Deliverable D1.4

Final project report

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Notice

TABLE OF CONTENT

PURPOSE

This report describes the main activities conducted within the MICA project between 01 February 2017 (project month 15) and 31 January 2018 (project month 26) and is to be read in continuation of Deliverable 1.3, the First year report, which covered the first 14 months of the project.

EXECUTIVE SUMMARY

The MICA project consortium has conducted a significant amount of research and data/information compilation work as well as analysis throughout the 26 months of the project timeframe. Besides delivering on the objectives laid out for the project, MICA also paved the way for future work:

The development of the *EU-Raw Materials Intelligence Capacity Platform* which was tied to overcoming several challenges to achieve a new intelligent search engine, the *Dynamic Decision Graph*, that guides a user by means of expert knowledge, provides a standalone tool for application both in the Raw Material Knowledge Gateway developed by JRC but also in different thematic contexts.

Further, the elaboration of *flowSheets*, or, in other words 'recipes' to guide users through a sequential process on how to solve a particular question or problem, shed light on the complex work lying ahead for policy-driven research on how to unravel the complexities tied to what might at first appear as seemingly 'simple' resource-related questions.

Several challenges had to be overcome in the interdisciplinary collaboration that shaped work within and across Work Packages. Most importantly, the Platform development experienced some delay due to the innovative nature of its design, but it is on track for completion by the time the reporting period is concluded. As always, the delivery of a new solution comes with risks. MICA has certainly been designed to take on this risk in order to come forward with a new direction for making data, information and knowledge available for a wide range of identified stakeholders: MICA has the potential to significantly shape their understanding of the complexity of mineral (raw) material matters by supporting them in building up knowledge on how to look at and work with their respective questions and problems.

DELIVERABLE REPORT

1. Introduction

The MICA project ran over 26 months from 01 December 2015 to 31 January 2018. In the second project period which is covered in this report, 13 deliverables were due for completion and submission, as listed in section 2, Table 1. These deliverables span across all work packages. Further, additional work was conducted which is also explicitly indicated in Table 1 and was deemed beneficial for the project and beyond, This additional work is either not specified at all or not specified in detail as output in the grant agreement.

Table 1 Linkages between project objectives and deliverables produced.

No. of Deliverable	Title of Deliverable	WP no.	Lead beneficiary	Type	Dissemination level	Due date (month)
D1.4	1.4 Final report	WP1	1 – GEUS	Report	Public	26
Work towards reporting requirement.						
D2.2[1]	2.2 Stakeholder Needs	WP2	2 – Fraunhofer	Report	Public	14
Work performed towards objective 1.						
D3.2	3.2 Final inventory	WP3	3 – NERC	Report	Public	20
Work performed towards objective 2.						
Additional output: **Online MICA metadata catalogue** (http://metadata.mica-project.eu/mmd)						
D3.3	3.3 Report on the transformation of data into information and knowledge	WP3	3 – NERC	Report	Public	22
Work performed towards objectives 2 and 3.						
D3.4 & D4.4	3.4 & 4.4 Integrating data, methods and expert knowledge to inform mineral intelligence	WP3	3 – NERC	Report	Public	24
This work is jointly performed with that of D4.4 towards objectives 2, 3 and 5.						
Additional output: **Elaboration of 21 FlowSheets** during the extra expert workshop held in Leiden.						
D4.3	4.3 Case study reports	WP4	4 – UL-CML	Report	Public	22
Work performed towards objective 3.						
D4.4 & D3.4	4.4 Integrating data, methods and expert knowledge to inform mineral intelligence	WP4	4 – UL-CML	Report	Public	24
No. of Deliverable	Title of Deliverable	WP no.	Lead beneficiary	Type	Dissemination level	Due date (month)
This work is jointly performed with that of D3.4 towards objectives 2, 3 and 5.						
Additional output: **Elaboration of 21 FlowSheets** during the extra expert workshop held in Leiden.						

[1] Deliverable 2.2 is mentioned in this periodic report despite its timely completion during the previous reporting period but due to its findings' relevance for the activities in this report.

D5.2	5.2 Report on the development and application of the RMI-MATRIX	WP5	5 – Minpol	Report	Public	20
Work performed towards objective 4.						
D5.4	5.4 Report on Pilot Foresight	WP5	11 – LPRC	Report	Public	20
Work performed towards objective 4.						
D5.5	5.5 Raw materials Foresight Guide	WP5	11 – LPRC	Report	Public	20
Work performed towards objective 4.						
D5.6	5.6 Report on RMI implementation status quo and needs in EU-28	WP5	5 – Minpol	Report	Public	24
Work performed towards objective 4.						
D6.1[2]	6.1 Development of the Search, Inference and Ranking Modules	WP6	6 – BRGM	Report	Public	22
Work performed towards objective 5.						
Additional output: **Elaboration of 21 FlowSheets** during the extra expert workshop held in Leiden.						
D6.2	6.2 Note accompanying the delivery of the EURMICP system	WP6	6 – BRGM	Other	Public	25
Work performed towards objectives 5 and 6.						
D7.5	7.5 MICA dissemination events ("mid-way" and final)	WP7	7 – EGS	Other	Public	26
Work performed towards objective 6.						
N/A	fact-/doc-/linked-/flow-Sheets	across all	Consortium	Other	Public	26
Additional output[3]: **Elaboration of fact-/doc-/linked-/flowSheets by Consortium members** which authored the Sheets, reviewed them and are making them available						

[2] The name of the additional Deliverable D6.0 was 'Note accompanying the first stabilized version of the MICA DDG' which content originally was to be described in D6.1. Thus, D6.1 was provided with a new title.

[3] The grant agreement does not specify a specific amount of fact-/doc-/linked-/flowSheets for elaboration and the output is therefore indicated as 'additional' – the overview production sheet accessible via the member access from the MICA website shows the current total number of completed sheets. The Sheets are also accessible from there.

2. Explanation of the work carried out by per Work Package

The main objectives of MICA are numbered here for reference further on in the report:

1. Identification and definition of stakeholder groups and their raw material intelligence (RMI) requirements,
2. Consolidation of relevant data on primary and secondary raw materials,
3. Determination of appropriate methods and tools to satisfy stakeholder RMI requirements,
4. Investigation of (RMI-) options for European mineral policy development,
5. Development of the EU-Raw Materials Intelligence Capacity Platform (EU-RMICP) integrating information on data and methods/tools with user interface capable of answering stakeholder questions,
6. Linking the derived intelligence to the European Union Raw Materials Knowledge Base (EU-RMKB)

In the following, the project results towards these objectives are provided.

2.1 Work package 1: Project management

Lead beneficiary: GEUS;
Other beneficiaries involved: primarily all WP leaders, namely from Fraunhofer-ISI, NERC, UL-CML, MinPol, BRGM, EGS, and in specific cases all beneficiaries and Linked Third Parties.

Specific deliverables during this second project period:

No. of Deliverable	Title of Deliverable	WP no.	Lead beneficiary	Type	Dissemination level	Due date (month)
D1.4	1.4 Final report	WP1	1 - GEUS	Report	Public	26

The work package 1 (WP1) project management task covers:

(a) the daily management of the project and consortium including financial, administrative and operational management with the WP leaders, the monitoring of progress, the coordination of dependencies across WPs, also in cooperation with the WP leaders. Regular web- or teleconferences (via GotoMeeting) with the consortium, and in particular with the WP leaders, ensures close coordination including of progress towards deliverables, interim and final reporting.

(b) the management of the Advisory Board (AB) which involves the general interaction with members of the AB including communication about project progress, the arrangement of AB meetings and the compilation and dissemination of feed-back from the AB to the rest of the consortium.

WP1 defined the ethical conditions, which applied for the consortium during the project work. These are described in Deliverable 1.5, where it is explained how the consortium should deal with research involving human participants, including volunteers for social or human science research, with the collection and/or storage of personal data, and the involvement of non-EU countries.

WP1 has held, in continuation of the work described in Deliverable 1.3, the second General Assembly in Paris (June 13-15, 2017) in collaboration with BRGM. The consortium and the AB members participated, and a Management Board Meeting and an AB Meeting was held in connection with the General Assembly. The AB discussed MICA and provided recommendations at the meeting which are accessible from the minutes of the AB Meeting of June 14, 2017, and matched the discussion of the AB at the Final event on January 23, 2018. The main points are summarized here:

- Projects, including MICA, need to focus on knowing the concrete stakeholders, and pursuing the dialogue with these stakeholders; the presence with an introductory MICA presentation at industry events is key, e.g. at the European Metallurgical Conference (Leipzig in 2017), Eurometaux; BGR, DERA are organizing events and so is BRGM. Also the annual US-JP-EU meeting on raw materials is an important outlet, as well as Euromin, and on a national level for instance the raw materials working group of the German Industry Association (BDI). EITRM has an events calendar with an overview of suitable events.
- Industry associations were identified as having a high interest in MICA, specifically the manufacturing industry.
- Sustainability planning needs to start early for EU projects:
    - Sustainability needs to be engrained into the wording of future calls
    - Several paths are laid out:
        - DG JRC and its RMIS as overarching interface between the European Raw Material Knowledge Base (EURMKB) and end-users to host MICA (continuity of funding is not ensured).
        - Yet, JRC doesn't have data ownership, and this is where the Minerals4EU Foundation was proposed. The MICA Grant Agreement specifies that WP7 will ensure a transfer of MICA outputs into the Minerals4EU Permanent Foundation at the end of the project. This is also elaborated in D7.3, heading 10. Exploitation Plan, which specifies that exploitation activities will focus on the effective ingestion of the MICA outcomes into the Minerals4EU Foundation;
        - Other avenues mentioned were:
            - EPOS, EGDI, ERANET, GeoERA, EITRM and its InfoCentre where MICA could be made available,
            - or, as pursed with INTRAW: a semi-commercial not-for-profit avenue based on membership/subscription fees to finance MICA's operation beyond project end;
            - Crowd-funding.
- An estimate of the cost to maintain MICA is needed as part of a closing-survey when the Platform is launched, involving i.e. asking participants to register their 'willingness to pay'.
- The benefit of MICA lies in the data, specifically the scrutiny and quality-control it has undergone as part of the peer-review process.
- Parallel-funded EU projects should be putting forward the same recommendations on the way forward after project end for ensuring sustainability so to gain leverage. The significant value contained in the deliverables and outputs of projects lose their value if they remain isolated as one-off rather than sustained investments. A continuous stream of data, in contrast, is valuable (as i.e. pursued at the USGS).

- The high level steering group of the EIP, the Sherpa group which is advising the EC directly, are receiving letters from institutional directors and national governments to support certain thematic issues in the elaboration of the next framework programmes. It is here where the voices of the institutions partaking in the EU-funded projects can be heard. This is an avenue to be used/pursued.

In addition to the regular email and phone contact, the MICA management board met four times in teleconferences during the second and final reporting period (May 19, 2017; October 02, 2017; December 07, 2017; January 10, 2018).

WP1 has also facilitated the implementation of the flowSheet workshop in Leiden (October 10-11, 2017); an addition to the GA. WP1 has been considerably involved in steering the activities towards the platform elements developed in WP6, with and between the various WP6 partners (BRGM, GEUS, GeoZS, LIG, JRC), mostly between BRGM and GEUS, but also with JRC for the interaction between the back-end of the MICA SheetEditor with the front-face, developed by JRC.

WP1 was involved in coordinating the fact-/doc-/flow-/linkedSheet production by consortium partners. The checking and overview of produced sheets was monitored and checked by GTK.

