D8.3 IMPACT ASSESSMENT AND EXPLOITATION INTERIM REPORT

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ABSTRACT

Exploitation activities are critical components of any H2020-funded project's success. The following document provides a comprehensive summary of ASHVIN's strategy, business model, targeted market, challenges, competitors, and information about the conducted with the partners to brainstorm the key exploitable results. It lays out the current market insights and specifies the various market domains ASHVIN could target by pursuing its exploitation strategy.

KEYWORDS

Digital Twin, Building Information Modelling, Communication, Exploitation, Market, Sustainable, Strategy, Business Model

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DISCLAIMER

ACRONYMS & DEFINITIONS

AEC	Architecture Engineering Construction
AI	Artificial Intelligence
BIM	Building Information Modelling
BMS	Building Management System
ER	Exploitable Results
GDPR	General Data Protection Regulation
IoT	Internet of Things
KER	Key Exploitable Results
ML	Machine Learning
RTLS	Real-time Location Tracking System
TRL	Technology Readiness Level
ICT	Information and Communication Technology
EU	European Union
VC	Venture Capital
CAGR	Compound annual growth rate

ASHVIN PROJECT

ASHVIN aims at enabling the European construction industry to significantly improve its productivity, while reducing cost and ensuring absolutely safe work conditions, by providing a proposal for a European wide digital twin standard, an open-source digital twin platform integrating IoT and image technologies, and a set of tools and demonstrated procedures to apply the platform and the standard proven to guarantee specified productivity, cost, and safety improvements. The envisioned platform will provide a digital representation of the construction product at hand and allow to collect real-time digital data before, during, and after production of the product to continuously monitor changes in the environment and within the production process. Based on the platform, ASHVIN will develop and demonstrate applications that use the digital twin data. These applications will allow it to fully leverage the potential of the IoT based digital twin platform to reach the expected impacts (better scheduling forecast by 20%; better allocation of resources and optimization of equipment usage; reduced number of accidents; reduction of construction projects). The ASHVIN solutions will overcome worker protection and privacy issues that come with the tracking of construction activities, provide means to fuse video data and sensor data, integrate geo-monitoring data, provide multi-physics simulation methods for digital representing the behavior of a product (not only its shape), provide evidence based engineering methods to design for productivity and safety, provide 4D simulation and visualization methods of construction processes, and develop a lean planning process supported by real-time data. All innovations will be demonstrated on real-world construction projects across Europe. The ASHVIN consortium combines strong R&I players from 9 EU member states with strong expertise in construction and engineering management, digital twin technology, IoT, and data security / privacy.

TABLE OF CONTENTS

INDEX OF FIGURES

INDEX OF TABLES

1. INTRODUCTION

This deliverable reports the Interim exploitation activities of the **ASHVIN** project and the plans of each partner for further exploitation into the future.

ASHVIN's Impact Assessment and Exploitation Plans report has been developed through a creative process of reflection and fermentation among project partners, each of one representing different stakeholder groups, this plan reflects their positions and views for ensuring maximum impact. Moreover, the exploitation plan is a living document that will be constantly revised and updated throughout the lifespan of the project. The last iteration will include all updates of the exploitation achievements reached between M19 and M36, the final business model for the **ASHVIN** solution and a detailed roadmap for additional efforts and milestones to be executed after the end of the project, in order to achieve sustainability.

The importance of all exploitation activities has been a high priority for all partners since the beginning of the project, as they are the main means to determine and measure the success of the project as a whole. Moreover, **ASHVIN** exploitation activities not only focus on exploiting and showcasing **ASHVIN** platform to the end users, but also aim to engage those users throughout the whole process of **ASHVIN** tools development in order to know their demands and respond to the market requests.

The structure of this deliverable is as follows:

- **Section 2** discusses the **ASHVIN** vision by mentioning project's Value Proposition and Tangible exploitable Assets.

- **Section 3** positions **ASHVIN** in the market by presenting a detailed market analysis covering all business areas of the project. Furthermore, ASHVIN competitors are identified and analysed.
  The Section 3, also introduces **ASHVIN** Business Model Canvas that will be the basis of generating **ASHVIN** Business Scenarios followed by an overview through SWOT analyses.

- **Section 4** covers the information related to the ASHVIN exploitation workshop and highlights the exploitation strategy and Key exploitable results. Partners exploitation and expectation claims are analysed using **BFMULO matrix**.

- In **Section 5** each partner presents in details its individual exploitation strategy in the context of the **ASHVIN** project**.**

- Lastly, In **Section 6** as a final section, presents number of conclusions and a plan for the next period.

2. ESTABLISH THE VISION FOR ASHVIN

This section is dedicated to discussing the key exploitation features that will guide the exploitation activities during the **ASHVIN's** lifecycle.

Value proposition of a business initiative is the most important factor that must be defined early in the project. Value proposition should be a brief but at the same time comprehensive statement of a project, addressing questions like: what value is delivered to the stakeholders? Which one of the business problems are solved and which needs are satisfied? What kind of products and services are offered to each stakeholder segment?

In order to reach to a solid and appropriate value proposition that will refer to ASHVIN as a whole bringing out all its innovations, project's tangible assets that will be produced during its lifetime are identified. Even though it is highly recommended to continuously monitor the market and revise these assets and exploitable results according to the achievements of exploitation activities during project's lifecycle, the initial analysis should consider project's core objectives and the envisioned results so as to conclude to the key elements of each asset that won't change. Such aspects include the innovation itself, the motivation and the added value offered to ASHVIN stakeholders.

2.1 Value Proposition

Value proposition usually refers to why customers recognize and are willing to buy the products or services of a particular enterprise, that is, what value the products or services of an enterprise can bring to customers. To this extent, the value proposition determines the positioning and integration of the strategic direction, operation structure and overall business process of the enterprise.

The report presents **ASHVIN'S** value proposition which is based on the following 4 categories listed below in Figure1 with the same objective of **optimizing collective performance**.

Figure 1: ASHVIN'S four value proposition.

The adoption of a digital twin can reduce operating costs by up to 35%, while at the same time decreasing carbon emissions, ensuring a healthier workplace and improving the user experience. **ASHVIN** will be able to accelerate corporate evolution by, incorporating sustainable design to drive operational excellence. This workplace transformation has identified four value propositions that address industry challenges and will generate cost savings.

Building maintenance and operations

For **ASHVIN** one of the tangible impacts of a digital twin would be in the operations and maintenance phase of the building's life cycle. According to a joint study by Harvard Business Review and Microsoft, **66%** of global organizations identify energy management as the prime reason for adopting smart technologies. Further, **72%** of executives stated that their prime business goal was to reduce facility inefficiencies and operational costs. The predictive nature of an **ASHVIN** tool can reduce maintenance costs by its ability to collect, monitor and analyse real time data while utilizing ML models to mitigate future risk. Installing sensors throughout a building can automatically enable predictive maintenance protocols, which are deployed as an alternative to traditional maintenance schedules.[1]

[1]*Digital twin: the Age of Aquarius in construction and real estate (scl.org.au)

Environmental impact and sustainability

Nowadays solutions that reduce resource usage are increasing in value, not only because of the potential for cost savings, but also due to the social responsibility to address climate change impact. Thus, in **ASHVIN** by leveraging digital twins, IoT sensors and IoA augmentation; owners and facility managers can reduce a building's environmental footprint by decreasing energy consumption from various components and systems. These optimization capabilities not only capture significant energy savings, but will also enable companies with large carbon footprints to drastically reduce their emissions and global impact.

Health and Safety

According to International WELL Building Institute (IWBI),[2] "our physical environment impacts our health more than lifestyle, medical care and genetics". As we spend 90% of our time indoors, the built environment leads to a profound impact on people's health, wellbeing, happiness and productivity. A survey of employees working in WELL-certified office buildings reported that 92% of the respondents enjoyed a positive effect on health and wellbeing. The technology used in **ASHVIN**, such as digital twins, can have a comforting effect for **professionals in the design, construction and operations sectors, which are high-risk industries putting people at the heart of decisions.**

People improvements

Building owners can also enhance the security for their employees and assets of construction sites by installing automated security systems as part of the digital twin. AI image recognition in the IoT would monitor areas that are usually monitored by security personnel. Threat detection is substantially improved and no longer requires as large of a security team. Companies can reduce labour costs pertaining to security up to 50% by leveraging a digital twin model.

We will not describe again the **ASHVIN digital tool kit** like **4DV-C,4DV-DSMT, CMT, DES, BRICS, GEN, RISA, GISI** as they have already been described in detail in **D2.1** and **D4.1** respectively.

2.1.1 Examples of Industry applications

In the following figure we present few examples of industry applications across the four defined value propositions of Digital twins that are similar to ASHVIN.

