PANORAMA Project

18 February 2021

KAVA Reference (Number, Acronym, Full Title): PANORAMA - Physical AccouNts Of RAw MAterial stock and flow Information Service
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Acronyms

EC	European Commission
EE MR I-O	Environmentally Extended Multi-Regional Input-Output
EGDI	European Geological Data Infrastructure
ELV	End of Life Vehicle
EXIOBASE	EXIOBASE project (http://exiobase.eu)
IO	Input-Output
JRC	Joint Research Centre of the European Commission
M4EU	Minerals 4EU project (http://minerals4eu.eu)
MRIO	Multi-Regional Input-Output
ProSUM	Prospecting Secondary raw materials in the Urban mine and Mining waste (http://www.prosumproject.eu/)
RMIS	Raw Materials Information System
RoW	Rest of the World
SUT	Supply Use Table
UC	Use cases
UML	Unified Modeling Language, used in the field of software engineering that is intended to provide a standard way to visualise the design of a system

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Executive summary

The aim of the PANORAMA project is to build a comprehensive Material Stock and Flow Database to support decision making on raw materials (primary and secondary minerals resources) by industry and governments in the European Union. It is also to integrate, fill the gaps and reconcile the best databases to a balanced system with the most experienced players. The result is in form of a web-based information service system aligned with the existing Raw Materials Information Service (RMIS) hosted by the European Union's Joint Research Centre (JRC) and, if possible and relevant with the European Geological Data Infrastructure (EGDI, EuroGeoSurveys).

More specifically, workpackage 6 is in charge of managing the datasets which after the application of improved reconciliation procedures, lead to develop a solidly-built professional web application serving balanced stock-flow diagrams. These information services are made available to the panel of end users through a graphic interface with data download functionalities.

The underlying database has first been modelled as part of Task 6.1. As presented in D6.1 "Data Model Evolution and Code Lists", it builds on the results of two previous projects, namely ProSUM and EXIOBASE which produced European and global databases dedicated to the Urban Mine/Urban Waste and Multi-Regional Environmentally Extended Supply and Use / Input-Output, respectively. Considering the PANORAMA thematic objectives, the database structure has been refined as a consequence of the advanced works in work packages 3, 4 and 5.

As a result of this work in Task 6.2, the present document describes the detailed functional and technical specifications as well as all other aspects useful to the PANORAMA database and data dissemination application, such as hardware, software and human constraints and the corresponding IT infrastructure.

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1. Introduction

1.1 Purpose of the document

The aim of this document is to describe several functionalities and the technical specifications of the PANORAMA data dissemination web application and the corresponding IT infrastructure.

The purpose of the functional specifications is to describe:

- All the application features,
- The manipulated objects, their goals and operating principles.

Based on the recommendations from the state-of-the-art study (refer to D6.3 "PANORAMA Information Service Portal"), the corresponding functionalities are included during the web-enabled application design stage. The user screens implementing them are detailed in a complementary report (D6.4 "PANORAMA Information Services: web application and users' guide".

The detailed technical specifications present the technical aspects to implement and operate the PANORAMA database and data dissemination application, such as hardware, software and human constraints and the corresponding IT infrastructure. Their purpose is to describe precisely:

- Hardware and software environments (also refer to the PANORAMA IT Infrastructure technical Note),
- Implementation of the application,
- Programming requirements (also refer to the PANORAMA IT Infrastructure technical Note),
- Deployment of the application (also refer to the PANORAMA IT Infrastructure technical Note),
- Security elements put in place (also refer to the PANORAMA IT Infrastructure technical Note),
- The respective roles of the contributors setting up and operating the PANORAMA IT infrastructure.

1.2 Scope of application

The Material Stock and Flow database produced by the PANORAMA project concerns a set of commodities (presently 3), manufactured products (presently 630) and it covers the EU-28 countries and the rest of the word. It consists in a complex data structure and represents a very large asset of data resulting from reconciliation procedures and balancing routines.

This comprehensive contents is made accessible to the end users in a simple way through a web enabled application and balanced stock-flow diagrams. Three points of view are proposed, i.e. "By Commodity", "By Product" and "By Country". The graphic interface proposes a series of information services, user-driven filters and data download functionalities.

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2. Project Framework

Context: The aim of PANORAMA Project is to map the flows and stocks of raw materials in order to improve competitiveness and sustainability of this sector in Europe. The results, in form of web-enabled information services, will help industrial firms and associations to understand supply chain vulnerabilities, as well as further understanding of the 'urban mine' – what volumes of secondary materials are where, and what this means for an optimal economy of scale for their exploitation.

Need: This project proposes to create such services, well aligned with the EU DG JRC's Raw Materials Information Service (RMIS). They utilise the experience gathered in a large number of underlying EU funded projects. They link information about materials to standard economic accounting, which in turn are proposed to authorities, investors, and firms to assess how sound materials management can support economic performance and jobs. This aims to help industrial firms and associations to understand supply chain vulnerabilities, as well as further understanding of the 'urban mine' – what volumes of secondary materials are where, and what this means for an optimal economy of scale for their exploitation.

