ALAN MARTIN REDMOND

May 15, 2025 | 5PM CET | | EN BUILDING METHODOLOGY

MBSE Approach to Creating and Exploiting Digital Systems for HORIZON Europe

OBEO

Capella™

AGENDA

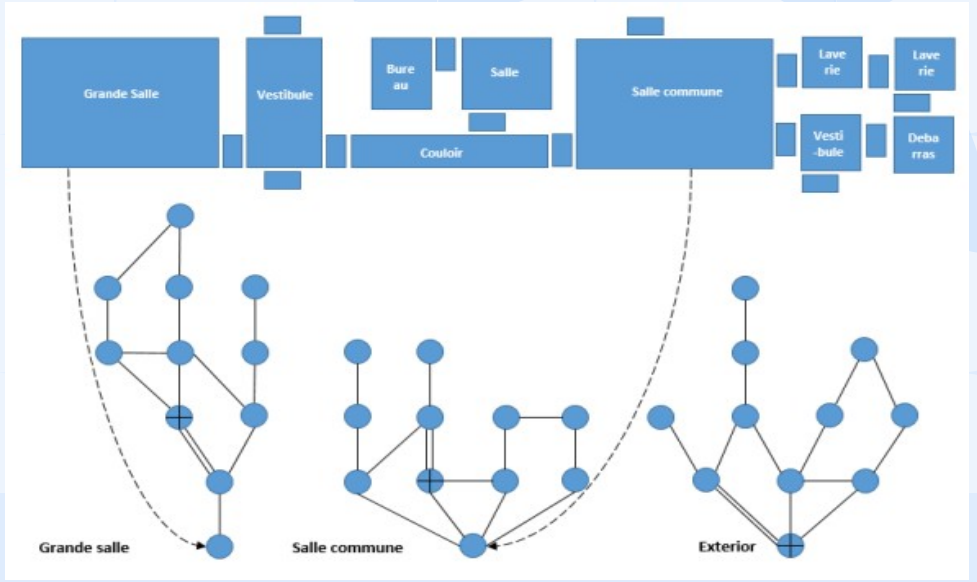
- This session will highlight the use of MBSE Pillars on two case studies:

  - The Conceptual Architecture Requirements for French Digital Building Logbook (30 mins); and
  - Circular Systemic Solutions for the Construction Industry (20 mins)

#NANTES #TECH

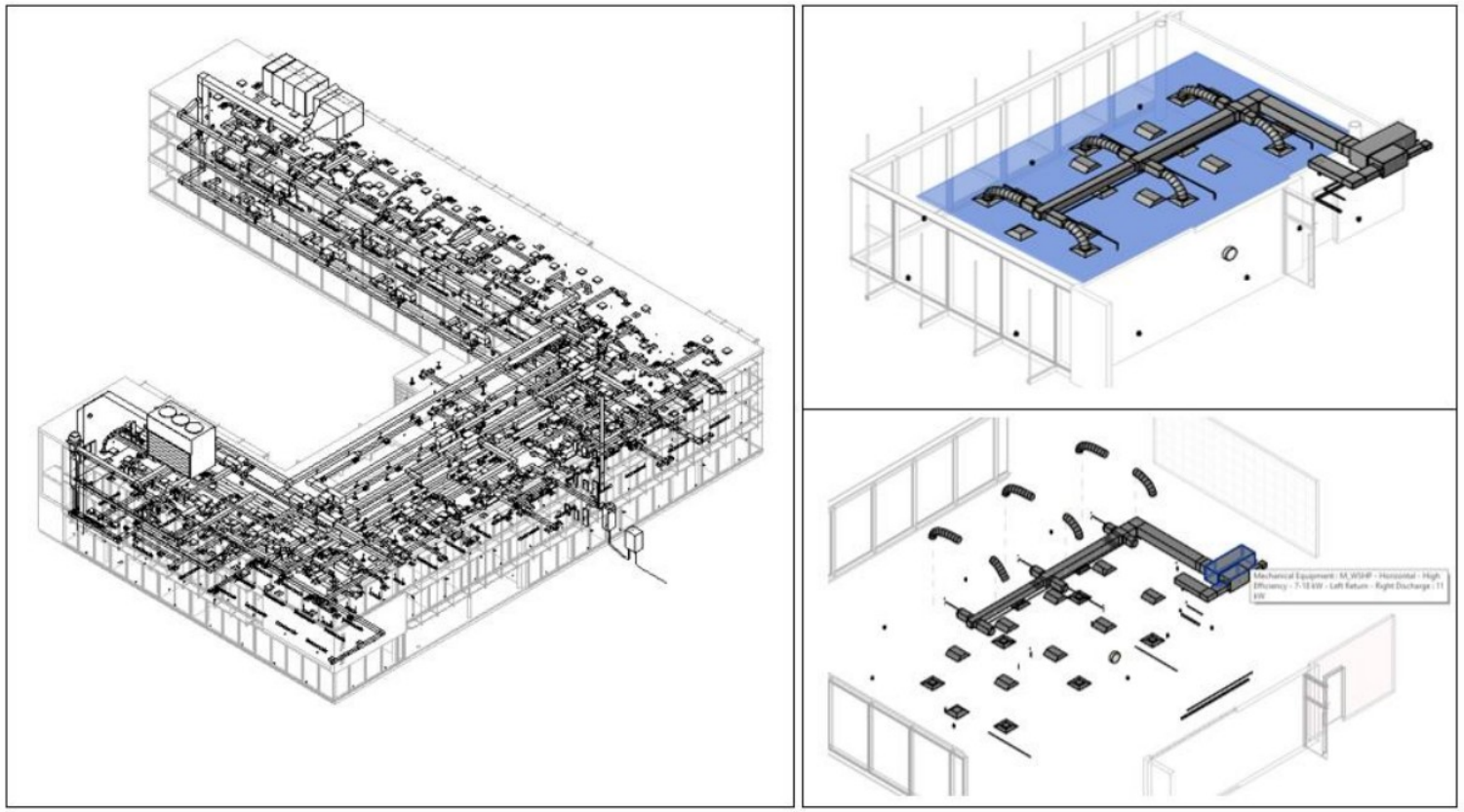
BASELINE – SYSTEMATIC & SYSTEMIC THINKING

« A simple house plan, its representations as rooms and **as a network** ».The same network can be arranged in steps of depth considered from the point of view of different spaces, showing how a **single system of spaces** is objectively different from different points of view.

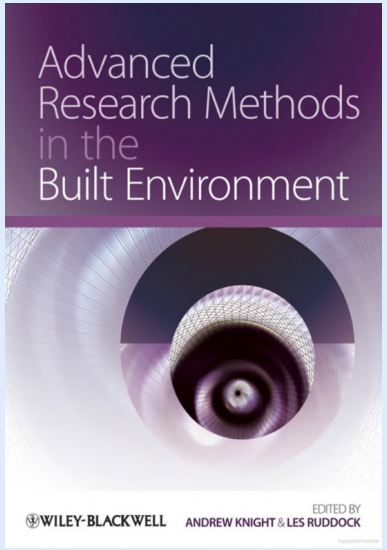


Measuring the Performance Characteristics of MBSE Techniques with BIM for the Construction Industry Conference Paper · September 2018 DOI: 10.1109/DeSE.2018.00047

A. Models and Simulations



“System of systems” is a collection of task-oriented or **dedicated systems that pool their resources and capabilities together to create a new, more complex system** which offers more functionality and performance than simply the sum of the constituent systems



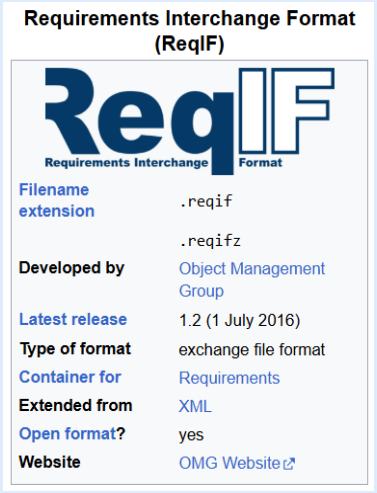
2 Architectural Research 14
Alan Penn
Introduction 14
A sketch of architectural design 15
The structure of architectural research 17
Space syntax and the social logic of space 18
Conclusion 25
Note 27
References 27

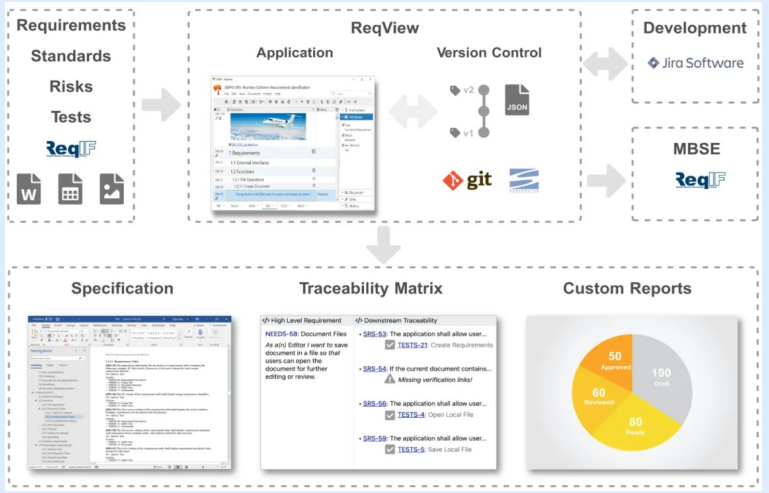
- Hillier, B., Hanson, J. and Granha, H. (1987) Ideas are in things: An application of the space syntax method to discovering house genotypes, Environment and Planning B: Planning and Design, 14(4), 363-385.
- Hanson, J. (1999) Decoding Homes and Houses, Cambridge University Press, Cambridge.

NARRATIVE (DISCLAIMER-PERSONAL EXPERIENCE)

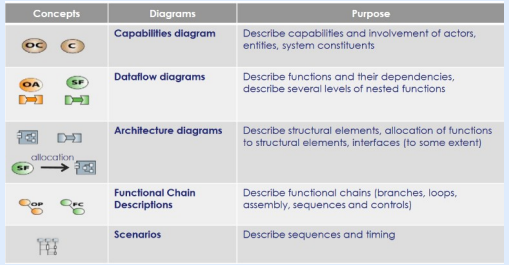
- The Demo Blog project featured requirements captured at an early phase.
- OBEO training was chosen to enhance both the requirements and also collaboration between partners.
- The logical architecture in case study 2 is sometimes at best “abstract” to present exchanges between concepts.

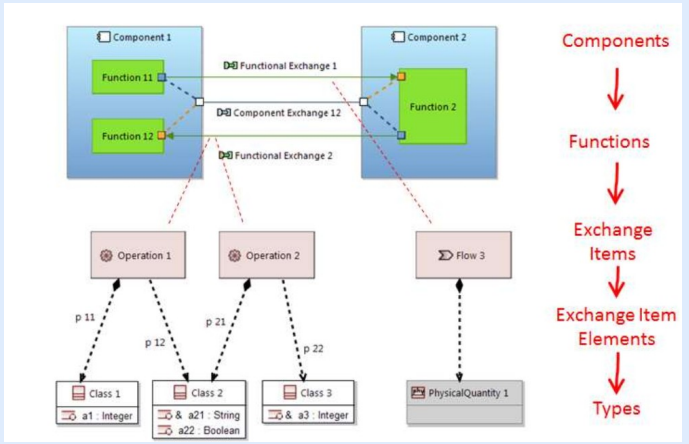
Requirements





In-flight Entertainment System





Integration of Capella with Requirements Tools | Capella P4C | OBEO
https://www.youtube.com/watch?v=LFW6uToCWTI

CASE STUDY 1 – LIVE PROJECT

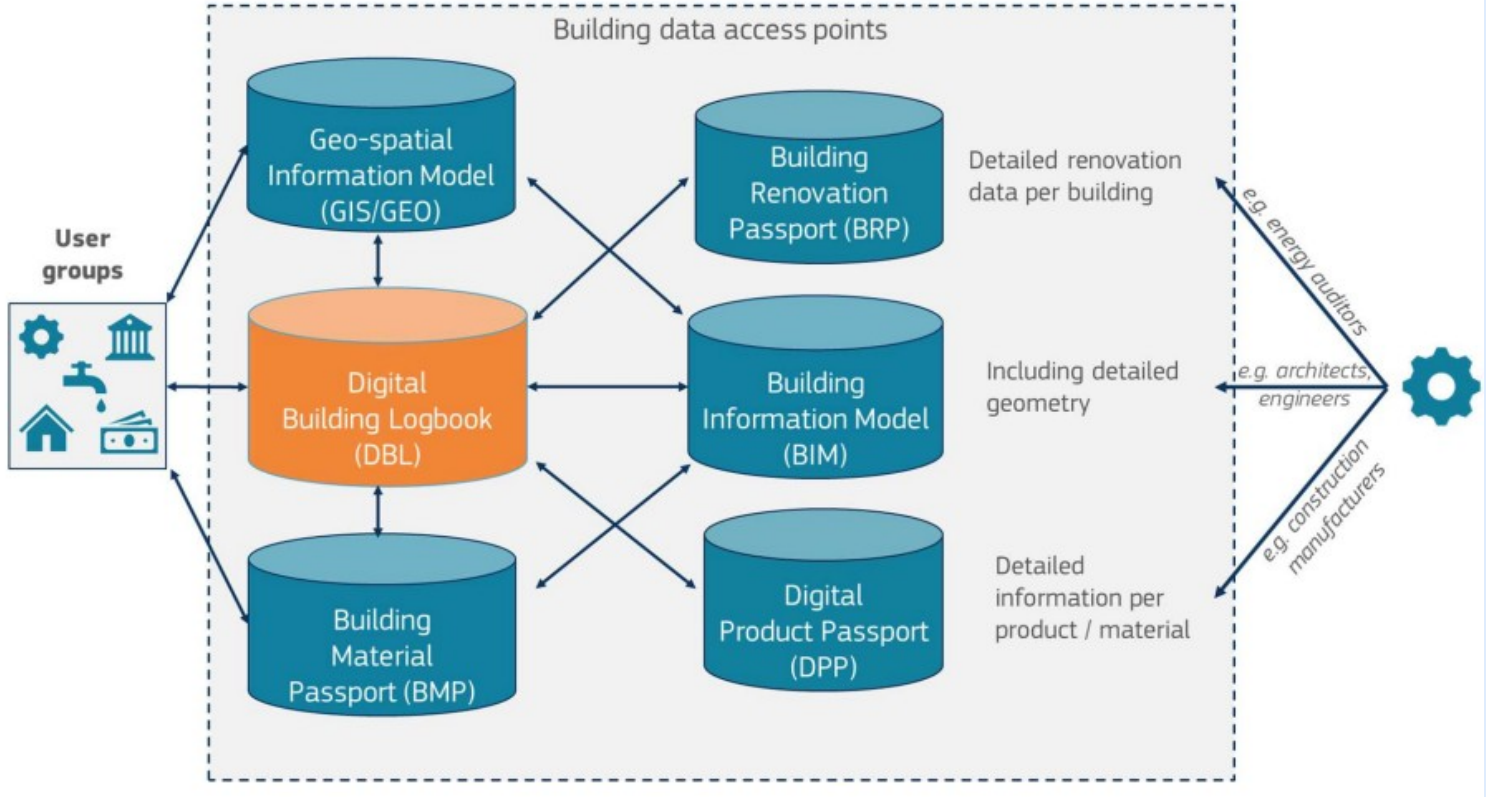
The ‘Demo Blog’ project highlights system science approach in understanding all aspects of systems, and systems thinking array of methods to define relationships and perspectives in order to provide requirements based on identifying systems, which are composed of parts and wholes.

Demo Blog

https://demo-blog.eu/

https://www.thinkmind.org/library/IARIA_CONGRESS/IARIA_Congress_2024/iaria_congress_2024_2_100_50052.html

WHAT IS A DIGITAL BUILDING LOGBOOK



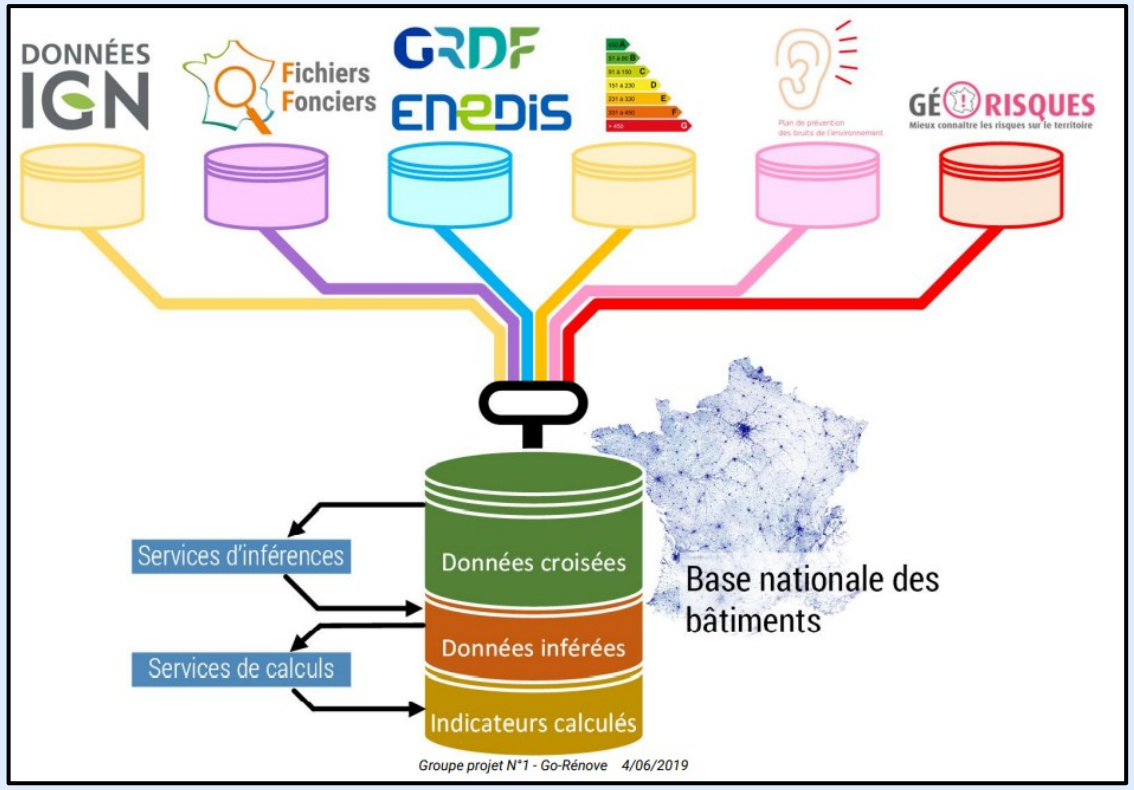
- A digital building logbook is a common repository for all relevant data.
- It enables a variety of data, information and documents to be recorded, accessed, enriched and organized, under specific categories.
- It represents a record of major events and changes over a building's life-cycle.

