>*** and noticed that the uprising trend can be split into three distinct stages. The early observation years (2017-2018) mark ***Stage-1*** is characterised by a surge in R&D and funding. The subsequent ***Stage-2*** (2018-2020) has marked an acceleration, with more mature R&D and early stage financing entering the loop, indicating a heightened interest in disruptive technologies. Finally, (although partial) the closest observation period (2020-present) in ***Stage-3*** shifted the trend to ***a more focused and mature innovation landscape of digitalisation in the construction sector, hinting that a certain degree of stabilisation could be ahead,*** with technologies ready to be applied to mainstream practices.

<sup>125</sup> A z-score model has been built based on a mixed scoreboard of innovation intensity indicators, like R&D and funding.



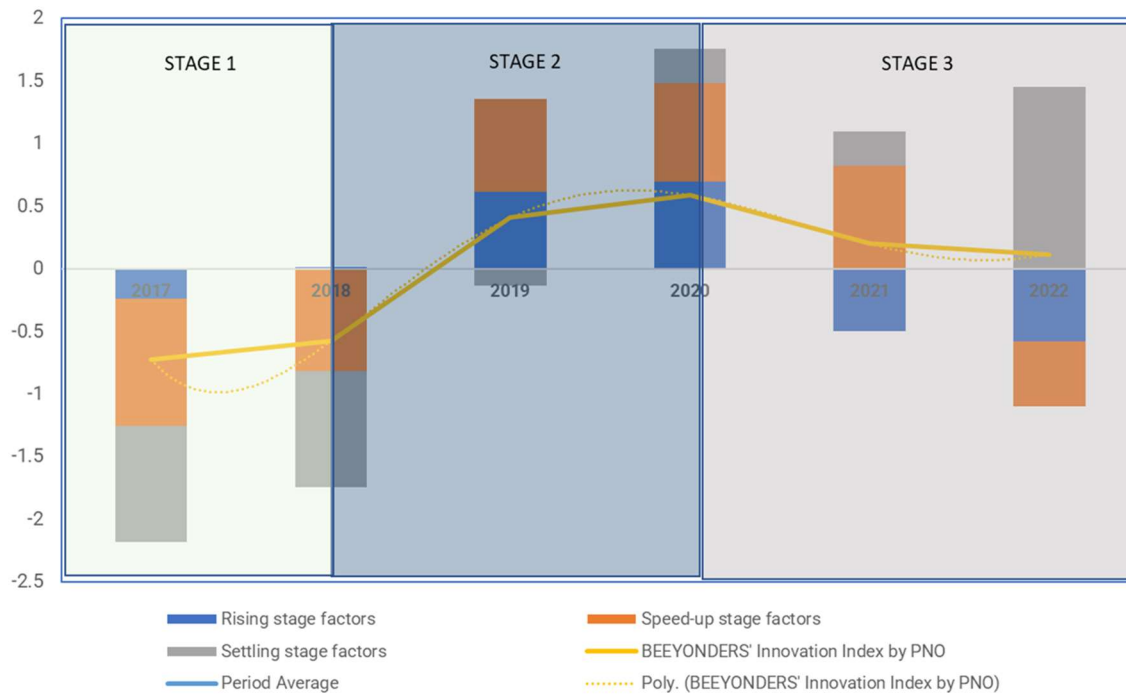


Figure 19: The Technology and Investment Trend.

The direct correlation between this technological and investment insight with the BEEYONDERS project underscores that *several players are already attempting to influence the current market*. However, *the market has yet to peak, even as the technology matures. The innovation developed within BEEYONDERS is on the right track to penetrate the market, aligning with the evolving dynamics observed in the broader construction sector.*



## 4. Competitor Landscape

In the rapidly evolving landscape of the construction industry, a diverse array of stakeholders competes to lead the market and carve out their mark in this dynamic sector. As digitalisation finds its way to contribute to the construction industry, the competition intensifies from traditional know-how to cutting-edge disruptive technology. From industry veterans to agile startups, the spectrum of competitors displays the industry's trajectory.

### 4.1. Autonomous Air Vehicles



Figure 20: Flyability Elios by Kopterflug  
Image Credit: Kopterflug

construction uses.