WP1 co-organized with WP7 a dissemination event in Helsinki (June 07, 2017) as a side-event to the World Circular Economy Forum (June 05-06, 2017). WP1 was also presented at the World Resources Forum in Geneva (October 24-25, 2017) as well as at the Raw Materials Week (RMW) in Brussels (November 09, 2017) upon which further contact with JRC was pursued by WP1 to enter a discussion on how MICA and Raw Material Intelligence System (RMIS – see http://rmis.jrc.ec.europa.eu/), newly released at the RMW could best be integrated, such as via the RMIS-Raw Material Knowledge Gateway (RMKG). This is also discussed in section 7.2, pp. 38.

With a view to further dissemination activities, WP1 was encouraged by WP7 to lead the elaboration of an article on the MICA project for the 44th Issue of the European Geologist on Geology and a sustainable future which focuses on H2020 projects (see here: https://eurogeologists.eu/wp-content/uploads/2017/12/EGJ44_lr-1.pdf).

Findings of relevance for policy

1. **Raw materials intelligence (RMI) should transcend the realm of the mining, metals and minerals sectors:**
   Stakeholder questions focus not just on resource availability but also on environmental, social and economic aspects:
   - many of the questions refer to the whole supply chain
   - Need for **information throughout the supply chain**
   - This knowledge is important to **support raw material policies**
2. **A variety of data and methods is required** to provide 'modern' mineral intelligence:

Stakeholder questions are complex and require data and methods in addition to geological data and methods. Industrial Ecology methods and data can be a powerful addition as they speak to the geological methods (assessing flows and stocks of (raw) materials) and extend to metal flows and stocks in society. As such, they can bridge knowledge gaps: primary/secondary production (urban mine).

3. **RMI should include the future** to enable policy and decision making for the somewhat longer term. Large knowledge gaps exist and persist in the areas of waste, recycling, circularity, urban mining. It is important to fill those gaps.
4. **The MICA platform (EU-RMICP)**: An advanced, standalone online tool with a flexible ontology structure (consisting of various stakeholder-defined domains, concepts and subconcepts) to obtain data and information on mineral (raw) materials through structured and guided queries, based on raw material knowledge.

2.2 Work package 2: Stakeholder identification, appraisal and mapping of stakeholder needs[4]

Lead beneficiary: Fraunhofer-ISI;
Other beneficiaries involved: GEUS, NERC, UL-CML, Minpol, BRGM, EGS, EFG, NTNU.

No. of Deliverable	Title of Deliverable	WP no.	Lead beneficiary	Type	Dissemination level	Due date (month)
D2.2	2.2 Stakeholder Needs	WP2	2 - Fraunhofer	Report	Public	14
Work performed towards objective 1.						

Deliverable 2.2 documents the identification and mapping of stakeholders' needs and requirements related to raw material intelligence (RMI), according to the specifications of Task 2.3 of the Description of Work.

The main target groups of the empirical needs appraisal are definitive, dominant and dependent stakeholders (as per the three main stakeholder attributes – power, legitimacy and urgency – of Mitchell et al. (1997); see Figure 1)[5]. The MICA consortium consists of organisations that are considered **definitive stakeholders** in RMI, i.e. they have power and legitimacy in the RMI discourse and their RMI needs should be gathered urgently. They include geological surveys, other public research institutes, universities, research & technology organisations, intelligence institutes, professional organisations, mining and extraction industry, material production industry, recycling and

[4] This WP is included in the current reporting period despite completion in project month 14 as it constitutes a connecting element: It delivered suggestions for redesigning the MICA ontology and as such presents a cornerstone to the project's framing.

[5] For the definition and classification of stakeholder groups please refer to D2.1 (Erdmann, L.; Eckartz, K.; Moller, B.; Tercero Espinoza, L.A.; Teufel, B.; Fuchs, M.; Machacek, E.; Thorsoe, K.; Petavratzi, E.; Brown, T.; Voet, E. van der; Falck, E.; Bisevac, V.; Hofmeister, T.; Quental, L.; Katalin, S.; Radwanek-Bak, B.; Arnbom, J.-O. (2016): Stakeholder Identification and Analysis. H2020-Project MICA, Deliverable D2.1: 115 p., *http://www.mica-project.eu/?page_id=99*).

material recovery industry, innovation initiatives, project management agencies, ministries of economic affairs and ministries of education & research.

Dominant stakeholders have legitimacy and power in the RMI discourse, but are not represented in the MICA consortium. They include the manufacturing industry as a user of materials and the re-manufacturing industry and governments formulating raw material policies.

Dependent stakeholders with less power but equal legitimacy compared to dominant stakeholders are accounted for in accordance with the EU's Responsible Research and Innovation framework (EC 2012). They include industry sectors potentially affected by minerals RMI (e.g. the bio-based industry) and civil society organisations (e.g. environmental non-governmental organisations (NGOs)).

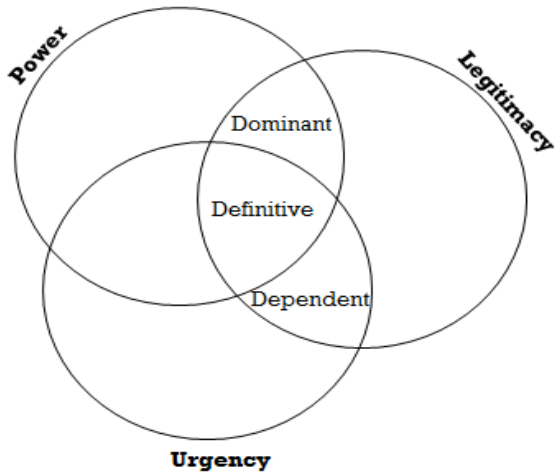


Figure 1 Stakeholder types. Source: adapted from Mitchell et al. 1997.

Three empirical appraisal types (surveys, stakeholder workshop and interviews) were designed to collect RMI stakes in a broad and multi-facetted way:

(1) *Three online surveys* (by the Association of the European Geological Surveys (EGS), the European Federation of Geologists (EFG) and with industry associations) were conducted between June and September 2016 to reach many stakeholders for identification and assessment of their RMI needs which resulted in a total of 95 (almost) completely filled in questionnaires.

(2) A *stakeholder workshop* was held on 27 September 2016 at the Eurometaux's premises and gathered 25 stakeholders from industry, research and governments clustered in four focus groups: the Mineral Deposit Community, the Mining Community, the Urban Mining Community and the Materials Community. The focus groups refined the interim results and suggested further needs related to RMI from their different institutional backgrounds.

(3) In addition, *20 interviews* were conducted with representatives from NGOs and industry, EU agencies, ministries, cities, finance, education and consumers. The interviews explored RMI needs in depth and closed major gaps in the targeted stakeholder landscape.

Findings from the empirical appraisal types

Surveys
The EGS Survey reached almost two thirds of the geological surveys organised under the umbrella of EGS. Respondents consider *budget pressure* and *public attitudes towards exploration and mining, raw material abundance and a European Circular Economy* as major strategic issues. Most needs for improvement of raw material information are broadly confirmed (onshore and offshore resource potential, Greenfield and Brownfield exploration, historical exploration and mining data, abandoned mining sites, raw material criticality, and supply and demand trends, to policies, reporting issues and stakeholder identification), but *above ground infrastructure stock and subsurface infrastructure stock* are not yet issues for the majority of respondents.

The EFG Survey enhanced the knowledge and understanding of raw material information needs of professional geologists as potential users of the envisaged online platform. They belong to four major organisation types: academia/university/research institute, consultancy/planning office, geological survey and industry. The need for *improving access to raw material information* in order to support them in responding to information needs is pointed out broadly in all response categories (including land use constraints, investment in exploration and mining, existing and planned mining ventures, mining operations and environmental, health and safety issues).

The Industry Survey reached strategic management within the industry associations covering large parts of the supply chain from material processing to recycling. Industry associations broadly emphasize the strategic relevance of *trade and environmental policies and regulations*. The need for improving access to *specific raw material information* in order to support them in responding to specific information needs varies depending on the industry associations' positions in the value chain. Frequently mentioned topics of interest include material price development, raw material processing industry plants and structure, supply chains and regional industry clusters, stocks and flows of secondary resources, and technologies (e.g. agile re-manufacturing). The industry associations' members and key external stakeholders increasingly ask for life cycle analyses, recycling streams, innovations and conflict mineral due diligence.

Further analysis of the three surveys revealed that **the Sustainable Development Goals and data selection options in the MICA Online Platform are particularly important**. Depending on the raw material knowledge domain, information is non-existent or not exploited sufficiently giving hints for designing the MICA Online Platform.

Stakeholder workshop
The stakeholder workshop enabled the raw material information needs to be sharpened and raised a number of additional aspects. Major amendments generated by four focus groups related to *actors in charge of local raw material availability and waste registers, links to existing data bases and projects, information about by-products, inventory and composition of stocks, mining venture sites, profitability and risks, supply chains/value chains, material fate between primary production and its secondary production, and properties of alternative materials for the design stage*. All in all it was found that MICA should make clear to the Online Platform user what can be expected of its services.

Interviews
The interviews explored raw material information needs in depth. Interviewees interested in investment topics asked for *area/country comparisons of exploration projects, propensities to invest, availabilities and costs of production factors and financial models for regeneration of mining sites*. Supply chain/value chain information needs of the interviewees include *trade-related, material/design-related, transparency and sustainability issues*. A number of NGOs, consumer organisations, trade unions, environmental NGOs and transparency & democracy NGOs, share the need for *transparent information of corporate actors/networks* but differ with regard to the part of the supply chain they engaged with. Civil society actors wish to be on an equal level on raw material information with private and public sector actors through better access to such raw material information. The interviews on urban mining and cities specified information needs with regard to stocks and flows, best waste management practices and actors.

Ten options for **redesigning the MICA Ontology** in its version of 29 July 2016 were suggested:

1. Differentiate existing concepts according to stakeholders' perceptions of the raw material field (see Figure 2).
2. Consider stakeholders' needs for navigating the numerous raw-material related actors, initiatives and projects at EU and other levels
3. Assist tracing material fates between virgin raw materials statistics and waste statistics
4. Account for technology/innovation (available/emerging) as a sub-concept of raw material related processes
5. Support supply chain/value chain analysis
6. Introduce a material/design perspective on raw materials
7. Assist stakeholders to find financial information on mining companies and networks
8. Account for trade as a well visible concept
9. Sort out, if and how to address procurement, standards, skills, property issues and communication
10. Provide orientation according to the Sustainable Development Goals

The empirical needs appraisal has reached stakeholders in RMI systematically and in large breadth. With the methodological approach and the research restrictions considered, the assessed RMI needs and requirements were seen as sufficiently diverse and comprehensive.

The suggestion for the redesign of the MICA Ontology was taken up in surveys by work packages 3, 4, 5 and in WP 6, and resulted in the design of the following 7 domains (topics sorted according to end-user interests), broken down into numerous concepts (see Figure 2).

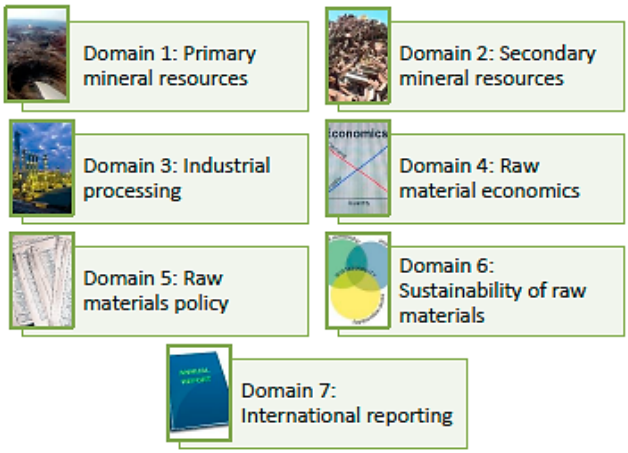


Figure 2 Groups of 7 domains of questions or queries by end-users.

