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A Framework for Adaptability, re-use and Deconstruction of Buildings, Aligned with the Principles of Circular Economy

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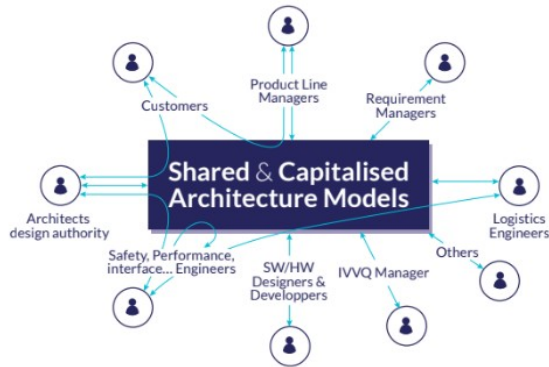
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DESIGN FOR ADAPTABILITY, RE-USE AND DECONSTRUCTION OF BUILDINGS, IN-LINE WITH THE PRINCIPLES OF CIRCULAR ECONOMY (BUILT4PEOPLE PARTNERSHIP) HORIZON-CL5-2024-D4-02-04

DIGITAL MODELS



Supporting Efficient Collaboration in engineering 'ARCADIA'

- MBSE is a methodology that focuses on creating and exploiting digital system and engineering domain models.
- This is provided as the primary means of exchange of information, feedback, and requirements, as opposed to document-centric systems engineering.
- It involves the entire process of capturing, communicating, and making sure that all the digital models we use to represent a system are coordinated and maintained throughout the entire life-cycle of the system.

No.	Participant legal name	Shortname	Country	Type
1	F6S Network Ireland Limited	F6S	IE	Global Innovators Network
2	Associacao para O Polo Das Tecnologias Da Informacao, Comunicacao E Electronica	TICE	PT	National Portuguese ICT Cluster
3	Visabeira Investigação e Desenvolvimento, S.A	Visabeira	PT	RTO
4	Professionshojskolen University College Nordjylland	UCN	DK	Department of Architectural Technology & Construction Mgt
5	Slovenski Gradbeni Grozd, Gospodarsko Interesno Zdruzenje	SGG	SI	Cluster, industry association
6	Centro Tecnologico Da Ceramica E Do Vidro	CTCV	PT	RTO
7	NEOECO Development	Neo-Eco	FR	SME
8	Institutul Național de Cercetare-Dezvoltare În Informatica ICI Bucuresti Romania	ICI	RO	RTO
9	InoSens Doo Novi Sad	INO	RS	SME
10	Zentrix Lab Ou	ZENTRIX	EE	SME
11	Charitable Foundation "Ukraine Resilience"	CFUR	UA	Non-Profit Organisation
12	GT Gorsko	GORSKO	SI	SME (Construction Firm)
13	Brisk GROUP	BRISK	RO	Consultancy Construction Firm
14	FONATERM	FONATERM	SI	SME

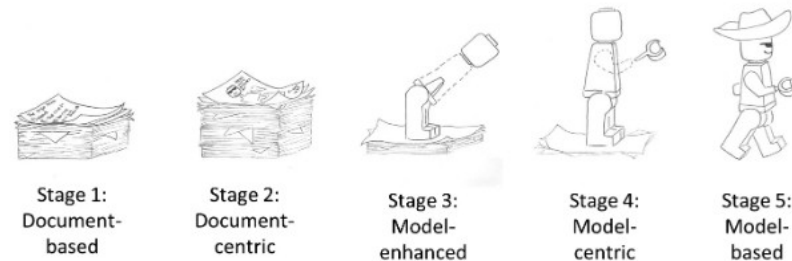
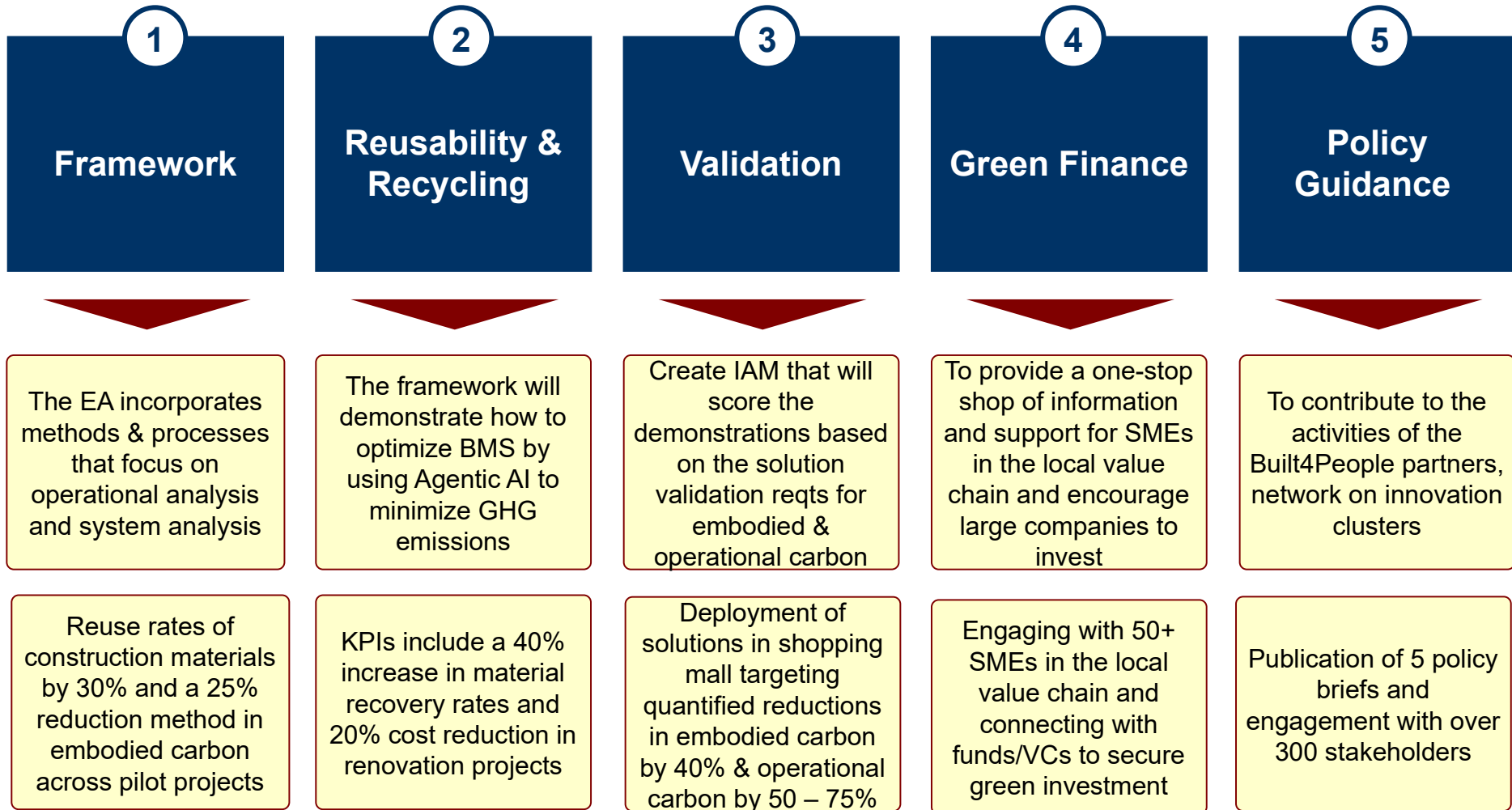


