D8.5 IMPACT ASSESSMENT AND EXPLOITATION FINAL REPORT

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ABSTRACT

The deliverable updates on the impact assessment, market analysis and swot analysis of the project done in the previous deliverables. The deliverable further expands on the exploitation plans and the licensing of the platform and its components.

KEYWORDS

Impact Assessment, Commercialisation, Exploitation, Marketing, Digital Twins

REVISIONS

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DISCLAIMER

ACRONYMS & DEFINITIONS

AI	Artificial Intelligence
AR	Augmented Reality
BCF	BIM Collaboration Format
BIM	Building Information Modelling
CEN	European Committee for Standardization
HSE	Health, Safety and Environment
IEC	International Electrotechnical Commission
IEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
MoU	Memorandum of Understanding
PEST	Political, Economic, Socio-Cultural, Technological
R&D	Research and Development
R&I	Research and Innovation
RTD	Research and Technical (or Technological) Development
RTOs	Research and Technology Organisations
SDOs	Standards Developing Organizations
SMEs	Small and Medium Enterprises
SWOT	Strengths, Weaknesses, Opportunities, Threats
TRL	Technology Readiness Level
VR	Virtual Reality

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 behaviour 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. **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.

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1 INTRODUCTION

The ASHVIN project aims to address the evolving market of digital construction within the European industry, targeting a broad array of end customers that range from large construction firms to small and medium-sized enterprises (SMEs) engaged in building and infrastructure development.

By integrating cutting-edge digital twin technology, ASHVIN seeks to enhance the efficiency, safety, and sustainability of construction projects, providing tools that allow for real-time monitoring, predictive maintenance, and improved decision-making. The project's offerings are particularly designed to appeal to stakeholders who are increasingly prioritizing innovative, data-driven solutions to stay competitive and compliant with stringent EU regulations on construction safety and environmental impact.

The objective of this deliverable is to update the market analysis done in the previous deliverables, the impact assessment and SWOT analysis included. We also aim to specify the requirements to be taken into account for successful exploitation in relation to proper IPR Management of the platform and individual components.

Towards this direction the deliverable is structured in the following way:

Section 2 updates the market analysis done in the previous deliverables with specific focus on digital twin market and the European construction industry as a whole.

Section 3 does impact assessment specifically the impact on Political, Economic, Social, Technical, Legal and Environmental aspects of a solution such as Ashvin and how it can effect the successful exploitation.

Section 4 updates on the strengths, weaknesses, opportunities and threats of Ashvin which will help the earlier mitigation of the weaknesses and threats for the successful exploitation.

Section 5 presents the key competitors of Ashvin and its technologies.

Section 6 takes into account the knowledge generated by each partner in the project and how they can exploit it in other activities.

Section 7 looks at the business models that Ashvin can adapt to and how to proceed with them.

Section 8 works on defining an IPR management plan for the individual components and Ashvin as a whole.

2 UPDATES TO MARKET ANALYSIS

This section of the deliverable documents the updates on the market analysis done in the previous deliverables, specifically D8.3.

2.1 DIGITAL TWIN MARKET UPDATES

The digital twin market has seen rapid growth and development since 2022, fuelled by advancements in technology and increasing adoption across various industries. Digital twins, which are virtual replicas of physical entities, systems, or processes, have become pivotal in optimizing operations, enhancing productivity, and driving innovation across sectors such as manufacturing, automotive, aerospace, healthcare, and more. As of 2023, the market was valued at approximately $10.1 billion, with projections suggesting a potential rise to $110.1 billion by 2028[1]. This represents a compound annual growth rate (CAGR) of 61.3%, signalling strong and sustained market expansion over the coming years.

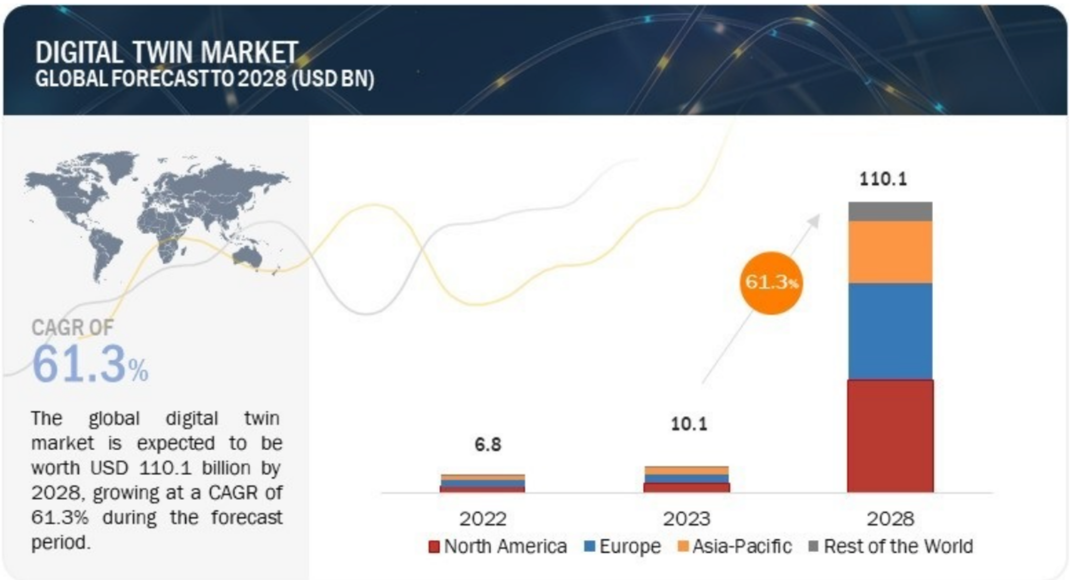

Figure 1 Digital Twin Market size.

Several factors contribute to this robust growth:

- **Technological Integration**: The core driver is the deeper integration of technologies like AI, IoT, ML, and big data analytics. These technologies enhance the capabilities of digital twins, allowing for more accurate simulations and effective predictive analytics. They enable digital twins to process and analyze data from various sensors and sources in real time, providing insights that drive efficiencies and innovations in industrial and business processes.
- **Industry 4.0 and Automation**: The ongoing global transition towards Industry 4.0 has spurred the adoption of digital twins. In industries such as manufacturing, aerospace, and automotive, digital twins are increasingly used

[1] https://www.marketsandmarkets.com/Market-Reports/digital-twin-market-225269522.html

to optimize production lines, reduce downtime, and enhance the design and testing of new products and systems.

- **Government Initiatives and Investment**: Significant government funding and initiatives aimed at digital transformation across the globe have provided a fertile ground for the growth of digital twins. Programs supporting smart cities, advanced manufacturing, and healthcare innovations often prioritize technologies that enable simulation and real-time analytics, key features of digital twins[2].

Digital twins have found applications across a diverse set of industries:

- **Manufacturing**: Utilized for monitoring production lines in real-time, optimizing manufacturing processes, and predictive maintenance.
- **Aerospace and defence**: Employed in the simulation and testing of aircraft systems under various operational scenarios to improve safety and efficiency.
- **Automotive**: Used to design and test vehicle systems, enhancing performance and safety while reducing development time and costs.
- **Healthcare**: Increasingly used to simulate human organs or entire health systems for research and to improve patient care outcomes.[3]

North America has been leading the digital twin market, thanks to the presence of major technology firms and robust infrastructure supporting innovation. The region's market dominance is supported by the widespread adoption of Industry 4.0 technologies and substantial investments in research and development.

Europe and Asia Pacific are also showing significant growth in digital twin adoption. In Europe, the push for digital transformation and the integration of Industry 4.0 technologies across various sectors are key growth drivers. Meanwhile, Asia Pacific is witnessing rapid market expansion due to increased investments in digital infrastructure and government initiatives promoting smart city projects and industrial automation.

The digital twin market is set to transform numerous industries by providing detailed insights into products and operations, allowing for better planning and decision-making. With the market expected to grow exponentially in the coming years, digital twins will play a crucial role in the digital transformation journeys of many businesses globally.

2.2 EUROPEAN CONSTRUCTION INDUSTRY

The European construction industry is a significant component of the region's economy, contributing to infrastructure development, housing, and commercial spaces. The sector's performance is closely tied to the economic health of the European Union and its member states, influenced by factors like government spending, private investment, and regulatory policies.

