opertus mundi

Asset Operations

Report on Deliverable D3.5

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Abstract

This report presents an overview of Deliverable D3.5 "Asset Operations", i.e., the components of OP Core//Operations responsible for (a) supporting suppliers in defining and managing the license, price models, and contracts of their assets, as well as the search facilities of the catalogue for prospective consumers (wizards), (b) the management of all asset transactions (Transaction Manager), and (c) the interface and analytics services for asset transactions (Sales Manager). First, we present the standard publishing flows for all types of assets, exhaustively demonstrating and discussing how the developed wizards empower asset providers. Similarly, we present how the catalog's search facilities have been extended to leverage the underlying information for asset

discovery. Then, we present how transactions are modelled, instantiated, and monitored in the marketplace in accordance with our established business models, offerings, and workflows. Towards this, we present all related facilities, from the asset delivery, up to payment processing. Finally, we detail the interface and all analytics facilities developed for asset owners, which provide them with comprehensive view and insights over all asset transactions.

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Executive Summary

This report presents an overview of Deliverable D3.5 “Asset Operations”, i.e., the components of OP Core//Operations responsible for (a) supporting suppliers in defining and managing the license, price models, and contracts of their assets, as well as the search facilities of the catalogue for prospective consumers (wizards), (b) the management of all asset transactions (Transaction Manager), and (c) the interface and analytics services for asset transactions (Sales Manager). These components *in tandem* ensure that all types of assets are traded within the marketplace under the same standardized, strict, and traceable flows.

In Section 1, we present the publishing flow for the two major types of assets supported by the Topio marketplace, i.e., vector and raster data. In addition, we present how a new OGC asset can be generated based on an existing (published) asset. We follow each step of the publishing process focusing our discussion on the specific areas of interest of this report. As such, we examine the creation of a contract template for a particular asset and its management. Next, we explore and discuss the supported pricing models per type of asset and means of delivery, explaining for each their reasoning and potential co-existence for a single asset (i.e., assets available through multiple pricing models). Finally, we showcase how publishers can manage and edit this information, thus managing the complete lifecycle of their assets.

In Section 2, we preset how a prospective client’s experience is augmented by the integration of contract, terms, and pricing information for asset discovery. First, we showcase the catalog’s search and filtering facilities, and specifically how this additional metadata can be applied in asset search. Next, we present and discuss the framing of this information in the standard asset’s view, thus allowing its assessment and comparison with similar assets. Finally, we present how dynamic pricing models are delivered to prospective clients, exploring their options and considerations.

In Section 3, we present how asset transactions are modelled, instantiated, and monitored in the marketplace in accordance with our established business models, offerings, and workflows. First, we provide an overview of the workflow engine applied in the OpertusMundi marketplace, and offer examples of how workflows are authored, invoked, and monitored. Next, we discuss the core modelling concepts and decisions regarding the lifecycle of asset transactions within the broader operation of the marketplace, as well as the corresponding components providing them. Finally, we present how payments are received and processed by the platform’s commercial provider.

In Section 4, we detail the interface and all analytics facilities developed for asset owners, which provide them with comprehensive view and insights over asset transactions. These services are fully integrated in the marketplace’s dashboard, offering timely and actionable information for all related steps of asset transactions. Towards this, our presentation follows the purchase of an asset from the viewpoints of both the owner and consumer, exploring the different options available to them. Finally, we present the analytics services developed specifically for asset owners, which provide both a high-level and detailed view of asset transactions, their performance, as well as broader insights related to the marketplace.

Finally, in Section 5, we present the implementation details for the presented for all software components presented in the previous sections, i.e., the publishing wizards, search facilities, the Transaction Manager and Sales Manager of OP Core//Operations. As these components extend, reuse, and are integrated to, other components of the catalog and OpertusMundi platform, our discussion similarly builds upon this output and the corresponding deliverables to avoid verbosity and maintain the focus of this report.

Abbreviations and Acronyms

API	Application Programming Interface
BPM	Business Process Management
BPMN	Business Process Model and Notation
CRS	Coordinate Reference System
CSV	Comma Separated Values
JSON	JavaScript Object Notation
OGC	Open Geospatial Consortium
REST	REpresentational State Transfer
WFS	Web Feature Service
WMS	Web Map Service
XML	eXtensible Markup Language

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1. Publishing wizards

In this section, we present the publishing flow for all major types of assets supported by the Topio marketplace. These include commercial file assets, i.e., vector, raster, tabular, or multidimensional data, but we also present how an open data asset offered for free can be also published in the marketplace. In addition, we present how a new OGC asset can be generated based on an existing (published) asset. Finally, we also discuss how satellite imagery from various Earth Observation collections can be made available in the marketplace. We follow each step of the publishing process focusing our discussion on the specific areas of interest of this report. As such, we examine the creation of a contract template for a particular asset and its management. Next, we explore and discuss the supported pricing models per type of asset and means of delivery, explaining for each their reasoning and potential co-existence for a single asset (i.e., assets available via multiple pricing models). Finally, we showcase how publishers can manage and edit this information, thus managing the complete lifecycle of their assets.