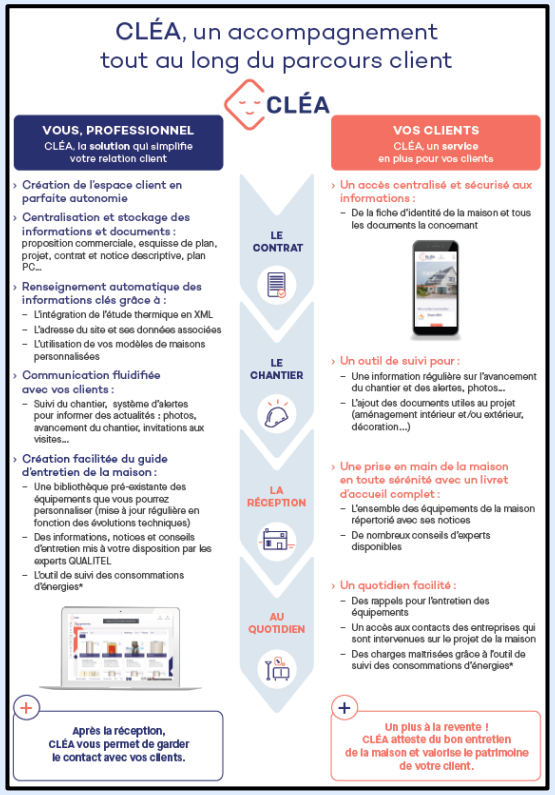
- **The need for change (new methodologies/new architectures)**: 'The majority of this data stored (IAQ, operational energy use, smart buildings potential and life cycle emissions, building ratings, certificates and circularity) in the logbook are **static in nature**, while others, such as meters and intelligent devices, are dynamic and **need to be automatically and regularly updated**.'

FRENCH DEMO (BDNB + CLÉA)

https://www.cstb.fr/bases-donnees/base-donnees-nationale-batiments

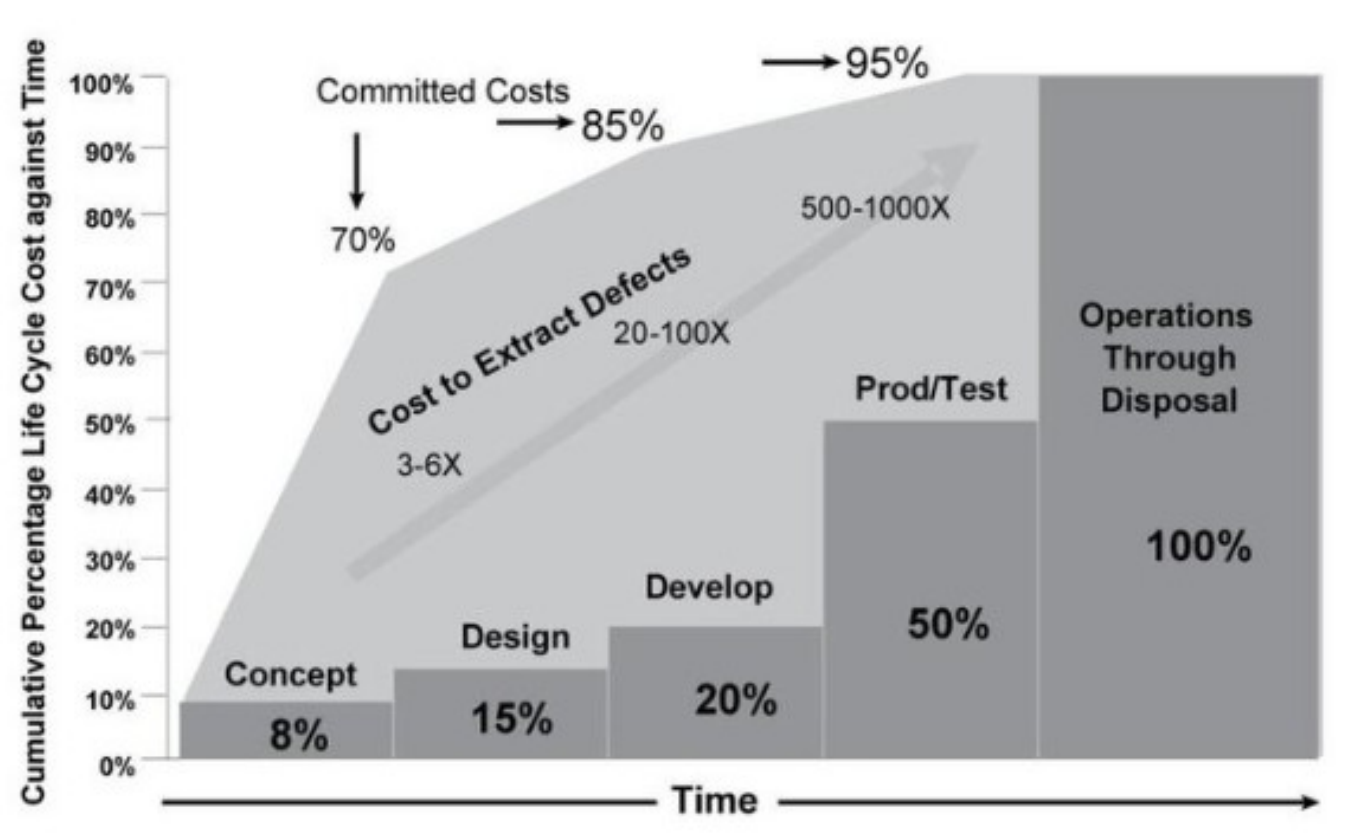
https://www.qualitel.org/professionnels/actualites/clea-simulation-de-travaux-pour-particuliers/





Subtask 1.1.3: Define specifications for the automated renovation advice tool (EST, CSTB, QUAL)
The specifications produced for each demo will be presented according to general requirements/capabilities, behaviour, architecture/structure, verification and validation. This common presentation will enable in-depth comparison of the planned approach between the demo's and encourage wider adoption of the learnings.

WHY SYSTEMS ENGINEERING

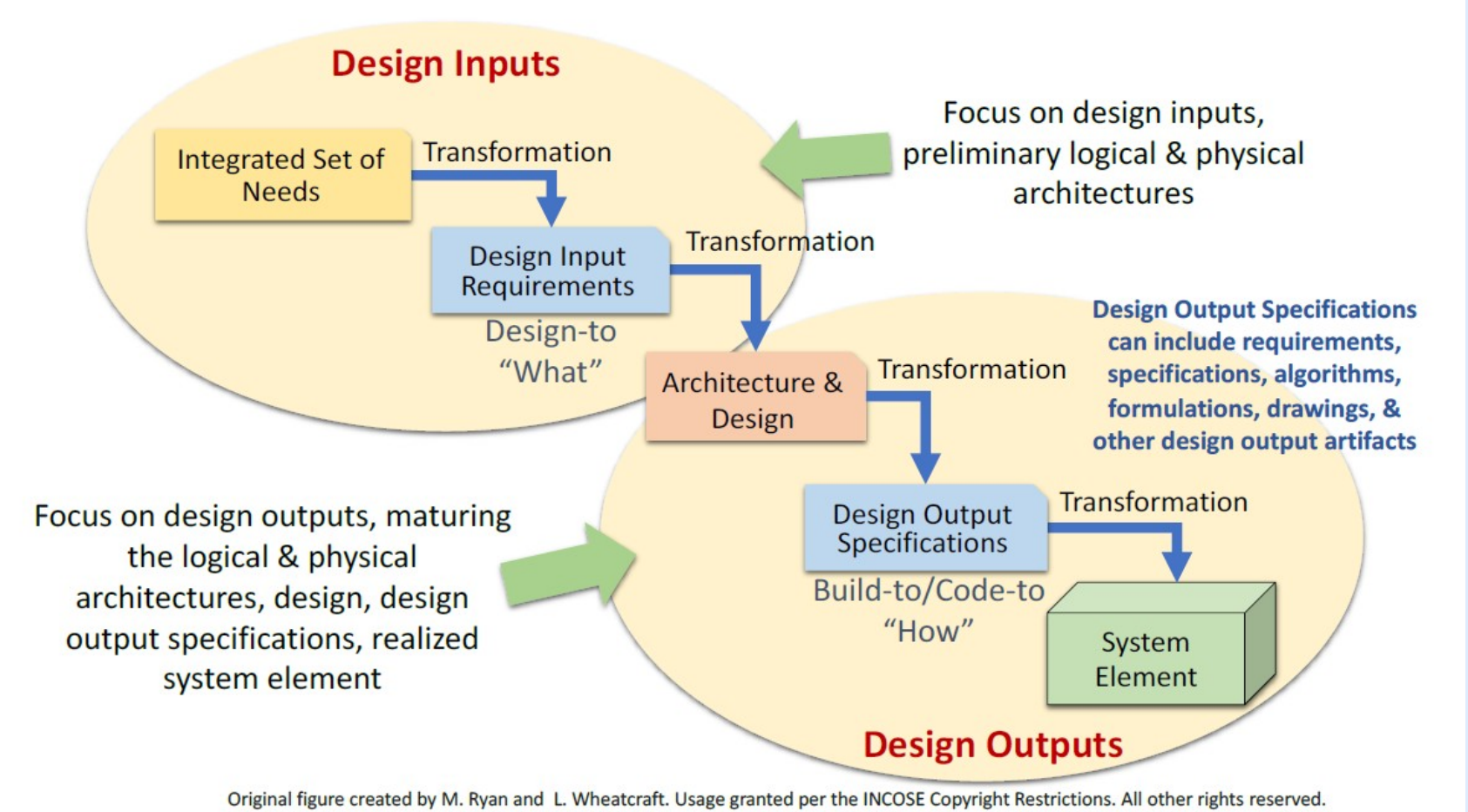


Committed life cycle cost against time (Walden et al., 2015), derived from 1993 Defense Acquisition University (DAU)

- "**Requirements management** is another pervasive mechanism that forces conversation between program managers and chief systems engineers. Effective requirements management practices help program managers and chief systems engineers align their work so that customers receive ideal solutions and desired program benefits, and value is realized for the business" *Rebentisch, E.S. et al, (2017), ISBN 9781119258926,*

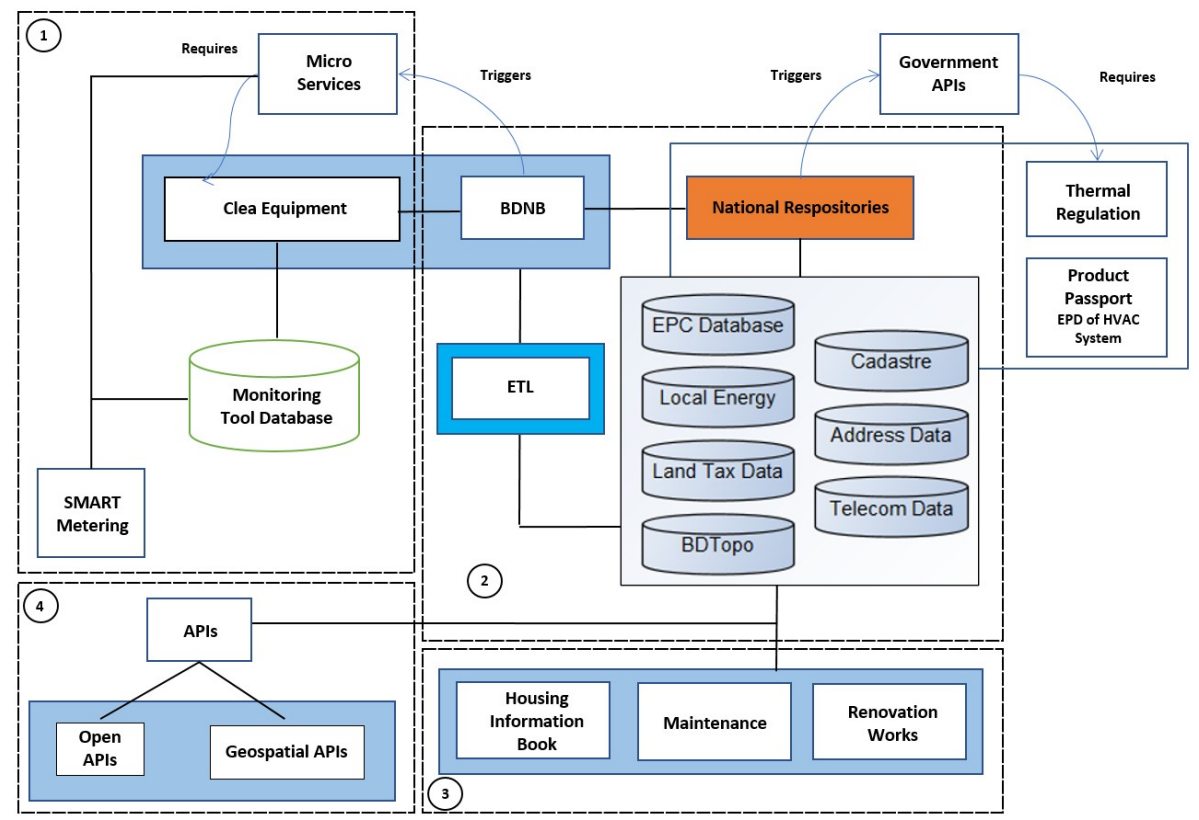
- ***The INCOSE Systems Engineering Vision 2020 (2007) defines MBSE*:** "The formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the [concept stage] and continuing throughout development and later life cycle [stage]" **.**

INCOSE REQUIREMENTS

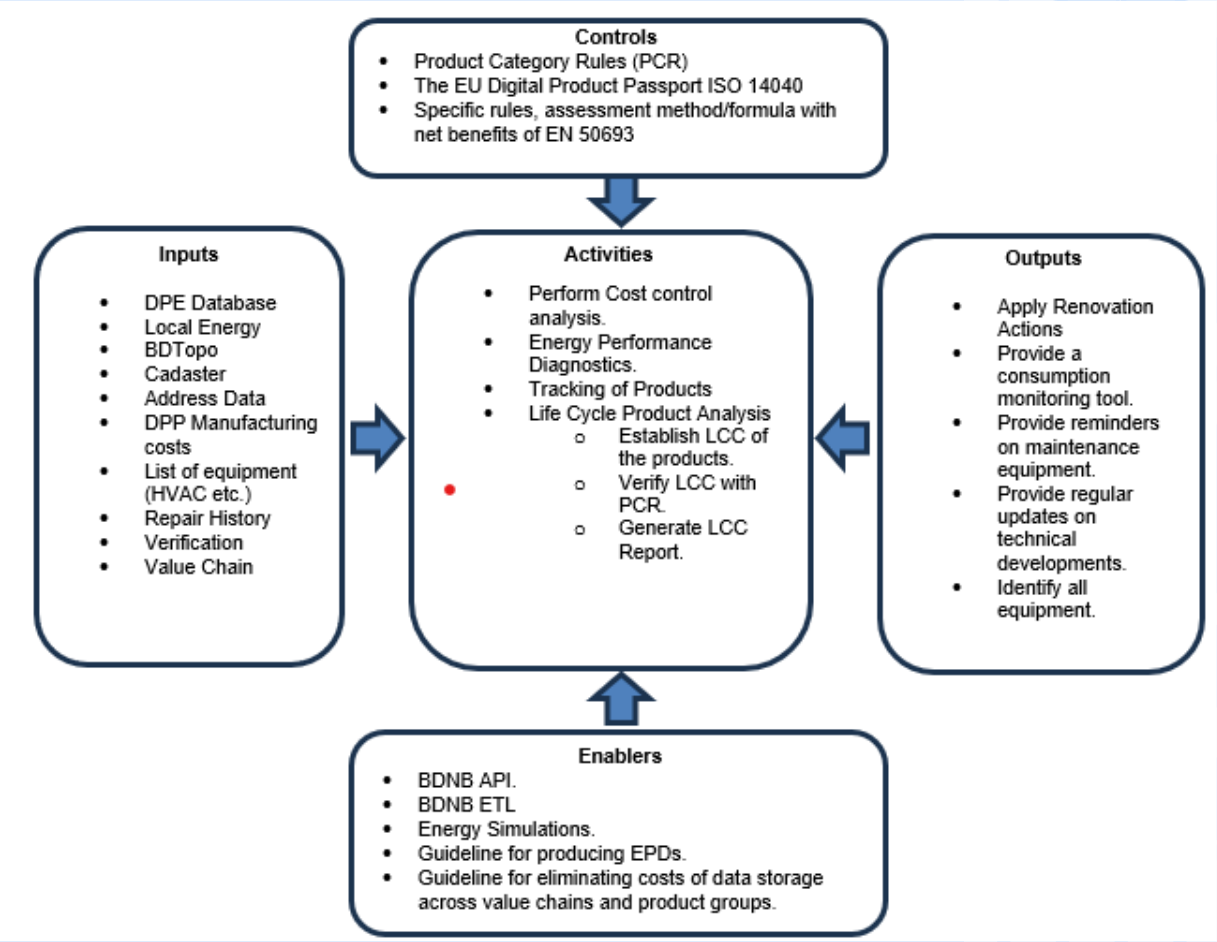


Needs and Requirements in Context (INCOSE Guide to Writing Requirements 1 July 2023)

INTERFACE CONTROL DOCUMENT REQUIREMENTS FOR ENERGY RENOVATION TOOLKIT



CLEA and BDNB interface overview



Input/Output Diagram for Systems Requirements (Energy Renovation Tool)

DIGITAL MODELS

- 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**.

