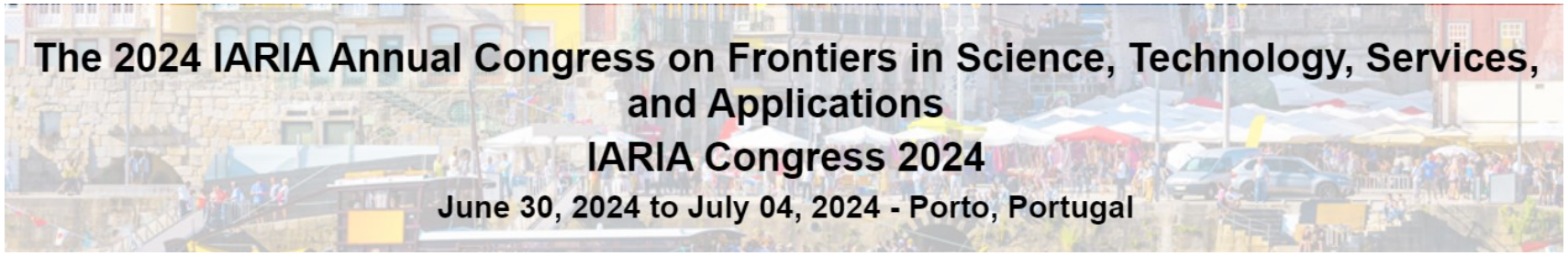


The Conceptual Architecture Requirements for French Digital Building Logbook.

Alan Martin Redmond, Division of Information Technology, CSTB, France

Co-funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme, under grant agreement No. 101091749

BIOGRAPHY

Alan Martin Redmond is Doctor Research and Expertise Engineer, with the division of Information Technology at **The Centre Scientifique et Technique du Bâtiment - CSTB** (is the French national organisation providing research and innovation, consultancy, testing, training and certification services in the construction industry). Where he predominately focuses on: Building Informatics - programmes de recherche nationaux (ministères, agences d'objectifs) et européens.

He is **INCOSE (CSEP) member with Association Française Ingénierie Système (depuis 2014)** and Membre des Recherches et Innovations en IS.

He is also a professional member of IEEE - France Chapter Section (The Institute of Electrical and Electronics Engineers), where he also a member of IEEE SA: Digital Twin of the Earth – Tools and Resources for Interoperable Development and Operations Home.

Alan holds **Doctor of Philosophy, Part of the Computer Sciences Commons, and the Construction Engineering and Management Commons from Technological University Dublin**, Professional Certificate in Systems Engineering from UC Irvine, Postdoctoral Research from University of Toronto, Department of Civil Engineering.

For the past three years he has been a committee member of the **IARIA // MODERN SYSTEMS, International Conference of Modern Systems Engineering Solutions**. To date he has published numerous of scientific articles predominantly featuring smart cities and state-of-the-art technologies.

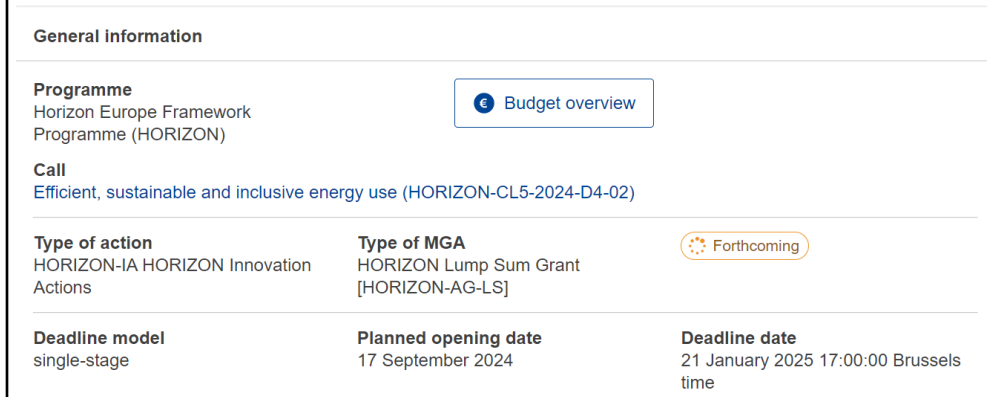
Alan Martin REDMOND, PhD, CSEP (Systems Engineer Professional/INCOSE)
Docteur - Ingénieur de recherche et expertise
Direction Technologies de l'Information, Division Support aux Politiques Publiques & Cloud
Tél. : +33(0)4 93 95 64 15

European Commission | EU Funding & Tenders Portal

BIM-based processes and digital twins for facilitating and optimising circular energy renovation (Built4People Partnership)

EU Funding & Tenders Portal (europa.eu)

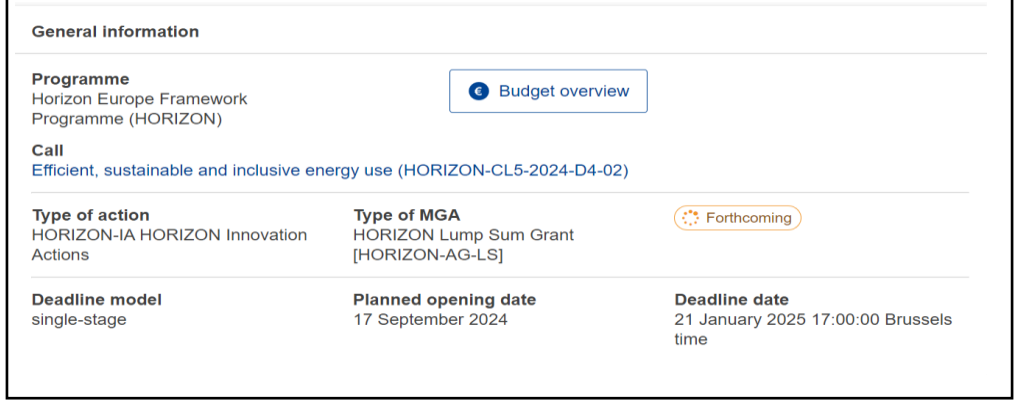
- HORIZON-CL5-2024-D4-02-03
- Ouverture : Septembre 2024
- Deadline : Janvier 2025
- Type of action : Innovation Action
- EU contribution : Up to 5 M€



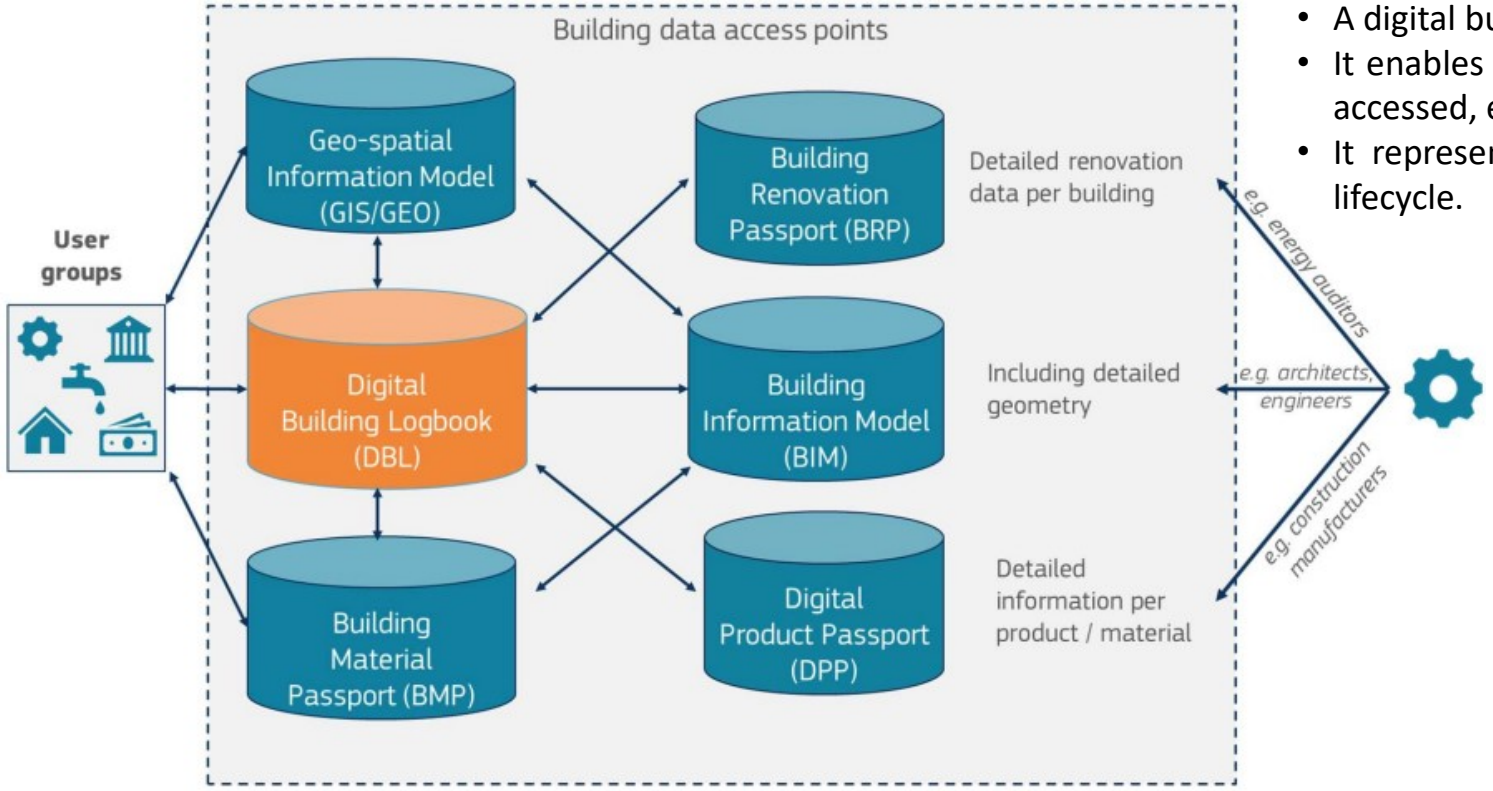
HORIZON-CL5-2024-D4-02-05: Digital solutions to foster participative design, planning and management of buildings, neighbourhoods and urban districts (Built4People Partnership)