[2] https://www.wellcertified.com/

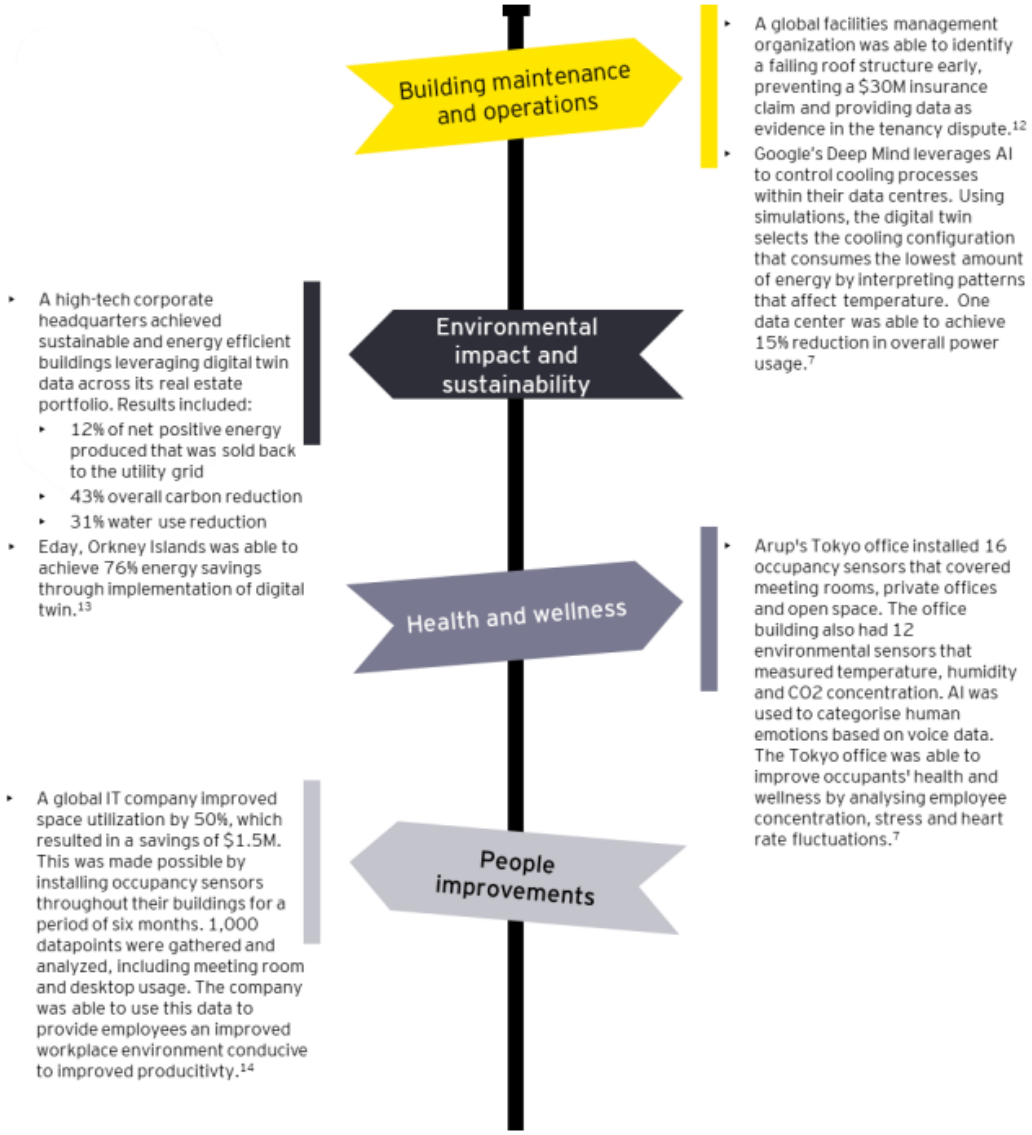

Figure 2: Examples of industry applications

2.2 Tangible Exploitable Assets

In this section, we highlight the elements of ASHVIN we believe can be exploited and therefore we will monitor them during the duration of the project to guide the partners to develop them in a way that can lead to successful products even after the end of the project. **ASHVIN** exploitable assets and results have been defined in detail under section 4 of this report via BFMULO analysis. The following figure provides a summary overview of the key outputs of the project.

Figure 3: ASHVIN tangible assets-the big picture

3.POSITIONING ASHVIN TO THE MARKET

3.1 Overview

The ultimate goal here is to position **ASHVIN** to the market. In which market sectors it makes sense for the innovative **ASHVIN** platform to penetrate, which are the trends of nowadays, is ASHVIN positioned in them, etc.

Construction is one of the most data-intensive industries, requiring information to be readily available, accurate, complete, fast, and in a clear format that the recipient can understand, as this industry impacts all of our lives on daily basis. Massive volumes of data are generated throughout the construction project lifespan, from conceptual

planning to decommissioning. The ability to collect and manage the flow of information and evaluate the vast amount of data and derive relevant insights is critical to the project's success.
Although the construction industry has a reputation for being conservative when it comes to technical breakthroughs and applications, it has made great progress in the last several decades to better information management through the use of Building Information Modelling (BIM). BIM has been one of the most important techniques for approaching building design holistically, improving communication and collaboration between key stakeholders, increasing productivity, improving the overall quality of the final product, reducing fragmentation in the construction industry, and increasing efficiency for more than a decade. However, the data created throughout the operating and utilization phases is not captured by BIM.
As Industry 4.0 develops, it is critical that construction embraces new technologies.
ASHVIN IoT platform is totally ready and interoperable with a wide range of design and engineering applications, following the path of technological advancement and digitalization.[3]

While digital twins are not a new concept, their deployment with IoT connectivity, ML, AI and enhanced BMS is just beginning to take shape specially in the construction industry. As a result, the potential is profound. The benefits of physics-based digital twins are expected to continue expanding over time, with layers upon layers of data informing and improving the way buildings are designed, built and operated. The influx of aggregated information will achieve operational efficiencies at scale, moving the global needle to advance sustainability efforts and reduce climate impacts.
It is typical that innovation in technology leads to skepticism. However, so do all market disruptors. **Digital twins are becoming the market differentiator that will have the biggest impact on building efficiencies, cost optimization, operational intelligence and decarbonization.[4]**

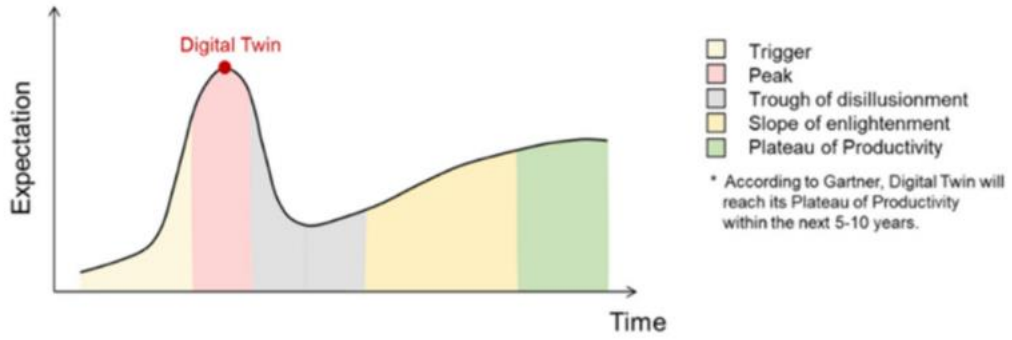

Figure 4: Innovation hype cycle of Digital Twin acc. to Gartner survey.[5]

[3] Sustainability | Free Full-Text | Sustainable Business Model Based on Digital Twin Platform Network: The Inspiration from Haier's Case Study in China (mdpi.com)
[4] https://ec.europa.eu/docsroom/documents/45547/attachments/1/translations/en/renditions/pdf
[5] https://www.researchgate.net/publication/343649999_Digital_Twin_in_construction_An_Empirical_Analysis

ASHVIN will break all barriers to the adoption of digital twins for construction in the EU market by providing:

I. **An IoT enabled, edge-cloud supporting digital twin platform** that is open, affordable and highly extendible
II. **A set of digital twin tools and interoperability solutions** to support all stages of the product development life Cycle
III. **Validated and standardised procedures for digital twin-based activities** throughout the whole product development lifecycle.

These innovations will disruptively advance the current state-of-the-art in all the three areas.

3.2 Market Insights and Business Requirements

The existence of several firms active in digital twin technologies, as well as supportive government measures, have contributed to the growth of the digital twin market. As a result of the COVID-19 issue, critical infrastructure businesses are focused on strategic alliances to support development projects.
Germany is known for its advanced technological capabilities and will play an important part in the development of the European market. In the country, digitization is taking place on a wide scale in several sectors such as healthcare and infrastructure. Many domestic businesses have responded by developing digital twin solutions.

Europe Digital Twin Market share was estimated to be **USD 1 billion in 2019 and is expected to register a lucrative growth with at a CAGR of over 30% between 2020 and 2026 and is expected to surpass a valuation of $9.5 billion.** The region is well-known for the development and application of innovative technology in a variety of industries. Owning to the growing need for virtual technologies and high-end analytical tools to assist in creating future processes across industries, digital twin technology has gained traction in various European countries in recent years.

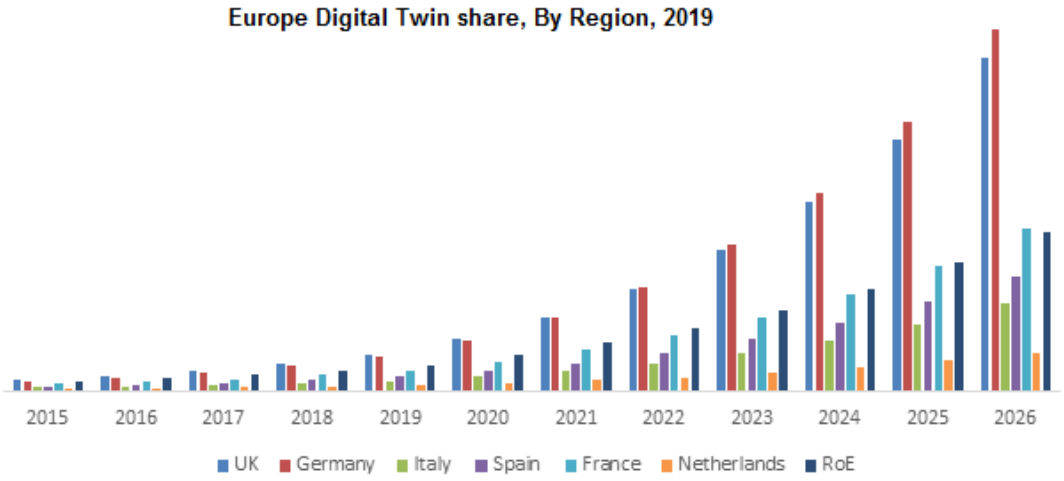

Figure 5: Europe Digital Twin Market Share[6]

By providing a proposal for a pan European digital twin standard, an open-source digital twin platform integrating IoT and image technologies, and a set of tools and demonstrated procedures to apply the platform and the standard proven to guarantee specified productivity, cost, and safety impediments, our project, **ASHVIN** will strive to enable the European construction industry to significantly improve productivity while reducing costs and ensuring absolutely safe working conditions.

The integration of digital twin technology with practically every stakeholder presents a strategic solution to address challenges across the full spectrum of **ASHVINS** asset's life cycle. The benefits of digital twins are varied; however, they can generally be categorized into the following three key business drivers:1.) **Creates a centralized database and single source of truth.** 2.) **Supports decision-making for allocating investment dollars.** 3.) **Accelerates continuous process optimization.**

Three factors that shape the business value of digital twins of built environment:[7]

- The long-term source of value for digital twins results from savings in operations, maintenance and learning for new development of buildings and infrastructure. Scale of operations is necessary to leverage that value, and it requires long periods of time. Thus, the business models must either address large clients only, or they must aggregate small scale owners and operators to create a critical mass of value. This suggests that the 'low hanging fruit' i.e., the **main clients for digital twins of buildings and infrastructure are large scale public or private owners and operators**.
- The value of digital twins for infrastructure is stored in the information. Digital twin vendors can generate value by generating, organising and making information accessible, rather than selling software, which would fast become a commodity.
- Digital twin models cannot be compiled by the staff of building or infrastructure owners, for two reasons: a) highly specialized knowledge is needed for compiling digital twins, and b) the effort for compiling a digital twin is concentrated at the start of their life.