Findings of relevance for policy

Both D2.1 (Stakeholder Report) and D2.2 (Stakeholder Needs Report) hold important policy-relevant findings beyond the exploitation within MICA.

WP2 identified and systematically defined 90 stakeholder groups in RMI at a medium-level of granularity (D2.1, pp. 26-83). Usual suspects and unexpected stakeholder groups are both included. For example, nine different civil society organisation (CSO) groups are distinguished. The **stakeholder group repository** differentiates stakeholder groups according to their plausible functions in RMI without being too detailed. For each stakeholder group the context of identification is indicated, e.g. whether stakeholders of that group responded to recent relevant stakeholder consultations or R&D calls.

In particular, the stakeholder group repository can be used as a reference for the **justification of inclusion and exclusion of certain stakeholder groups in raw material research and policy-making**. The stakeholder repository has the potential to improve stakeholder management approaches in three major application fields:

- the design of RMI research programmes and the evaluation of RMI proposals ("improve usefulness and excellence")
- raw material governance ("improve legitimacy and acceptance")
- raw material foresight ("improve anticipatory intelligence and policy scoping")

MICA used the typology of Mitchell and colleagues (1997) to relate stakeholder groups to MICA with its concrete aims and funding conditions (D2.1, pp. 14-15). Any other specific raw material related question will require a regrouping of stakeholder groups. For example, measures to support the circular economy may lead to a classification of geological surveys as dependent stakeholders instead of definitive stakeholders. Other stakeholder classification systems than Mitchell and colleagues' approach (1997) exist, emphasizing e.g. affected stakeholders by mining (e.g. bio-

based industry), hidden stakeholders (e.g. raw material thieves) or emerging stakeholders in RMI (e.g. prosumer communities).

The 90 stakeholder groups can assist to reassess past and current research and policy activities and to develop new ones in a more inclusive, justified and smarter way. It is recommended to put each of the 90 stakeholder groups on a separate card and to **explore the implications of emerging raw material research and policy themes on different stakeholder groupings**.

WP2 gathered stakeholder needs empirically in a broad and multi-facetted way, including three online surveys, a multi-stakeholder workshop with 25 participants and 20 interviews. 700 statements, expressing the RMI needs of definitive, dominant and dependent stakeholders in MICA's potential RMI services were sorted, assessed and mapped (D2.2 pp. 11-18). MICA's approach stands out, as **stakeholders were asked what they actually need**. The insights gained are condensed into a 45 pages report plus additional material (D2.2).

The MICA project was able to exploit a significant share of stakeholder needs in designing its RMI services. Some needs could not be addressed, because the required expertise to provide a decent answer was not available to the MICA consortium; other needs could not be addressed, because the raw material information required could not be delivered by external experts. For example, three European recycling associations consulted could not provide useful advice on how to identify certified recyclers throughout Europe. It is recommended to revisit the Stakeholder Needs Report (D2.2, in particular pp. 19-38) to reassess for MICA's service gaps **whether there is raw material information available** at all to address the stakeholders' needs. The stakeholder needs inventory could thus be used to proactively address stakeholders RMI needs not yet met sufficiently by MICA's services.

In addition, the map of stakeholder needs can be revisited and further exploited to **assist a better integration of stakeholders in raw material policy-making**. Stakeholder needs may support building alliances in line with EU raw material policies. Alternatively, emerging stakeholder needs in raw material policies (e.g. by prosumer communities, additive manufacturing, local on-demand production) may give occasion to reassess EU policies and to consider revisions.

2.3 Work package 3: Data for raw materials intelligence capacity

Lead beneficiary: NERC;
Other beneficiaries involved: GEUS, Fraunhofer, UL-CML, Minpol, BRGM, BGR, GTK, NTNU.

No. of Deliverable	Title of Deliverable	WP no.	Lead beneficiary	Type	Dissemination level	Due date (month)
D3.2	3.2 Final inventory	WP3	3 - NERC	Report	Public	20
Work performed towards objective 2.						
Additional output: **Online MICA metadata catalogue** (http://metadata.mica-project.eu/mmd)						
D3.3	3.3 Report on the	WP3	3 - NERC	Report	Public	22

	transformation of data into information and knowledge					
Work performed towards objectives 2 and 3.						
D3.4 & D4.4	3.4 & 4.4 Integrating data, methods and expert knowledge to inform mineral intelligence	WP3	3 - NERC	Report	Public	24
This work is jointly performed with that of D4.4 towards objectives 2, 3 and 5.						
Additional output: **Elaboration of 21 FlowSheets** during the extra expert workshop held in Leiden.						

Deliverable 3.2 provides *a summary report on the final inventory of data on mineral raw materials*. This is a follow-up report from D3.1 Draft inventory of data on raw materials and it provides an overview of the progress made since. D3.2 should be read in combination with D3.1 for a full understanding of the development process of the metadata inventory.

This report focuses on the gathering of data and the development of metadata records, as well as the outcomes of the efforts undertaken to map the identified data to the methods defined by WP4). It also summarizes the results of two workshops undertaken on data uncertainty, provides an update of the progress made towards the online inventory and summarizes the decisions and work progress made for linking the MICA metadata inventory to the MICA online platform. Key findings include:

- Data identification and gathering, development of metadata records: A total of 410 metadata records now form part of the MICA metadata inventory. Several MICA partners and linked third parties have participated in the data collation process, provided their insight and assisted with the development of metadata records.
- Mapping data to methods: Identified datasets from the WP3 dataset list were mapped to methods (identified in WP4 and described in D4.1) with a group of experts from the MICA consortium. This allowed for identifying data gaps where an expansion of the current WP3 inventory list could fill these, or where datasets do not exist and therefore future research is required to address them. It also identified gaps in the list of methods that may require further development.
- Data uncertainty: The workshops provided insight on concerns about data uncertainty and how these are dealt with by data users and -providers. It also provided information about the role and connections between metadata and data uncertainty and how uncertainty could be communicated more clearly to users.
- Online metadata inventory: The online metadata MICA inventory is publicly available and contains 410 records, namely 188 non-geographic datasets, 168 datasets, and 54 series (see http://metadata.mica-project.eu/mmd, and snapshot thereof in Figure 3 and Figure 4). The online metadata listed in the inventory include all the links to the MICA ontologies and are harvestable for use by the Triple Store and the MICA platform. Some issues with the GeoNetwork continue to exist, in particular with the presentation of the data in the user interface. These are however issues associated with the GeoNetwork itself that we have no control over, but we communicated to the GeoNetwork developers. Some additional

attempts to improve if possible the user interface will be undertaken during January. Testing of the inventory to identify mistakes or missing information was also undertaken. The issues highlighted during the testing period were addressed and resolved in January 2018.

- Linking the MICA metadata inventory with the Raw Material Intelligence Capacity Platform (RMICP) of WP6: During several discussions on how to link the two systems, a procedure was agreed whereby metadata records will be harvested by the RMICP for inclusion in the MICA online platform.

The final list of records is available from the very end of the project.

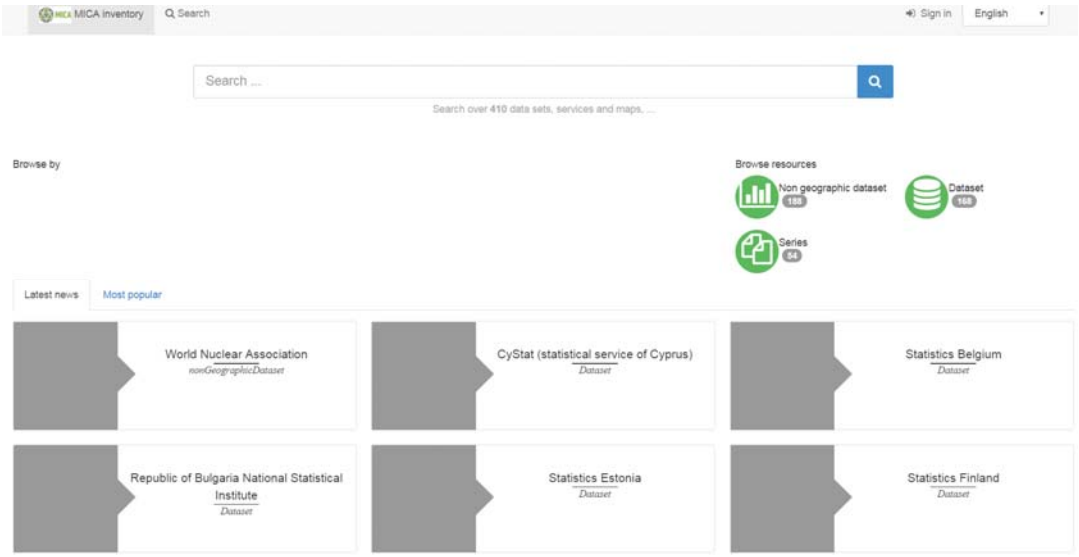


Figure 3 Public access to the extensive online metadata inventory.

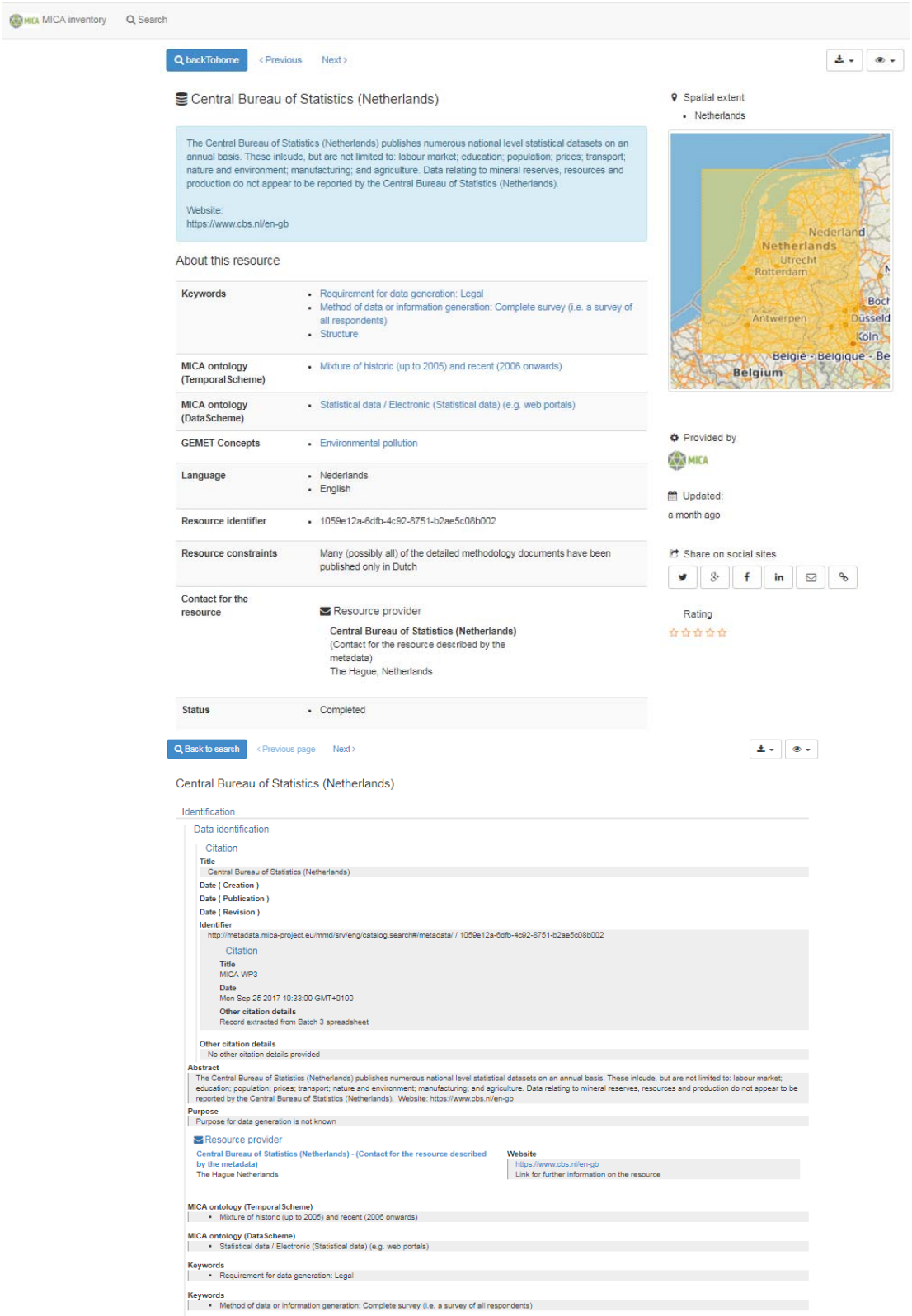


Figure 4 Excerpt from a metadata entry. Default view (first figure) and Full view (second figure). The full view provides all the data recorded, whereas the default view only provides specific fields.