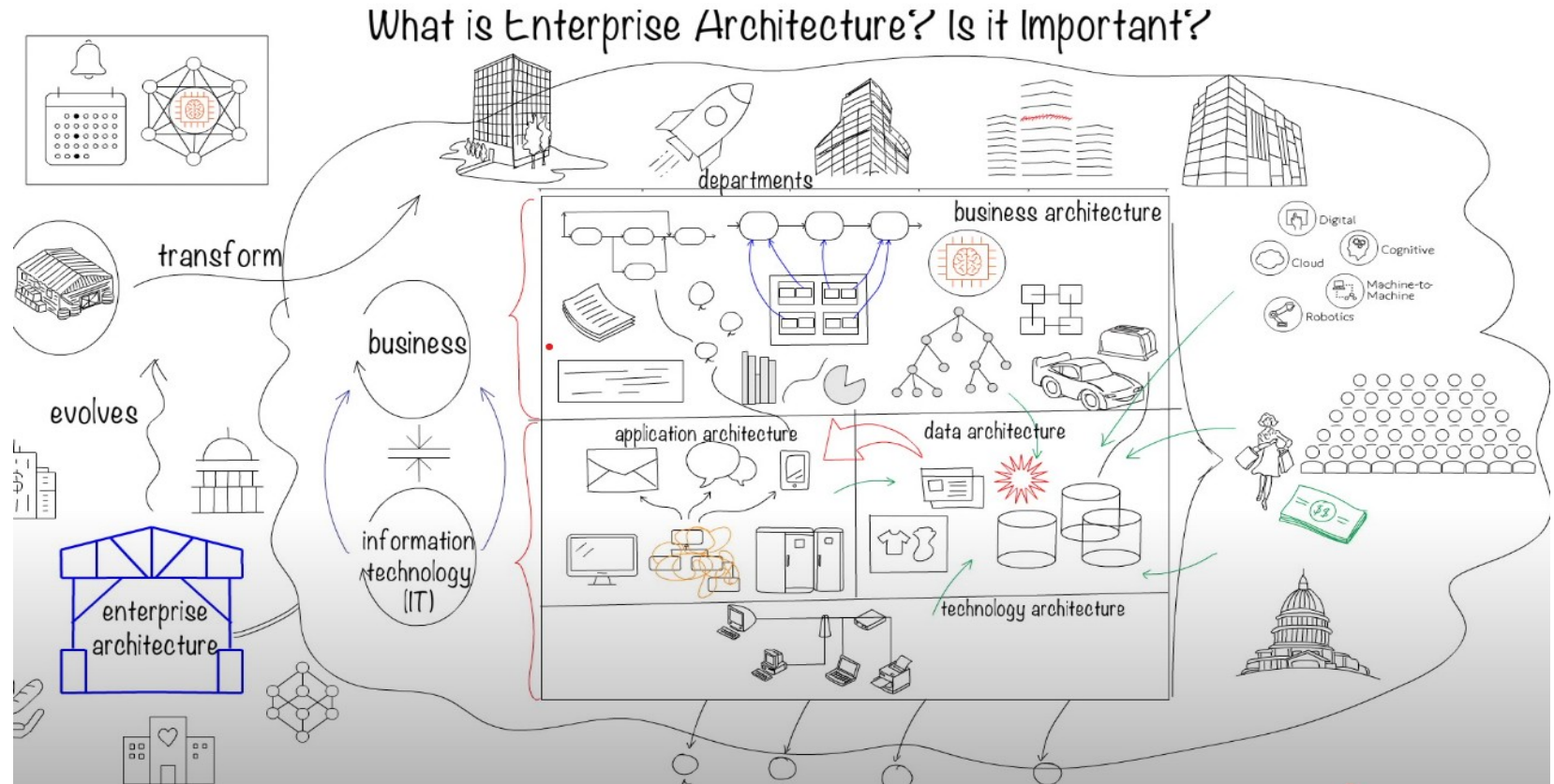
Figure 2.10 – The evolution of MBSE (Holt & Perry 2020)