ANSYS BLOG MAY 25, 2022

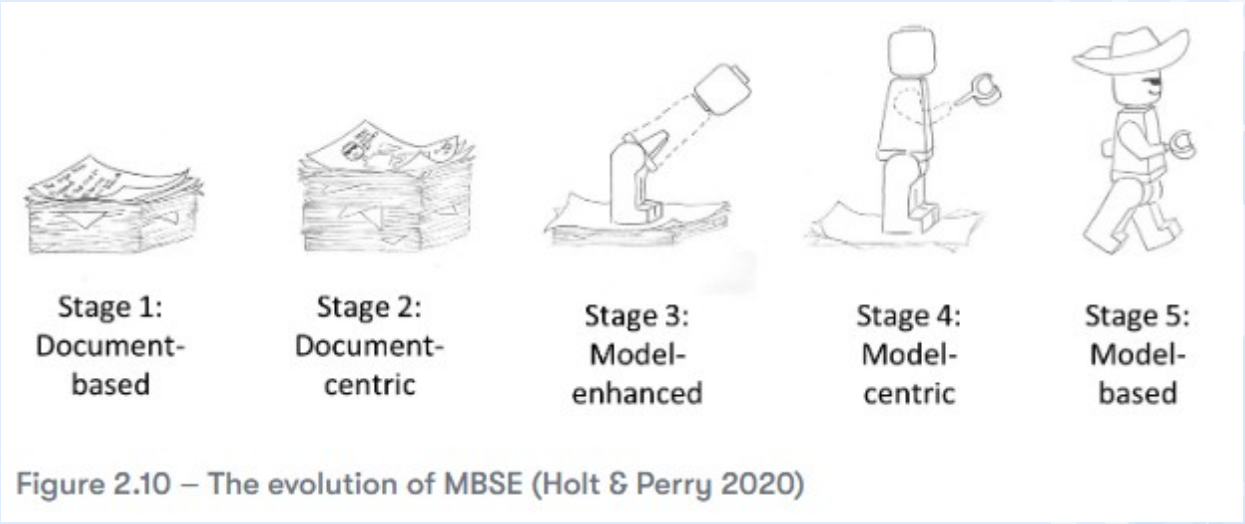
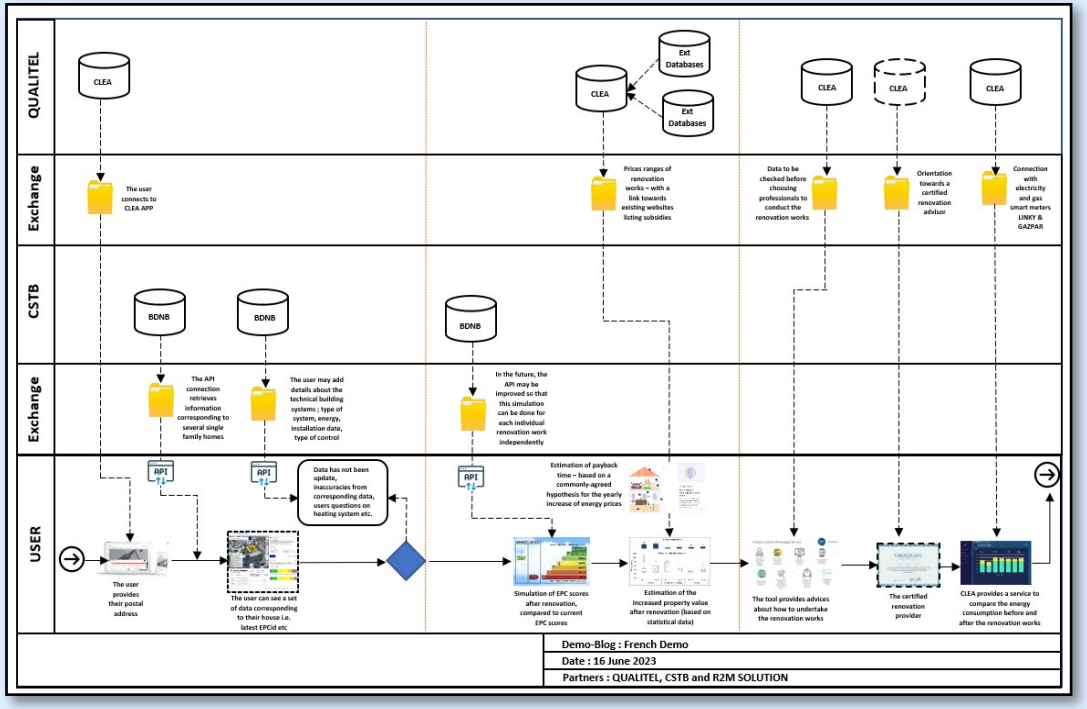
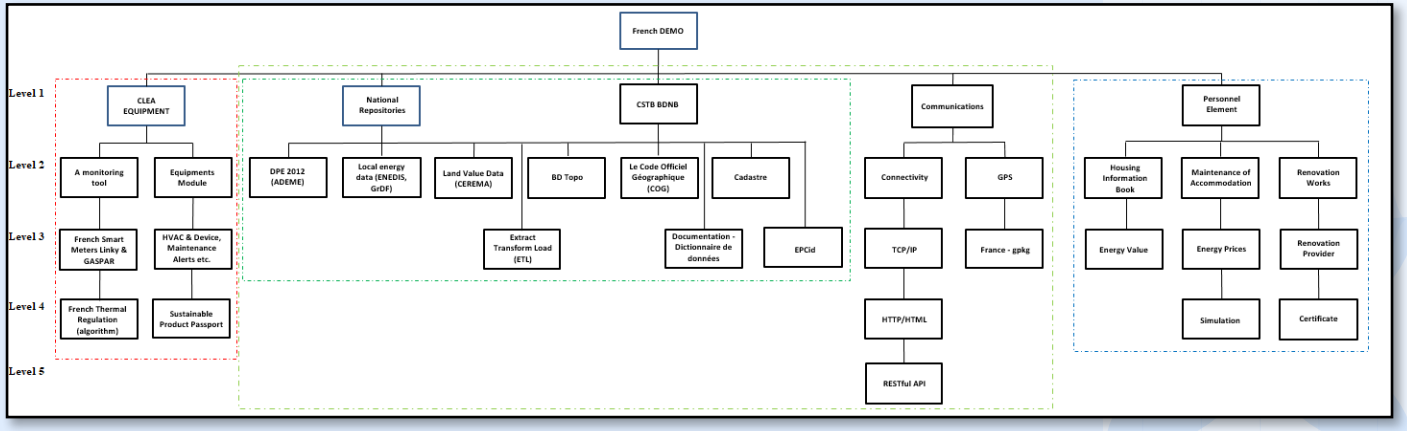


Figure 2.10 – The evolution of MBSE (Holt & Perry 2020)

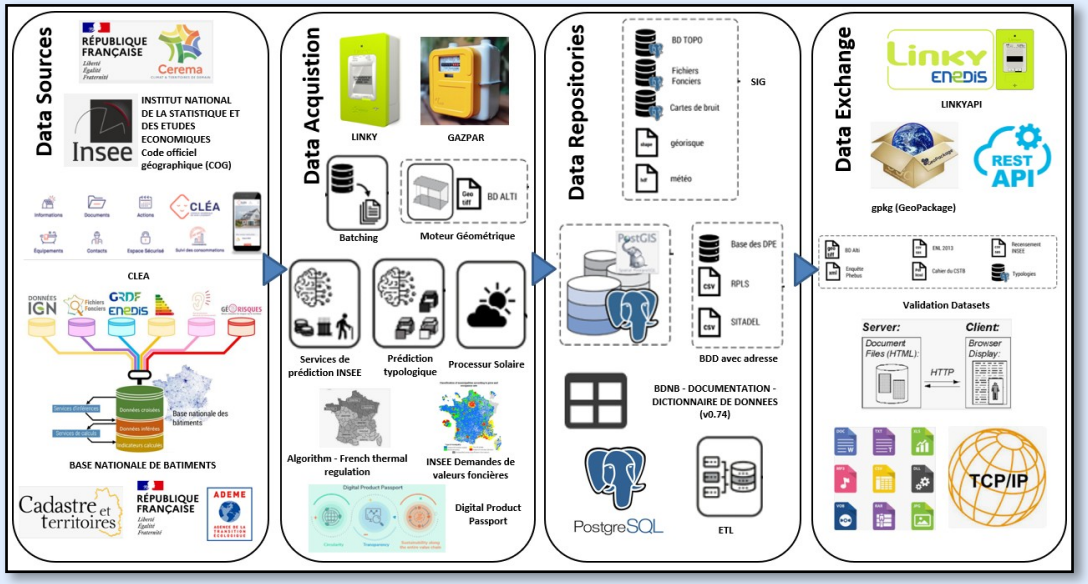
Supporting Efficient Collaboration in engineering 'ARCADIA'



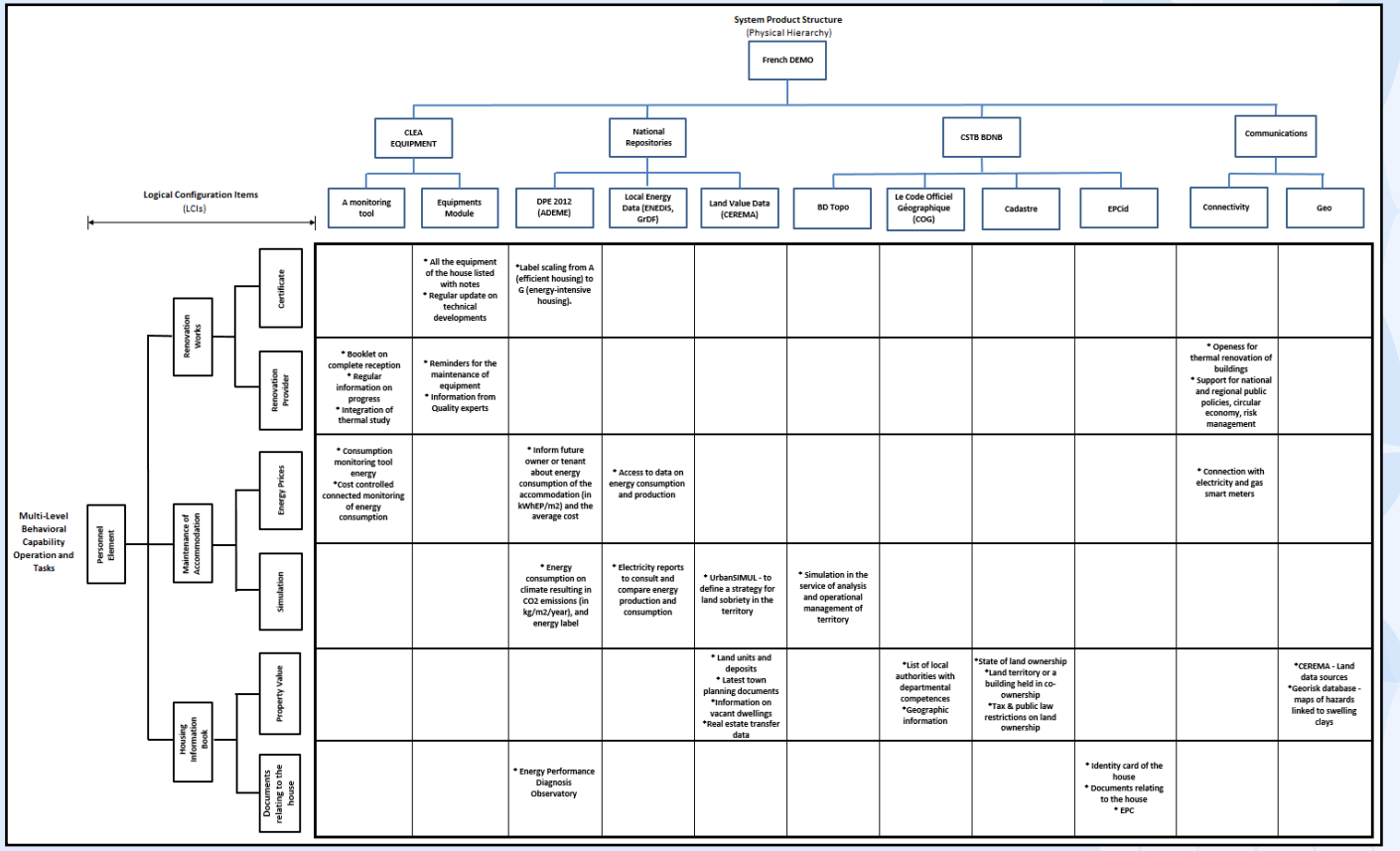
Business Process Map



System Elements



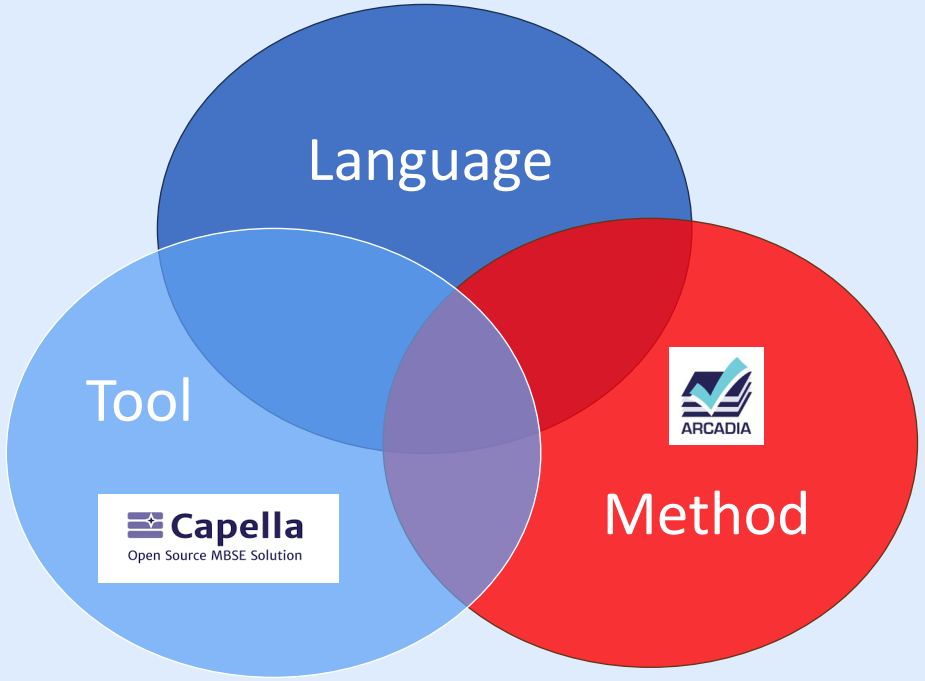
Process Architecture



Capabilities & Requirements

HOW DID I IMPROVE THE SITUATION

OBEO & Thales MBSE Training



Methodology and High level concepts and viewpoints

ARCADIA

Purpose-built to provide the notation and diagrams fitting the Arcadia approach

Capella
Open Source MBSE Solution

	PURPOSE	FUNCTION	BEHAVIOR	STRUCTURE	INTERFACES
OPERATIONAL ANALYSIS Waht the stakeholders need to accomplish	What is the aircraft maintenance operator expecting ?	How and when interactions with stakeholders occur ?	What can go wrong for the aircraft operator ?	Who does it interact with ?	What information is exchanged between aircraft maintenance operator and FAA ?
SYSTEM NEEDS ANALYSIS What the system has to accomplish for the stakeholders	What services shall the system provide ?	What actions are expected from the system from the external entities	What are the operational modes of the system (manual, semi-automated,...)	Who will the system interact with ?	What are the external interfaces of the system ?
CONCEPTUAL ARCHITECTURE How the system will work to fulfill expectations	What is the contribution of the constituents to the services the system shall provide ?	What is to be performed by these components ?	What are the operational modes of a constituant ? Are they consistent with system modes ?	What is the high-level, conceptual decomposition of my system ?	What are the interfaces between these components ?
FINALIZED ARCHITECTURE How the system will be developed and built	How each component contributes to providing the system services ?	What actions are expected to be implemented by the SW team in the next increment ?	How to ensure that the SW and HW constituents are available in a given mode ?	What are the HW and SW components of the system ?	What is the detailed definition of the data the drone will send to the ground station ?

