Digitization of the Construction Industry. Engineering Organizations in Support of European Initiatives, BIM Standardization and Accelerating BIM Adoption.

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Construction 4.0
BIM - at the heart of the digital transformation of construction sector

European policies and initiatives in support of digitalization of the construction sector
BIM standardization

Engineering organisations in support of Construction sector digitization
Policies about Digitizing European Industry
Coordination of European, national & regional initiatives-Digitizing European Industry strategy (DEI)

**COM(2016) 180 Digitizing European Industry-Reaping the full benefits of a Digital Single Market (DEI) April, 2016**

The Initiative is a key element of the Digital Single Market strategy.

The purpose - to reinforce the EU's competitiveness in digital technologies and to ensure that every business in Europe - whichever the sector, wherever the location, whatever the size - can draw the full benefits from digital innovations.

The initiative introduces a set of measures that build on and complement the various national initiatives on digitizing industry as well as measures to increase investment through strategic partnerships and networks.

The Initiative establishes a coordination framework for national and EU level initiatives and relevant policy actions, including investment in digital innovation capacity. This coordination is at the core of the Digitizing European Industry strategy.

Digitalisation of products and services can add more than €110 billion of annual revenue for industry in Europe until 2020.
Digitizing European Industry Initiative (DEI) - five main pillars:

- **The European Platform of national initiatives** is the core part of the overall coordination framework of DEI.

- **Digital innovations for all: Digital Innovation Hubs (DIHs)** - research and technology center or an innovation-oriented university department, where SMEs and mid-caps **test the latest digital technologies** and get **training, financing advice**, market intelligence and **networking** to improve their business.  
  European network of Digital Innovation Hubs - European catalogue of DIHs - 379 DIHs in EU 28; 210 - focus on Artificial Intelligence and cognitive systems; Mobilising € 500 million of EU funding on Digital Innovation Hubs (2016-2020).

- **Strengthening leadership through partnerships and industrial platforms** - Supporting **Public-Private Partnerships** (Digital PPPs).  
  Mobilising **€3 billion EU investment** (2018–2020) for PPPs that support:  
  - 5G, the IoT, High Performance Computing, robotics and data technologies;  
  - **digital industrial platforms** for “smart” factories, hospitals, farming, buildings, autonomous driving etc.  

- **Preparing Europeans for the digital age** - Upskilling the workforce and piloting EU-wide initiatives to show how **education systems** could respond to the digital needs of Europeans. 15% of the EU investment in DIHs is dedicated to **skills development and training**.
Erasmus Program - doubling of the budget to €30 billion-education, training, mobility

COM(2018)434 - Digital Europe Program for the period 2021-2027- €9.2 billion
(Proposal for a Regulation, Council agrees its position, 4 December 2018)

First ever funding program dedicated solely to supporting digital transformation in the EU;

five strategic areas: - €9.2 billion
*high-performance computing and data;  *cybersecurity protection of the EU digital economy;
*artificial intelligence;  *better use of digital capacities and interoperability;
*advanced digital skills.

Digital innovation hubs: the proposal foresees a central role for digital innovation hubs in the implementation of the program

More operational synergies are expected through better linkage with other EU programmes, such as Horizon Europe, the Connecting Europe Facility and the European Regional Development and Cohesion Funds and the new European Defence Fund.

Horizon Europe: Framework programme for research and innovation 2021–2027

Ninth Framework Programme (FP9) - €100 billion (an increase of 29 %)

Horizon 2020 (FP8) - over 18 000 projects, with over €31 billion awarded, as of May 2018

Horizon 2020 WP 2018-2020 - €30 billion in research and innovation, 500M€ DIHs
“Construction 4.0” - "branch" of Industry 4.0 - digitalization of the construction industry.

**BIM** – centerpiece of Construction 4.0 but it is not the only element. What else is “Construction 4.0”?

*European policies and initiatives* in support of digitalization of the construction sector. *Engineering organisations in support of Construction sector digitization.*
The construction sector is very important to the EU economy:

- 9% of EU’s GDP and 42 million jobs (29% of total employment across EU) and 3.1 million enterprises, 95% SMEs).
- Energy efficiency in buildings - a key for the transformation of the EU’s energy system.
- Important impact on energy, climate change and the environment - It uses about 50% of the raw materials taken from the earth and generates about 40% of all greenhouse gas emissions in Europe.
- Impact on users’ convenience and welfare (accessibility, safety & security, indoor air quality, etc.).
- Even more important - various global megatrends: the population of the world’s urban areas is increasing, migration into urban areas, climate change and a new global push for infrastructure.

Construction industry is a strong indicator of the economic stability. Construction is at the very heart of smart and sustainable growth and jobs and is responsible for achieving the SDGs.
Over the past 20 years, however, the construction industry has fallen behind. Global productivity growth trend shows that productivity, predictability, labor and skills shortage are well-documented facts.

Similar to other sectors, construction is already experiencing its own "digital Revolution".

But, like other traditional sectors, the construction sector is lagging behind significantly in terms of its digitization.

**Reasons:**

- traditional technological processes - the sector’s difficulty in adopting and adapting to the new technologies (risks and costs);
- fragmentation of the sector, lack of collaboration along the asset creation chain, the challenges related to standardization.

Within 10 years, full-scale digitization could help the industry save an estimated 12-20%, equal to between $1 trillion and $1.7 trillion annually./The Boston Consulting Group/.

**Through circular economy and climate change commitments, the construction sector must embrace digital in order to do more with less.** The adoption of open standards in the BIM ecosystem has the potential to reduce barriers for SMEs operating in the construction sector.

