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SUM4Re

Creating materials banks from digital urban mining

D1.5 Schematic architecture of data workflows

Interfaces between Digital Material Passports & Existing Databases

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EXECUTIVE SUMMARY

Abstract

To fulfill the ambitions of SUM4Re, interoperability between the data platforms utilized to analyze material data and produce digital material passports and digital product passports is essential. The proof of concept and schematic architecture delivered in this task demonstrate a method of data sharing between the acquisition tools and the three data platforms utilized in SUM4Re.

Summary

At present, existing platforms that process material data, such as Concular, Genia, and Cirdax, operate in silos, each contributing useful functions but lacking interoperability. The central question of this task was how interoperability could be achieved to enrich DMPs and DPPs with a combination of acquisition data and data in existing inventories.

To address this, methods of enabling a reliable data workflow between the platforms were investigated. A proof of concept was developed using LiDAR scan data from the use case in The Hague, together with baseline inventories. The solution introduced a central system connected through a REST API and unique identifiers, enabling data ingestion, retrieval, standardization, and visualization across the three platforms. A complementary approach using UUIDs coordinated by Cirdax was also proposed to ensure consistent identification and exchange of material data. APPENDIX A of the report includes step-by-step instructions on the demonstrator developed as the proof of concept for this task.

The proof of concept validated that interoperability is feasible, showing how data can be shared, standardized, and enriched by each platform. However, limitations remain, including ambiguity in identifying building elements, lack of metadata to track updates, differences in environmental modeling, reliance on organizational participation, and incomplete workflows for acquisition data standardization and UUID assignment.

This report includes future recommendations for the work that will build on this foundation, including implementing a UUID system, developing reliable metadata records, and adopting consistent standards for UUID labeling, IFC versions, and environmental modeling. Workflows for scan data processing and tagging should be standardized and tested across all SUM4Re use cases. Further investigation into the optimal design and business case of the central system is also needed, as its potential for wider implementation could significantly enhance data flows and support circular construction practices.

GLOSSARY

Terms, Abbreviations, and Acronyms

EC	European Commission
DMP	Digital Material Passport
DPP	Digital Product Passport
DBL	Digital Building Logbook
BIM	Building Information Modelling
CBIM	Circular Building Information Modelling
IFC	Industry Foundation Classes
PoC	Proof of Concept
UUID	Universally Unique Identifier
API	Application Programming Interface
NCDM	National Construction Material Database

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1. Introduction

1.1 Background

To achieve the overarching goals of SUM4Re, it is essential to enable effective data sharing between the scanning technologies that capture information from existing buildings, the platforms that process this data, and the associated Digital Material Passports (DMPs) and Digital Product Passports (DPPs).

In this deliverable, we present an overview of the three data platforms utilized in SUM4Re, together with a schematic architecture that illustrates data sharing between acquisition tools and these platforms. We also describe the proof of concept (PoC) developed to demonstrate this interoperability, while noting that the full PoC is documented in a separate report.

By establishing common workflows and demonstrating the exchange of information across multiple platforms, this work contributes to improved interoperability in the built environment data ecosystem. The use of standardized identifiers facilitates compatibility between diverse tools and systems, reducing duplication of effort and enabling more seamless collaboration across stakeholders. This PoC provides a foundation that will be further developed in later work packages.

1.2 Research Question

At present, no solution exists that fully supports the data workflow required to generate DMPs and DPPs by combining data from advanced acquisition technologies with information already stored in existing platforms. While several platforms perform some of the necessary functions to process building material data for inclusion in digital passports, they currently operate in silos, lacking interoperability.

1.3 Objective

The objective of this task is to address the interoperability challenges among three existing data platforms - Concular, Genia, and Cirdax - in order to enable the data workflow required to assimilate material data into the DMP and DPP structures currently utilized by the platforms. To achieve this, we propose an interoperability solution and demonstrate its feasibility through a PoC, which serves as the foundation for further development in WP7.

1.4 Methodology

Several approaches for establishing data workflows between the platforms were investigated. Using sample data acquired through a LiDAR (Light Detection and Ranging) scan from the donor building in the Hague use case (Kindcentrum Binckhorst), as well as baseline inventory data, a proposal for the data architecture was developed. This proposed solution was then tested and validated in the PoC.

1.5 Results

The PoC successfully demonstrates interoperability between the data platforms, enabling workflows that integrate both acquisition data and existing platform data. Identified limitations have been documented, and recommendations have been made for further development of the solution in subsequent work packages, including WP7.

2. Material Life-Cycle

2.1 Schema of material life-cycle

The SUM4Re project aims to extend the lifecycle of building materials through circular reuse. Achieving this requires complex data acquisition and processing workflows. By integrating data collected from demolition sites with information stored in existing databases and ensuring interoperability between the platforms that manage this data, up-to-date, accurate, and detailed DMPs and DPPs can be generated and shared. The use of these passports makes the processes of material recovery and reuse in other buildings more feasible, reliable, and robust, supporting the systematic implementation of circular construction practices.

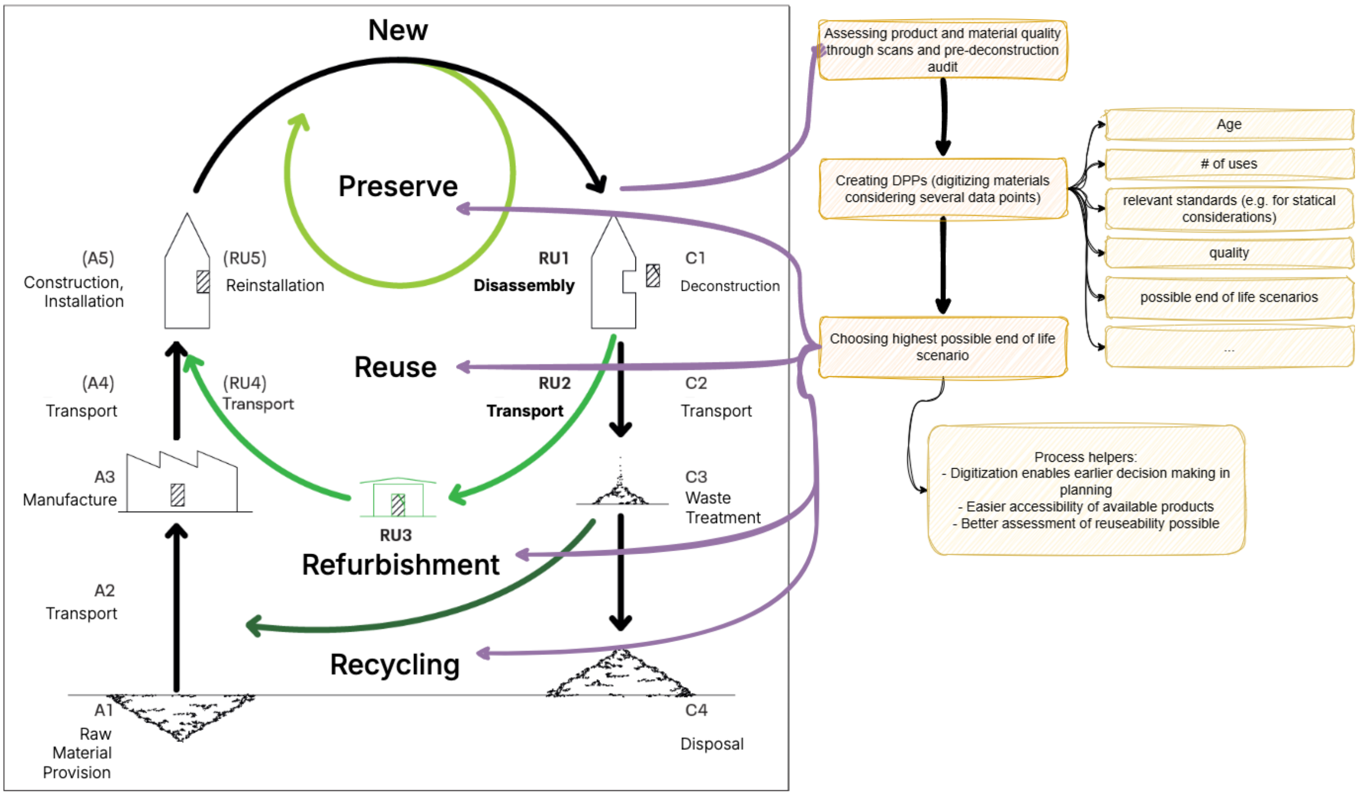


Figure 1. Schema of material life-cycle extension

3. Data Platforms

3.1 Key Platform Features

For the proof of concept, three complimentary platforms were used: Concular, Cirdax, and Genia. Each plays a distinct role in processing and exchanging building material data. Concular contributes capabilities for circular construction workflows and lifecycle assessment calculations, Cirdax provides tools for structured data management and the processing and production of DMPs and DPPs, and Genia offers advanced processing features to visualize 3D models and data as a user interface. Together, these platforms demonstrate how their combined strengths can streamline data sharing and foster reliable, interoperable digital product information.

3.1.1 Concular

Concular is a data-driven platform designed to support calculations related to building material circularity. It draws on existing databases and standards, while allowing the import of multiple file types, including tables and Building Information Modelling (BIM) models, with automated data ingestion. Once data is loaded, users can manually map products and materials or apply predefined defaults from Concular's extensive library, with the option to override and customize entries.

The platform organizes products and objects according to four key factors: origin, separability, deconstructability, and reusability. Together, these form the basis for calculating material lifespans and circularity potential. This structured approach is complemented by robust features such as Life Cycle Assessment (LCA) overviews and a Circularity Score (0-100) that indicates how well a material or object can be reused in the future. Data is also divided into pre-use and post-use phases, offering valuable insight into both the source of materials and their potential applications after deconstruction.

Users can access dashboards that visualize building data and calculation results, supporting decision-making and enabling the export of reports with graphs and visual representations for communication with external stakeholders.

3.1.2 Cirdax

Cirdax is a dedicated data management system designed to support the structured collection, storage, and processing of information within pilot and research projects. Its primary function is to ensure the systematic safeguarding of inventory results and related datasets, thereby enabling reliable analysis and reporting.

The system allows for the integration of both manually collected inventory data - such as material and product specifications and their respective conditions - and digitally generated data from external tools. In doing so, Cirdax functions as an intermediary platform that not only consolidates information but also enriches it by facilitating interoperability between different technological environments.