Objective: To design and implement a reliable tool that can map efficiently the stocks and flows of materials in order to improve their supply in Europe and strengthen the competitiveness in this sector.

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3. Functional scope

3.1 General process flow

In the PANORAMA project we can find tree majors actors CML, GEUS and BRGM. They all interact in the project data update chain as describe the schema below.

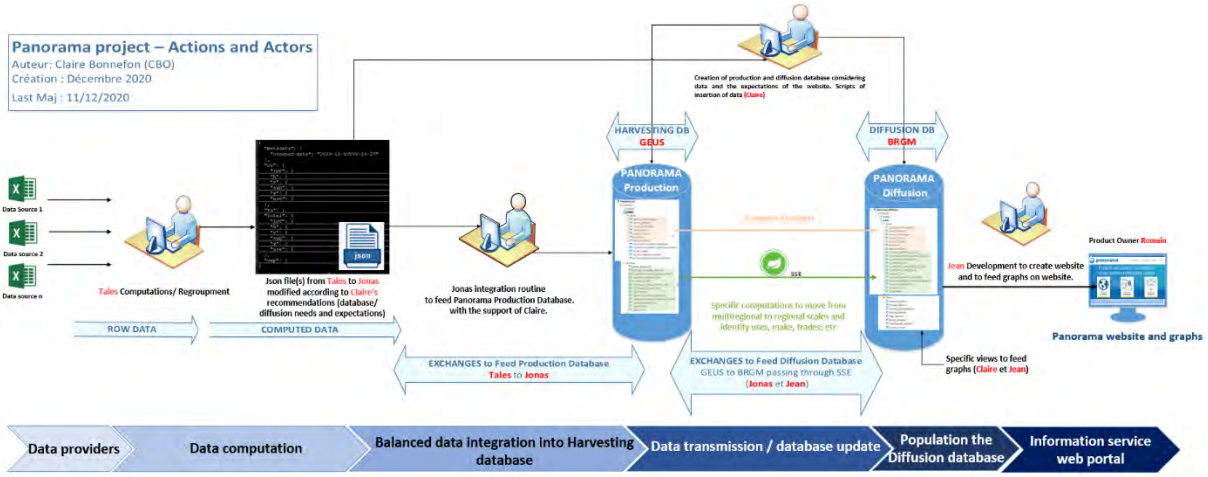

Figure 1: General workflow from data providers to the web portal

Figure 1 shows from left to right the general workflow and the respective contributors:

1. Data providers
2. Data computation / data balancing (CML)
3. Balanced data integration into the Harvesting database (GEUS)
4. Data transmission/database update (GEUS→ BRGM)
5. Population/update of the Diffusion database (BRGM)
6. Information service web portal (BRGM)

3.2 General data flow

From a general point of view, data on international trade flows between different regions of the world and by product (MRIO) multi-regional supply-use (MR-SUT) flows come from several producer sources such as EXIOBASE, ProdCom, EORA, etc.

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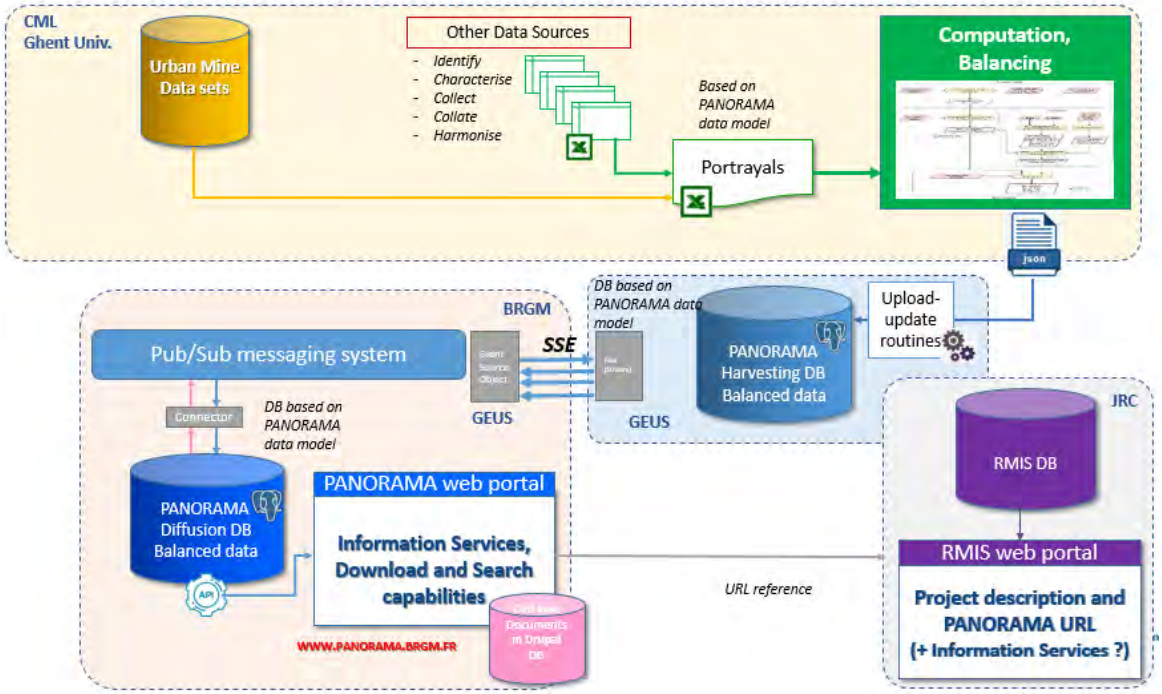