What is digitalisation?

BIM - centerpiece of Digital transformation of Construction sector

Improve planning, construction and renovation processes
Robots, 3D printers, 3D scanners, satellite imaging, drones, AI

Sustainable energy and environment
Smart materials, Circular economy

Big data

Improve operation and maintenance of buildings
Sensors, IoT

Digital construction

BIM
Applications of BIM along the engineering and construction value chain

There is a common misconception about the simplicity of BIM /just 3D models and “Hollywood style” visualisations/

Building Information Modelling is a process of creating and managing the data of a building in its whole life-cycle.

BIM is a digital tool disrupting the construction industry as a platform for central integrated design, modelling, asset planning running and cooperation.

BIM provides all stakeholders with a digital representation of a building’s characteristics in its whole life-cycle, from early conception to demolition and form a reliable basis for decision-making.

BIM facilitates collaboration among all stakeholders from early design to decommissioning phase – real time data sharing and coordination, team-working with structured, shareable information in digital form.

BIM is not just 3D modelling, it’s the conversation

Collaboration is central on any BIM project.

“Better Information Management”
## BIM maturity levels

It is not possible to move brutally from a traditional modelling approach towards an open BIM approach. BIM is a gradual progression towards greater collaboration, and greater sharing of increasingly standardised project information.

This progression is described by the four levels of BIM. The BIM maturity is presented as “wedge”

Levels 0 to 2 are clearly described.

### BIM Level 2
- Stakeholders use 3D CAD, exchange information **in common file formats** and share data electronically through a centralized information management system called a **Common Data Environment (CDE)**.

### BIM Level 3
- Is not fully described yet, but it is going to be about:
  - More integrated, centrally held project models that everyone on the team can access and modify.
  - Also known as BIM in the cloud, all parties collaborate through digitally shared space.
  - Full interoperability of software and open access to it.
  - It has a focus on the **lifetime management of a building**, not just its design.

**Indicators** measure **four aspects of evaluation**: content, digitalization, interoperability and collaboration for the project stages and for the asset management - the level reached could be different for each aspect.
5-D functionality can integrate design, cost, and schedule in a 3-D output.

Building information modeling (BIM) is a digital representation of the physical and functional characteristics of a project, forming a reliable basis for decisions during the project’s life cycle.

Elements of a 3-D model are linked to the execution schedule.

Elements of the 3-D model are used to develop budget and linked to cost heads.

BIM Dimensions

 McKinsey & Company
Positive effects of BIM:

**BIM-enabled projects - more productive, predictable and profitable** - less rework, fewer errors, enhanced collaboration, and design data that can ultimately be used to support operations, maintenance, and asset management.

- A US study discloses that **lack of access to information in Facility Management and Operation** of a 20,000 m² building generates an extra cost over 30 years of almost EUR 2 mill.
- A British BIM report - discloses that BIM **increases competitiveness and the ability to export service**; **24.6% improvement in productivity** on UK Government projects using BIM; **capital cost savings of 19.6%** due to use of BIM, saving £840m on £3.5bn of construction spend in the 2013/2014 financial year.
- Savings as a direct result of BIM on several large international projects, 199 days and £65k worth of time was saved on the development Abu Dhabi Airport; a reduction of 30% in construction time of Shanghai Tower (Hoar, 2017).

**In general**, the digitization of the construction sector is expected to significantly **reduce** the total construction **costs** and completion **time**

- **10% productivity improvement** of the European construction sector would generate savings of €130 billion
- BIM contributes to meeting the objectives of **sustainable construction** and improving the energy efficiency of buildings; Digitalisation acts as an accelerator and **enabler of many of the SDGs**.
BIM as a strategic factor in achieving economic, environmental and social benefits

Governments and public contractors across Europe and around the world take proactive steps to encourage the use of BIM in the public sector (following the recommendations of the 2014 Public Procurement Directive)

UK: the world leader in the implementation of BIM

The UK Government’s BIM mandate has been in place since April 2016. The mandate requires that all projects funded by central government be delivered with ‘fully collaborative 3D BIM’- BIM Level 2

Germany: 2020 is the great challenge: The Federal Ministry of Transport and Digital Infrastructure - a national step plan for the BIM implementation was presented in 2015 - BIM will be introduced by 2020 as the new standard for transport infrastructure projects. Similar plans are scheduled for other public works.

Spain: public infrastructures get BIM in 2018

Denmark, there will be a mandate for all projects in 2022

Similar rules already apply in the Netherlands, Finland and Norway.
What has the 2018 NBS /UK BIM Report shown?

• The majority of those surveyed believe BIM will help to **reduce both construction costs and completion times**
  Slightly **fewer** agree that it will help **reduce greenhouse gas emissions or reduce the trade gap**, but overall there are **clear and tangible benefits** to BIM adoption.

• BIM usage has increased by **12% compared to last year**
  Now nearly **three quarters** of those surveyed are ‘aware and using’ BIM, only 1% unaware. BIM has **gone from a niche platform to the norm**.

• The number of those who have adopted BIM, but who **use it only on a minority of projects** has dropped from a third to **around a quarter**
  “**Extrapolating** the growth that we’ve seen in BIM usage within organisation since 2015 suggests that we’ll **reach 90% within the next three to five years**”.

**UK Government strategy 2025 - objectives**

- **Lower costs**
  - 33%
  - Reduction in the initial cost of construction and the whole life cost of built assets.