M. Lionel YAPI (THALES GROUP)
M. Martin Le Bourgeois (OBEO)

WORKFLOW STRUCTURE

Workflow of Clea and BDNB Interface

Operational Analysis

Define Stakeholder Needs and Environment

Capture and consolidate operational needs from stakeholders
Define what the users of the system have to accomplish
Identify entities, actors, roles, activities, concepts

System Analysis

Formalize System Requirements

Identify the boundary of the system, consolidate requirements
Define what the system has to accomplish for the users
Model functional dataflows and dynamic behaviour

Logical Architecture

Develop System Logical Architecture

See the system as a white box
Define how the system will work so as to fulfill expectations
Perform a first trade-off analysis

Physical Architecture

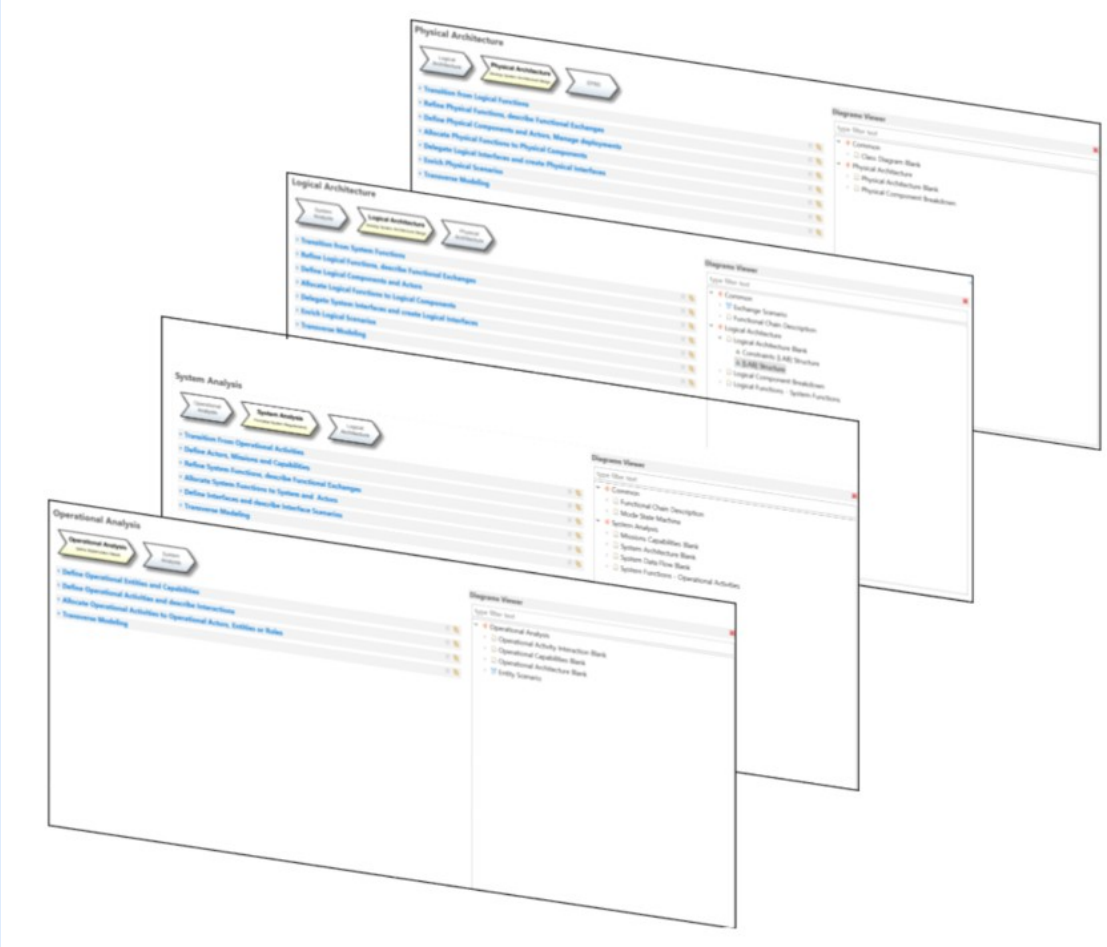
Develop System Physical Architecture

How the system will be developed and built
Software vs. hardware allocation, specification of interfaces, deployment configurations, trade-off analysis

EPBS

Formalize Component Requirements

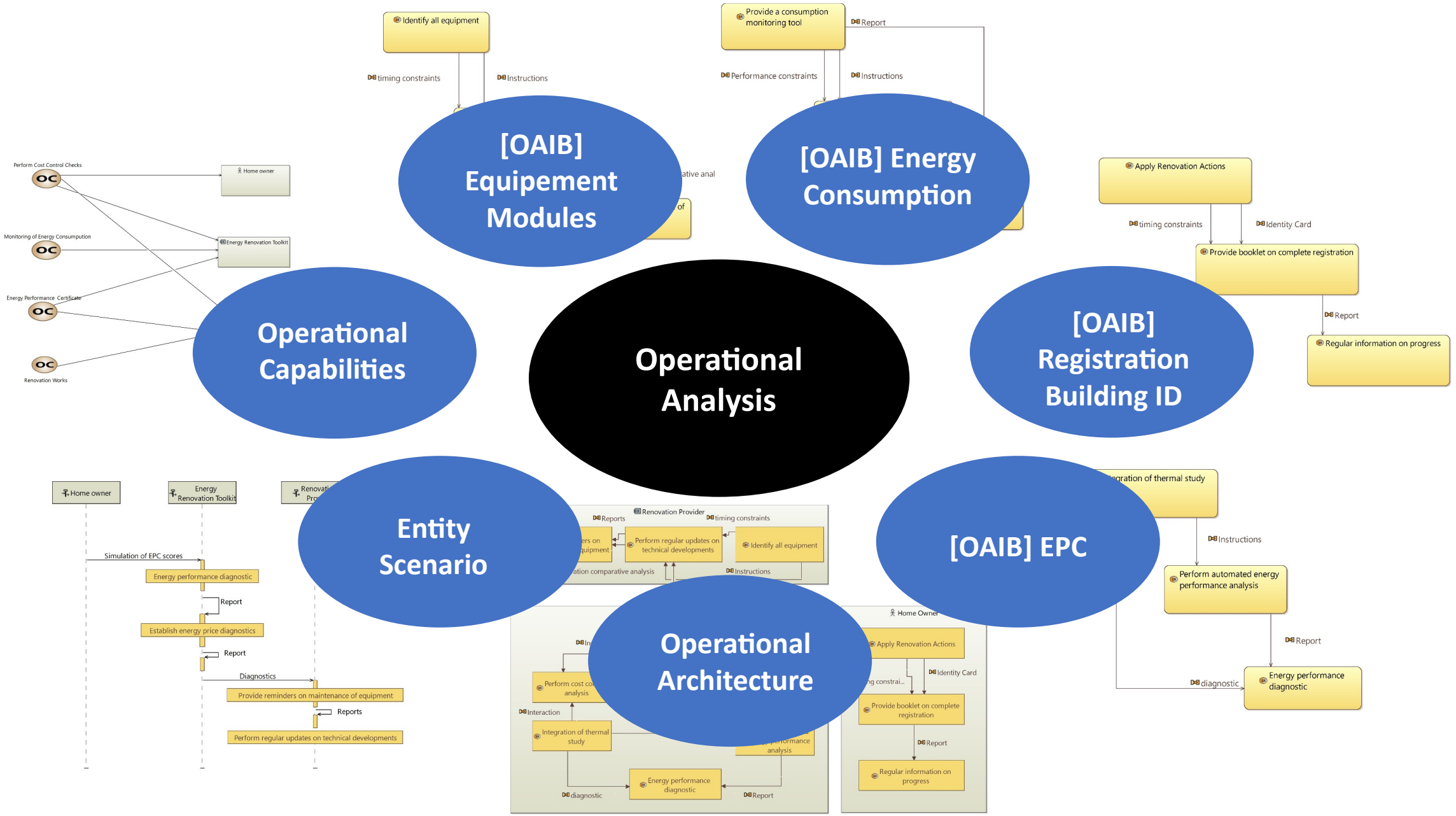
Manage industrial criteria and integration strategy: what is expected from each designer/sub-contractor
Specify requirements and interfaces of all configuration items



OPERATIONAL ANALYSIS
WHAT THE STAKEHOLDERS NEED TO ACCOMPLISH

PURPOSE	FUNCTION	BEHAVIOR	STRUCTURE	INTERFACES
What is the Home Owner expecting for maintenance	What and When interactions occur	What are the challenges (go wrong)	What does it interact with	What information is exchanged between Home Owner and ToolKit and Provider

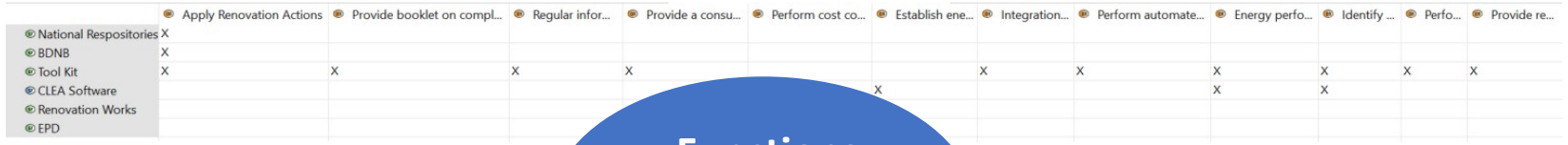
Operational Analysis workflow and main diagrams



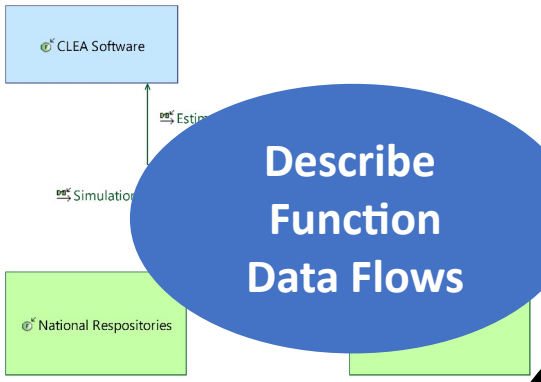
SYSTEM ANALYSIS
WHAT THE SYSTEM HAS TO ACCOMPLISH FOR THE STAKEHOLDERS

PURPOSE	FUNCTION	BEHAVIOR	STRUCTURE	INTERFACES
What Services shall the system provide	What actions are expected from the system by the external entities	What are the operational modes	Who will the system interact with	What are the external interfaces of the system

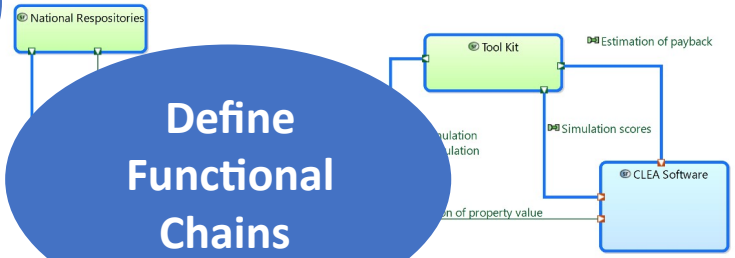
System Analysis workflow and main diagrams



Functions and Traceability

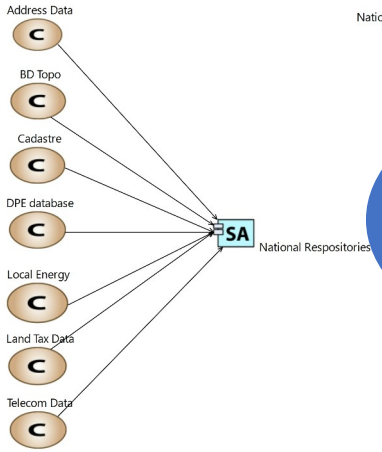


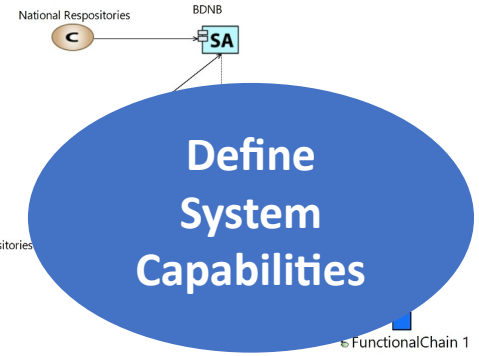
Describe Function Data Flows



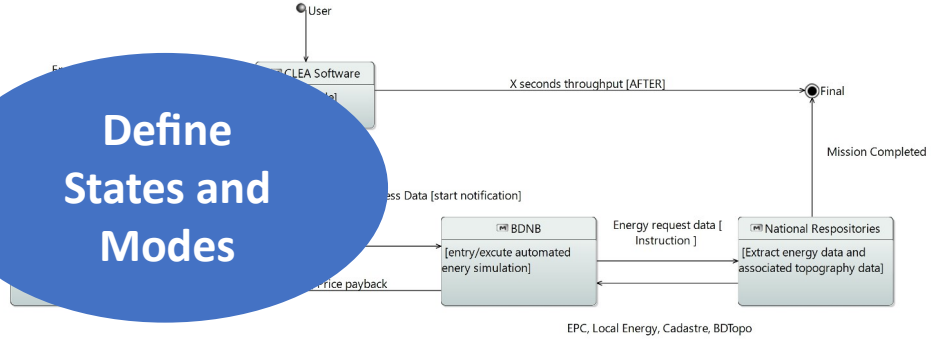
Define Functional Chains

System Analysis

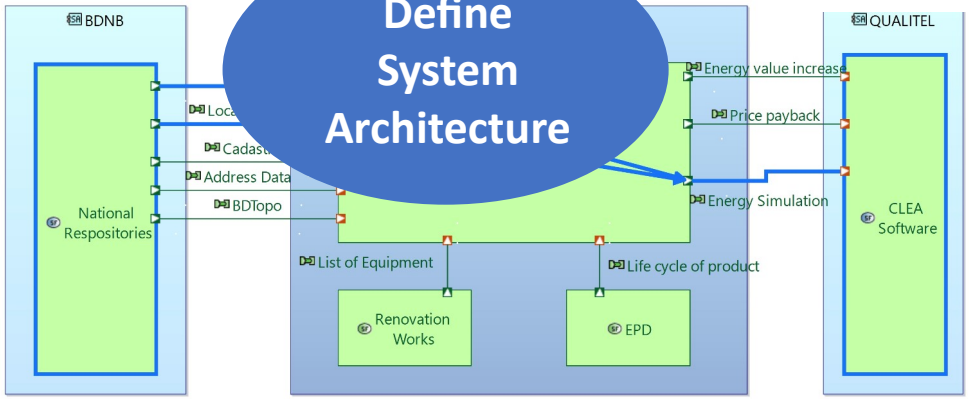




Define System Capabilities



Define States and Modes

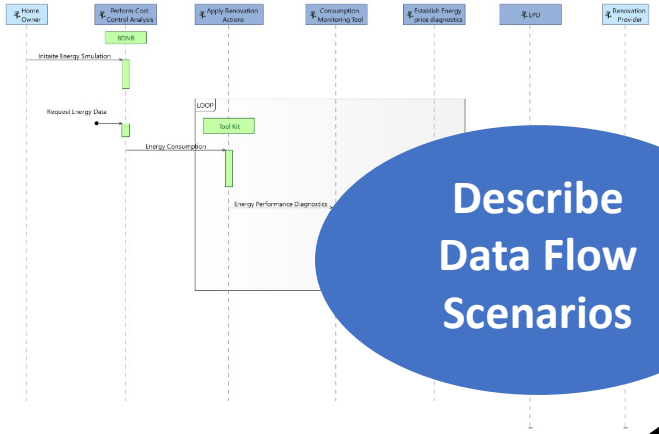


Define System Architecture

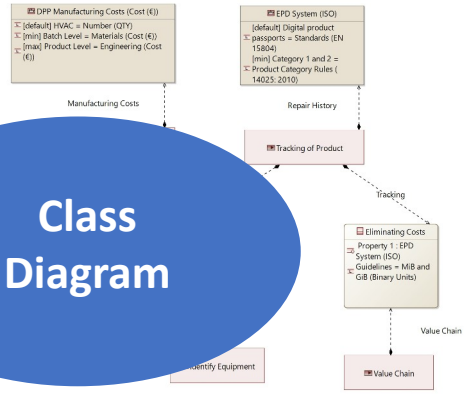
LOGICAL ARCHITECTURE
HOW THE SYSTEM WILL WORK TO FULFILL EXPECTATIONS

PURPOSE	FUNCTION	BEHAVIOR	STRUCTURE	INTERFACES
What is the contribution of the constituent to the services the system shall provide?	What is to be performed by these components?	What are the operational modes of a constituant? Are they consistent with system modes?	What is the high-level conceptual decomposition of my systems?	What are the interfaces between these components?

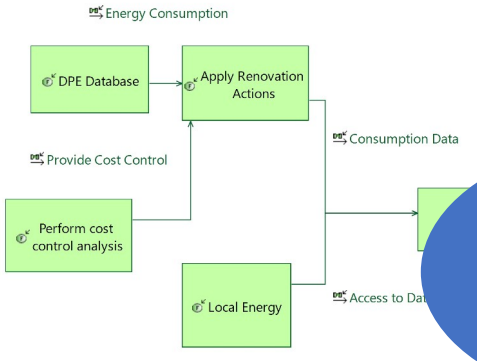
Logical Architecture workflow and main diagrams



Describe Data Flow Scenarios

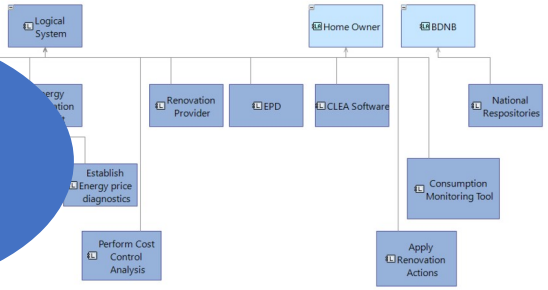


Class Diagram



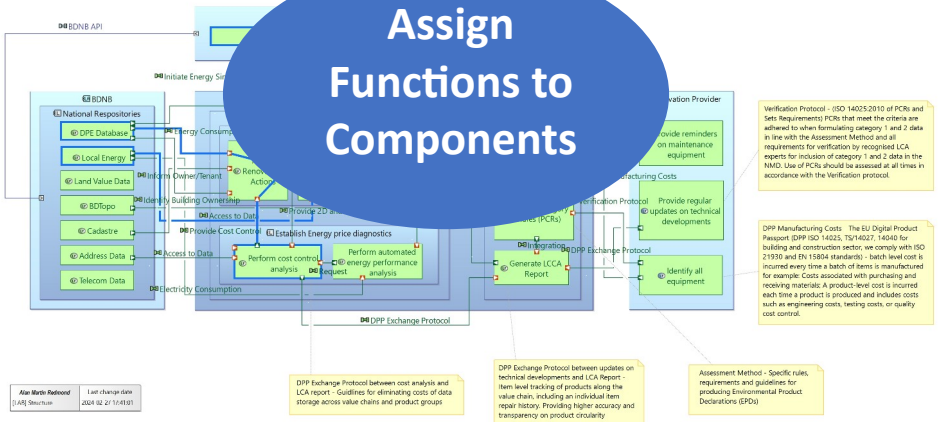
Define Logical Functions

Logical Architecture



Refine Logical Functions

Assign Functions to Components

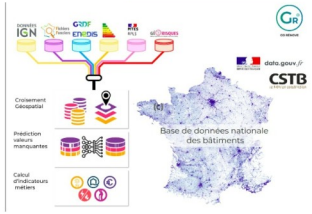


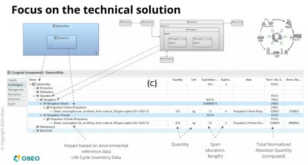
LOGICAL ARCHITECTURE COLLABORATION MODEL

FunctionalChain 1

Name	Last change date
Constraints [LAB] Structure	2024-02-12 09:55:09
Alan Martin Redmond	Logical Architecture BDNB et CLEA

BDNB API





Home Owner

CLEA Software

Provide Price Payback

Life Cycle Product Analysis

Initiate Energy Simulation

Identify Propert Value Increase

Start Notification

BDNB

National Respositories

DPE Database

Local Energy

Land Value Data

BDTopo

Cadastre

Address Data

Telecom Data

Energy Consumption

Inform Owner/Tenant

Identify Building Ownership

Access to Data

Provide Cost Control

Access to Data

Electricity Consumption

Logical System

Energy Performance

Energy Renovation Toolkit

Energy performance diagnostics

Consumption Data

Integration

Apply Renovation Actions

Provide a consumption monitoring tool

Thermal Study

Assessment Method

Provide 2D and 3D Modeling

Automated Instruction

Establish Energy price diagnostics

Perform cost control analysis

Request

Perform automated energy performance analysis

DPP Exchange Protocol

EPD

Establish an LCC of the products

DPP Exchange Protocol

DPP Manufacturing Costs

Verify LCCA with Product Category Rules (PCRs)

Verification Protocol

Integration

DPP Exchange Protocol

Generate LCC Report

Renovation Provider

Provide reminders on maintenance equipment

Provide regular updates on technical developments

Identify all equipment

Verification Protocol - (ISO 14025:2010 of PCRs and Sets Requirements) PCRs that meet the criteria are adhered to when formulating category 1 and 2 data in line with the Assessment Method and all requirements for verification by recognised LCA experts for inclusion of category 1 and 2 data in the NMD. Use of PCRs should be assessed at all times in accordance with the Verification protocol.