Figure 2: General data flow

The source data (EXIOBASE in a first step) are processed by CML. The treatment (Computation & Balancing) consists in complementing the missing data using a "balancing routine" (Python scripts) developed by the University of Leiden.
Once the data is completed and balanced, it is saved in a JSON format file. It is then transmitted to GEUS via an FTP transfer platform.

Using an import routine, the data is saved from the JSON file to the PANORAMA Harvesting database hosted by GEUS. This database contains technical views generated by SQL scripts allowing to pre-calculate and pre-format the data that will feed the graphs of the web portal. Once the views are populated, the corresponding data is transmitted to BRGM via a Server-Sent Event (SSE) protocol and dedicated server.

The data is imported in the PANORAMA Diffusion database hosted by BRGM via this pub/sub mechanism (SSE). It allows a more flexible automatic update of broadcast data as soon as the source data changes, the Harvesting database in our case. The information services accessible to the end users on the PANORAMA web portal are graphics generated using the data from the Harvesting database. In this database, there is at least one view per graphic displayed on the web portal operated by BRGM.

This result is aligned with the existing Raw Materials Information Service (RMIS) hosted by the European Union's Joint Research Centre (JRC). In Nov. 2020, the RMIS team released a technical recommendation note "Channelling knowledge from H2020 projects into the Raw Materials Information System (RMIS) (https://rmis.jrc.ec.europa.eu/uploads/Technical_guidelines_for_knowledge_transfers_into_RMIS.pdf). It turns out that the PANORAMA database and web portal are way too large and complex to be

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integrated in the RMIS infrastructure. Rather, both systems can be linked using the "Raw Materials Knowledge Gateway" facility proposed by the RMIS. Consequently, the PANORAMA web portal will be referenced in this gateway at the "European Level" to be accessible by the RMIS end users.

3.3 Developed Use Cases

The diagram on figure 3 summarises the project functionalities of the PANORAMA IT platform. It is based on the data flow presented here above. On the left hand side of the diagram, the diffusion website allows the user to navigate through different data stock and flow information. The interface proposes several visualisation options like bar charts, maps and Sankey's diagrams. The anonymous user can use different search criteria to find the required information and display it in form of dedicated graphics. The data subset used to generate them can be downloaded. The authenticated user can update the editorial content and pages of the website.

On the right hand side of the diagram, an IT user with a specific role (administrator) is authorised to configure the IT platform, such as trigger a full indexing of documents, configure the pub/sub system, etc.

