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Table of Contents

Introduction	4
1. EIRENE Services and Open Access System	4
2. Open Access System v1	5
2.1 Service Catalogue	6
2.2 Open Access Backoffice	6
2.3 Metrics and Statistics	7
2.4 Limitations and Learning Points	7
3. Open Access System v2	7
3.1 Key Requirements	8
3.2 Service Catalogue	8
3.2.1 Main Concepts and System Requirements	8
3.2.2 Structure of Services	8
3.2.3 Laboratory Services Structure	9
3.2.4 Laboratory Service Axioms	9
3.2.5 Sample Collection Concept	10
3.2.6 CRA Hub as an OA Service Catalogue	10
3.2.7 Implementation	11
3.3 Open Access Backoffice	19
3.3.1 Main Concepts and System Requirements	19
3.3.2 Administrative Information	19
3.3.3 OA Request Types	20
3.3.4 OA Request Process	20
3.3.5 Implementation	23

Introduction

The EIRENE Research Infrastructure represents a groundbreaking initiative to advance exposome research across Europe by providing harmonized access to specialized analytical services. As environmental and health research increasingly demands sophisticated analytical capabilities spanning multiple disciplines, the challenge of coordinating access to distributed facilities has become paramount. The EIRENE Open Access system addresses this challenge by creating a single, transparent entry point to services distributed among national hubs and specialized facilities across Europe.

The system's development reflects both the technical complexity of integrating diverse analytical capabilities and the organizational challenge of coordinating international research infrastructure. From its initial pilot at a single Czech facility to its current design for pan-European deployment, the OA system demonstrates how digital platforms can effectively bridge the gap between distributed research capabilities and user needs, while maintaining the scientific rigor and transparency essential for world-class research infrastructure.

The system evolved through two versions: OA v1, a pilot implementation at RECETOX RI that processed 333 requests across 3 facilities, and the current OA v2, designed for pan-European deployment. The system consists of two integrated modules: a Service Catalogue for service discovery and request composition, and a Backoffice for administrative management and evaluation. Key innovations in v2 include the "sample collection" concept for ensuring request feasibility, integration with the CRA Hub platform, and support for multi-facility, multi-service requests across the six EIRENE pillars (chemical, toxicological, and biological profiling; human and environmental data & samples; and tools).

1. EIRENE Services and Open Access System

EIRENE Research Infrastructure (RI) has been designed to provide the European research community with harmonised access to advanced services supporting exposome research. These services span across the six EIRENE pillars — **chemical profiling, toxicological profiling, biological profiling, human data & samples, environmental data & samples, and tools** — and are distributed among national hubs and specialised facilities across Europe. Ensuring equitable, transparent, and efficient user access to these services is a central objective of the Preparatory Phase Project (PPP).

To achieve this, the project has developed an architecture of the **Open Access (OA) system**, which constitutes the single-entry point for all EIRENE services. The OA system harmonises service discovery, streamlines access procedures, and enables transparent evaluation of user requests. It builds on experiences from other European research infrastructures (e.g., BBMRI, ELIXIR) while tailoring solutions to the specific requirements of exposome science.

The OA system is structured around two complementary modules:

- **OA Service Catalogue** – a publicly accessible, web-based interface allowing potential users to explore available services, compare conditions across providers, and compile tailored requests. The catalogue is integrated with the CRA Hub platform, linking EIRENE services with wider resources relevant for chemical risk assessment.

- **OA Request Module (Backoffice)** – an administrative environment for managing submitted requests, including eligibility checks, scientific and ethical evaluation, coordination of service provision across facilities, contractual arrangements, and reporting of delivered outputs.

Together, these two modules provide a **single, open, and transparent entry point** to distributed services across EIRENE, while ensuring:

- **Discoverability** of services across all pillars and facilities.
- **Feasibility checks** through the “sample collection” concept ensuring compatibility of requested services.
- **Efficiency** by enabling multiple services to be combined into a single request.
- **Transparency** via documented evaluation, contracting, and feedback procedures.
- **Scalability** to incorporate new services, facilities, and user communities as EIRENE evolves.