- **Lower emissions**
  - 50%
  - Reduction in greenhouse gas emissions in the built environment.

- **Faster delivery**
  - 50%
  - Reduction in the overall time, from inception to completion, for new build and refurbished assets.

- **Improvement in exports**
  - 50%
  - Reduction in the trade gap between total Exports and total imports for construction products and materials.

- **Lack of in-house expertise** is the main barrier to BIM adoption
- **Lack of training**;
- **Lack of time to get up to speed**;
- **Lack of client demand**.
The UK Government BIM mandate requires projects to be at Level 2 BIM. The **Government is committed to Level 3 BIM**, and in the 2016 budget policy paper, is told that: ‘The government will develop the next digital standard for the construction sector – Building Information Modelling 3 – to save owners of built assets billions of pounds a year in unnecessary costs, and maintain the UK’s global leadership in digital construction.’

**What is the 'next BIM'?** - Digital Built Britain Strategy – Level 3 BIM 2016/2020
Firstly, getting true Level 2 BIM used in more projects.
Secondly, describing, agreeing on and implementing Level 3 BIM
The **technical challenges are likely to be overcome** in the near future - more difficult to change existing processes and to **increase collaboration**, including **data sharing**.

Of course, there are other things on the horizon too: AI, generative design, offsite manufacture, 3D printing and the Internet of Things. All these items (and others) have the potential to transform the design and construction industries.

At the same time, they will all **rely on the fundamentals of BIM** being in place: **collaborative working, 3D design** and **rich, standardized design information**.

**BIM Level 2** will increasingly be seen as a foundational step for the digitization of the industry.
BIM is the centerpiece of Construction 4.0, but it is not the only element

What else is “Construction 4.0”?

The digitalization of the construction industry has many aspects and includes many advanced processes and technologies.

In the report of the World Economic Form “A Breakthrough in Mindset and Technology” several new technologies are identified together with their possible impact on the industry.

While most other industries quickly embraced the new technologies and opportunities, the construction sector responded hesitantly.

BIM is both happening now and has a pivotal effect on construction

Future Impact and Likelihood of New Technologies
(Source: “Shaping the Future of Construction”)
An Action Plan to Accelerate BIM Adoption

World Economic Forum (WEF) Initiative on the ‘Future of Construction” have prioritized BIM adoption as a critical step toward transforming the construction industry.

- Set the right motivation for BIM adoption—understanding of BIM’s benefits
- Enhance collaboration on Projects
- Enable all stakeholders
  - Change behaviors and processes, not just technology

The European Engineering organizations must be proactive in:

- Achieving greater communication and BIM awareness raising;
- facilitating transfer of knowledge, expertise and capabilities at EU level.
Digital transformation of the Construction sector

European policy and Initiatives

• COM(2016) 0180 Digitizing European Industry. Reaping the full benefits of a Digital Single Market
• COM(2016)0178 European Cloud Initiative - Building a competitive data and knowledge economy in Europe
• COM(2016)0381 New Skills Agenda for Europe, 10 June 2016, Blueprint for Sectoral Cooperation on Skills Initiative for selected sectors
• COM/2017/0228 Mid-Term Review on the implementation of the Digital Single Market Strategy A Connected Digital Single Market for All
• COM(2017) 0572 Making Public Procurement work in and for Europe /BIM in Public Procurement /
• SWD(2017) 0157 Digital4Development: mainstreaming digital technologies and services into EU Development Policy; Framework for main-streaming digital technologies, contributing to the achievement of the SDGs
• CEN Workshop Agreement - CWA 17316: 2018 - Smart CE marking for construction products
• COM(2018) 232, Towards a common European data space, 25 April 2018
• COM(2018) 237, Artificial Intelligence for Europe, 25 April 2018
• COM(2018) 795, Coordinated Plan on Artificial Intelligence, 7 December 2018
Support public sector take-up

Support Research & Innovation

Support construction value chain and SMEs

Create momentum

Support horizontal activities

Commission initiatives & support
Commission initiatives in support of digital evolution of Construction

Support public sector
- EU BIM Task Group, 2016;
- Roadmap, December 2018–promoting the common digital platform for construction in public and private sector

Support construction value chain and SMEs
- Study: support digitalisation of construction and its SMEs: Ongoing; DIHs as a policy instrument
- Smart CE marking for construction products, CEN Workshop Agreement, 2018 CEN,CPE

Create momentum /Monitoring the progress of digitization of construction
- High Level Tripartite Strategic Forum on Construction 2020
- Thematic group1: Digitalization of the construction sector
- LinkedIn Group: Construction 4.0 Europe

Support horizontal activities
- BIM standardization: CEN/CENELEC TC 442
- *Digital industrial platform for Construction sector*
- BIM Dictionary

Support Research & Innovation
- Smart buildings, “big data”, IoT, AI, robots in construction
- technology-oriented PPPs, research “smart” materials, BIM in improving the energy efficiency of buildings, prefabricated building components…

Investment for digital education, developing digital competences and skills;
- New Skills Agenda for Europe, Blueprint for Construction Sector Skills, “Digital Europe” Program;
- Erasmus, Horizon 2020, Horizon Europe…
European digital platforms are operating systems that integrate different technologies and various applications and services in specific industrial sectors. The goal: Fostering digital innovation in specific sectors. The European digital platform for construction is intended to serve the purpose of facing the main challenges related to the uptake of digital tools in support of the digital evolution of the sector.
European digital industrial platform for the Construction sector

HORIZON 2020 / WP 2018-2020
Call: Digitizing and transforming European industry and services: digital innovation hubs and platforms
DT-ICT-13-2019: Digital Platforms/Pilots Horizontal Activities