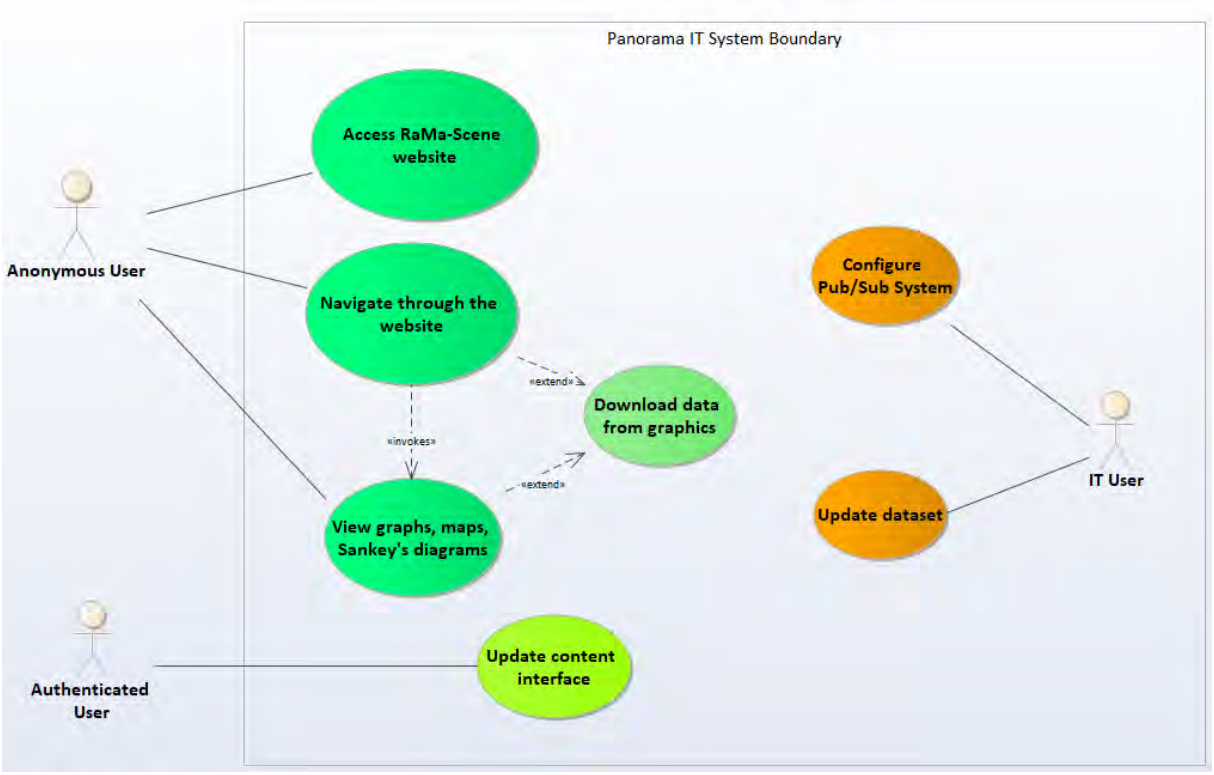

Figure 3: Diagram of use cases of the PANORAMA platform

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3.3.1 UC 1: Access the RaMa-Scene website

Title	UC1: Access the RaMa-Scene website
Description	To redirect via a URL to the RaMa-Scene website.
Actors	Any public concerned without restriction of right or particular profile. Anonymous users.
Trigger event	The user clicks on the link to be redirected to the RaMa-Scene website.
Nominal scenario	Clicking on the link of the RaMa-Scene web site causes the opening of a new browser window and opens the "About" page of the https://www.ramaScene.eu/ web site.
Precondition	Website is available.
Post condition	Display of the "About" page of the RaMa-Scene website.
Constraint	Availability in the PANORAMA website of the correct URL of the RaMa-Scene website.

Table 1: Access RaMa-Scene website

3.3.2 UC 2: Navigate through the website

Title	UC2: Navigate through the website
Description	This is to allow the end user to navigate through all the website pages, which can also be directly accessed through the link "**site map**" at the footer of the pages.
Actors	Any public without restriction of right or particular profile. Anonymous users.
Trigger event	A user connects to the URL web site to search for information.
Nominal scenario	Open a browser, enter the URL of the PANORAMA web site, and browse through all the pages.
Precondition	Web site is available.
Post condition	Display information, pages, articles, graphics, etc. of the web site.
Constraint	N/A

Table 2: Navigate through the website

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3.3.3 UC 3: Visualise graphs, maps and/or Sankey's diagrams

Title	UC3: Visualise graphs, maps and/or Sankey's diagrams
Description	Display stocks and flows information of products and/or materials in a graphical form according to the selected filters. The graph can be a bar chart, a Sankey's diagram or a geographical map depending on the availability of the data necessary to generate the type of display.
Actors	Any public without restriction of right or particular profile. Anonymous users.
Trigger event	User having performed a search and chosen a type of visualisation through the "Access data" link on the web site. The proposed filters are: countries, commodities and products.
Nominal scenario	Connect to the PANORAMA website, click on the "Access data" button and select a criteria in the dropdown menu. The choice can be "By Country", "By Commodity" or "By Product". Once the choice is done, a combined selection list allows the user to choose the visual elements and secondary filters. This list is filled only with data allowing the generation of graphics. The criteria are not proposed in the list if there is no data to generate a graph.
Precondition	Site and visual elements (graphics, diagrams, etc.) available.
Post condition	Displays the graph corresponding to the selected criteria and filters.
Constraint	Availability of data to generate the desired type of display.

Table 3: Visualise map and/or Sankey's diagrams

3.3.4 UC 4: Download data from the graphics

Title	UC4: Download data from the graphics
Description	A user wishes to download data about the stocks and flows of materials or components used to generate the graphics. Once the graph is displayed, and in order to trigger the data download, the user selects one of the proposed export formats (CSV, TXT, JSON, etc.). The data is downloadable in compressed files.
Actors	Any public without restriction of right or particular profile. Anonymous users.
Trigger event	Click on the download button next to the graphic.
Nominal scenario	Connection to the PANORAMA website and carrying out a data visualisation with a graph. Click on the "Download" button and choose the desired data export format. A popup appears and the user saves the item on his workstation.
Precondition	A graph must have been generated and displayed.
Post condition	Saving compressed data files on the user's workstation.
Constraint	The volume of the compressed files does not exceed 200 MB.