3.2.1 Short Terms Prediction for Digital Twins

According to the EY report on Digital Twin: the Age of Aquarius in construction, construction productivity has steadily declined since 1964, the digital twin presents an opportunity to shift archaic business models to the Age of Aquarius. **Construction** and real estate have operated on simple hand-made drawings for thousands of years. Only recently are we seeing the very basics of digitization come into play. Technological innovation paired with the digital twin will take us to this next coming of age. **With global housing crisis, consistently exceeding budgets and schedules, global warming, pandemics, slowing production, demographic changes, more demanding workers and greater globalization, the world cannot afford to wait for**

[6] Europe Digital Twin Market Share & Size 2026 | Growth Analysis (graphicalresearch.com)
[7] 2020_Brilakis_BuiltEnvDT.pdf (tum.de)

digital enhancements to mature at the traditional pace. The most innovative companies realize this; hence **ASHVIN** can take advantage of this and suggest companies to adopt.

While it is still too early to provide an assessment of the impact of the COVID-19 outbreak, the construction sector has been and is expected to be significantly affected. In fact, a recent survey conducted by an EU construction association shows that **62% of construction sites have been significantly affected or even closed throughout the first quarter of 2020–** causing productivity loss, delays and additional costs. In addition, construction investment has declined following the potential drop in the number of building permits, administrative bottlenecks for processing such permits and the potential absence of the workers. As explained by a stakeholder interviewed for this study, while contracts already signed are expected to be completed (thus maintaining a certain level of activity), new contracts are still uncertain. Following the outbreak of COVID-19 epidemic, **it is becoming ever more apparent that digital technologies will play an increasing role in what will be the recovery but also the new normal of the sector**. As highlighted in a recent study, this new normal is an opportunity for disruption and growth. Indeed, during the COVID-19 outbreak, the construction sector partly shifted towards remote ways of working: architects and engineers are relying more heavily on BIM 4D and 5D to re-plan projects and adapt schedules. In addition**, Digital Twin solutions are also increasingly used from start to end of the construction project.** In the longer-term, trends such as offsite construction are also expected to pick up, following the need to build in controlled environments (which is even more important in a world that requires close management of the movement and interaction of workforces). A recent study [8] confirmed this finding – adding that over 50% of survey respondents (global construction companies decision makers) have already increased investment notably in digitalisation and supply-chain control.

3.3 Digital Twin Market Challenges

Within **ASHVIN** we have identified some preliminary challenges that are related to the Digital Twin Market and some of them like **Limited Interoperability**, **Market confusion** and **High Stakes** were identified during the **D8.1** report. In this section market challenges have been defined more in depth, These were already considered during the last 18 months of the project.[9]

Cybersecurity and **data privacy** are becoming increasingly important as the ability of digital twins to bidirectionally control assets continues to expand. IoT-enabled sensors and other sources collect a host of sensitive information regarding occupants and the design of assets. To mitigate potential cyber-attacks, a secure environment must be

[8] https://www.rolandberger.com/publications/publication_pdf/tab_digitization_construction_industry_e_final.pdf
[9] https://www.researchgate.net/publication/357001969_Industrial_Revolution_40_in_the_Construction_Industry_Challenges_and_Opportunities

designed to adhere with industry security standards. Legal requirements such as the **General Data Protection Regulation (GDPR)** in the EU have been enacted in the last decade, making it necessary for firms to place strong controls around data encryption, access privileges and security audits. A **sustainable, holistic framework** that addresses **ongoing technology threats**, **governing security solutions** and **resiliency requirements** is critical for maintaining controls and mitigating risk. Human impacts also manifest. Similar to access and security on a smartphone, collecting this sensitive data has benefits that can far outweigh the downside. However, many workers are becoming hypersensitive to data collection in the workplace. For the digital twin to be effective in improving health and safety, this must be addressed with the firm's labour force by obtaining consent to the "opt-in" settings.

Other **challenges include managing stakeholders** and developing the right skill sets for implementation. Successful adoption of a digital twin model requires resources with advanced analytical skills, a strong understanding of the industry, and technical expertise of the necessary tools This will establish new positions, such as data scientists and systems engineers, within construction and real estate firms. Furthermore, resources with project management and business process skills are critical as they develop a formal road map and steer the implementation. This is needed to ensure that every investment sought by the firm has a purpose, plan and direction aligned with adoption.

3.4 Competitive Landscape and Analysis

The competition to **ASHVIN** is relatively high and should not be underestimated especially in a highly innovative and trending area like IoT. There are a few larger players, specifically **Microsoft, Autodesk, and Bentley Systems that are already experimenting with similar technical solutions**. Additionally, many of ASHVIN´s tools are based upon their technology and experience, which underlines their expertise in these markets. ASHVIN also plans to target **Insurance companies** like **Allianz[10], FUNK[11]**, **Liberty special markets[12]**, **Starr insurance** etc that insures construction building phase as there could be huge potential for collaboration in that market. Other competitors will most likely be small **IoT companies, incumbents, start-ups and tech giants**.

European construction incumbents

"Next, the digitization efforts of some of Europe's leading construction companies are assessed". Except for the industry-wide adoption of Building Information Modelling (BIM), construction companies seem to "spray and pray" their investments in a wide array of digital technologies. The innovations mostly target company processes, leaving them lacking an industry-wide entrepreneurial view. Investments are relatively

[10] https://www.agcs.allianz.com/solutions/energy-construction-insurance.html
[11] https://www.funk-gruppe.de/en/industries/industry/construction
[12] https://www.libertyspecialtymarkets.com/de-en/product/construction-insurance-europe

low, less than 1 % of revenue on average. Therefore, latest trend[13] shows that construction companies have mostly invested in technologies that optimize their core businesses in order to reduce costs. **Skanska**, for example, invested significantly in **IoT, smart sensoring technologies, robust wireless networks and real-time location tracking systems (RTLS)** to transform its construction sites into digital workspaces. The results of which are **Real-time information flows, increased worker safety and enhanced jobsite visibility,** which allows teams and owners to make informed decisions while reducing risk. **ASHVIN** can take a lot of positives from new entrants' approach and adapt itself before launching in the market.[14]

Company	Revenue (€B)	BIM	Drones	VR	AR	Additive manuf.	AI & Big data	IoT & sensoring	Robotics	Generative design
Acciona	7.3	◕	◔	◔	◔	◑	○	◔	○	◔
ACS	34.9	◕	○	○	◔	◔	◔	○	◔	○
Balfour	7.9	●	◑	◑	◔	◔	◑	◕	◔	○
BAM	6.6	◕	◕	◕	◑	◑	◕	◑	◑	○
BESIX	2.4	◕	◔	◑	◔	◔	◔	◔	◔	○
Bouygues	32.9	◕	◕	◔	◔	◑	◑	◑	◔	◔
Eiffage	15.3	◕	◔	◑	◔	◔	◔	◔	◔	○
FCC	5.8	◑	◔	○	○	○	○	◔	○	○
Ferrovial	12.2	●	●	◔	◔	◔	◕	◔	◔	○
NCC	5.3	◕	◕	◕	◕	◑	○	○	○	○
Skanska	15.3	●	◕	◑	◑	◑	◔	◕	◔	○
Strabag	13.5	◕	◑	◑	○	◑	◔	◔	◔	○
Vinci	40.9	●	●	◔	○	◔	◑	◔	◔	○

● Daily business ◕ Multiple projects ◑ Single project / prototype ◔ Interest published / research started ○ No investment yet

Figure 6: Digital technology adoption by European construction incumbents

ConTech start-ups

The size of the market and the fact that opportunities are literally around every corner makes construction an appealing industry for outsiders. The exponential upward trend in capital investments in construction start-ups is illustrative of investors' attitudes. These start-ups provide focused solutions around a single technology, solving specific but industry-wide problems, mainly around BIM, additive manufacturing.
Following are some of the large venture capital ConTech deals in recent history which ASHVIN can take advantage of and learn from their approach.

[13] https://www2.deloitte.com/nl/nl/pages/energy-resources-industrials/articles/incorporating-digital-technologies-into-the-construction-industry.html
[14] Point of View on Digital Construction The business case of incorporating digital technologies into the construction industry- Deloitte

-FINALCAD

Founded in 2007 in France
Deal size: 35.5m EUR series C
Total Funding: 57m EUR
Valuation: 100m EUR

FINALCAD provides mobile construction software and predictive analytics that help construction stakeholders anticipate and fix issues found during a building's journey. Developed BIM solution for structures and finishes. FINALCAD is already active in 10,000 projects across 35 countries.[15]

-ATHEER[16]

Founded in 2011 in the US
Deal size: 12.3m USD series C
Total Funding: 29.5m USD
Valuation: ~90m USD

Atheer is an augmented interactive reality platform designed to enhance the productivity and safety of deskless professionals. It enables users to view critical work information in their field-of-view and interact with it using familiar gestures, voice commands and motion tracking.

- 3DR[17]

Founded in 2012 in the US
Deal size: 53m USD series D
Total Funding: 164m USD
Valuation: ~110m USD

3DR is a provider of smart drones intended to offer site scanning and land mapping services. It collects accurate aerial data of jobsites, turns drone photos into maps, models and point clouds, and provides comprehensive onboarding and ongoing support.

Tech giants

In recent years, tech giants have disrupted several industries. Apple has changed the way we listen to music and use our phones, while Amazon has changed the way we read through its Kindle e-book reader. Airbnb has disrupted the hospitality industry, Uber the taxi industry and LinkedIn recruiting. It was inevitable that tech giants would eventually turn their attention to the construction industry. And some of them have been very effective. **Alphabet's (Google) Sidewalk Labs** won a billion-dollar project to transform Toronto's waterfront area, and Elon Musk's **The Boring Company** won its first billion-dollar contract within 18 months of launching at Chicago's O'Hare International Airport. There's also **Amazon**, which announced its investment in the

[15] https://www.finalcad.com/
[16] https://www.atheerair.com/
[17] https://3drobotics.com/company/about-3dr/

modular prefabricated housing **ConTech Plant Prefab**, and **Microsoft**, which is spending heavily on its **Azure Digital Twin concept**, where users leverage real-time data to virtually replicate the physical world to enhance operations of buildings across the entire life cycle. It enables increased visibility, safety, and efficiency in and around a building during its design, construction and operation.

3.4.1 Key Takeaways for ASHVIN

1. **Funds are needed for a breakthrough.**
   The start-ups and tech giants that successfully entered the construction industry were backed by big investments. In fact, having a deep pocketed stakeholder behind an open-source platform can be a blessing.
2. **Be cautious in asset-centric thinking (digital first).**
   New entrants bring "asset-light" strategies and think digital first, while incumbents often focus on adding new tech to legacy products and processes. Construction tech has largely followed these paths to adoption: from academic research, through implementation by start-up, to start-up acquisition by established vendor. We can use the same strategy when considering the market penetration of ASHVIN digital twin.
3. **Identify the critical data elements to own.**
   Owning the data has proven critical in driving early financial returns for most SaaS start-ups, Incumbents often still work with unstructured data.
4. **Speed.**
   Speed matters. Exponential growth techniques are rapidly evolving, requiring constant iterations. New entrants never wait for a perfect product, starting instead with minimum viable products. Incumbents need agility in their organizations.