Requirements & Measurements

5 Objectives

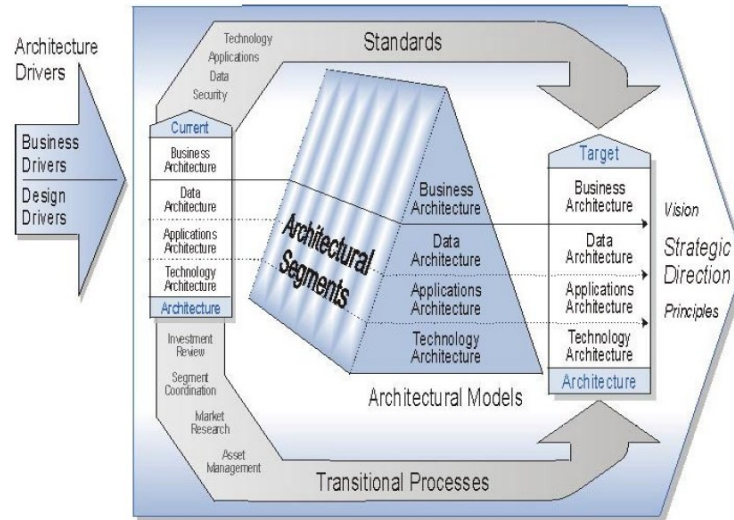


ENTERPRISE ARCHITECTURE

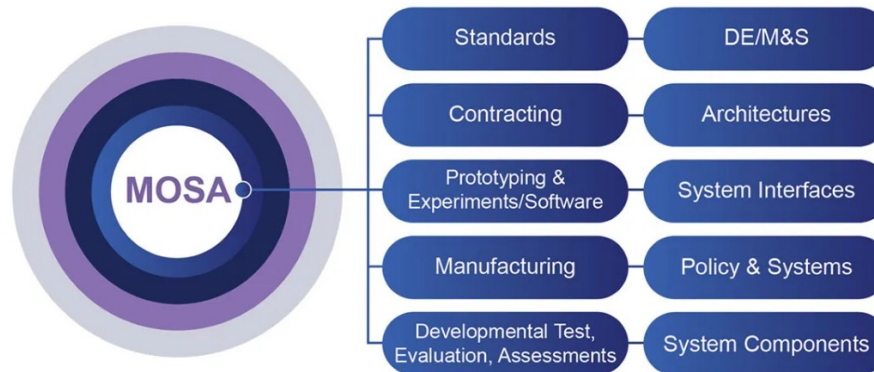


https://www.youtube.com/watch?v=9TVc32M_gIY 'Dr. Raj Ramesh'

SYSTEMS ENGINEERING ARCHITECTURE



Structure of the U.S. "Federal Enterprise Architecture Framework" (FEAF) Components, presented in 2001



MOSA is involved in many areas in engineering across the system life cycle.

The Modular Open System Architecture ecosystem depends on active involvement by multiple stakeholders across the Department of Defense.

5 PHASES

- **Operational Analysis** – Define Stakeholder Needs and Environment;
- **Solution Analysis** – formalize solutions requirements;
- **Logical architecture** – develop solutions logical architecture;
- **Physical architecture** – develop solutions physical architecture; and
- **End Product Breakdown Structure (EPBS)** – formalize solutions component requirements.

PHASE 1 OPERATIONAL ANALYSIS

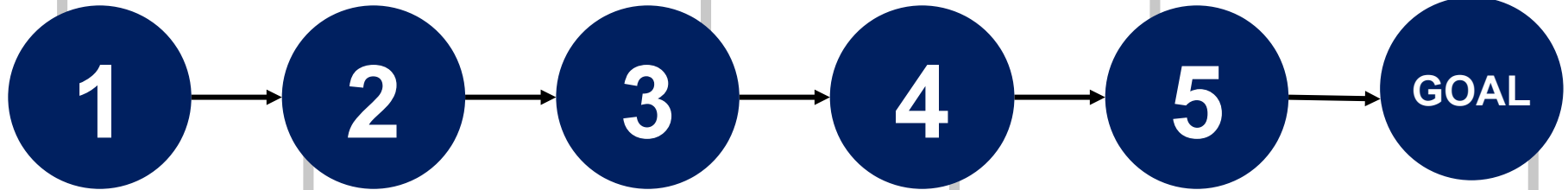
- Identify specific needs for reuse & recycling of building elements & products
- This phase involves:
 1. Capture & consolidate operational needs
 2. Correct development & deployment
 3. Concept operations - characteristics

PHASE 3 LOGICAL ARCHITECTURE

- Design & implement inclusive, accessible, sustainable, resilience, performant solutions
 1. White box – allowing the pilot study demonstrators to understand the internal workings of solutions
 2. Define how the individual architectures will work to fulfill