Please note that all screenshots and descriptions are correct as of the time of this writing and are expected to be modified in the future, as the platform continues to be in development, even after the end of the OpertusMundi project. Further, the platform's messages, labels, and assets (data, services) presented in the screenshots that follow are integrated for testing and illustration purposes only and hence may not correspond to actual commercial/proprietary geospatial assets. As such: (a) the same assets may appear multiple times, (b) the content of assets is derived from open licensed assets, (c) the provided metadata (e.g., pricing, terms, profiling) may not be accurate.

1.1. Initiating publishing

A supplier can publish an asset directly from her *Dashboard*, which offers full control over all its activity in the marketplace as shown in Figure 1. By either clicking on the + button in the sidebar or the button "*Add an Asset*" (highlighted in the green box), the supplier can publish from scratch a new asset in the marketplace easily, thanks to a step-by-step wizard. If the publication of an asset is not yet complete (e.g., in draft status), the supplier is informed with a notification icon (red circle) next to the *Assets* option in the Dashboard. Any such assets are also displayed in the list with a notification next to their state. Of course, suppliers retain full control and can manage their assets by applying certain actions on each of them (*publish, edit, delete, create* an API or services), as highlighted in the red box in Figure 1 and detailed in Section 1.7.

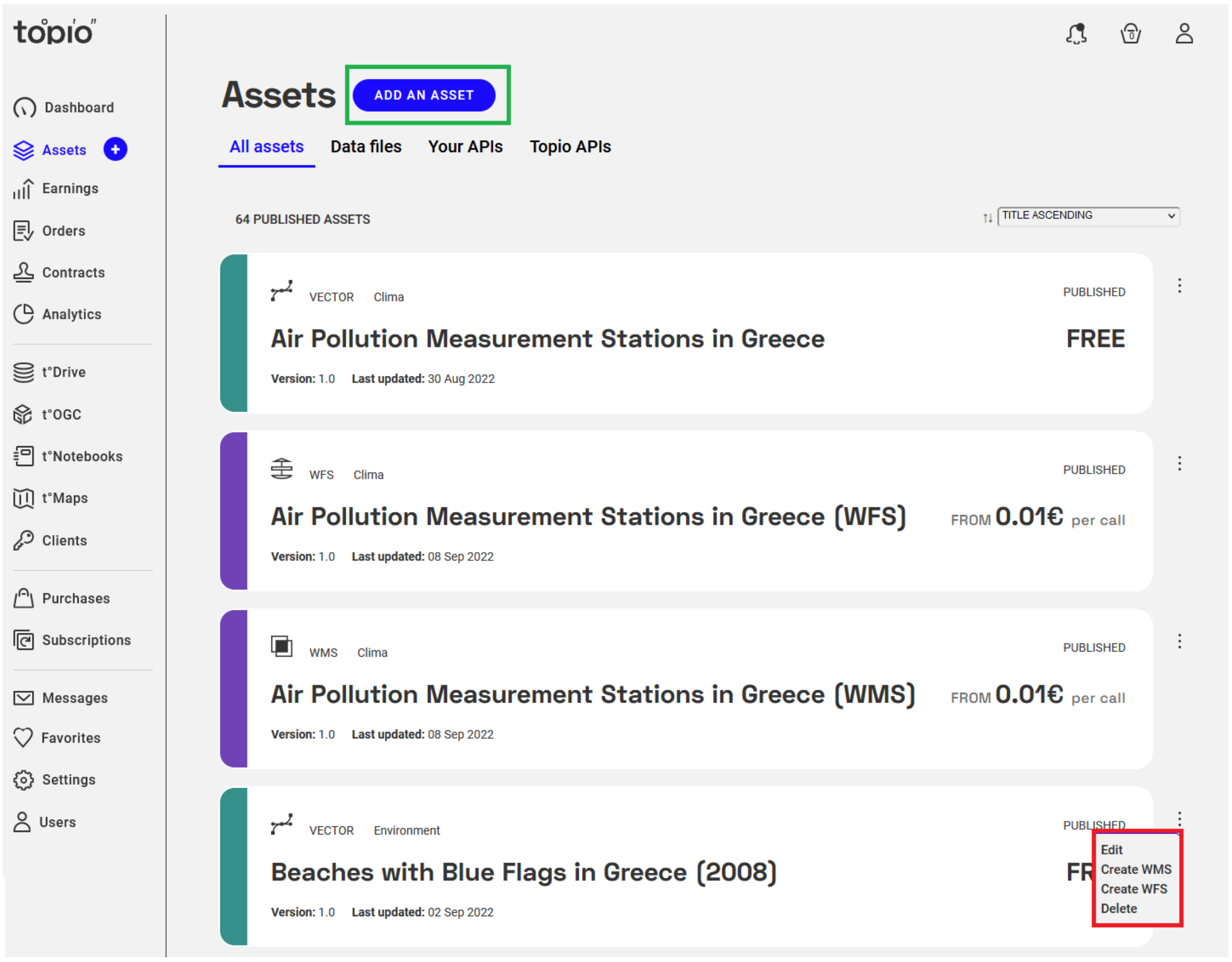


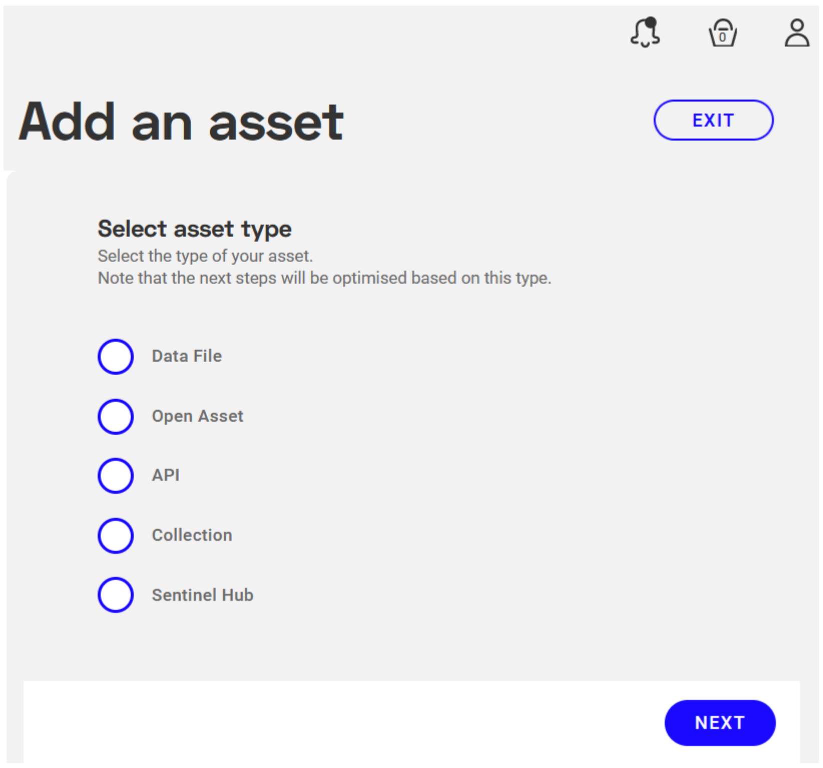
Figure 1: Initiating publication of an asset from the supplier's Dashboard

Once the supplier chooses to add an asset from scratch, a step-by-step wizard is launched. Adding a data file asset to the marketplace has some differences from publishing other types of assets (e.g., API, EO), but generally the wizard involves similar steps with appropriate options at each step. The first step involves the specification of the ***asset type*** (Figure 2). Currently, this can be one of the following:

- *Data file* (vector, tabular, raster, NetCDF). The supplier will be asked to upload a file asset that will be traded through the platform. All types of geospatial data and formats (vector, raster, NetCDF), as well as *non-spatial* data (e.g., statistics) are allowed. The flow for publishing such an asset is detailed in Section 1.2.