3.4.2 Other Potential Competitors

The digital twin platform provided by **ASHVIN** refers to any user interested in extracting its benefits in the construction lifecycle. **ASHVIN's** focus is mostly on organizations that are active in technical innovation, research contributions, business activity, or commercial enterprise that are leveraging the full potential of the construction sector's digitalisation.

As such, the following companies can be counted as potential competitors to **ASHVIN** and at the same time **ASHVIN** might also impact these companies by providing digital services with first of its kind IoT integrated digital twin platform as an open-source backbone:

1) **Brinja:** Brinja[18] creates intelligent construction workplaces like smart home systems but designed specifically for the production of new buildings. The

[18] https://en.brinja.se/om-brinja

company is dedicated and passionate about improving safety, efficiency and sustainability on construction sites.

2) **ClimaTwin:** ClimaTwin's [19] mission is to transform how infrastructure stakeholders mitigate climate risks by leveraging climate models, digital twins and computer science.

3) **Cityzenith:** Cityzenith[20] is implementing urban Digital Twins initiative in 10-15 major cities to help their commercial building owners dramatically reduce carbon emissions as well as greatly improve efficiencies and operating costs for the built environment.

4) **Builtstream:** Builtstream [21] is a SaaS platform offering an integrated, automated process for creating engineering-grade, intelligent 3D digital twins of buildings and other structures. ISO standard building information models (BIM) are constructed from laser scans and image data uploaded to the platform. The technology uses proprietary algorithms and AI to automate the model-creation process. The built stream platform enables building designers, developers, builders, landlords, property managers and collaborators to share, annotate, update and analyse building models in real time. It provides visibility into building structures, systems and performance, minimizes construction and management costs, and optimizes built-asset data management.

5) **Autodesk:** Autodesk Tandem [22] is a cloud-based digital twin technology platform. It enables projects to start digital and stay digital, transforming rich data into business intelligence. By harnessing BIM (Building Information Modeling) data throughout the process, AEC firms can create and handover a digital twin to building owners and operators. The easily accessible, contextual, and insightful data they receive makes for ready-to-go operations.

6) **PassiveLogic:** PassiveLogic [23] starts with the fundamental requirement a control system and embeds a complete Autonomous Platform for Buildings. It's like having a superhero on every project. Built on a digital twin foundation, PassiveLogic installation requires 90% less effort than a conventional Building Management System (BMS) yet provides a whole value-chain of solutions not previously possible.

7) **SenSat:** SenSat[24] creates digital twins – infusing real-time datasets from a variety of sources. The result is an accurate, digital and up-to-date copy of the real world in a machine-readable format. This enables offline industries, such as infrastructure, to make more informed decisions and accurate analysis,

[19] https://climatwin.com/
[20] https://cityzenith.com/discover-digital-twins
[21] https://builtstream.com/
[22] https://intandem.autodesk.com/
[23] https://passivelogic.com/
[24] https://www.sensat.co/platform/

driving vast improvements in safety, cost-efficiency, waste generation, project collaboration and carbon reduction.[25]

8) **iModel.js:** iModel.js is a commercial initiative connected to the infrastructure company Bentley and focuses on infrastructure modelling. It uses BIM as the modelling framework and offering npm [26] packages. It doesn't look like iModel.Js built for the heavy computing that comes with some Multiphysics models.

*Compared to above solutions, the viability of using digital twin technology and IoT has already been proven on pilot projects of the **ASHVIN** consortium members. The constant flow of real-time data from IoT sensors combined with historical data from other projects demonstrated by **ASHVIN partners will be useful not only in** monitoring current job sites, but also in providing the required historical data for predictive and prescriptive analytics using advanced artificial intelligence (AI) methods and also inform design.*

*On a number of pilot projects, **ASHVIN** consortium partners have built such digital twin technology implementations: Spain with partner UPC's advanced sensor systems on bridges; the Netherlands with partner NGEO's integration of soil measurements to get feedback on the stability of ground, slopes, and piles; Germany with partner DTT's RFID tags on prefabricated construction modules to streamline supply chain logistics; Poland with the accurate digital representation of the energy behaviour of buildings based on building monitoring systems by partner FAS; Sweden with exploring how anonymized data collected from the construction site can be used for safety management while ensuring privacy rights by partner NCC.*

*The basic technologies that enable the usage of integrated digital twin platforms have also been demonstrated by **ASHVIN** partners: MFL, which has created one of the leading Open Source IoT platforms, allowing seamless integration of all types of devices, including advanced sensor systems and cameras, that can track the status of building products, construction equipment, and environmental conditions; DTT, has created a game-engine based platform to store and handle large amounts of geometrical data and information for representing complex construction products.*

Since our **value creation** depends on the new technical innovation possibilities, most companies will not know that a better solution exists, and we need to approach them directly. Our **main advantages** compared to the existing and widely used solutions are the following: **guaranteed specified productivity, cost reduction, safety improvements, and improved sustainability**. To quantify our impact, the estimated influence in some areas is the following:

[25] https://www.gim-international.com/content/news/sensat-raises-us-10m-as-investors-back-simulated-reality-tech#:~:text=SenSat%20creates%20digital%20representations%20of,in%20a%20machine%2Dreadable%20format

[26] npm (npmjs.com)

Budget Reliability - Up to 40% decrease in non-budgeted adjustments[11]	**Faster Delivery -** Up to 7% reduced project lifetime
Life-cycle Optimisation – Up to 9% lower operating costs. A 10% productivity improvement would generate savings of €130 billion	**CAPEX -** Financial opportunity in the range of 10-20% of capital project expenditure

Figure 7: Estimated value of digitalisation.

3.5 Business Model Canvas- Starting Point [27]

In order to better visualise and understand **ASHVINS** Integrated Solution key elements, all partners have joined forces in order to create a detailed Business Model Canvas that will help us recognise and act towards a successful sustainability model for our solution. Moreover, it will be used to communicate business goals both in the consortium and to other interested parties (during M18-M36). Presented Canvas in Figure 7 was derived by the results of the workshop and feedback collected by the partners, it will be re-evaluated and finalised during the Final Exploitation report in M36, when the final version of the tools and their functionalities will be released.

Business Model Canvas

Key Partners	Value Propositions	Key Activities	Customer Relationships	Customer Segments
• Construction Site Owners • Investorsand Shareholders • Infrastructure Owners (Highway, Railway, Airport, Waterway) • Governments • ConTech Companies • Technology Providers • Research Institutes	• Provide digital services with the first of its kind IoT integrated digital twin platform as an Open Source backbone. • Whole new spectrum of possibilities associated to real-time acquistiton, management and prevision of as-build condition. • Increase the safety of construction work, directly benefiting construction workers. • ASHVIN Digital Twin Toolkit.	• Automated Progress Monitoring • Resource Planning & Logistics • Safety Monitoring • Quality Assessment • Image based 3D Representation • Risk Management • Lifecycle Management • Health Monitoring into FEM and Digital Twins	• Consulting • Personalized Assistance • Self Service Documentation	• Engineers • Architects • Researchers • Students • ConTech Startups • European Construction Incumbents • Engineering Companies • Construction workers • Construction site owners • BIM Users • Tech Giants
Key Resources • Know how • Experience • Values (Gratitude, Persevarance and Determination) • IoT and Digital Twin skills • AI • Cloud Infrastructure • Consulting		ASHVIN	**Channels** • Project Documentation • Publications • Open Access to Research • Surveys/Opinion Polls • Technology Licensing • Consultancy Services	

Cost Structure	Revenue Streams
• Labor costs • Maintenance • Marketing and Evangelization costs • Product cost • IT Infrastructure cost	• Consulting • Training • Subscription fee for users • Support services

Figure 8: ASHVIN Business Model Canvas

Our main channel in Sales and marketing will be in approaching companies and explaining our innovative product with its advantages. However, collaborations and Marketing campaigns could also prove to be useful after acquiring the first customers e.g., with advertisements.

[27] New Business Models and Digital Platforms in Construction 4.0 | by Autodesk University | Autodesk University | Medium

3.5.1 Pricing Model

At this stage, it is difficult to determine a fitting pricing model. There are a lot of options that could ultimately prove to be the best. As an open source project the most intuitive model with the advantage of a relatively stable and safe cash inflow would be to use a **subscription model**. This must be evaluated in more detail during the Final report in M36 as well as any other pricing option. Another possibility would be **Bundle pricing or Paid feature requests,** which means creating varying service packages for different customers that include and offer limited functions of ASHVIN. Since the platform will increase its value with more customers, penetration pricing could essentially be an efficient way to jumpstart our numbers of customers in the beginning while keeping the overall long-term profit high.

3.6 ASHVIN Market Domain

ASHVIN market domains related to Digital Twin Market were defined into 3 categories, **End Users**, **Project Lifecycle** and **Industry** in the D8.1 report. In this section we will perform the in-depth analysis of these markets.

Figure 9: ASHVIN Market Domains

I. By End-User:

Government: Digital twins of larger, more expensive government assets are not only viable, but also have the potential to provide enormous benefits to government agencies and military groups. For both the government and the military, the use of digital twins for facility utilization and contract tracing may be of special relevance right now. The capacity to use digital twins for contract tracing could be valuable both for planning purposes and in response to outbreaks, especially with the current COVID-19 pandemic and firms trying to bring personel back into workplaces in a controlled and low-risk manner. Having a better, more in-depth understanding of facility utilization may assist agencies not only advise and lead workplace flexibility programs, but also plan and implement modifications to accommodate their developing workplace requirements.

Whether a digital twin is built as part of the AEC lifecycle for a new building or by scanning and modelling existing structures, it has the potential to provide enormous value to government facilities teams. It can help boost energy efficiency when

combined with other technologies and data, which is important at a time when green initiatives are becoming more important. It may assist facilities teams with maintenance and provide a wealth of information about the various systems that make a building function. It can even assist a government agency in making its facilities more adaptable to a changing workforce.

Engineers: By creating a replica of the planned production process, a digital twin allows engineers to identify potential process errors before the product goes into production.Engineers can interrupt the system in order to create unexpected scenarios, analyse the system's response, and identify mitigation solutions. This new feature improves risk assessment, speeds up the creation of new goods, and increases the reliability of the production line. Engineers and operators can monitor buildings and systems even when they are not on-site thanks to digital twins. They have remote access to a thorough perspective of physical assets. The need for facility managers and engineers to be on-site at all times is no longer necessary. Maintenance engineers, for example, can consult the digital twin for specifications, helping them to better understand how and why things were designed, as well as simplify maintenance.