PHASE 5 FORMALIZE SOLUTIONS COMPONENT REQUIREMENTS

- Increase awareness on best practices
- Managing of industrial criteria & integration strategy
- Market segment and commercial success
- Business models and recommendations



PHASE 2 SOLUTION ANALYSIS

- Model & support the circular economies supply to extend service life of buildings
- This phase is known as the operational concept - select the business case, what the solutions must accomplish for the pilots, in terms of functional data flows and integration

PHASE 4 PHYSICAL ARCHITECTURE

- Configure & integrate solutions in local and regional value chains
- This phase concentrates on using the knowledge of how the solutions will be developed to actually testing them in the 3 pilot studies

USE CASES

- The defined set of innovative solutions developed during the framework will be tested via 8 use cases addressing different target groups.
- Combining solutions, products & techniques, and process & methods towards achieving increased availability, access & management of life cycle data

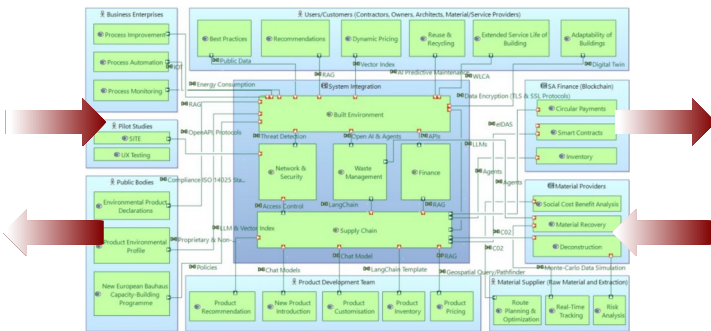
Federated Enterprise Architecture

State of the Art Line of Business

Innovative Tools (INNT)	Framework Products and Techniques (P&T)	Process and Methods (P&M)
INNT1) AI, IoT and Agents for BMS	P&T1) Digital Building Logbooks including DPP, BRP and MP	P&M1) Buiness Process Mapping
INNT2) Graph Technology	P&T2) Security Transactions including Data Encryption, and Payments Certs (eIDAS) etc.	P&M2) Life Cycle Analysis including SCBA
INNT3) Large Language Models including LangChain - GenAI, and Chat models	P&T3) Open Source: Open LCA and Open API	P&M3) Federated Architectures including Linked Data CDE
INNT4) Digital Twins, BIM and GIS Platform	P&T4) Semantic Analysis Techniques, RAG and Indexes	P&M4) MBSE
INNT5) Distributed Ledger Technologies / Blockchains		P&M5) ETL Data Integration
INNT6) Preventative and Predictive Maintenance - RAM		P&M6) Real-Time Linked Data Space

▪ The Federated Framework consists of 16 interconnected modules that include key enabling tools, processes and methods.

The Framework MBSE for Enterprise Architecture



▪ The framework's vision is the development of products/materials/services including those that contribute to dissembled and reused, and CO2-storing materials etc. and also cyphering of materials via Graph Technology.

A Combination of Framework Modules

- ☒ UC1: Circular Construction & Reuse Framework
- ☒ UC2: Digital Platform of Solutions
- ☒ UC3: Real-Time Data-Space
- ☒ UC4: RAM Knowledge Platform
- ☒ UC5: Cybersecurity & Supply Chain Transparency
- ☒ UC6: LCA models for Renovation Planning & Design
- ☒ UC7: Operational Carbon Management Systems
- ☒ UC8: Accelerator for Green Finance Investments

Use Cases	Innovation Tools						Products and Techniques				Process and Methods						Markets		
	1	2	3	4	5	6	P&T1	P&T2	P&T3	P&T4	P&M1	P&M2	P&M3	P&M4	P&M5	P&M6	M1	M2	M3
UC1 Circular Construction and Reuse Framework	X	X									X	X	X					X	X
UC2 Digital Platform	X	X					X						X		X	X			
UC3 Real-Time Linked Data Space	X	X					X									X			
UC4 RAM Knowledge Platform	X											X							
UC5 Cybersecurity and Supply Chain Transparency																			
UC6 LCA Models for Renovation Planning and Design	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X			
UC7 Operational Carbon Management Systems	X	X	X	X	X	X								X	X	X			
UC8 Accelerator for Green Finance Investments	X	X	X	X	X	X	X	X	X	X							X	X	X

▪ The defined set of innovative solutions developed during the framework will be tested via 8 use cases addressing different target groups.

▪ The use cases will represent an already proven concept for the viability of combining these solutions, products & techniques, and process & methods towards achieving increased availability, access, and management of lifecycle data in the built environment.

Eight Use Cases

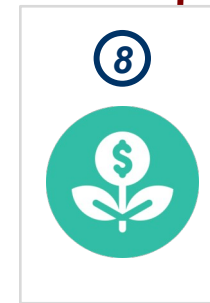
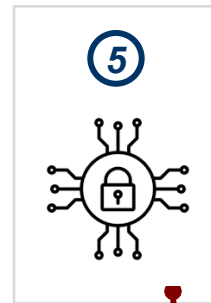
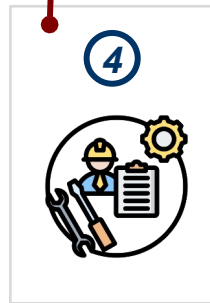
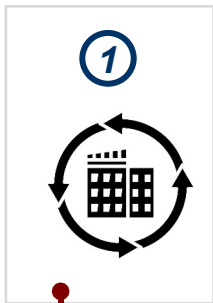
Proposed Solutions, Products & Techniques, and Process & Methods

Digital Platform of Solutions – aligned with the concept of Federated CDE that requires solutions & technologies for development to include; folders with documentation & list of materials and tasks.