EU Funding & Tenders Portal (europa.eu)

- Ouverture : September 2024
- Deadline : January 2025
- Type of action : Innovation Action
- EU contribution : Up to 8 M€

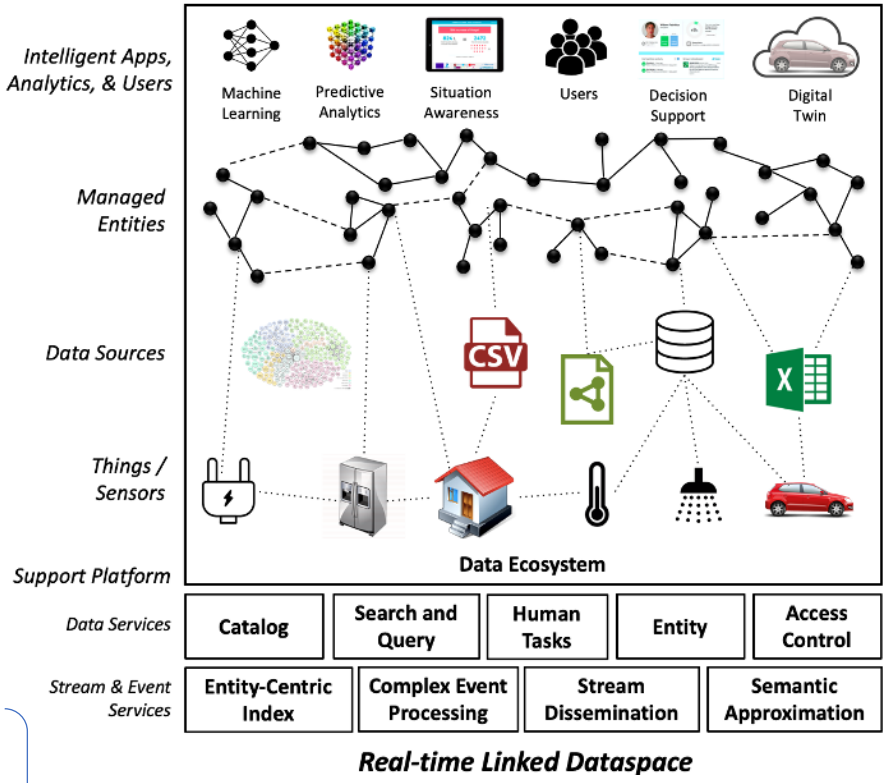


What is a Digital Building Logbook



Technical Guidelines for DBL – DBL Study Team: Ecroys, TNO, Arcadis and Contecht

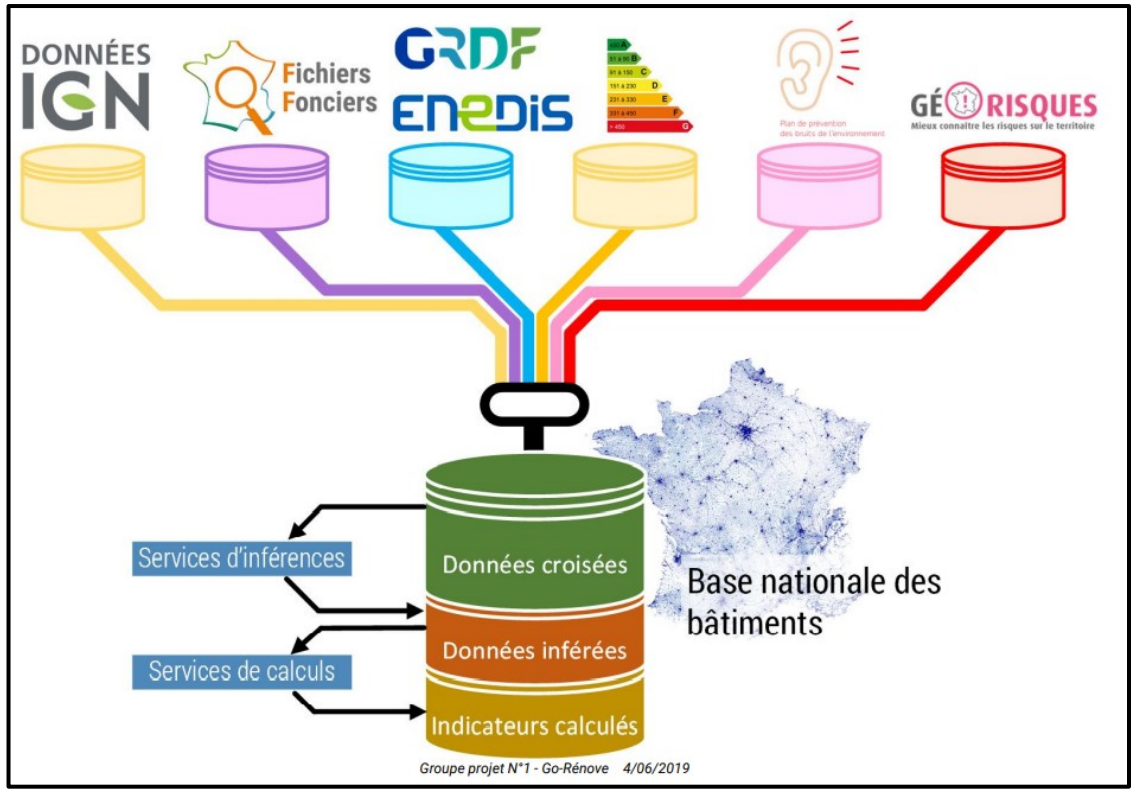
- A digital building logbook is a common respository for all relevant data.
- It enables a variety of data, information and documents to be recorded, accessed, enriched and organised, under specific categories.
- It represents a record of major events and changes over a building's lifecycle.

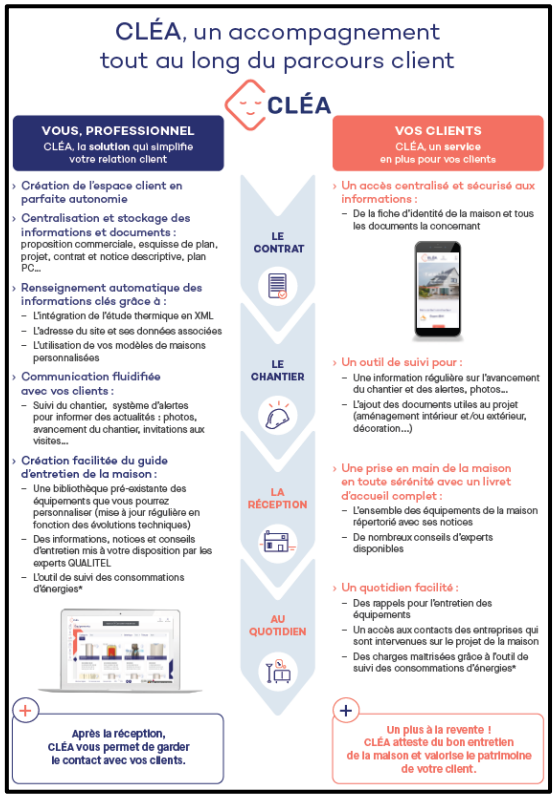


https://dataspaces.info/#overview

The majority of this data stored (IAQ, operational energy use, smart buildings potential and life cycle emissions, building ratings, cert, and circularity) in the logbook have a more **static in nature**, while others, such as smart meters and intelligent devices, are dynamic and need to be automatically and regularly updated.

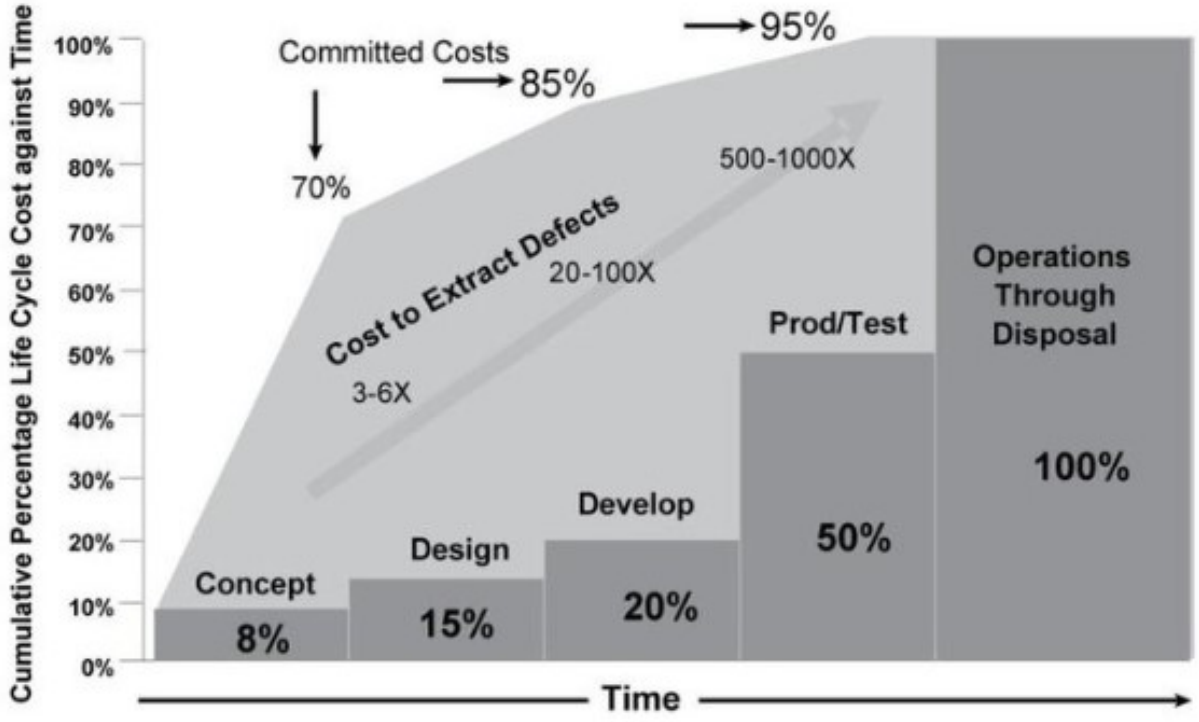
French DEMO (BDNB + Cléa)