DPP Manufacturing Costs - The EU Digital Product Passport (DPP ISO 14025, TS/14027, 14040 for building and construction sector, we comply with ISO 21930 and EN 15804 standards) - batch level cost is incurred every time a batch of items is manufactured for example: Costs associated with purchasing and receiving materials; A product-level cost is incurred each time a product is produced and includes costs such as engineering costs, testing costs, or quality cost control.

(c) Extract, Transform, Load

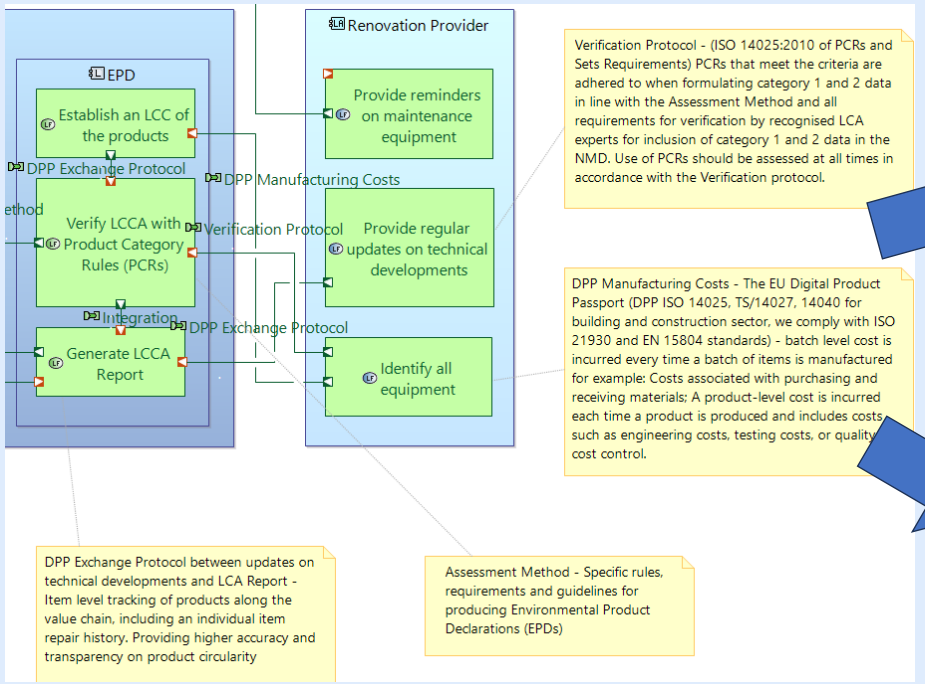
Produce a replicable model for energy efficiency retrofits of existing buildings

DPP Exchange Protocol between cost analysis and LCC report - Guidlines for eliminating costs of data storage across value chains and product groups

DPP Exchange Protocol between updates on technical developments and LCC Report - Item level tracking of products along the value chain, including an individual item repair history. Providing higher accuracy and transparency on product circularity

Assessment Method - Specific rules, requirements and guidelines for producing Environmental Product Declarations (EPDs)

THE ENVIRONMENTAL PERFORMANCE FOR CONSTRUCTION WORKS



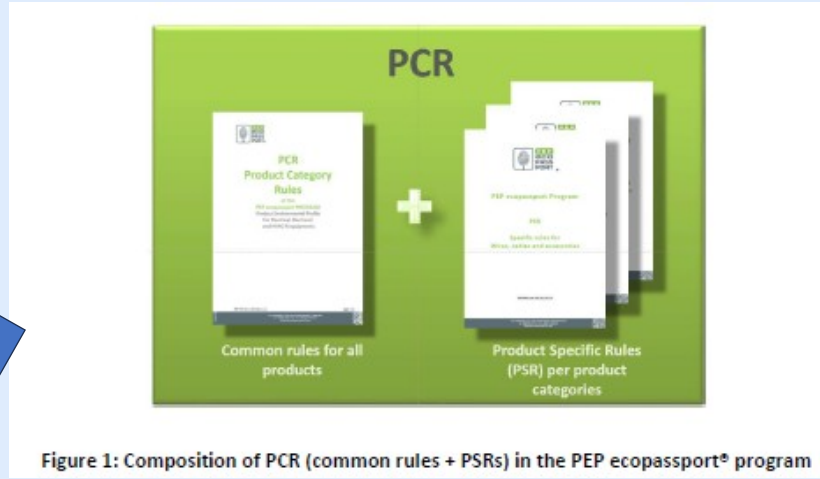
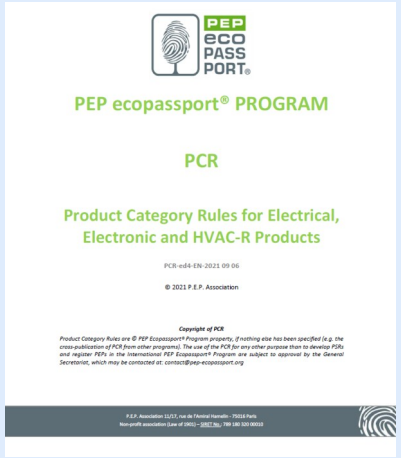


Figure 1: Composition of PCR (common rules + PSRs) in the PEP ecopassport® program



Appendix B: Diagram of the system boundaries for the LCA

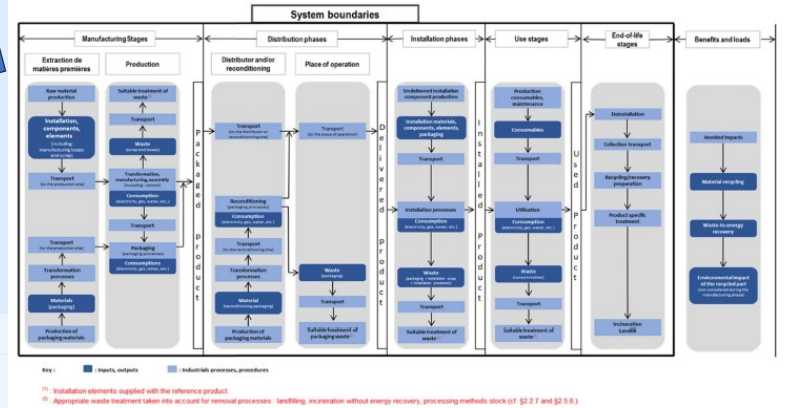


Figure 3: System boundaries according to PCR edition 4.0

PEP-PCR–ed4-EN-2021 09 06 Page: 58/78

Appendix C: Specificities for the Product Environmental Profile within the French regulatory framework[26]

C.3) LCA REPORT

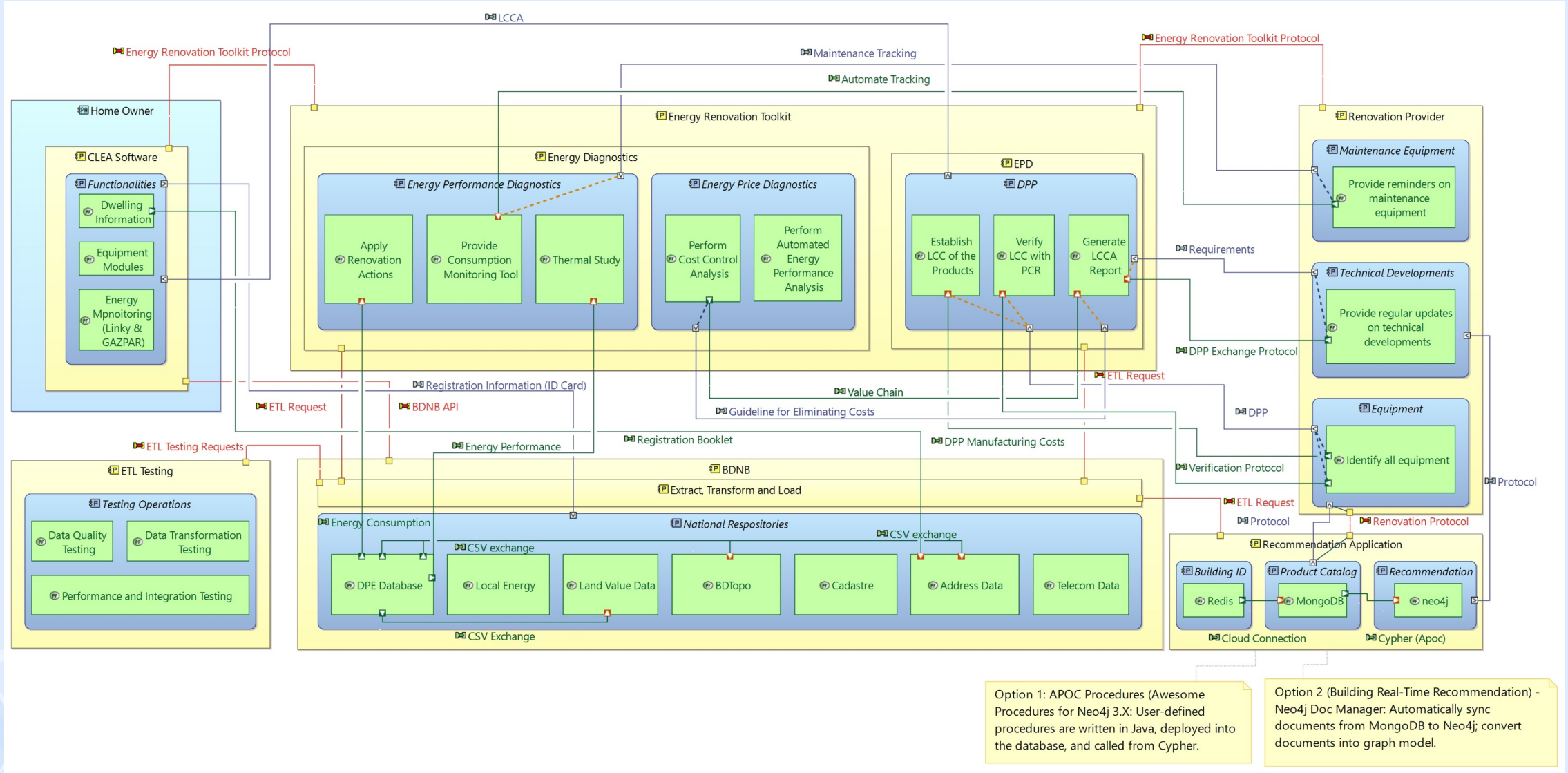
Complementary to information mentioned in Chapter 3, the PEP LCA report shall contain the following information so they could be delivered to PEP ecopassport® program or any administrative authority, or their representative, in charge of auditing and control:

- Raw materials, materials and product components origins,
- Identification of non-included inputs in life cycle inventory according the cut off rules,
- Total weights of non-included inputs in life cycle inventory according to cut-off rules,
- Life cycle inventory calculations results,
- Justification of product reference service life,
- For secondary data based on public or private database: documentation on technology, geography and time representativeness, database references and datasets references,
- Life cycle inventory scenarios,
- Manufacturing sites covered by the EPD,
- For each site: unitary production defined within the functional unit,
- If a sampling method was used: justification of sample technology, geography and time representativeness,
- Validity framework information for the declaration of a joint EPD (see appendix A),
- Information of parametrized declaration (see Chapter 2.6).

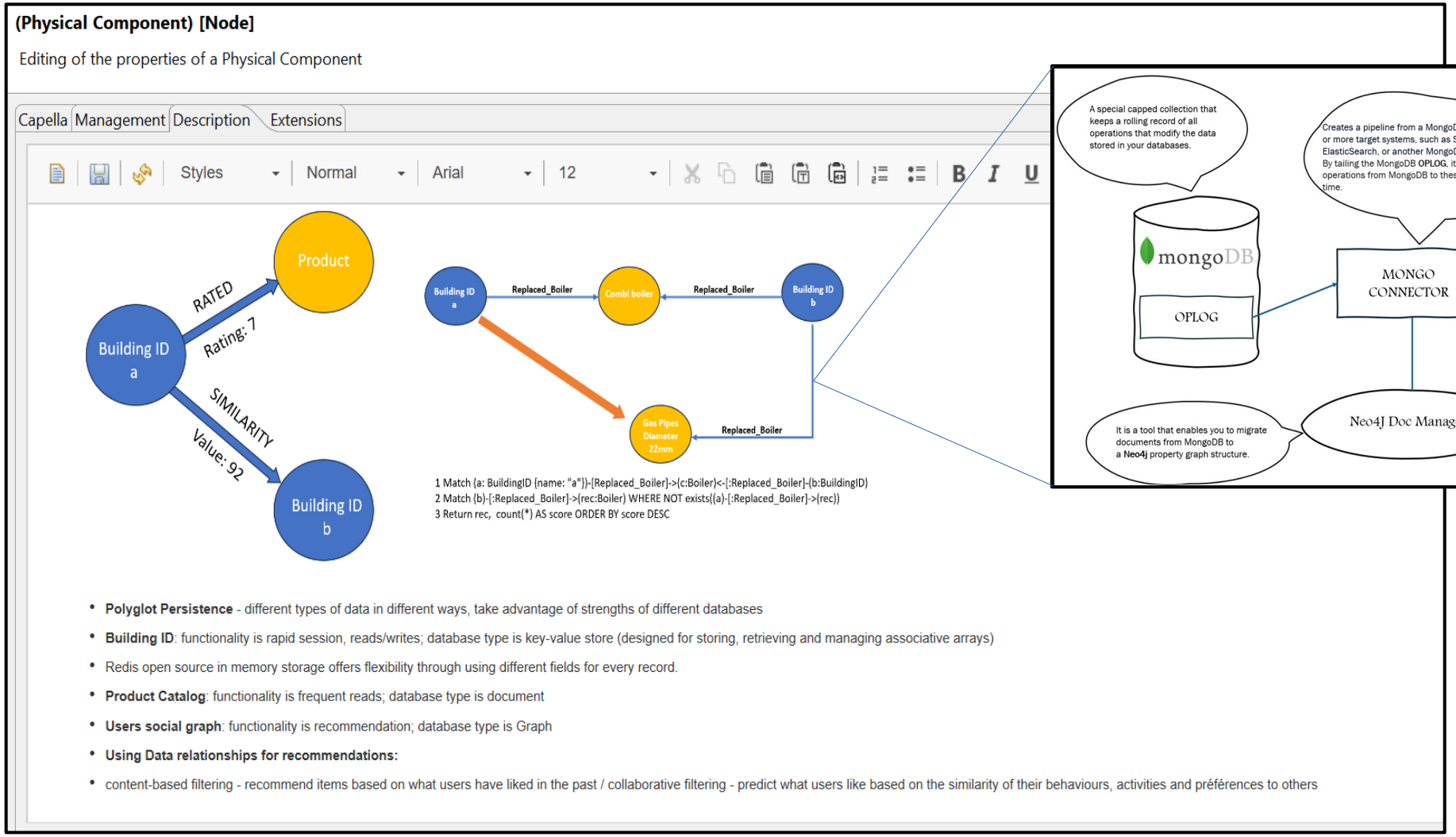
FRENCH DEMO REQUIREMENTS

1.1	Information Exchange (Files and Data)
1.1.1	The Energy Renovation Toolkit shall provide a mechanism and interfaces for CLEA software to connect with BDNB dataset allowing a technical characterisation of existing buildings. Reminder, the BDNB is the merging of national repositories (EPCs for example), data-crossing algorithms and CSTB energy simulation tool.
1.1.2	CSTB shall facilitate the exchange mechanism between the USER via CLEA Software and BDNB with secure access, reception, and registration of requests linked by BDNB RESTful APIs. The required open data databases (Building-ID, National address base, Cadastre, BD Topo, Official geographic code, DPE 2012, Local energy data) of the BDNB shall be interconnected by CSTB ETL.
1.1.3	The exchange mechanism shall also facilitate the calculation indicators of performance for energy simulations diagnostics, and access to registered EPC data.
1.1.4	The CLEA Software shall provide the Energy Renovation Toolkit with RESTful API access to LINKY ENEDIS and GAZPAR GRDF data streams. They are respectively the electricity and gas national network providers and handle real hourly energy consumption at deliver point (generally at dwelling scale)
1.1.5	The CLEA Software shall provide a mechanism and interfaces for Energy Renovation ToolKit to supply the renovation provider with access to submit the required data files for the Housing Information Book, and centralization storage of information and documents: commercial proposal, plan sketch, project, contract and descriptive notice, plan layout, and experts' advice (LCC). Typically, Automatic completion of key information exchanges shall be provided.
1.1.6	The exchange mechanism shall also facilitate exchange of data (XML files) for the integration of the thermal study and consumption monitoring tool provided by CERQUAL
1.1.7	The CLEA Software shall provide a mechanism and interfaces for Energy Renovation ToolKit to supply the client with open access to submit the required data files for the House maintenance, and A pre-existing library of equipment to customize (regular update in depending on technical developments).
1.1.8	The exchange mechanism shall also facilitate a user-interface to retrieve data from cadaster provided by BDNB API to obtain general dwelling information. Typically, equipment modules (user guides for HVAC & devices, maintenance alerts) shall be provided.
1.2	**Information from other sources**
1.2.1	Information provided by the renovation provider on identified equipment prior to installing shall be referenced to The EU Digital Product Passport DPP ISO 14040 and EN 15804 standards for batch and product level costs and exchanged as part of the EPD to establish an LCA of the products.
1.2.2	Information provided by the renovation provider on regular updates on technical developments shall be verified by ISO 14025:2010 of PCRs Set requirements that adhered to formulating category 1 and 2 data in line with the assessment method of all requirements for verification by recognized LCA experts for inclusion of category 1 (in relation to EN 15804) and 2 (in relation to EN 15804/A2:2019) data in the National Environmental Database .
1.2.3	Information provided to the EPD system shall be managed by CLEA and exchange protocols for generating LCA reports and inputs to perform cost control analysis.

