

Deliverable 2.14

Release of the ITINERIS Terminology Service



Deliverable no.	D2.14
Work package	WP2 - ACCESS TO FACILITIES, FAIR DATA AND RELATED SERVICES
Intermediate Objective	IO2.4
Deliverable type	<input type="checkbox"/> Document, report <input type="checkbox"/> Websites, patent filings, videos, etc. <input checked="" type="checkbox"/> Other: Service
Dissemination level	<input checked="" type="checkbox"/> Public <input type="checkbox"/> Restricted
Estimated delivery (bimester)	B21
Actual delivery date	16/02/2026
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Comments	

LIST OF ACRONYMS

API: Application Programming Interface

FAIR: Findable, Accessible, Interoperable, Reusable

Gen.O.M.A.: GENeric Ontology Matching Architecture

GUI: Graphic User Interface

ITINERIS: ITalian INtegrated Environmental Research Infrastructures System

M2M: Machine to Machine

MAPLE: MAPping Architecture based on Linguistic Evidences

OU: Operative Unit

OWL: Web Ontology Language

RDF: Resource Description Framework

REST: Representational State Transfer

RI: Research Infrastructure

SA: Semantic Artefact

SKOS: Simple Knowledge Organisation System

SPARQL: Simple Protocol and RDF Query Language

TIF: Terminology Interoperability Framework

TS: Terminology Service

WP: Work Package

URI: Uniform Resource Identifier

URL: Uniform Resource Locator

INTRODUCTION

The deliverable 2.14, produced within the framework of ITINERIS, is part of the activity 2.4 of the Work Package (WP) 2 concerning the access to facilities, FAIR data and services provided by the 22 Italian environmental Research Infrastructures (RIs) involved in the project. This deliverable belongs to the intermediate objective of Bimester 21 and it is produced under the responsibility of the Operative Unit (OU) of the National Research Council, Research Institute on Terrestrial Ecosystems (CNR-IRET) in Lecce.

The objective of this deliverable is to describe the key functionalities of the ITINERIS Terminology Service (TS) (<https://terminologyservice.itineris.cnr.it>) which provides a unique access point to Semantic Artefacts (SAs) used and/or managed by ITINERIS RIs and related communities, thereby strengthening semantic interoperability through the reuse of existing terminologies.

METHODS

The key functionalities and requisites of the ITINERIS TS were defined based on two main activities aimed at understanding the semantic standards and technologies used by the ITINERIS community. These activities were fundamental to develop a flexible service able to ingest and manage all such kinds of standards and to deliver them through machine-to-machine (M2M) and graphical user interfaces (GUI). The main feature of the TS is to represent the unique access point to SAs used and/or managed by ITINERIS communities. These SAs were compiled (Pulieri *et al.*, 2024) and analysed (Deliverable 2.11; Di Muri *et al.*, 2024) to assess aspects such as availability in existing catalogues, modelling languages and formats, licences and versioning management. This analysis was used to define the requirements to support their management within the TS and to determine which catalogues should be queried by the service.

In addition to this analysis, the ITINERIS TS was developed by following the set of principles and strategies describing the architecture of the Terminology Interoperability Framework (TIF; Deliverable 2.13). The TIF implementation aims to harmonise the access to and the information exchange of terminologies to seamlessly integrate and manage them within a unique environment. In essence, the TIF served as the scaffold for the development of services aiming at facilitating the interchange and harmonisation of terminologies. Thus, TIF established the standards for the correct functioning of the ITINERIS TS leading to an easy and seamless flow in the discovery, access, exchange and harvesting of terminologies.

RESULTS

The ITINERIS TS supports semantic interoperability in the environmental domain through the adoption of semantic technologies and standards. Concerning the technologies, the software ShowVoc (Stellato *et al.*, 2025) and VocBench (Stellato *et al.*, 2020) are used to browse, search, access and manage SAs and their alignments. These technologies can handle SAs represented in RDF, and which are modeled in different languages (e.g. SKOS, OWL) and formats. The use of standards and semantic web technologies within the TS enable the collection and management of different types of SAs (e.g. ontologies, thesauri, glossaries) generated and/or used by different scientific communities and RIs.