The European construction market, reaching approximately USD 2752.75 Billion in 2023, has shown resilience and gradual recovery following economic downturns, including the recent impact of the COVID-19 pandemic. As of 2023, the industry has been experiencing a rebound, driven by increasing demand for residential construction

[2] https://www.grandviewresearch.com/industry-analysis/digital-twin-market
[3] https://www.fortunebusinessinsights.com/digital-twin-market-106246

and renovation, sustained public sector investment in infrastructure, and growing interest in sustainable construction methods. The market is poised for sustained expansion, projected to grow at a Compound Annual Growth Rate (CAGR) of 4.90% between 2024 and 2032, ultimately surpassing a valuation of around USD 4233.96 billion by 2032.[4]

The key trends of the include are the following:

- Sustainability and Green Building: There is an increasing emphasis on sustainability within the construction sector. This includes energy-efficient buildings, the use of sustainable materials, and compliance with green regulations such as the EU's Green Deal, which aims to make Europe climate-neutral by 2050.
- Digitalization and Technology Adoption: Digital tools like Building Information Modeling (BIM), digital twins, and AI are becoming more prevalent. Projects like ASHVIN play a crucial role in pushing the boundaries of how digital technologies can enhance efficiency and productivity in construction projects.
- Urbanization: The continued trend of urbanization across Europe is driving demand for new urban infrastructure, residential buildings, and renovations of existing structures to accommodate growing urban populations.
- Regulatory Environment: The construction industry in Europe is heavily regulated to ensure safety, quality, and environmental sustainability. Changes in regulations, particularly in relation to environmental impact, significantly influence market dynamics.
- Labor Market Challenges: Like many regions, Europe faces challenges related to skilled labor shortages in the construction industry, exacerbated by an aging workforce and the need for more tech-savvy professionals due to digitalization.

The European construction market is characterized by a mix of large multinational corporations and small to medium-sized enterprises (SMEs). Major players include Vinci, Bouygues Construction, ACS Group, and Skanska, among others. These companies often engage in cross-border operations within and outside the EU, benefiting from the region's single market.

Innovation is a significant driver for the construction industry in Europe. The integration of IoT, digital twins, and smart building technologies is enhancing the construction and maintenance phases of projects. European firms are increasingly investing in R&D to develop new construction technologies that align with global trends and regulatory demands for sustainability and efficiency.

The construction sector in Europe is subject to stringent regulations that govern everything from building standards to worker safety and environmental protection. The EU's directives and regulations, such as the Energy Performance of Buildings Directive (EPBD) and the Construction Products Regulation (CPR), set standards that must be met across member states.

[4] https://www.expertmarketresearch.com/reports/europe-construction-market/requestsample

Looking ahead, the European construction industry is expected to grow, driven by increasing demands for sustainable and smart infrastructure, ongoing urbanization, and the renovation wave promoted by the EU to enhance the energy efficiency of buildings. However, the sector must navigate challenges such as regulatory changes, supply chain disruptions, and labor shortages to maintain its growth trajectory.

3 IMPACT ASSESSMENT

3.1 POLITICAL IMPACT

The ASHVIN project, with its focus on integrating digital twin technologies in the construction industry, inherently carries political implications. The project's outcomes and practices intersect with political priorities, such as economic development, innovation in industry, environmental sustainability, and labour regulations.

ASHVIN contributed to the European Union's digital agenda by fostering technological innovation within the construction industry. The project's success has been instrumental in demonstrating the EU's commitment to leading the digital transformation in traditionally analog sectors. This aligns with EU policies aimed at enhancing the global competitiveness of European industries.

By showcasing the efficacy of digital twins, ASHVIN has can influence policy-making around construction technology. The project has provided tangible examples that policymakers can reference when drafting legislation to encourage digital adoption in construction, which is a significant sector in terms of employment and GDP contribution in many EU countries.

The collaborative nature of the ASHVIN project, involving a consortium of public research institutions and private enterprises, exemplifies the EU's approach to fostering public-private partnerships. This model is politically significant as it demonstrates an effective way to leverage public funding for maximizing innovation and economic development.

In summary, the ASHVIN project's political impact is multifaceted, reflecting the European Union's strategic interests in digital innovation, sustainable development, labor market evolution, and regulatory influence. By driving change in these areas, ASHVIN has contributed to the political landscape, demonstrating the role of technological projects in shaping policies and advancing societal goals.

3.2 ECONOMICAL IMPACT

The economic impact of the ASHVIN project extends beyond the construction industry, influencing broader economic indicators and behaviours. ASHVIN's digital twin technology has streamlined construction processes, leading to cost savings through improved resource allocation and reduced waste. The optimization of materials and labor has resulted in more efficient project timelines and budgets, directly affecting the profitability of construction enterprises.

The project's success will spurr increased investment in the construction technology sector. Venture capital and private equity funds have shown greater interest in financing innovative startups and established companies that adopt or develop similar technologies, indicative of a healthy, growing market.

By equipping European construction companies with cutting-edge digital tools, ASHVIN will enhance their global competitiveness. The ability to deliver projects more quickly, with higher quality and lower costs, has made European firms more attractive partners on the international stage. The shift toward digitalization driven by ASHVIN will lead to the creation of high-skilled jobs in software development, data analysis, and construction technology. This supports economic growth and aligns with the EU's agenda to foster a knowledge-based economy.

Small and medium-sized enterprises (SMEs), including startups, will benefit from the open-source aspect of ASHVIN's platform. This will lower barriers to entry for smaller players, enabling them to innovate and grow, which diversifies and strengthens the industry. The increased productivity in construction projects will have a multiplier effect on the economy, leading to greater output and subsequent investment in other sectors. This, in turn, will stimulat economic growth and generated additional tax revenue for governments.

Delays in construction can have significant economic consequences. ASHVIN's predictive modelling and simulation capabilities have mitigated such risks, resulting in more predictable project outcomes and economic stability for stakeholders.

3.3 SOCIOLOGICAL IMPACT

The success of the ASHVIN project will reverberate through various strata of society, reshaping social dynamics and influencing collective behaviors and norms. The successful implementation of digital twin technologies will fundamentally alter the construction industry's workforce dynamics. It will necessitate a shift towards more knowledge-intensive roles, promoting lifelong learning and continuous professional development. This could lead to a societal value shift that places greater emphasis on tech literacy and adaptability in the labor market. With an increased focus on safety through predictive analytics and real-time monitoring, ASHVIN's success will raise the bar for occupational safety standards. This will foster a societal expectation of safer working conditions, not just within construction, but across all industrial sectors.

ASHVIN's collaborative approach will set a precedent for inclusive project development, encouraging communities to engage in dialogue about local construction initiatives. Successful community engagement strategies could become a blueprint for future projects, enhancing civic participation and empowerment. By demonstrating the effectiveness of sustainable construction, ASHVIN will encourage societal endorsement of green living spaces. The project's success will validate eco-friendly practices and could influence individual choices, pushing sustainable living from a niche preference to a societal norm.

As digital twin technology modernizes the construction industry, it also presents an opportunity to attract a more diverse workforce. The success of ASHVIN could break down traditional gender roles and encourage more women to pursue careers in construction and STEM fields. By promoting the use of digital twins in construction, ASHVIN's success will highlight the role of technology in making infrastructure more accessible. This could have broader implications for social equity, as improved infrastructure can lead to more inclusive societies.

The broader societal impact of ASHVIN's success will be an enriched cultural attitude towards technology. As people witness the tangible benefits of digital twins in construction, technology will be seen as an enabler of progress, fostering a culture that embraces innovation. With the potential for more remote monitoring and project management, ASHVIN's success might influence work-life balance, allowing professionals to spend less time on-site and more time with their families, thus strengthening family and community bonds.

The sociological impact of the ASHVIN project's success is expected to be transformative, leading to a society that is more technologically adept, prioritizes safety and sustainability, values continuous education, and promotes inclusivity and social equity. The ripple effects of these changes will be felt in everyday life, work, community engagement, and policy-making, contributing to a more progressive and resilient social fabric.

3.4 TECHNOLOGICAL IMPACT

The technological success of the ASHVIN project is poised to have far-reaching effects on the construction industry and beyond, driving innovation and setting new standards in the application of digital twins. ASHVIN's success will catalyze advancements in digital twin technology, pushing it to new frontiers. It will set a benchmark for the accuracy, reliability, and utility of digital twins, influencing their broader application across various sectors.