Table 4: Download data from the graphics

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3.3.5 UC 5: Update content interface

Title	UC5: Update content interface
Description	A user with the necessary role (website manager/editor) needs to authenticate to the website "back office" in order to update articles, pages, contextual elements, etc.
Actors	Website manager/editor (authenticated)
Trigger event	The user authenticates himself on the website and accesses the "back office" website management menus to modify the content of the site.
Nominal scenario	Login to the website with username and password. Modification, addition of contents, articles and pages through the Drupal context menu. Once updates are made and published, they are visible to all anonymous users.
Precondition	Web site is operational.
Post condition	Updated information is available to all anonymous users.
Constraint	Permanent availability of the web site and the authenticated user has the necessary skills in Drupal content management.

Table 5: Update content interface

3.3.6 UC 6: Configure Pub/Sub system

Title	UC6: Configure the Pub/Sub system
Description	The IT infrastructure user wishing to update the Pub/Sub messages in the case of data updates or scalable data maintenance.
Actors	IT infrastructure user only (authenticated).
Trigger event	Modified data structure requiring a modification of the Pub/Sub message structure or IT system maintenance.
Nominal scenario	The IT user puts the system in maintenance mode, first, and logs on the technical platform. He/she carries out the necessary modifications, tests and restarts the PANORAMA IT infrastructure.
Precondition	The IT user has the necessary computer skills to perform maintenance work on the Pub/Sub system.
Post condition	The computer system is operational again.
Constraint	No online user connected to the website. Strong skills of the IT user.

Table 6: Configure the Pub/Sub system

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3.3.7 UC 7: Update dataset

Title	UC7: Update dataset
Description	As soon as a new data set is generated by the balancing routine, processes are launched to update the PANORAMA databases for access through the website.
Actors	IT infrastructure user only (authenticated).
Trigger event	The project IT infrastructure user receives a new data set from the balanced data producer.
Nominal scenario	At the request of the data producer, the IT user triggers the processes (Job Rundeck) to (1) integrate the update into the Harvesting database, and (2) send the update in form of SSE messages to update the Diffusion database accordingly. This job can possibly be automated to be triggered according to a period still to be determined.
Precondition	New data set is available in unchanged format.
Post condition	Updated data is available and retrievable on the website.
Constraint	No change in the format structure of the new data set.

Table 7: Update dataset

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4. The PANORAMA data model

4.1 Conceptual data model

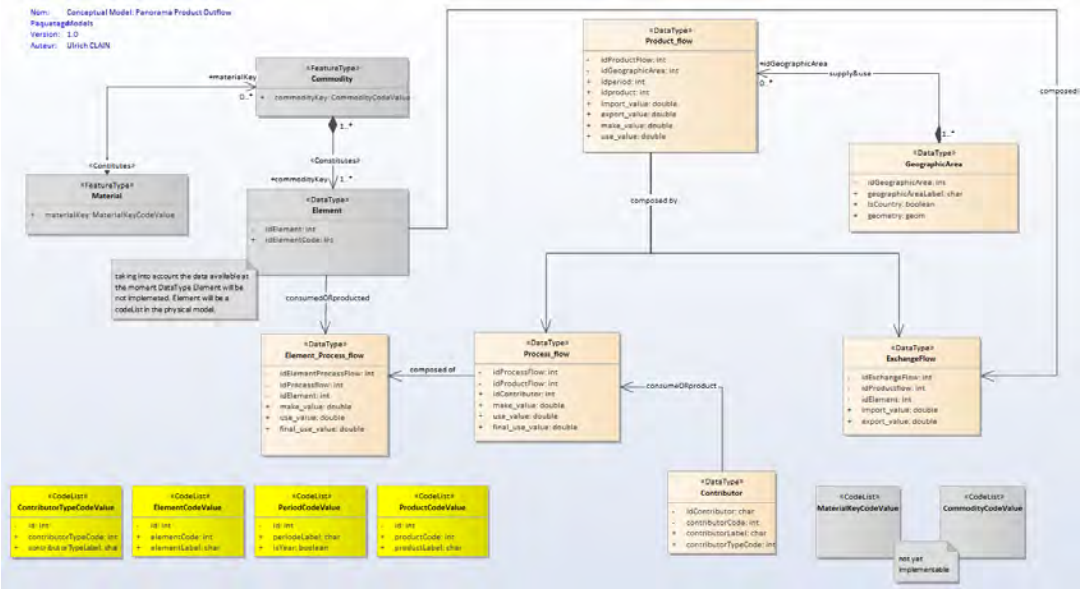

Figure 4: Conceptual data model of PANORAMA database

The conceptual model is developed using the Unified Model Language (UML), which is used to provide a standard way to visualise the system design. It identifies features and feature types in a conceptual way and their respective relationships.