Preparation of digital industrial platform for construction sector

- Define reference architecture for digital industrial platform for construction sector
- Take into account Level(s), the recently developed framework to assess environmental performance of buildings, including circular economy aspects
- Take stock of ongoing initiatives, promote mutual learning and coordination, and identify knowledge and intervention gaps
- Building Information Modelling and building passports are part of scope

1 M € • Deadline: 14th November 2018 • At least one CSA will be supported
New technologies and digitalization set the future skills demand

COM(2016) 381 New Skills Agenda for Europe, 10 June 2016
Blueprint for Sectoral Cooperation on Skills
Initiative for selected sectors /to address the challenge of skills shortages/

Blueprint for Sectoral Cooperation on Skills – Construction Sector
- **Supported area**: energy efficiency; digitalization; circular economy
- **European project “Construction Blueprint”**, EUR 4 million, 4-years long; Erasmus+ funding, *FUNDACION LABORAL DE LA CONSTRUCCION /ES/ ;* end of January 2019
  The aim: to define a **new strategy** for **professional competences/skills and qualifications** for the construction industry in Europe

15% of the EU investment in Digital Innovation Hubs is dedicated to skills development and training.

**European Construction Sector Observatory**, launched in 2015 • individual country profiles, fact sheets on individual national and/or regional policy measures and analytical reports - **Improving the construction sector human capital basis**
Now, digital technologies are gradually entering the construction industry, changing how infrastructure, real estate and other built assets are designed, constructed, operated and maintained. The economic and social impact could be substantial given that the construction industry accounts for 6% of global GDP.

In parallel to the new technologies, there are several global megatrends that urge/should motivate players in the construction industry to rethink long-established practices.

Among the most impactful are increasing population, fast urbanization, climate change, resource scarcity and a growing talent gap /especially pressing more than 200,000 people are moving into cities from rural areas every day – houses crisis/.
Future Scenarios and Implications for the Industry

March, 2018

Three futuristic scenarios for the industry / Image: World Economic Forum, Boston Consulting Group

- **Building in a virtual world.** Artificial intelligence (AI), software systems and autonomous construction equipment replace most manual work throughout the engineering and construction value chain.
- **Factories run the world.** Construction activities move largely to factories and the industry uses lean principles and advanced manufacturing processes to pre-fabricate modules that are later assembled on-site.
- **A green reboot.** The construction industry uses sustainable technologies and new materials to meet tough environmental regulations.

Existing capabilities, business models and strategies will be not sufficient for success. unclear which route construction will take, and very likely that the future will include elements of all three scenarios.
Six key actions will be relevant in any possible future:

✓ Attract new talent and build up required skills

✓ Integrate and collaborate across the construction industry’s value chain

✓ Adopt advanced technologies at scale

✓ Maximize the use of data and digital models throughout processes

Further key actions are: to review existing product portfolios and embrace new business opportunities; and to enable change-management and adaptiveness

The construction industry’s decision-makers should understand the disruption outlined in the future scenarios as a wake-up call. They should use the identified key actions to prepare and shape a prosperous future of Construction industry.
Opportunity in today’s construction technology ecosystem

What are the emerging trends?

- emerging constellations of solutions around established use cases,
- accelerating technology investment, /Investment in construction technology has doubled over the past decade/.
- an expanding set of promising use cases.

The most prominent constellations:

- 3-D printing, modularization, and robotics; could boost the sector’s productivity by five- to tenfold.
- digital twin technology - dynamic view of the project and real-time comparison of progress - minimize rework. *Drones and satellite imagery* - key components of many reality capture efforts. *Integration of 3-D models generated by drone imagery, monitored using Internet of Things sensors. Exact digital replica of a project’s physical reality.*

- artificial intelligence (AI) and analytics;
- supply chain optimization and marketplaces.
3D printing in construction

3D printing - the production of physical objects layer-by-layer by an automated, computer-controlled machine, based on digital 3D models.

Predicted growth of the 3D printing:
- fabricating complex shapes onsite or offsite,
- flexibly and cheaper than traditional methods,
- shortening construction time and making it more predictable,
- capacity to use recycled materials,
- reducing costs which is increasingly important
- Policies foster the implementation of 3D printing in the construction sector.

YHNOVA project - key lessons learnt
- 3D printing cannot yet do it alone,
- As for today, 3D printing may be best fit for specific purposes, such as specific building components
- the biggest issue - 3D printing material and the lack of standards

3D printing is at a stage between the demonstration and the early stage of niche market.

Table 1: Examples of application of 3D printed solution in the construction sector