The OA system has been developed in two main phases:

- **Version 1 (v1)** was implemented and has been in production since Q3 2023. It was based on the OA system developed in the EIRENE coordination hub. It extended the existing access tools, enabling the first operational integration of service cataloguing and request management across selected EIRENE facilities. This early version served as a proof of concept and provided valuable feedback on technical and procedural aspects of user access.
- **Version 2 (v2)** has since been conceptually designed, introducing an extended structure, new concepts (e.g., service ontology, sample collection logic, integration with CRA Hub), and a more robust back-office module. Implementation is currently in progress. By the end of the PPP, a **pilot of the service catalogue** will be made available, demonstrating the new functionalities and providing the basis for further scaling towards the operational phase of the RI.

2. Open Access System v1

The first version of the EIRENE Open Access (OA) system was developed to streamline the submission and evaluation of requests for access to research infrastructure. It was piloted at a single institute — **RECETOX RI (EIRENE CZ)** — and entered production in **Q3 2023**. The system provided an initial operational proof of concept for the OA framework, enabling transparent access to selected services through an online catalogue and coordinated evaluation via a dedicated back office.

The OA system v1 consisted of two complementary web applications:

- **Service catalogue:** <https://openaccess.recetox.cz>
- **OA Backoffice:** <https://openaccess-bo.recetox.cz>

These tools were designed to support both service users (discovery and submission of requests) and service providers (administration, evaluation, and monitoring of requests).

2.1 Service Catalogue

The **service catalogue** is a publicly accessible web interface that allows potential users to explore available services, specify their requests, and submit them electronically.

Services in OA v1 were organised according to the main **RECETOX facilities**:

- **Central laboratories**
 - Trace Analytical Laboratories
 - Biomarker Analytical Laboratories
 - Microbiome Laboratories
- **Population studies and biobanking**
 - CELSPAC services
- **Other services**
 - Internships
 - Specialised laboratories supporting research
 - Training offers

Users could request one or multiple services at the same time, but only within the scope of a single facility. This limitation simplified processing but reduced flexibility for more complex, multi-facility needs.

2.2 Open Access Backoffice

The **OA Backoffice** (<https://openaccess-bo.recetox.cz>) was developed as the administrative counterpart to the catalogue. It allowed facility managers and coordinators to process received requests through a transparent workflow.

User roles included:

- **OA Administrative Coordinator** – responsible for formal validation and coordination.
- **Facility Managers** – responsible for service delivery planning.
- **Evaluators** – experts assessing feasibility and scientific quality.

Request states and transitions:

- **SUBMITTED** – created by applicant.
- **VALIDATED** – formal requirements checked by OA coordinator.
- **IN EVALUATION** – under scientific and feasibility review.
- **REJECTED IN EVALUATION** – request not found feasible, lacking capacity, or insufficient scientific quality.
- **ACCEPTED** – request approved and scheduled for fulfilment.
- **IN PROCESS** – services are being delivered.
- **DONE** – request successfully completed.
- **REJECTED** – invalid request not accepted.
- **CANCELLED** – revoked due to errors or withdrawal.

This structured workflow introduced transparency and accountability into the access process and supported harmonisation with future RI-level procedures.

2.3 Metrics and Statistics

Since its deployment in Q3 2023, the OA system v1 has achieved measurable uptake:

- **333 requests** submitted and processed.
- Fully deployed across **3 core facilities** organised into **7 independent departments**.
- Operational experience established baseline requirements for scaling up to multi-facility and multi-national contexts.

2.4 Limitations and Learning Points

The pilot implementation provided valuable insights but also revealed several limitations that must be addressed in the next iteration:

- **Restricted multi-facility access** – users could not combine services from different facilities into a single request. Instead, multiple requests had to be submitted, increasing administrative burden.
- **Single-provider limitation** – each service could only be associated with one facility, limiting flexibility and user choice.
- **Absence of user accounts** – requests were handled via email-based communication, with no persistent user profiles, history of submissions, or dashboards for tracking.
- **Limited request tracking** – users had minimal visibility into the status of fulfilment beyond email updates.

Despite these constraints, OA v1 successfully demonstrated the feasibility of an integrated online request system and provided critical feedback for the design of OA v2, which introduces a more advanced catalogue structure, multi-facility support, and improved user interaction.

3. Open Access System v2

The second version of the EIRENE Open Access (OA) system has been designed to support the specific needs of a **distributed European research infrastructure**. Unlike the first pilot system, which was confined to a single national node, OA v2 reflects the requirements of a **multi-node, multi-service, and multi-facility environment**. It is closely aligned with the diversity of services offered under the six EIRENE pillars and incorporates specific principles for service fulfilment that respect the complexity of laboratory work, sample handling, and international collaboration.