Deliverable 3.3 explores how raw materials data and information investigated by the MICA project can be used to deliver knowledge and support mineral intelligence; it presents the development of *a knowledge management model, the Data-Information-Knowledge-Intelligence (DIKI) model for raw materials* (see Figure 5). This report provides a synthesis of work undertaken within WP2, WP3 and WP4, which assists in delivering knowledge on raw materials to various stakeholder groups. The purpose of D3.3 is to *define the terms of data, information and knowledge within the raw materials context and describe the steps required to derive desirable knowledge and justify data/information needs.*

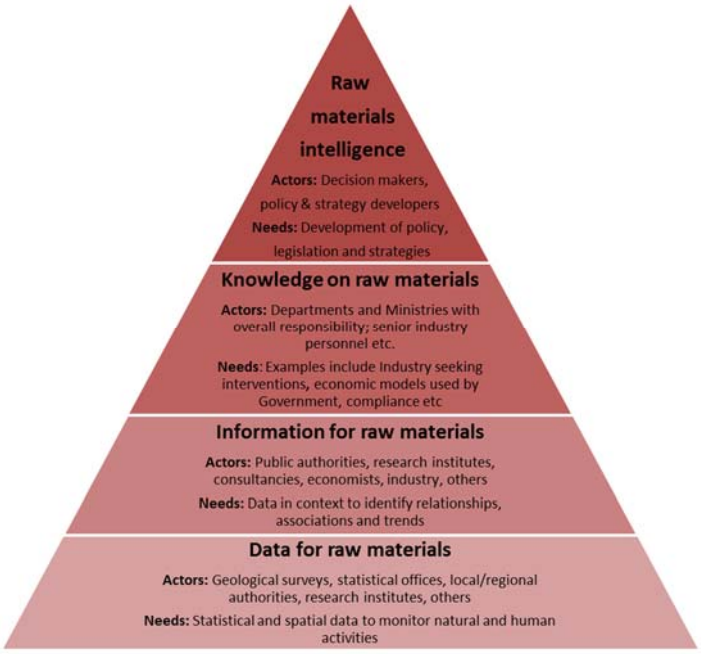


Figure 5 Data-Information-Knowledge-Intelligence (DIKI) model for raw materials
Note: This hierarchy describes levels of interpretation and analysis needed to move from data to intelligence; reiterative processes.

Raw materials knowledge is delivered by the European Raw Materials Intelligence Capacity Platform (EU-RMICP) through MICA FlowSheets, LinkSheets, FactSheets and DocSheets, and by the project deliverables that provide knowledge independent of the platform which addresses questions of relevance for mineral intelligence, and mineral policy.

Specifically, D3.3 explores how data and information are transformed into knowledge for raw materials and delivers a conceptual framework, which explains the transformation process. It also produces *clear definitions of the terms data-information-knowledge-intelligence*, which constitute key components of the MICA project, as well as the EU Raw Materials Knowledge Management Base. The term raw materials intelligence is discussed and reference to relevant literature underlying the development of this model is made. Several examples from the raw materials field and the MICA project are given to demonstrate the applicability of the proposed model and explain the transformation process.

The combined Deliverable 3.4 and Deliverable 4.4 explores how raw materials data (provided by WP3), methods (provided by WP4) and expert knowledge (delivered by the MICA consortium and external invited experts) can be integrated to deliver a pathway to an answer to a question or problem with a mineral (raw) material theme. It outlines the *'thinking process' that an expert would follow to reach to a result*, with the aim to raise awareness about the considerations one should have in mind when seeking an answer to a specific raw material question. The ultimate goal of the proposed framework is to support stakeholders who miss the expert knowledge to *develop independent thinking*. The framework described corresponds to the development process of flowSheets in the MICA vocabulary. Several important remarks, regarding data and methods availability and gaps, as well as expert insight requirements are made throughout the report and they are explored in detail using stakeholder questions delivered to MICA as the starting point.

The methodology appeared to be applicable to a variety of questions and it consists of the following steps:

- Translate the stakeholder question, which is by nature imprecise, into a more re-fined and demarcated question or set of questions that can be answered using raw materials data and methods.
- Identify data needs and databases that could provide the relevant information.
- Identify the need for application of one or more specific methods, to process the data into relevant information.
- Provide expert insight about gaps in data or/and methods, issues with existing methodologies, datasets, technical input, uncertainties or other information that are hard to capture by reading a report or methodology manual.
- Outline a series of steps that stakeholders could follow to guide them to an answer.

Even though it is not possible to answer all stakeholder questions, developing pathways to potential answers, explaining the 'thinking process' and identifying related data and methods is very valuable. *flowSheets (see* Figure 6 *for an example)* provide exactly this, *they convey expert insight, raise awareness about the considerations that one should make (data and methods) and clearly outline the complexity of the research project.*

The provision of a good answer demands a clear and precise question. Breaking down an imprecise question posed and assigning boundary conditions can help to simplify it. The tem-plate and procedure described in this report may serve future research to enhance and possibly 'automate' the process.

Combining data and methods to answer a question is not always straightforward, as it often requires expert insight by a multidisciplinary group of experts, including the stakeholder(s) who posed the question in the first place.

A fundamental conclusion of this work is that all stakeholders, both those asking the questions(e.g. industry, open research calls, governments etc.) and those responding to them, need to have a clear understanding of the steps involved and the associated tools that are available to respond to

such questions. Raising awareness and understanding among all the parties involved, based on clear and transparent communication, is paramount.

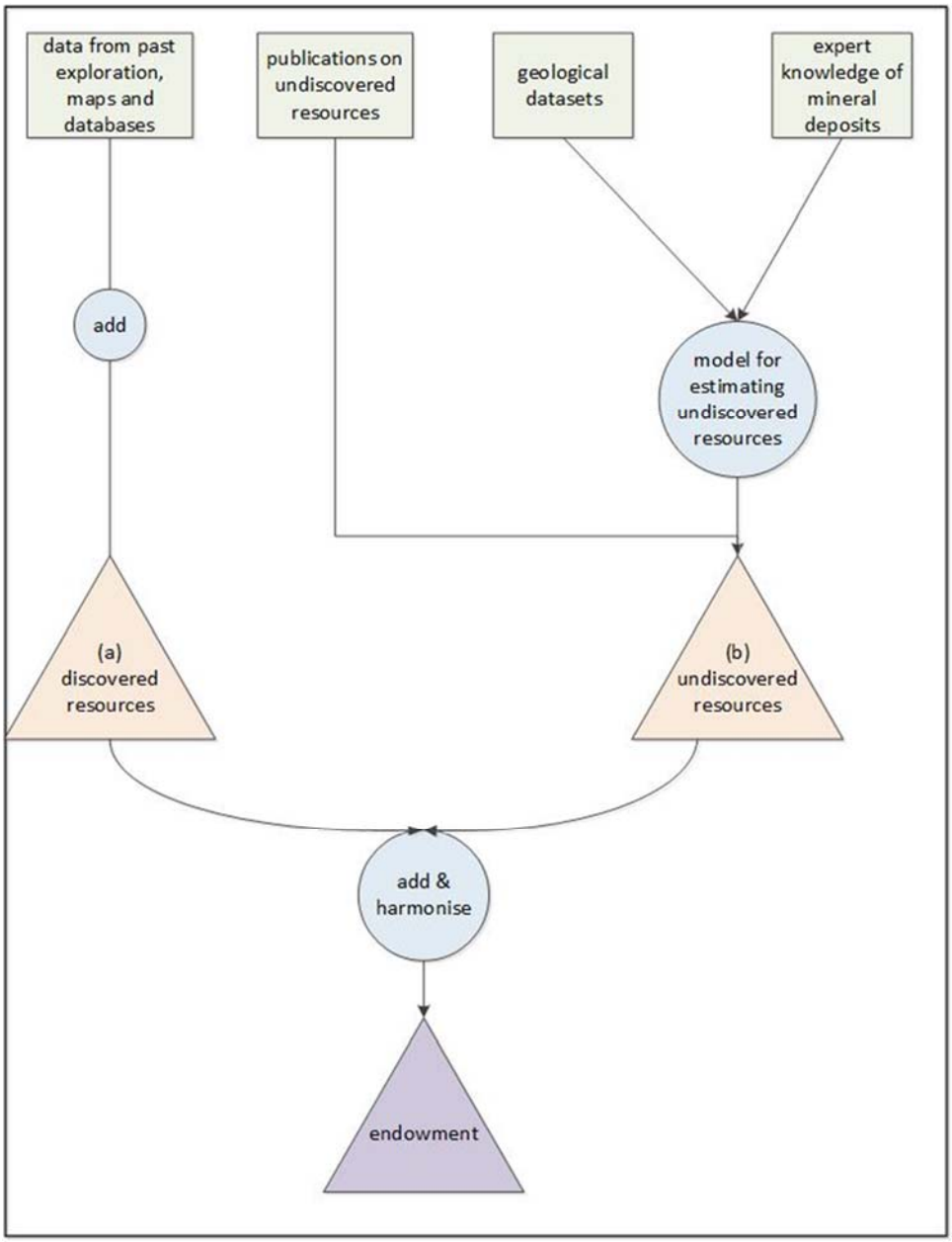


Figure 6 flowSheet diagram of research question 1: What is the total mineral endowment of copper in Europe?

Findings of relevance for policy

The work delivered by WP3 is linked to the objectives of the EU Raw Materials Knowledge Base (EURMKB). The **knowledge management framework** proposed in Deliverable D3.3 could underpin the EURMKB, as it sets **clear definitions on the terms data, information,**

knowledge and intelligence for raw materials. It also explains clearly the different actors and needs associated with each tier of the pyramid. For example, the framework could be used to track what data, information and knowledge are required by decision makers, in order to be able to respond adequately to a specific issue or topic of interest.

The work delivered by WP3 and described in deliverables D3.1, D3.2, D3.3 and D3.4 & D4.4 is highly relevant to the JRC Raw Materials Information System (RMIS) and discussions for **linking the MICA metadata inventory with RMIS** should be explored further.