The TS collects SAs from distributed sources (i.e. catalogues of SAs) and makes them available via GUIs and M2M web services.

COLLECTION OF SEMANTIC ARTEFACTS' CATALOGUES

The ITINERIS TS integrates 28 catalogues of SAs which are used and/or managed by ITINERIS RIs (Table 1). Connectors to these catalogues were built via REST APIs, SPARQL endpoints and *ad hoc* scrapers depending on the technologies adopted by the catalogues harvested. The integration of the 28 catalogues within the ITINERIS TS allow users to search and access SAs distributed across different sources from a unique access point.

1. Federated search of semantic artefacts

From the [Catalogues page](#), users can perform keywords-based searches of SAs available within the 28 external catalogues connected to the ITINERIS TS. Searches can be executed on all connected sources or on a subset of sources selected by the users. Registered users can also indicate a list of “favourite” catalogues and perform searches on the same selection. Selecting/Filtering options facilitate users from different RIs and communities in searching domain-specific SAs.

2. Unique access point to distributed semantic artefacts

Users can browse and access SAs available within different semantic artefacts' catalogues through a unique interface. Semantic artefacts metadata are harvested from the original catalogues and can be inspected by users. Access to semantic artefacts is guaranteed by SAs' URIs and catalogues web pages.

3. Monitoring semantic catalogues' updates

A number of operations are available to keep the ITINERIS TS up-to-date with the catalogues' content. Users can perform automatic scans on the available semantic catalogues to visualise and harvest novel SAs available in the connected sources or to check for the latest versions of SAs. In addition, the system allows administrators to constantly monitor the status of the connected catalogues and enable/disable catalogues' visibility.

Table 1. List of semantic artefacts' catalogues (names and URLs) connected to the ITINERIS Terminology Service.

Catalogue Name	Catalogue URL
AberOWL	http://aber-owl.net/#/
AgroPortal	https://agroportal.lirmm.fr/

ARDC Research Vocabularies Australia	https://vocabs.ardc.edu.au/
OntoPortal-Astro	https://ontoportal-astro.eu/
Basic Register of Thesauri, Ontologies & Classifications	https://bartoc.org/
BiodivPortal	https://biodivportal.gfbio.org
BioPortal	https://bioportal.bioontology.org/
Bioregistry	https://bioregistry.io/
Portal for European Data	https://data.europa.eu/en
EarthPortal	https://earthportal.eu/
EcoPortal	https://ecoportal.lifewatch.eu/
EMBL-EBI Ontology Lookup Service	https://www.ebi.ac.uk/ols4/index
German Federation for Biological Data	https://www.gfbio.org/
I-Adopt	https://i-adopt.github.io/terminologies
IndustryPortal	https://industryportal.enit.fr/
Linked Open Data Cloud	https://lod-cloud.net/
Loterre	https://loterre.istex.fr/en/
Linked Open Vocabularies	https://lov.linkeddata.es/dataset/lov/
MatPortal	https://matportal.org/
MedPortal	https://medportal.bmicc.cn/
Marine Metadata Interoperability Ontology Registry and Repository	https://mmisw.org/
NERC Vocabulary Server	https://vocab.nerc.ac.uk/
OBO Foundry	https://obofoundry.org/
Ontobee	https://ontobee.org/
EUR-OP	https://showvoc.op.europa.eu/#/home
TechnoPortal	https://technoportal.hevs.ch/
TERN Controlled Vocabularies	https://linkeddata.tern.org.au/prez/tern-cv/v/
TIB Terminology Service	https://terminology.tib.eu/ts/

COLLECTION OF SEMANTIC ARTEFACTS

The ITINERIS TS hosts approximately 100 SAs of those listed in Pulieri *et al.*, 2024. These SAs are stored into the service's triple store (i.e. GraphDB), thus allowing users to perform different tasks including browsing/access, terminological search, multilingual exploitation, version management and semantic annotation.