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

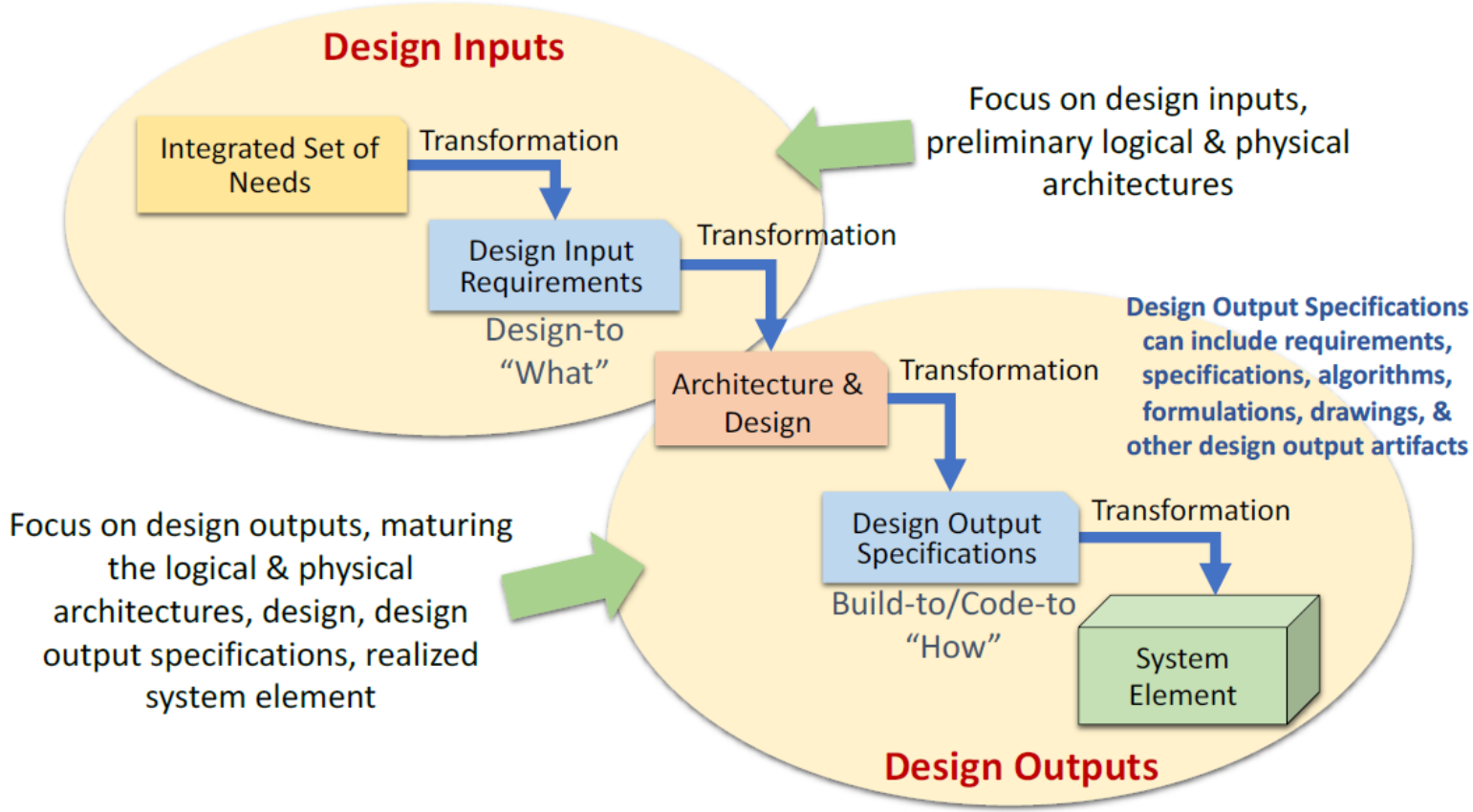


Committed life cycle cost against time (Walden et al., 2015), derived from 1993 Defense Acquisition University (DAU)

"**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,*

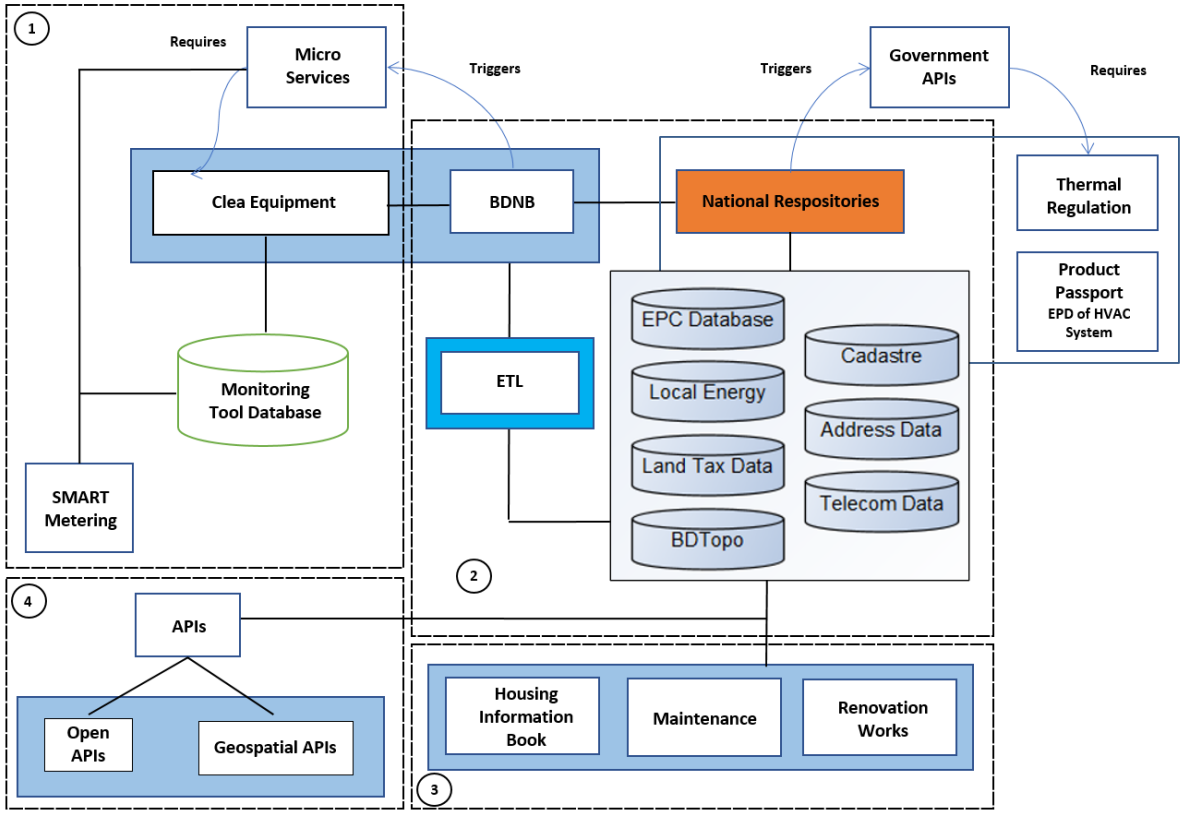
***The INCOSE Systems Engineering Vision 2020 (2007) defines MBSE*:** "The formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the [concept stage] and continuing throughout development and later life cycle [stage]"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