Architects: Architects will be able to better persuade customers of the merits of their projects using digital twins since they will have the data to back up their claims and be able to show the benefits. This will be especially crucial for assets that can be maintained. Therefore, **Generative design** and **digital twins** provide them the ability to quickly explore, optimise, experiment and automate the creation and design of spaces

II. By Project Lifecycle:

Design Phase: The Digital Twin can act as a base for prefabrication as well as a more important means of enhancing industrialized efficiency. The digital twin transforms into a live model that is upgraded as the design and planning process progresses, allowing for greater transparency. During the design stage of large construction projects, details like road elevations and sewage may be assessed for any possible concerns, and fixes can be made and synced instantly. By allowing us to properly appreciate and optimize a design, digital twins will remove uncertainty, latency, and inaccuracies and help to build a better design for constructability.

Construction Phase: A digital twin can provide a regularly updated information source to the complete team during the project's various construction stages. The data flow between the office and the field, including asset tags, maintenance records, inspection records, and work planning details, is kept and retrieved from a single location. Companies may monitor work against a timeline developed using 4D modeling, anticipating potential problems that cause construction setbacks and mitigating them before they occur, thanks to the digital twin's constant real-time sync.

Operation: Once a project is fully constructed and operational, the digital twin is an as-built model for the owner-operator. There is a bi-directional flow of data between the digital twin and its physical counterpart, using IoT data points to provide real-time analysis on system performances. These analyses are then used to increase efficiencies on the systems and provide maintenance information to prevent possible

downtime. Digital twins could correlate data sets such as asset usage or environmental impact to simulate and predict necessary maintenance or to implement mitigation measures. Hence, they can help to inspect, predict and manage failures and shape the maintenance policy for future operations.

III. By Industry:

Primary Market-
Construction: Here are the possible digital twin applications in the construction site:
-Automated Progress Monitoring: Progress monitoring ensures that the job is done according to the designs and specifications. An as-built state of a building or structure can be compared to an as-planned execution in BIM and appropriate measures could be taken to address any aberrations by recreating an as-built state of a building or structure.
-As-built vs As-designed models: It is feasible to track changes in an as-built model on a daily and hourly basis using real-time digital twins.
-Resource Planning and Logistics: Companies could prevent over-allocating resources and dynamically estimate resource requirements on building sites using digital twin technology, reducing the need to relocate resources across large distances and enhancing time management.
-Safety Monitoring: The companies may track people and dangerous spots on a site using digital twins' real-time site reconstruction capability, preventing inappropriate behavior, the use of risky products, and activity in hazardous zones.
-Quality Assessment: A video or photographic image can be used to check the condition of concrete using image-processing techniques.

Secondary markets: The automotive and transportation industries are expected to account for the majority of growth. The rising demand for 3D simulation and 3D printing software across applications such as fleet management, vehicle design, and simulation is driving this section's growth. Other industries, such as aerospace, military, retail, healthcare and Insurance, energy and utilities, IT and telecom, and others, are predicted to grow rapidly. The increased adoption of automation technologies such as RPA, industry 4.0, and others is causing the growth rate to increase. As these technologies become more widely adopted, ASHVIN will have more opportunity to access these markets and provide solutions for end-users.

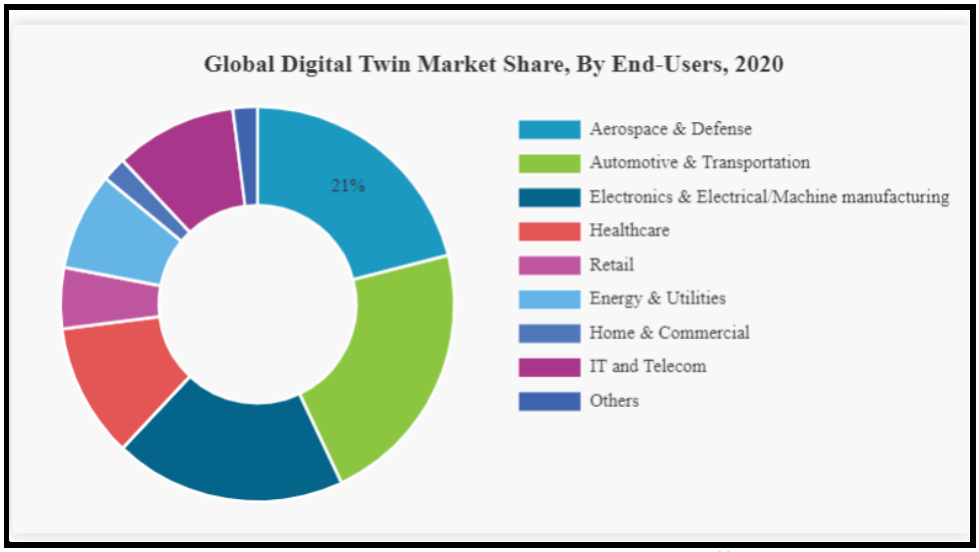

Figure 10: Global Digital Twin Market Share[28]

3.7 SWOT Analysis

This section provides a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, listing the internal strengths and weaknesses of the ASHVIN solutions as well as the opportunities and threats faced by **ASHVIN** due to changes in the external environment. SWOT Analysis is a strategic planning tool for evaluating the above factors for a project or a business venture. This process allows **ASHVIN** to identify internal and external factors that are favourable and unfavourable to achieve its objectives. More specifically it provides the opportunity to:

- Recognize the strengths of its situation
- Define the weaknesses, which the consortium partners will try to minimize later.
- Recognize the possible threats and treat them in a planned and organized way.

[28] https://www.fortunebusinessinsights.com/digital-twin-market-106246

Table 1: SWOT analysis for ASHVIN

Strengths	**Weaknesses**
• End to end security and privacy. • ASHVIN will impact companies providing digital services with the first of its kind IoT integrated digital twin platform as an Open-Source backbone. • A set of validated methods and procedures that allow construction professionals to leverage the digital twin standard and the platform during designing / engineering, constructing, and maintaining a building, a bridge, or an industrial complex. • Interoperability processes that allow to seamlessly switch between different levels of detail and information views to support the entire product development lifecycle from one single source of truth. • Holistic innovation approach to productivity and resource efficiency. • The ASHVIN platform gives a linked-data API with a well-thought-out user rights management framework, users with the right permissions will be able to download, export, and use all information they have access to at any time, while ensuring data security and privacy. • ASHVIN provide the means for harmonising digital twin data across all required software for all phases in the product development life cycle.	• A lack of marketplace feedback as part of requirements gathering or changing market requirements could result in implementing the tools wrongly. • Still to be seen if the market is mature enough to take-up the project results. • Unpredictability and potential users' interest in adopting the project results.
Opportunities	**Threats**
• Standardization activities / product creation. • Benefit from emerging markets growing. • IoT based digital twin platform market has a rise trend. • Several Contech and SMEs may adopt ASHVIN solutions due to its practicality. • Optimized Asset Performance and Sustainability. • Simplify the requirements of energy consumption and lightings. • Regional construction firms can boost their international standing by leveraging cutting-edge technology to produce the best product efficiency and performance.	• Limitation in understanding and adopting ASHVIN Technology as a whole. • Very Fast evolving technology. • Lack of information of IoT based solution implementation in construction sector. • The construction industry is known as a laggard in adopting digital technologies. • Tracking construction operations with cameras and sensors are not acceptable on most European construction sites and are rejected by labour unions and worker rights organizations. • Existing standards and regulations across Europe.

4.WORKSHOP CONTENT

4.1 Exploitation Strategy Workshop

The first exploitation workshop took place virtually during the 3rd General assembly meeting of **ASHVIN week** (26 January, 2022). Three hours were dedicated to the workshop and following topics were discussed abd brainstormed using the **MIRO BOARD** tool:

1. Exploitation terminology.
2. Identification of the KERs.
3. Characterization of the KERs.
4. Partners' exploitation claims and expectations.
5. IPR related issues.
6. Risk assessment.

DTT as an exploitation leader (represented by Rahul Tomar and Biraj Harnal) led the workshop and most of the consortium partners were involved both by providing information and by contributing to the discussion. The purpose of the exploitation workshop was twofold: first, to introduce the exploitation and exploitation suggestions to the partners; and second, to collect data needed for the Initial Exploitation Plan (D8.3). The data will also benefit the planned update of the Market Assessment and Business opportunities.

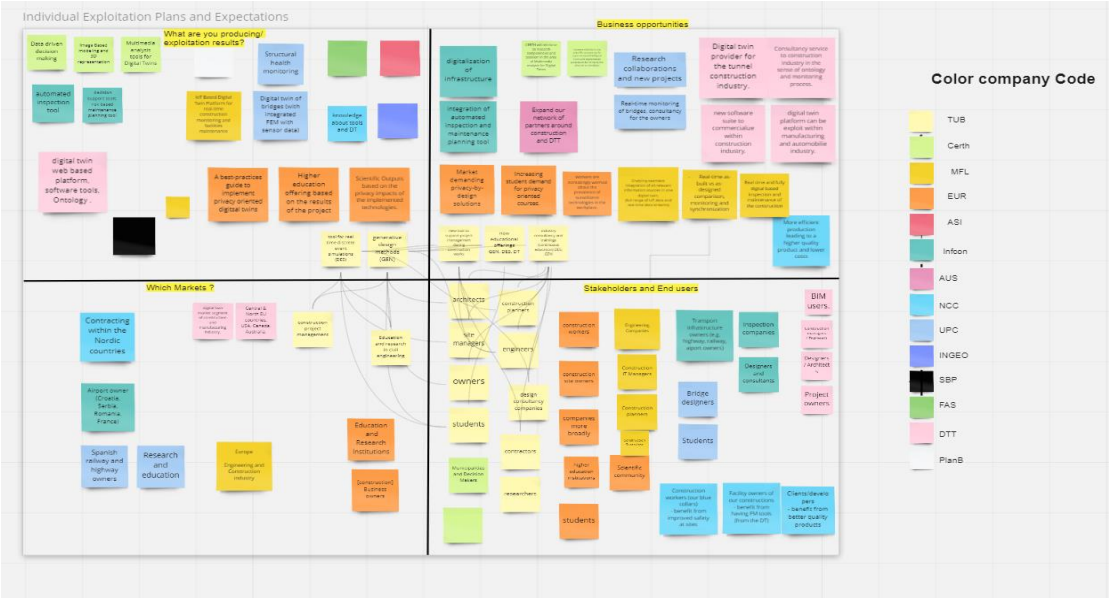

Figure 11: Brainstorming session screenshot during ASHVIN exploitation workshop.