The design of OA v2 is therefore both a technical and organisational exercise. It not only addresses the **practical challenges of integrating services provided by different institutions** but also translates the **principles of open, transparent, and harmonised access** into a digital system capable of scaling across countries and disciplines.

Equally important, the architecture of OA v2 builds on the **learning points from the first version**. The limitations identified in OA v1 — such as the inability to combine services across facilities, the absence of persistent user accounts, and the lack of support for sample-based feasibility checks — have been systematically analysed and translated into new design

principles. OA v2 thus represents a **step change** from a local proof-of-concept to a framework suitable for pan-European deployment.

3.1 Key Requirements

The conceptual design of OA v2 was guided by several fundamental requirements derived from both the experiences of OA v1 and the operational needs of EIRENE RI:

- **Support for a multi-node infrastructure:** the system must accommodate requests spanning facilities in different countries, while preserving the autonomy of national hubs.
- **Common services across multiple providers:** one service can be offered by several facilities, each with potentially different capacities, conditions, and pricing schemes.
- **Iterative evaluation process:** requests may require staged evaluation, including feasibility checks, ethical considerations, and scientific quality assessment.
- **Robust service catalogue:** the system must expose a structured and comprehensive catalogue of services, capable of being searched, filtered, and compared by users.
- **Transparency and traceability:** the full lifecycle of each request should be visible to both users and administrators, supporting accountability and monitoring.
- **Integration with CRA Hub:** the OA system must interoperate with the Chemical Risk Assessment Hub, embedding EIRENE services within a broader ecosystem of datasets, tools, and resources.

These requirements reflect a **shift from a single-facility access tool to a federated, pan-European service gateway**.

3.2 Service Catalogue

3.2.1 Main Concepts and System Requirements

At the heart of OA v2 lies the **service catalogue**, a web-based interface through which users can discover, compare, and request EIRENE services. The catalogue embodies the following principles:

- It provides a **single (open) access point** to all services across EIRENE.
- Services are offered by **multiple facilities from multiple institutions** but displayed through one harmonised interface.
- **One service may have multiple providers**, with different prices, sample requirements, or logistical arrangements.
- Services are **not redistributed across facilities**: each request must be feasible within the constraints of the facility or facilities chosen.
- Users can **combine multiple services in a single request**, provided that feasibility is ensured (see sample collection concept).

The catalogue thus not only functions as a **registry of services** but also as a **decision-support tool**, helping users to structure their requests in ways that are scientifically meaningful and practically achievable.

3.2.2 Structure of Services

To reflect the breadth of exposome research, services in OA v2 are organised into the six **EIRENE pillars**:

1. **Chemical profiling**
2. **Toxicological profiling**
3. **Biological profiling**
4. **Human data & samples**
5. **Environmental data & samples**
6. **Tools** (models, data processing pipelines, specialised software)

This structure provides both scientific orientation and operational clarity. It allows researchers to identify services according to their domain of interest, while also supporting cross-pillar combinations for integrative projects.

3.2.3 Laboratory Services Structure

Among all EIRENE services, **laboratory services** play the most prominent role in the pilot phase. Laboratory analyses form the backbone of exposome research, generating quantitative and semi-quantitative data on exposures and biological responses.

For this reason, laboratory services have been chosen as the **primary focus for OA v2 development and demonstration**. The pilot catalogue concentrates on laboratory analyses and related workflows, with the aim of later extending the model to other pillars (e.g., data tools or population studies).

3.2.4 Laboratory Service Axioms

The design of laboratory services in OA v2 is grounded in a set of **axioms and conceptual building blocks**:

- **Profiling domain** = the **purpose** of analysis (chemical, toxicological, biological).
- **Analytical approach** = the **strategy**, distinguishing between quantitative/target analysis and semi-quantitative/non-target screening.
- **Analytical method** = the **technology** used (e.g., LC-MS, ICP-MS, ELISA).

This triad (purpose, strategy, technology) provides a clear semantic framework for classifying services.

Examples include:

1. Target MS – heavy metals in urine samples.
2. Quantitative inflammation protein panel of serum/plasma samples.
3. Chemical profiling / Target MS – Bisphenols – Urine.
4. Chemical profiling / Target MS – PAHs – Human blood.
5. Biomarker profiling / Non-target MS – small molecule screening via LC-HRMS – Plasma.