RAM Knowledge Platform – will demonstrate the potential of preventative and predictive maintenance algorithms and systems to enable calculations on mechanical systems.

LCA models for Renovation Planning & Design - will demonstrate how tools developed under the framework will empower building stakeholders to streamline processes, efficiency, and drive sustainable transformations.

Accelerator for Green Finance Investments - will focus on Getting Buy-In to advance Green Infrastructure.



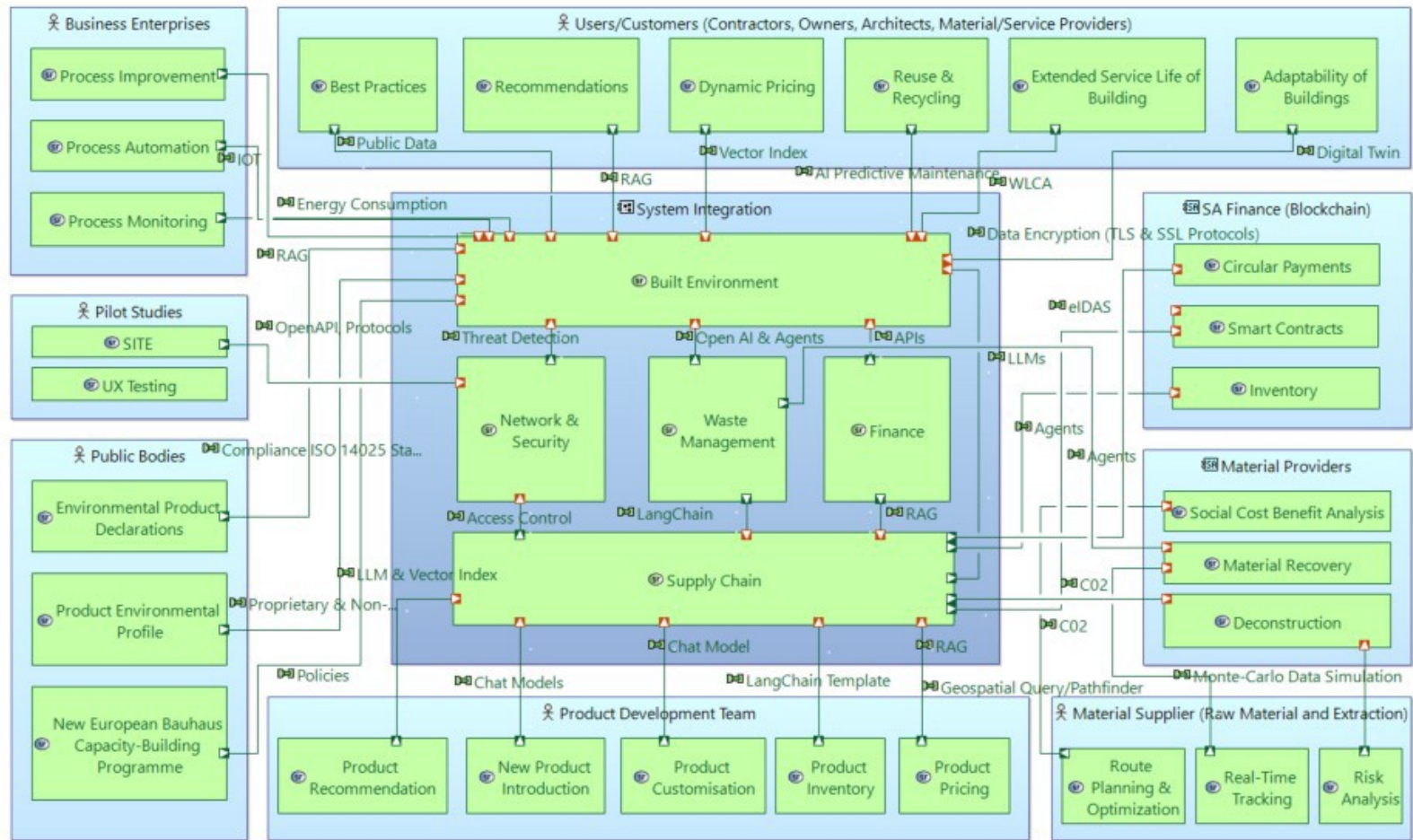
Circular Construction & Reuse Framework – using AI and graph technology to help source materials locally and alternative materials that are bio-based. UC1 will advise local businesses through local sourcing which can lead to economic growth and job creation, and social benefit.

Real-Time Linked Data-Space – focuses on integrating supply chain monitoring data analysis, such as data from sensors and IoT devices in existing or similar buildings, into an interoperable digital twin knowledge graph. Real-time visualization of embodied carbon, indoor climate metrics, and the adaptability of building systems.

Cybersecurity & Supply Chain Transparency – use blockchains to trace the sourcing of CO2-storing materials such as sustainably sourced long-lived bio-based materials, products & innovative lower emission materials.