INCOSE REQUIREMENTS

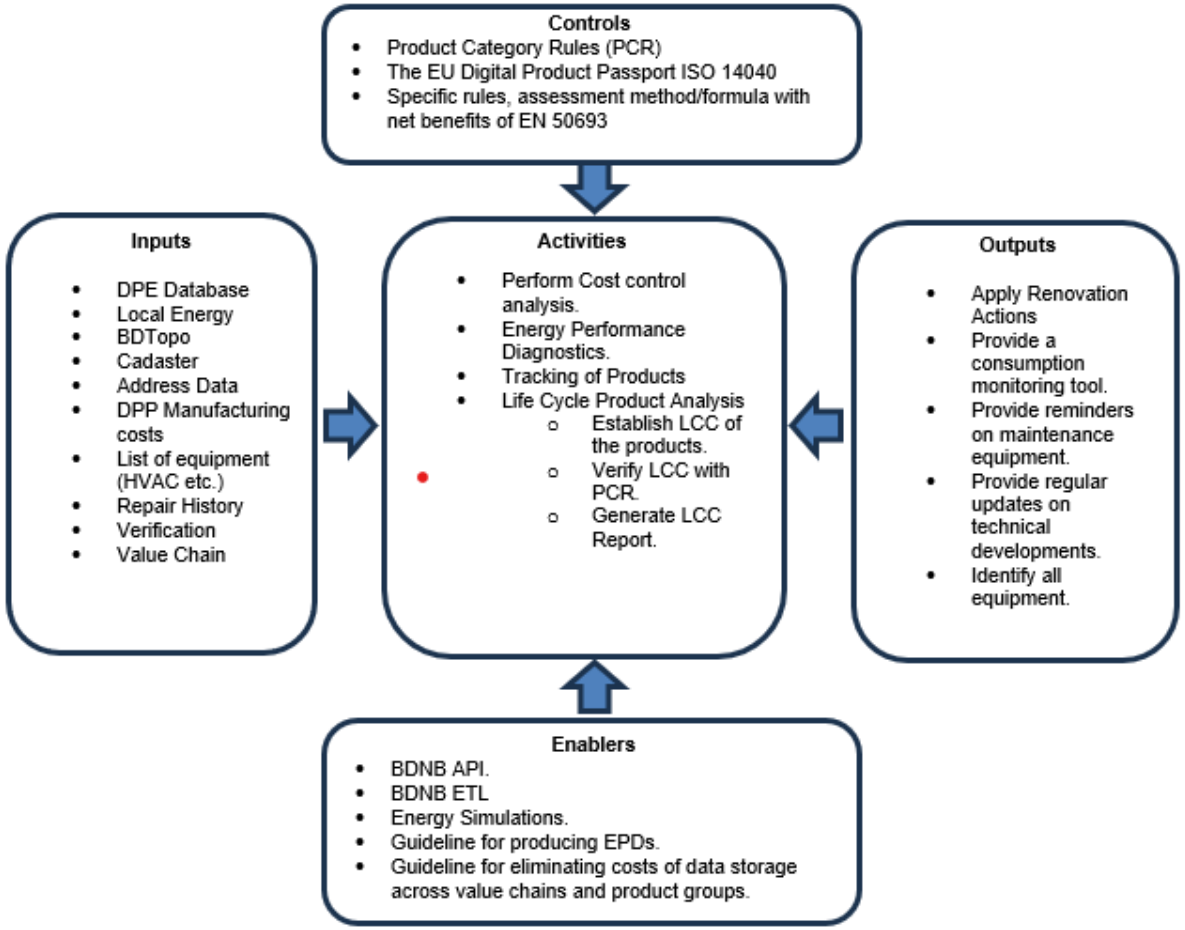


Needs and Requirements in Context (INCOSE Guide to Writing Requirements 1 Jul 2023)

Interface Control Document
Requirements for Energy Renovation Toolkit



CLEA and BDNB interface overview



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

Digital Models

Model-based systems engineering (MBSE) is a methodology that focuses on creating and exploiting digital system and engineering domain models **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 lifecycle of the system**.

ANSYS BLOG MAY 25, 2022

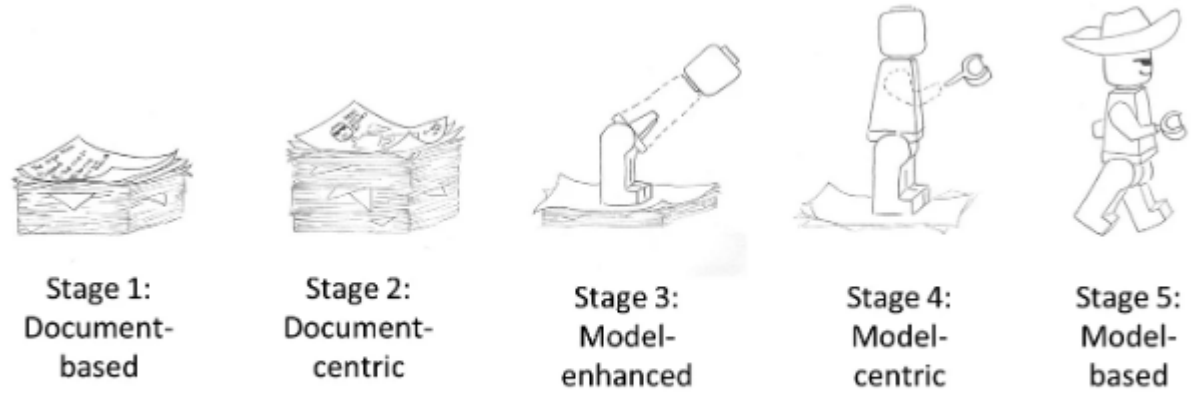
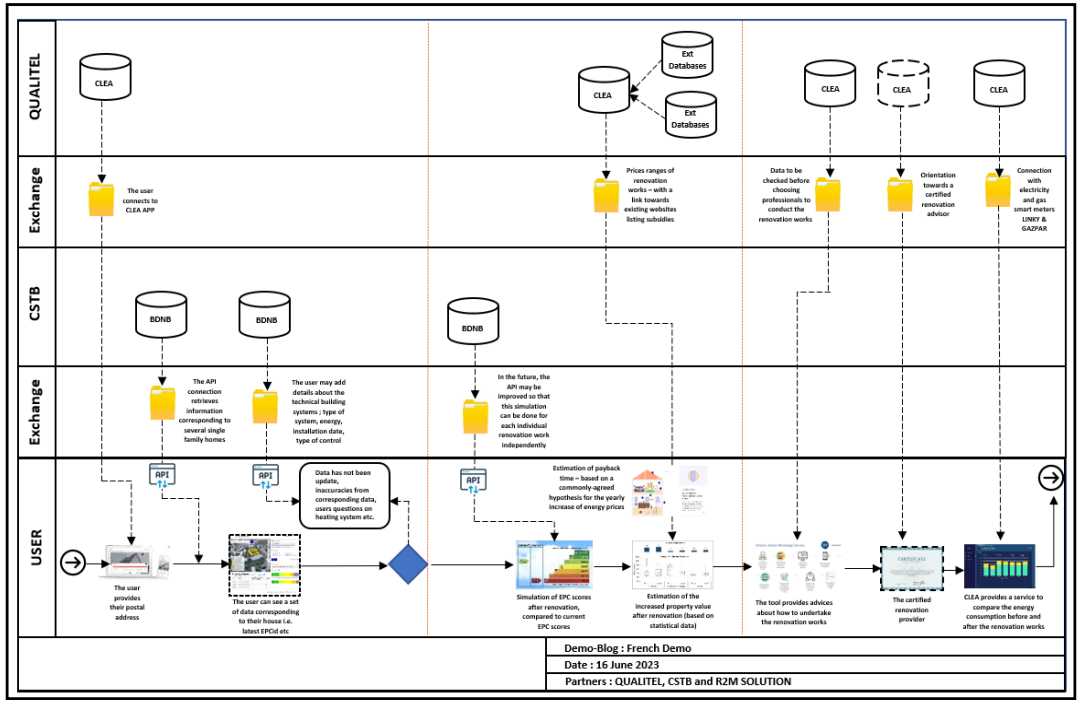
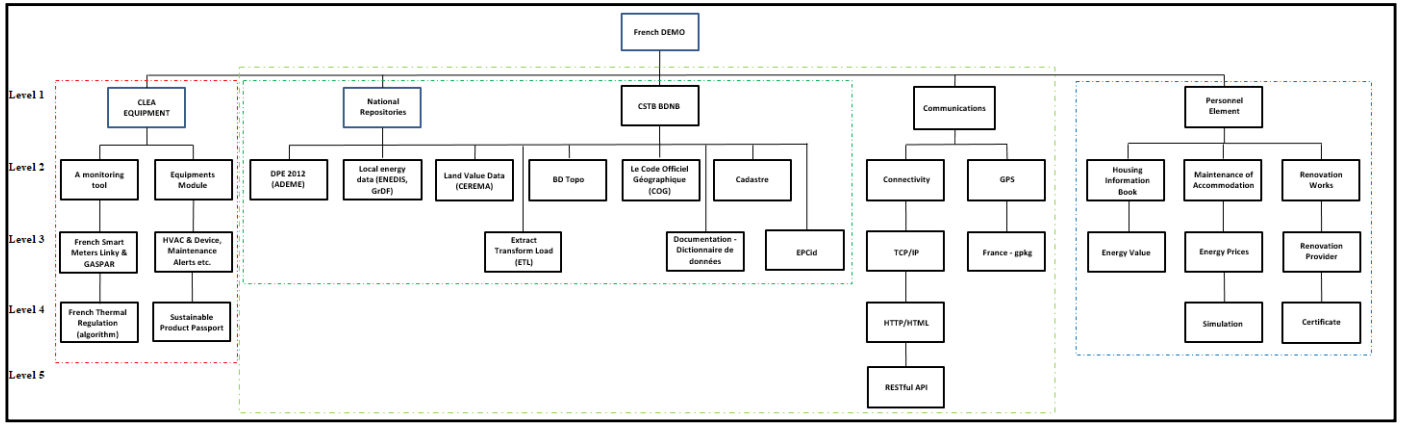


Figure 2.10 – The evolution of MBSE (Holt & Perry 2020)

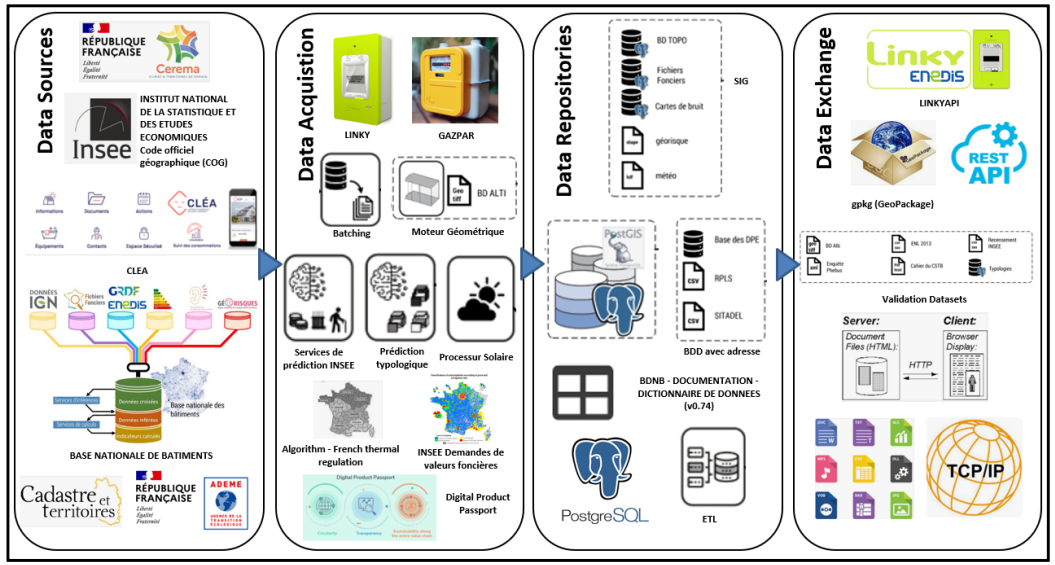
Supporting Efficient Collaboration in engineering 'ARCADIA'