- *Open asset*. This option also concerns data files (of the same types and formats as for data files) but offered with an open license free-of-charge. *Note that this functionality is currently reserved only for Topio.*
- *API*. A supplier can create a new API based on a file asset already traded through the marketplace or uploaded by the supplier in his own storage space in the Topio Drive. As

explained in Section 1.5, the flow for publishing an API asset slightly differs in certain steps from those regarding a data file.

- *Collection*. This concerns a collection of already published assets from the same supplier that can be purchased together, possibly with a discount.
- *Sentinel Hub*. This option specifically concerns *Earth Observation (EO) assets* from Sentinel Hub concerning satellite imagery products from various open and proprietary EO collections.



Select asset type

Select the type of your asset.
Note that the next steps will be optimised based on this type.

- ○ Data File
- ○ Open Asset
- ○ API
- ○ Collection
- ○ Sentinel Hub

Figure 2: Specifying the type of a new asset

Note that at any stage of the wizard, a supplier can:

- *Save* her current choices in the wizard as an *asset draft*; this asset is marked with the red notification in the dashboard, so that the supplier is reminded to come back and complete the pending steps.
- *Exit* the wizard; a warning will appear to enable her to save any changes as in a draft asset or discard them completely.

1.2. Adding a data file asset

Once the supplier chooses in the wizard to add an asset from a *data file* (as shown in Figure 2), she must proceed step-by-step with each successive tab as detailed next. Note that this functionality covers four different types of assets (*vector, tabular, raster, NetCDF*) widely used in geospatial applications and services.

1.2.1. Metadata

This step specifies standard metadata information for the data file asset, such as title, type, description, format, coordinate reference system, etc. Depending on the asset type (vector, raster, tabular, NetCDF), the respective file formats are shown as options (e.g., ESRI shapefile is shown for vectors only, GeoTIFF for raster only, etc.). As shown in Figure 3, the supplier can fill in values for each item as prescribed by the *OP Schema* (see D2.1). Such standard metadata are available in the platform under a CC-BY-NC 4.0 license to facilitate asset discovery from consumers.