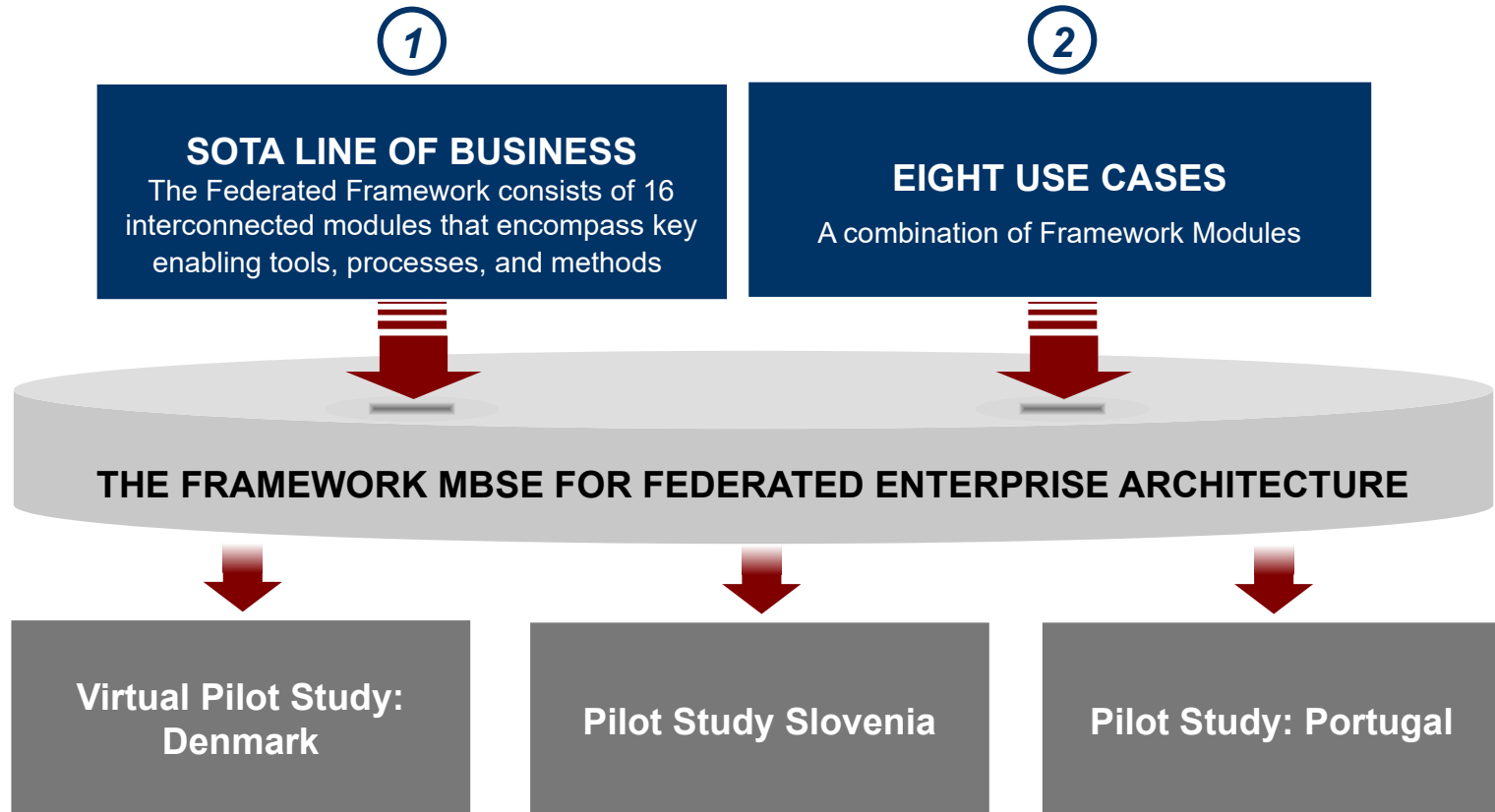
Operational Carbon Management Systems - demonstrates the power of AI agents for energy monitoring and optimization including dynamic Pricing. The operational carbon management systems access real-time feeds and data from captured sensors (IoT) related to energy consumption of building elements and products.

THE FRAMEWORK MBSE FOR FEDERATED ENTERPRISE ARCHITECTURE



DEMONSTRATIONS

To test these innovations and use cases, the demonstrations will cover a spectrum of many items included in the EU policy and market trends regarding data management in the built environment.



ARCHITECTURES (Capella technology and its ecosystem <https://youtu.be/o64pje-DdXE>)



RDB of Suppliers Catalogues



RDB of Reusable Materials



EPD Catalogues

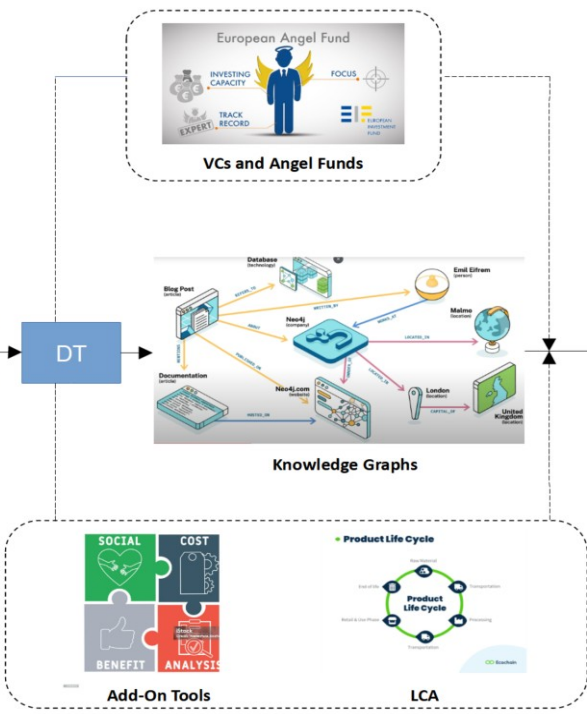
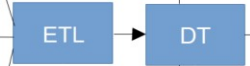
Title of the activity: "Digital Environmental Awareness Activity via Social Media Platforms..."