<table>
<thead>
<tr>
<th>Area of application</th>
<th>Typology</th>
<th>Examples</th>
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<tbody>
<tr>
<td>Buildings</td>
<td>Compact single houses; social housing, office building</td>
<td>Yhnova project in Nantes, France to build social housing</td>
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<td>Five 3D printed house in Eindhoven, the Netherlands</td>
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<td>3D printed building in Copenhagen, Denmark</td>
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<td>Dubai Future Foundation office building</td>
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<td>Bridges</td>
<td>Pedestrian bridges, cyclist bridges</td>
<td>3D printed footbridge in Madrid, Spain</td>
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<td>3D printed footbridge in Amsterdam, the Netherlands</td>
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<td>3D printed cyclist bridge in Amsterdam, the Netherlands</td>
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<tr>
<td>Printed moulds</td>
<td>Unique design, shape and form (i.e. non-standard objects)</td>
<td>Double-curved wall panel for the London Crossrail Project</td>
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<td>Hilo Project in Dübendorf, Switzerland</td>
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<tr>
<td>Building components</td>
<td>Facades, joints, partition walls, power sockets</td>
<td>A roof canopy’s network of steel for the office building 6 Bevis Marks in the City of London (complex nylon sleeves 3D printed)</td>
</tr>
<tr>
<td>Architectural models</td>
<td>Small-scale models</td>
<td>Used for the work related to Sagrada Familia, Barcelona, Spain</td>
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<td>Interior design</td>
<td>Interior and furniture design</td>
<td>IKEA’s first 3D printed wall decoration</td>
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<td>Omedelbar Hand or knitted armchair</td>
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<td></td>
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<td>Steelcase’s 3D printed wall decoration</td>
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<td>Ventury’s Eiffel chairs</td>
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Source: European Construction Sector Observatory

financing support; knowledge, network and experience sharing; regulations and standards
Drones: picturing the future of construction

Drones - unmanned aerial vehicles/aircraft systems

The benefit of drone use is in the high quality data acquired by the drone sensors, which can be processed and analyzed to deliver important insights to all stages of the construction.

Cheap and efficient ways for:

- Preconstruction and site planning
- Mapping of construction sites in real time cartographical representations, thermal imaging, materials quantities
- Collecting three-dimensional information to be integrated within existing BIM systems

Communication and management activities - real time accurate data exchange, tracking of the construction process progress against the schedule, better manage resources

Building surveys - easy air access, gains in productivity, up to 400 times increased efficiency in site surveying, 40% lower costs, improved survey accuracy

Site inspections

Visualisation of construction progress or of ready buildings,
What differentiates AI from other digital technologies is that AI are set to learn from their environments in order to take autonomous decisions. 

AI-based systems can be purely software-based, (e.g. conversational assistants, image analysis software, search engines, speech and face recognition systems) or can be integrated in hardware devices (e.g. autonomous cars, drones, medical devices, advanced robots).

Artificial Intelligence (AI) is a branch of computer science referring to “the ability of a digital computer or computer-controlled robot to perform tasks associated with human intelligences”.

Machine Learning - a subset of AI that learns from large amounts of data to make predictions on probable outcomes.

AI is the step beyond ML, yet AI needs ML to reflect and optimize decisions. AI uses what ML has gained to simulated intelligence.

AI leads to intelligence or wisdom and the end goal is to simulate natural intelligence to solve complex problems across the world.
Artificial intelligence - area of **strategic importance** and a **key driver** of economic development. Socio-economic, legal and **ethical impacts** have to be carefully addressed.

An AI race for leadership - the US, China, Europe (mostly UK)

AI research and industrial applications - a strong and unprecedented political support, the transformational power of AI technologies for businesses and societies.

Amid concerns that Europe is lagging behind to the US and China, in April 2018:

**European approach to Artificial Intelligence and robotics**

- Being ahead of technological developments and encouraging uptake by the public and private sectors /increasing annual investments in AI by 70%/ 
- Preparing for socio-economic changes brought by AI;
- Ensuring an appropriate ethical and legal framework /Data policy and liability regulations/


**EU project AI DIH Network**, 30 Digital Innovation Hubs (DIHs) with focus on Artificial Intelligence have been selected to take part in a mentoring and coaching program.

**Innovate Europe**

**Competing for Global Innovation Leadership**

*World Economic Forum Report, January 2019*

**European Innovation Model**

Building blocks for European innovation:

1. Pan-European approach
2. Corporate-start-up collaboration
3. Innovation funding
4. Enabled government and public institutions
5. Data access and protection
6. Entrepreneurial talent
7. Digital education, reskilling and upskilling:
8. Gender diversity
9. Digital infrastructure and interoperability
10. Harmonized legislation and standards
Artificial intelligence provides tremendous **benefits** to **improving the productivity** in construction / including cost and schedule overruns and safety concerns/ proven high return on investment (ROI)

The **companies that are applying Artificial Intelligence to its projects are able to generate 50% more profit.**

**Current Application of AI in Construction**

Still, adoption of AI solutions is quite low in E&C in a fairly nascent levels for actions such as:

- **Project schedule optimizations and enhanced planning.**
- **Image recognition which helps analyze video data in order to improve safety on-site and training.**
- **Enhanced analysis of data using sensors to provide real-time solutions, reduce costs, and provide preventative maintenance.**

**How AI can be applied to Construction**

According to the report by McKinsey&Company

Five AI-powered applications from other industries - direct application in the construction sector:

1. **Transportation route optimization algorithms for project planning optimization.**
   
   AI Technique “Reinforcement Learning”
   
   Allows algorithms to learn based on trial and error and find the best way to execute an action.

2. **Pharmaceutical predictive AI solutions for constructability issues - project risk forecasting and management**

   For example, Autodesk has launched **BIM 360 Project IQ**, a software that uses connected data and **machine learning** to forecast and prioritize high-risk issues and provide insight into the main challenges that construction managers face.
Artificial Intelligence in Construction

3. Retail supply chain optimization for materials and inventory management.

Modularization and prefabrication construction

AI Supervised learning applications can improve the supply chain coordination, controlling its costs and overall cash flows.

4. Robotics for modular or prefabrication construction and 3-D printing.

Based on Machine Learning - a longer-term opportunity to maximize the benefits of modularization and 3-D printing.

An example of this - the use of robotic arms, which learn from simulations so they can prefabricate material or perform maintenance tasks effectively.