A key feature of Cirdax lies in its capacity to generate multiple types of output, ranging from standard data exports in .csv and .xlsx formats to comprehensive material, product, and building passports in .pdf format. These passports provide structured summaries of the stored data, ensuring that information can be communicated efficiently with other databases and digital tools.

Beyond its technical role as a repository, Cirdax contributes strategically to the interoperability of digital platforms. By providing protocols for data transfer, integration, and consolidation, it supports the development of a coherent digital ecosystem in which information is not only stored securely but also made accessible, exchangeable, and usable across different stages of analysis and decision-making.

In Cirdax, the following registration classifications are used that are either common in The Netherlands or in the EU:

- **NL-SfB coding**: For categorizing materials and products.
- **10R model**: To determine what happens to the material.
- **Lansink's Ladder**: For defining the waste stream.
- **Layers of Brand**: For the situating of materials and products.
- **NEN 2767**: For condition assessment of materials and products.
- **ICE DB V3.0**: For calculations.

3.1.3 Genia

Genia is an interactive visualization platform designed to display infrastructure models and manage the data associated with each element. It enables users to explore 3D models, filter objects, and access detailed information such as materials, dimensions, quantities, and performance indicators.

By providing an intuitive interface for viewing both the model and its underlying datasets, Genia supports efficient data analysis and enhances decision-making throughout the lifecycle of buildings and infrastructures. Within the project, Genia plays a key role in demonstrating how complex data can be processed, visualized, and shared seamlessly, contributing to the creation of reliable and interoperable digital material and product passports.

3.2 Platform Complementarities and Gaps in Relation to the Research Question

The three platforms demonstrate complementary capabilities that together establish a robust foundation for digital material data exchange. Concular excels in assessing material circularity through structured calculations, LCA, and the assignment of circularity scores. Its classification of products by origin, separability, deconstructability, and reusability directly supports SUM4Re's objective of extending material lifecycles. Cirdax contributes by providing a structured data management environment that ensures the secure storage, classification, and systematic processing of inventories, while also generating standardized outputs in the form of DMPs, DPPs, and building passports. Genia complements these functionalities by translating complex datasets into accessible, interactive 3D visualizations, thereby facilitating decision-making and demonstrating how digital information can be integrated into user-oriented workflows.

While Concular, Cirdax, and Genia offer complementary functionalities, significant gaps remain that constrain their interoperability and the realization of a fully integrated workflow. In Concular, the platform's strength lies in circularity assessments, life cycle calculations, and the assignment of Circularity Scores, yet it operates primarily as a self-contained calculation environment. Data imported from external sources, whether through tables or BIM models, requires manual mapping, and the reliance on default product datasets can limit flexibility. Without standardized identifiers or consistent integration protocols, Concular's outputs may not be readily interoperable with other platforms, creating the risk of data duplication or misalignment when combined with Cirdax or Genia.

Cirdax serves as a structured repository and processing platform, consolidating both manually collected and digitally generated inventory data. Its classification schemes provide rigor, but are not universally adopted outside the platform and across the EU. Consequently, integrating Cirdax data with external tools or visualization platforms like Genia may require extensive translation, mapping, or standardization. Moreover, while Cirdax supports the generation of DMPs, DPPs, and related reports, it does not inherently facilitate dynamic updates across connected platforms, limiting the real-time interoperability needed to support iterative project workflows.

Genia excels in visualizing 3D models and associated material data, providing a user-friendly interface to explore complex datasets. However, Genia's role is largely observational rather than computational, therefore, it is heavily dependent on the consistency and quality of input data from other platforms.

3.3 Platform Demonstrations

A video compilation that demonstrates the functionalities of each platform is available via this link:

Platform Demonstration Videos

Please note that in the interest of privacy, some elements in the demonstrations have been blurred.

4. Proof of Concept & Schematic Architecture

The proposed solution addresses the interoperability gaps among the platforms by enabling standardized data exchange between them. In this solution, the platforms do not connect directly via an interface, but via a central system, hosted by the owner of the Genia platform. The central system is a new infrastructure developed by Tecnalia within the SUM4RE project and currently hosted by them, although it could be hosted by any partner in the future. Independent from any specific system or platform, it is built on the data model scheme defined in Section 4.1, enabling centralized data management in a scalable way with support for multiple concurrent actors. Through unique identifiers and a Representational State Transfer Application Programming Interface (REST API), it integrates data from acquisition methods, which can then be incorporated into the three platforms. In this way, data that would otherwise remain siloed within the three platforms can be shared seamlessly, with each platform transforming the data according to its own functionalities and intended purposes.

The proof of concept demonstrates how data from a single building element can be processed across Concular, Cirdax, and Genia, with each platform contributing distinct functionalities for data transformation. The schematic architecture illustrates the interoperability pathways and the role of the central system in facilitating communication.

In addition, we propose the development of a Universally Unique Identifiers (UUID) system to ensure consistent identification of materials and data across the platforms. Aside from data obtained through the acquisition methods, a portion of building material data is included as baseline inventories in the Cirdax platform, obtained via manual input or other sources. Parallel to the development of this PoC, task 10.2 in SUM4Re develops these baseline inventories as complimentary to the scans. By using a UUID system, this baseline data can be shared consistently between Cirdax and the other platforms, and transformed by each without risking duplicates, inaccuracies or lost data.

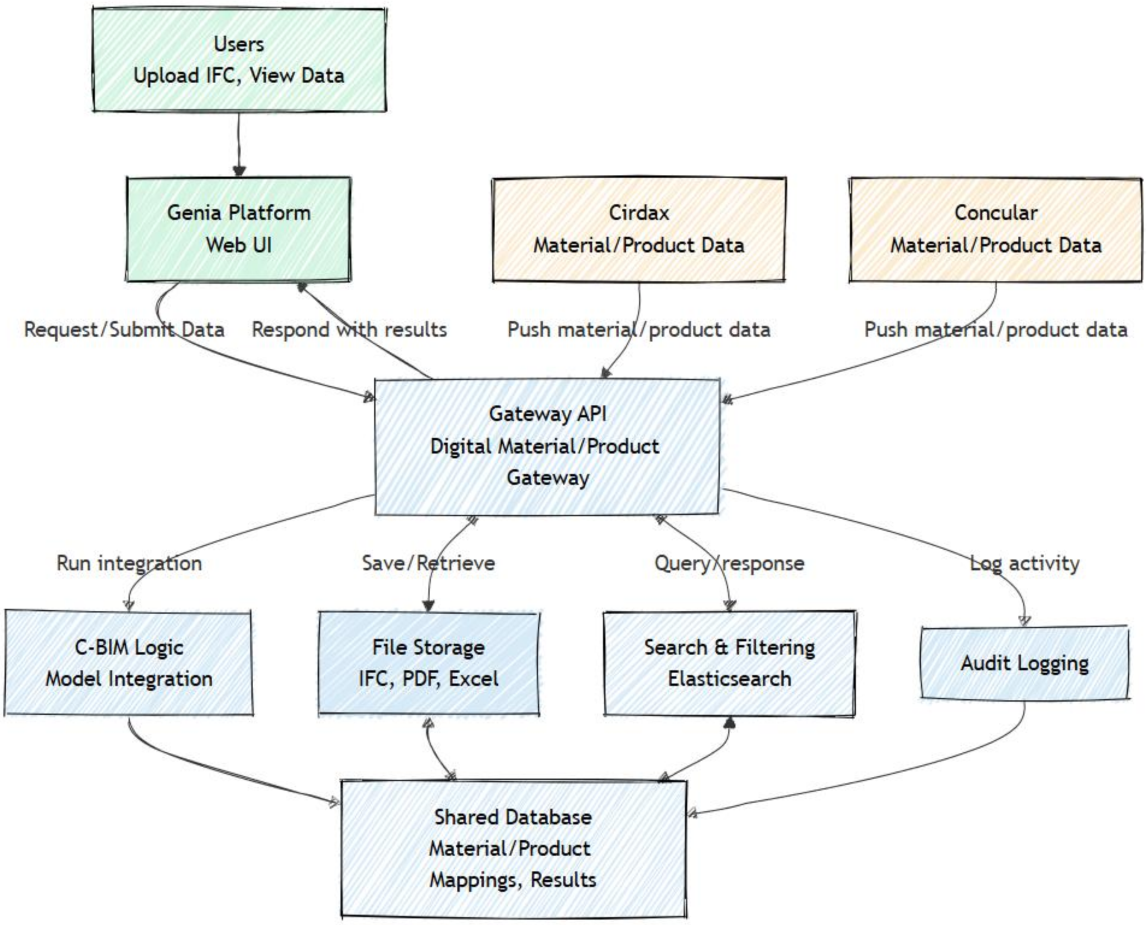


Figure 2. Integration framework.

The diagram in Figure 1 outlines the integration framework connecting the Genia platform with Cirdax and Concular providers, highlighting the flow of data through the Gateway API.

4.1 Proof of Concept

Within the PoC of the SUM4Re project, the Genia platform provides a REST API to manage information about products and materials. Each product can be composed of one or more associated materials, and each provider company periodically updates the properties of these entities through the API using the unique identifier `sum4reId`. Additionally, the platform integrates DPP and DMP, allowing each entity to be linked to its digital passport via `passId`, ensuring data traceability and harmonization throughout the lifecycle.

Material Model

Field	Type	Description
sum4reId	string	Unique SUM4Re identifier for the material.
providerId	string	Identifier of the data provider company.
projectId	string	Identifier of the related SUM4Re project.
passId	string	Identifier of the associated Digital Material Passport.
properties	object	Technical/environmental properties of the material (JSON).
createdAt	datetime	Record creation date.
updatedAt	datetime	Record last update date.

Product Model

Field	Type	Description
`sum4reId`	string	Unique SUM4Re identifier for the product.
`providerId`	string	Identifier of the company owning the data.
`projectId`	string	Identifier of the related SUM4Re project.
`passId`	string	Identifier of the associated **Digital Product Passport**.
`properties`	object	Product properties (composition, EPD, LCA, etc.).
`ifcBuildingElementId`	string	Identifier of the IFC building element for BIM traceability.
`createdAt`	datetime	Record creation date.
`updatedAt`	datetime	Record last update date.

The GENIA platform plays a key role in achieving the SUM4Re objectives by enabling the standardization and unification of product and material data across different companies. Through its central API and data model, GENIA ensures that information such as material properties, product specifications, and associated DPPs and DMPs is structured and accessible in a consistent way. This allows the IFC viewer and other integrated tools to operate seamlessly without needing to adapt to the diverse data models and workflows of individual companies.