In general, each service can be expressed as a combination of:

Profiling domain × Analytical approach × Group of chemicals/panel × Matrix.

This formulation ensures consistency in service descriptions and comparability across facilities.

3.2.5 Sample Collection Concept

A central innovation of OA v2 is the **sample collection concept**, designed to ensure feasibility of complex requests.

- A sample collection represents a **set of samples with a common matrix** (e.g., urine, blood, plasma).
- All services within a sample collection must be **compatible** and **processable by at least one facility**.
- If no facility can provide the full set of requested services, the user must create **multiple sample collections**, implying larger sample volumes and additional aliquoting.
- Sample collections thus prevent the redistribution of biological material across facilities, respecting both ethical and logistical constraints.

Beyond feasibility, the concept also supports **optimisation**:

- **Effective use of samples** – maximising the range of analyses from limited aliquots.
- **Cost optimisation** – enabling price comparisons across providers.
- **Logistical efficiency** – minimising international shipments or choosing geographically proximate facilities.

By embedding this logic into the catalogue and shopping cart interface, the system actively assists users in structuring scientifically valid and logistically feasible requests.

3.2.6 CRA Hub as an OA Service Catalogue

The **CRA Hub** provides the natural integration environment for the EIRENE OA catalogue. As a portal dedicated to chemical risk assessment, it already offers an extensive overview of capacities, datasets, and tools. Embedding the EIRENE service catalogue within the CRA Hub achieves several objectives:

- It positions EIRENE services within the broader **ecosystem of resources for chemical risk assessment**.
- It ensures **semantic and technical interoperability**, building on the FAIR principles and metadata standards already being advanced in the PARC partnership.
- It brings **added value for users**: in addition to discovering datasets and models, they can directly request laboratory and analytical services from the same portal.
- EIRENE services are clearly identifiable and filterable within CRA Hub, ensuring visibility while maintaining integration with the larger resource inventory.

Through this integration, the CRA Hub becomes not only a knowledge portal but also an **access gateway to experimental capacity**, bridging the gap between data resources and laboratory infrastructures.

3.2.7 Implementation

The implementation of the OA v2 service catalogue follows a **user-centred design** process and has been progressively elaborated through detailed wireframes and functional epics. The prototype demonstrates how complex service requests can be structured, managed, and submitted in practice. Its features are organised around a set of supported use cases that reflect the workflow of a typical EIRENE service user.

1. Service discovery and filtering

The catalogue provides a **tabular overview of laboratory services**, enriched with metadata such as profiling domain, screening approach, matrix, parameter group, laboratories offering the service, pricing ranges, and sample volumes. Users can apply multiple filters — by matrix, parameter group, analytical method, country, or laboratory — to refine the list of services. This allows researchers to quickly identify services relevant to their experimental design (Fig. 3.1 *Catalogue overview*; Fig. 3.2 *Filtered catalogue view*).

2. Adding services to the shopping cart

Each service entry can be added to a **shopping cart**. When a user attempts to add a service, the system checks whether a compatible **sample collection** exists. If not, the user is prompted to create a new collection by specifying matrix, number of samples, and volume per sample (Fig. 3.3 *Add to cart – new collection dialog*). If compatible collections already exist, the user can either reuse them or create a new one (Fig. 3.4 *Add to cart – reuse existing collection*).

3. Sample collection management

Sample collections are the central unit for request feasibility. They group together all services that share the same matrix and can be fulfilled by at least one facility. The system allows users to:

- create new collections,
- edit existing collections (e.g., update sample counts or volumes),
- remove collections if they are no longer needed.

The interface ensures that matrix type cannot be changed once services are added, thereby preserving internal consistency (Fig. 3.5 *Edit sample collection*).

Resources
Laboratories

Shopping cart
and sample collections

Filters

Matrix

Param. group

Paramameter

Analytical method

Country

Name of laboratory

Pricing range

Volume range

Laboratories

14 / 101

Matrices

3 / 24

Parameters

84 / 580

Analytes

5 / 7 287

Laboratory Services

/

Laboratory list

/

Laboratory map

Profiling domain	Screening approach	Matrix	Parameter group	Laboratories	Pricing	Sample volumes	Add to cart
Chemical profiling	Target screening	Blood	PG1	Lab01, Lab02, 4 other...	1-3\$ per sample	1-3ml	+
Chemical profiling	Target screening	Blood	PG2	Lab01, Lab 02	2-5\$ per sample	1-3ml	+
Chemical profiling	Target screening	Urine	PG3	Lab 02	1-3\$ per sample	2-3ml	+
Chemical profiling	Target screening	Urine	PG4	Lab 03	2-5\$ per sample	1-3ml	+
Chemical profiling	Target screening	Soil	PG5	Lab 02	1-3\$ per sample	2-3ml	+
Chemical profiling	Target screening	Water	PG6	Lab 02	2-5\$ per sample	1-3ml	+

1

2

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4

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...