Community Engagement Platform

#CEStakeholderEU

European Circular Economy Stakeholder Platform

Web Service Platform



Neo4j Dash for BI

Recommendations

An extension of the movies dashboard with more complex Cypher and customized visualizations.

Author: [Harold Anudeig](#)

movies recommendations beginner actors gds

Load

Bill of Materials

This dashboard shows how to model a BOM in Neo4j and query the BOM as a graph.

Author: [Pierre Haltermeyer](#)

bom model products

Load

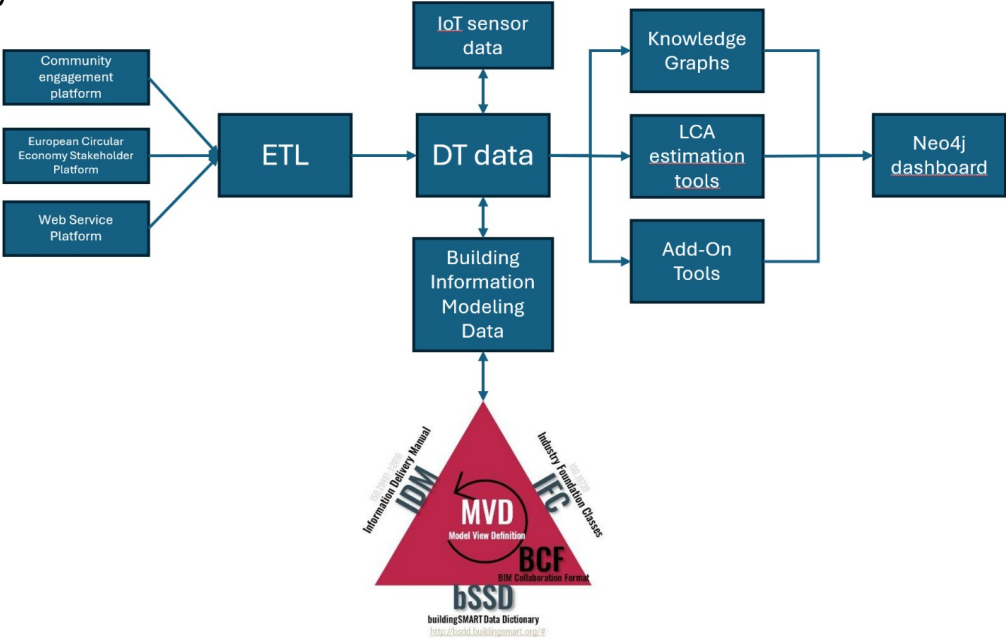
ISO/IEC 39075:2024 Information technology — Database languages — GQL

PILOT STUDY: DENMARK & ROMANIA (UCN, BRISK GROUP & ICI)

Key Elements of the Danish Virtual Pilot:

- Interoperability Testing: Ensuring seamless data integration using BIM, open standards, and federated architecture for decentralized Lines of Business (LOBs).
- Lifecycle Optimization: Simulating adaptability, disassembly, and reuse scenarios for building elements.
- Cybersecurity Enhancements: Securing the integrity of supply chains through advanced measures.
- Data-Driven Collaboration: Utilizing real-time linked data spaces and graph technology to support decision-making across stakeholders.
- Real-world data: Will be used from material performance and life cycle analyses will be utilized to validate the demonstrator's interoperability and accuracy

UC1	Circular Construction & Reuse Framework (<i>AI enabled tracking on a Carbon Platform</i>)
UC2	Digital Platform (<i>interoperability via Digital Twin Integration</i>)
UC3	Real-Time Linked Data-Space (<i>Environmental Data Integration</i>)
UC5	Cybersecurity & Supply Chain Transparency (<i>through blockchains-based product passports</i>)
UC8	Green Financing Accelerator (<i>access to green subsidies & ESG investments</i>)



PILOT STUDY: SLOVENIA (SGG, GORSKO, and FONATERM)

The demonstration planned for Cirkulane (Slovenia), is a prefabricated, residential wooden house, addressing the challenges of Build4People topics, including circularity and sustainability.

UC1	Circular Construction & Reuse Framework
UC2	Digital Platform
UC3	Real-Time Linked Data-Space
UC5	Cybersecurity & Supply Chain Transparency
UC6	LCA models for Renovation and Planning
UC7	Operational Carbon Management Systems
UC8	Green Financing Accelerator