4.2 Schematic Architecture

The schematic architecture illustrates the data flow within the Products and Materials Central System as implemented in the SUM4Re PoC. The process begins with the scanning phase, where information about products and materials from the project is extracted and uploaded into the central platform.

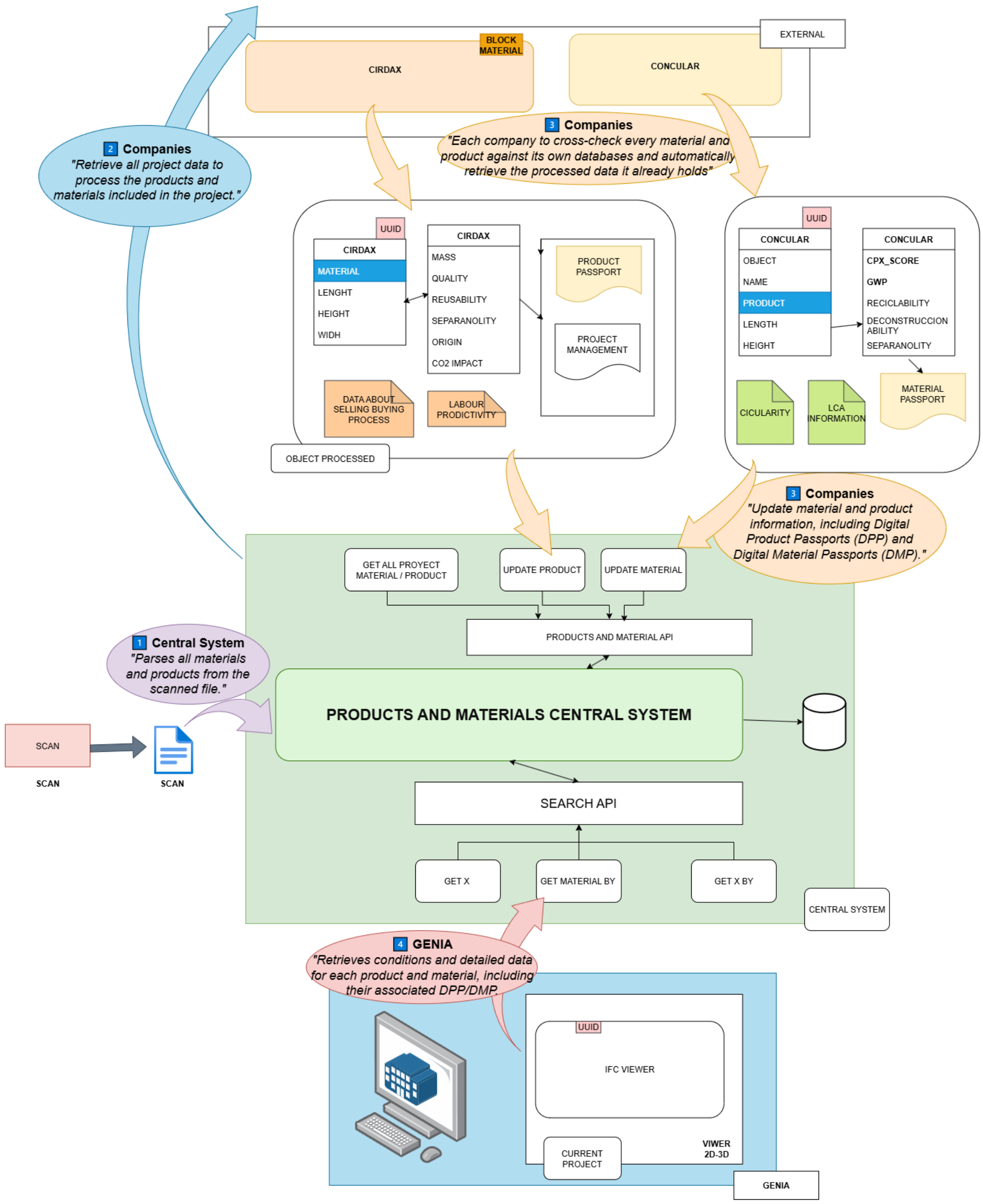


Figure 3. Schematic architecture illustrating how the central system enables interoperability between Concular, Cirdax, and Genia.

Actors

- **Central System**: New infrastructure developed within the SUM4RE project, independent from any specific platform. It enables centralized data management in a scalable way, supporting concurrent access and ensuring standardized data across all participants.
- **GENIA**: Visualization environment that retrieves harmonized information from the Central System and displays it through the IFC viewer.
- **Cirdax and Concular**: Product and material databases that provide data on material and product properties, circularity, and lifecycle assessment.

Data flow

The following data flow explains the numbered steps in Figure 3, showing how information is ingested, retrieved, standardized, and consumed across the actors.

1. **Data Ingestion** – The **Central System** parses all the scanned information, identifying the **products** and **materials** defined in the project. This forms the basis of the shared dataset managed within the platform.
2. **Data Retrieval** – Participating **companies** access the central platform to **retrieve all project data** relevant to the products and materials they are responsible for. This allows them to process, verify, and enrich their own datasets accordingly.
3. **Data Update and Standardization** – Each company to cross-check every material and product against its own databases and automatically retrieve the processed data it already holds. At this stage, the associated **DMP** and **DPP** are also created or linked via the passId. This step ensures that data from different companies is **standardized**, avoiding the need for the IFC viewer and other integrated tools to adapt to heterogeneous company-specific models.
4. **Data Consumption and Visualization** – The **GENIA** platform retrieves structured and harmonized information from the central database, including the DPP/DMP data for each product and material. This enables the **IFC viewer** to visualize the complete set of properties and lifecycle data in a **unified and interoperable format**.

By structuring the data flow in this way, the platform ensures that the **DMP** and **DPP** are seamlessly integrated into the overall process. This supports the **SUM4Re objectives** by enabling a **consistent, centralized, and standardized** representation of information across all stakeholders, while facilitating **interoperability** with external tools and viewers.

4.3 Gateway Interface

This section proposes a RESTful API Gateway designed for the SUM4RE project, for enabling data exchange between Genia, Cirdax, and Concular platforms. The architecture utilizes a shared server and database environment, potentially hosted by Tecnalia, facilitating essential data integration, interoperability, and visualization.

4.3.1 Data flow and integration scheme

The Gateway serves as the central component of a federated data infrastructure, enabling collaboration across multiple partners while allowing each to retain control over their internal systems. At the heart of this gateway is a shared server and database, which acts as the central hub for storing SUM4RE-specific data and results.

Cirdax, Concular, and Genia each manage their own internal databases and business logic independently. However, they collaborate by selectively pushing essential data into the shared server, contributing to the creation of enriched Circular Building Information Models (C-BIMs). The system's key components are:

- Shared Server and Database: The central repository for harmonized data and results relevant to SUM4RE.
- C-BIM Module: A collaborative layer developed by Cirdax, Concular, and Tecnalia that integrates IFC models with material and product passport data and testing outcomes. This enriched data is made accessible through Genia’s 3D Viewer.
- Cirdax & Concular Servers: These handle proprietary business logic and maintain detailed internal datasets. They contribute selectively to the shared gateway, transferring only data relevant to the SUM4RE project.

- Tecnalia Infrastructure (Optional Hosting): Tecnalia may host the shared server, supporting both infrastructure and collaborative efforts in data integration and interoperability.

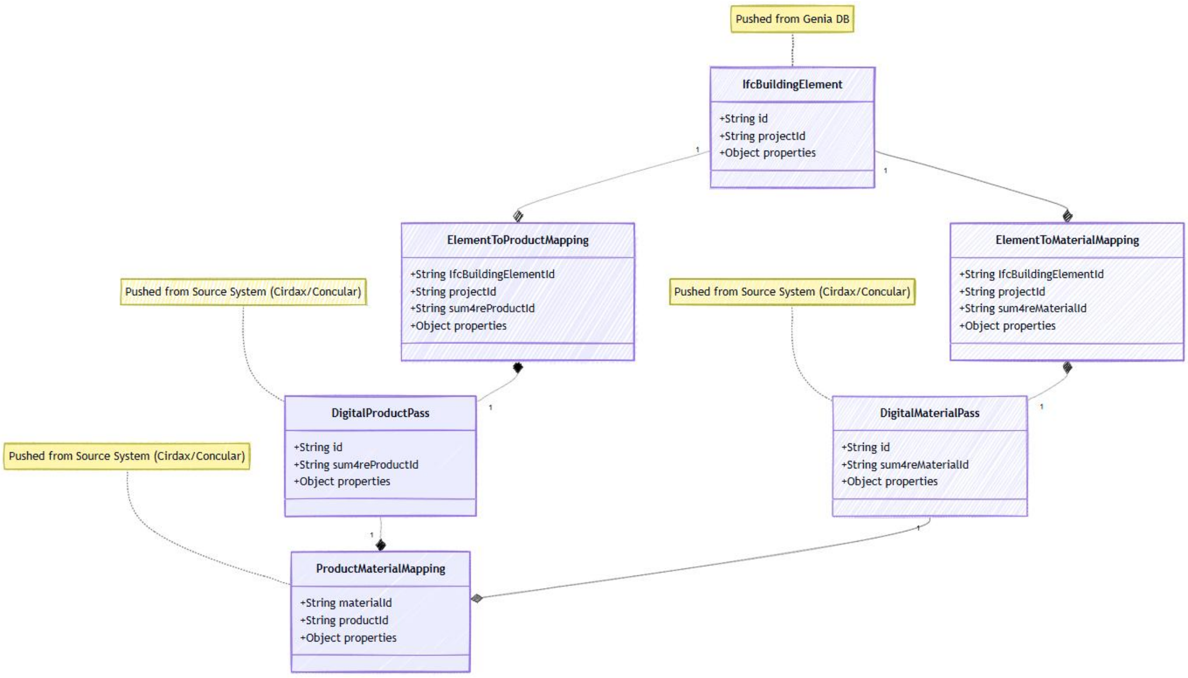


Figure 4. Data Model for Mapping IFC Elements to Digital Material and Product Passports.

The diagram in Figure 4 illustrates the key aspects of the integration between the platforms, highlighting the relationships between IFC building elements, materials and products. Each material can be used in multiple IFC building elements, and each IFC building element can consist of multiple materials and products. These relationships are managed through API endpoints, which handle the creation, retrieval, and maintenance of these data mappings. The mapping relies on unique identifiers (e.g., sum4reIds) to reference specific materials and products stored in external systems like Cirdax and Concular. This approach allows users to query all mappings related to a specific material or product within a project, facilitating the calculation of for instance total material usage by aggregating quantities across IFC building elements.