The project's achievements will accelerate the integration of IoT devices in construction, leading to smarter, more connected worksites. This could inspire a surge in IoT development, promoting the creation of more sophisticated sensors and devices tailored to the specific needs of the construction industry. The demand for software capable of handling the rich data provided by ASHVIN's digital twins will stimulate the development of new software solutions. This could result in more robust analytics platforms and user-friendly interfaces that bring the power of digital twins to a wider audience.

ASHVIN's success will enhance Building Information Modeling (BIM) practices by integrating them with live data and predictive analytics. This will transform BIM from a static to a dynamic process, revolutionizing project management and operational maintenance. The project's achievements in digital twin technology will likely contribute to setting new industry standards, influencing how future construction projects are planned, monitored, and executed. ASHVIN's methodologies could become the go-to standard for construction digitization efforts.

The project's successful deployment of digital twins in construction will provide a solid foundation for the development of smart cities. ASHVIN's technologies could become integral in designing cities that are efficient, sustainable, and responsive to the needs of their inhabitants. With its emphasis on resource efficiency, the success of ASHVIN will underscore the role of technology in achieving sustainable development goals. It will demonstrate how technological innovations can lead to environmental conservation in construction and urban development.

As digital twins become more entrenched in construction, secondary technological innovations are expected to arise, such as augmented reality for on-site visualization and machine learning algorithms for predictive maintenance.

The success of the ASHVIN project will not only transform the construction industry but also signal a shift toward more integrated, intelligent, and sustainable practices in technological applications. The project's ripple effects will be seen in the evolution of smart infrastructure, the emergence of new software and hardware ecosystems, and the overall elevation of technology's role in societal advancement.

3.5 LEGAL IMPACT

ASHVIN project will likely influence the legal landscape significantly, impacting legislation and regulatory practices within the construction industry and related areas of digital innovation. The integration of IoT and digital twin technologies in construction will necessitate the development of more nuanced data privacy regulations. The project's success will push lawmakers to refine legal frameworks to protect personal data while enabling the beneficial use of digital monitoring in construction environments.

ASHVIN's achievements will encourage the standardization of laws surrounding digital construction practices. Legal precedents and codes will need to evolve to accommodate the use of digital twins, ensuring that all new digital methodologies are within a clear legal framework that promotes safety, reliability, and accountability. The creation and implementation of novel technologies by ASHVIN will set a trend in intellectual property law related to construction technologies. The success of these technologies will lead to a rise in patents and trademarks, necessitating robust protection and clear guidelines for licensing and technology transfer.

Contractual relationships in construction will undergo transformation. Legal contracts will need to incorporate provisions for the use of digital twins, including data handling, system reliability, and performance metrics. The project's outcomes will drive the creation of contract templates that address the complexities of digital technology integration in construction projects.

The improved safety outcomes achieved by ASHVIN's technologies will raise the bar for what is considered 'reasonably practicable' in terms of providing safe work environments. This may result in tighter health and safety legislation, with digital monitoring and risk assessment becoming legally mandated practices.

With the adoption of ASHVIN's digital twin technologies, insurance policies and liability clauses will adapt to cover the specific risks and benefits associated with their use. The success of such technologies will lead to the creation of insurance products tailored to the risks of digital construction environments.

Government procurement policies will be updated to prioritize the inclusion of digital twin technologies for public infrastructure projects, reflecting the project's success in enhancing efficiency and transparency.

The ASHVIN project's success will be a key driver in the evolution of legal frameworks, impacting not only the construction industry but also the broader legal considerations related to technology use, data protection, and environmental sustainability.

3.6 ENVIRONMENTAL IMPACT

The successful implementation of the ASHVIN project's digital twin technologies will generate a ripple effect across environmental conservation and sustainability efforts within the construction industry and beyond. The precision afforded by digital twin technology will lead to more efficient use of materials and energy. Optimized planning and execution can significantly reduce the waste generated by construction projects, conserving natural resources and minimizing environmental footprints.

Through improved logistical planning and resource management, ASHVIN's success will contribute to a decrease in carbon emissions associated with construction activities. It will advance the industry’s ability to meet stringent environmental standards and support global climate change mitigation efforts. Digital twins will enable more sustainable urban and infrastructure planning, helping to design buildings and cities that are energy-efficient and have minimal ecological impact. This will promote biodiversity and contribute to the creation of green spaces in urban environments.

The project's comprehensive approach to monitoring and managing construction projects will improve lifecycle assessments, providing detailed insights into the long-term environmental impacts of buildings and infrastructure. The environmental achievements of the project will inform policy development, leading to the adoption of stricter regulations that promote environmentally friendly construction practices. These policies will likely mandate the use of digital tools that enable tracking and reducing environmental impacts.

The construction industry's transformation, propelled by ASHVIN, will inspire other sectors to adopt similar digital twin technologies for environmental monitoring and management, leading to cross-industry improvements in sustainability. Digital twin technology enables the monitoring of material flows, which can support the implementation of circular economy principles in construction. By facilitating the reuse and recycling of materials, the project's success will further reduce environmental degradation.

By optimizing the use of machinery and reducing the need for on-site presence through remote monitoring, ASHVIN will help lower the energy consumption of construction operations, making them more sustainable. The visibility of the project’s environmental benefits will raise public awareness and acceptance of sustainable construction technologies, leading to increased demand for green buildings and infrastructure.

The environmental impact of the ASHVIN project’s success is anticipated to be profound, contributing to a more sustainable construction industry that is in harmony with ecological preservation and the global agenda for environmental responsibility.

4 UPDATED SWOT ANALYSIS

4.1 STRENGTHS

- Integration and Compatibility: Over the years, ASHVIN successfully enhanced the interoperability of its platform, allowing seamless integration with various construction management software.
- Market Recognition: The project gained significant recognition within the EU construction sector for its innovative approach to productivity and safety, driving a rise in adoption rates.
- Compliance Mastery: ASHVIN adeptly navigated the complex regulatory environment, aligning its offerings with GDPR and other EU directives, bolstering stakeholder confidence.
- Sustainability Leadership: In line with the European Green Deal, the project became a leader in promoting green construction practices through its digital twin solutions.

4.2 WEAKNESSES

- Cultural Resistance: The project contended with cultural resistance within the construction industry, particularly from sectors slow to adopt new technologies.
- Technical Support Hurdles: As the technology matured, providing comprehensive technical support across the diverse user base presented challenges, especially in regions with less developed digital infrastructure.
- Cost Implications: Small and medium enterprises found the cost of full-scale implementation to be a significant hurdle, despite recognizing the long-term benefits of digital twin adoption.

4.3 OPPORTUNITIES

- Funding Influx: Post-pandemic recovery funds and green initiatives across the EU opened new funding avenues for digital construction technologies and benefitting projects like ASHVIN.
- Cross-industry Application: ASHVIN found new opportunities in infrastructure management and smart city development, demonstrating the versatility of its technology.
- Education and Upskilling: The project spurred the development of dedicated training programs for construction professionals, facilitating smoother technology adoption and creating a more skilled workforce.

4.4 THREATS

- Competitive Pressure: Advancements in AI and IoT led to a surge of new market entrants, placing pressure on ASHVIN to continuously innovate and maintain its competitive edge.
- Economic Uncertainties: Economic uncertainties, including the repercussions of Brexit and the energy crisis, impacted investment and prioritization of technology in construction.
- Cybersecurity Concerns: Heightened instances of cybersecurity threats in recent years led to increased scrutiny and hesitance among potential clients to adopt cloud-based construction management platforms.

- Labor Dynamics: Shifts in the labor market, influenced by automation and digitization, brought challenges in maintaining a balanced workforce skilled in both traditional construction and digital technologies.

5 COMPETITOR ANALYSIS

For competitors update of Ashvin, initially mentioned in Deliverable 8.3, with its focus on digital twin technologies within the construction industry, we need to consider both direct and indirect competitors. These competitors are likely engaged in similar initiatives aimed at improving productivity, safety, and resource efficiency through digital innovations.