Focusing on cutting-edge innovations in the ever-growing sector, we can look at the players actively doing their part in the current market. The first observation dwells on the population of autonomous air vehicles. Big companies like Terra Drone<sup>126</sup> produce their drones regardless of market usage. In contrast, companies of the same scale, like KAWADA Technologies<sup>127</sup> and Amey,<sup>128</sup> focus on using their drones for the building construction and maintenance market. However, Terra Drone has been trying to specialise several types of drones within the building construction and maintenance industry by actively participating in funded projects to employ drones and their usefulness in maintaining occupational health and safety. Smaller companies like Kopterflug<sup>129</sup> had already decided their speciality in the inspections for the building construction sector, while Aeromedia UAV<sup>130</sup> and ASDRO<sup>131</sup> open up possibilities to generalise in any

<sup>126</sup> Terra Drone (2023). Company Profile. Retrieved 2023.

<https://terra-drone.net/global/company/>

<sup>127</sup> KAWADA Technologies (n.d.). *About KAWADA Technologies*. Retrieved 2023.

<https://www.kawada.jp/global/>

<sup>128</sup> Amey (2020). *AmeyVTOL trials UK first 'beyond visual line of sight' drone inspection*. Retrieved 2023.

<https://www.amey.co.uk/media/news/2020/april/ameyvtol-trials-uk-first-beyond-visual-line-of-sight-drone-inspection>

<sup>129</sup> Kopterflug (2022). *Professional drone inspections for the construction industry*. Retrieved 2023.

<https://www.kopterflug.de/inspektion-in-bauwirtschaft/>

<sup>130</sup> AEROMEDIA (2020). *Industrial Inspection with Drones*. Retrieved 2023.

<https://aeromedia.es/inspeccion-industrial/>

<sup>131</sup> ASDRO (2023). ASDRO – The high-flyers with perspective. Retrieved 2023.

<https://www.asdro.de/>



## 4.2. Autonomous/Teleoperated Ground Vehicles and Collaborative Robots

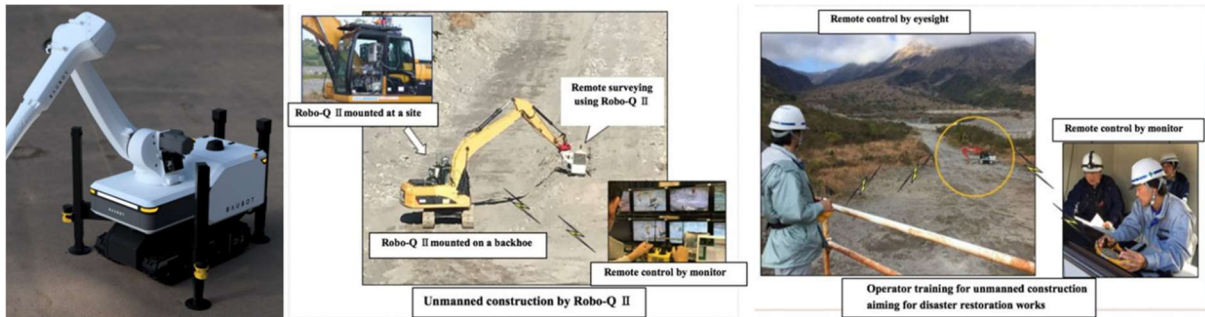


Figure 21: Autonomous/Teleoperated Ground Vehicles and Collaborative Robots

Image Credit: Left – Baubot MRS12 for various construction environments (Baubot); Middle, Right – Robo-Q II construction disaster response machine (Fujita Corporation)

As for autonomous and teleoperated vehicles, both large companies like Fujita Corporation<sup>132</sup> and smaller ones like ARAV<sup>133</sup> and Cybernetix SA<sup>134</sup> are playing in a general way, offering their products and services for various construction sites. Companies like Ken Robotech<sup>135</sup>, Kobots<sup>136</sup>, and Baubot<sup>137</sup> are entering the market to promote automation and human-friendly worksites, boosting the fewer work-related strains and injuries using their innovations.

<sup>132</sup> FUJITA (2017). *Development of Advanced Remote-Controlled Robot (Robo-Q II) and Operators for the Unmanned Machines*. Retrieved 2023.

<https://www.fujita.com/news-releases/170227.html>

<sup>133</sup> ARAV (2023). *About Company*. Retrieved 2023.

<https://www.arav.jp/>

<sup>134</sup> Cybernetix SA (2023). *Operation & Maintenance Robotics Solutions and Services*. Retrieved 2023.

<https://www.cybernetix.fr/our-solutions/operation-maintenance-robotics-solutions-and-services>

<sup>135</sup> Ken Robotech (n.d.). *Creating the World's Most Human-Friendly Worksite*. Retrieved 2023.

<https://en.kenrobo-tech.com/>

<sup>136</sup> Kobots (2023). *About Kobots*. Retrieved 2023.