The **MICA metadata catalogue** (http://metadata.mica-project.eu/mmd) includes a variety of records related to several different topics, which addresses the whole life cycle of raw materials. In order to accommodate such diverse metadata records, a lot of thinking and iterations with stakeholders took place to develop a suitable metadata template. The template is **ISO compliant**, for most records also **INSPIRE compliant** and **suitable for describing non-geographic datasets**, which are currently not described adequately by existing templates. The development undertaken in MICA should be taken into consideration by future projects as well as **future initiatives looking at statistical data harmonization.** Metadata play a significant role in reducing data uncertainty and the template developed by MICA WP3 is comprehensive enough to enable the reporting of detailed information to support any dataset. The scope of the MICA metadata catalogue could expand further to accommodate many more themes, or topics of interest.

An important outcome of WP3 is the **elaboration of a methodology** to assist stakeholders and decision makers to develop pathways to answers for questions or issues surrounding raw materials. The method developed is described in the combined deliverable D3.4 & D4.3. The method attempts to empower stakeholders who miss the knowledge to develop independent thinking and therefore better approach questions and topics they are concerned with. This work is highly relevant to decision makers, who are often asked to take action against complex issues. It can help them phrase their concerns and thinking better, but also ask for the right questions from the expert community, for example in the form of **well-defined research programs**. The work developed in this combined deliverable, should be continued and expanded in the future, not because we believe that it is possible to answer every question, but because **it is important to develop pathways for key issues of concern and within them to identify data, methods and knowledge that is already in place or not**.

2.4 Work package 4: Methods and tools for mineral intelligence

Lead beneficiary: UL-CML;
Other beneficiaries involved: Fraunhofer, NERC, BRGM, NTNU, UCL ISR.

No. of Deliverable	Title of Deliverable	WP no.	Lead beneficiary	Type	Dissemination level	Due date (month)
D4.3	4.3 Case study reports	WP4	4 - UL-CML	Report	Public	22
Work performed towards objective 3.						
D4.4 & D3.4	4.4 & 3.4 Integrating data, methods and expert knowledge to inform mineral intelligence	WP4	4 - UL-CML	Report	Public	24
This work is jointly performed with that of D3.4 towards objectives 2, 3 and 5.						
Additional output: **Elaboration of 21 flowSheets** during the extra expert workshop held in Leiden.						

Deliverable 4.3 presents case studies that illustrate the use of selected MICA methods to address common stakeholder questions. The case studies include 7 methods/stakeholder topics (in bold):

1. **Dynamic material flow analysis** (dMFA) demonstrates how this tool can be used for strategic decision-making for raw materials within both i) policy and ii) industry, using aluminum as a case. To illustrate the benefits of dMFA for industry, the first section of this case study showed how dMFA can be used to estimate future scrap amounts by alloy and type to identify the potential of current applications and identify effective interventions to open up new recycling pathways. This case study can answer stakeholder questions about forecasting of material flows, anticipating potential challenges, and evaluating strategies for addressing these challenges under different contexts.
2. **Scenario development** illustrates how scenarios can be developed for forecasting metal futures and estimating their associated environmental impacts. In this study, Life Cycle Sustainability Assessment (LCSA) was used to forecast how the impacts of 7 major metals, including aluminum, iron, copper, zinc, lead, nickel and manganese, will develop in the future and the magnitude of these impacts at a global level. This case study demonstrated how LCSA can be used to answer stakeholder questions about the environmental impacts of metals and the related future global consequences.
3. **Trade** describes the importance of tracking the movement of materials across borders for better understanding the flows of any one metal and the accumulation of in-use stocks in different regions. Because trade data are generally unavailable, this information has to be estimated. This study describes methods for estimating these data using copper as a case and answers stakeholder questions related to methods for geopolitics and supply chains.
4. **Uncertainties** recognizes the presence of uncertainty in any aspect of mineral intelligence and illustrates how uncertainty can be quantitatively dealt with, in particular, for material flow analysis. This study uses the rare earths in the EU-28 as a case and details two data reconciliation methods, their respective caveats and the preferable method depending on the specific case. This case study answers stakeholder questions related to the robustness of model results and data quality.
5. **Urban mining** shows how data and methods included in the MICA raw materials intelligence system can be used to answer stakeholder questions related to i) estimating the size of urban mines, ii) assessing the availability of these materials for secondary metal production and iii) determining how urban mines can be accessed. This study uses the urban mine of residential buildings in Amsterdam as a case and a combination of methods to detail the potentials and

obstacles of analyzing urban mines. This case study answers stakeholder questions related to methods for assessing amounts, qualities, and accessibility of secondary resources of the future.

6. **Computable general equilibrium** (CGE) models deal with the economic modelling of materials and, in particular, provide details on how CGE models can be modified to allow greater consideration of specific resources and can then be used to consider specific policies on resource efficiency and the circular economy. This study uses steel as a case and analyses the future of steel in China and how this will impact the EU. This case study answers questions related to the use of economic models for calculating material stocks and flows and related energy use and greenhouse gas (GHG) emissions.
7. **Criticality** represents a common stakeholder topic and explores some key features of criticality assessments and discusses issues associated with undertaking such assessments. The current list of critical raw materials for the EU is used as an illustrative example. This case study answers stakeholder questions regarding the usefulness and limitations of different approaches to criticality assessments.

While the case studies showcase the benefits of the MICA methods and how they can be used to answer stakeholder questions, they also illustrate that there are common challenges shared by all methodologies when applying them to raw materials. These challenges relate to data availability/data quality, developing consistent system definitions, uncertainty within scenario development and modeling and stakeholder communication.

A **flowSheet workshop** was organized jointly by UL-CML and NERC (BGS) at UL-CML in Leiden, the Netherlands, from October 10-11, 2017 during which 21 FlowSheets were jointly elaborated by MICA experts of different disciplinary backgrounds.

For a description of joint **Deliverable 4.4 and Deliverable 3.4**, please consult section 2.3, which also includes an **example of a FlowSheet** (see Figure 6).

Findings of relevance for policy

Mineral Intelligence relies on data, methods, expertise, interdisciplinary cooperation, open mindedness, and common sense. With a focus on methods, as is the starting point of WP4, we draw the following general conclusions:

1. So far, raw materials intelligence has focused on primary production and has taken a geological perspective. The MICA project has shown that **other methods, specifically industrial ecology methods, provide an essential addition to geological methods** when addressing stakeholder questions. Stakeholder questions are not limited to primary production but include a wide range of questions, especially on supply chains, sustainability aspects, urban mining and circular economy.
2. **Inventories, data and methods to assess urban mines, waste flows and secondary production must be improved.** To increase secondary production and move to-

wards a circular economy, **urban mines** are an important source to consider. Investigating urban mines is in its first stages of development. **Geological methods may be applied** to assess the potential of these urban mines as well as for geological mines.

3. Stakeholder questions are often complex and cover different aspects. **Integration of methods from different disciplines** is therefore essential to support minerals policies and strategies. Geological methods, industrial ecology methods, economic methods and forward looking methods can and should be combined.

To better support raw materials policies, we make some recommendations below on the use and development of methods. We found that in many cases, methods are already available that can be used to answer different types of stakeholder questions, yet they fall outside the scope of current policies and strategies. We recommend **methods must be developed and especially applied to three areas**:

1. **organising supply chain information** with regard to origins and fate of raw materials, to enable policy applications such as
    - product / building passports
    - certification systems
    - trade flows of commodities in products
    - waste streams and recycling
2. **estimating the effectiveness of policies**, for example resource efficiency and circular economy policies, on raw materials extraction and use, with regard to
    - Material availability / criticality
    - Economic aspects: costs, benefits, market development, jobs, growth
    - Environmental aspects: energy and GHG emissions, biodiversity impacts
    - Social aspects: health, working environment, wages, workforce, local population wellbeing, equity

    To some extent, these methods are available, but the use and integration of them could be improved.
3. **forecasting material demand and supply, and the related environmental impacts**. In this area, methods and models still need to be developed to a large extent. In such forecast, information and modelling is required with regard to
    - Socio-economic driving forces of demand and supply
    - Technological aspects that determine production capacity, but also resource efficiency and environmental impacts
    - Scenario storylines to sketch potential futures and their consequences for demand and supply of materials

    A specific area in this field is the opportunities offered by a **linking up with Integrated Assessment Modelling (IAM)**, such as is already being done in the field of climate change. These models have already implemented storylines and translated this into a set of socio-economic variables. This can provide **a starting point for the development of resource scenarios** as well. The combination is very useful for:

- Aligning resource scenarios with climate scenarios
- Establishing quantitative linkages between climate change and resource extraction and use
- Integrating impact assessment of resource and climate policies

2.5 Work package 5: Minerals policy context

Lead beneficiary: Minpol;
Other beneficiaries involved: GEUS, Fraunhofer, NERC, LPRC, NTNU, UCL-ISR.

No. of Deliverable	Title of Deliverable	WP no.	Lead beneficiary	Type	Dissemination level	Due date (month)
D5.2	5.2 Report on the development and application of the RMI-MATRIX	WP5	5 - Minpol	Report	Public	20
Work performed towards objective 4.						
D5.4	5.4 Report on Pilot Foresight	WP5	11 - LPRC	Report	Public	20
Work performed towards objective 4.						
D5.5	5.5 Raw materials Foresight Guide	WP5	11 - LPRC	Report	Public	20
Work performed towards objective 4.						
D5.6	5.6 Report on RMI implementation status quo and needs in EU-28	WP5	5 - Minpol	Report	Public	24
Work performed towards objective 4.						

Deliverable 5.2 investigates the minimum set of tools/methods needed to develop a coherent and comprehensive mineral policy-making framework. The Deliverable develops a Raw Material Intelligence (RMI)-MATRIX that allows the identification of strong, medium and worst cases for RMI development (see Table 2).

Table 2 RMI-M to applied for screening of EU-28 ('x' – the parameter is applied at the level of strong/medium/weak scenario, '-' – the parameter is not applied at the level of strong/medium/weak scenario).

RMI (policy) scenarios/value	MCA	MFA	MIA/DGD	MDoPI/LUP	CE	MC/Forecast	Mineral policies/ strategies
Strong	x	x	x	-	-	x	Name of the strategy
Medium	-	-	-	x	x	-	
Weak	-	-	-	-	-	-	

Note: MCA – Mineral consumption analysis, MFA – Material flow analysis, MIA – Mineral inventory analyses, DGD – Digital geological database, MdoPI – Mineral deposit of public importance, LUP – Land-use planning, MC – Mineral consumption.

For a more detailed analysis, this simple version could be potentially extended by adding several possibilities representing strong, medium or weak scenarios. For instance, a strong scenario for access to mineral resources (column MDoPI/LUP) represents a) efficiently working implementation of MDoPI into LUP or b) efficiently working minerals safeguarding via other mechanism. A medium scenario could be understood as a) the access is restricted to selected minerals (e.g. reserved minerals), b) the access is secured via land-use planning for all minerals but not working properly, c) the access to minerals is limited by other elements. A weak scenario would mean that the country is not securing the access to minerals by any tool or instrument. However, this extension would require definition of different possibilities of interpretation for each element, which could result in complex assessment. Thus, for the purposes of MICA (and D5.6) it was suggested to use a simple and quick screening as provided in Table 2.

Deliverable 5.4 summarizes the *WP5 Raw Materials Foresight Methodology Workshop*, held in Las Palmas de Gran Canaria, Spain, on the 10th and 11th of May 2017 to inform policy-making and provide *recommendations for foresight methodologies to the MICA online platform* (RMICP) and Deliverable D5.5 *Raw Materials Foresight Guide*.