4.2 ASHVIN'S Key Exploitable Results

Prior to the workshop, 5 ERs were identified and mentioned in D8.1 report. During the workshop after rigorous brainstorming among partners current ER's were updated and

4 new ER's were added officially. All these decisions were taken on the basis of the results of previous 17 months of the ASHVIN project.

As exploitation states, project results can be used in further research activities other than those covered by the project, or in developing, creating and marketing a product or process, or in creating and providing a service. As a consequence, the exploitation route options can be divided into several categories, such as:

- Further research
- Developing and selling own products/services
- Spin-Off activities
- Cooperation agreement/Joint Ventures
- Selling IP right/Selling the (IP based) business
- Licensing IP rights (out-licensing)
- Standardisation activities (new standards/ongoing procedures).

ASHVIN consortium will also explore the possibility for designing and implementing an **exploitation (commercial, product-oriented) Website** for ASHVIN. The existing website is just a home for the project. In this activity all partners will be engaged.

The following updated table summarizes general exploitable intentions for each of the **ASHVINS** ER's.

Table 2: ASHVIN Key Exploitable Results.

Exploitable Results	Involved Partners	Exploitation Intention
1) Automated Progress Monitoring	DTT, MFL, CERTH, NCC	Progress monitoring verifies that the completed work is consistent with plans and specifications. Based on IoT supported site observations the percentage of work done can be determined at every stage of the project. Site managers can use this information to better plan ahead.
2) Real-time as-built vs as-designed comparison	DTT, TUB, MFL, NCC	With a real-time digital twin that can accurately represent behaviour (for example structural or energy-related), it is possible to track changes in an as-built model — daily and hourly. Early detection of any discrepancies with the initial design intend can be can detected and mitigated. This will allow more **reliable construction**, less rework, and higher quality.
3) Better & improved resource planning and logistic	PlanB, NCC, TUB	**ASHVIN** provides automatic resource allocation monitoring and waste tracking, allowing for a

		predictive and lean approach to resource management.
4) Better safety Monitoring	EUR, NCC, NGEO, DTT,TUB	The real-time site reconstruction feature digital twins allows the industry's companies to track people and hazardous places on a site to prevent inappropriate behaviour, usage of unsafe materials, and activity in hazardous zones.
5) Automated damage detection algorithms using deep-learning model	CERTH, INFCON, UPC	While the use of deep learning techniques in health monitoring systems for civil structures is gaining momentum, inspection datasets that can be utilized to develop automated damage detection models have emerged. Yet the majority of them are focused on characterizing the whole image as "crack" or "no crack". Furthermore, the enclosed images usually depict crack instances with a solid background, leading to datasets heavily tailored to the objective. In ASHVIN we aim on creating realistic datasets by collecting images from demo sites enclosing a wide variety of defects, background types, viewpoints.
6) Image based 3D representation into a Digital Twin	CERTH, DTT	The scope is to explore online (real-time or near real time) techniques for 3D representation from 2D visual footage of indoors or outdoors construction and building environments, to deliver eventually a product capable for fast digitalisation of the physical world, in a Digital Twin engine.
7) GIS based risk management tool	INFCON, UPC	GIS based risk predictive maintenance tool, based upon a series of KPIs embedded within the digital twin platform
8) KPI framework for digital twin-based life cycle management	All	KPI and PI indicators for productivity, resource efficiency, cost, health and safety aspects of design, construction and maintenance stages of all types of structures linked to digital twin requirements.
9) Structural health monitoring integration into FEM and into digital twins (for bridges and geotechnical structures)	UPC, NGEO, MFL, CERTH, INFCON	Sensors → Simulation → ASHVIN Platform → Simulation → Sensors Data flow and update of the structural models with the sensors data.

4.3 Partner's exploitation and expectation claims

This chapter aims to highlight the exploitation intentions of the consortium partners. It is done through the BFMULO analysis. The analysis is applied to evaluate the

involvement of each project partner in all identified ERs of the ASHVIN project. These findings further serve as a basis for both the IPR management and partners' individual exploitation plans.

Joint exploitation activities carried out by ASHVIN partners envision to make an actual impact in the research and industrial communities. Our main goal is to raise awareness about the plethora of technical issues addressed by the **ASHVIN tools** and the **ASHVIN IoT platform** to facilitate the adoption of the innovative project results both by SMEs and researchers interested in the Digital Twin System.

4.3.1 BFMULO analysis

To develop adequate exploitation plan and strategy, it is necessary to determine involvement of project partners in each of the ERs. The BFMULO matrixes have been created for all ERs and partners were asked to fill them in according to their exploitable intentions. Partners indicate their intentions through writing letters B, F, M, U, L, and O. Partners are aware that they might choose more than one letter (or none) to each of the results. The letters stand for:

• **B** = IPR's on background information, information, excluding foreground information, brought to the project from existing knowledge, owned or controlled by project partners in the same or related fields of the work carried out in the research project.

• **F** = IPR's on foreground information, Information including all kind of exploitable results generated by the project partners or 3rd parties working for them in the implementation of the research project. To have an F in an exploitable result it is necessary that a partner has a task(s) in the project related to that very result.

• **M** = Making the products, manufacturing and selling or directly implementing it through own facilities and skills.

• **U** = Using the result, implemented with own knowledge to develop new ranges of products or newer processing. Furthermore, the direct or indirect utilization of foreground in further research activities other than those covered by the project, or for developing, creating and marketing a product or process, or for creating and providing a service.

• **L** = Licensing the result, therefore earning from a negotiation towards third parties outside the Consortium.

• **O** = Other, any other exploitation means (e.g.: consultancy, provide services, etc).

This analysis has been performed for each of the **ASHVIN's** ERs during the exploitation workshop. Partners were asked to indicate their involvement in each of the ERs and the following matrix summarizes partners' exploitable intentions, expectations, and claims.

Table 3: BFMULO matrix of the ASHVIN ERs

Partner	ER1-	ER2-	ER3-	ER4-	ER5-	ER6-	ER7-	ER8-	ER9-
TUB	…..	BFMUL	FML	FML	…….	…….	…….	BFMUO	……..
CERTH	FML	FML	…..	.....	BFML	BFML	…..	.....	.....
MFL	BFMULO	BFML	……	…….	…..	……	……	BFMUO	MULO
EUR	.....	.....	.....	M O	.....	.....	.....	M	…..
ASI	……	…….	…….	…….	……..	……..	…….	UO	……..
Infcon	.....	.....	.....	.....	B F M U L O	.....	B F M U L O	B F M U O	B U O
AUS	…….	…….	…….	……	…….	……	…….	O	…….
NCC	FMU	FMU	FU	FU	……	…….	……	BFMUO	……
UPC	……	……	…….	…….	FML	…….	FML	BFMUO	BFML0
INGEO	.....	.....	.....	.....	.....	.....	.....	BFMUO	B F M U O
SBP									
FAS									
DTT	B F M L	F M L O	.....	B F M L O	.....	B F M L O	.....	BFMUO	.....
PlanB	…….	……	BFMULO	……..	……	……	…….	ML	……..

4.3.2 Technology Readiness Level Development

The TRL scale is a metric for describing the maturity of a technology. The acronym stands for Technology Readiness Level. The scale consists of 9 levels. Each level characterises the progress in the development of a technology, from the idea (level 1) to the full deployment of the product in the marketplace (level 9). The scale is in detailed described below:

Table 4: Technology Readiness Level Scale[29]

Level 1	Basic Research: basic principles are observed and reported
Level 2	Applied Research: technology concept and/or application formulated
Level 3	Critical function, proof of concept established.
Level 4	Laboratory testing of prototype component or process.
Level 5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)

[29] https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

Level 6	Prototype system verified.
Level 7	Integrated pilot system prototype demonstrated.
Level 8	System complete and qualified.
Level 9	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Table 5: TRL of ASHVIN ERs

Tentative KER	Partners	From TRL	To TRL
Automated progress monitoring	DTT, MFL, CERTH, NCC	3	6
Real-time as-built vs as-designed comparison	DTT, TUB, MFL, NCC	2	6
Better & improved resource planning and logistic	Plan B, NCC, TUB	4	6
Better safety monitoring	EUR, NCC, NGEO, DTT,TUB	2	6
Automated damage detection algorithms using deep-learning model	CERTH, INFCON, UPC	3	6
Image based 3D representation into a Digital Twin	CERTH, DTT	2	6
GIS based risk management tool	INFCON, UPC	1	6
KPI framework for digital twin-based life cycle management	All	2	6
Structural health monitoring integration into FEM and into digital twins (for bridges and geotechnical structures)	UPC, NGEO, MFL, CERTH, INFCON	3	6

4.3.3 Workshop Conclusion

The common understanding of what the exploitation is and what it involves, helps to contribute to efficient exploitation of the project results. For this exact reason, the workshop begun with said explanations. To indicate the development of each of the ERs, the matrix was updated together with the project partners. Simultaneously, to prevent any conflict regarding the IP rights, the BFMULO matrix was reviewed and

updated by partners to illustrate the exploitation claims. This matrix is closely linked to the IPR management, which suggest the types of IP protection. The last part of the workshop dealt with the risk assessment and aimed to explain the methodology, which helps to identify possible risks. The exploitation workshop also served the purpose to collect a set of data needed for this particular deliverable (D8.3). All observations, comments and conclusions were noted and implemented into this deliverable. To collect the missing data, new template will be created and circulated among the consortium partners.

5. INDIVIDUAL ASHVIN EXPLOITATION STRATEGY

This section provides an overview of how the ASHVIN work relates to partner's product or services. Each partner in ASHVIN has a specific exploitation plan covering how they are planning to use the scientific and technical output of the project to help develop their current business or create new ones. Partners have concentrated on identifying leads and opportunities which can be followed during the Second half of the project and will lead to a concrete plan for implementing individual exploitation strategies during the next phase. Partners were also asked to indicate the types of individual exploitation which interested them and the results of most interest. Individual exploitation plans of all partners are presented in Appendix.