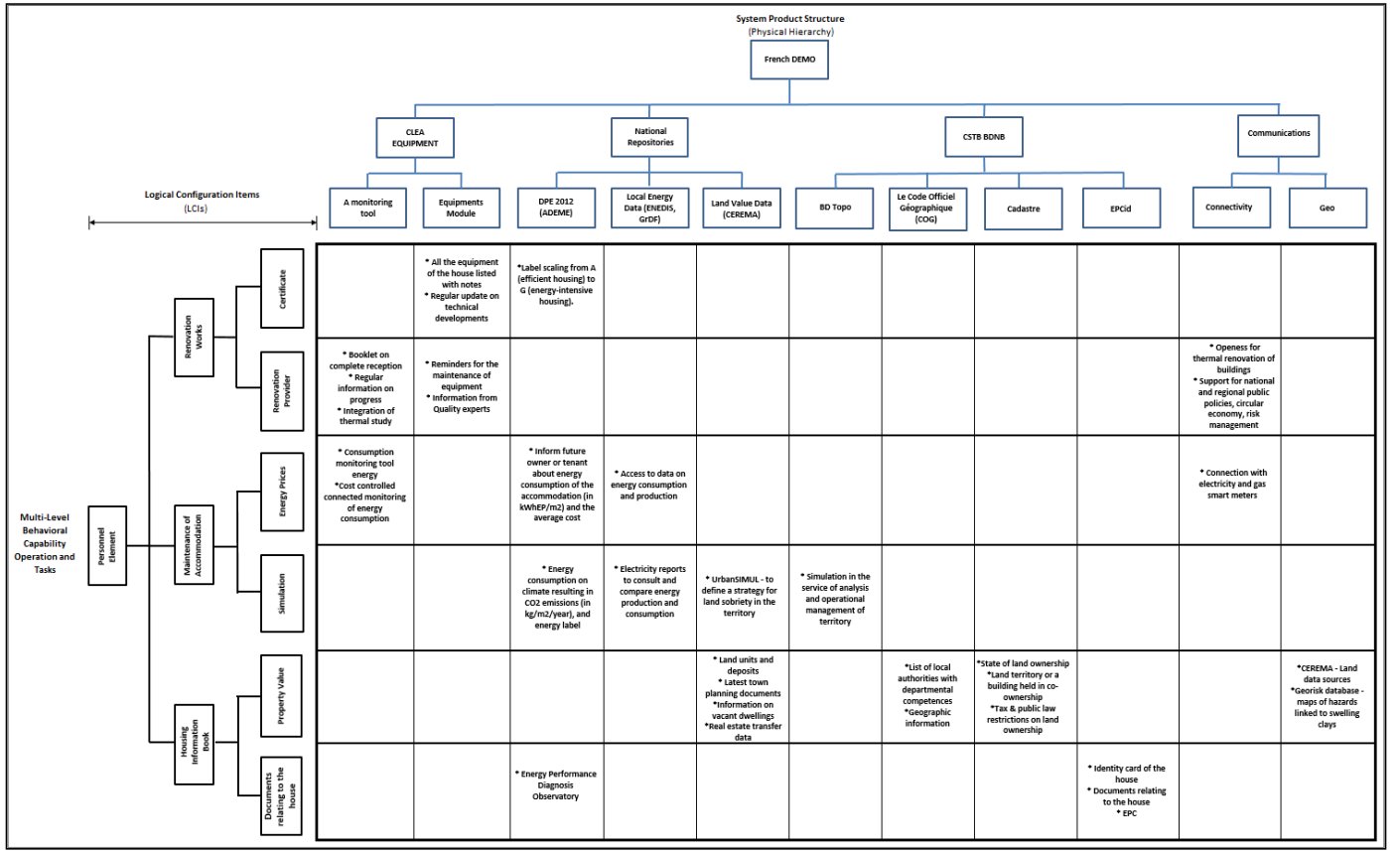
Business Process Map



System Elements



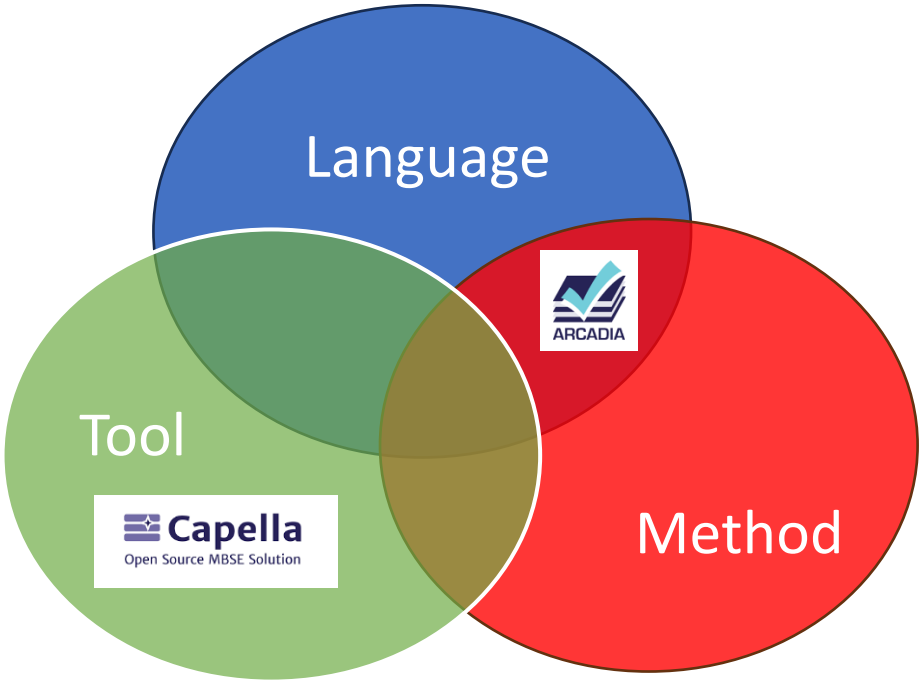
Simplified Architecture



Capabilities & Requirements

HOW DID I IMPROVE THE SITUATION – *"I got schooled"*

THALES MBSE Pillars



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)

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

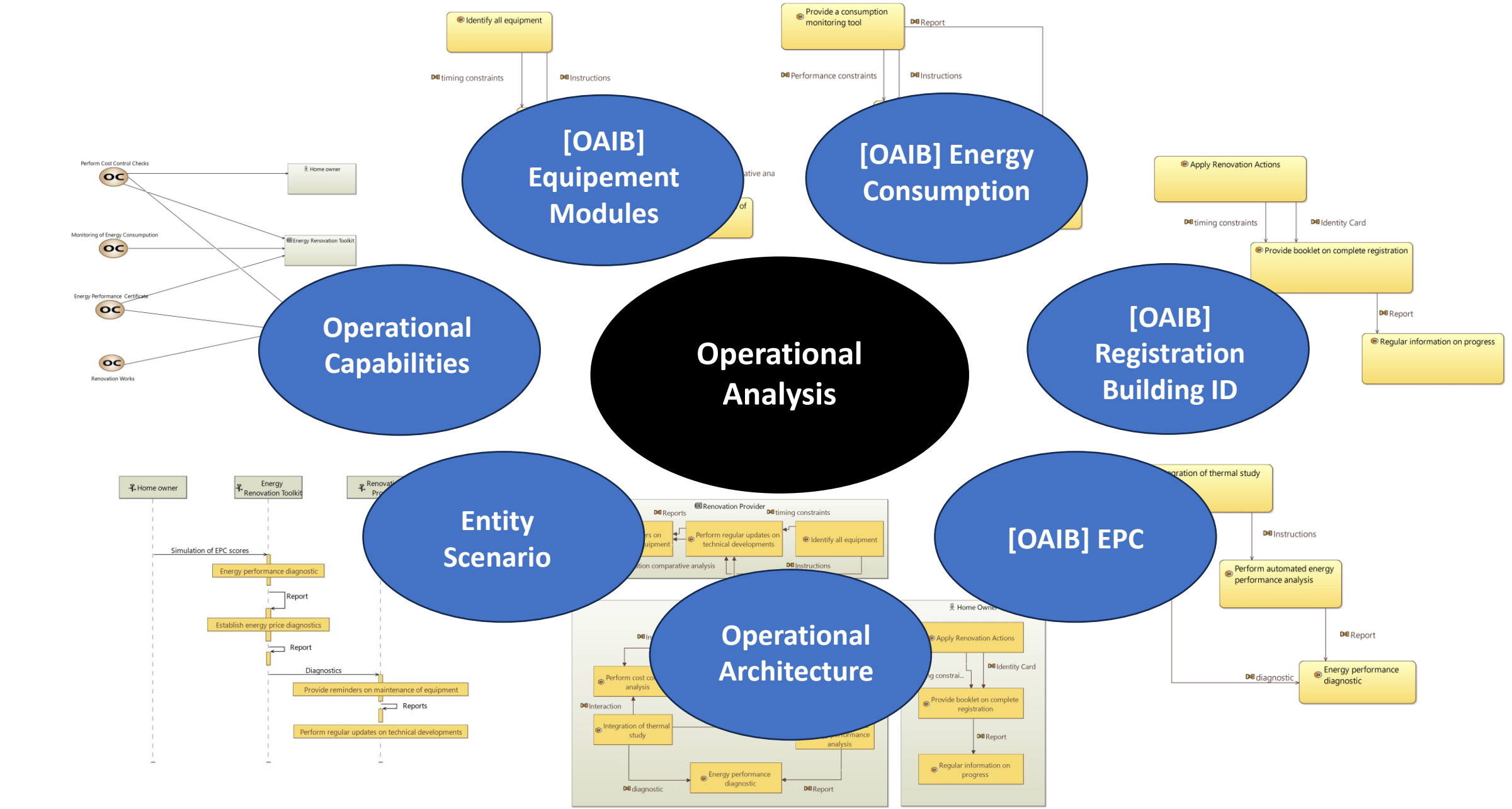
Formalize Component Requirements

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	How 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