Of course, specifying metadata can be done directly in this form, by filling in at least all *mandatory metadata items* (*title, type, abstract, format, version*), highlighted in a red box in Figure 3. Furthermore, the supplier can include a wide range of other *optional metadata*, organized in separate sections as listed in Table 1.

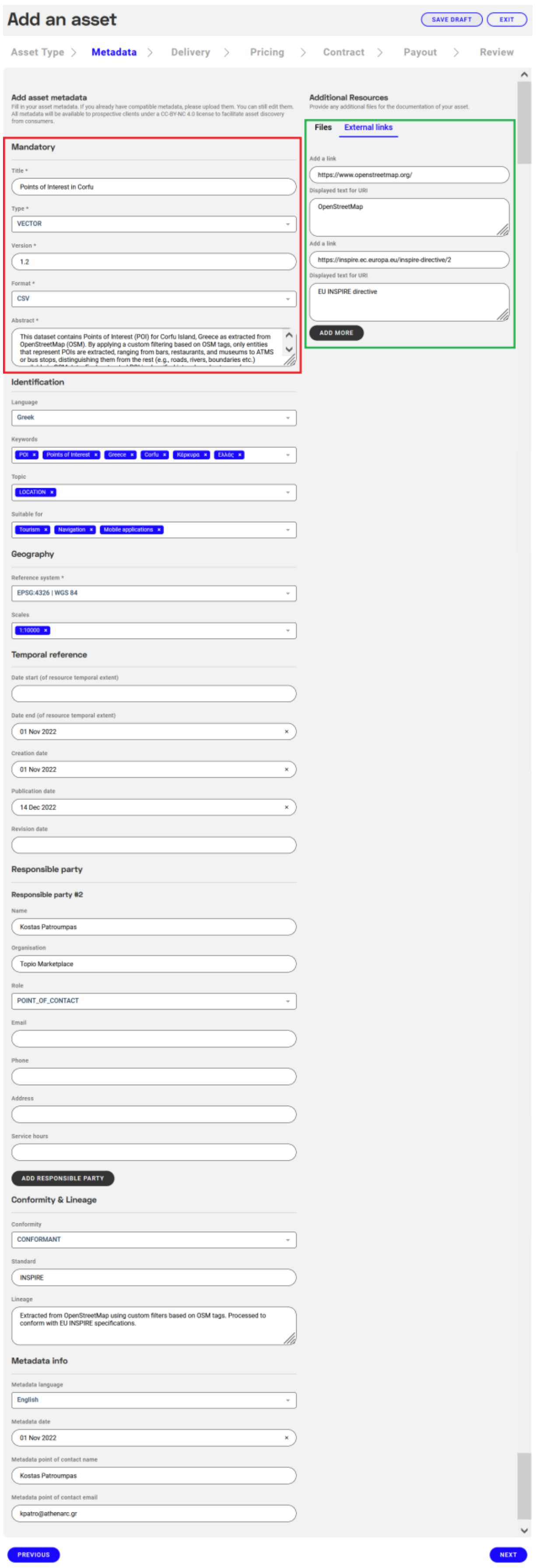
Table 1: Standard metadata for data file assets

Section	Metadata Items	Notes
Mandatory	Title	Name of the dataset
	Type	Vector, Raster, NetCDF, Tabular
	Version	Version/subversion, Year, etc.
	Format	Depends on asset type; e.g., ESRI Shapefile is shown for vectors only, GeoTIFF for rasters, etc.
	Abstract	Text with detailed description of the asset
Identification	Language	Main language of text contents in the dataset
	Keywords	Supplier-specified tags to be used in asset discovery (search) by users
	Topic	Classification according to INSPIRE Topic Category[1]
	Suitable for	Supplier-specified application domains where this asset is best suited for, like *Tourism, Navigation, Mobile applications*, etc.
Geography	Reference system	EPSG code of the coordinate reference system (CRS)
	Scale	Scale of the data (for vectors only)
	Resolution	Image resolution (for rasters only)
Temporal reference	Temporal extent	Time period (Date start - Date end) on which the data is valid (e.g., for sensor measurements)

[1] https://inspire.ec.europa.eu/metadata-codelist/TopicCategory

Section	Metadata Items	Notes
	Creation date	
	Publication date	By default, this is the date the asset is published in the marketplace
	Revision date	
Responsible party	Name	
	Organization	Multiple responsible entities can be specified, each with a distinct role
	Role	Owner, Publisher, Custodian, User, Distributor, Originator, Point of Contact, Processor, Author
	Email	
	Phone	
	Address	
	Service hours	
Conformity & Lineage	Conformity	to a known standard, e.g., OGC, ISO, INSPIRE
	Lineage	Owner's knowledge about the lineage of a dataset
Metadata information	Metadata language	
	Metadata date	
Additional resources	File(s)	Files in various formats (DOC, TXT, PDF, XML, etc.) offering extra information or documentation for the dataset; multiple files may be uploaded
	URL(s)	Links to websites with detailed information, use cases, etc.; multiple URLs can be added

The more complete metadata the supplier offers, the more chances for her asset to qualify in the various criteria set by users of the platform when they search for assets (Section 2.1).