The recommendations for foresight methodologies to the MICA online platform were threefold: (1) Relevant topics are to be featured in D5.5 and it should be described how foresight can be integrated to the platform; (2) New FactSheets are to be produced for the MICA online platform and possible constraints to be considered; (3) Foresight methodologies: from integration to strategy, side benefits of foresight processes and importance of each step in a foresight exercise.

Deliverable 5.5 Raw Materials Foresight Guide provides guidelines for conducting foresight exercises and providing methodological recommendations for mineral raw materials policy making, in the context of strategic RMI. The proposed process for 'Raw Materials Foresight Intelligence' in the context of the MICA online platform is illustrated in Figure 7 and follows four steps:

(1) (Future-oriented) queries: end-users have specific questions and needs related to future projections; foresight intelligence relates to the platform's answers to such questions;
(2) At first, information (Fact- and DocSheets) related to foresight concepts, frameworks methods and tools will be presented, offering the possibility to the user to better understand how foresight can help in answering the question, as well as informing on how to adapt or reshape the question in function of the foresight scope. Advanced users of foresight may skip such step;
(3) In parallel, data and sources of relevant data may also be provided as answer to such questions that, in a foresight context, can serve as input for the process, as well as on the application of the foresight methods and tools;
(4) Finally, the platform can also inform on past raw materials case studies, setting potential references for the users to explore according to their needs.

The Guide seeks to increase efficiency and effectiveness of EU activities related to raw materials policy planning.

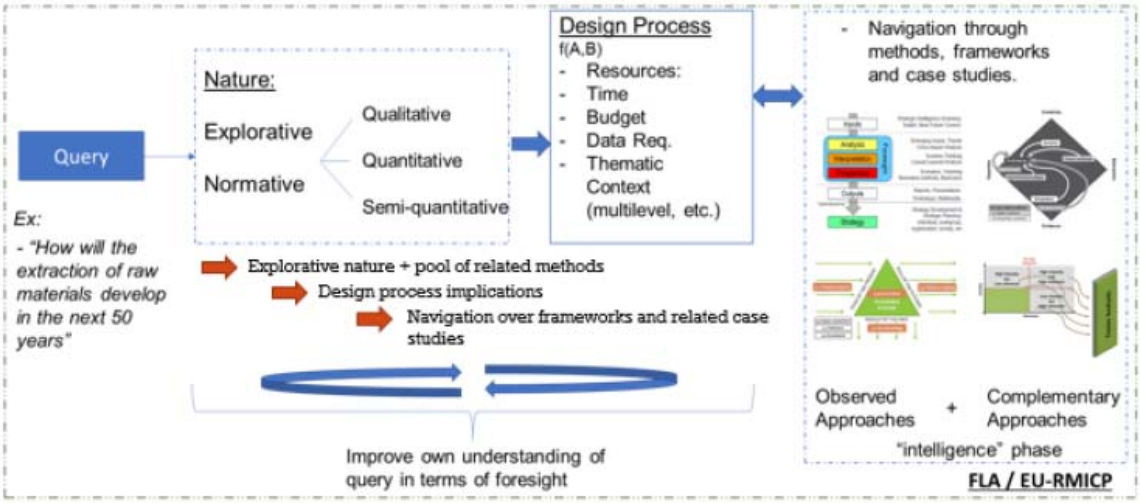
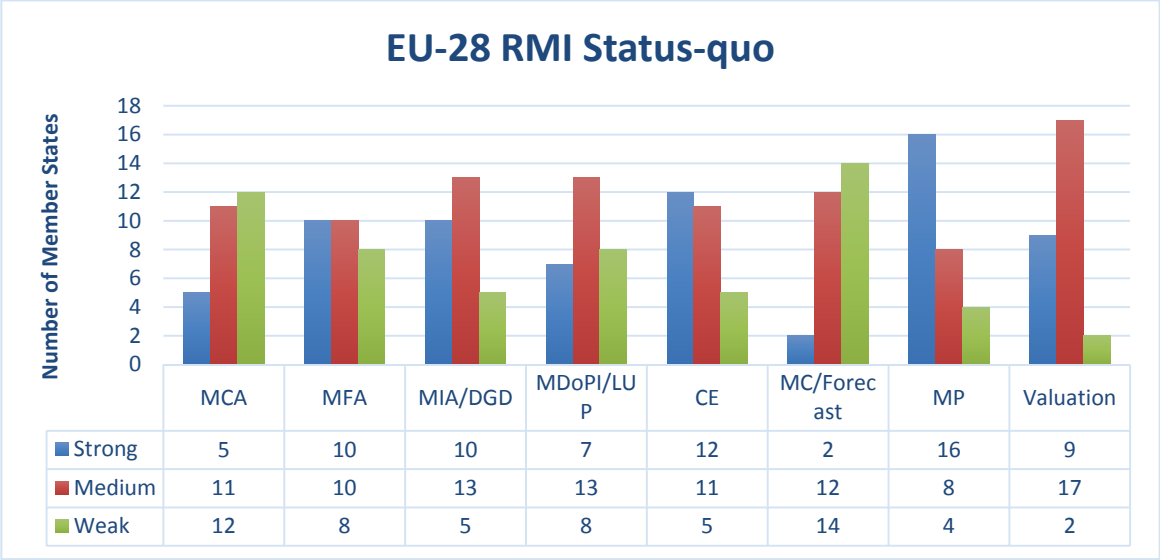


Figure 7 Schematic overview on the process of foresight & the MICA online platform.

Deliverable 5.6 assesses the RMI status quo in Europe drawing on the RMI-Matrix shown in Table 2 and examines how it influences the current mineral policy. The RMI-Matrix for EU countries is screened for the capacities, methods and tools employed and policy recommendations are made; see Figure 8.

Among the ten countries that have been found to have an overall *strong (strong or medium) policy framework* and are implementing most of the key parameters pointed out as important for the positive development of a mineral policy scenario are AT, CZ, DK, IE, IT, NL, PL, PT, SE and UK. Cyprus and Luxembourg, according to the screening, represent countries with a weak mineral policy scenario. In the case of Luxembourg no sufficient information is available about most of the RMI aspects. The majority (17) of the countries are indicating a medium (medium or weak) scenario, i.e. they are applying some of the tools to a certain extent.



	MCA	MFA	MIA/DGD	MDoPI/LUP	CE	MC/Forecast	MP	Valuation
Strong	5	10	10	7	12	2	16	9
Medium	11	10	13	13	11	12	8	17
Weak	12	8	5	8	5	14	4	2

Figure 8 EU-28 RMI Status-quo per parameter.

Close to all EU-28 countries are conducting MFA and monitoring indicators (i.e. Domestic Material Consumption – DMC) based on Economy-wide MFA, used i.e. for monitoring resource efficiency (resource productivity GDP/DMC). However, it is not always very clear to what extent they are using these indicators for policy design and decision making. Only Austria (AUTMIN PLAN) and Italy (PIAE) were identified as using demand forecasting for mineral planning policy. In some countries this is applied only for selected minerals (e.g. aggregates, metals).

Countries identified to have *a strong circular economy agenda and targets* are AT, CZ, FR, DE, NL, SI, SE, and UK. Most of the countries are implementing some of the resource efficiency concepts in their policy framework and they are ranked in the medium scenario: BE, DK, EE, FI, EL, IE, IT, LV, LT, LU, MT, PL, PT, and ES. Countries which were assessed to have poorly implemented circular economy and resource efficiency concepts are BG, HR, CY, HU, RO and SK.

Almost all Member States were identified to have developed some kind of policy or strategy focused on mineral resources. Six of them are oriented only toward the mining stage of mineral development. It is found that demand forecast is not often used, with some countries using it only for aggregates. In turn, 14 countries use *back-cast* trend check (based on DMC) to design mining/mineral policies.

Most of the countries have a centralized data collection of mineral resources and reserves, however only ten of them in harmonization with internationally recognized standards (JORC, PERC or UNFC). A consequent translation of identified mineral resources and mineral potential into land use planning (LUP) connected with their protection is not always present. Only seven countries have been evaluated to have this linkage strongly developed (AT, DK, EE, PL, PT, SE and UK). In 13 countries the linkage between mineral deposits and LUPs exists but without effective protection.

Findings of relevance for policy

The following **recommendations** for improving the foresight practice in the raw materials sector and in mineral raw materials policy design were made in *Deliverable 5.5* which could be implemented by the European Commission and other organizations at the EU level with a raw material focus:

(1) Set up of **early warning/horizon scanning capacity for raw materials**, especially related to topics such as 'supply risk' (see i.e. Lee et al., 2012; Köhler et al., 2015);
(2) Improve the attention towards topics such as **secondary resources and resource governance** with explicit foresight components e.g. the future of mining wastes;
(3) As the EU has been consistently improving its capacity to deal with raw materials issues since the launch of the Raw Materials Initiative in 2008, **normative foresight studies** can now suggest how to envision a desirable future and "how to get there";

(4) Important initiatives, such as the **EIT Raw Materials**, identify and offer targeted programmes related to raw materials and can prompt the inclusion of foresight planning in forward-looking (raw) material projects and R&D initiatives.

Furthermore, the importance of demand-supply oriented analysis including back casting and forecasting is highlighted in *Deliverable 5.6*. The findings lead WP5 to recommend the **use of the DCM/MFA approach much more frequently for mineral policy discussions** and to preferably combine Mineral Consumption Analysis (MCA) and DCM. Other concepts which are highly recommended for implementation in national policies are related to **resource efficiency and circular economy** - how waste can be turned into a resource (closing a loop initiatives). In this regard, having a minerals policy regularly updated with effective monitoring tools is key.

Finally, it is important to develop and keep open a dialog with all stakeholders. The effective **information flow** should be working not only **horizontally at EU level** (scientific communities – industry - European Commission) **but also vertically at EU-national-regional level**. Especially in countries with decentralized system of governance (but not only), the importance of regions is crucial when it comes to access to land (in terms of mineral resources) or dialogue with the public (the so-called *Social License to Operate*). The exchange of good practices and sharing of experiences is of utmost importance (*Deliverable 5.6*).

2.6 Work package 6: European Raw Materials Intelligence Capacity Platform Development

Lead beneficiary: BRGM;
Other beneficiaries involved: GEUS, GeoZS, GTK, JRC, NERC (BGS) and LIG (Laboratoire d'Informatique de Grenoble).

No. of Deliverable	Title of Deliverable	WP no.	Lead beneficiary	Type	Dissemination level	Due date (month)
D6.1	6.1 Development of the Search, Inference and Ranking Modules	WP6	6 - LIG[6]	Report	Public	22
Work performed towards objective 5.						
D6.2	6.2 Note accompanying the delivery of the EU-RMICP system	WP6	6 - BRGM	Other	Public	25
Work performed towards objectives 5 and 6.						
Additional output: **Elaboration of 21 FlowSheets** during the extra expert workshop held in Leiden.						

[6]BRGM is the lead beneficiary of D6.1, while subtask T6.4 'development of the select and rank modules' is led by UJF-LIG, with BRGM support.