As we have to manipulate complex data of international trade flows by products, by industries and between different regions of the world, we chose to implement the entities in the following way:

- A <<*process_flow*>> entity that will characterise the product exchange flow according to industries (contributors in our diagram);
- A <<*element_process_flow*>> entity that composes and gives finer granulometry details on the exchange flow;
- An <<exchange_flow>> entity that specifies the import/export values of products and their finer compositions (Elements, materials, substances);
- A <<*product_flow*>> entity that includes products, materials and elements. This entity provides details on the values of imports, exports, supply and demand, by product and by geographical region of the products. It is composed with the <<exchange_flow>> and <<process_flow>>;
- A <<geographicArea>> entity that relates to the product flows described above and their geographical location.

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These entities are linked to different lists of codes that characterise and standardise the manipulated data. Among them, there are lists (non-exhaustive) of:

- Countries
- Contributors (Industries)
- Products
- Materials
- Elements

4.2 The physical data model

The physical database model, used by both GEUS and BRGM, uses the entities manipulated by the PANORAMA project as database table names.

Entities manipulated by the PANORAMA IT infrastructure:

Entity	Description	Type
contributor	This entity is used to record the type of contributors producing and/or receiving the product and/or item.	Table
Geographic_Area	This entity is used to record the different geographical areas manipulated in the system.	Table
mr_extraction_outflow_contributor	This entity records for each industry the flow of products to contributors by and for countries.	Table
mr_extraction_outflow_contributor_element	This entity records item-related values by element, (industries, end-users, etc.) for each product to the contributors.	Table
mr_sut_context	This entity is used to record the relationship between industries and the values of inputs and outputs, supply and demand of products.	Table
mr_sut_contributor_product	This entity records product-related values by country, by contributors (industries, end-users, etc.) and countries to which the contributors belong.	Table
mr_sut_contributor_product_element	This entity records item-related values by element, (industries, end-users, etc.) for each product to the contributors.	Table
Codelist_ContributorType	Value list of contributor types	Code list
Codelist_Element	Element value list	Code list
Codelist_outflowtype	Outflow value list	Code list
Codelist_Periode	Value list of the periods related to the data.	Code list
Codelist_Product	Product Value List.	Code list

Table 8: Entities manipulated by the IT system

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The physical database (DB) model (Figure 5) is developed from the conceptual model. The DB model has 7 tables for data (entities) and 5 tables for code list (datatypes).

The database is built using datatype constraints from the code list so data with specific datatypes can only be inserted if the datatype is found in the specific code list. This means that if a dataset is updated with new datatypes (as foreseen by WP5 it will happen) we must delete the old dataset, then update code list and insert new dataset

Figure 5: Physical data model of PANORAMA database (developed from them conceptual model)

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5. Data exchange

5.1 Data transfer from CML to GEUS

Source data from the Multi-Regional Matrix is stored and shared in JASON format. Several silos of this matrix are transformed into JSON file(s).

Figure 6: Multi-regional supply-uses tables and JSON file

As part of the project activity perimeter and in view of the progress, the "IOT" and "h" silos will not be implemented.

The MR-SUT model silos are described using several fields. Following is the table of correspondence between the fields of the matrix and the JSON file:

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		Json objects describing fields						Value (Correspond to)	
JSON objects		Input (Source Region)	Output (Target Region)	Product	Industry (Contributors)	FD (Contributors)	Primary_imput (Extensions)	Cu,Ta (Substance)	Total
~~IOT~~	~~Multiregional input output tables~~	~~X~~	~~X~~	~~X~~	~~X~~			~~Substance~~	~~Product~~
~~trad~~	~~Bilateral trade~~	~~X~~	~~X~~	~~X~~				~~Substance~~	~~Product~~
h	Multiregional final demand extensions	(Region)	(Region)			X	X	Substance for all products	All Substances for all products
v	Multiregional industry extensions	(Region)	(Region)		X		X	Substance for all products	All Substances for all products
sup	Multiregional supply tables	(Region)	(Region)	X	X			~~Substance~~	Product
y	Multiregional final demand	X	X	X		X		~~Substance~~	Product
use	Multiregional use tables	X	X	X	X			~~Substance~~	Product

Figure 7: Correspondence table between the MR-SUT matrix and the JSON file

Several data with different meanings (regional, multi-regional) are stored in the same objects. For dissemination, it is necessary to have a view of the regional data, which means dividing the data into silos according to the data they are composed of, and more specifically the fields. The "definition of objects at the regional scale" is defined by the "JSON object" in the following table:

			Json objects describing fields						Value (Correspond to)	
JSON objects		Regional Scale Objects definition	Input (Source Region)	Output (Target Region)	Product	Industry (Contributors)	FD (Contributors)	Primary_imput (Extensions)	Cu,Ta (Substance)	Total
~~IOT~~	~~Multiregional input output tables~~	??	X	X	X	X			~~Substance~~	~~Product~~
~~trad~~	~~Bilateral trade~~	??	X	X	X				~~Substance~~	~~Product~~
h	Multiregional final demand extensions	Make= Negative value Final_Use_Extension = Positive value	(Region)	(Region)			X	X	Substance for all products	All Substances for all products
v	Multiregional industry extensions	Make= Negative value Intermediate_Use_Extension = Positive value	(Region)	(Region)		X		X	Substance for all products	All Substances for all products
sup	Multiregional supply tables	Correspond to the Make	(Region)	(Region)	X	X			Substance	Product
y	Multiregional final demand	Multiregional (import/export) when input <> output (for final use) Regional_final_use when input = output	X	X	X		X		Substance	Product
use	Multiregional use tables	Multiregional (import/export) when input <> output (for intermediate use) Regional_use when input = output	X	X	X	X			Substance	Product