Add asset metadata

Fill in your asset metadata. If you already have compatible metadata, please upload them. You can still edit them. All metadata will be available to prospective clients under a CC-BY-NC 4.0 license to facilitate asset discovery from consumers.

Mandatory

Title *: Points of Interest in Corfu

Type *: VECTOR

Version *: 1.2

Format *: CSV

Abstract *: This dataset contains Points of Interest (POI) for Corfu Island, Greece as extracted from OpenStreetMap (OSM). By applying a custom filtering based on OSM tags, only entities that represent POIs are extracted, ranging from bars, restaurants, and museums to ATMS or bus stops, distinguishing them from the rest (e.g., roads, rivers, boundaries etc.)

Identification

Language: Greek

Keywords: POI, Points of Interest, Greece, Corfu, Κέρκυρα, Ελλάς

Topic: LOCATION

Suitable for: Tourism, Navigation, Mobile applications

Geography

Reference system *: EPSG:4326 | WGS 84

Scales: 1:10000

Temporal reference

Date start (of resource temporal extent):

Date end (of resource temporal extent): 01 Nov 2022

Creation date: 01 Nov 2022

Publication date: 14 Dec 2022

Revision date:

Responsible party

Responsible party #2

Name: Kostas Patroumpas

Organisation: Topio Marketplace

Role: POINT_OF_CONTACT

Email:

Phone:

Address:

Service hours:

Conformity & Lineage

Conformity: CONFORMANT

Standard: INSPIRE

Lineage: Extracted from OpenStreetMap using custom filters based on OSM tags. Processed to conform with EU INSPIRE specifications.

Metadata info

Metadata language: English

Metadata date: 01 Nov 2022

Metadata point of contact name: Kostas Patroumpas

Metadata point of contact email: kpatro@athenarc.gr

Additional Resources

Provide any additional files for the documentation of your asset.

Add a link: https://www.openstreetmap.org/

Displayed text for URI: OpenStreetMap

Add a link: https://inspire.ec.europa.eu/inspire-directive/2

Displayed text for URI: EU INSPIRE directive

Figure 3: Specifying metadata for a new file asset

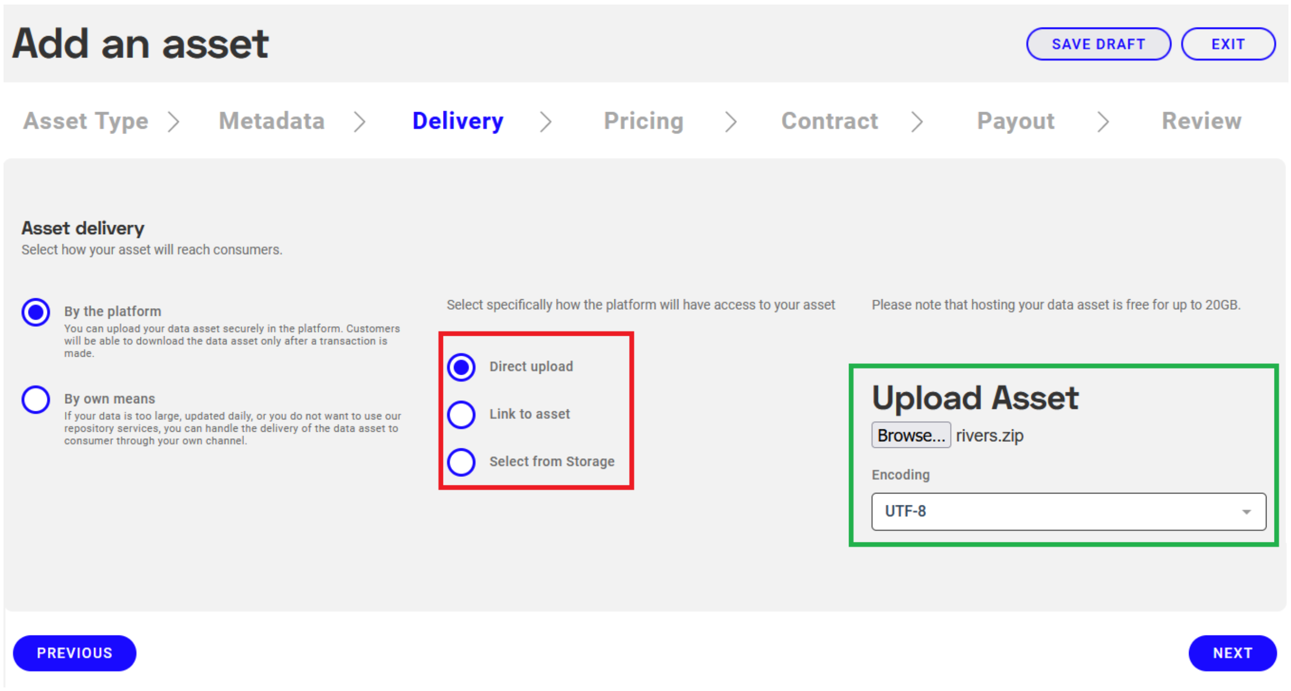
Suppliers can also supply *additional metadata resources*, highlighted in the green box in Figure 3. Suppliers can upload documents detailing the production process or the specifications of the asset, details on the attribute schema) as well as external links related to the asset, such as webpages with full documentation, use cases, videos, etc., thus offering prospective customers more information about this asset. Note that the platform does not alter or revise any of the standard metadata specified by the supplier; these appear in the asset view page as originally specified (Section 2.2.4).