5.1 DIRECT COMPETITORS

Direct competitors to ASHVIN would be other projects or companies specifically developing digital twin technologies for the construction industry. Some potential examples include:

- Autodesk BIM 360: Autodesk's BIM 360 is an advanced construction project management tool that integrates BIM (Building Information Modeling) with real-time data from construction sites to manage project workflows efficiently. This tool provides a direct overlap with some functionalities of ASHVIN, particularly in construction monitoring and real-time data utilization.
- Bentley Systems: Bentley Systems offers comprehensive software solutions for advancing infrastructure, including SYNCHRO, a 4D construction modeling suite. These tools provide planning, scheduling, and project management capabilities integrated with BIM, directly competing with aspects of ASHVIN like the 4DV-D and 4DV-C components.
- Trimble Connect: Trimble Connect is a collaborative tool for construction management that links stakeholders and workflows with accurate data throughout the construction lifecycle. It offers similar digital twin applications, focusing on real-time updates and cloud-based collaboration.
- Siemens Building Twin: Siemens provides a comprehensive digital twin solution specifically designed for the lifecycle management of building and infrastructure projects. Their Building Twin integrates physical and digital data across the lifecycle, enabling predictive analytics and maintenance, directly competing with ASHVIN's objectives.
- Dassault Systèmes' 3DEXPERIENCE: Dassault Systèmes offers the 3DEXPERIENCE platform, which includes capabilities for creating virtual twins of urban and built environments. This platform allows for simulation, visualization, and collaboration across the planning, design, and maintenance phases, similar to functionalities provided by ASHVIN.
- AECOM and Bentley's Digital Twins for Infrastructure Projects: In collaboration with Bentley Systems, AECOM has been deploying digital twin technologies across major infrastructure projects. This partnership leverages Bentley's iTwin platform to enhance the design, construction, and operation of infrastructure assets, aligning closely with ASHVIN's digital twin objectives.
- Hexagon PPM: Hexagon PPM's digital twin solutions offer a smart digital reality with project execution and asset management tools designed for the architecture, engineering, and construction sectors. Their technology focuses on using real-time data to drive efficiency, directly targeting the core benefits of ASHVIN.
- Topcon Positioning Systems: Topcon offers advanced solutions integrating real-time data and visual analytics for construction projects. Their positioning

technology and software suites help streamline construction workflows and are used for monitoring structural health, directly competing with some of ASHVIN's real-time monitoring and visualization goals.

5.2 INDIRECT COMPETITORS

Indirect competitors include a broader range of technological solutions that overlap with the functionalities offered by ASHVIN but are not exclusively focused on the construction industry or digital twin technology. Examples include:

- IBM Maximo: IBM Maximo is an asset management tool equipped with IoT capabilities, which indirectly competes with ASHVIN's asset management aspects. Although not specific to construction, its broad application across various industries for asset and operations management places it as an indirect competitor.
- Oracle Construction and Engineering: Oracle offers a suite of software that helps manage the lifecycle of construction projects, including planning, scheduling, and risk management. While it focuses more broadly on project management and less on the digital twin aspect, its comprehensive coverage makes it an indirect competitor.
- SAP Digital Twin: SAP's approach to digital twins is generally focused on manufacturing and logistics. However, its applications for monitoring assets and integrating complex system data can indirectly compete with digital twin technologies in construction, offering similar benefits in terms of operational efficiency and predictive maintenance.
- Microsoft Azure Digital Twins: Microsoft's Azure Digital Twins is a platform that enables users to create digital representations of real-world environments and infrastructure. While its applications span various sectors, its use in building management systems and smart city frameworks can indirectly compete with digital twin applications in construction.
- Google Cloud IoT: Google Cloud IoT provides a suite of tools to manage IoT device data and integrate it with analytics and machine learning services. For construction, this can facilitate smart building solutions and efficient resource management, offering indirect competition through its broad IoT integration capabilities.
- Schneider Electric EcoStruxure: Schneider Electric's EcoStruxure architecture is an IoT-enabled system architecture and platform that delivers solutions across various industries including buildings, data centers, and infrastructure. The platform's ability to optimize operations and maintenance through advanced analytics could serve similar needs to those targeted by ASHVIN, albeit more broadly.
- Cisco Digital Network Architecture (Cisco DNA): Cisco DNA offers an intent-based networking solution that captures and uses contextual data from network environments. In construction, the ability to manage and automate networks can indirectly impact the efficiency of digital tools used in the planning and management phases.
- Honeywell Forge: Honeywell Forge is an enterprise performance management software that can be applied to buildings and industrial facilities, optimizing operations and helping with predictive maintenance. Its functionalities overlap

with the asset management and predictive analytics aspects of digital twins in construction.

5.3 SUMMARY OF COMPETITOR ANALYSIS

ASHVIN faces both challenges and opportunities from direct and indirect competitors. Direct competitors, such as other digital twin and BIM integration tools, may offer specialized functionalities that overlap with some of ASHVIN's features, particularly in areas like 4D modelling. Indirect competitors include broader technological platforms that, while not exclusively focused on the construction sector, provide solutions that enhance operational efficiencies across various industries, which could encroach on the market space targeted by ASHVIN.

Despite these challenges, ASHVIN distinguishes itself through strategic use of the partners expertise and a commitment to innovations specifically tailored to the construction industry. By integrating advanced multi-physics simulations, applying stochastic modelling techniques, and engaging extensively with stakeholders, ASHVIN crafts a unique value proposition. The project also emphasizes construction-specific safety and productivity enhancements, strict compliance with EU regulations, and solutions geared towards local market needs. Through these focused efforts, ASHVIN has developed tools that effectively differentiate it from competitors, securing a distinct segment in the market.

6 INDIVIDUAL KNOWLEDGE EXPLOITATION

6.1 TUB

Table 1 Individual Knowledge Exploitation (TUB)

Knowledge Generated	Potential future Use
Educational offerings on generative design, Discrete Event Simulation and Digital Twin; Research opportunities in GEN, DES tools	Support in academic environment and industry consultancy; Development of a new tool for Project Management activities during construction works
Development of advanced project management algorithms for construction simulation	Creation of a digital twin-centered curriculum for engineering students

6.2 CERTH

Table 2 Individual Knowledge Exploitation (CERTH)

Knowledge Generated	Potential future Use
Multimedia analysis and computer vision for Digital Twins	Increase visibility in scientific community; Enhance data fusion procedures for the digital-physical connection
Advanced algorithms for image-based 3D modeling and object recognition	Developing public domain datasets for construction-related AI research

6.3 MFL

Table 3 Individual Knowledge Exploitation (MFL)

Knowledge Generated	Potential future Use
Integration of all-relevant information sources in one digital twin; Real-time as-built vs as-designed comparison	Real-time and fully digital-based maintenance and inspection of construction
Innovative IoT deployment strategies for real-time data collection in construction	Collaboration with urban planners to use digital twins for smart city initiatives

6.4 EUR

Table 4 Individual Knowledge Exploitation (EUR)

Knowledge Generated	Potential future Use
Compliance with privacy and data protection regulations in the digital twinning process	Development of privacy by design solutions; Privacy-oriented courses for students; Solutions addressing workers' concerns over workplace surveillance technologies
New methodologies for privacy impact assessment in digital twin data processing	Establishing a privacy audit service for construction projects using digital twins

6.5 INFCON

Table 5 Individual Knowledge Exploitation (INFCON)

Knowledge Generated	Potential future Use
Digitalization of infrastructure; Development of BIM models and digital twins; Automated inspection and predictive maintenance	GIS-based decision support tools for maintenance planning; Lifecycle management for civil engineering structures
Implementation of UAV technology for comprehensive asset mapping	Development of training modules for UAV operators in infrastructure inspection

6.6 NCC

Table 6 Individual Knowledge Exploitation (NCC)

Knowledge Generated	Potential future Use
Use of digital twin and other tools for efficient production	Internal process improvement; Data provision for tool development
Insights into the integration of digital twin data with construction site logistics	Offering consultancy on digital strategy for construction firms aiming for digital transformation

6.7 UPC

Table 7 Individual Knowledge Exploitation (UPC)

Knowledge Generated	Potential future Use
Structural health monitoring; Real-time monitoring of bridges	Enhancement of academic curricula with case studies on digital twin implementations
Application of AI for predictive analytics in structural health monitoring	Expanding services to include real-time monitoring solutions for large-scale infrastructure

6.8 DTT

Table 8 Individual Knowledge Exploitation (DTT)