Specifically, the diagram depicts:

- The ElementToProductMapping entity, responsible for managing associations between IFC elements and products.
- ElementToMaterialMapping entity, responsible for managing associations between IFC elements and materials.
- The ProductMaterialMapping entity, which handles the relationship between materials and products, including the material and product identifiers along with related properties.

The data model illustrates the following one-to-many and many-to-one relationships:

- One-to-many between IfcBuildingElement and ElementToProductMapping
- One-to-many between IfcBuildingElement and ElementToMaterialMapping
- Many-to-one from ElementToMaterialMapping to DigitalMaterialPass
- Many-to-one from ElementToProductMapping to DigitalProductPass

- One-to-many between DigitalMaterialPass and ProductMaterialMapping
- One-to-many between DigitalProductPass and ProductMaterialMapping

This data model currently assumes a many-to-many relationship between IFC elements and product/material passports. This is achieved using mapping entities ElementToProductMapping and ElementToMaterialMapping. However, this structure can be adjusted to a one-to-many relationship depending on how product and material passports are defined and structured within the IFC model.

Specifically, if each material is intended to belong exclusively to a single product, the current many-to-one relationship from ProductMaterialMapping to DigitalMaterialPass could be simplified into a one-to-one relationship. Consequently, this would establish a straightforward one-to-many relationship between products and their associated materials.

4.3.2 API Endpoints overview

The Gateway acts as a centralized API for managing, linking, and tracking digital materials and products in a digital environment. Table 1 and Table 2 present an overview of the main elements of the proposed API. Assuming Cirdax/Concular manages the DMP and DPP data, the API should ensure that Genia can access this information and link it to IFC elements.

Table 1. Integration and data exchange.

Operation	*Method*	*Endpoint*	*Description*
Push materials from Cirdax and Concular	POST	`/gateway/{providerId}/projects/{projectId}/materials`	Transfers selected material passport data from external providers (Cirdax or Concular) to the shared database. If the material record already exists in the database, it will be updated with the new information. If the material doesn't exist, a new record will be created. Returns object with created sum4reMaterialId.
Push products from Cirdax and Concular	POST	`/gateway/{providerId}/projects/{projectId}/products`	Transfers selected product passport data from external providers (Cirdax or Concular) to the shared database. If the product record already exists in the database, it will be updated with the new information. If the product doesn't exist, a new record will be created. Returns object with created sum4reProductId. Message body could contain optional product and material mappings.
Push product material mapping from Cirdax and Concular	POST	`/gateway/{providerId}/projects/{projectId}/productsMaterial`	Transfers product material mappings data from external providers (Cirdax or Concular) to the shared database. If the mapping record already exists in the database, it will be updated with the new information. If the mapping doesn't exist, a new record will be created. Returns object created.
Retrieve Materials for Project (Genia)	GET	`/gateway/projects/{projectId}/materials`	Get direct linked materials data to IFC elements in the project, and related details. *Note: Materials not linked directly to* IFC elements *(e.g. linked to products) may be retrieved using the search functionality described in Table 3.*
Retrieve Products for Project (Genia)	GET	`/gateway/projects/{projectId}/products`	Get products data, and related details.

Table 2. Material/Product Linking (Managed by Genia).

Operation	*Method*	*Endpoint*	*Description*
Link Material to IFC Element	POST	`/gateway/projects/{projectId}/elements/{ifcBuildingElementId}/materials/{sum4reMaterialld}`	Link material to an IFC element.
Unlink Material from IFC Element	DELETE	`/gateway/projects/{projectId}/elements/{ifcBuildingElementId}/materials/{sum4reMaterialld}`	Unlink material from an IFC element.
Link Product to IFC Element	POST	`/gateway/projects/{projectId}/elements/{ifcBuildingElementId}/products/{sum4reProductld}`	Link product to an IFC element.
Unlink Product from IFC Element	DELETE	`/gateway/projects/{projectId}/elements/{ifcBuildingElementId}/products/{sum4reProductld}`	Unlink product from an IFC element.

4.3.3 Operational and Integration Considerations

The table below lists the main technical and functional needs for the Gateway API, including access control, data checks, logging, search, real-time updates, and storage.

Table 3. Technical and functional needs for the Gateway API

Category	**Description**
Access Management & API Authentication	- Securely manage authentication tokens/API keys (e.g. based on OpenID Connect and OAuth 2.0) within Genia. - Define roles with appropriate scopes, for instance: • Admin: Full access (create, link, export) • Editor: Link/unlink materials and products • Viewer: Read-only access to IFC elements and passports
Validation & Data Conformance	- Apply JSON Schema validation for all API inputs, including verification of mandatory vs. optional fields in the schema (e.g., material ID, type, and sustainability data as mandatory; quantity optional). - Validate ids, units, types, and ranges (e.g., prevent negative densities). - Enforce standardized digital material passports (e.g., sustainability fields must be present).
Audit Logging & Change History	- Log critical actions for traceability: • Material creation, updates, and deletions • Linking/unlinking to IFC elements • PDF/Excel exports/downloads

Search & Filtering	- Enable attribute-based filtering (e.g., low CO_2, high recyclability). - Use a search-friendly database like Elasticsearch. - Sample API endpoints: • GET /materials/search?recyclability>80&co2<10 • GET /projects/{projectId}/materials?rel=all • GET /projects/{projectId}/materials?fireRating=B - Add filter UI in Genia for passport attributes.
Webhooks & Real-Time Updates	- Use webhooks to sync updates from Cirdax and Concular to the shared server enabling Genia to reflect new/updated material and product data without polling, improving responsiveness. - Cirdax and Concular are the source systems for material and product data. These systems generate events whenever material and product data are modified within their respective databases. - The shared server acts as the destination system. It receives the webhook notifications directly from Cirdax and Concular. - Payload sent to destination system (Webhook Payload), includes for instance: • Event Type: Clearly indicating the event (e.g., "material.updated," "material.deleted") • Timestamp: When the event occurred. • Material ID: Unique identifier of the material in the source system. • Material Data: Attributes such as name, properties, type, and any other relevant details. • Source System Identifier: Indicating whether the update originated from Cirdax or Concular.
Documentation	- Publish an OpenAPI (Swagger) specification. - Host developer-friendly documentation with: • Endpoint and payload overviews • Webhook formats • Auth setup instructions • Example workflows
Infrastructure & Data Storage	- The Gateway must have well-structured storage and hosting to manage IFC elements, material/product mappings, and associated properties. - The database (potentially hosted by Tecnalia) should support scalability, high availability, and interoperability. - Genia must also support file storage/export for formats like PDF and Excel. Endpoints for file handling (upload, download, export) should be considered if integrated via the GatewayAPI.

The table below summarizes the components illustrated in the diagram in Figure 1 (Integration Framework) and their roles in managing, processing, and displaying material and product data.

Table 4. Description of components in the integration framework.

Component	*Description*
Shared Database (Material Mappings, Results)	- Central data store for the SUM4RE project - Records mappings between IFC elements, materials, and products - Stores results such as quantities, sustainability metrics, and evaluation scores from Cirdax and Concular - Project-specific and scoped to avoid full duplication of source databases
C-BIM Logic (Model Integration)	- Intelligence layer connecting IFC data from Genia with material/product data from Cirdax/Concular - Computes or compiles C-BIM (Circular BIM) views or summaries - Prepares enriched content for visualization in Genia's 3D viewer (e.g., test results, material passports, lifecycle info)
File Storage (IFC, PDF, Excel)	- Manages all file-based data exchanges - Stores uploaded IFC files from Genia users - Handles exported reports (PDF/Excel) with material passports, mappings, quantities, or summaries - Supports secure, scalable object storage with access control and temporary download links
Search & Filtering (Elasticsearch)	-Enables fast, user-friendly querying -Supports filtering of material/product passports (e.g., CO_2 footprint, recyclability, fire rating) - Allows querying of IFC elements and their linked materials/products
Audit Logging	-Tracks all critical system actions -Records who created or modified mappings -Logs export events and material data updates -Essential for accountability, compliance, and troubleshooting, especially in collaborative environments

4.4 Complimentary Approach

Complimentary to the architecture proposed above, this architecture utilizes UUIDs with central coordination handled by one designated platform.

Cirdax is a data management system designed to safeguard information on materials, products, and buildings. The platform provides a REST API that enables the exchange of DMPs, DPPs, and digital building passports (DBPs), along with all supplementary data required to generate or enhance these passports.

The primary function of Cirdax is to translate building inventories into structured data, which are subsequently processed into passports that communicate through a unique identifier with the central SUM4Re server.

As illustrated in Figure 4, Cirdax supplies data that can be accessed, imported, and exported by other data systems. The information secured within Cirdax is continuously updated when necessary, ensuring that all passports are represented as accurately as possible within the system and that the correct data is consistently available for communication via the SUM4Re server.