Deliverable 6.1 presents the methodology and the queries and algorithms implemented for the functioning of the EU-RMICP, specifically, the ranking by pertinence of the data/information/knowledge for different answers brought by the MICA Expert System to a question or a query of an end user. This ranking is dependent on the information provided by the end user during navigation. This Deliverable is a continuation of D6.0 which accompanied the release of the first operational prototype of the EU-RMICP in December 2016. The Platform brings relevant 'answers' of the type 'how to proceed for …' on numerous questions related to mineral resources, covering significant parts of mineral supply chains, from prospecting to recycling, taking into account the environmental, technical, political and social dimensions. To meet this challenge, the EU-RMICP is based on an ontology of the domain of mineral resources (coupled with more generic cross-functional ontologies, relative to commodities, time and space), which represents the domain of the questions of the users (experts and non-experts). The user navigates this ontology by using a Dynamic Decision Graph (DDG) which allows her/him to discover the solutions which (s)he is looking for without having to formulate any question. The system is coupled with a 'RDF TripleStore', a database storing the ontologies, factSheets, docSheets and flowSheets (i.e., specific formatted forms) respectively related to methods, documentation and scenarios and metadata (Figure 9).

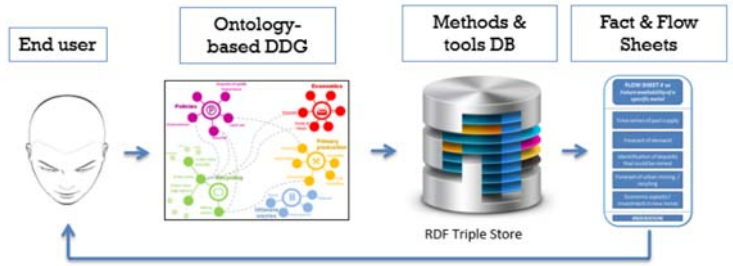


Figure 9 WP6 objective, and the Dynamic Decision Graph.

The results of a query will be presented by pertinence or relevance in the RMICP, to make the system most convenient for the end user. In other words, the answers brought by the system will take into account all the information related to the navigation on the ontology-based DDG. This allows a ranking of the fact-/doc-/flow-/linked-Sheets presented to the end user.

The system has been designed so the end user doesn't necessarily have to formulate a question. The navigation on the ontology-based Dynamic Decision Graph (DDG) allows the user to select the concepts and sub-concepts which are closest to what he/she has in mind (see Figure 10). This is possible because the Main Ontology has been designed by the MICA Experts to cover most of the topics related to the Raw Materials domain from prospecting to recycling, taking into account the environmental, technical, political and social dimensions.

The *MICA Main Ontology* actually covers *7 thematic domains*: 'Primary' and 'Secondary Mineral Resources', 'Industrial Processing and Transformation', 'Raw Materials economics' (including CRMs), 'Raw materials Policy & Legal Framework', 'Sustainability of Raw Materials' and 'International Reporting' (Figure 10). The *DDG offers in a single place, a unique access to most of the data available*, including a contextual access to resources like the European legislation, and an access to several key

studies like the Minventory study[7] (Parker et al., 2015), or the Material System Analysis[8] (BIO by Deloitte, 2015).

The first functionality of the DDG and its side applications is *an 'intelligent' search engine* in which *data, information and knowledge are strongly and cleverly connected* which allows for it to be a *powerful decision-aid tool*. Thus, the DGG is not a 'pure' search engine that simply generates a pre-formulated answer as we experience with many other search engines.

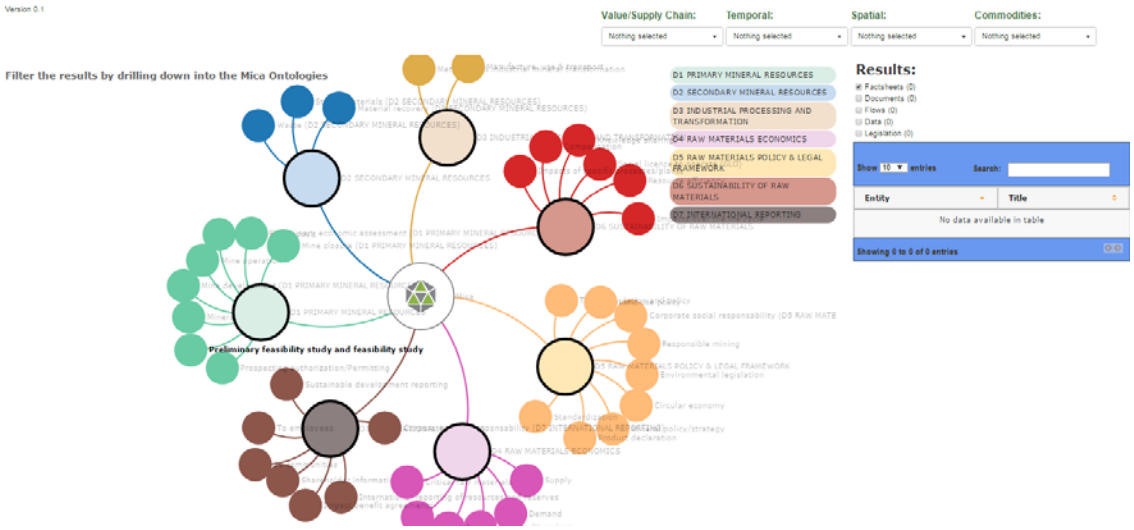


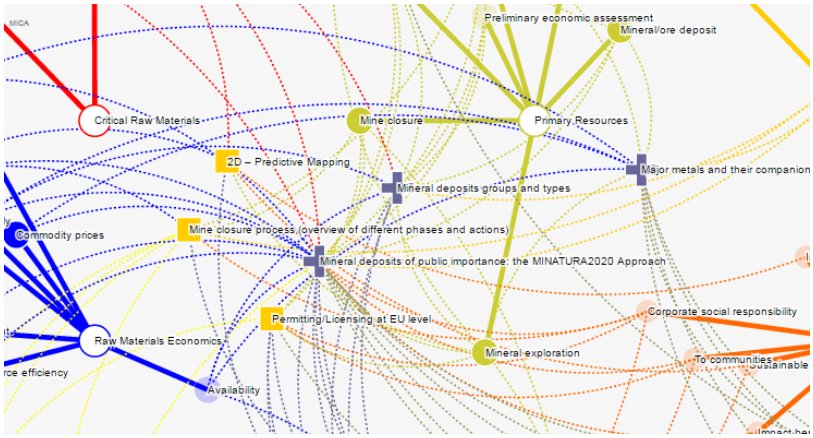
Figure 10 The DDG interface showing the main ontology and the 7 domains covered, representing about 300 concepts and sub-concepts.

Each of the concepts and sub-concepts is attached to one or several 'Sheets' which describe methods and tools, giving recipes on 'how to proceed to get such or such result', and provide the end user with the most relevant documents and data sources related to the query or question in mind. These different Sheets (see Figure 11; docSheets for documentation, factSheets for methods and tools, flowSheets for complex scenarios, or 'recipes', linkedSheets for 'external high-quality' resources) are attached to one or several concepts, but they can also be linked together: e.g., a factSheet can be linked to another related factSheet, to one or several docSheets which describe some aspects, to some piece of EU legislation, to some types of data. In other words, a Sheet is not an isolated element. Thus, when navigating the DDG and choosing one or several concepts, the end user will get very closely related Sheets, and other, less closely related sheets but are nonetheless relevant to provide a comprehensive overview related to the query/question.

[7] http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8273&lang=en
[8] https://ec.europa.eu/jrc/en/scientific-tool/msa

FactSheet

Scope (conceptual model & main characteristics)
...
Range of relevant applications or topics
...
Data needs, databases
...
Model used
...
System and/or parameters considered
...
Time / Space / Resolution /Accuracy
...
Indicators / Outputs / Units
...
Treatment of uncertainty, verification, validation
...
Main publications / references
...
Related methods
...
Key relevant contacts
...
INDEXATION



In order to be retrieved and selected during the navigation over the ontology within the DDG, factSheets (blue crosses) and docSheets (orange squares) are annotated and indexed over the main ontology (and transversal ontologies too). The lines materialize the links between factSheets and docSheets with various concepts and sub-concepts.

Figure 11 Left: Structure of a factSheet, showing the different rubrics and the Indexation section. Right: factSheets and docSheets indexation over (or annotation with) the main ontology.

Deliverable 6.1 describes the developed 3 modules/algorithms:

1. Search and Select: find all the resources annotated by the concepts, these concepts having been selected by the user when 'making the query', i.e., during the navigation over the Main Ontology in the DDG.
2. Inference and Saturation: inference means creating new facts (new assertions and new relations) in the TripleStore to facilitate and optimize searches. Because the strategy to create these new facts consists in deducting all possible assertions, this action is called 'saturation'. The TripleStore is therefore saturated by these deductions. This module is based on the semantics of the SKOS knowledge representation language which describes the ontology.
3. Ranking: the search results, found by the search module, are ranked according to their relevance. The relevance is based on the proximity between the semantic annotation of the resources and the search concepts expressed by the user in the query.

Deliverable 6.2 provides an *exhaustive note accompanying the release of the final version of the EU-RMICP*. The EU-RMICP is based on an ontology of the domain of mineral resources (coupled with more generic cross-functional ontologies, relative to commodities, time and space), which represents the domain of the questions of the users (experts and non-experts).

The user navigates in the ontology by *using a Dynamic Graph of Decision (DDG),* which allows him/her to discover the solutions which he/she is looking for without having to formulate any question (Figure 10). The system is coupled with a 'RDF Triple Store' (a database storing the ontologies), factSheets, docSheets and flowSheets (i.e., specific formatted forms) related to methods and documentation, scenarios and metadata (Figure 12).

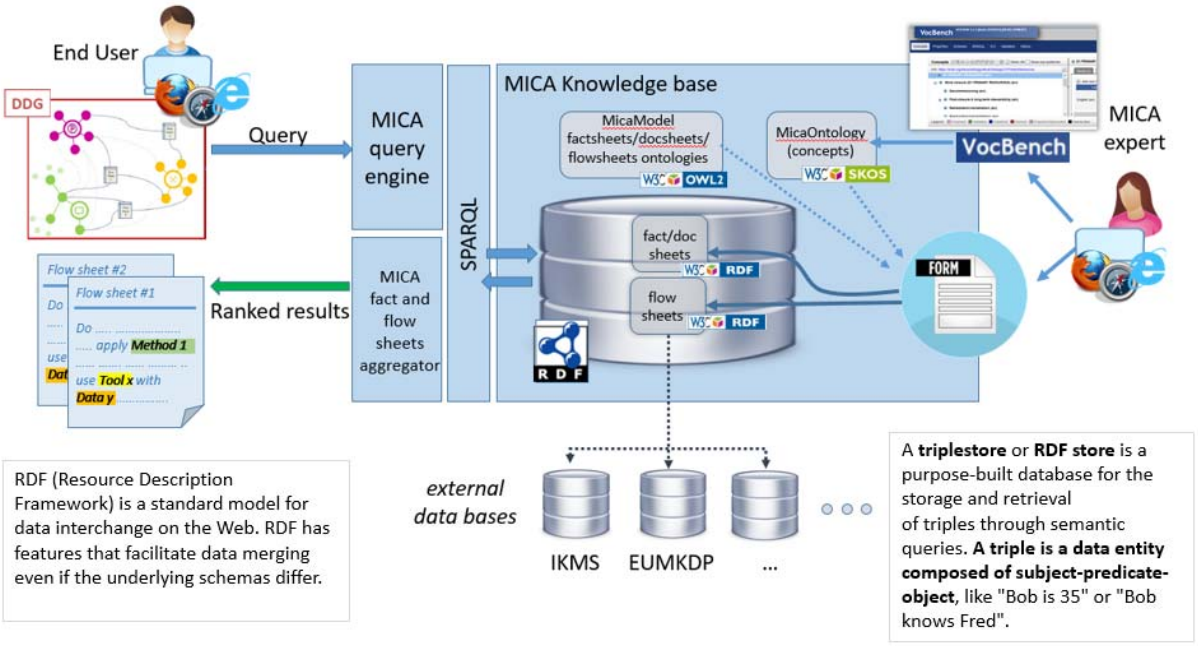


Figure 12 The MICA Expert System. General architecture of the EU-Raw Materials Intelligence Capacity Platform.