1. Access to semantic artefacts

Semantic artefacts available within the TS can be accessed from both M2M and GUI interfaces.

Users can browse and access SAs from the main [Semantic Artefacts page](#). The web page offers selections and filtering options to facilitate users in the search and discovery of SAs. For each available resource, key descriptive metadata are available from the front-end

including title, URI, description, model language and lexicalisation. Registered users can also indicate a list of “favourite” SAs and perform terminological searches on the same selection.

Semantic artefacts can also be explored within the TS through a front-end component for formulating, validating and executing SPARQL queries.

2. Terminological Search

A Global Search function available in the [Search page](#) enables users to retrieve terminologies. Using a keywords-based search, users can retrieve all pertinent terminologies from the SAs available within the ITINERIS TS. The search function has been developed to support both simple and advanced textual queries across labels and local names. Faceted filters can refine results based on SAs’ metadata. The ranking order of the search results is provided according to different criteria such as terminologies update status, multilingual availability, and the number of semantic relationships with other SAs.

3. Multilingualism

Semantic artefacts can include terminologies expressed in multiple languages. The linguistic information is included in both data (e.g. labels and annotations) and metadata of SAs and it is preserved and managed within the TS. From the [Translation page](#), terminologies expressed in different languages can be searched and discovered from available SAs. In addition, the TS uses multilinguality to support more effective terminological search and filtering, to improve the ranking and selection of terminologies, and to promote interoperability and reuse of SAs in international and interdisciplinary research environments.

4. Versioning management

The ITINERIS TS supports the versioning management of SAs by monitoring sources and detecting changes via automated diffing processes. These processes identify additions, modifications, deprecations, or deletions of terminologies within SAs. When changes are detected, the system preserves previous versions and records updated versions alongside their provenance and versioning metadata. This approach ensures traceability over time and enables the maintenance of terminological mappings and semantic relationships. Versioning management is key to consistency, reliability, and long-term reuse of SAs and their alignments as the underlying resources evolve.

5. Annotation

Semantic annotation is a core functionality for interoperability, enabling the linking of digital objects (e.g. datasets, publications, or services) to terminologies which univocally describe them. The terminological search function assists users in selecting appropriate terminologies for annotation tasks. Annotations are stored, along with their metadata, to ensure integrity, maintainability, and reusability of digital objects. Lastly, the annotation function improves data findability and interoperability, allowing exploration via keyword-based search, semantic navigation, and graph-based visualisation.

ALIGNMENTS

The TS include services to create/manage alignments and to exploit/visualise them by taking advantage of VocBench and ShowVoc functionalities and of other integrated software (i.e.

Gen.O.M.A.). The integration of such services within a unique system enhances semantic interoperability in the environmental domain and reduces existing terminological redundancies among SAs created independently by different communities as described in Di Muri *et al.* 2024.

1. Generation of novel alignments

Gen.O.M.A. (Enea *et al.*, 2015) is the alignment software integrated within VocBench which enables the automatic identification of alignments between terminologies of two SAs. Gen.O.M.A. is compatible with different semantic models of the RDF family including OWL ontologies or SKOS thesauri and glossaries. Within VocBench, the software Gen.O.M.A. interacts with the MAPLE software (Fiorelli *et al.*, 2019) which analyses the different mapping scenarios based on SAs metadata and suggests the best strategy to perform the alignments. Gen.O.M.A. then propose the set of lexicographic mappings (i.e. based on labels) with their most likely alignment type (e.g. *skos:exactMatch*, *skos:closeMatch*, *skos:broadMatch/narrowMatch*, *owl:sameAs*, *owl:equivalentClass*, *owl:equivalentProperty*). Thanks to these two software, the process of alignment discovery between SAs is completely automatic and becomes quick and efficient even for large resources.