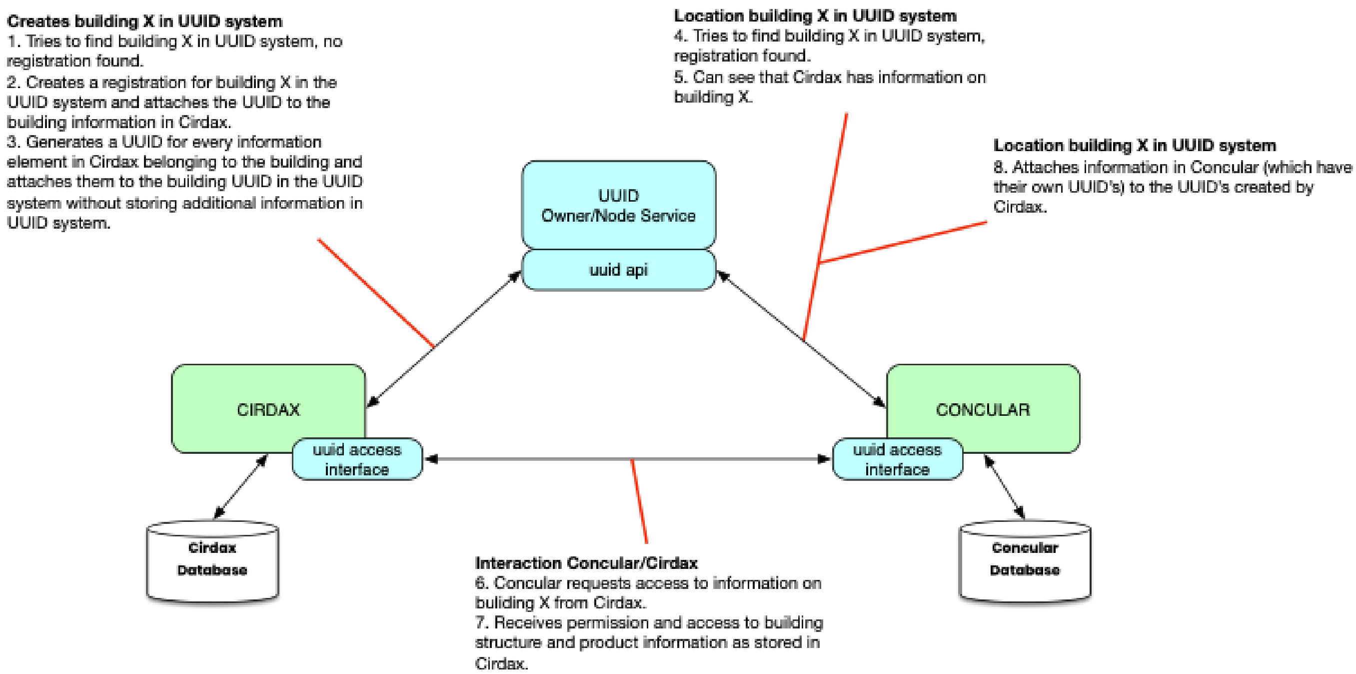


Figure 5. The UUID architecture enabling the sharing of building data between platforms

4.5 Demonstrator

The video demonstrator for the proof of concept can be found here:

Proof of Concept Video Demonstrator

A step-by-step guide to the proof of concept can be found in APPENDIX A: Proof of Concept – Demonstrator Guide.

5. Conclusion and Recommendations

5.1 Proof of Concept

This task addresses the interoperability gaps between existing, independent data platforms that each contribute unique functionalities to the processing of building material data for DMPs and DPPs that are essential for the extension of the material lifecycle.

Data platforms that operate in siloes can transform important material data, but without sharing this data between platforms, important information is lost or duplicated, and reliability is compromised. In this deliverable, we have demonstrated a proof of concept of how the interoperability between these platforms can be resolved using a central system. From data acquired through scanning methods that are entered into the central system, the use of a REST API and unique identifiers allow the sharing of data between platforms and the enrichment of DMPs and DPPs with data transformed by each platform. This proof of concept was tested and validated, and a demonstrator provided.

Regarding scalability, in this first approach the system has been conceived as a data repository exposed through an API, fully agnostic to visualization tools. It manages synchronized standard models with high complexity and is designed to support large-scale concurrent access. This architecture provides a robust and scalable backbone for data management, while visualization or other platforms simply interact with it through requests.

Additionally, a complimentary approach was proposed using UUIDs to identify and seamlessly share data between the platforms, coordinated by Cirdax. This will allow data from baseline inventories and other sources in Cirdax to be consistently and reliably shared between the three platforms.

This provides the foundation required for the further development of an integrated solution to be undertaken in WP7.

5.2 Limitations

While this solution establishes a foundation for interoperability and standardized data sharing across the three platforms, several limitations remain:

- **Ambiguity in identifying identical building elements:** The IFC Global ID is used to determine which objects to fetch or update; however, there is no guarantee that objects with the same ID are identical or contain the same properties. For example, if system A contains an outdated file compared to system B, objects may differ in dimensions or materials despite sharing an ID.
- **Lack of property metadata:** Although the integration updates building element properties successfully, there is no record of who made the change, when it occurred, or what was updated. In practice, multiple integrations could overwrite the same properties without awareness of conflicts.
- **Differences in environmental modeling:** Entities such as building elements and products are modeled differently across platforms, which can lead to inconsistencies in interpreting environmental information. For instance, in this integration, Concular and Tecnalia handle Global Warming Potential (GWP) values differently.
- **Dependence on organizational participation:** The efficacy of GENIA relies on the active cooperation of all participating companies, each of which must integrate its own systems and data models into the platform. Without full integration, standardization is less effective, limiting interoperability and reducing the completeness of data required for SUM4Re’s objectives.

Additionally, the workflow for incorporating acquisition data into the central system—including its standardization and assignment of UUIDs—has not yet been addressed.

5.3 Recommendations

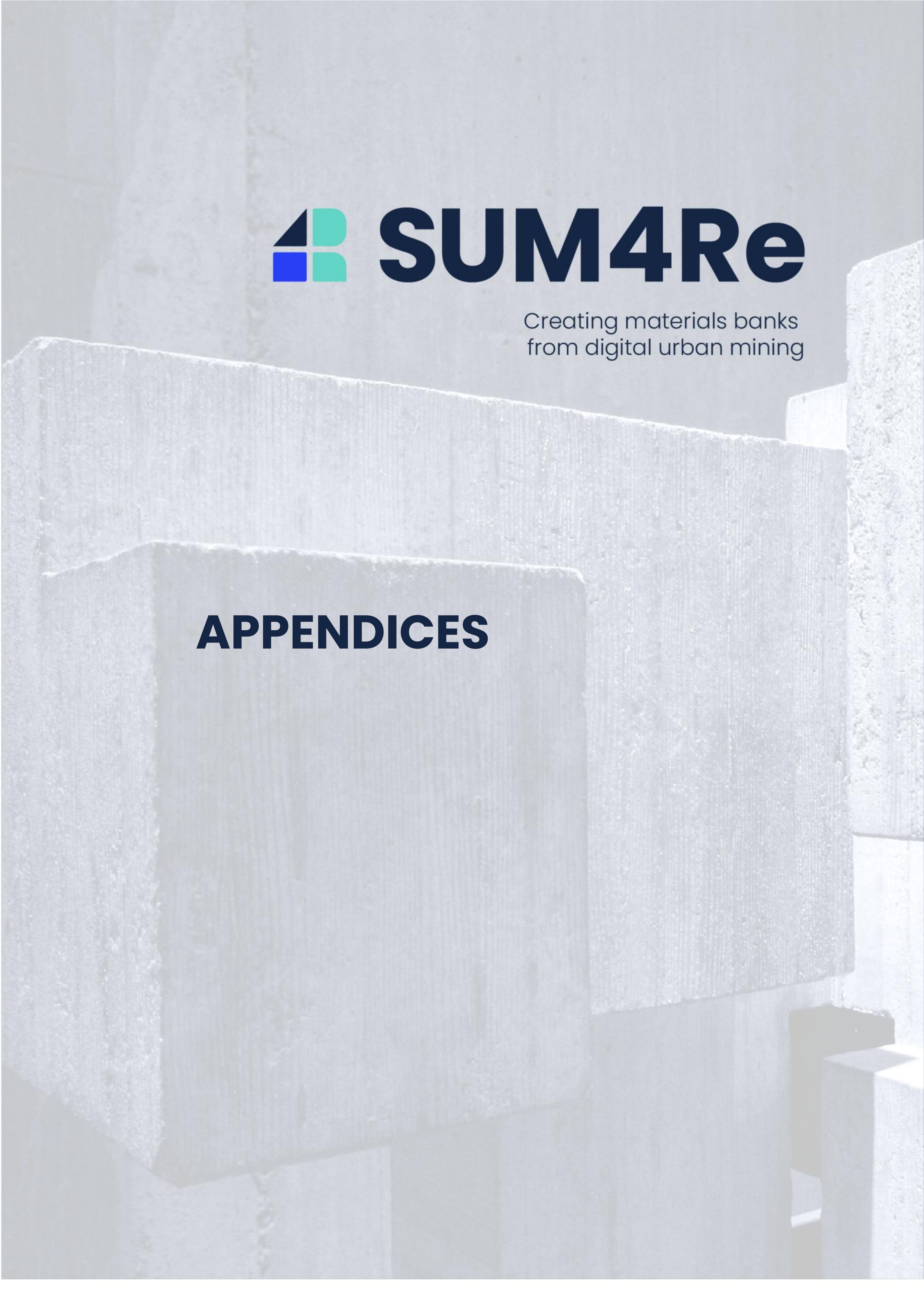
The tasks of WP7 should build upon the architecture established and tested in this deliverable to develop a central system where acquisition data can be seamlessly integrated and consistently tagged. In the further course of the project, important new functions will be added. A key goal is to enable all data to be requested from Genia as a single user interface. Furthermore, great importance will be placed on utilizing decentralized systems that provide the user experience of a centralized system. This will be achieved by empowering the UI to query required information on-demand directly from all connected sources. Such a federated approach offers greater flexibility and scalability than a single central database, as new tools and information sources can be easily integrated in the future. It also enhances efficiency by ensuring users retrieve only the specific, up-to-date data relevant to the products they are investigating. This ad-hoc request mechanism also provides a pathway to address some of the limitations identified. By storing the origin of the data and keeping track of how each actor manages or transforms information, the system can generate a reliable property metadata record, avoiding silent overwrites.

Regarding the dependence on organizational participation, this is an inherent characteristic of an ecosystem built on company data. Establishing common standards and clear workflows will reduce integration complexity and provide a shared framework, though some degree of cooperation will always be required. Companies that wish to share information will still need to coordinate with GENIA to determine what data is made accessible. Nevertheless, under the new vision in which GENIA requests information directly from the companies' systems, this cooperation becomes simpler and more streamlined, even if it can never be entirely eliminated.

The successful implementation of a UUID system will be key to resolving ambiguities in identifying identical building elements. Leveraging the existing functionalities of Cirdax, together with the potential adoption of Blockchain technologies, provides a viable pathway toward establishing a reliable metadata record.

To ensure consistency, existing standards for UUID labeling should be adopted, while addressing the current gaps and limitations in digital modeling standards. Likewise, the IFC version to be used across platforms - and for processing acquisition data - should be jointly agreed upon and set as a project-wide standard. The processing of scan data, its incorporation into the central system, and its assignment with unique identifiers should also be standardized and tested across the three SUM4Re use cases. This will help establish a reliable workflow that can be consistently applied to future cases and practical implementations.

Finally, the practicality, exploitability, and potential business case for this system beyond the SUM4Re research project should be assessed. The opportunity for broader public implementation is significant, with the potential to substantially improve data flows in construction and circularity practices.