The exploitation activities are a central point of interest in ASHVIN for each partner individually but also jointly. The heterogeneity of the consortium partners' activities will lead to different types of individual exploitation strategies which can be either non-commercial (academic/research) or commercial (industrial). Nevertheless, strong sustainable joint exploitations have been identified:

Table 6: ASHVIN Exploitation Strategy

PARTNER	BUSINESS OPPORTUNITIES	MARKET	EXPLOITATION RESULT	STAKEHOLDERS
TUB	TUB will be mostly focussing on how to support academic environment but also on relation of higher academic environment with the industry. They are planning to provide educational offerings on generative design, Discrete Event Simulation and Digital Twin, and also support in research opportunities on these areas and the GEN, DES tools they are developing in ASHVIN project. TUB also plans to develop new develop a new tool to support Project Management activities during construction works. TUB will also explore in the industry consultancy and training area, especially for	Education and research, civil engineering domain, construction project management, European design industry, decision makers for construction markets. Opportunity to transfer the knowledge to different markets like manufacturing, automotive.	-Tool for generative design methods and real-time discrete event simulations. -Framework for early phase design -Evidence based design rules -Parametric model and logical rules	Researcher (using these tools as a starting point and then exploring diff ideas), engineers, architects, site managers, owners, students, contractors, design consultancy companies, construction planners

	continuous education as there is a huge potential in that sector.			
CERTH	CERTH will reinforce its research competencies and position in the area of Multimedia analysis and computer vision for Digital Twins. Increase visibility in the scientific community for topics around the Digital Twins, computer vision based 3D representation and data fusion procedures for bringing the physical to the digital.	Education and research, construction project management, European design industry, decision makers for construction markets.	-Data driven decision making, --Image based modelling and 3D representation, -Multimedia analysis and data fusion for Digital Twins.	Researchers, engineers, architects, construction site owners, municipalities & public sector, Decision makers.
MFL	1. Enabling seamless integration of all-relevant information sources in one digital twin (full range of IOT data and real-time data streams) 2. Providing the real-time as-built vs as-designed comparison, monitoring and synchronization 3. Real-time and fully digital based maintenance and inspection of the construction.	Europe- engineering and construction industry mainly	Same as KER in the proposal. -IOT based digital twin platform for real-time construction for monitoring and that can progress monitoring and refine the completed work to prove that it is consistent with plan and the idea is that it can support the site observation with percentage.	Engineering companies, Construction IT managers, Construction planners and supervisors

EUR	Erasmus University Rotterdam whose focus in ASHVIN project is on ensuring compliance with all privacy and data protection regulations, focusing on the potential for personal data to become vulnerable in the digital twinning process.EUR sees a great opportunity in providing privacy by design solutions as there is a lot of demand in the market, along with this EUR will explore in the area of Privacy oriented courses for students which is also in huge demand.Lastly, as we know workers are extremely worried about the prevalence of surveillance technologies in their respective workplace, So EUR can indulge in this area quite comfortably..	Education and research institutions, construction business owners	-A best practices guide to implement privacy oriented digital twins. -Higher education offering based on the reults of the project. -Scientific outputs based on the privacy impacts of the implemented technologies.	Construction workers, construction site owners, higher education institutions, students
INFCON	1. Digitalization of infrastructure, scanning and inspection using UAVs. 2. Development of BIM models and digital twins. 3. Automated inspection, detection of damages and prediction of performance. 4. Decision making tool for predictive maintenance planning.	Geographically: Southern-Eastern Europe Airport owners, transport infrastructure owner. Municipalities, public agencies.	-Automated inspection using UAVs. -GIS based decision support tool for risk based maintenance planning tool. -KPI framework for lifecycle management for all types of civil engineering structures. -KPIs for digital twin management	Infrastructure owners (highway, railway, airport, waterway owners), inspection companies, designers and consultants.

NCC	Using digital twin and other tools would lead to more efficient production. High quality end product and low production cost.	Commercial real estate developing, Engineering and contracting for the Nordic market	-Gaining knowledge about tools and Digital twin which could be used to improve internal processes within our company. -Contributing to other partners that develop tools by providing data, images and domain knowledge (including interviews and feedback on tools).	Improved safety on site to benefit construction workers; facilitate owners of constructions will benefit from having facility management (FM) tools inheriting the digital twin to work in future in management and maintenance. Client who hired them as contractors will benefit from better quality products. Construction managers will have better control of progress, quality and safety on site.
UPC	Research collaborations and new projects, real-time monitoring of bridges, consultancy for owners.	Spanish railway and highway owners, research and education	-Structural health monitoring, -Digital twin of bridges with integrated FEM with sensor data	Bridge Designers, Student
DTT	1. Digital twin provider for the tunnel construction industry. 2. Consultancy service to the construction industry in the sense of ontology and monitoring process. 3. New software suite to commercialize within construction industry. 4. Digital twin platform can be exploited within manufacturing and automobile industry.	Digital twin market segment of construction and manufacturing industry. Central and North EU countries, USA, Canada and Australia.	-Digital twin web based platform, -Software tools, Ontology	BIM Users, Construction managers/engineers, Designers/architects, project owners

PlanB	Provide expertise regarding digital twin set up, application and organisation for project planing and execution, based on, among other things, the identified KPIs in Ashvin.	Northern Europe construction industry. Civil works and buildings.	-Different concepts for digital twin-based construction with focus on **health & safety, lean planning and resource efficiency.**	Construction IT managers, Construction Managers, Construction planners and supervisors
FAS	Using digital twin and other tools for increasing the competitiveness of the company and possibility to offer more innovative services (renovation with digital twin support). FASADA is a SME doing building renovation and new building construction (with focus on envelopes)	Poland, renovation and construction of buildings (residential, educational, offices)	-Contribution to the tool development. FAS is the user of the digital twin tools and platform as the renovation company	Public and private building owners and real state companies
ASI	Positioning as enabler for stakeholder to initiate standardization in the field of BIM and associated digital twin standards	Digital twin market segment of construction and manufacturing industry in the European Union and globally (CEN and ISO)	-Digital Twin Standards	Infrastructure operators users, civil engineers, designers/architects
INGEO	Structural health monitoring of geotechnical structures allows to move to full probabilistic analysis and model updating within a digital twin environment.	Ports and transport infrastructure owners worldwide	-Demonstrated digital twin based on SHM system for quay wall	Ports and transport infrastructure owners Designers and consultants
SBP	Digital twins of stadia roofs and bridges; additional DT-package as application for the assesset management and structural health-monitoring of structures	Public sector, Private, worldwide	-Evidence-based design tool, -Systematic collection of data and cumulation in knowledge database, -Stadium roof DT application	Public and private building sector

AUS	1. Formulate a NGO (Association) with partners from the consortium and other partners from LC-EEB-008 projects 2. Integrate with existing association (Building Digital Twin International)	Research Institutions Policy Makers Construction Companies Technology Providers	-Online Community about Digital Twin in Construction	Research Institutions Construction Companies Technology Providers

6.CONCLUSION AND FUTURE STEPS

Over the last 17 months, the **ASHVIN** consortium has invested effort into defining and concluding on the most appropriate exploitation paths in order to ensure that **ASHVIN** results will be able to fully exploit and remain sustainable even after the project ends. The aim of this deliverable was to provide Intermediate version of the Exploitation plan for **ASHVIN** project results both in the case of academia and industry. The implementation was supported by the first exploitation workshop, where modifications in the list of exploitable results were discussed, as well as characterizations of individual results were updated. Appropriate business models and market plans also have been developed in this deliverable and will be updated and modified in the following months, in order for the exploitation paths to come to fruition and the opportunities to be realised. Engagement of all partners, via concrete plans and signed agreements, with clear roles and responsibilities into this joint effort will increase the possibilities of a successful commercialisation and market uptake of ASHVIN results.

In the next steps, we plan to implement and run the knowledge base as well as constantly update it with relevant information and note the results, avoid IPR infringement and mitigate risks that could endangered the exploitation. in the D8.5 report, which is the final version of this deliverable to be submitted at the end of the project. In the second half of the project from month 19 to month 36, the project will accelerate with the development of new tangible and more concrete results, different formats of activities such as workshops, webinars and roundtables will be used to explore and exploit these results with external stakeholders.

It is critical for the whole consortium to define the exact milestones that need to be met in order to support the ultimate target of continuing implementing an accurate and targeted exploitation strategy. Some of the most critical deadlines are presented below which are expected to be executed during the next period of the project.

Critical Exploitation Milestones (Internal):

- **Finalise Business Surveys and elaborate feedback (M30):** Finalise business surveys and interviews with the end users, public polls, webinars with pilot users elaborate feedback and provide input to the tool owners in order to adjust/verify their tools and fine tune our ASHVIN business model.
- **Business Model – Final Version (M32):** Finalise the desired Business Model and define role for each partner. In the second iteration, key resources, relationships and channels will also be examined.
- **Go to Market (M34):** Create a business plan, including a Financial Plan and a Rollout Plan for the **ASHVIN** Solution. IPR agreements and interim results to generate the business plan are also finalised in this plan
- **Pitching presentation (M35):** Create a Pitching Presentation as a support tool to the Business Plan, which can be exposed to potential end users and VCs.
- **Collect and assess feedback from Web-Based Random Polling (M36):** Collect feedback from the Web-Based Random Polling and integrate it to the final deliverable.

DTT will secure involvement of all project partners in exploitation activities, guide them through the process and encourage them to contribute to the exploitation.

ANNEX A: REFINEMENT OF INDIVIDUAL EXPLOITATION PLANS

Table 7: ASHVIN-Refinement of Individual Exploitation plans

PARTNER	INDIVIDUAL EXPOLITATION PLAN
TUB	TUB will use the results of the ASHVIN project directly in improving its educational offers within the TU Berlin's Bachelor and Master programs in civil engineering and architecture. Besides the traditional education program, TUB aims to provide continuous education programs in the form of training events to allow the practitioners to gain the knowledge of implementing and using digital twins for their business cases, using ASHVIN platform as the core of such programs. Additionally, together with the partners the TU Berlin will look for ways to bring ideas developed during the ASHVIN project to the market by founding innovative new start-ups. As entrepreneurial university, founding new businesses and bringing ideas to the market lies at the core of TUB's mission.
CERTH	CERTH is interested in commercialising the developed services by setting up a spinoff company or licensing the developed modules to interested clients. CERTH is already providing research services and results to the local and European industry through direct research contracts and licensing agreements. Part of the CERTH's business plan is to participate in several new spin-off commercial companies capable of exploiting its research when new market needs and solutions are identified.
MFL	The main exploitation outcome for MFL will be IoT Based Digital Twin Platform for real-time construction monitoring and facilities maintenance. Enabling seamless Integration of all-relevant information sources ranging from representation of the physical assets, full range of IoT data and real-time data streams, advanced machine learning, supported image-based data collection methods, structural health, and environment and GIS dat) - In one digital twin, and with user rights management framework, and permissions to download, export, and use all information they have access to at any time, innovation will provide: - Real-time as-built vs as-designed comparison, monitoring and synchronization - Real time and fully digital based inspection and maintenance of the construction and existing facilities. This will provide Mainflux Labs added value and unique selling points for Engineering and Construction industry but also for independent software vendors, system integrators, which operate within construction, real estate and facility operation & maintenance domain. Secondary, but also significantly important exploitation outcome for acquiring above mentioned target segments will be credibility, reference and domain knowledge of the construction industry from participating in the H2020 project with consortium partners like TU Berlin, TU Delft, NCC, FAS, and others.
EUR	Like the other partners from the higher education sector, EUR will use the results of the ASHVIN project directly in improving its educational offers within its Bachelor and Master programs. Additionally, the ASHVIN project will allow EUR to gain deep insights