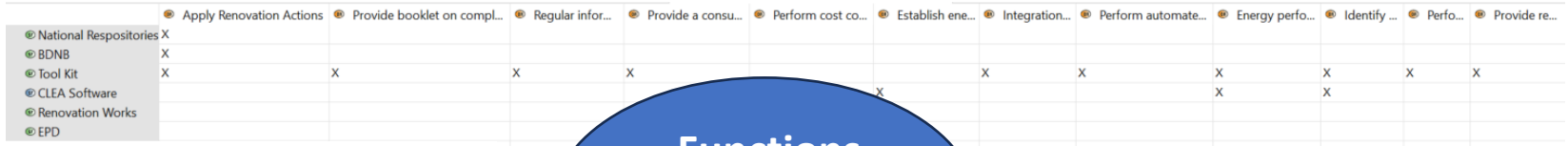
Operational Analysis workflow and main diagrams



System Analysis – What the System has to Accomplish for the Statkeholders

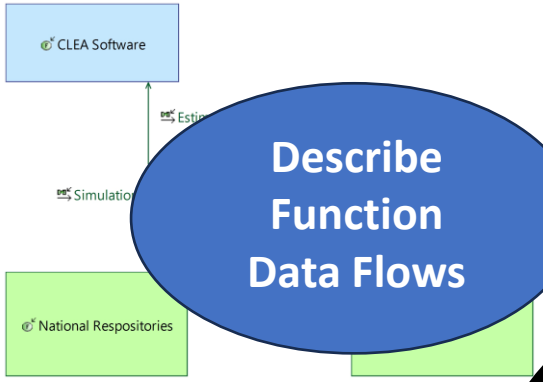
PURPOSE	FUNCTION	BEHAVIOR	STRUCTURE	INTERFACES
What Services shall the system provide	What actions are expected from the system by the external entities	What are the operational modes	Who will the system interact with	What are the external interfaces of the system

System Analysis workflow and main diagrams

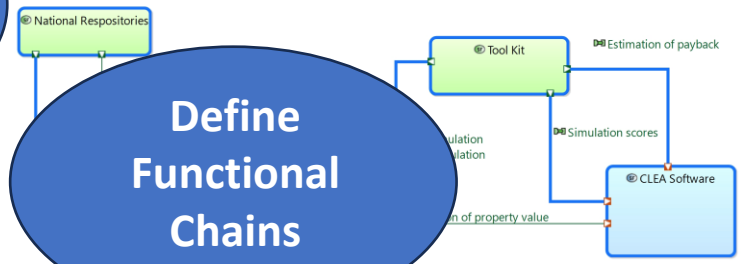


Functions and Traceability

Describe Function Data Flows

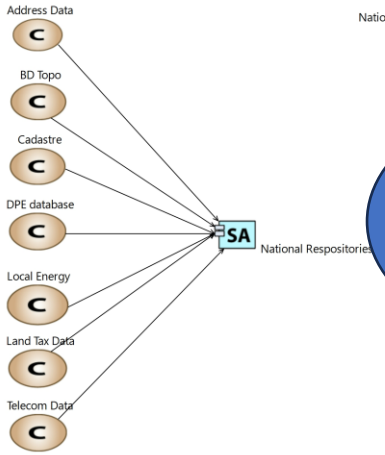


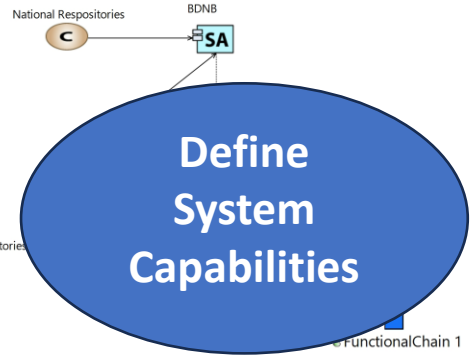
Define Functional Chains



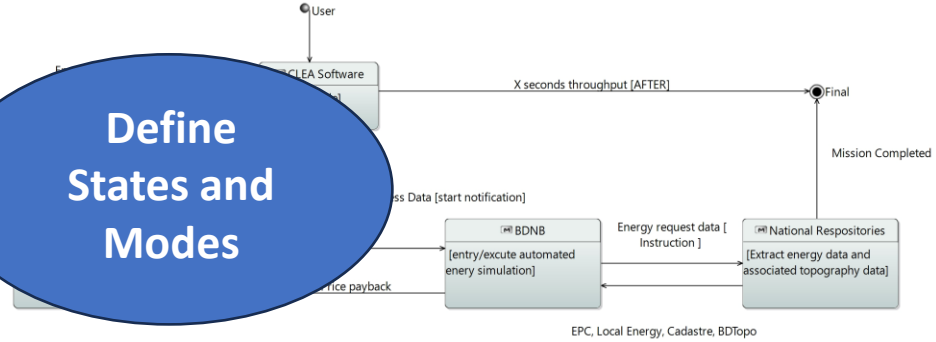
System Analysis

Define System Capabilities

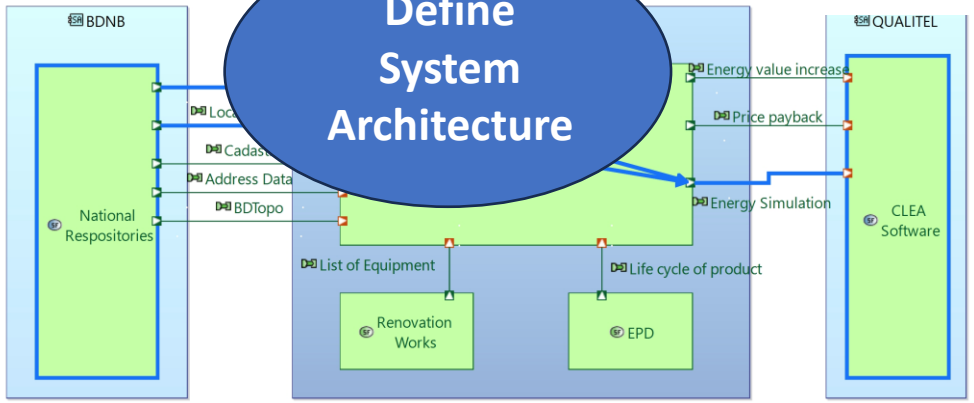




Define States and Modes



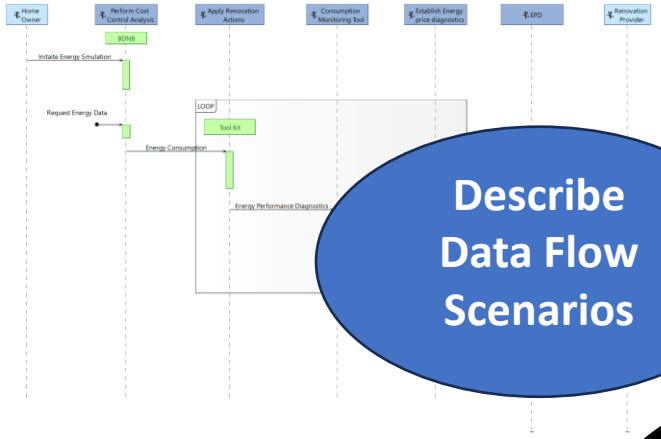
Define System Architecture



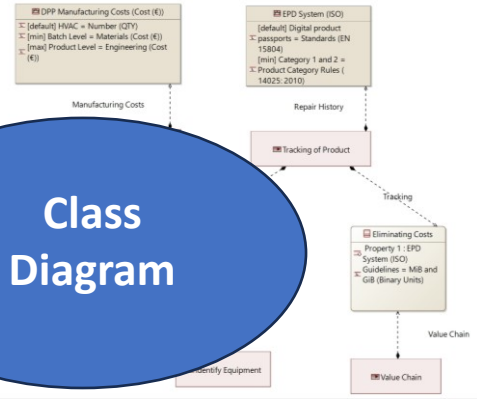
Conceptual Architecture – How the System will work to fulfil expectations

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?