SUM4Re

Creating materials banks from digital urban mining

APPENDICES

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LIST OF APPENDICES

LIST OF FIGURES IN THE APPENDICES

APPENDIX A: Proof of Concept – Demonstrator Guide

This proof of concept demonstrates the integration of the Concular, Genia, and Cirdax platforms within a data workflow relevant to the SUM4Re project. Its primary objective is to enable the reliable and streamlined exchange of data between these platforms, facilitating the access, import, and export of information necessary to enrich DMPs and DPPs with data from acquisitions technologies and baseline inventories, processed using each platform's unique capabilities.

The example used in this PoC is data related to a door in the donor building, Kindcentrum Binckhorst, in The Hague. The building was scanned using LiDAR technology, and the IFC model produced from the scan used in this PoC.

The PoC includes:

- An integration sequence diagram
- Step by step description and screenshots
- Reference source code
- Instruction for the use of the demonstrator

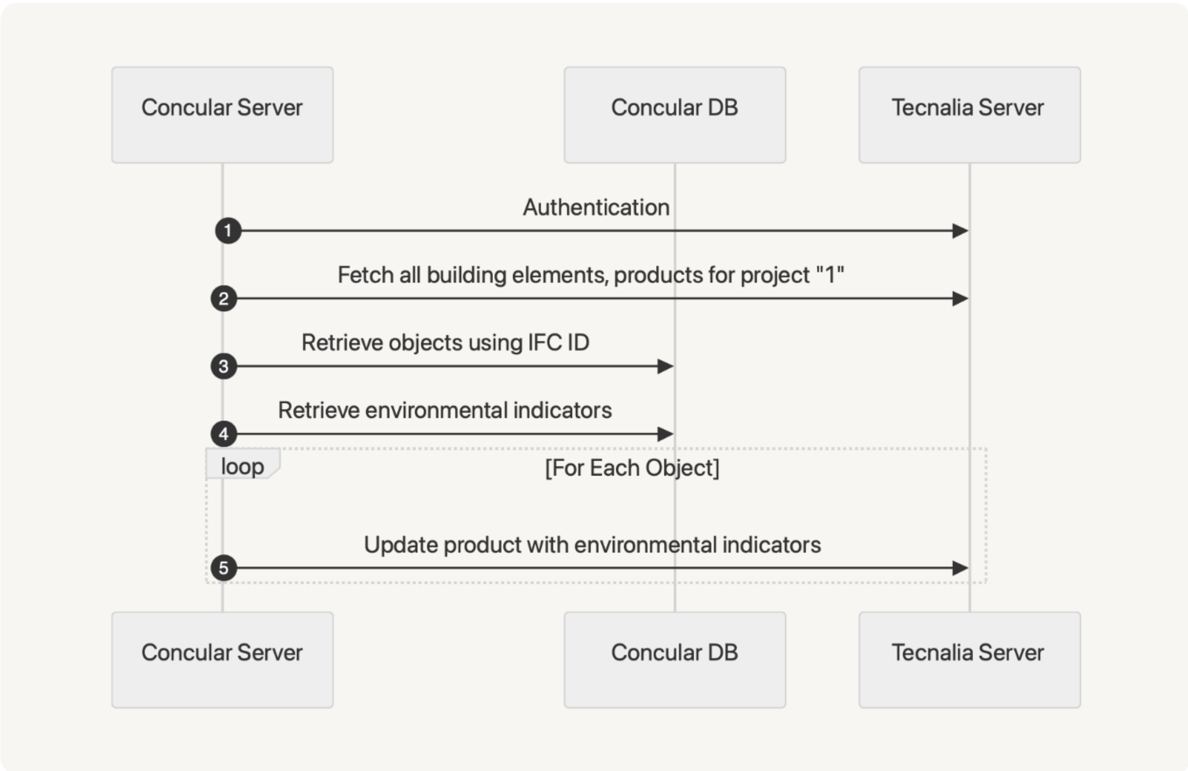


Figure 1-A. Integration Sequence Diagram.

[3] The assumption is that the same IFC file is used in both servers

[4] The Concular Performance Index (CPX) score and Global Warming Potential (GWP) are retrieved. This can easily be extended to 100+ different environmental indicators available in the Concular Database.

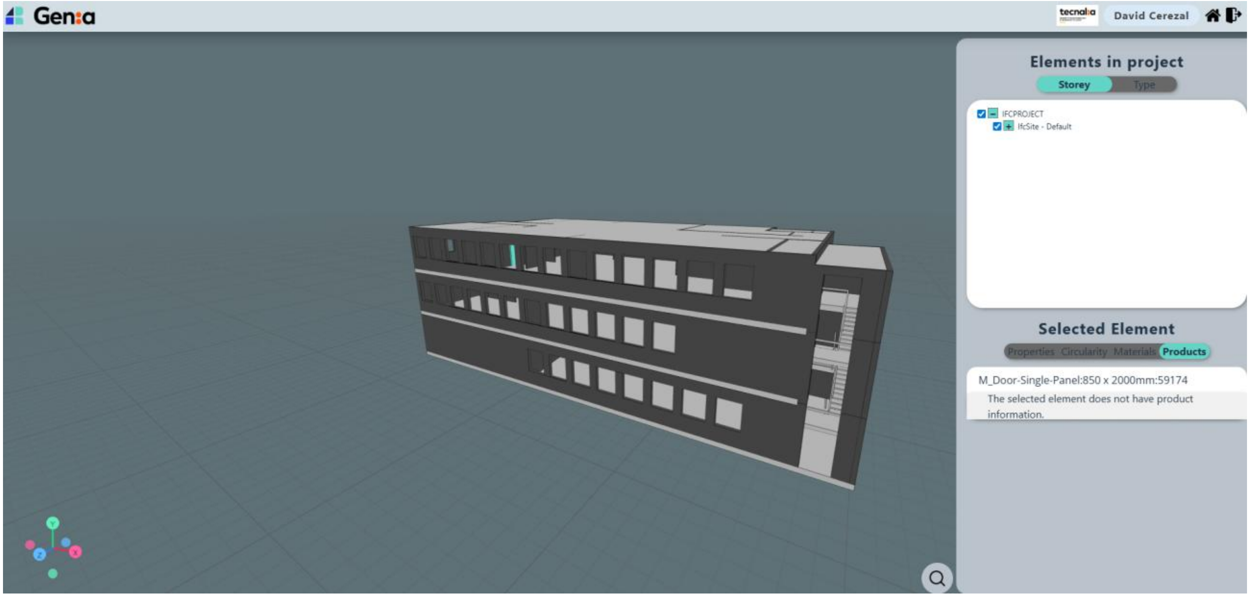


Figure 2-A. CPX and GWP variables absent in Genia.

The goal is to obtain the cpx score and gwp total for the door. In the Genia platform, these values are absent and will be obtained from the other platforms.

Steps 1-2: Authentication and fetching information

For security reasons, an authentication credential (token) needs to be used before information can be retrieved. The Concular server has a client_secret which is required to start the security credentials exchange. This secret was given offline and is not part of the integration code. The very first part of the integration is to get the Token which is then added in every request.

```
root@ip-10-0-221-176:/code# python manage.py update_sum4re 1
INFO 2025-08-25 11:19:44,325 report.services.sum4re - Token: eyJhbGciOiJSUzI1NiIsInR5cCI6ImF0K2p3dCIs
XlHeUluVi1aOG5GZ0ZkamhBcVp1aklvIiwic3ViIjoic3VtYTRyZS1hcGkiLCJpYXQiOjE3NTYxMTM1ODQsImV4cCI6MTc1NjExNz
51cmJhbi50ZWNuYWxpYS5kZXYvYXV0aCIsImF1ZCI6Imh0dHBzOi8vc3VtNHJlLnVyYmFuLnRlY25hbGlhLmRldi9hcGkifQ.rUu
0K-WH63MKNUileQqEOt3yvoawqdLq1y02Tn2RI49TWHVAWCovyXbP8O8ViPkZQU5babLy2an6iZHOsCWrkA_47h-Plve03G2tHYL
9OtFNpmIs2gQK1PYoiXemjmHf23auDdDFDdz-t_wYYOgtlfeWxRpy36RRPzsuXLhFtSM-zk3QcB7KdvqUrlTk4NTK8isCX2GUPHn
```

Figure 3-A. Sample token.