1.2.2. Delivery

In the third step in the wizard, the supplier can specify how the asset will be delivered to customers after purchase. As depicted in Figure 4, there are two main options for asset delivery:

1. *By the platform*: If delivery will be effectuated *by the platform*, the supplier must specify how the platform will get access to this asset. There are three available options for providing the asset data to the platform, as shown within the red box in Figure 4: (i) by *directly uploading* files to the repository (indicated with the green box), and optionally specifying their character encoding (if not, UTF-8 is the default encoding); (ii) providing a valid web link (e.g., an ftp site, Dropbox) where the asset is available; or (iii) even specifying the path to her own storage space (*Topio Drive*) in the platform, where the asset has been already uploaded. Note that in some cases, the asset itself may consist of multiple files. For instance, a *vector* shapefile must include at least a .shp file (containing geometries), a .dbf file (with thematic attribute data), and a .shx file (for indexing shapes of geometries). Similarly, a *raster* image can be stored in a file in TIFF format but may be also accompanied with a .tfw file for georeferencing the image. Such assets should be compressed in a single .zip file, which is specified in this wizard. Once published, the asset will made available to consumers after purchase through the platform's repository for direct downloading.

(b) By the supplier's *own means*. Alternatively, suppliers can handle themselves the delivery of the data asset to consumers. Suppliers may use their own channel for delivery if the data is too large and cannot be held in the Topio Drive due to quota constraints, or if data is updated frequently (e.g., daily), or in case that suppliers do not wish to use the repository services of the platform. The supplier can thus choose to deliver the asset by specifying the method (e.g., through physical media such as CD or DVD sent by post) or digital delivery (e.g., a server or ftp site).



Add an asset

Asset delivery
Select how your asset will reach consumers.

[✓ By the platform]
You can upload your data asset securely in the platform. Customers will be able to download the data asset only after a transaction is made.

By own means
If your data is too large, updated daily, or you do not want to use our repository services, you can handle the delivery of the data asset to consumer through your own channel.

Select specifically how the platform will have access to your asset

[✓ Direct upload]
Link to asset
Select from Storage

Please note that hosting your data asset is free for up to 20GB.

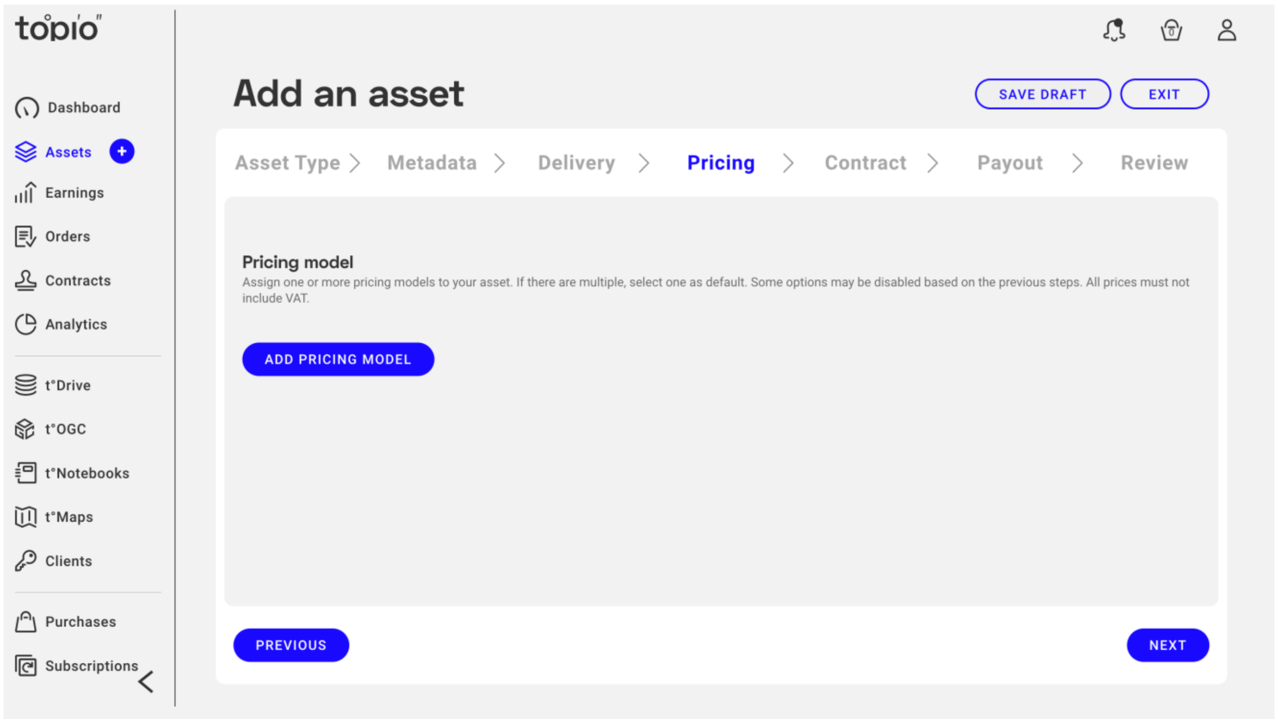
Upload Asset
Browse... rivers.zip
Encoding: UTF-8