Knowledge Generated	Potential future Use
Digital twin platform for the tunnel construction industry	Development of new software suite; Consultancy services
Customized digital twin solutions for complex underground construction environments	Licensing of digital twin technology to other construction sectors beyond tunneling

6.9 PLANB

Table 9 Individual Knowledge Exploitation (PlanB)

Knowledge Generated	Potential future Use
Expertise in digital twin set up for project planning and execution	Concepts for digital twin-based construction focusing on safety, lean planning, and resource efficiency
Lean construction methodologies integrated with digital twin insights	Providing certified digital twin integration services to project management firms

6.10 FAS

Table 10 Individual Knowledge Exploitation (FAS)

Knowledge Generated	Potential future Use
Renovation support with digital twin tools	Innovative service offerings in building renovation and construction
Innovative approaches to historical building renovation using digital twins	Partnering with heritage conservation agencies for digital preservation projects

6.11 ASI

Table 11 Individual Knowledge Exploitation (ASI)

Knowledge Generated	Potential future Use
Standardization in the field of BIM and digital twin standards	Formulation of Digital Twin Standards
Development of international collaboration frameworks for BIM standardization	Leadership in global forums for the advocacy and adoption of BIM standards

6.12 INGEO

Table 12 Individual Knowledge Exploitation (INGEO)

Knowledge Generated	Potential future Use
Structural health monitoring of geotechnical structures	Digital twin based on SHM system for quay wall monitoring
Advanced geotechnical analysis tools integrated with digital twin technology	Offering consultancy for the implementation of geotechnical digital twins in emerging markets

6.13 SBP

Table 13 Individual Knowledge Exploitation (SBP)

Knowledge Generated	Potential future Use
Digital twins for stadia roofs and bridges; Asset management and structural health-monitoring	Evidence-based design tool; Systematic data collection for knowledge database
Optimization techniques for the maintenance schedules using digital twin data	Creating an educational platform for sharing best practices in asset management using digital twins

6.14 AUS

Table 14 Individual Knowledge Exploitation (AUS)

Knowledge Generated	Potential future Use
Formulation of an NGO for digital twin advocacy	Online community for Digital Twin in Construction
Establishment of global partnerships for digital twin interoperability standards	Coordinating international digital twin hackathons to drive innovation

7 POTENTIAL BUSINESS MODELS

7.1 EXPLOITATION

The partners of the project may exploit the results of the project in two ways. Either by offering them individually to clients or customers, or jointly as a platform encompassing all the tools. Section 6.1 outlines both the ways of exploitation related to the pure functionality of the tools, describes the exploitation of them and the applicable business models.

7.1.1 INDIVIDUAL EXPLOITATION

In both cases of individual exploitation presented as follows, partners own the specific IP rights to the respective tools (exploitable assets) they developed. They choose whether to exploit their respective tool for commercial or research purposes or not at all.

7.1.1.1 Commercial Exploitation

In the case of individual commercial exploitation, all tools originating from the Ashvin project remain with their respective developing party and may as such be individually commercialised by each party in separate businesses and without a joint platform. Each party is individually and fully responsible for all business tasks along the value chain of its tool(s) and no joint appearance in the process of approaching of potential clients is conducted by the different developers. All general and further particularities regarding the commercial exploitation of each tool lie with the respective party and are thus not outlined here at this point.

7.1.1.2 Research Exploitation

In the case of individual research exploitation, the tools originating from the joint Ashvin project remain with their respective developing party and may as such be individually utilized for further research purposes. Whether this research is conducted by the initial researcher/developer or another party authorized at the discretion of the latter remains open and potentially different for each tool. In research, the tools facilitate breaking ground in the state-of-the-art of emotional analysis, behavioural analysis, 3D modelling software and textual generation. All particularities regarding the research exploitation of each tool lie with the respective developing party and are thus not outlined at this point.

7.1.2 PLATFORM EXPLOITATION

The platform can be exploited by forming different business models of the companies that can use the platform to generate customers and revenues. The 2 ways to do that is, firstly selling the Ashvin software completely to clients (Product based business model) while holding distribution rights to it (for e.g. Microsoft Windows); Secondly by selling the software as a service (Service based business model) where we provide the model where the software can be accessed by the client using web application or similar tool and they pay for using the software (for e.g. Amazon Web Services)

7.1.2.1 Product based business model

In a traditional business model, Ashvin consortium or a company jointly created sets up a sales department as well as uses the current clients of the consortium members as customers for Ashvin. In this scenario, multiple versions for the software will have to be provided to the customer at similar price points but different focus based on the cohort of customers.

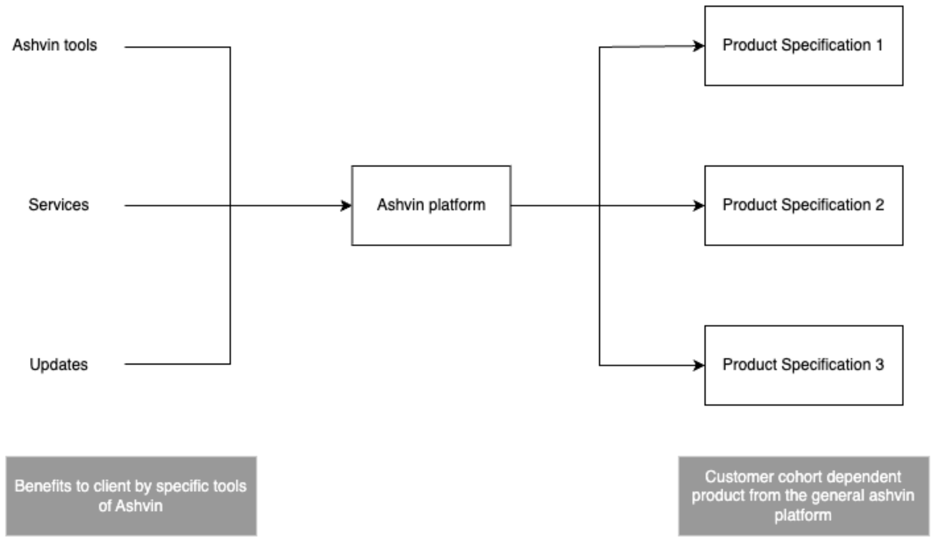

Figure 2 Schematic Outline of the product offering

7.1.2.1.1 Servicing of Clients

When offering such a product with limited specification available for specific customer cohorts, the Ashvin entity should be able to work on resolving as many general bugs in the system but at the same time provide possibility for each client to be able to voice their bugs which can be solved at each update. This would help in reducing the time needed for servicing clients but at the same time increase the bugs being reported and solved. Developing forums or using currently available forum platform to act as a CRM system would help in better management of the customer's requests.

7.1.2.1.2 Pricing and monetization

The pricing and monetization strategy in this case would include through pricing methodology which is based on the price of the competitors as well as keeping in mind the profitability of the entity created. The pricing for all the specifications offered could be similar but can also be different based on the financial capacity of the cohort being targeted by the product specification type.

The monetization would work on selling the product but can also include the selling add-ons on top of the product as extra purchases as well as the level of customer support can be monetized in this scenario.

7.1.2.2 Service based business model

In a service-based business model, the platform functionalities are provided as a service to the client, this can be different services for different client and functionalities that can be offered to the client. The services can be customisable based on client needs and the purchasing power of the client. In this scenario, a subscription-based model can be deployed to further enhance the experience of the client.

7.2 LEGAL FRAMEWORKS OPPORTUNITIES

There are multiple legal and organisation options available to the developing parties of the Ashvin, to be able to develop, construct the platform or software to be offered, market it and agree upon return attributions to different parties. A clear coordination is advised due to the number of tools the developers and partner in the Ashvin development. This also increases the complexity of the legal agreements and the organization structures.

7.2.1 NEW LEGAL ENTITY AND COMPANY

The first and easiest option available to the project parties would be to set up a new, separate legal entity and standalone company. The companies and parties involved in the development of the tools would, upon creation, take an equity stake in the entity. Thus, it will be represented as a direct subsidiary of the companies/organisations involved. In exchange, all parties, as beneficiaries, are required to shift their IP rights for their tools to the new entity or license them to the latter, convert or raise other resources such as financial capital, business infrastructure, and HR to and for the entity, and arrange a management structure for it. Depending on each party's contribution in all these regards, differently sized equity stakes in the new entity may result, which warrant different claims on future returns of the business.