This particularly innovative system can be widened (perimeter or scope and granularity) and represents now a prototype of a modern expert system.

In practice, this system will be connected with the existing Knowledge Data Platforms, e.g. the IKMS (EURare), the EU-MKDP (Minerals4EU), the EU-UMKDP (ProSUM), the EU-CRMKDP (SCRREEN), the European Geological Data Infrastructure (EGDI) developed by EuroGeoSurveys (EGS) and the RMIS 2.0 (Raw Materials Information System) which are currently being developed by the European Commission DG JRC in Ispra, allowing them to enable their users from benefitting of the Expert System, when they enter the platform through the interface shown in Figure 13.

Figure 13 Front-face, entry page to the EU-RMICP. Source: www.mica-project.eu

Findings of relevance for policy

With the release of the EU-RMICP (Deliverable D6.2), it seems useful to re-put this work into context or into perspective, and summarize or reformulate the overall objectives of the project:

- **What is the issue being addressed?** For around ten years, a huge effort has been made in Europe to provide end users in a seamless way with public data related to raw materials. However, most of the stakeholders have neither the comprehensive set of skills for using these data made available on recently developed spatial geoportals and associated Knowledge bases nor the know-how to implement specific methods and tools which would allow answering their questions/problems. **The ambition of MICA and its ontology-based DDG is to help them, on how to proceed to get to a pertinent answer (nearly) whatever the question or the query is.**
- **Why is it important for society?** This is important because such a project allows end users to better understand the background of data, methods and processes, on which decisions are made which will later on influence their life. This project thus offers the possibility to get an insight on the mechanics supporting a decision-making process.

- **What are the overall objectives?** One of the overarching objectives of this approach is to make people aware of the role of raw materials in their life, all along the supply chain, delivering a balanced vision of the constraints and of the benefits.

The approach developed inside MICA is totally new, and makes this project in essence a research/innovation project. In practice, this project is laying the foundations of **a Raw Materials Expert System**. The interest is that **the results can be used and upgraded by new projects for potential different applications**. The perimeter of the ontology and its depth/granularity can be easily extended and the mechanics behind can be used for expertise/decision-making in other domains/sub-domains linked to raw materials. The system can thus be seen as **a powerful, one-stop-shop or one-stop information gateway** and can play the role – even if it is not its first application – **of an 'intelligent' search engine in the Raw Materials domain, and also act as a powerful decision-aid tool**.

This is also the reason why the **MICA DDG will be connected to the RMIS 2.0** (Raw Materials Information System) currently being developed by the European Commission DG JRC in Ispra, thus contributing to extend the capabilities of this system in terms of knowledge dissemination, both very precisely, on one topic, and contextually (Deliverable D6.1).

2.7 Work package 7: Communication, outreach and linkages

Lead beneficiary: EGS;
Other beneficiaries involved: GEUS, Fraunhofer, Minpol, EFG, JRC.

No. of Deliverable	Title of Deliverable	WP no.	Lead beneficiary	Type	Dissemination level	Due date (month)
D7.5	7.5 MICA dissemination events ("mid-way" and final)	WP7	7 - EGS	Other	Public	26
Work performed towards objective 6.						

Deliverable 7.5 is concerned with the "mid-way" and final dissemination events. The "mid-way" dissemination event took place on June 7th, as a side event to the World Circular Economy Forum (WCEF) from June 5th to June 6th in Helsinki, Finland. Flyers were distributed at the WCEF to raise awareness of the event and invite participants and a brief pitch of the side event was delivered at the WCEF on June 6th. The dissemination event included a presentation of the MICA project, and a demonstration of the proto-type and was followed by a question and answer session and discussion of the MICA RMICP functionality. Participants at the event included, among other, representatives from EIT Raw Materials, the World Resource Forum, a private recycling firm, and government ministries. Participant data was collected to ensure these stakeholders are informed of ongoing activities in MICA. A news article on the event is available in the news section of the MICA project website.

In this second phase of the project, a promotional and a tutorial video were developed, by EFG and JRC, respectively. The access details for these can be obtained from Figure 14.

In addition, MICA was recently presented at a FORAM organized side-event to the World Resources Forum in Geneva in October 2017, and at the Raw Material Week (RMW) 2017 in Brussels in November 2017, and news feeds via twitter and via the news section of the project website reported on these presentations. Further, a social media campaign was conducted in the aftermath of the RMW to promote MICA.

Furthermore, the article 'Clearing the sky from the clouds – the MICA project', which will be forthcoming in the 44th Special Issue of the European Geologist (http://eurogeologists.eu/journal/) provides a concise description of MICA and positions this project in the context of other current H2020 funded projects in the mineral (raw) material domain.

The final dissemination event takes place on January 23, 2018 at the EGS premises with the purpose of informing the MICA consortium about the project results, and offering an opportunity for stakeholders to see a live-test of the MICA RMICP.

Figure 14 Communication and outreach tools.

Findings of relevance for policy

Results and outcomes of the MICA project can be exploited by (1) use as symmetric access to improved information (lowers barriers to entry for businesses, supports freedom of movement of goods and services, improves civil society policy and decision making, lowers cost and improves research and public engagement), (2) re-application of the technology (tools and software applied in new subject areas) and (3) commercial information trading.

Sustainability possibilities are, like in all other Coordination and Support Action projects, limited due to (a) low revenue generation from commercial / not-for-profit activities and (b) a baseline activity in a publicly funded body is not possible. Furthermore, (c) absorption into future projects / frameworks is not likely, the most probably way is (d) an informal one **via multiple institution copies / network**s.

The MICA project is the outcome of the **call on methods and analysis on European Union Raw Materials Knowledge Base (EURMKB) as stated in the EIP on Raw Materials SIP**. The EIP SIP was the base for the Societal Challenge 5 Raw Materials part of the H2020 Work Programme. Besides MICA, there are few other projects related to EURMKB with EGS partners, such as Minerals4EU (past), ProSUM (past) and ORAMA (on-going, started 2018). The sustainability of Minerals4EU and ProSUM is also not yet secured, even if some activities towards it have taken place (establishing the Minerals4EU Foundation[9], ProSUM business plan).

Several options are available for MICA: (1) an i**ntegration either into the DG JRC Raw Materials Information System (RMIS)**, or (2) integration into the **European Geological Data Infrastructure (EGDI),** that would in future become part of the **Geological Service for Europe (GS4EU)** run by EuroGeoSurveys' members. GS4EU should be established after the successful completion of the GeoERA programme. Both aforementioned systems are to be closely linked – today there is already **a Gateway in RMIS where some EGS project portals are accessible.**

EGS and DG JRC have had Collaboration Agreements in the past, the last of which will be renewed in 2018. This is another (3) possibility for MICA to achieve its sustainability. There is also an option of (4) **a new grant** that would assist with the sustainability of the MICA outcomes – **the call should be introduced into the Horizon 2020 Work Programme**, preferably for the 2020 Calls.

[9] This is the option that was indicated in the MICA grant agreement, jointly with WP7 enabling the integration of MICA into Minerals4EU – please see also section 2.1, p.8.

3. Impact of the MICA project

The identification, appraisal and mapping of stakeholder requirements performed in WP2 has had a significant impact on the structuring of the EU-RMICP content which is provided to the stakeholders. Specifically, the domains of the ontology which guides the EU-RMICP user, have been adapted in response to the feedback received from the stakeholders. The particular impact of this MICA WP is on the further development of the RMIS 2.0 – it allows for it to be even more user-friendly by considering the specific needs of stakeholders and importantly, by guiding them to the places in the platform that provides the data and information where they would intuitively associate it to be.

The data for raw material intelligence capacity which was collected, sorted and prepared as metadata records in WP3 has a direct impact on all delineated stakeholders in the mineral (raw) material field:
They have free access to the online metadata inventory which comprises 410 records, namely 188 non-geographic datasets, 168 datasets, and 54 series, see http://metadata.mica-project.eu/mmd. The impact thereof is broad as data is made more easily accessible, and above all, is structured to facilitate rapid, systematic searches for mineral (raw) material topics.

In WP4, methods and tool for mineral intelligence were provided which have a twofold impact: (1) jointly with the innovative flowSheets, they enable users of the EU-RMICP to find solutions to particular queries they have by using these methods and tool and by drawing data and information from the EU-RMICP and (2) they also provide users with an understanding (a) of the complexity of both data and information needed to compile answers to particular queries and questions and (b) of the intricacy of decision-making processes that pertain to the mineral (raw) material field.

The elaboration of the Raw Material Intelligence (RMI)-Matrix and application in the EU-28 context of WP5 illustrates the possibility of an effective screening of the (non-)availability of a minimum set of tools/methods required to develop a coherent and comprehensive mineral policy-making framework. The application of the RMI-Matrix can have a clear impact to the policy-design process. A similar impact can be generated from the application of the Raw Materials Foresight Guide which provides guidelines for conducting foresight exercises and provides methodological recommendations for mineral raw materials policy making, in the context of strategic RMI.

WP6 delivers the EU-RMICP and thus, provides a far-reaching impact to the various stakeholders in the mineral (raw) material field: The platform can serve users to find pathways on how to derive an answer for a particular question by listing the sequence of steps to be taken with the necessary data and information. Behind this guidance is the Dynamic Decision Graph (DDG), an innovative feature which allows for the user guidance based on the search criteria chosen by the user. Specifically, the impact of the DDG could be its featuring in/with the RMIS 2.0. It is a standalone tool that doesn't necessarily need embedding, e.g. in the RMIS, but could be if evaluated as useful.

4. Deviations from Annex I

The list of milestones (MS) does not specify a particular target for when the subtask T6.5 'Development of the central base of the EU-RMICP' [Leader GEUS with the support of JRC, GeoZS, BRGM, UJF-LIG, GTK] requires completion by. In task T6.5 challenges arose in the development of the MICA SheetEditor as part of the back-end of the platform, and its integration with the front-face. This included also a challenge with the Triple Store database.

Delays in the described task and MS3 have the consequence of a delayed final integration of the platform and the delay in requesting consortium partners to contribute with feeding data and information into the platform. Corrective actions were taken in form of the recommended actions (as per section 1.3.5 WT5 Critical Implementation risks and mitigation actions, Annex I of the Grant Agreement) with regard to risk R4 'Deliverables not delivered on time – delays in project, domino effect where deliverables are connected or interdependent'.

Specifically, with a view to risk R4, the recommended close communication with the WP leader and contributors of particular elements to the specific tasks was closely pursued, in accordance with clear protocols for communication, to limit deviations from the time plan to the minimum. This allowed for the development of a timely solution, namely a purpose-coded program that is centered on the automatic upload of fact-/docSheets while the functional challenges of the MICA SheetEditor and the Triple Store database are being resolved. Once these challenges are resolved, the manual upload and annotation of all Sheets can progress in line with the envisaged approach. A timeline for resolving the challenges and for initiating this uploading process has been approved among the WP leaders at the Final Event and was sent out to the entire consortium on January 26, 2018.

In the context of the experienced challenges related to T6.5, the interim measures taken ensured a demonstration at the Final and Review event in form of a video. Further work on the EU-RMICP progresses in the aftermath of the Final and Review event to make up for time lag which resulted from the challenges encountered in the MICA SheetEditor development and Triple Store interaction.