<https://kobots.com/about-2/>

<sup>137</sup> Baubot (2023). *The Future of Construction is Here*. Retrieved 2023.

<https://www.baubot.com/>



### 4.3. Specialised Robotic Functions



Figure 22: Specialised Robotic Functions

Image Credit: Left – NOVA S Spraybot (ARE23); Middle – IP03 Posture Ergoskeleton (GOBIO)

Right – Engineering Grade AR Wearables (XYZ Reality)

In the robotic innovation sector, not every SME generalises their innovation like Conrobotix<sup>138</sup> and EVOCONS<sup>139</sup>. Some other SMEs are specialising in their robotic functions. For example, ARE23,<sup>140</sup> with its NOVA-S robots, focuses on automating manual processes in the decorative painting market. Other innovations closer to human application are the exoskeleton for general construction by GOBIO<sup>141</sup>, wearables

<sup>138</sup> Conrobotix (2019). *About the company*. Retrieved 2023.

<https://www.conrobotix.no/om-selskapet>

<sup>139</sup> EVOCONS (n.d.) *About the company*. Retrieved 2023.

<https://evocons.es/nosotros/>

<sup>140</sup> ARE23 – Nova Spraytec GmbH (2023). *About Us*. Retrieved 2023.

<https://www.novaspraytec.com/>

<sup>141</sup> GOBIO (2023). *Industrial Exoskeleton*. Retrieved 2023.

<https://gobio-robot.com/exosquelettes-industriels/>



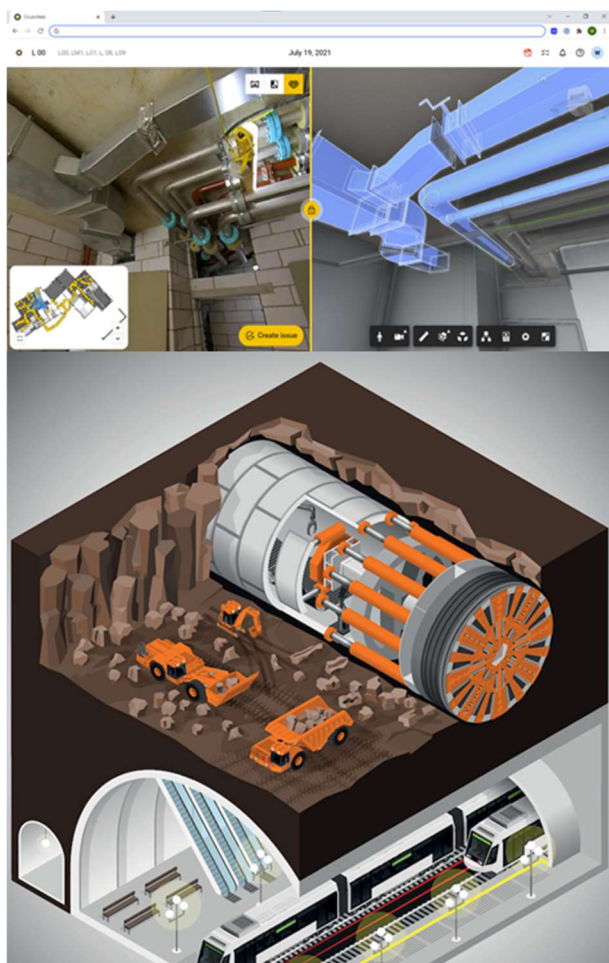


Figure 23: Digital Twin  
Image Credit Top – Oculo, Bottom – Tunnelware  
by DigitalTwin Technology GmbH

by IQWEAR that generalise in all kinds of construction, and XYZ Reality<sup>142</sup> wearables that cover the building construction sector. Building Information Modelling (BIM)

From the BIM category, the market already acknowledges Bim&Co SAS<sup>143</sup>, Creook<sup>144</sup>, Graitec Group<sup>145</sup>, Modulous<sup>146</sup>, and Naska.AI,<sup>147</sup> which stand for road construction and maintenance sites and are replicable for various general construction industries.

## 4.4. Digital Twin

To conclude the innovations available in the current market for digitalisation in the construction sector, several competitors already existing in the market that bring Digital Twin into the industry include LocLab (part

<sup>142</sup> XYZ Reality (2023). *Engineering Grade AR™*. Retrieved 2023.