	into privacy and safety issues as they directly relate to the construction industry to inform its general-purpose management research portfolio.
NGEO	The ASHVIN project will allow NGEO to develop new consultancy services that will not only allow for passive monitoring of construction earth and foundation works, towards predictive and prescriptive based regimes. The risk-based management and control-based frameworks developed within ASHVIN will provide an outstanding opportunity for NGEO to increase the sophistication, but also the reach of its services across Europe.
UPC	From the academic perspective, UPC, and, the School of Civil Engineering has a long record of research and development of numerical methods and simulations in the realm of civil infrastructure. Enabling the embeddedness of sensors feeding real-time data to those models represents a considerable leap from the research perspective but most importantly, from the perspective of linking physical and digital assets. UPC also plans to use key ASHVIN results for knowledge transfer into industry: the new set of sensing methodology for structural monitoring and the tailor-made connection to the digital twin structure. All these developments will open new sector markets, will be exploited by sharing the knowledge with the different sector agents, and can lead to technology transfer in the form of the creation of spin-off companies aiming to commercialise some of the new technologies developed.
ASI	The insights gained from the activities during the project will enable ASI to broaden its network of stakeholders from industry, research and other relevant groups in the areas of BIM and construction, increase opportunities to actively contribute to new projects by working on the development of new and revision of existing standards. In addition, expansion of the field of expertise of ASI will lead to the extension of consultancy services and strengthen the reputation of ASI as a partner in various R&D projects, responsible for standardization activities. Finally, participation in the ASHVIN project will support the visibility and competitive position of ASI as a standard developing institution on national as well as international level.
INFCON	INFCON is one of the European leaders in providing consultancy services in the area of life cycle management, monitoring and asset management. The ASHVIN project will allow INFCON to substantially improve its consultancy services in the area of digitalization of infrastructure, structural health monitoring, digital twin-based model matching, and risk based maintenance planning.
PLANB	Plan B will strengthen its capability to assist its clients to take advantage of digital twin technology and methods. Plan B will develop its methodology for process management and classification that will contribute to its edge and competitive advantage in the market. Plan B will expand its customer base and services as a result of the capabilities developed by participating in the project. In addition, Plan B is also engaged in training of professionals in which the results from the project will be used to create capabilities and resources in the market.
AUS	AUS will leverage the outcomes of ASHVIN in its mission to bridge the divide between the high-tech Research + Innovation and the market. This will be achieved by exploiting the knowledge acquired in previous and ongoing projects with a focus on marketing services and ecosystem dynamization. Participating in ASHVIN is an opportunity to contribute to the uptake and validation of the Digital Building Twins market, reinforcing and enlarging our portfolio of technical partners in advanced manufacturing and

	processing. This will allow the organization to expand our range of services towards other customers and partners, in the European and international range.
DTT	ASHVIN project's vision was preconceived long back within our organisation to develop and integrate within the existing digital twin platform. We had our initial market analysis done and now by this project we can be able to validate our analysis within all the 9 different demonstration sites and then finalise the business model for our product to the different market segments. This project is letting us work with the market leaders and researchers from different verticals. Our current market segment is Tunnel construction but via this project we can be start expanding towards building, bridges and industrial construction.
FAS	FASADA is a renovation company (SME) with core business focused on construction and renovation of buildings. Therefore, the company is interested in exploitation of digital twins for buildings and ASHVIN platform. In this way the company will increase its competitiveness and will have the opportunity to offer new more complex service to public and private investors.
NCC	Currently, the digital twins we have made is basically a static digital version of the physical product where the assets (down to size of 32 mm) have been modelled and QR-codes provide means for the facility managers to keep track of the individual buildings (for example, replace a broken light bulb). The next step, that ASHVIN will help to provide, is transforming this static digital BIM model into a dynamic one where IoT sensors and images give update during construction as well as feeding input to our design department. This will increase predictability and mitigate risks leading to a safer and more efficient work site, improving time and cost delivery substantially. The results will provide us with a competitive edge but we also expect new services and business models to appear. The results are not connected to an individual business area but can be scaled to include all our businesses: building, infrastructure, industry and property development.
SBP	Structural design is an experience-based, rational, but also creative process that has always been supported by collection of data and experience. A new aspect of the approach within the ASHVIN project is the clear structuring and the data-supported holistic consideration of the most diverse aspects of the design. This insight into a wide range of decision variables not only serves to improve the design regarding the defined key performance indicators, but also increases the understanding of the design engineer, his productivity through the availability of knowledge databases, and facilitates the communication of design decisions. The evidence-based tools will allow to structure much of SBP's past knowledge and the envisioned parametric design tool will help SBP to increase its overall design productivity and strengthen further the rational and holistic design approach.

ANNEX B: EXPLOITATION PLAN PHASES

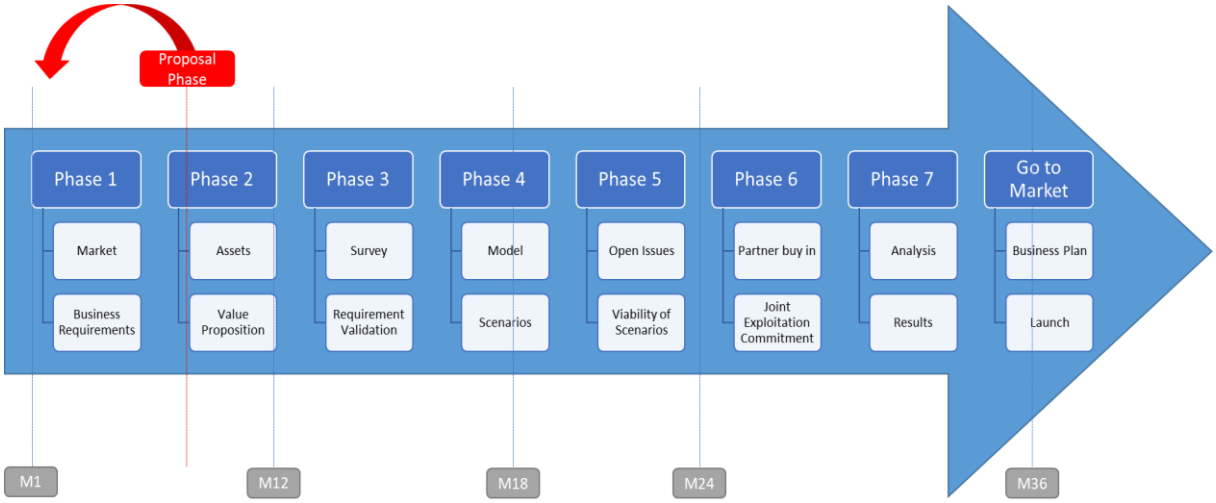

Figure 12: ASHVIN Exploitation plan phases

ANNEX C: ASHVIN DIGITAL TWIN TOOLKIT

Along with the concept of the **IoT-driven digital twin platform**, **ASHVIN** introduces a **digital twin toolbox** that extends existing ICT methods and innovations from low technology readiness levels to proven technical solutions at the system or the sub-system level. All developed innovations are built upon the **ASHVIN digital twin platform** and are linked to digital twin data.

BRICS- *Evidence based design support tool for productivity resource efficiency and safety.*

GEN-*Generative design modeller to support design for productivity, resource efficiency and safety.*

DES-*Simulation-based real-time construction site and logistics planning tool.*

4DV-D- *Construction site simulator for early design phases with 4D visualizer.*

4DV-C- *Construction monitoring tool with productivity and safety KPI decision making dashboard.*

SMT- *Privacy ensuring safety management, simulation, and training tool.*

CMT- *A configuration management tool to track as-designed and as-built, as well as, to allow for seamless commissioning.*

RISA- *Risk-based status assessment tool with KPI dashboard.*

MATCH FEM-*Multi-physics model matching tool for status assessment of bridges and buildings.*

GISI-*GIS integrator for digital twin-based asset management.*

ANNEX D: ASHVIN KEY PERFORMANCE INDICATORS

Key performance indicators (KPI: s) in the ASHVIN project have already been defined and presented in a previously published deliverable, ***D4.1*****,** within the project.

The key performance indicators are productivity, resource efficiency and safe construction work. These constitute of various performance indicators (PI: s) who are quantifiable and measurable sub-criteria's of a KPI

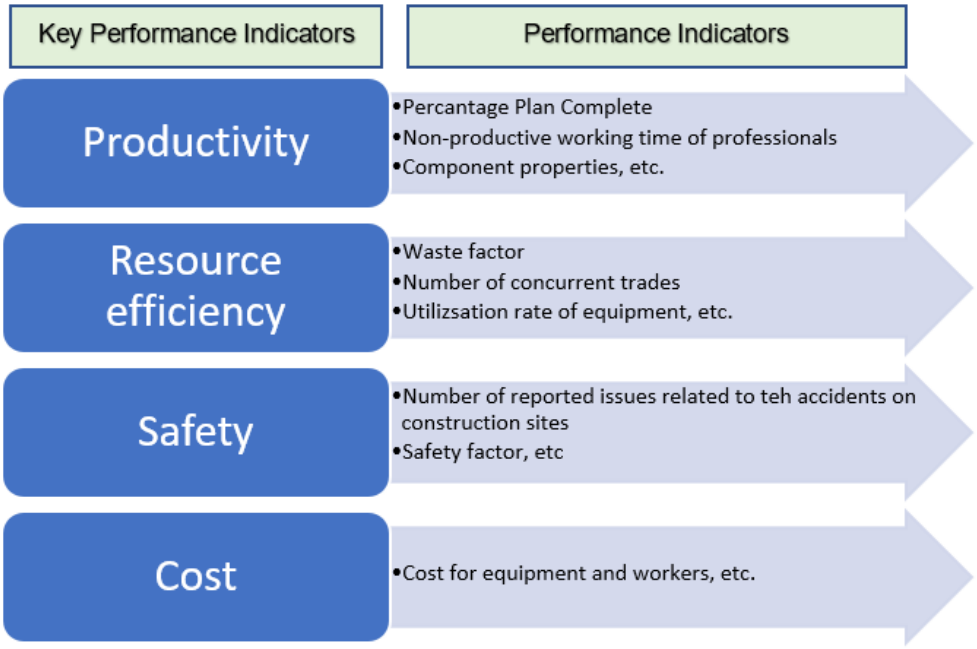

Figure 13. Definition of Key Performance Indicators and Performance Indicators for ASHVIN project.