Figure 8: Correspondence table between the MR-SUT matrix and the reworked JSON file

Green Cell means that at multiregional scale, input and output region are the the same.
The repartition of the information, displayed on the schema bellow, can be interprated as following:

- Mr-sup *(make)* contains regional information (input and target region are the same) about product/element production by the contributor “Indrustry”.
- Mr-use *(intermediate use)* contains:
  - regional information (input and target region are the same) about product/element intermediate-use by the contributor “Indrustry”.

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- multiregional information (input and target are different) about product/element intermediate-use trade (import export) by the contributor “Indrustry”. Input region export to the target region. Output region import from the input region.

- Mr-y *(final use)* contains:
  - regional information (input and target region are the same) about product/element final-use by the contributor “Final” (FD)
  - multiregional information (input and target are different) about product/element final-use trade (import export) by the contributor “Indrustry”. Input region export to the target region. Output region import from the input region.
- Mr-v is an intermediate/industry extension corresponding to the extraction outflow for “Indrustry”. This silo contains regional information (input and target region are the same) about primary-imput/outflow generate/produce by the contributor “Indrustry”. Negative values are linked to the supply/make activities whereas positive value can be linked to the intermediate-use activities.
- Mr-h is an final-demand extension corresponding to the extraction outflow for “Final-demand”. This silo contains regional information (input and target region are the same) about primary-imput/outflow generate/produce by the contributor “Final” (FD). Negative values are linked to the supply/make activities whereas positive value can be linked to the final-use activities.

Thus, the original MR-SUT schema becomes for the PANORAMA project:

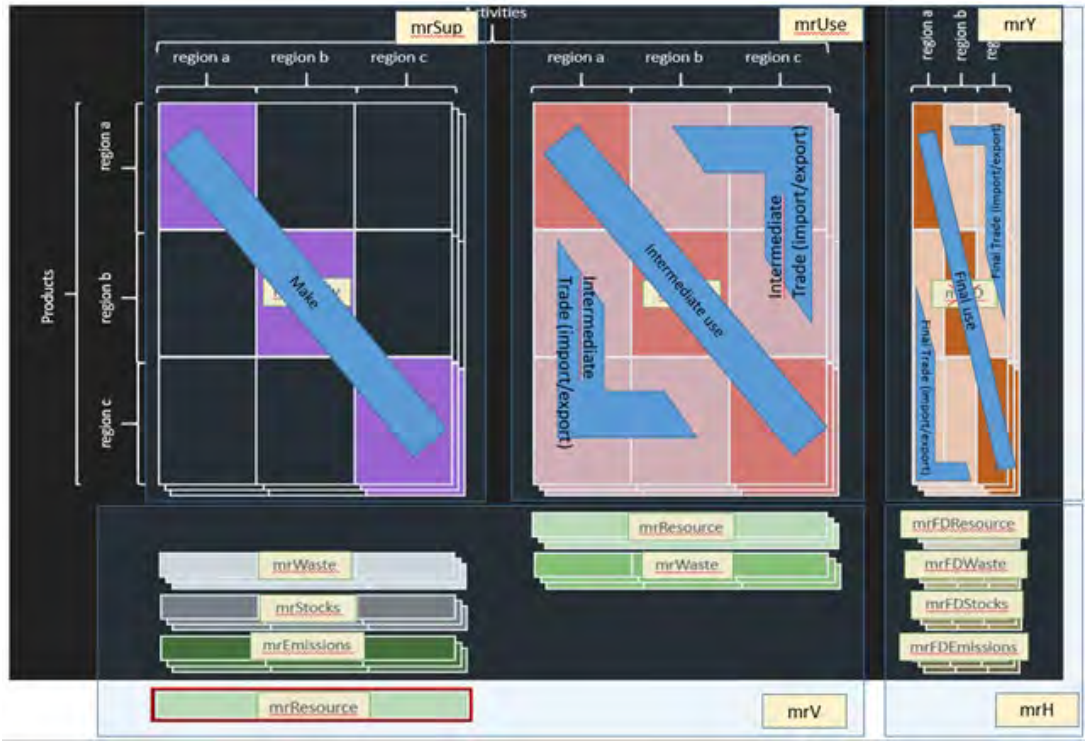

Figure 9: Multi-regional supply-uses tables for PANORAMA project

In order to reorganise the data at the regional level, some views on the Harvesting database have been produced (rework in progress due to a malfunction in the current system related to the volume of data).