2. Alignments validation

Within ITINERIS, the automatic discovery of alignments through Gen.O.M.A. was followed by the validation of such alignments performed by domain experts. Within VocBench, registered users can be invited to edit an alignment project between two SAs and evaluate the alignments discovered by the software. Users can then act as validators by rejecting/accepting/editing the alignments found and their specific relationships. A total number of 19610 alignments belonging to eight different alignment projects were validated by four domain experts engaged in ITINERIS activities (Table 2).

Table 2. List semantic artefacts aligned and related number of mappings validated by the domain experts.

Semantic artefacts		N° of alignments
Environmental Thesaurus	Traits Thesaurus	758
GEneral Multilingual Environmental Thesaurus	Environmental Thesaurus	116
Environmental Thesaurus	ACTRIS Vocabulary	2159
Environmental Thesaurus	Theia/OZCAR Thesaurus	2770
GEneral Multilingual Environmental Thesaurus	AnaEE Thesaurus	3098
AnaEE Thesaurus	ACTRIS Vocabulary	2091
Environmental Thesaurus	AnaEE Thesaurus	8177
SeaDataNet Parameter Discovery Vocabulary	Environmental Thesaurus	441
Total number of alignments		19610

DISCUSSION

The ITINERIS TS represents a unique access point to SAs within the environmental domain, making it a key tool for finding, accessing and reusing vocabularies, ontologies, thesauri developed and used by ITINERIS RIs and their communities. Through the TS connectors, at the moment, 28 catalogues of SAs can be interrogated simultaneously for search and discovery purposes. The service is, however, built as a modular and flexible tool which can be further expanded to allow the inclusion of additional catalogues and SAs. So far, different types of connectors were built to allow catalogues integration within the service. Depending on the technological characteristics and access models of the source catalogues, the service supports both singleton connectors, developed as bespoke integrations for specific catalogues (e.g. AberOWL, ARDC, Loterre), and configurable connectors based on widely adopted technologies (e.g. OLS, OntoPortal, FAIRsharing). This dual approach ensures interoperability with existing heterogeneous systems while lowering effort required to extend services to additional catalogues.

Although different metadata schema are used to describe semantic artefacts available in the different sourced catalogues, within the TS, the Metadata Registry allows the harmonised distribution of SAs metadata. The Metadata Registry enable a standardised description of metadata through the exploitation of community-accepted, commonly used metadata standards such as VoID (Alexander et al. 2011), DCAT 3 (W3C, 2014), Lime (Fiorelli et al., 2015). This harmonisation layer is designed to ensure consistency in the description of key SAs metadata such as titles, descriptions, licences and versioning.

While search and discovery of SAs and their associated metadata can be performed through the connections with external catalogues, the terminological search is performed among the SAs available in the TS and which are directly used and/or managed by ITINERIS RIs. Users can contribute directly or suggest the addition of further resources (i.e. SAs or catalogues) within the TS enabling the system to grow with time and to stay updated with the latest needs of the community. The system was in fact conceived since its design to be dynamic so that it can continue to satisfy the evolving requirements of the ITINERIS community within and beyond the life span of the project. This approach reinforces the role of the ITINERIS TS as a collaborative service for the management and evolution of semantic knowledge in environmental research.

The coupling of VocBench/ShowVoc functionalities and related services for alignment generation, management and visualisation allow the extension, maintenance and exploitation of semantic mappings intra and inter-domains. Such open tools can be exploited by the ITINERIS community to continue the activity of building cross-links among existing SAs thus strengthening semantic interoperability across SAs and systems using their lexicalisations.

The TS provides a sustainable and future-proof solution capable of addressing the evolving requirements of the ITINERIS community both during and beyond the lifespan of the project. This is achieved by combining the federated integration of distributed catalogues and SAs, the metadata harmonisation based on established standards, and advanced search, discovery and management functionalities for SAs, terminologies and their semantic alignments.

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