20

Fig. 3.1 Catalogue overview

12

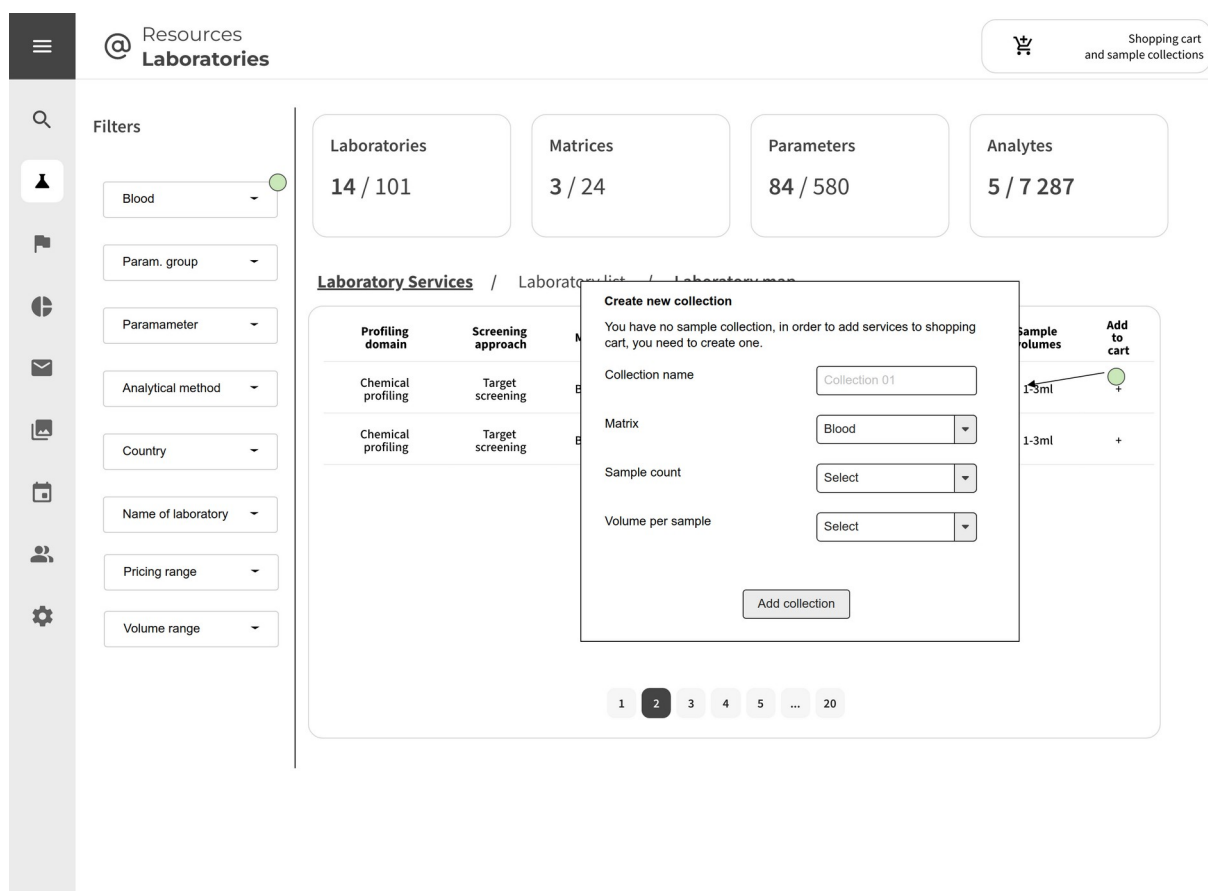


Fig. 3.3 Add to cart – new collection dialog

Resources
Laboratories

Shopping cart and sample collections

Filters

Blood

Param. group

Paramameter

Analytical method

Country

Name of laboratory

Pricing range

Volume range

Laboratories

14 / 101

Matrices

3 / 24

Parameters

84 / 580

Analytes

5 / 7 287

Laboratory Services /

Profiling domain	Screening approach		Sample volumes	Add to cart
Chemical profiling	Target screening	Choose an existing collection	1-3ml	+
Chemical profiling	Target screening	Add to new collection	1-3ml	+

1

2

3

4

5

...