Figure 4: Delivery options for a new asset

1.2.3. Pricing

This step concerns the specification of the *pricing model(s)* for the new data asset. The supplier must select *at least one* such model from those available for this type of asset, such as free, fixed, fixed per rows, etc. *Multiple pricing models* may be chosen, e.g., a vector data asset may be marketed both as a one-time purchase but may also be available with per-row charging (0-1000, 1000-2000, etc.).

When the user reaches the pricing step, she is presented with a button titled “Add Pricing Model”, as illustrated in Figure 5. Upon clicking on the button, she is presented with the various pricing model options.



Pricing model

Assign one or more pricing models to your asset. If there are multiple, select one as default. Some options may be disabled based on the previous steps. All prices must not include VAT.

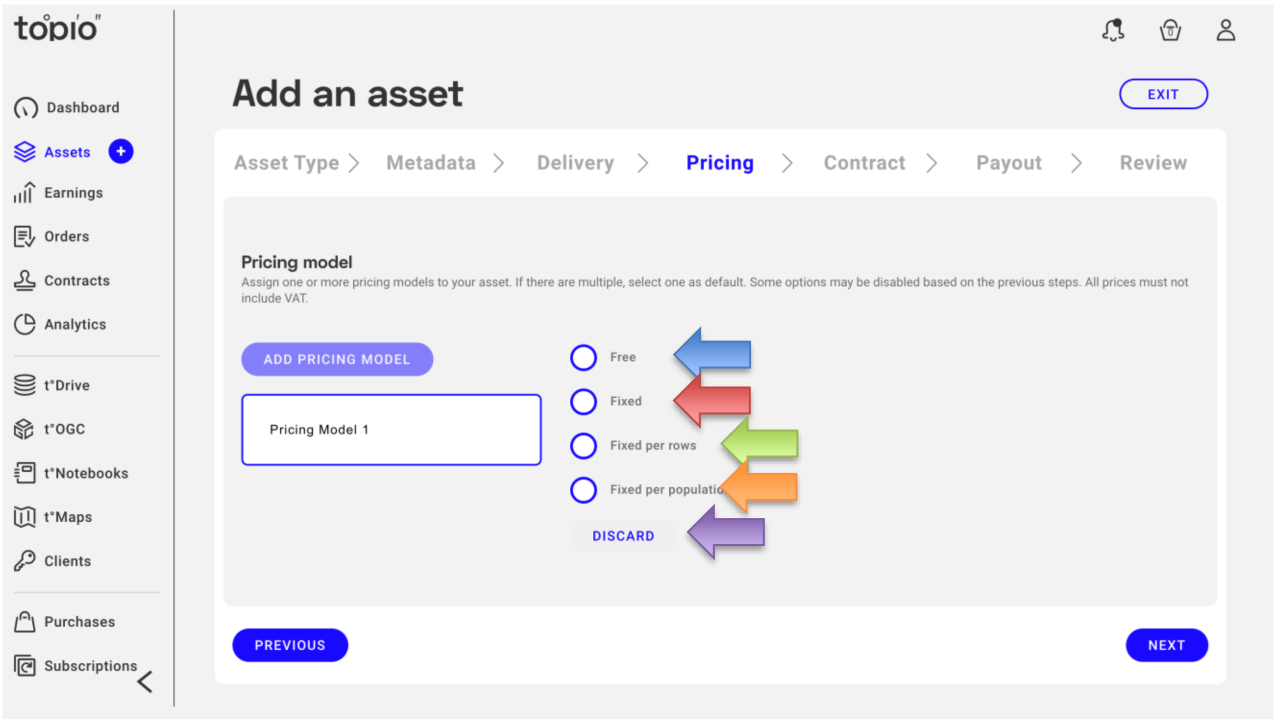
Figure 5: The pricing step of the asset publishing wizard

There are four different pricing models for file assets that are currently supported by Topio:

- **Free** (blue arrow in Figure 6): The user must select this pricing model if she desires to offer her asset for sale via Topio for free, under an open license.
- **Fixed** (red arrow in Figure 6): Choosing this pricing model, enables the purchase of this pricing model by prospective clients in its current, past, and future versions. Clients automatically get access to newer versions of the data asset whenever they become available and for a period that the seller defines. This is the preferred option for products updated relatively frequently.
- **Fixed per rows** (green arrow in Figure 6): This pricing model offers the asset for purchase by prospective clients in a piecewise manner. Clients can select and purchase only a subset of the data asset by defining the area of interest (e.g., country, city) they are interested in. The seller will be remunerated based on the number of rows provided, with a guaranteed minimum number of rows per purchase. Optionally, the supplier can also define discounts to incentivize consumers in purchasing more rows of her product.
- **Fixed per population** (orange arrow in Figure 6): This pricing model is similar to the previous one. The main difference lies in the remuneration of the supplier, which is based on the *population coverage* in the selected area, with a guaranteed minimum per purchase. The density of the population is calculated based on the most recent Eurostat census data (2011), the geographical coverage of the file that is being uploaded for sale in Topio, and the geographical area selected by the user. For example, if the data asset covers the entire Europe and a user selects an area covering only the cities of London and Paris, the

population coverage is calculated by dividing the total population of Europe with the sum of the populations of London and Paris.