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These views of the Harvesting database will be shared (with code lists, orange squares) with the Diffusion database. In this database, the production views start with tables.
Then, other views are created in the Diffusion database. They are used to formalise the data for the representation on the web portal as may Information Services in form of graphs (bar charts, maps, etc.).

5.2 Data storage size in the PANORAMA Harvesting database

As shown on figures 1 and 2, the PANORAMA IT infrastructure includes two databases: The Harvesting database is hosted by GEUS and the Diffusion database is hosted by BRGM. The latter feeds the PANORAMA website.

Table 9 shows the estimated data storage size in the PANORAMA Harvesting database for 1 year (2011), 3 commodities, 630 products, 29 countries (EU-28 + rest of the world).

Table name	Rows in the DB	Size	Unit
codelist_contributortype	4	32	kB
codelist_element	3	32	kB
codelist_outflowtype	12	32	kB
codelist_period	1	48	kB
codelist_product	630	176	kB
contributor	170	64	kB
geographic_area	29	32	kB
mr_extraction_outflow_contributor	28,463	2,944	kB
mr_extraction_outflow_contributor_element	15,055	1,520	kB
mr_sut_context	109,502	13	MB
mr_sut_contributor_product	6,300,119	647	MB
mr_sut_contributor_product_element	18,900,357	1,865	MB
Test phase: 1 year (2011) EU→EU (29 countries)	Sum	2,530	MB

Table 9: Data storage size in the PANORAMA database in 1 year (2011)

5.3 Data transfer from GEUS to BRGM

The data transfer from GEUS to BRGM is provided by the pub/sub system using the SSE-server component. Each time the Harvesting database at GEUS finds updated data in the database, it sends a message to the BRGM Diffusion database saying that there is new data. Then, the BRGM server database initiates a communication with the Harvesting database at GEUS and starts the data transfer to the BRGM database

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In this project, in order to synchronise the data between the Harvesting database and the Diffusion database, the choice was made to implement a simple and efficient technology, the Server-Sent-Events (SSE) protocol.
Indeed, using HTTP requests, transiting via a client-server system between BRGM and GEUS, at each modification and/or update of the source data (GEUS), the data is updated in the Diffusion database to generate graphs with the freshest raw data. The API (BRGM client) initiates communication with the server (GEUS) and asks it whether it has any data to update. If not, the communication stops and nothing happens.
If there is data to be updated, the server push/sends a series of messages to the client (which it stores in a cache) containing the orders to be carried out (add/update/delete) as well as the data itself to be taken into account. The server cuts the connection once the last instruction has been sent to the client.

6. CONCLUSION

Deliverable D6.2 describe the first steps of the PANORAMA developments website that improves the communication and the exchanges about the diffusion of comprehensive material stock and flow data based on the underlying conceptual and physical modelled database.

The underlying database was first modelled as part of Task 6.1. As presented in D6.1 “Data Model Evolution and Code Lists”, it builds on the results of two previous projects, namely ProSUM and EXIOBASE which produced European and global databases dedicated to the Urban Mine/Urban Waste and Multi-Regional Environmentally Extended Supply and Use / Input-Output, respectively. Considering the PANORAMA thematic objectives, the database structure has been refined as a consequence of the advanced works in work packages 3, 4 and 5.

In order to build the IT infrastructure of the PANORAMA project, which manipulates the notions of stocks and flows materials and map them, we tried to deploy relatively simple technical components as well as a relevant, robust and flexible architecture.

Starting from the tables of the multi-regional import/export models (MRIO - which aim at coupling the national Input-Output data with the international trade matrix MRSUT and this, in order to characterise the flows materials, both by type of product, but also by origin and geographical destination, we imagined and designed a conceptual and physical model capable of integrating deconstructed (by CML), computed and improved data. What also deserves to be highlighted is the innovative aspect of this project concerning the hosted IT infrastructure through different partners (CML, GEUS and BRGM). This has forced us to design robust and flexible systems that use innovative technologies such as pub/sub system mechanisms and push notification services such as the SSE protocol.

These information services are made available to the panel of end users through a graphic interface with data download functionalities.

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This result is aligned with the existing Raw Materials Information Service (RMIS) hosted by the European Union's Joint Research Centre (JRC). In Nov. 2020, the RMIS team released a technical recommendation note "Channelling knowledge from H2020 projects into the Raw Materials Information System (RMIS) (https://rmis.jrc.ec.europa.eu/uploads/Technical_guidelines_for_knowledge_transfers_into_RMIS.pdf). It turns out that the PANORAMA database and web portal are way too large and complex to be integrated in the RMIS infrastructure. Rather, both systems can be linked using the "Raw Materials Knowledge Gateway" facility proposed by the RMIS. Consequently, the PANORAMA web portal will be referenced in this gateway at the "European Level" to be accessible by the RMIS end users at large.

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