20

Fig. 3.4 Add to cart – reuse existing collection

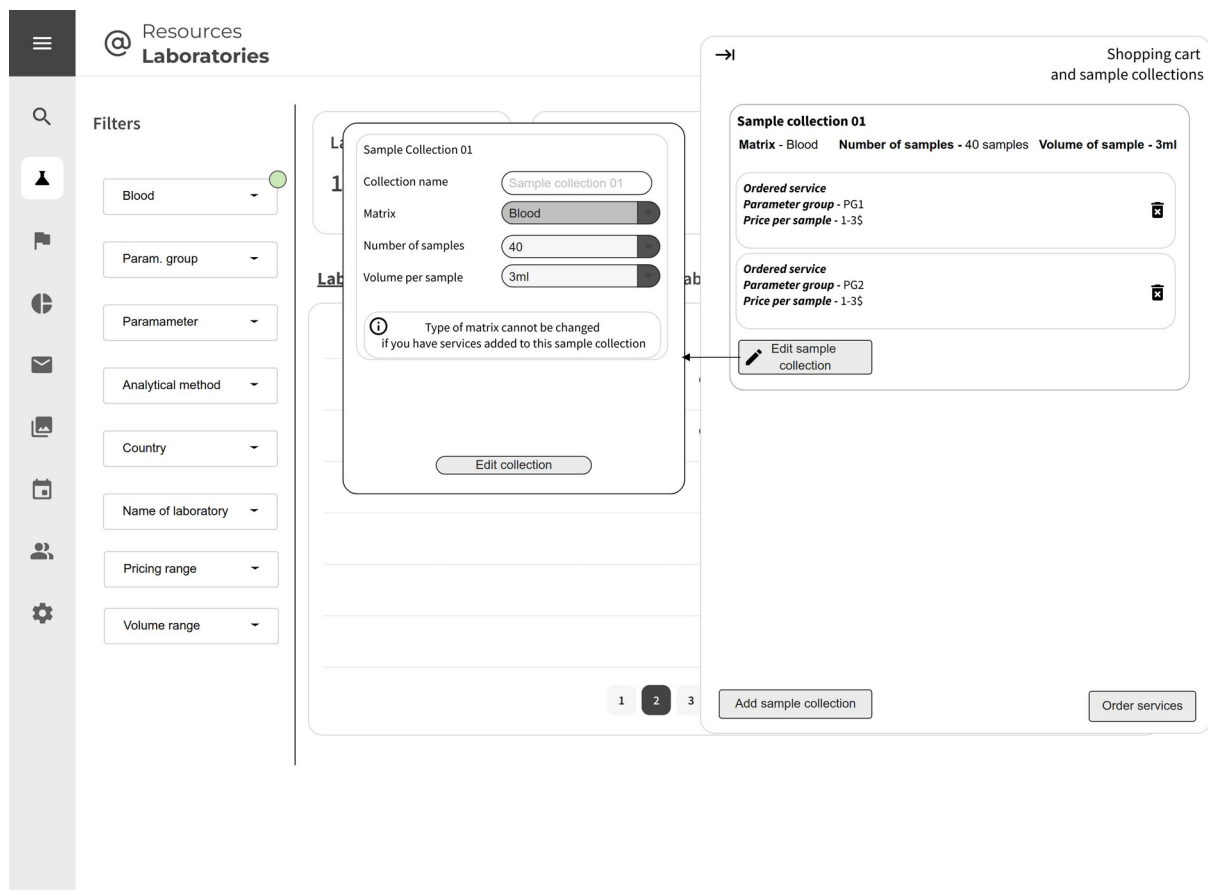


Fig. 3.5 *Edit sample collection*

- **Sample efficiency**, by grouping analyses to maximise use of available aliquots.
- **Cost efficiency**, by enabling transparent price comparisons across laboratories.
- **Logistical efficiency**, by allowing preference for providers in the same country or region, thereby reducing shipment complexity.

Together, these features demonstrate how the **conceptual elements of OA v2 — service ontology, laboratory axioms, and sample collections — are translated into an interactive, user-friendly environment**. The prototype catalogue thus represents a significant advance from OA v1, offering researchers a realistic way to compose multi-service, multi-provider requests within the distributed infrastructure.