The AEC industry is using machine learning for generative design in order to identify and avoid clashes among the various models created by teams in the planning and design phase.

5. Healthcare image recognition for risk and safety management.

When AI Machine-learning methods are applied for image recognition with drones and 3D images, engineers compare developing and final products against initial designs, or identify safety risks in project sites based on millions of drone-collected images.

Additional machine learning algorithms with potential to disrupt E&C - the number of AI solutions applicable to E&C are potentially endless.

Refining quality control and claims management.

Deep learning technique /Neural networks/ - assess drone-collected images to compare construction defects against existing drawings.
Artificial Intelligence in Construction, BIG data

Artificial Intelligence and BIM

AI improves Building Information Modeling (BIM). AI, drone images and the data that is gathered help create models that can be compared to those made by BIM. Thus, creating the opportunity to reduce decision making time drastically.

Boosting project monitoring and risk management.

Combination of BIM, AI, drone, and laser capabilities - applications would dramatically reduce decision-making cycles in a construction project from a monthly basis to a daily basis.

Constant design optimization - a recommender system approach (supervised learning)

Applications can recommend to engineers and architects the use of a specific design - a structural solution...

AI applications are at an early stage of development and the future development of AI is highly uncertain.

The pace and direction of technological progress in AI is difficult to predict.

A considerable expectation on the potential of combining Big data and AI

Smart technologies and the IoT enable the collection, storage, analysis and distribution vast amounts of data - ‘Big Data’ (the proliferation of high-volume data).

The construction industry uses and generates huge quantities of data which can be used to understand behavior, assess performance, improve market competitiveness, allocate resources, and so on.
BIG data – main driver in E&C

New technologies and applied digital models generate and need significant amounts of data. Data is the raw material on which many applications of Machine Learning (ML) and narrow AI are based.

Data - the “new oil” of the data-driven economy. Real-time communication and collaboration in construction, collecting all the data available on a project and use BIM as the central data hub, we can get to a point where we start learning from one project to another. The common data environment (CDE) - the single source of information used to collect, manage and disseminate information - facilitates collaboration.

To remain competitive and to be fit for the future, the construction sector needs to embrace data driven technologies. Data – the most valuable resource for the future of the sector.

"Because the impact of AI is depend on having the right data, E&C leaders cannot take advantage of AI without first undertaking sustained digitization efforts. This includes investing in the right tools and capabilities for data collection and processing, such as cloud infrastructure and advanced analytics.” /McKinsey & Company/

Doing business would be impossible without access to interoperable data. An important step towards enhancing data interoperability between different systems and stakeholders is adopting international standards.

Construction need to become data driven for future success

European Cybersecurity Act, Regulation 12.03.2019, improve cybersecurity in a broad range of digital products (e.g. Internet of Things) and services. COM(2018) 232 final "Towards a common European data space", 25.4.2018


The European Open Science Cloud (EOSC) aims to give Europe a global lead in scientific data infrastructures

BIM standardization
Just as standards were crucial during the first industrial revolution, over 250 years ago, today standards will once more play a key role in the transition to a new digital era.

Standardization issues are perceived as the most important barrier for digitalization, including both the lack of standards, and the use of too many different standards.

International Standards ensure:

• compatibility and interoperability of data, ensure spread of knowledge and innovation globally;
• safety and minimize risk for the new generation of smart technologies characterized by big data, increased integration, cloud storage and open communication of devices.

DEI priority: Promote the development of Interoperability standards

ICT standards are recognized as a cornerstone of the Digital Single Market.

ICT Standardisation - five priority areas: 5G, cloud computing, IoT, data technologies and cybersecurity.
A process is only successfully standardized if it is executed each time in a predefined (optimal) way by processing the same activities in the same order and producing exactly the same specified output. /Schäfermeyer & Rosenkranz (2011)

Standardization of workflows is desirable within manufacturing and prefabrication industries where the same products are generated repetitively, however there is less clarity whether this definition is applicable to BIM processes within AEC industry.
Today the larger contracting companies employ standardized BIM-Manuals when procuring design services.

The question is: what is within these so-called organisation-specific BIM-Manuals that may be standardized to the benefit of the wider industry?

**Impact** of discrete in-house BIM Manuals which are emerging in Europe as a response to a lack of leadership in BIM adoption may have an adverse effect on the competitiveness.

Furthermore, because many BIM practice procedures are hidden within organisation’s discrete BIM-Manuals, with restricted audiences, a real risk of developing a constellation of fragmented Manuals is possible.
According to a survey, many industry practitioners consider a lack of standards a major obstacle to the effective utilisation of ICT in construction.

The same survey reveals Architects invest the most amongst consultants in BIM and drive comes mostly from enthusiastic individuals (bottom-up) as opposed to management (top-down).

The development of BIM is progressing rapidly and requires the application of common standards (CEN, ISO) to ensure future interoperability and compatibility of data sharing and use - open BIM Standards for interoperability and data management - reduce barriers for SMEs operating in the construction.

What the industry needs is “big and open” BIM, which integrates the entire value chain and is characterized by full interoperability of software and open access to it.

General framework for the management of digital data - quality data exchange between all participants in the value-chain - a common technical language for all European countries is needed.
Area where standardisation on BIM is needed:

Exchange of information between software applications used in the construction industry.
The leading organisation in this domain is buildingSMART which has developed and maintains Industry Foundation Classes (IFCs) as a neutral and open specification for BIM data model - a data schema, that allows information to be exchanged in a consistent data format regardless of which software was used to create the original information.