This structure is straightforward and allows for clear attribution of the returns the invested parties. It also ensures a high base level of engagement by the parties and their agents due to the significant initial legal, financial, and business-related commitments. This would help in mitigation any issue that could manifest and affect the success of Ashvin platform after its launch.

7.2.2 JOINT VENTURES

The second option includes creation of a joint venture. This is a contractual agreement between the tool-developing parties to commit certain resources to the joint cause of further development and marketing of the Ashvin tools in any of the forms described in section 5.1 and 5.2. Although a new legal entity might be created in this case as well, the committed financial, human and intellectual resources by the parties are possibly not organized and shifted to a different company with separate organizational structures but remain with the respective companies and parties who simply reallocate them within their existing cost centres, teams and departments. The business risk and associated liabilities are shared between the parties in the contractual arrangement.

A Joint Venture of the parties offers the possibility to transition to a full-scale company at a later stage and receiving external growth investments while possibly, and dependent on the extent of each parties commitments, being less tedious to liquidate and dissolve in case the Ashvin platform or software is not as successful as anticipated due to the comparatively lower level of legal commitment.

At the same time, a high negotiation effort is necessary to set up the contractual framework that incorporates and weighs all the different parties' commitments of resources and adequate claims to future returns of the JV.

7.2.3 SUPPLY CHAIN

In the third option, no initial contract or legal agreement between the Ashvin project partners is agreed upon to continue developing the Ashvin tools beyond the scope of the project. Nonetheless, interested partners that are motivated to create a Ashvin platform or software communicate further steps in its development and utilize their respective IP. Contracts are only made at a later stage of the development or product rollout process and rather between individual parties than the whole conglomerate.

Of all three options, this structure is dissolved the easiest and individual contracts agreed upon do not concern other conglomerate members not involved in those. Partners commit legally the least offering, provides them a large scope of action, room to manoeuvre their interests and a low initial business risk. They are not as heavily invested, in any respect, in the further development and marketing of a Ashvin platform or software as in the other legal frameworks.

Nonetheless, this work, which is at least at first largely conducted in good faith, might result in smaller engagement and unsatisfactory performance by some parties as no legal obligation exists outside the scope of their individual contracts with other parties. To ensure the Ashvin platform or software's success, which can reasonably be stated as a common goal of the parties, performance measurement and accountability processes would have to work even better than in the other cases.

7.3 WORKSHOPS ON BUSINESS MODEL DEFINITION OF ASHVIN COMPONENTS

The ASHVIN consortium members held an internal workshop on March 27, 2024, focusing on discussions and business model planning for their digital twin tools. The workshop took place at the Technische Universität Berlin, involving the Centre for Entrepreneurship. They validated new business models for four digital twin tools developed during the project, namely Discrete Event Simulation (DES), 4D Visualization during Construction Phase (4DV-C), Configuration Management Tool (CMT), and a Multi-physics model matching tool for bridges and buildings (Match-Fem). They used the Lean Canvas in a World Cafe format to foster collaboration and idea generation. The update ends with gratitude expressed for the engagement of the participants.

7.3.1 4DV-C + DES

The DES + 4DV-C business model focuses on partnerships with construction companies, software developers, and architects to develop and refine tools for construction visualization and event simulation. Key activities include research and development, construction workflows, and customer training. The value proposition lies in cutting overhead costs and improving project control. Target customers are construction-related firms and public entities, engaged through trust-building and continuous feedback. Sales channels are direct deals, conferences, and online marketing. Essential resources are civil engineers and developers, with a cost structure focused on personnel and marketing. Revenue is generated via licensing fees, consulting, and subscription services.

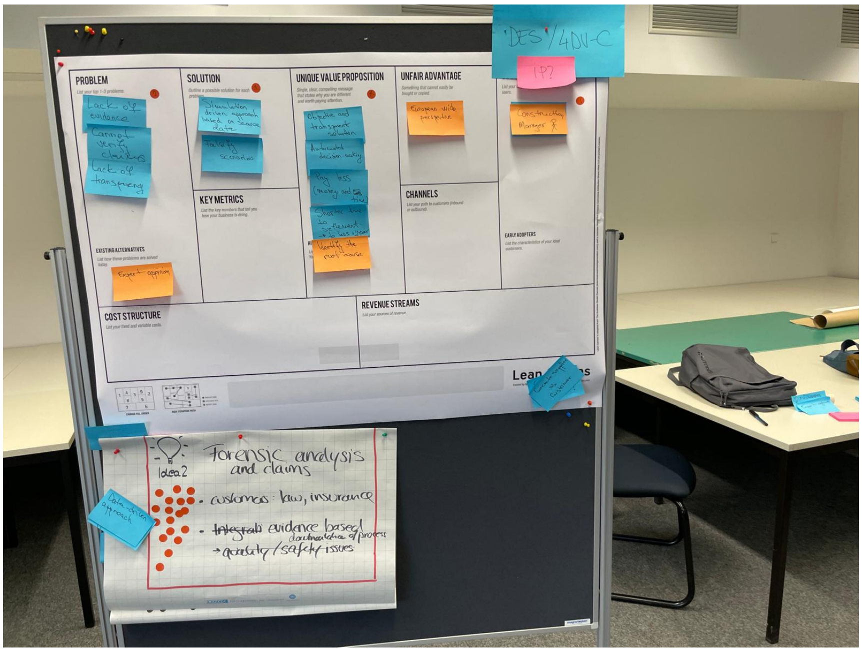

Figure 3 Lean canvas – DES + 4DV-C

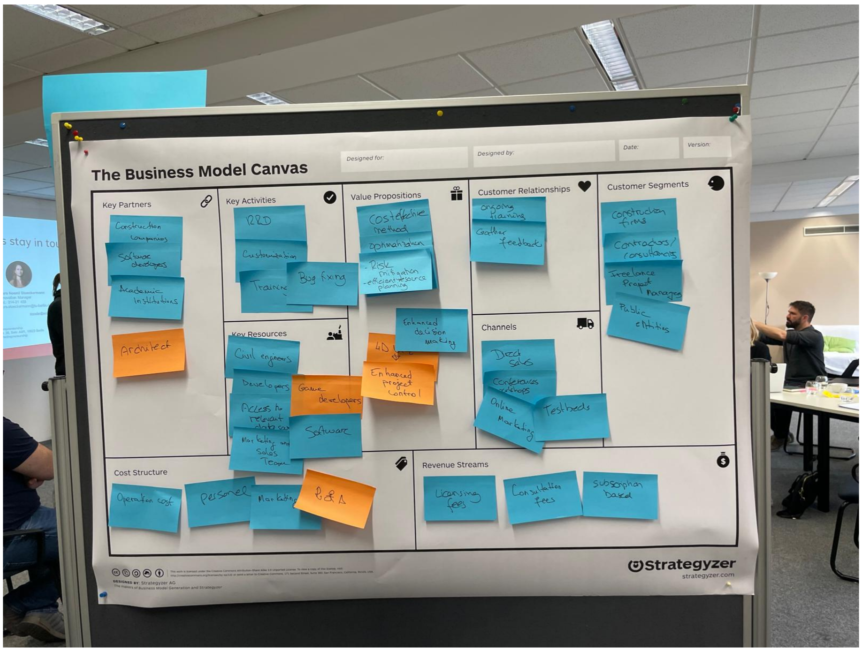

Figure 4 Business model canvas – DES + 4DV-C

7.3.2 MATCHFEM

MatchFEM's business model is framed around key partnerships with technology providers, construction companies, and academic institutions, with a focus on infrastructure and construction industry segments. Key activities include marketing, data analytics, and software coding for web-based tools. Value propositions include embedded analytics and assessment tools. The business model relies on cloud-based online services as the main channel, with key resources like structural engineers and centralized hosting. The cost structure emphasizes cloud services and personnel, with funding being a primary revenue stream, though specifics are not fully detailed in the image provided.

Figure 5 Lean Canvas - MatchFEM

Figure 6 Business Model Canvas – MatchFEM

7.3.3 CMT

The CMT business model involves partnering with construction companies, standardization bodies, and real estate developers. It engages in development, infrastructure work, collaboration, and sales as key activities. The model’s value proposition includes compliance with standards, training support, and change management for efficiency. Customer relationships are nurtured through support, consultancy, and training, targeting construction companies, public navigators, and QA teams. Channels for reaching these segments include direct sales and industry conferences. The model uses software developers and software as key resources. Costs are primarily from R&D, personnel, and operations, with revenue generated from licensing, consulting, and training fees.