3.3 Open Access Backoffice

While the service catalogue represents the **user-facing entry point** into EIRENE services, the **Open Access Backoffice** provides the corresponding **administrative and evaluative backbone** of the system. It ensures that requests submitted via the catalogue are formally validated, scientifically and technically assessed, contracted, monitored during their execution, and finally documented through results delivery and user feedback.

The backoffice is therefore not only a management tool for administrators and facility providers but also a guarantee of **transparency, fairness, and traceability** in the access process. It operationalises the principles of open access by making explicit the steps of evaluation and by ensuring consistent documentation across the distributed infrastructure.

3.3.1 Main Concepts and System Requirements

The design of the OA backoffice is guided by the need to support the **full lifecycle of a request**. Its functionality spans several interconnected domains:

- **Administrative processing**: registration of requests, validation of completeness, and assignment of evaluators.
- **Evaluation**: assessment of feasibility (availability of capacity, logistical conditions) and, where relevant, scientific excellence.
- **Capacity allocation and planning**: coordination across multiple facilities, ensuring that services can be delivered without overloading resources.
- **Price offer and contracting**: provision of transparent cost estimates and formalisation of access agreements.
- **Tracking of fulfilment**: monitoring progress as services move from initiation to completion.
- **Delivery of results**: ensuring that data, analyses, or other outputs are provided in a timely and standardised manner.
- **Feedback collection**: recording user feedback, including verification of acknowledgements and citations in scientific publications.

Together, these functions constitute a **robust governance layer** that complements the service discovery functions of the catalogue.

3.3.2 Administrative Information

To enable fair and well-informed evaluation, each request submitted by a user must include a **core set of administrative data**. This includes:

- **Personal and contact details** of the applicant.
- **Institutional affiliation** and, if applicable, details of the host institute.
- **Financing and timeline information**, specifying the expected source of funding and desired timeframe.
- **Project information**, describing objectives, research questions, and relevance of the services requested.
- **Key collaborators**, particularly in multi-partner or international projects.

This information provides evaluators with sufficient context to assess feasibility, ethical appropriateness, and alignment with the scientific objectives of EIRENE RI.

3.3.3 OA Request Types

Two principal types of requests are supported in OA v2:

- **Normal requests** – standard applications where financing has already been secured. These follow the full workflow of validation, feasibility assessment, contracting, and execution.
- **Pre-approval requests** – requests submitted prior to securing funding, typically in the preparation of project proposals. These are evaluated for feasibility, conditions, and indicative pricing. If the applicant subsequently secures funding, the request can be re-activated and re-evaluated under current capacity conditions.

This dual-track system acknowledges the realities of scientific funding cycles, offering researchers a way to plan realistically for infrastructure access.