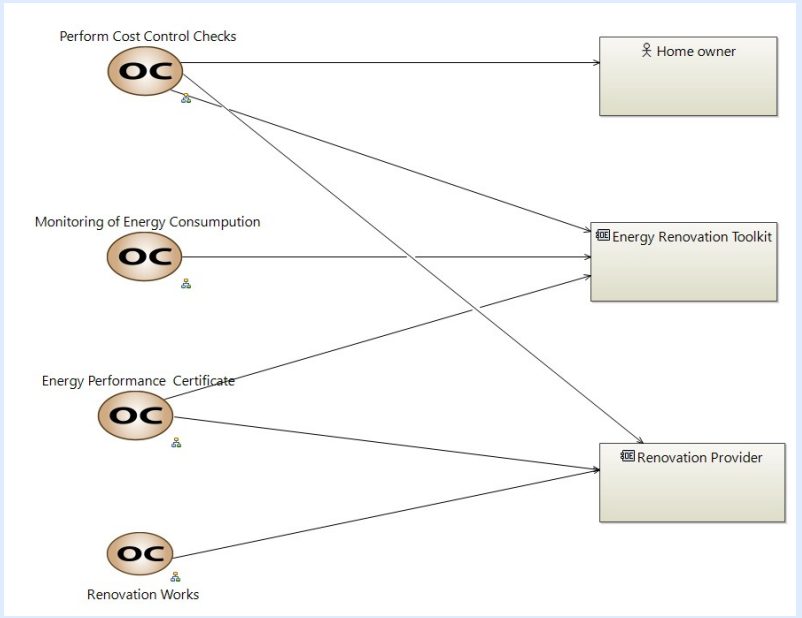
PHYSICAL ARCHITECTURE (DEVELOP SYSTEM ARCHITECTURAL DESIGN)

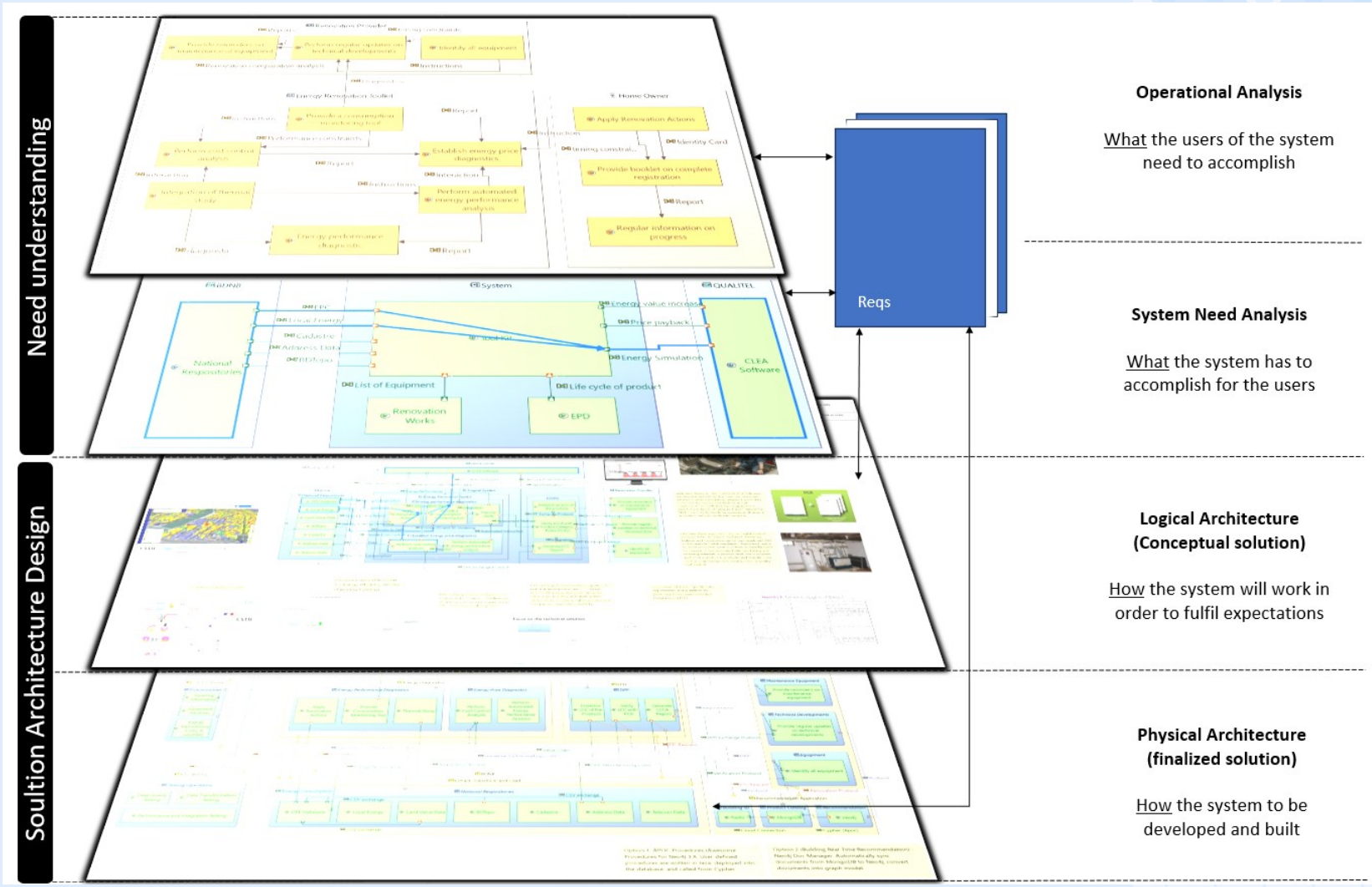


Building Real-Time Recommendation Application



MBSE – THE ARCADIA PERSPECTIVES





SUMMARY/RESULTS

Benefits Listed	Benefits Experienced on the Demo Blog Project
Improved communications	Not just among the BDNB team at **CSTB** (Mathieu THOREL) and the **QUALITEL** (Bertrand LECLERCQ)team but also with **Energy Saving Trust** (Sean LEMO) from the UK and their DBL Chimni – as their demonstration is also related to automated renovation advice and EST leads the deliverable associated with T1.1.3
Increased ability to manage system complexity	The workflows (Operational Analysis, System Ananlysis, Logical Architecture, and Physical Anaylsis) were essential to the creation of the requirements and The Interface Control Dcument. The step by step process which enabled transition from levels referring to needs of understanding to Solution Architecture design enabled the systems to be viewed from multiple perspectives.
Improved product quality	The ability to create a holistic model that incorporated all of the intergrated components while also allowing atomic sections to be analysed individually provided completeness. Furthermore, the models ability (intelligence) to recognise the previous levels information such as connections of components to functions and exchange items provided consistency and correctness.
Reduced Recycled Time	The opportunity to establish an early baseline featuring what the users of the system need to accomplish and what the system has to accomplish for the system, enabled a rapid impact analysis, design reuse (transition to levels) such as identifying the different levels of requirements for the renovation toolkit. This method presented early design decisions and discovery of potential errors.
Reduced Risk	The ability to discuss the design with the Senior Data Scientist at CSTB (for 'single responsibility') provided clarification of the surfacing requirements and design issues earlier in the process. For example; Version II of the ICD was very detailed at an early stage of the process.
Enhanced knowledge capture and reuse of the information	The three pillars associated with Capella – Arcadia (the tool, the language, the methodology) and the accompanying methods of Object Oriented Systems, Engineering Method (OOSEM) and that of M. Lionel YAPI (THALES GROUP), helped to capture the knowledge and determine the focus of resources to address the challenges, the stakeholders needs, the interfaces and the Architectural analysis.
Improved ability to teach and learn SE fundamentals	In essence the use of: Arcadia - Methodology and High level concepts and viewpoints and Capella - The purpose-built tool to provide the notation and diagrams fitting the Arcadia approach, was a rewarding learning experience for me and certainly added value to the project and highlighted the need for SE fundamentals.

CASE STUDY 2 – HORIZON EUROPE PROPOSAL

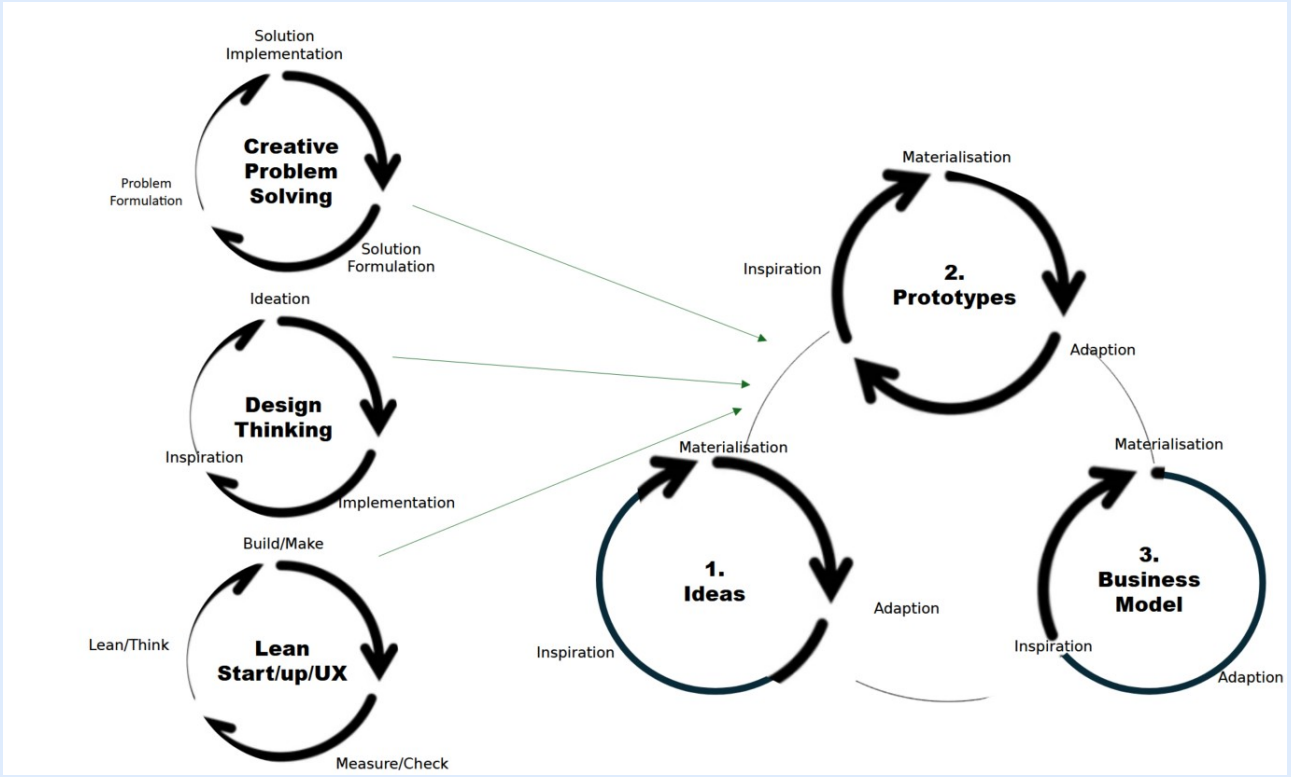
‘Design for adaptability, re-use and deconstruction of buildings, in line with the principles of circular economy (Built4People Partnership)’ will illustrate how MBSE helped design a federated enterprise architecture concept focusing on Circular Systemic Solutions and its ability to integrate different value chains and regions, that enhance overall system resilience.

F6S network partner

No.	Participant legal name	Shortname	Country	Type
1	F6S Network Ireland Limited	F6S	IE	Global Innovators Network
2	Associacao para O Polo Das Technologias 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 Technologico Da Ceramica E Do Vidro	CTCV	PT	RTO
7	NEOECO Development	Neo-Eco	FR	SME
8	Institutul Național de Cercetare-Dezvoltare In 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

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

https://www.horizon-europe.gouv.fr/horizon-europe-c-est-quoi-24104



Creative Problem Solving

Ideate – Develop-Implement-Clarify

SYSTEMS ENGINEERING PRINCIPLES

PRINCIPLE 1:

Systems engineering in application is specific to stakeholder needs, solution space, resulting system solution(s), and context throughout the system life cycle.

DESCRIPTION: This is the first and foundational statement on systems engineering. The product (system) and its operational environment drive systems engineering and the system integrating physics, logic, and social and cognitive relationships (context) that are foundational to the specific product or system. Essential to this is the understanding of the mission or use of the product as formulated by the product goals. This includes the aspects of the system needed to operate in an elegant manner and thus considers the entire product life cycle.

INCOSE – INTERNATIONAL COUNCIL ON SYSTEMS ENGINEERING

HORIZON-CL5-2024-D4-02-04

- The call is relevant for cities and regions that are looking to develop a circular systemic solutions in the construction and building sector;
- and that are looking to integrate innovative tools, products and techniques;
- for enabling construction and renovation that embeds the principle of extending the service life of buildings;
- And facilitating adaptability to changing user needs, reuse, and deconstruction, in a life-cycle optimization and circular economy perspective;
- To achieve this, projects should involve local and regional value chains, in particular SMEs, based on participatory approaches to increase innovation buy-in from users and flexibly adapt to local/regional sourcing of innovative products and materials to increase replication.

SYSTEM LIFE-CYCLE PROCESS

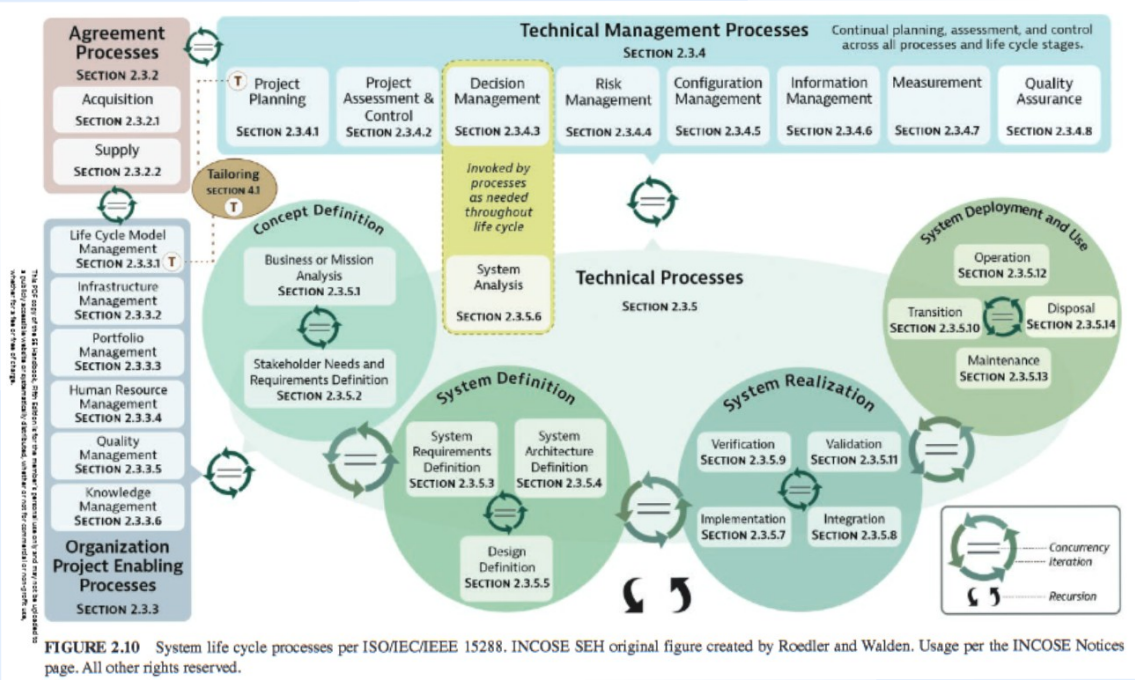
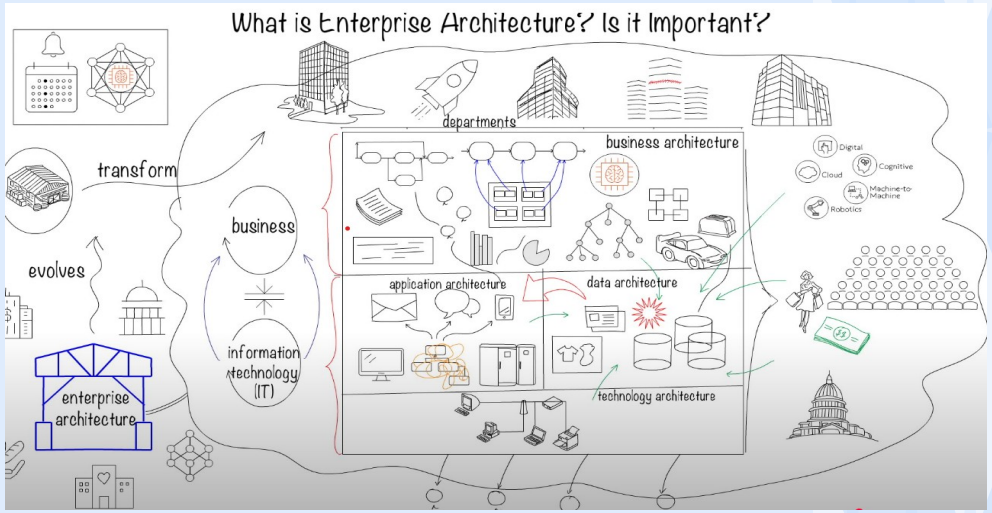


FIGURE 2.10 System life cycle processes per ISO/IEC/IEEE 15288. INCOSE SEH original figure created by Roedler and Walden. Usage per the INCOSE Notices page. All other rights reserved.