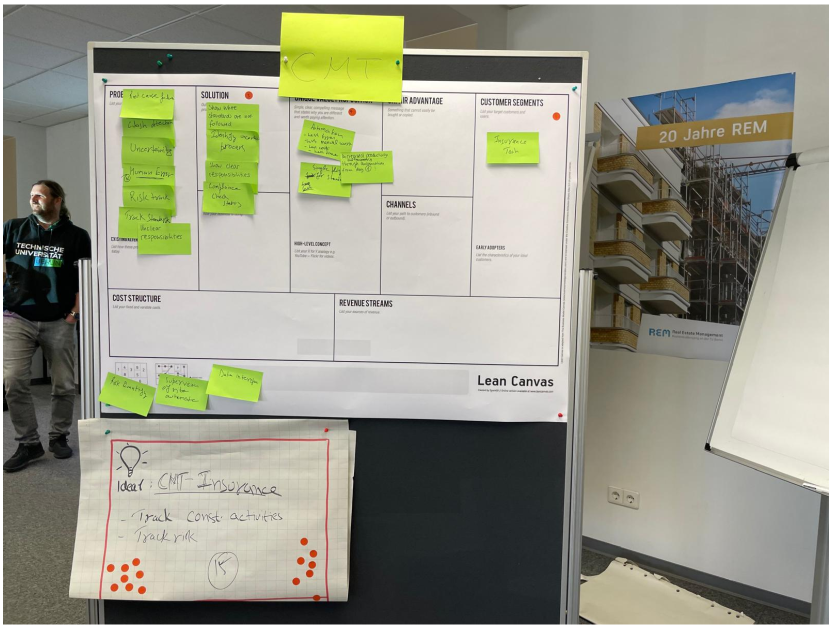

Figure 7 Lean Canvas – CMT

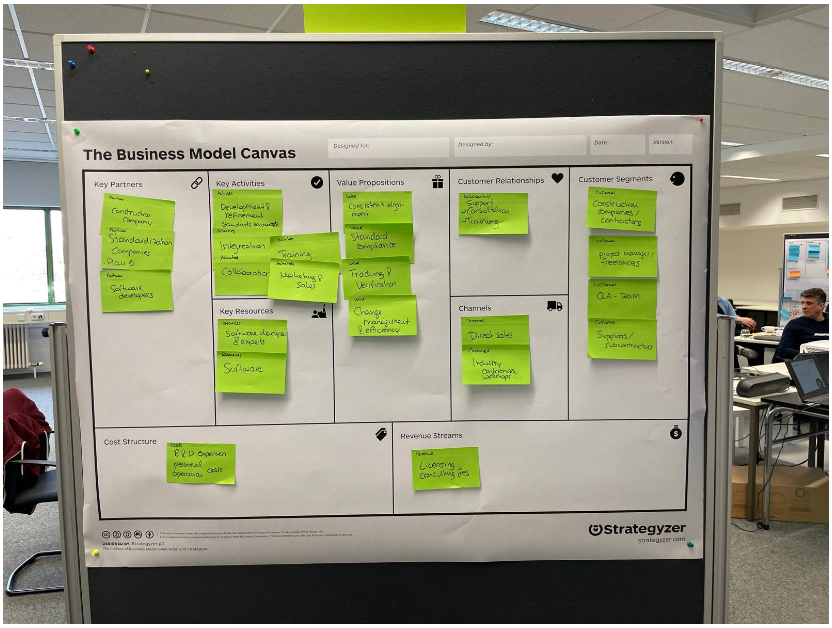

Figure 8 Business Model Canvas - CMT

8 IPR MANAGEMENT

To avoid the any potential issues that can arise from future commercialization activities, which can cause negative effects for the collaboration of the partners in the exploitation of the project results, all the members of the consortium has developed the necessary mechanism to protect the Intellectual Property in the context of Ashvin.

8.1 ASHVIN COMPONENTS

The following components have been developed during the lifecycle of the project

- **BRICS**: BRICS tool facilitates decision-making in design by calculating Performance Indicator (PI) values using mathematical algorithms, scoring, and ranking design solutions for optimal performance. These outputs enhance the knowledge-base for the GEN Tool's design process.
- **GEN**: The Generative design modeller, GEN, automates the creation of design alternatives focusing on productivity, resource efficiency, and safety. It uses KPIs developed by TU Berlin to evaluate each design solution.
- **DES**: DES is a simulation-based tool for real-time construction site and logistics planning. It uses stochastic simulations of construction activities, leveraging productivity data from the ASHVIN digital twin platform.
- **4DV-D**: 4DV-D provides early design phase simulation with a 4D visualizer to evaluate construction design options, helping compare impacts on productivity, resource efficiency, and safety.
- **4DV-C**: The 4DV-C tool is for construction monitoring, equipped with a productivity and safety KPI decision-making dashboard. It helps plan future construction sequences by visualizing past tracked activities.
- **SMT**: SMT ensures privacy in safety management, offering simulations and training tools to analyze safety hazards on site without identifying individual workers.
- **CMT**: CMT manages consistency among requirements, design, and configured items throughout the project lifecycle, integrating with the digital twin data for effective asset management.
- **RISA**: RISA is a risk-based status assessment tool with a KPI dashboard that aids in designing optimized maintenance plans by providing detailed asset status visualizations.
- **MatchFEM**: MatchFEM is a multi-physics model matching tool for assessing the status of bridges and buildings, adjusting simulation parameters stochastically based on sensor data for accurate representation.
- **GISI**: GISI integrates GIS with digital twin data for asset management, allowing tracking of asset status and management based on various KPIs.
- **EBD**: The EBD tool uses historic project data to provide design predictions, warnings, and recommendations at the early stages of AEC projects, enriching future design models and enhancing design quality.

8.2 LICENSING

To have a clear infrastructure for the redistribution and use of Ashvin tools and components, software licenses have been carefully considered. Software license is a legal instrument that is designed to give the developers the possibility of granting permissions to the third parties to use their software in case some exclusivity or copyrights of the owner are implied. Software licenses include a number of provisions that set liabilities and responsibilities that partners entering into a licensing agreement shall abide to. These can include limitations of liability, warranties and indemnity in case if piece of software infringes the IPR of others.

Licensing considerations and future decisions made for the whole platform or separate tools have major implications for the business models considered for Ashvin project.

Each user of the Ashvin tool would require a certain permission from the initial developer to use it. Choosing the suitable license will allow the owner of the component to grant the rights to use, reproduce and redistribute as we create derivative works at the same time retaining the IP rights.

8.2.1 TYPES OF SOFTWARE LICENSES

The partners would have to work on a consortium and individual level to define how their components will be used by third party developers to copy, modify or distribute their software. Thus, all the licenses can be grouped as:

- Proprietary licences
- Free and open source.

There are a number of considerations that have to be made by the party when choosing an appropriate license. This can include decisions on the goals such as whether a partner is concerned about a patent protection, whether future software can be used commercially, allows the redistribution and modification, allowed for private use, require the disclosure of the source code or license and copyright notice, state changes and liabilities, etc

8.2.2 FREE AND OPEN SOURCE

Free and open source licenses are generally being defined in GNU Bulletin, vol 1 no.1 covering four freedoms for free software as further defined by the Free Software Foundation:

1. The freedom to modify the program and release it to the public.
2. The freedom to run the program for any purpose
3. The freedom to redistribute copies
4. The freedom to study how the program works and to modify it

These four points in practice give the end users the rights needed to redistribute, modify and sell copies of the free software without any obligations and need any permission from the original developer. Nevertheless, it allows distributing the software for a given fee. There are also a number of license agreements that allow not reporting back or publishing the changes made to the original software.

8.2.3 COPYLEFT OPEN SOURCE LICENSES

Copyleft open source license is the one where whoever redistributes modified software must do so using the same license conditions that were adopted by the original software product. This implies that under a copyleft license, next iterations of the software will remain open source. This is also the case if a modified software is to be combined with other softwares. This, copyleft licenses also hold the title of 'viral licenses.