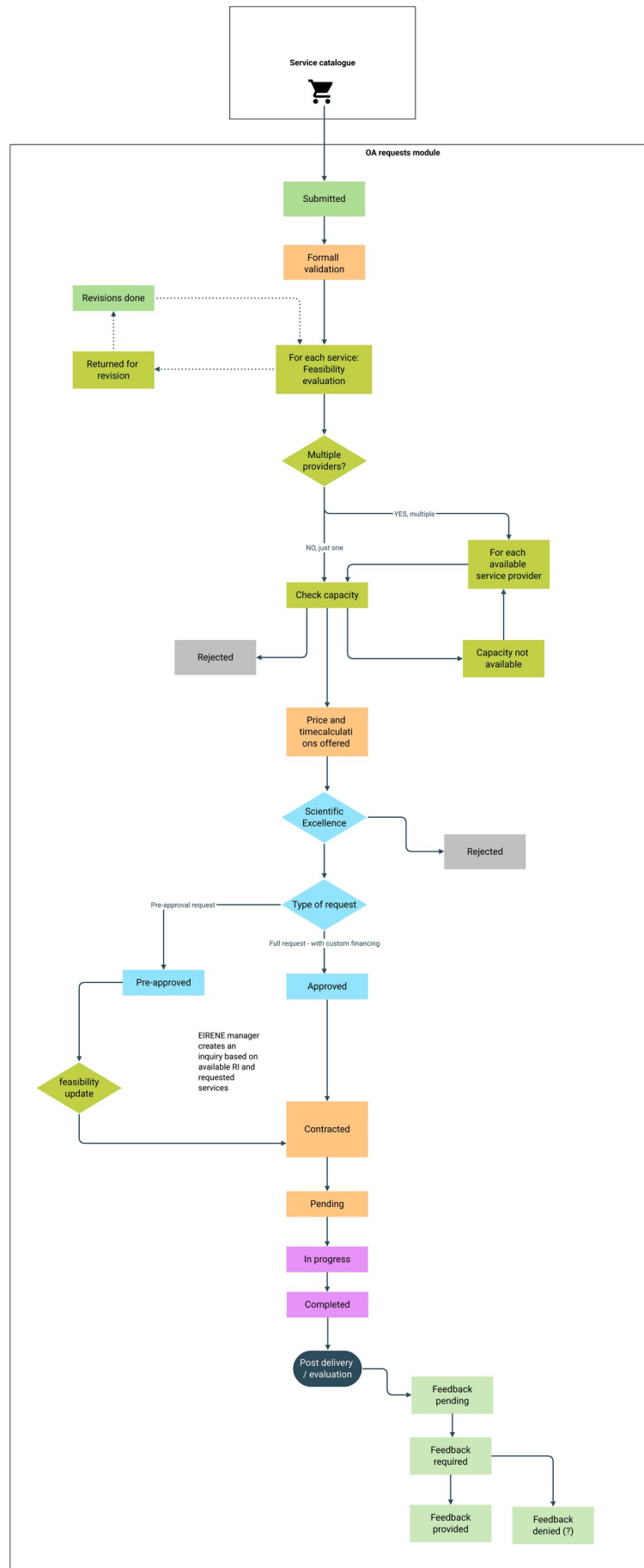
3.3.4 OA Request Process

The full OA request process is illustrated in *Figure 3.8*, which visualises the stages from submission to feedback. The workflow can be summarised as follows:

1. **Creating a request**
 - The user selects services in the service catalogue and organises them into sample collections.
 - Draft requests can be saved within the user profile until ready for submission.
2. **Submission**
 - Once all services, sample collections, and preferred laboratories are specified, the user submits the request for evaluation.
3. **Formal validation**
 - An EIRENE OA Manager verifies the request, checking attachments, documentation, and formal correctness.
 - Appropriate evaluators are identified and assigned.
4. **Feasibility evaluation**
 - Each service is evaluated for feasibility and available capacity.
 - Candidate providers are contacted sequentially, beginning with the user's preferred facility, in order to avoid communication overload across the network.

- If no provider can accommodate the service, the request (or part thereof) is rejected.
- 5. **Price and timeline proposal**
 - For feasible services, providers return indicative costs and timelines, which are communicated to the applicant.
- 6. **Scientific excellence evaluation**
 - Where relevant (particularly for requests without secured financing), a second-round evaluation of scientific quality is conducted.
- 7. **Approval and contracting**
 - Based on request type, applications are either **approved** (for funded requests) or **pre-approved** (pending funding).
 - Approved requests are formalised by contract, including agreed pricing and timelines.
- 8. **Execution and monitoring**
 - Contracted requests move to “Pending” and subsequently to “In progress”.
 - The backoffice tracks progress, ensuring transparency across facilities.
- 9. **Completion and results delivery**
 - Once services are completed, results are delivered to the applicant.
 - Requests are marked as “Completed”.
- 10. **Feedback and follow-up**
 - Users are asked to provide feedback.
 - Proper citation of EIRENE services in resulting publications is checked and recorded.

This staged process ensures that access is handled in a **systematic, transparent, and scalable** manner, balancing user needs with provider capacities.



3.3.5 Implementation

At present, the OA backoffice module is under detailed specification. Two implementation pathways are being explored:

- **Extension of existing RECETOX backoffice** (used in OA v1), adapted to support multi-facility and multi-service workflows.
- **Adaptation of the BBMRI Negotiator platform** (open source: [BBMRI-ERIC/negotiator](https://bbmri-eric.eu/negotiator)).

The preliminary review of BBMRI Negotiator revealed:

- Strengths: established workflows for request handling, integration with federated authentication services such as LifeSciences.org.
- Limitations: lack of support for EIRENE-specific requirements such as sample collections, multi-service request composition, and iterative evaluation.

Further analysis and prototyping will determine whether the Negotiator can be adapted or whether a custom-built backoffice solution is required. In either case, the goal is to ensure interoperability with the service catalogue.