Data dictionaries
International Framework for Dictionaries Libraries;
common language for the exchange of data on construction products.

Processes
Data delivery manuals

It is important to categorize and understand the strategic difference between branch or sector standards and organisation standards (which may be even company secrets) in a BIM context.
BIM standardization platform

Around 3 divisions are arranged BIM standardization themes:

Concepts
Common concepts and classification of concepts are necessary for everyone to speak the same language

Processes
a uniform processes for information delivery and a common working methodology is necessary

Data Model
Neutral formats for data models required for systems and players to exchange information clearly.
International BIM standardization

- A complex process involving many organizations.
- Liaisons with a plethora of different institutions ensure the completeness and inclusiveness of the process and the smooth acceptance of adopted standards.

VA: Vienna Agreement regulates the relationship between ISO and CEN
International BIM standardization

**CEN TC442 BIM**: Standardization in the field of structured semantic life-cycle information for the built environment.

**CEN TC287 GIS**: Standardization in the field of digital geographic information for Europe.

**ISO/TC211 GIS**: Standardization in the field of digital geographic information.

**ISO/TC59/SC13 BIM**: Organization of information about construction works.

**ISO/TC184/SC4 STEP**: Standards that describe and manage industrial product data throughout the life of the product.

**Open Geospatial Consortium**: International not for profit organization committed to making quality open standards for the global geospatial community.

**buildingSMART**: International organization which aims to improve the exchange of information between software applications used in the construction industry - has developed and maintains Industry Foundation Classes (IFCs-EN ISO 16739:2016) as a neutral and open specification for BIM data model.

**EU BIM Task Group**: It's aim is to bring together national efforts into a common and aligned European approach to develop a world-class digital construction sector - a pan-European network exchanging public sector expertise in the field of Building Information Modelling (BIM)

Liaisons are not only established between the relevant ISO and CEN technical committees but also with geospatial and industrial entities as well as with buildingSMART. There are many more liaisons but only those among the most important are presented here.

As geographic information system (GIS) is a key element in any infrastructure project there is the need to integrate BIM and GIS. Both technologies use standard and open data formats, but they are different and presently there is no direct translation.
ISO/TC 59/SC 13 "Organization of information about construction works”, International Organization for Standardization (ISO)

CEN/TC 442 "Building Information Modelling", European Committee for Standardization (CEN)

Standardization in the field of **structured semantic life-cycle information** for the built environment.

The committee will develop a structured set of standards, specifications and reports which specify methodologies to define, describe, exchange, monitor, record and securely handle asset data, semantics and processes with links to geospatial and other external data.


**Industry Foundation Classes (IFC)** for data sharing in the construction and facility management industries (ISO 16739:2013)


EN ISO 19650-2:2018 (WI=00442005) Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 2: **Delivery phase of the assets** (ISO 19650-2:2018)
CEN TC442 Building Information Modelling (BIM)

The overall benefits of the work of CEN/TC 442 are through BIM to support the visions for sustainable growth based on better resource efficiency through data sharing in the construction industry in Europe.

With the introduction of common standards and operating methods using BIM:

- **Reduce barriers** to operation and trade across the European market area and beyond.
- Reduce both the capital and operating cost of construction assets, reduce construction time.
- Improve the overall coordination of the constriction works and certainty of the construction output including increases in quality and reductions in defects.
- Improve resource efficiency of construction products and materials, improving both operating and embodied carbon performance.
- Support improvements in team working and collaboration.

The adoption of open BIM standards is an essential first step to industry digitalization providing a common interoperability.

General framework for the management of digital data - quality data exchange between all participants in the value chain - a common technical language for all European countries.
The UK move to international BIM standards

BIM, as practiced in the UK, has become the world’s leading approach to digital built environment.

BIM-globalisation push towards international norms and standards.

Internationalisation of processes around information management

Both new international standards provide guidance on the organisation of information about construction works and information management using BIM.

BS EN ISO 19650-1 and 2 are founded on the basis of tried-and-tested UK’s standards for information management using BIM - BS 1192:2007+A2:2016 and PAS 1192-2:2013

BS EN ISO 19650 is essentially an internationalisation of the UK’s BIM Level 2 model and contains all the same principles.

British Standards Institution, Centre for Digital Built Britain and the UK BIM Alliance in addition to various institutional bodies - smooth transition to the ISOs

UK BIM Alliance - Working Towards a Joined-up Approach to BIM: GOING DIGITAL A guide for construction clients, building owners and their advisers.
Smart CE Marking and BIM Standardisation

CEN Workshop Agreement - CWA 17316:2018 - Smart CE marking for construction products

- Reference document - a basis for the implementation of the smart CE marking concept into harmonised standards under the CPR 305/2011
- digitalise construction products information provided in the Declaration of Performance DoP in XML (machine-readable digital) format, the link included in the CE marking - use of "smart" devices, connected to internet
- CWA on Smart CE marking provides a link between the product and its DoP in a digital, machine and human readable format (XML)
- Facilitate the use of current CE label and DoP in a "smart" way by creating the digital connection between the construction product and the regulatory information related to it.

Smart CE marking initiative is an important piece of the large digital construction puzzle.

CEN/TC 442 Product Data Templates was used as input for the development of this document.

The CWA will be considered by CEN Technical Committees (TCs), including TC442.

In alignment with the work done by ISO/TC 59/SC 13 and CEN/TC 442, the Smart CE Marking initiative will enable users to exploit the data provided by manufacturers according to the latest standards for interoperability and data management.
Engineering organisations in support of Construction sector digitization

The digital journey of the Construction sector has begun and its success is largely depended on the quality of communication and collaboration between all stakeholders. Enhance collaboration - a principle within the construction industry.