Some of the most widespread and mostly used copyleft' licenses are the GNU General Public License (GNU GPL) and the GNU Lesser General Public License (GNU LGPL). The GNU GPL abides with all the freedoms of the Free Software Foundation's that were described earlier, whereas the GNU LGPL is can be seen as a less restrictive license since it allows a combination with some proprietary non-free software or modules.

8.2.4 MULTI LICENSING

Multi licensing is the method in which the release and distribution of the tools created during Ashvin project under several different licenses that respect various terms and conditions. With a Software that follows the multi licensing approach, the end user is able to choose the conditions and suitable terms for a desired use of the software. The distributor is also able to choose freely whether to distribute the software for free or for a fee with any of the licenses. This approach is best case of license compatibility issues arise and for the sake of market segregation.

Multi-licensing is mostly used to benefit from open source software business models that are later applied in a commercial environment. Therefore a partner of the project can consider to apply a propriety software license therefore allowing future creation of proprietary tools and software derived from original work, at the same time applying a copyleft free software/open-source license which has started earlier would require the application of the same license for any derived work. The multi licensing works by when the owner of the product provides an open source version free of charge while at the same time also offering proprietary licenses to commercial businesses which yields into profits. This model is quite similar to shareware.

A change of licensing terms is a possibility by the copyright holder; therefore, an approach of multi-licensing is best applied in cases when the software is also fully owned by the licensing entity. A multi-licensing scheme as proposed before (a combination of open source and proprietary licenses) in reality follow a single path: the community contributes to the product or a project whereas the product owner is not obliged to give back. Such multi-licensing approached fail to attract new developers in comparison to open source project.

8.2.5 DUAL LICENSING

There is a possibility to combine open source software license together with proprietary licenses but doing so can have effect on proprietary software. In case of modification of the open source software that was originally supplied with a copyleft license with proprietary software is going to mean that the code of the software will be contaminated with copyleft license making it open source. The consortium partners will have to pay attention to a degree of combination of two licenses keeping following aspect in mind:

- Any modification or combination of original open source opensource copyleft source code with a proprietary source code with result in open source mechanism for a combined derivative.
- One of the major implications of an OSS copyleft license is that distribution of a compiled software shall be followed by a distribution of the source code. This means that the strategy shall be thought through carefully if the goal is to keep the software proprietary, since disclosing a source code will have major implication on the chosen business model

- Open source executables are possible to combine using a common interface with proprietary executables applying a 'semi-permissive' OS license. This can be an LGPL or a permissive license like X/MIT. This also applies to any proprietary software accessing OSS software libraries.

The partners will have to keep in mind that this can affect the following:

- The backgrounds brought into the project
- The final licensing decision on the components that we will apply after the project end
- The consecutive distribution mechanism of the system.

8.3 LICENSING OF ASHVIN

This section looks at the requirements for Licensing Ashvin as a whole and concludes with a licensing recommendation.

8.3.1 INITIAL REQUIREMENTS

Working on various licensing requirements, it is expected to compare these against the requirements that the project imposes. For successful future exploitation, the following is being considered:

1. One source license-type should also be open in terms of interfacing (e.g. public APIs)
2. In terms of exploitation there should a possibility to combine the results and components of Ashvin with third party software and libraries. Ideally it should not contaminate third party software with Ashvin owned OS license.
3. During the project execution and platform development it should be rational for partners to contribute with existing backgrounds without it being 'contaminated' by the Ashvin open source license. The same applies to the source code, which should not be publicly obtainable when published with Ashvin.

Lastly, it is quite important that we are able to change the license type in the later stages and when the commercialization version of the platform is ready required by the proposed business models.

8.3.2 ASHVIN LICENSING OPTIONS

Considering the above-mentioned points regarding the requirements, there are several licensing options. Permissive OS license seems like the best option of the consortium to proceed with since strict (copyleft) open source licenses do not comply completely with the OSS licensing goals according to the consortium's requirements. In this chapter we analyse licenses that envision the exclusion of code with linkage to code licensed under another mechanism as well as change of license and a commercial use is allowed at any stage of the development process.

- MIT License: This license allows us to reuse software within a proprietary software proven the fact that any derivatives and copies of the licensed software mentions the MIT license terms and the clause regarding copyright as well as provides due credit to the owner/s. The user only has the right to distribute newly derived software without disclosing the code, but also has the possibility to redistribute the code. In both cases, the copyright notice should be linked to the code file.
- BSD 3-Clause license: BSD license is similar to MIT license but it incorporates a prohibiting notice that would not allow the use of the name of the copyright owner in promotion, and the copyright owner can ask the licenser to request for a monetary compensation for the reuse/access the software.

- BSD 2-Clause license: Similar as BSD 3-Clause license but the terms and conditions for the reuse of the copyright holder in promotion are removed.
- Apache license 2.0: Apache2.0, being the most popularly used, is similar to MIT License with a difference of expressing the grant of patent rights to the end-user with a requirement to include a notice to each derived. It also sets the condition that the party that has created a derivative could license it to a difference license (other than the original). Apache license also removes the liability of the party for the licensed software. Applying this license does not allow to charge any royalties for the initial backgrounds.
- GNU LGPL: The GNU Lesser General Public License allows the developers a possibility to use the given software along with their own without any requirements to further release the code. Under LGPL, the software components can be modified by the end-users provided that the source code is available. In case of MIT and Apache, such provision is only optional.

8.3.3 ASHVIN LICENSING CONSIDERATIONS

The licenses mentioned in the previous section seem to fit the purposes of Ashvin components. From the selected licenses, GNU LGPL requires that the source code of the LGPL code demanding the use of shared libraries instead of "full code integration" in case the entity has decided not to share the background code. Therefore, this may not be the best option for exploitation of the platform.

Not including the name of the copyright holders during the process of promotions may not produce any results therefore the BSD 3-Clause does not seem to fulfil the requirements for exploitation.

As being the most known and used license, the MIT License and Apache 2.0 constitute a good choice for an open source license. However, these have their advantages and disadvantages too. MIT License simply puts few restrictions on reuse but at the same time leave a lot of terms and conditions vague. The Apache License 2.0 is quite accurate and explicit in its definition but also more complex in its application leading to administrative overhead. Finally, the BSD 2 Clause license gives the licensor a possibility to ask for a monetary compensation for reuse. Therefore, the three licenses allow the licensor to request a fee for the software and the components developed during the project. Also, depending on the chosen business model from each partner and the consortium as a whole, it will be a possibility that a closed source is created after a few modifications. However, this is applicable if the following requirements for the backgrounds are met:

- Partner's background does not include any viral licenses that can contaminate the foreground,
- Commercial exploitation shall not be prohibited by the license
- Background components should not have any third-party software that would prohibit commercial use

To conclude this section and the IPR strategy discussed, we completed the activities with a proposition for the complete Ashvin platform. Given the requirements and the above-mentioned analysis, the best method to go forward it with an Apache v2.0. However, the final decision on the license will be made in the coming year once the entire platform is developed. For the time being, Apache license seems a good fit since it protects Ashvin platform from third parties that would be willing to claim a patent.

9 CONCLUSIONS

9.1 CONCLUSIONS

This deliverable document the updates on the market analysis and industrial analysis for the exploitation of the project and of the individual components. The deliverable outlines the Intellectual property rights management plan for the platform as well as of the individual components.

The deliverable presents the Political, Economic, Social, Technical, Legal and Environmental impact, which will positively contribute to the successful exploitation of Ashvin and SWOT analysis, identify strengths and opportunities, weaknesses and threats, with updates from D8.3.

Furthermore, in this deliverable we identify the competitors, both indirect and direct, that could hinder the exploitation of the Ashvin.

We also point out the business models that the consortium can potentially use for the exploitation of the project. The section also mentions different business models that the consortium can adapt to, both a product-based business model and a service-based business model. The section also details on the legal framework that the project partners can work on for exploitation purposes.

The final section describes the different types of software licenses and the best license for each of the individual components as seen fit by the component leader and the consortium. Finally, the section describes the licensing consideration and the decision to currently use Apache v2.0 license for the platform. The workshops help us understand more the value proposition of Ashvin components and how we can target potential users. This would also allow us to create a marketing/sales plan as well as the go-to market plan for the project components.

Finally, This deliverable creates a framework for the exploitation of the project results by the partners after the end of the project.