[https://www.xyzreality.com/augmented-reality-for-construction? gl=1\\*1jfwyu\\* up\\*MQ..\\* ga\\*MTgwOTcyNTIzNi4xNzAwNzcwMTU5\\* ga\\_0WVZRRE00X\\*MTcwMDc3MzE1OS4xLjAuMTcwMDc3MzE1OS4wLjAuMA..](https://www.xyzreality.com/augmented-reality-for-construction? gl=1*1jfwyu* up*MQ..* ga*MTgwOTcyNTIzNi4xNzAwNzcwMTU5* ga_0WVZRRE00X*MTcwMDc3MzE1OS4xLjAuMTcwMDc3MzE1OS4wLjAuMA..)

<sup>143</sup> Bim&Co (2023). *BIM*. Retrieved 2023.

<https://www.bimandco.com/bim/>

<sup>144</sup> Creook (2023). *BIM & VDC Digitalisation for manufacturers of Building & Architectural products*. Retrieved 2023.

<https://creook.com/en/>

<sup>145</sup> Graitec Group (2023). *Architecture, engineering, & Construction*. Retrieved 2023.

<https://graitec.com/uk/all-software-solutions-autodesk-graitec-others/aec-products/>

<sup>146</sup> Modulous (2023). *TESSA Software*. Retrieved 2023.

<https://www.modulous.com/tessa/>

<sup>147</sup> Naska.AI (2023). *AI Construction Services*. Retrieved 2023.

<https://naska.ai/>



of Hexagon)<sup>148</sup>, SwissInspect<sup>149</sup>, Takenaka<sup>150</sup>, Onocom<sup>151</sup>, DiConneX<sup>152</sup>, Oculo<sup>153</sup>, and DigitalTwin Technology GmbH<sup>154</sup>, where the company is also developing a specialised Digital Twin product for tunnel construction, populating the tunnel construction market with hyperTunnel<sup>155</sup>.

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<sup>148</sup> LocLab – Part of Hexagon (n.d.). *The Digital Twin Company*. Retrieved 2023.

<https://www.lociab-consulting.com/>

<sup>149</sup> SwissInspect (2022). *AI-Powered Solution for Traceable Damage State Estimation of Infrastructure and Buildings*. Retrieved 2023.

<https://www.swissinspect.io/>

<sup>150</sup> Takenaka (2021). *Initiatives for Digital Transformation through “Building 4.0 Digital Platform”*. Retrieved 2023.

[https://www.takenaka.co.jp/takenaka\\_e/library/news/2021/m1001\\_04.html](https://www.takenaka.co.jp/takenaka_e/library/news/2021/m1001_04.html)

<sup>151</sup> Onocom (2022). *Onocom: Japan’s Digital Construction Pioneer*. Retrieved 2023.

<https://www.onocom.co.jp/wp-content/uploads/2022/02/Newsweek-ONOCOM.pdf>

<sup>152</sup> DiConneX (n.d.). *About Company*. Retrieved 2023.

<https://diconnex.com/>

<sup>153</sup> Oculo (2021). *Solutions: the easiest way to a digital twin of your site*. Retrieved 2023.

<https://www.oculo.ai/solutions>

<sup>154</sup> DigitalTwin Technology GmbH (2023). *Products*. Retrieved 2023.

<https://www.digitaltwin.technology/>

<sup>155</sup> hyperTunnel (2022). *Transforming underground construction through AI, Machine Learning and Swarm Robotics*. Retrieved 2023.

<https://www.hypertunnel.co.uk/>



## 5. Conclusions

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This report elaborates on the current situation point of view of the construction sector, the trajectory of the forecasted future of the industry, how the technologies created in the BEEYONDERS project can fit each Use Case, the flow of the invention and the investment of the technology, and the currently available technology in the market.

This assessment helps understand the market as it is, where it is going from the present condition, and how to position BEEYONDERS' innovation as the solutions of the market:

- In general, the global construction industry is growing and is an almost never-saturated market. This market forecast is also backed by our observation toward the historical flow of the innovation and investment in the chosen years.
- Some situations that drive market growth are the government's spending on infrastructure development, the rise of industrialisation, the growing population and urbanisation, the number of smart cities appearing worldwide, and the collective demand for environmentally responsible construction and economy.
- Meanwhile, several industry restraints include the financial capacity of the construction budget, the time needed to solve the regulation and bureaucracy administration preceding the construction projects, and the availability of proper and skilled human workers to perform the projects.
- While BEEYONDERS' technologies fit perfectly to cater for the needs of the market in each of the selected use cases, it is wise to consider the best strategy to penetrate the market for each Use Case since there are already existing players offering technologies alternative to the ones developed in the project.