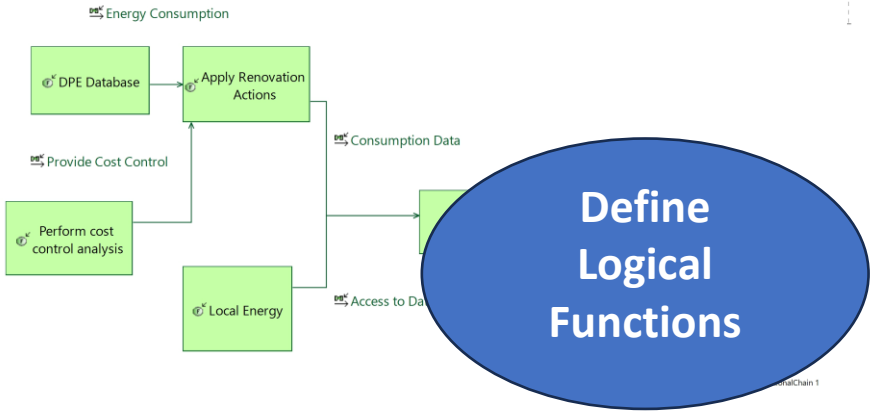
Logical Architecture workflow and main diagrams



Describe Data Flow Scenarios

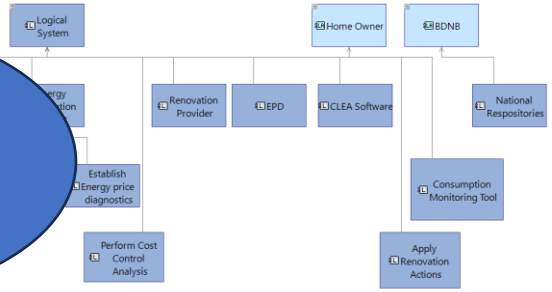


Class Diagram

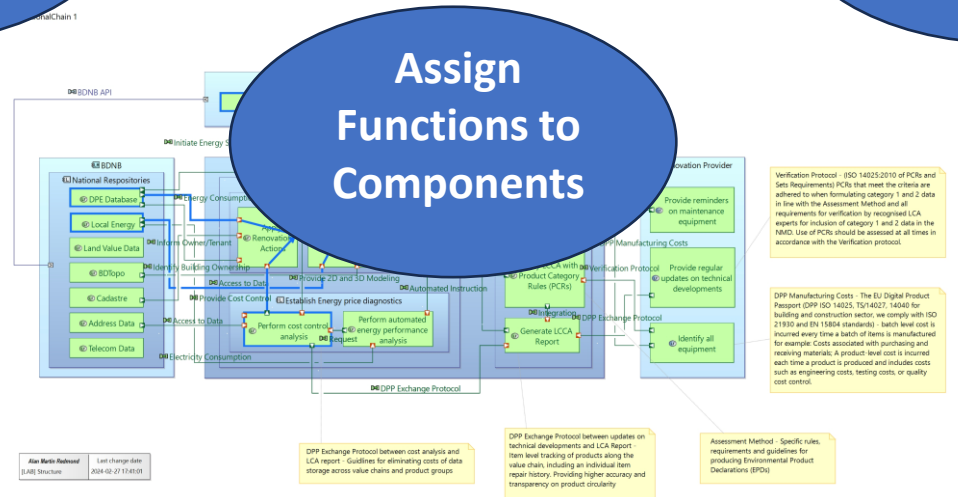


Define Logical Functions

Logical Architecture



Refine Logical Functions

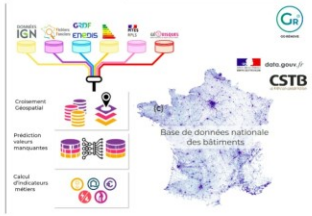


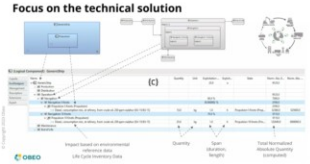
Assign Functions to Components

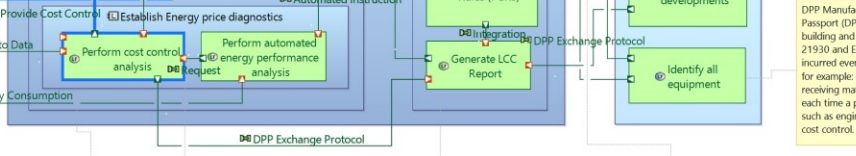
LOGICAL ARCHITECTURE COLLABORATION MODEL

FunctionalChain 1

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







(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

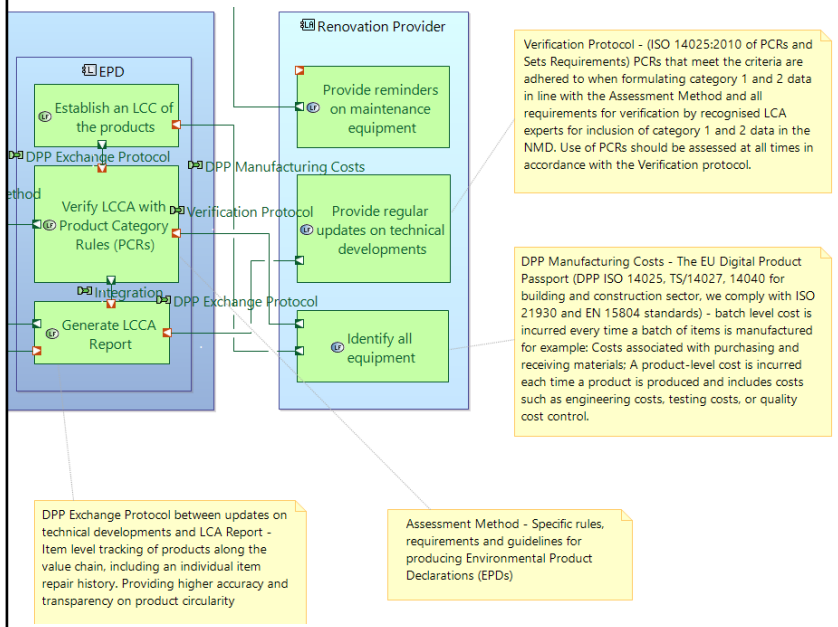
DPP Exchange Protocol between updates on technical developments and LCC Report - Item level tracking of products along the value chain, including an individual item repair history. Providing higher accuracy and transparency on product circularity

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

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.

The Environmental Performance for Construction Works



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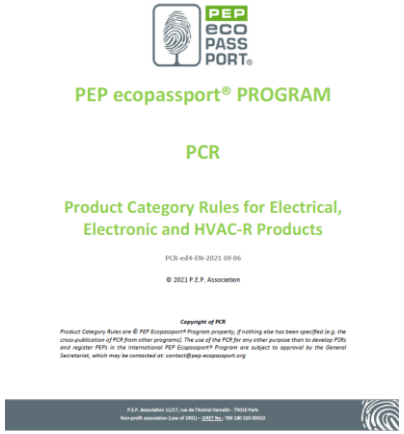
Assessment Method - Specific rules, requirements and guidelines for producing Environmental Product Declarations (EPDs)

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



Appendix B: Diagram of the system boundaries for the LCA

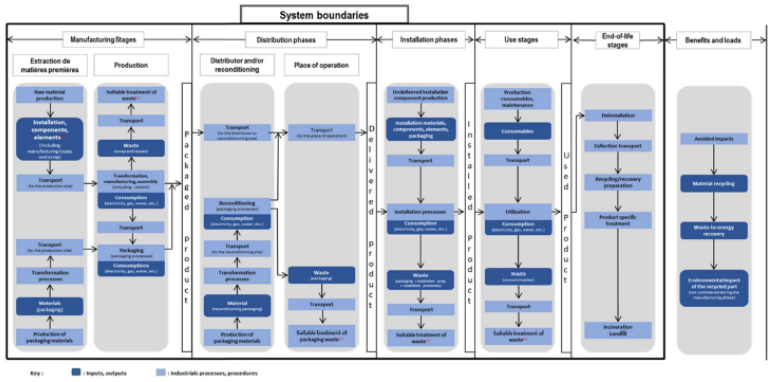


Figure 3: System boundaries according to PCR edition 4.0

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

C.3) LCA REPORT

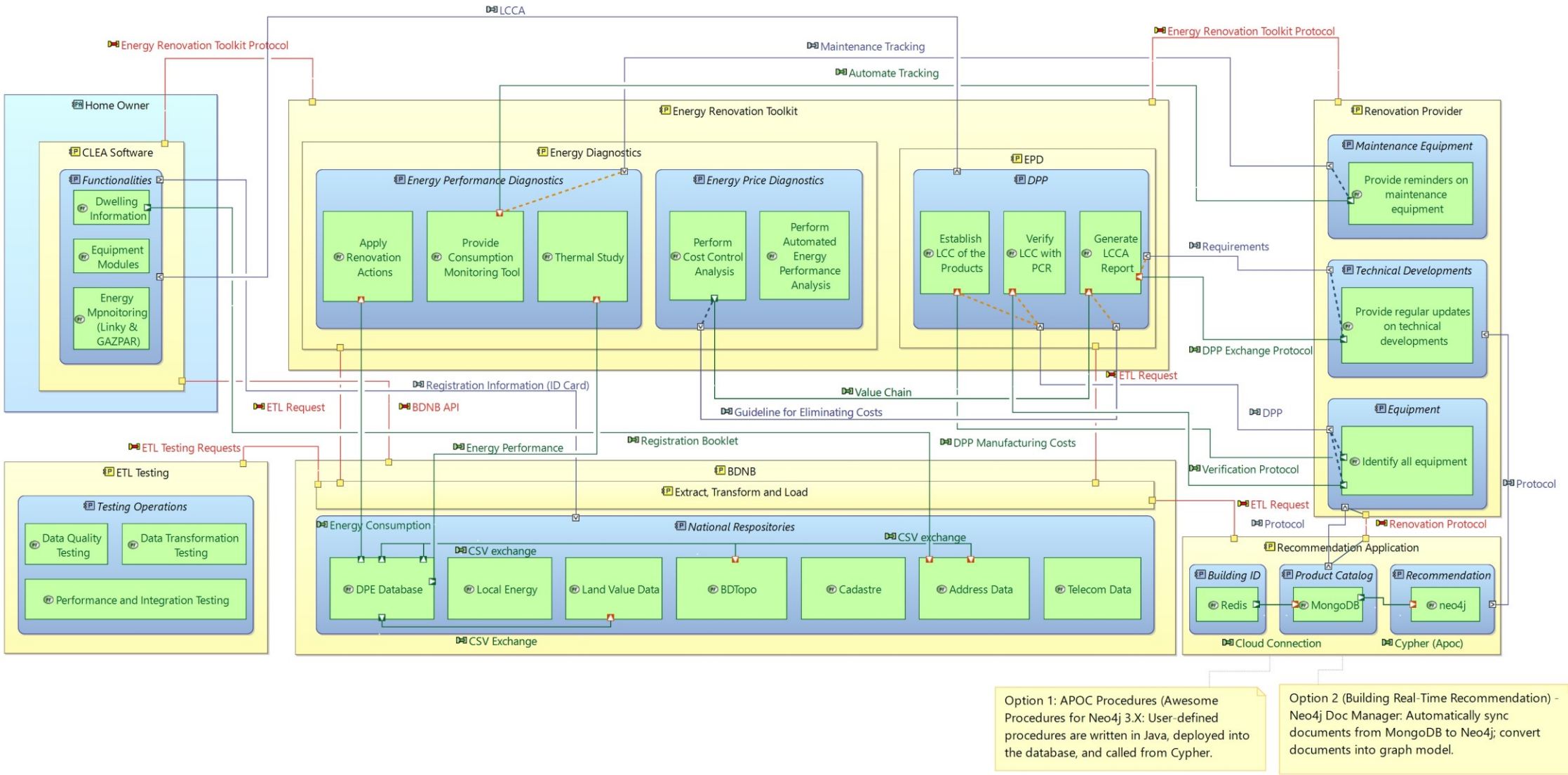
Complementary to information mentioned in Chapter 3, the PEP LCA report shall contain the following information so they could be delivered to PEP ecopassport® program or any administrative authority, or their representative, in charge of auditing and control:

- 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)



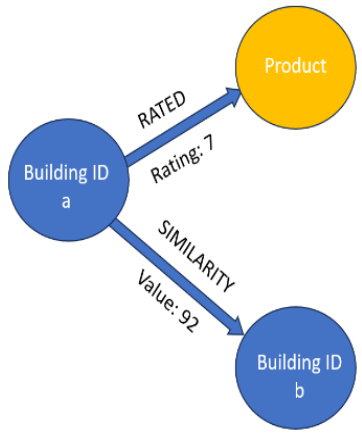
Building Real-Time Recommendation Application

(Physical Component) [Node]

Editing of the properties of a Physical Component

Capella | Management | Description | Extensions

Styles | Normal



- **Polyglot Persistence** - different types of data in differe
- **Building ID**: functionality is rapid session, reads/writes;
- Redis open source in memory storage offers flexibility th
- **Product Catalog**: functionality is frequent reads; databa
- **Users social graph**: functionality is recommendation; d
- **Using Data relationships for recommendations:**
- content-based filtering - recommend items based on wh

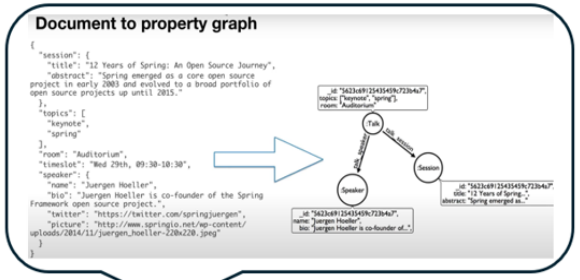
1

2

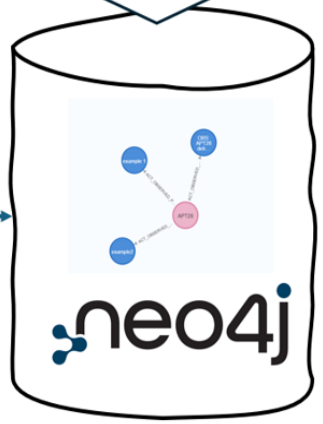
A special capped collection that keeps a rolling record of all operations that modify the data stored in your databases.

Creates a pipeline from a MongoDB cluster to one or more target systems, such as Solr, ElasticSearch, or another MongoDB cluster. By tailing the MongoDB **OPLOG**, it replicates operations from MongoDB to these systems in real-time.

Document to property graph



MONGO CONNECTOR

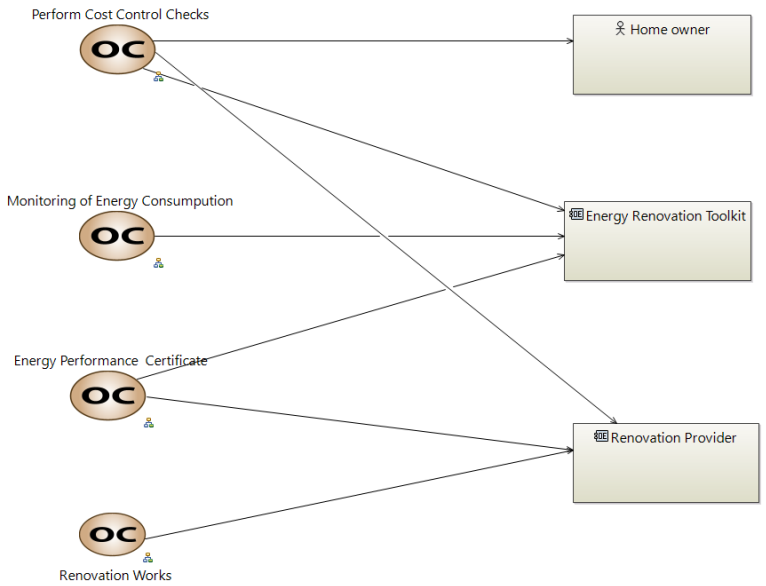


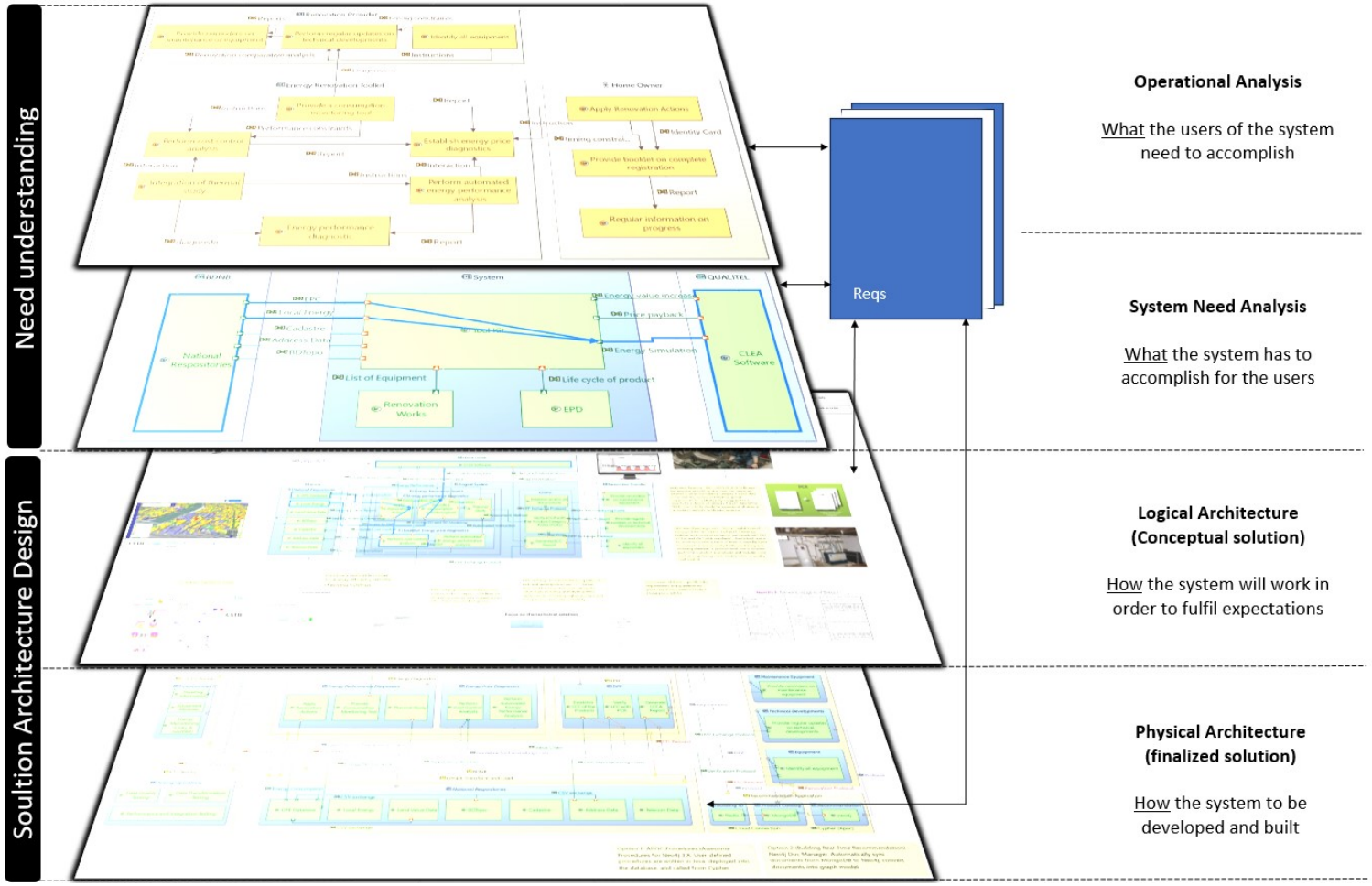
Neo4J Doc Manager

It is a tool that enables you to migrate documents from MongoDB to a **Neo4j** property graph structure.

MBSE – The Arcadia perspectives

[OCB] Operational Capabilities





Summary/Results

Quantitative data from Rogers and Mitchell, (2021) and Qualitative from OMG, MBSE Wiki, 2023, MBSE Events and related Meetings, INCOSE 2023 SEH

Benefits Listed	Benefits Experienced on the Demo Blog Project
Improved communications	Not just among the BDNB team at CSTB and the QUALITEL team but also with Energy Saving Trust 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.

THANK YOU

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