This is where EU Engineering organisations should show their support:

- ensuring political commitments of EU institutions to support an inclusive digital transformation of the construction sector;
- preparing European engineers for the digital future.

European Construction Industry Manifesto for Digitization, June, 2018

1. The European Union must take the political lead on digital construction
   Digitalisation of the construction industry should be a top political priority for all European institutions and should be part of the “Digitising European Industry” initiative

2. We need an appropriate regulatory framework on data policy
   better data quality and data management, address challenges around intellectual property rights and cybersecurity

3. The new EU budget must focus on digital skills, R&D and deployment of IT infrastructure
   the post-2020 Multiannual Financial Framework must focus on: digital skills, R&D and IT infrastructure
European Council of Civil Engineers (ECCE) conducted a survey among its members in order to get a picture of the close to the real status of the digital transformation of the construction sector within their countries.

The digital revolution in construction has arrived... are you ready?

Questionnaire on Digitization of the Construction Industry, BIM adoption

Topics:
  • The digital revolution in construction - Government regulations
  • Driving Digitization in the Building Industry with BIM
  • The standards in support of BIM use across borders
  • The role of Engineering organizations in support of digital transition across the construction sector in Europe

Engineering organizations need to be proactive in the process of digital transformation of the construction industry – They have a vital role to play for transferring lessons across national and regional boundaries and creating a more balanced understanding of digital transition across the construction sector in Europe.
ECCE Questionnaire: **Summary of findings**

The overall picture is mixed. The number of respondents was relatively small, so the results below needs to be taken as just indicative.

**The survey notes that:**

- A few ECCE members answered they have Government Strategy for digitization of the construction sector including National BIM policy Program. But more of them think Government regulations are crucial to promote BIM usage and adoption in strategic and significant projects;

- 70% of responded are not aware of BIM, beginners or no BIM experience
  - 25% - users in the moderate level
  - 5% - experts or advanced BIM users;

- All respondents answered their company/organization being extremely likely to use BIM in future;

- The primary BIM benefit identified - increased productivity/efficiency; better quality of project, reductions in design errors, reduced overall duration of the construction phase.
ECCE Questionnaire: **Summary of findings**

- **Current Obstacles** to Using BIM - No time to evaluate the option of the organisation using BIM, perceived low return on investment, lack of client demand, lack of in-house expertise, lack of training...
- Who would you say **is driving BIM adoption**? - government, software vendors, architects
- Who derives benefits from using BIM on projects – owners, general contractor, facility manager. Architects and Engineers – low benefits ;
- The most used BIM applications - Project visualization, 3D modeling/design, Clash detection, Laser scanning, 4D modeling ;
- Almost all members are aware of CEN and ISO BIM standards and see them important for accelerating the BIM adoption; National Standards Institutes are currently adopting CEN, ISO international standards ;
- Majority of participants consider that professional organizations at national and European level could have influence on BIM adoption - raising BIM awareness, changing the culture of collaboration, BIM training;
- Almost all members believe ECCE has a role to play in raising awareness and capability in support of the BIM agenda - the possible initiatives: CPD BIM training – Webinars, International Conferences on BIM adoption and exchange of best practices; Certrification of BIM training; International collaboration and participating in national and international BIM projects.
ECCE Questionnaire: **Summary of findings**

**Conclusions from the ECCE Questionnaire:**

- The uptake of new technologies as well as BIM adoption vary across the countries depending on the economy growth.
- The organisations consider digitization to be necessary and unavoidable.
- For now they do not see significant benefits for engineers.
- The organisations expect from ECCE:
  - to ensure political commitments of EU institutions to support the digital transformation of the construction sector; expressing timely a clear position on all European policies related to the Digital transformation;
  - to develop a common strategy and roadmap of BIM adoption / Networking Platform in favor of National Members
  - to support them in the process of BIM adoption through providing information on BIM good practices, CPD BIM training programs, EU funding for the implementation of the BIM Training Roadmap, projects focused on training and advanced digital skills, EU project for training of teachers, preparing the requalification study programs on Bc. and MSc. level, support the edition of electronic study materials etc.
  - to work to encourage young people into the engineering profession.
Working Towards a Joined-up Approach to BIM is very important. There is need to be changed behavior and processes, not just technology. There is a need for greater communication and awareness raising.

Engineering organizations have a vital role to play for transferring lessons across national and regional boundaries and creating a more balanced understanding of digital transition across the construction sector in Europe.

Engineering organizations need to work more collaboratively towards a new level of collaborative engineering knowledge management and to be committed to cooperate constructively towards achieving the engineering challenges of construction digitization and sustainable development, providing a continuous EU-wide dialogue.

Joint European approach is needed to develop a world-class digital construction sector.
Ljubljana Declaration Statement

Working Towards a Joined-up Approach to BIM is very important. There is a need to be changed behavior and processes, not just technology. There is a need for greater communication and awareness raising. A strong network facilitating transfer of knowledge, expertise and capabilities needs to be put in place at the European level.

Engineering organizations have a vital role to play for transferring lessons across national and regional boundaries and creating a more balanced understanding of digital transition across the construction sector in Europe.

Engineering organizations need to work more collaboratively towards a new level of collaborative engineering knowledge management and to be committed to cooperate constructively towards achieving the engineering challenges of construction digitization and sustainable development, providing a continuous EU-wide dialogue.