Step 1 – Business or Mission Analysis

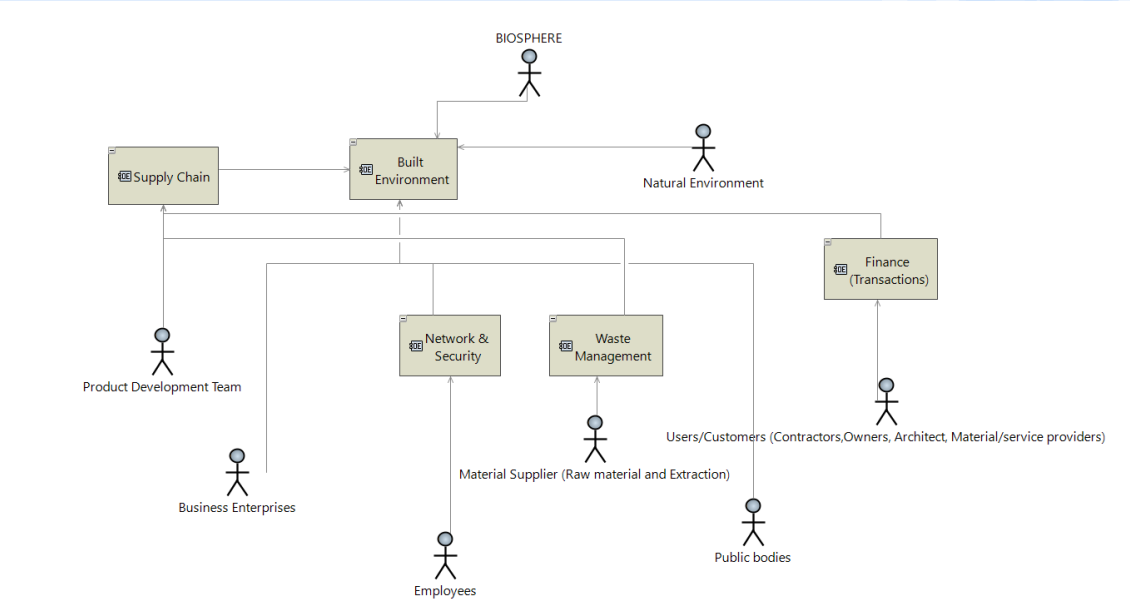
Step 2 – Stakeholders Needs & Requirements Definition

Step 1 - Enterprise Architecture

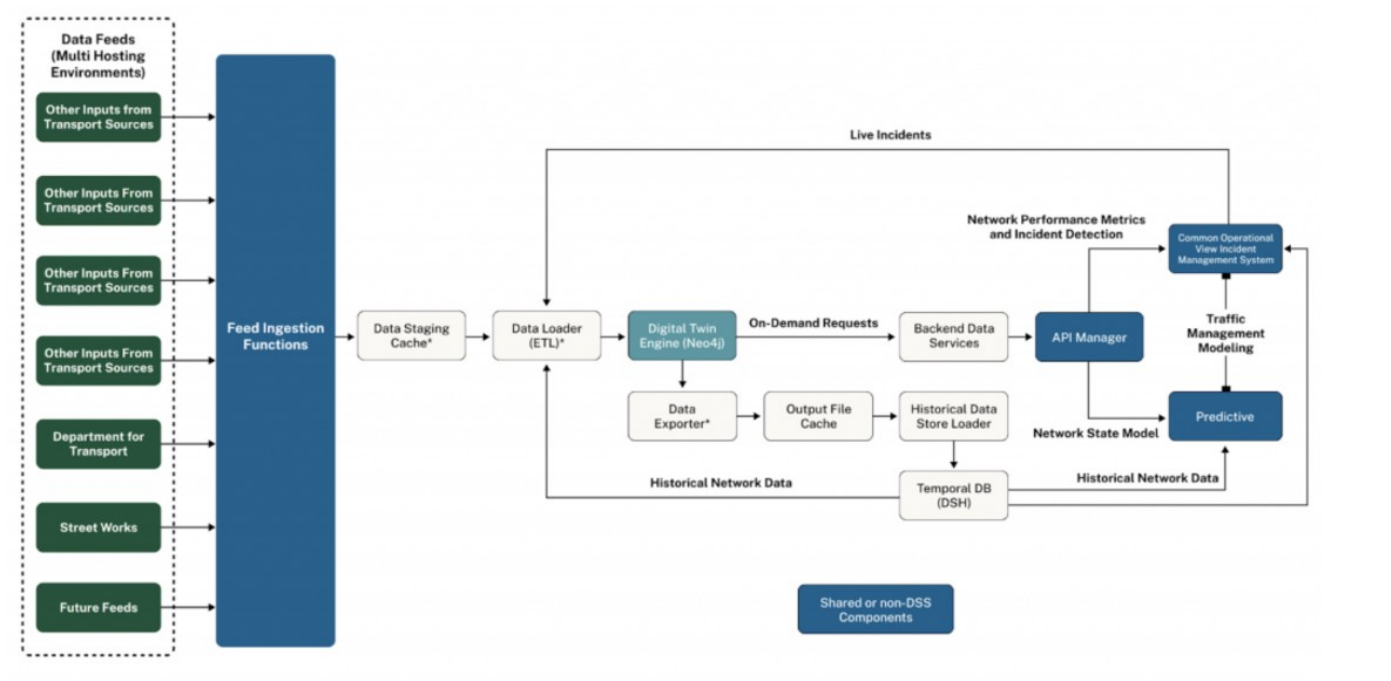


https://www.youtube.com/watch?v=9TVc32M_gIY (Dr. Raj Ramesh)

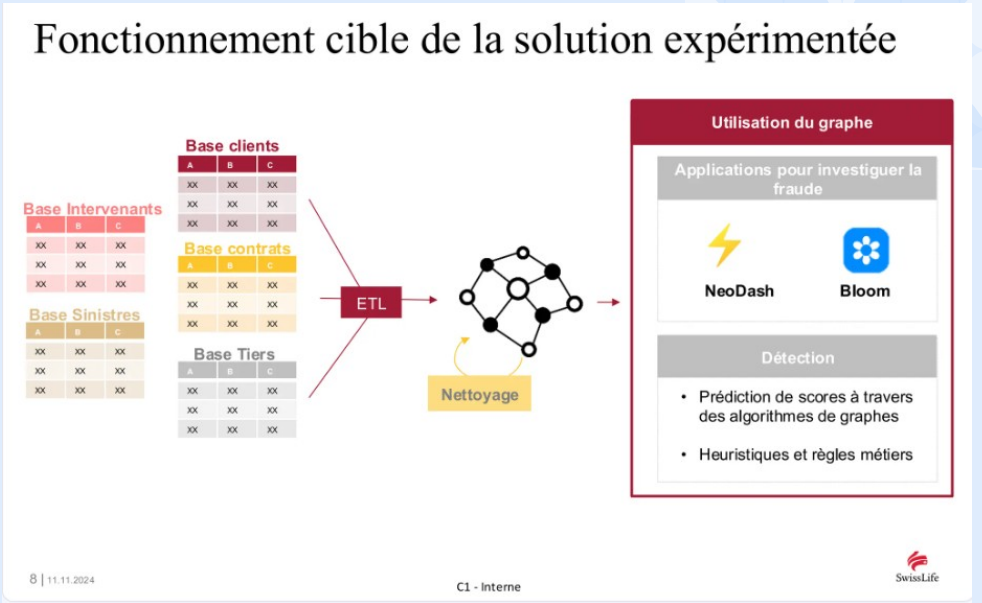
Step 2 – Stakeholders Needs & Reqts (capella)

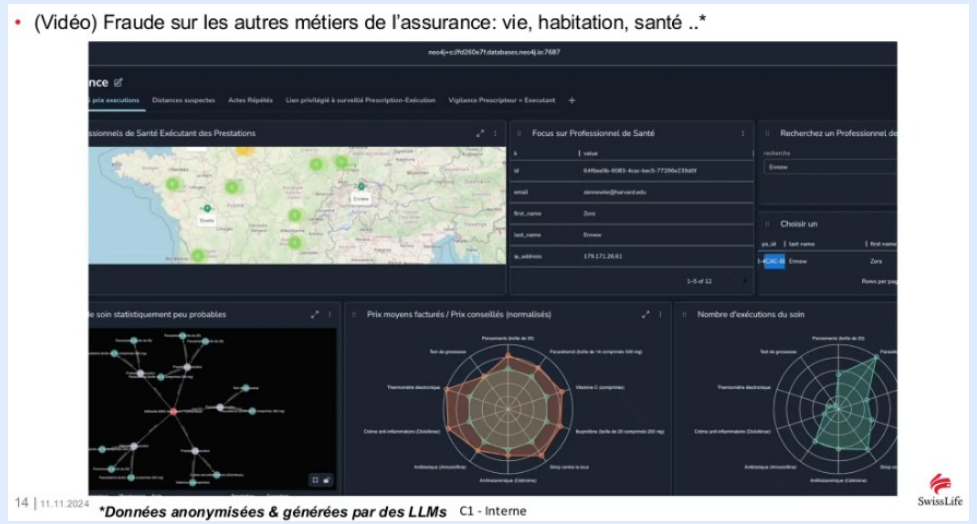


STATE OF THE ART - GRAPH TECHNOLOGY & CASE STUDIES



Using Graph to Power a Digital Transport Twin
https://neo4j.com/case-studies/transport-for-london

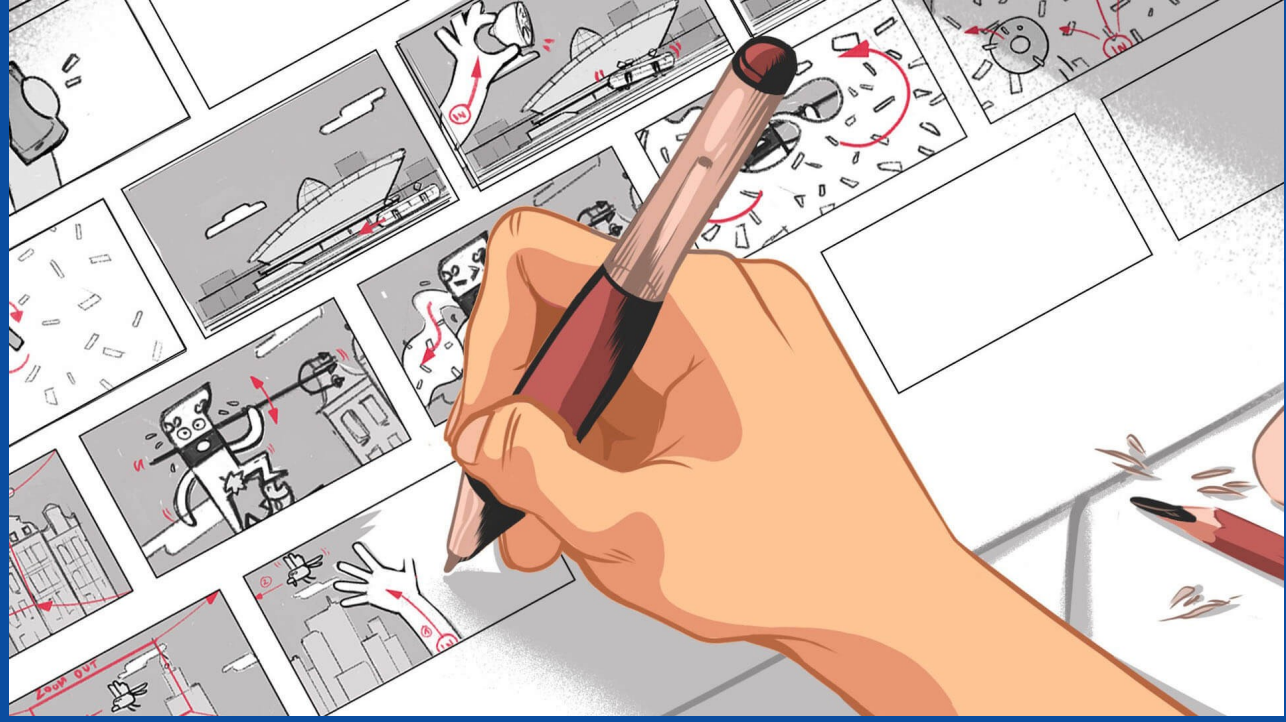


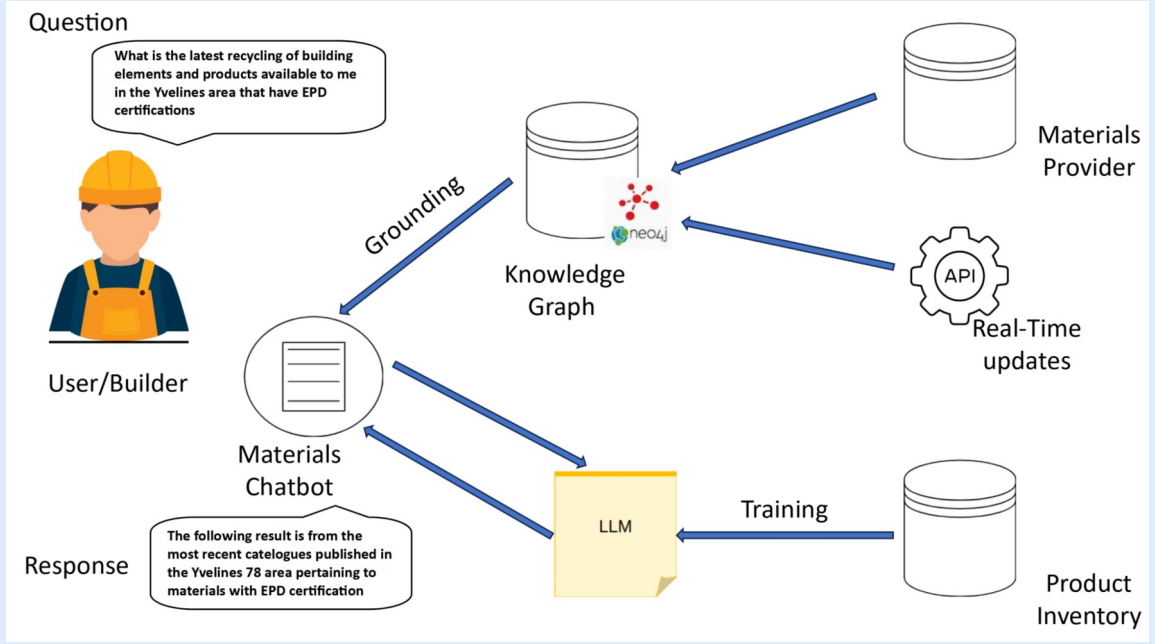


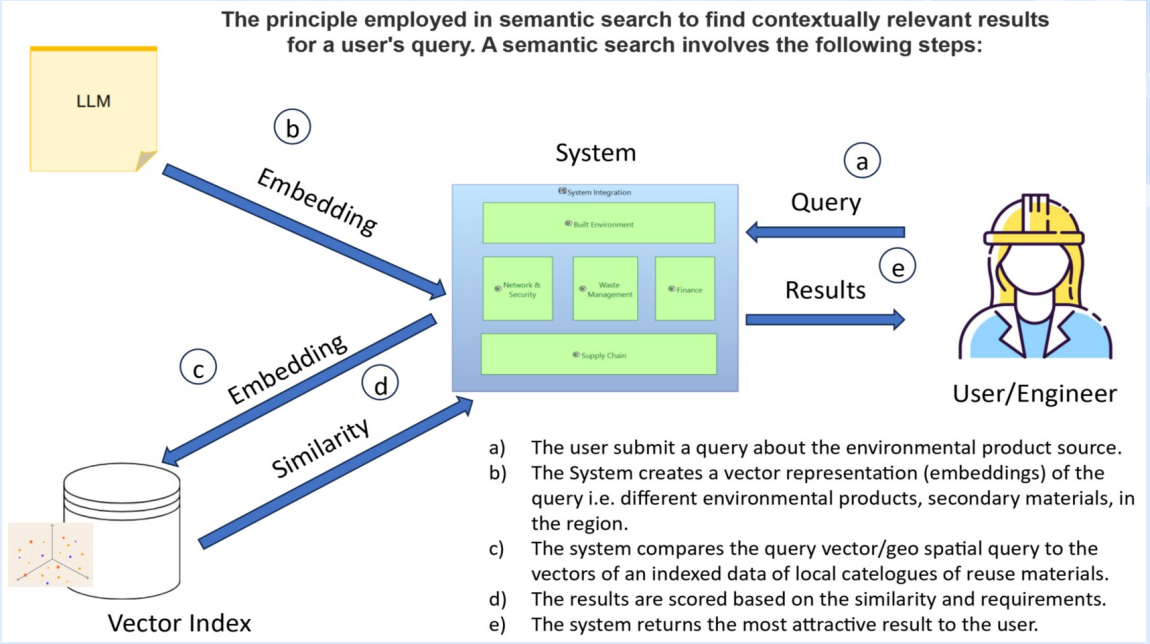
SWISS LIFE – ETL & Graphs

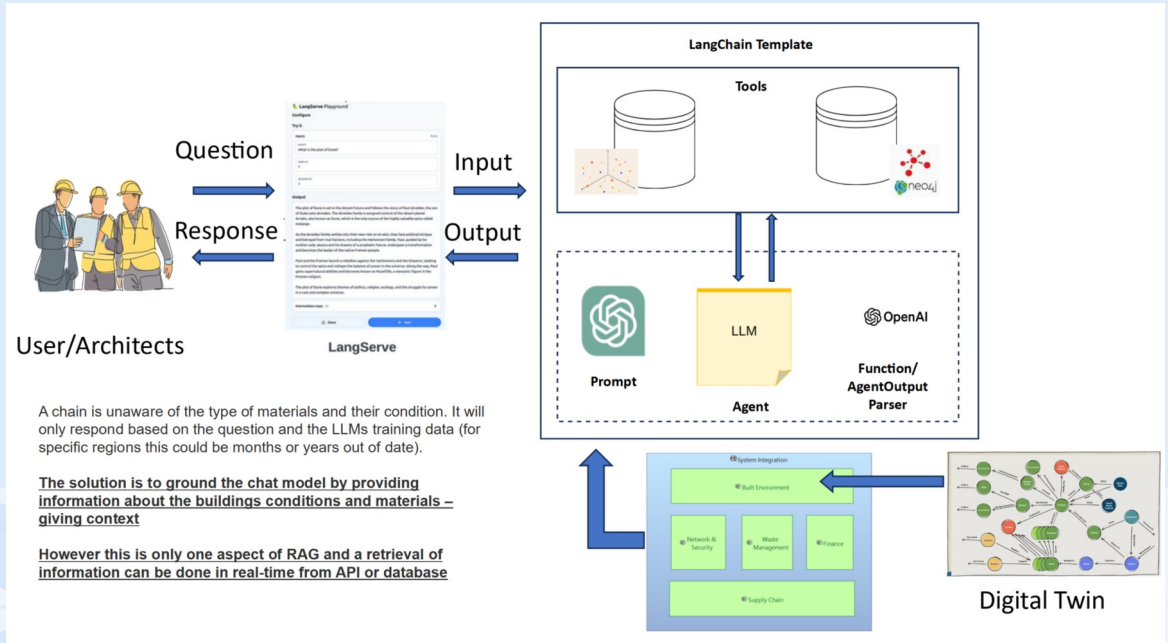
ISO/IEC 39075:2024 Information technology — Database languages — GQL