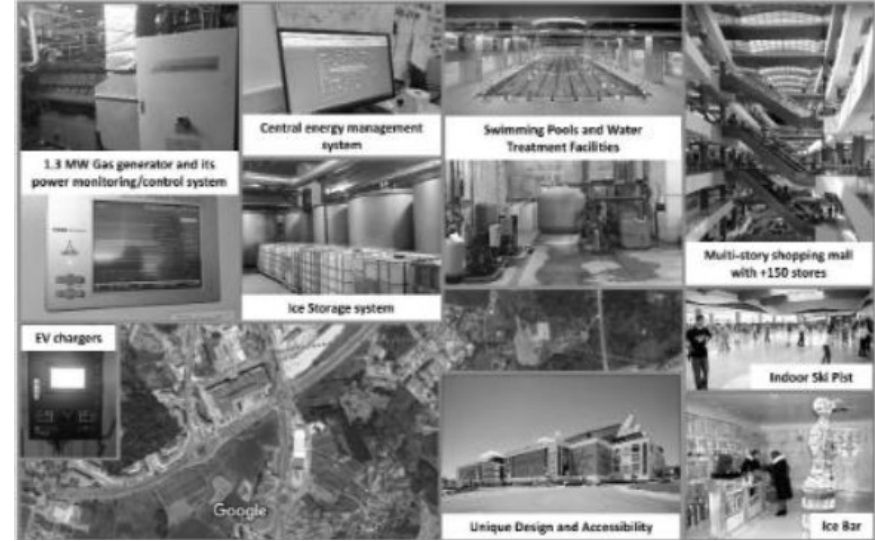
The Expected outcomes planned are related to improve :

- Adaptability of building design and solutions for different uses.
- Increased reuse of buildings components and increasing the end-of-life value.
- Extend services life by smart maintenance services, and
- Increase awareness and deploy best services in the demonstrators supply chain.

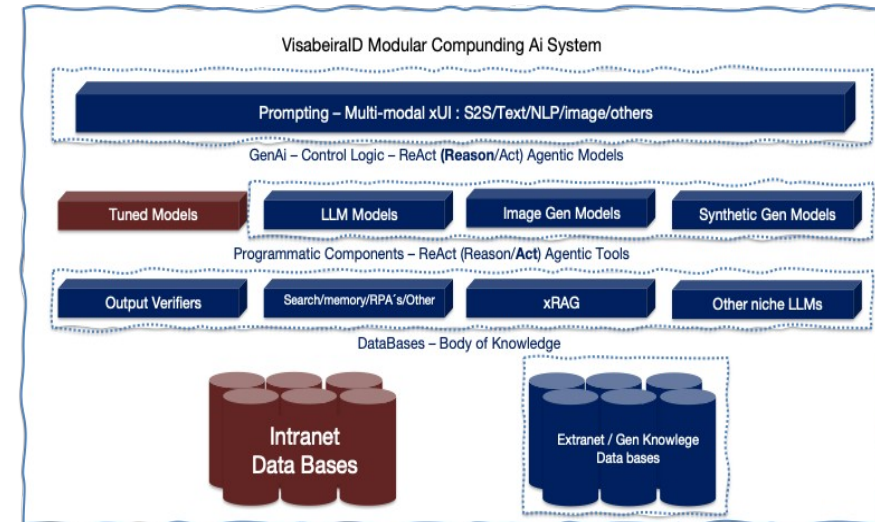
PILOT STUDY: PORTUGAL (VISABEIRA, CTCV and TICE.PT)

The 'Palacio do Gelo shopping mall' Pilot Study:

- Lifecycle Optimization: Agentic AI will be embedded within the building management system.
- Data-Driven Collaboration: The Portuguese use case focuses on maintaining present user QoE KPIs while lowering the current GHG building emissions footprint.
- The Pilot Study will address circular economy goals while adapting to local/regional sourcing of products and materials to increase replication.



UC2	Digital Platform (<i>Building systems' originated data, capturing real-time and historical building operations</i>)
UC3	Real-Time Linked Data-Space (<i>SCADA systems data used as sourcing, for creating an integrated digital twin of the building</i>)
UC4	RAM knowledge Platform (<i>include: i) Prompting Module ii) enAI ReAct (Reason/Act) Agentic Models: a set of GenAi models, following the ReAct paradigm (Reasoning + Acting), will be deployed; iii) Programmatic Agentic Tool Components</i>)
UC6	LCA models for Renovation and Planning (<i>enhance operational processes by integrating a systemic Agentic AI system approach that will enable energy optimization</i>)
UC7	Operational Carbon Management Systems (<i>environmental impacts and GHG emissions due to large-scale electricity consumption for lighting, climate control, and other energy-intensive systems</i>)



“Tools evaluation and holistic impact assessment”

1

Data Usage

Opportunities

Convert the best practices, processes, and methods, into a beta stage dashboard.

Trust

Point the Dnipor region to our best suited tech-powered solutions that can support sustainable reconstruction needs.

2

Data Engine

Platform

Develop a scorecard indicating each tool's level of applicability and usefulness.

Organization

Identify usefulness of the scorecard based on the needs & inputs that it provides.

3

Data Ecosystem

Sustainable Construction

Identify the most relevant and impactful aspects of market building.

Prescriptive Tool

City Government to become acquainted with the tools

SUMMARY

To integrate digital technologies, via advanced processes, with novel materials into a **decentralised Framework for (de)construction and renovation**.

The existing challenges of non-interconnected frameworks associated with monolithic, proprietary system provided the initiative **to design an interoperable ecosystem for tools, platforms, and processes that maintained autonomy**.

The use of MBSE approach is a process offered in the framework to define the solution design.

The concept of the pilot studies is **to facilitate the transition of the selected UCs bundle from the initial conceptual stage** to an advanced operational development stage based on constant evolution and learning.

The anticipated results of the overall process is to provide a long lasting impact on our understanding of **how an efficient design for adaptability, re-use and deconstruction of buildings should be approached**.



<https://dev.to/toobaliscious/-why-coffee-is-a-developers-best-friend-nkk>