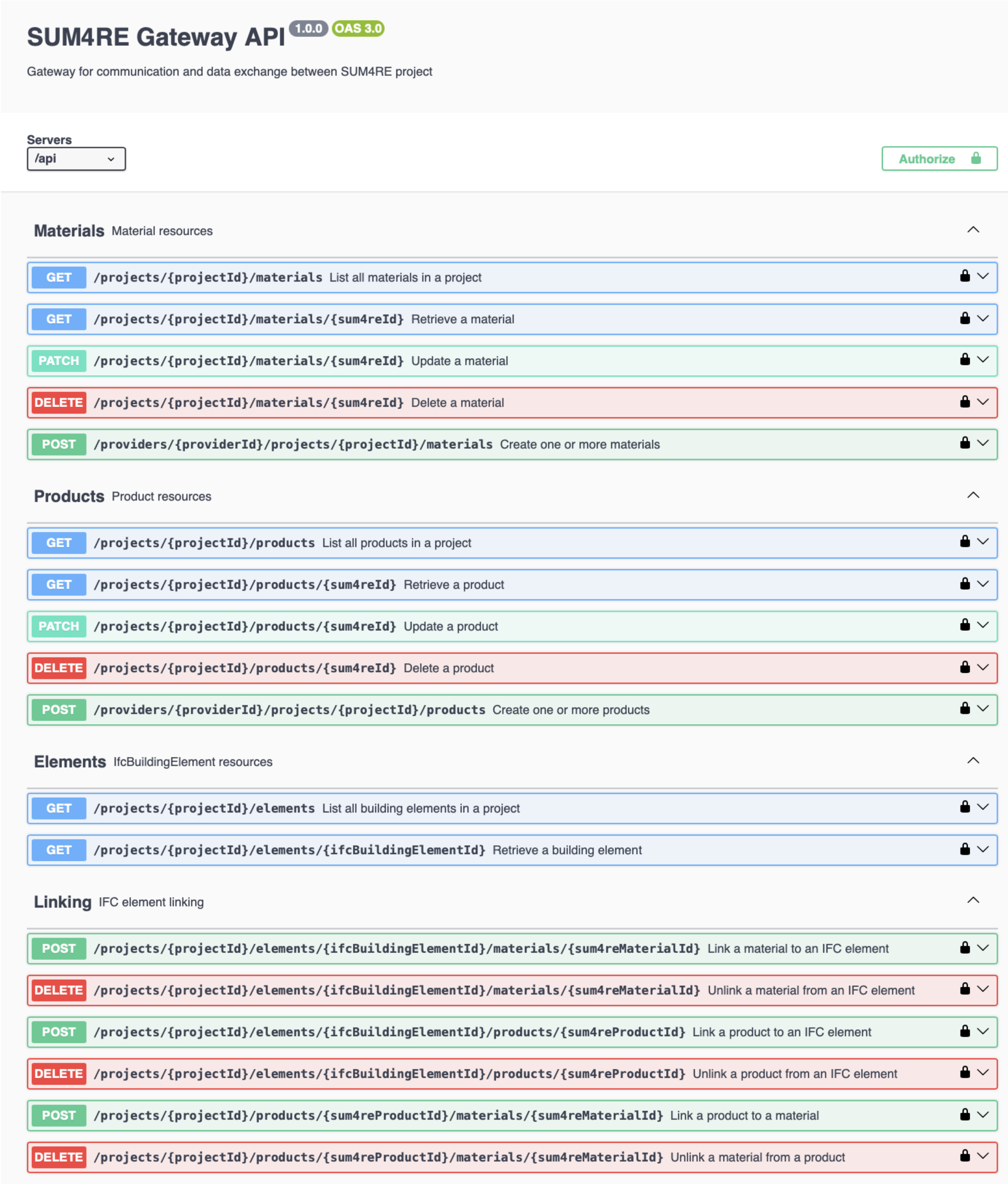


Figure 4-A. SUM4Re Gateway API, Tecnalia OpenAPI Documentation. Available at: https://sum4re.urban.tecnalia.dev/docs/.

Steps 3-5: Pushing information about environmental indicators

Once information from Tecnalia has been retrieved, it is cross-referenced with the information from Concular.

Here there's one key limitation: **we assume the same IFC file was processed the same in both servers.**

Once common elements between the two servers are found, the relevant information (CPX, GWP) is retrieved and we start updating the Tecnalia server. Here we see another limitation:

Tecnalia has a different data model than Concular. **One stores values per building element and the other per product, resulting in different building elements sharing the same properties.**

```
INFO 2025-08-25 11:19:44,572 report.services.sum4re - N° of distinct sum4re elements found: 21
INFO 2025-08-25 11:19:52,153 report.services.sum4re - Updating 84 elements for Sum4Re
INFO 2025-08-25 11:19:52,165 report.services.sum4re - Progress: 1/84
INFO 2025-08-25 11:19:52,166 report.services.sum4re - Updating 410aa84d-95d9-4084-aaab-48462f50ecdb
INFO 2025-08-25 11:19:52,343 report.services.sum4re - Progress: 2/84
INFO 2025-08-25 11:19:52,343 report.services.sum4re - Updating 410aa84d-95d9-4084-aaab-48462f50ecdb
INFO 2025-08-25 11:19:52,509 report.services.sum4re - Progress: 3/84
INFO 2025-08-25 11:19:52,510 report.services.sum4re - Updating 658c0953-5400-4d63-98ee-9299526e1659
INFO 2025-08-25 11:19:52,678 report.services.sum4re - Progress: 4/84
INFO 2025-08-25 11:19:52,678 report.services.sum4re - Updating 658c0953-5400-4d63-98ee-9299526e1659
INFO 2025-08-25 11:19:52,855 report.services.sum4re - Progress: 5/84
INFO 2025-08-25 11:19:52,855 report.services.sum4re - Updating 658c0953-5400-4d63-98ee-9299526e1659
INFO 2025-08-25 11:19:53,018 report.services.sum4re - Progress: 6/84
INFO 2025-08-25 11:19:53,019 report.services.sum4re - Updating 410aa84d-95d9-4084-aaab-48462f50ecdb
INFO 2025-08-25 11:19:53,167 report.services.sum4re - Progress: 7/84
INFO 2025-08-25 11:19:53,168 report.services.sum4re - Updating 410aa84d-95d9-4084-aaab-48462f50ecdb
INFO 2025-08-25 11:19:53,333 report.services.sum4re - Progress: 8/84
INFO 2025-08-25 11:19:53,334 report.services.sum4re - Updating 658c0953-5400-4d63-98ee-9299526e1659
INFO 2025-08-25 11:19:53,501 report.services.sum4re - Progress: 9/84
INFO 2025-08-25 11:19:53,502 report.services.sum4re - Updating 658c0953-5400-4d63-98ee-9299526e1659
INFO 2025-08-25 11:19:53,662 report.services.sum4re - Progress: 10/84
INFO 2025-08-25 11:19:53,663 report.services.sum4re - Updating 658c0953-5400-4d63-98ee-9299526e1659
INFO 2025-08-25 11:19:53,825 report.services.sum4re - Progress: 11/84
INFO 2025-08-25 11:19:53,825 report.services.sum4re - Updating 658c0953-5400-4d63-98ee-9299526e1659
INFO 2025-08-25 11:19:53,973 report.services.sum4re - Progress: 12/84
INFO 2025-08-25 11:19:53,973 report.services.sum4re - Updating 658c0953-5400-4d63-98ee-9299526e1659
INFO 2025-08-25 11:19:54,141 report.services.sum4re - Progress: 13/84
INFO 2025-08-25 11:19:54,141 report.services.sum4re - Updating 410aa84d-95d9-4084-aaab-48462f50ecdb
```

Figure 5-A. Execution logs of the integration.

Even though there are different elements (84), the same products (21) are shared over and again. This is a key limitation: both systems must share a basic model.

```
def update_sum4re_products_with_concular_values(project_id: str):
    """
    Integration with Tecnalia server to exchange information regarding a given project
    """
    # Step 1: Obtain auth credentials
    token = get_external_token()
    logger.info(f"Token: {token}")

    # Step 2: Pull all relevant building elements/products from Tecnalia for a given project
    sum4re_products = get_all_sum4re_products(project_id or "1", token=token)
    logger.info("Number of sum4re elements found: %s", len(sum4re_products.keys()))

    # Step 3: Get the intersection between the objects in Tecnalia and the Concular server
    # using the IFC Global ID
    object_qs = filtered_qs(list(sum4re_products.keys()))

    # Step 4: Query the Concular database for information (CPX, GWP) regarding
    # the building elememnts/products from Tecnalia
    columns = default_dynamic_columns()
    results = retrieve_values_for_mappings(object_qs, columns)

    # Step 5: For each object, push information into Tecnalia Server
    total = results.count()
    logger.info("Updating %s elements for Sum4Re", total)
    for idx, result in enumerate(results):
        logger.info("Progress: %d/%d", idx + 1, total)
        product_ids = sum4re_products.get(result["ifc_global_id"])

        if not product_ids:
            # Skip objects with no information
            continue

        for product_id in product_ids:
            # Make the HTTP request
            update_sum4re_product(
                project_id,
                product_id,
                result["values"],
                token=token,
            )
```

Figure 6-A. Reference source code.

Final step: Checking results

The Tecnalia server is queried for information regarding the properties of elements, and the two attributes set by Concular: cpx_score and gwp_total are now visible.

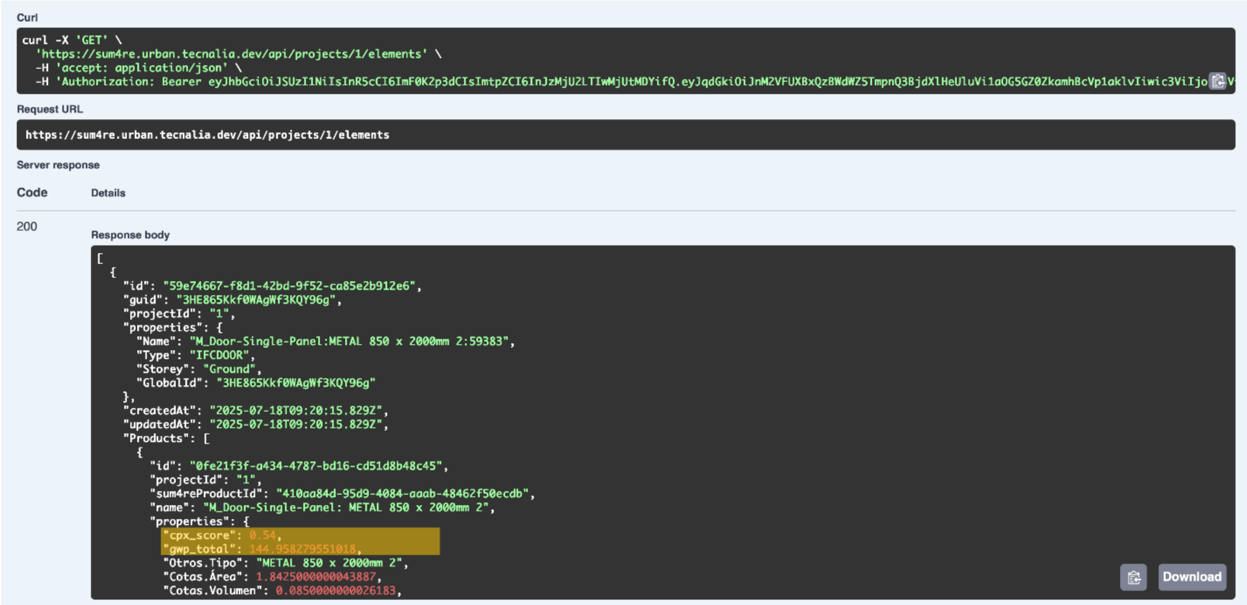


Figure 7-A. Successful integration of attributes.