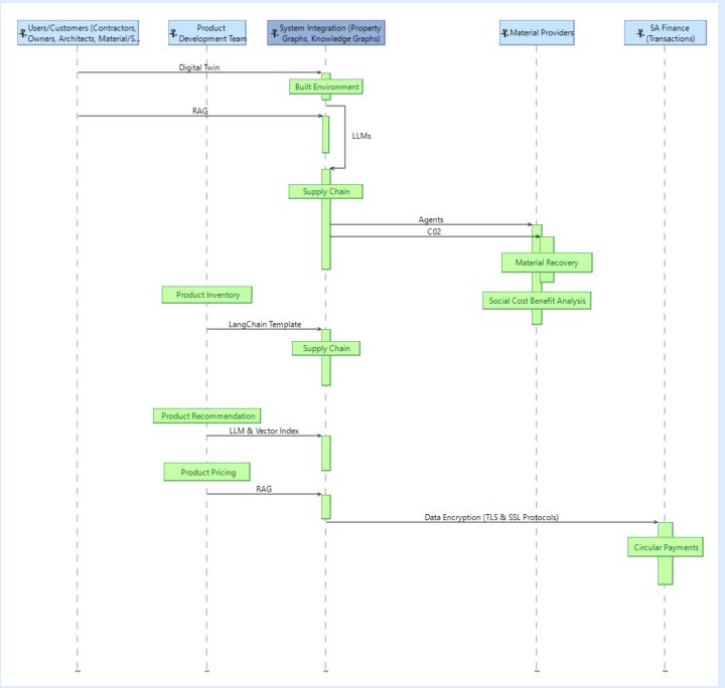
Story boards



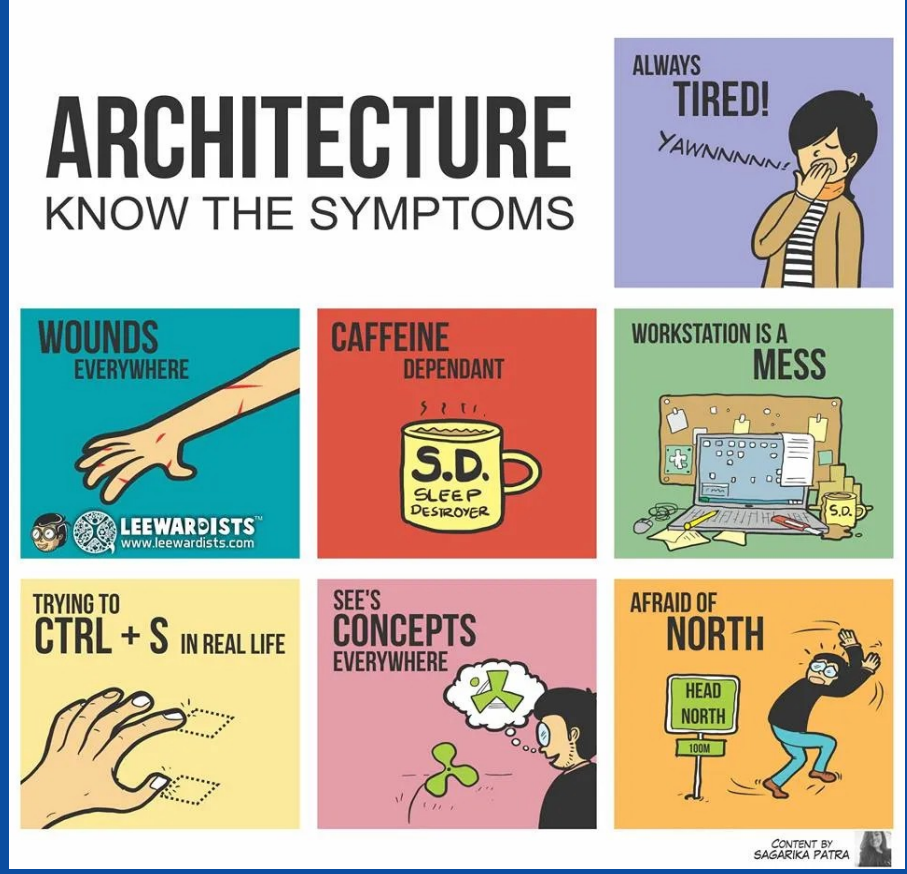

Question
What is the latest recycling of building elements and products available to me in the Yvelines area that have EPD certifications
Materials Provider
Grounding
Knowledge Graph
API
Real-Time updates
User/Builder
Materials Chatbot
LLM
Training
Response
The following result is from the most recent catelogues published in the Yvelines 78 area pertaining to materials with EPD certification
Product Inventory


The principle employed in semantic search to find contextually relevant results for a user's query. A semantic search involves the following steps:
LLM
b
Embedding
System
a
Query
e
Results
c
Embedding
d
Similarity
User/Engineer
Vector Index
a) The user submit a query about the environmental product source.
b) The System creates a vector representation (embeddings) of the query i.e. different environmental products, secondary materials, in the region.
c) The system compares the query vector/geo spatial query to the vectors of an indexed data of local catelogues of reuse materials.
d) The results are scored based on the similarity and requirements.
e) The system returns the most attractive result to the user.

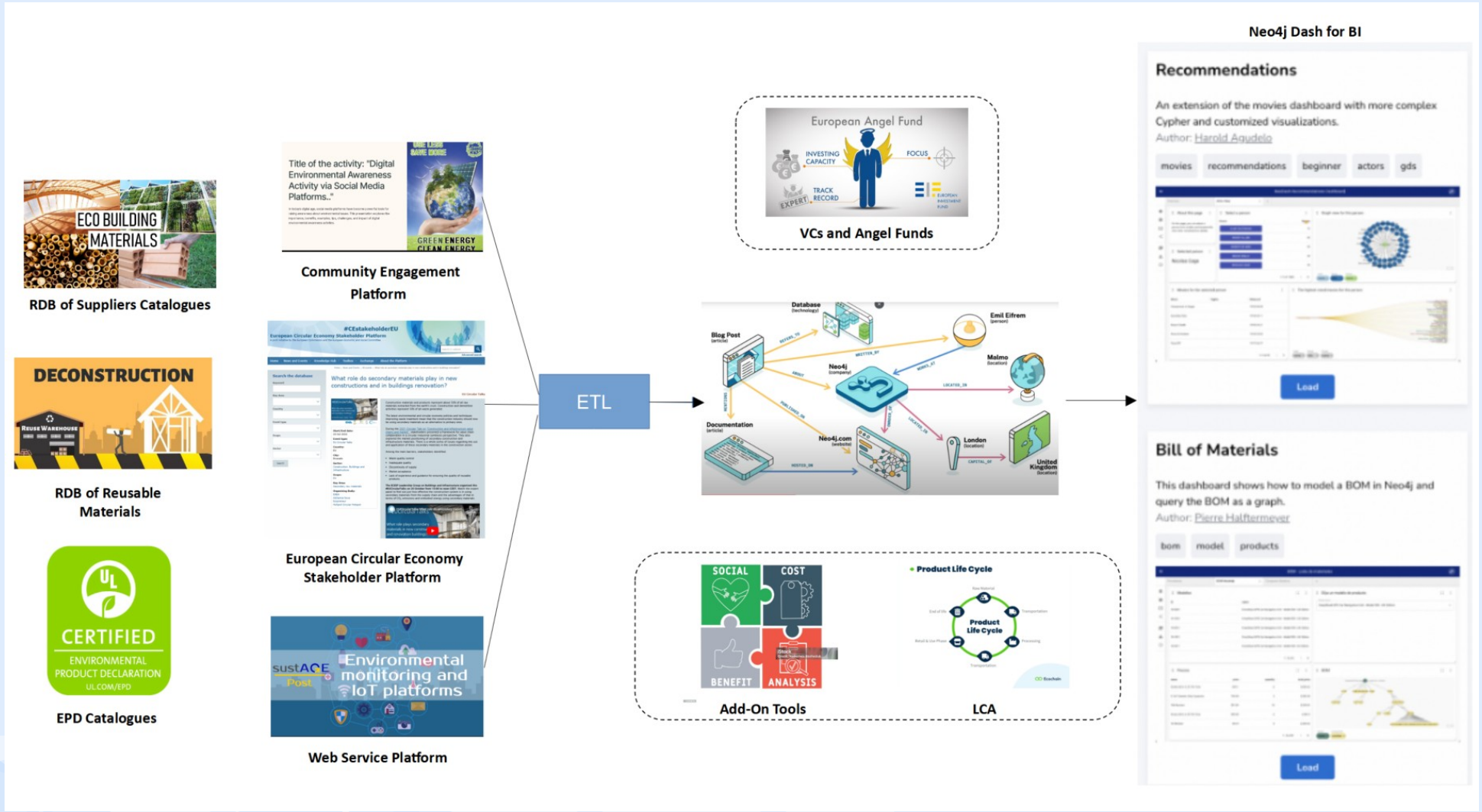

Question
Response
Input
Output
User/Architects
LangServe
LangChain Template
Tools
Prompt
LLM
Agent
OpenAI
Function/ AgentOutput Parser
A chain is unaware of the type of materials and their condition. It will only respond based on the question and the LLMs training data (for specific regions this could be months or years out of date).
The solution is to ground the chat model by providing information about the buildings conditions and materials – giving context
However this is only one aspect of RAG and a retrieval of information can be done in real-time from API or database
Digital Twin


Users/Customers (Contractors, Owners, Architects, Material/S...
Product Development Team
System Integration (Property Graphs, Knowledge Graphs)
Material Providers
SA Finance (Transactions)
Digital Twin
Built Environment
RAG
LLMs
Supply Chain
Agents
CO2
Material Recovery
Product Inventory
Social Cost Benefit Analysis
LangChain Template
Supply Chain
Product Recommendation
LLM & Vector Index
Product Pricing
RAG
Data Encryption (TLS & SSL Protocols)
Circular Payments

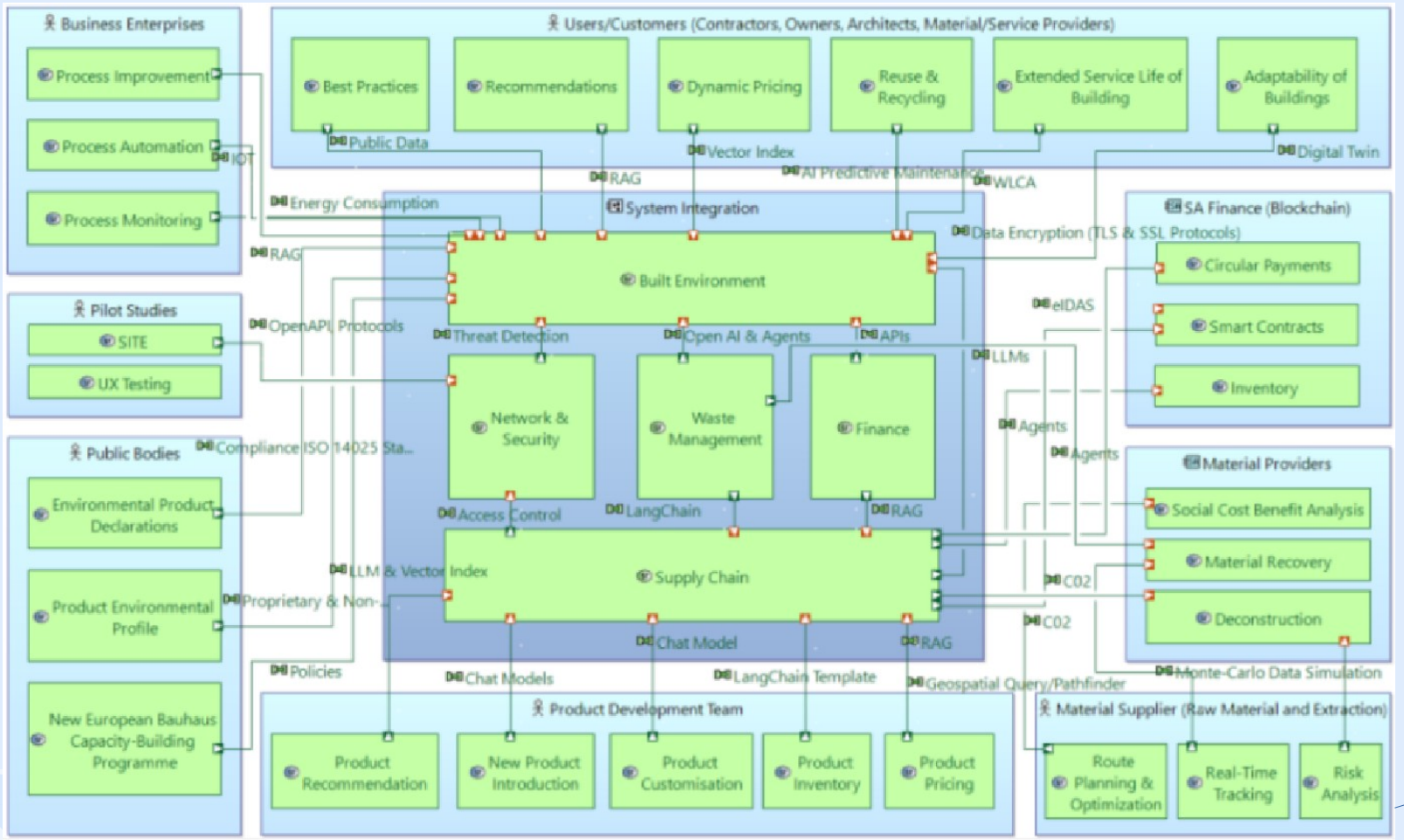
System Architecture

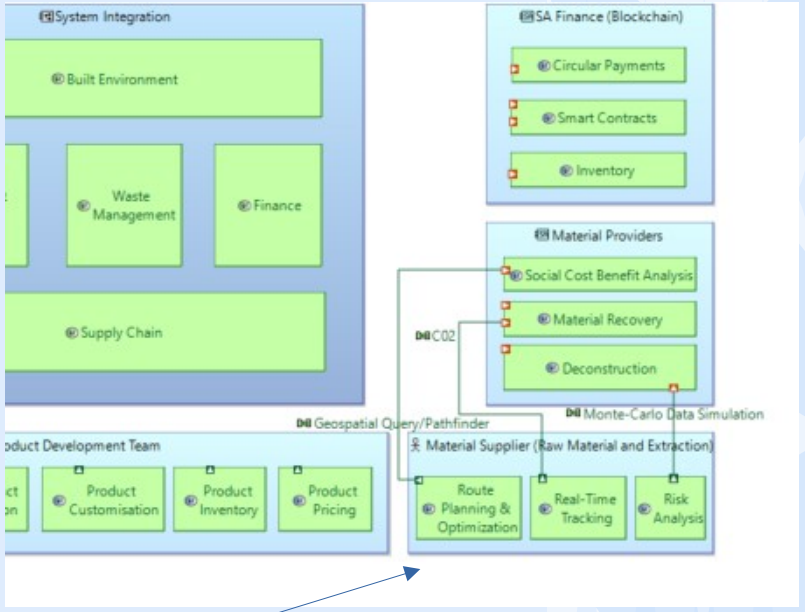


DEMONSTRATION



FEDERATED ARCHITECTURE





SUMMARY/RESULTS

Benefits Listed	**Benefits Experienced on the Horizon-CL5-2024-D4-04 call**
Improved communications	'Building an appropriate architecture means finding the most acceptable compromise between these viewpoints (ARCADIA/CAPELLA TRAINING notes)' – this was certainly evident when **communicating the business analysis and Stakeholders Needs & Requirement at the conceptual stage**.
Increased ability to manage system complexity	The Logical Architecture (LA) featuring the federated architecture conceptual framework identified **how the supply chain is to be constructed**. In addition it identifies **the relationships between the components that represent the consortium partners** in order to know exactly what we need to understand so that the business delivers values even at this minimum value product stage.
Improved concept quality	By modeling the architecture we can demonstrate how the different entities supports the business enterprise. Furthermore, by simplifying the complexity to udnerstand how **business & technology work together,** each of the consortium demonstration partners (x3) were able to identify and acknowledge **how their case study can be aligned with the overall architecture while advancing their business models**.
Reduced Time	The proposal consortium consisted of 14 partners from 8 different countries in Europe working together over a period of nearly 3 months. The **realtionship link between the business mission and stakeholders needs** triggered challenging discussions. In addition, it also recognised the activities to achieve the outputs **such as the entity sceanrios that featured the story board concepts**.
Reduced Risk	The federated framework identifies interoperability and information sharing between semi-autonomous de-centrally organized lines of business (LOBs), identifies **data encryption and secure electronic payments.** Moreover, the architecture triggers future discussion points i.e. NIS2 (Important entities - waste management) and The Coporate Sustainability Reporting Directive – CSRD for ESRS E4 | Biodiversity and Ecosystems, ESRS E5 | Circular Economy that can be advanced at a later stage as part of **Taxonomy mapping**.
Enhanced knowledge capture and reuse of the information	The visual connections in the LA highlighted the components (in blue), functions (in green) and exchange items (interactions/interfaces – in red) and of course the top down approach allows for information to be **incremental and iterative**. For example ; the federated architecure diagram mention AI agents for exchange functions but not the Model Context Protocol (MCP a new standard for connecting AI assistants to the systems). **The next models will revisit such issues**.
Improved ability to teach and learn SE fundamentals	In the construction industry 3 dimensional thinking is paramount, however sometimes the various exchanges between components are not fully analysed within the complexity of the supply chains. The use of Arcadia/Capella provided a methodology and tool to support the evolution of the PoC that **featured functional flow, structure, interfaces, and behaviour.**

SYSTEMS ENGINEERING & SEBOK

In 2024, INCOSE officially joined the World Federation of Engineering Organizations (WFEO). WFEO brings together national engineering institutions from over 100 nations and represents more than 30 million engineers.

Similar to INCOSE's Vision 2035, WFEO aims to promote the role of engineering in achieving UN sustainable development goals (SDGs). Joining the WFEO is a strategic outreach effort that aligns with INCOSE's new objective of being the trusted authority in systems engineering. Currently, INCOSE is the only organization with a systems engineering focus within the network.

INCOSE can play a pivotal role by incorporating systems thinking and systems engineering into the pursuit of the SDGs, ensuring that the engineering approach is holistic, sustainable, and adaptable.

WFEO-INCOSE Empowering Engineering Disciplines through Systems Engineering

The collaborative WFEO-INCOSE Working Group was created to support both organizations' strategic goals by promoting best practices, fostering innovation, and facilitating the integration of systems engineering principles across various disciplines.

31

INCOSE

SEBoK Stewards

INCOSE

IEEE SYSTEMS COUNCIL

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Thank you