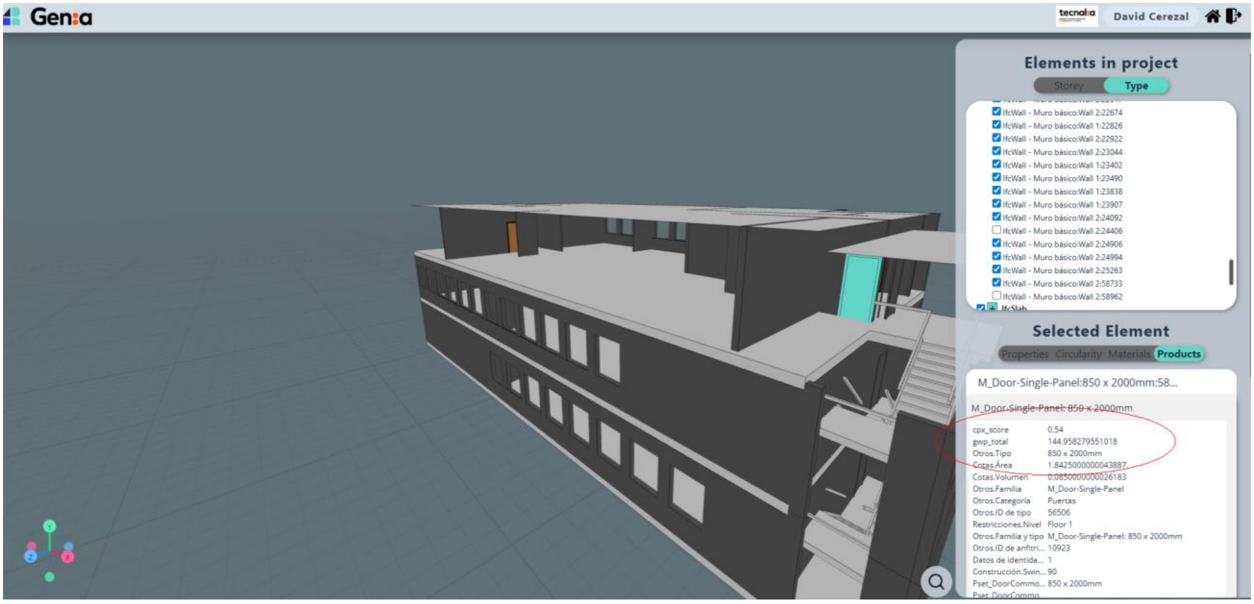


Figure 8-A. The 3D building model and detailed element information, including the obtained values, displayed in the Genia platform.

Users can filter objects and view properties like materials, dimensions, volume, and specific variables for efficient project analysis.

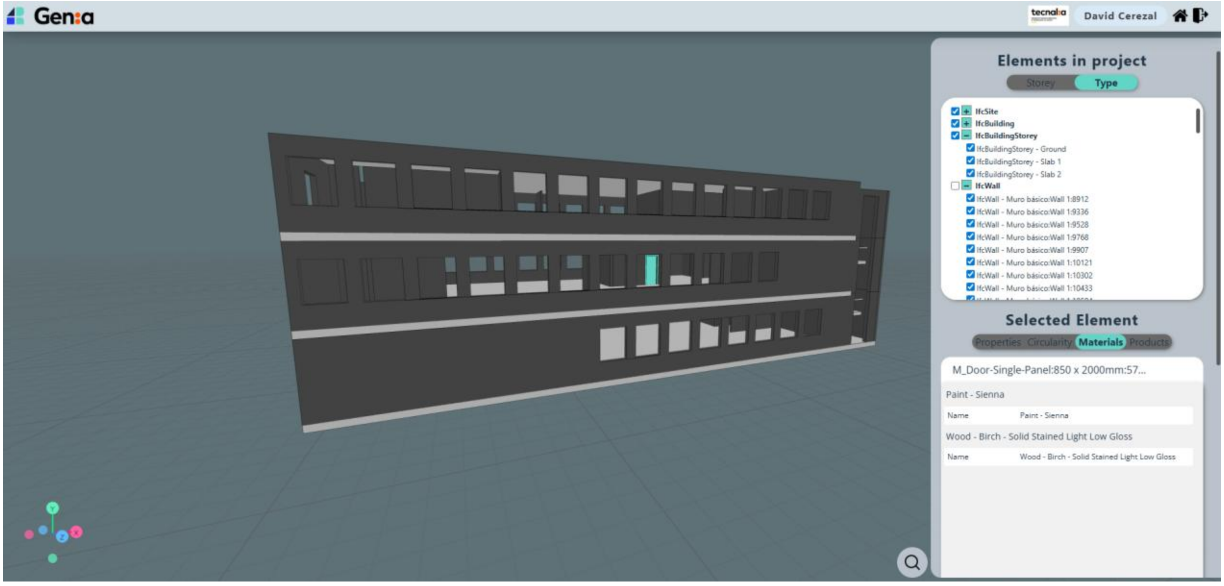


Figure 9-A. Material data for a selected element displayed in the Genia platform.

User can view detailed information such as material types, quantities, and properties.

The required variables are now visible to the viewer in the Genia platform. Additionally, the tool allows users to filter objects by type, category, or level and access comprehensive information for each element in the model. This includes details such as materials, precise dimensions, area and volume measurements, object families and types, as well as specific data like the `cpx_score` and `gps_total`. These features provide a complete overview of every component, enhancing analysis, decision-making, and project management efficiency.

Integration with DMP/DPP

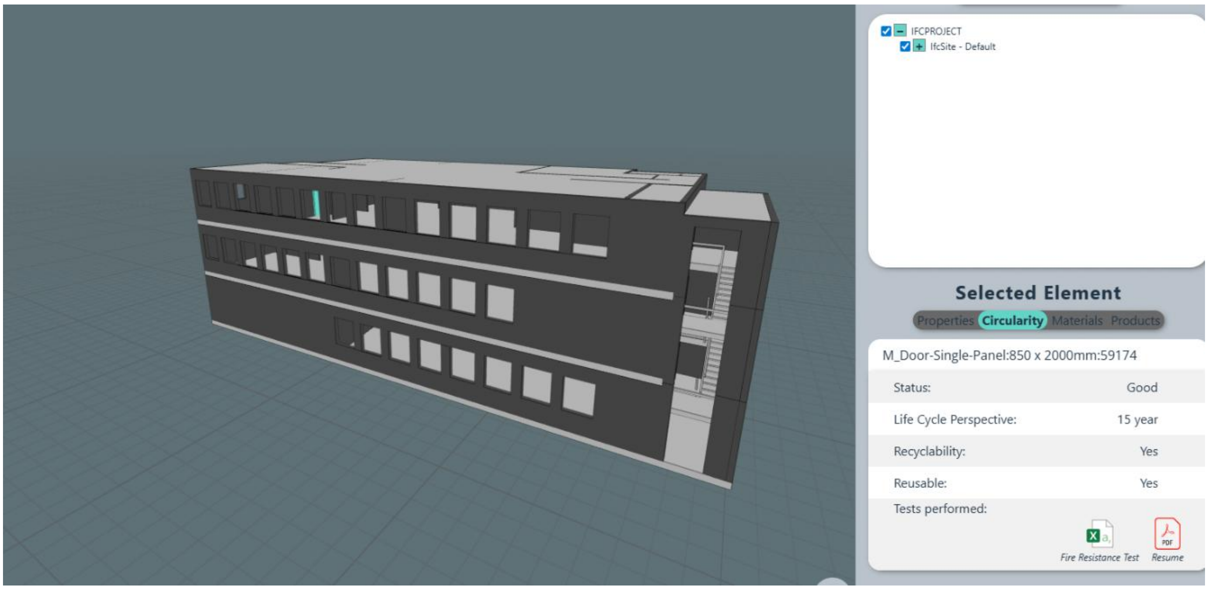


Figure 10-A. Possibility to attach DMPs and DPPs to materials or products in Genia.

The Genia platform will allow attaching the corresponding DMP and DPP directly to each material or product, enabling users to access all related documentation and data seamlessly.

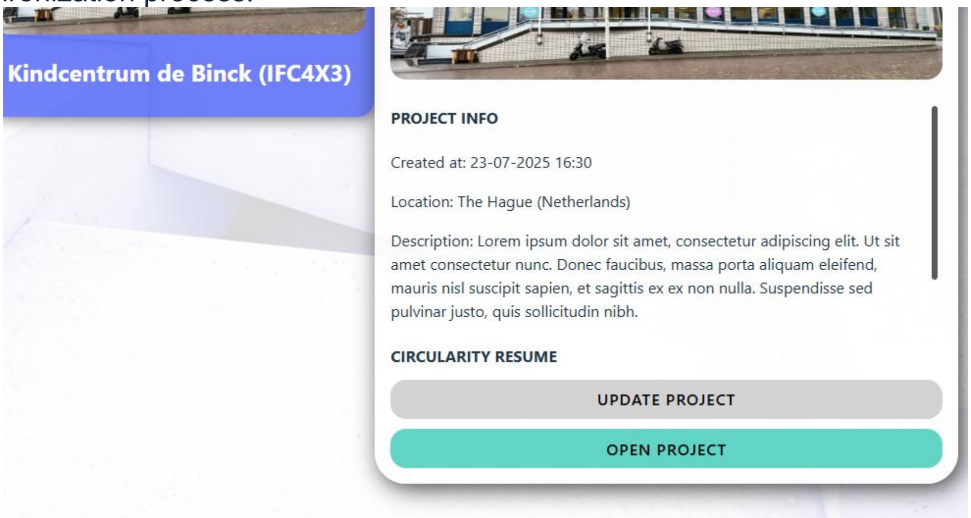
As part of the ongoing development, the integration of **DMPs** and **DPPs** will be implemented through the **central system**. Each material and product in the model will have an **associated passport** that consolidates all relevant data. The system will allow users to **view, edit, and enrich** these passports by adding **new information, test results, certificates, and supporting documents** directly within the platform.

This integration aims to **streamline data management** and ensure that information related to **material properties, lifecycle assessments, recyclability, and reusability** is always accessible and up to date. By linking DMPs and DPPs to each element, the platform will provide a **comprehensive and interoperable digital ecosystem**, supporting the European Union's objectives for **transparency, traceability, and circularity** in the construction sector.

Steps to Access and Use the Demonstrator

1. Go to the following URL: https://sum4re.genia.urban.tecnalia.dev/.
2. Log in using the provided credentials:
- **User:** `demo_user_1`
- **Pass:** `D3m0_Us€R_001`
- *For security reasons, self-registration of accounts is currently not enabled.*

3. Once logged in, navigate to the project you want to review.
4. Click on **"Open Project"** to view the object and check that the requested data is not yet available.
5. After this, the companies will add the missing data.
6. Once the data has been added, click on **"Update Project"** to trigger the synchronization process.



7. In the background, a **data update process** is executed by calling the **central server**.
- This process is normally triggered automatically via **cron jobs** every *X* period.
- For development purposes, it is currently set to run **once per day**, but in production it will be configurable and can be executed **on demand**.
- For this demonstration, after the synchronization, you should expect to see updated values for **`Gpx_score`** and **`gwp_total`**.
8. Finally, click again on **"Open Project"** to view the updated data in **Genia**.

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