The user can discard the current pricing model by clicking on the corresponding button (purple arrow in Figure 6).

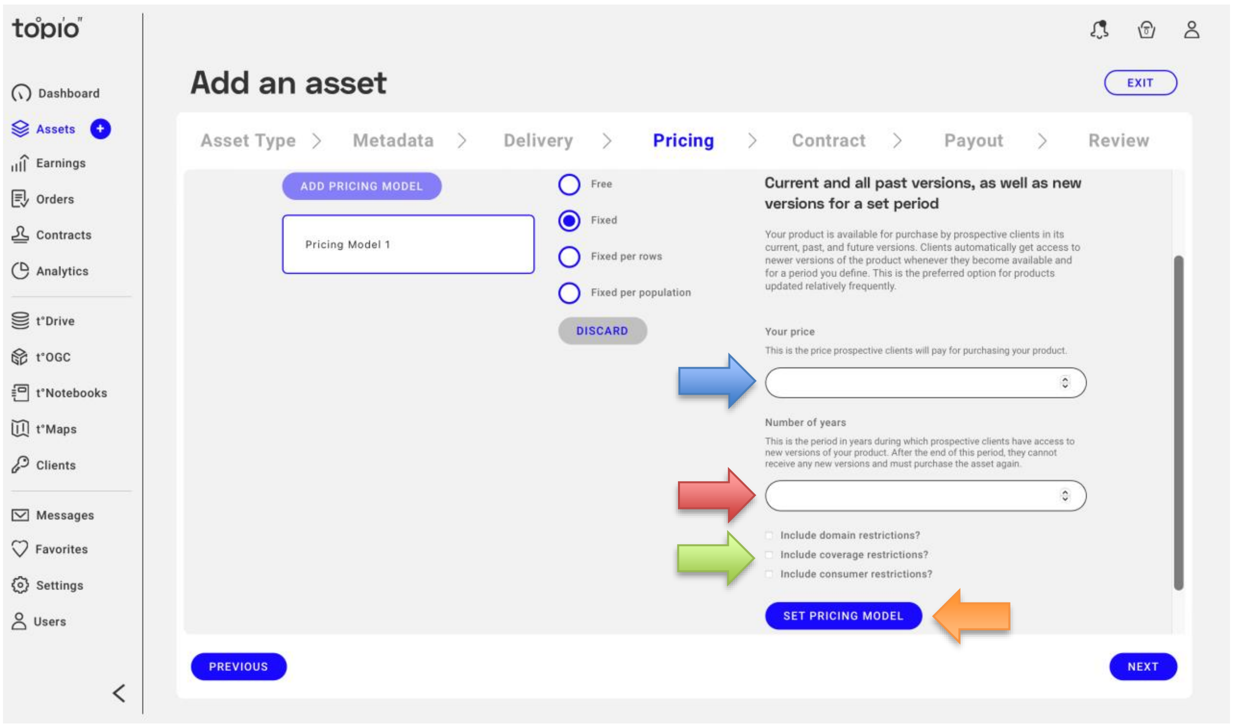


Pricing model

Assign one or more pricing models to your asset. If there are multiple, select one as default. Some options may be disabled based on the previous steps. All prices must not include VAT.

Figure 6: Specifying the pricing model(s) for a new data asset

After clicking on the pricing model at the middle pane (see Figure 6), a new pane appears on the right of the window, containing various fields that the supplier must define to add this pricing model to her data asset (see Figure 7). A short description regarding this pricing model is shown at the top of the pane. Below it, the user must fill-in the price under which she wants to offer the data asset (blue arrow in Figure 7). Below this field, the supplier must set the number of years during which prospective clients have access to new versions of the asset (red arrow in Figure 7). Optionally, the user can set several restrictions (green arrow in Figure 7), which will be covered in the next subsection (Section 1.2.3.1). Upon finishing the selection of the pricing model, the user must click on the “Set Pricing Model” button (orange arrow in Figure 7), to add it to the data asset under creation.



Free [✓ Fixed] Fixed per rows Fixed per population

Current and all past versions, as well as new versions for a set period

Your product is available for purchase by prospective clients in its current, past, and future versions. Clients automatically get access to newer versions of the product whenever they become available and for a period you define. This is the preferred option for products updated relatively frequently.

Your price

This is the price prospective clients will pay for purchasing your product.

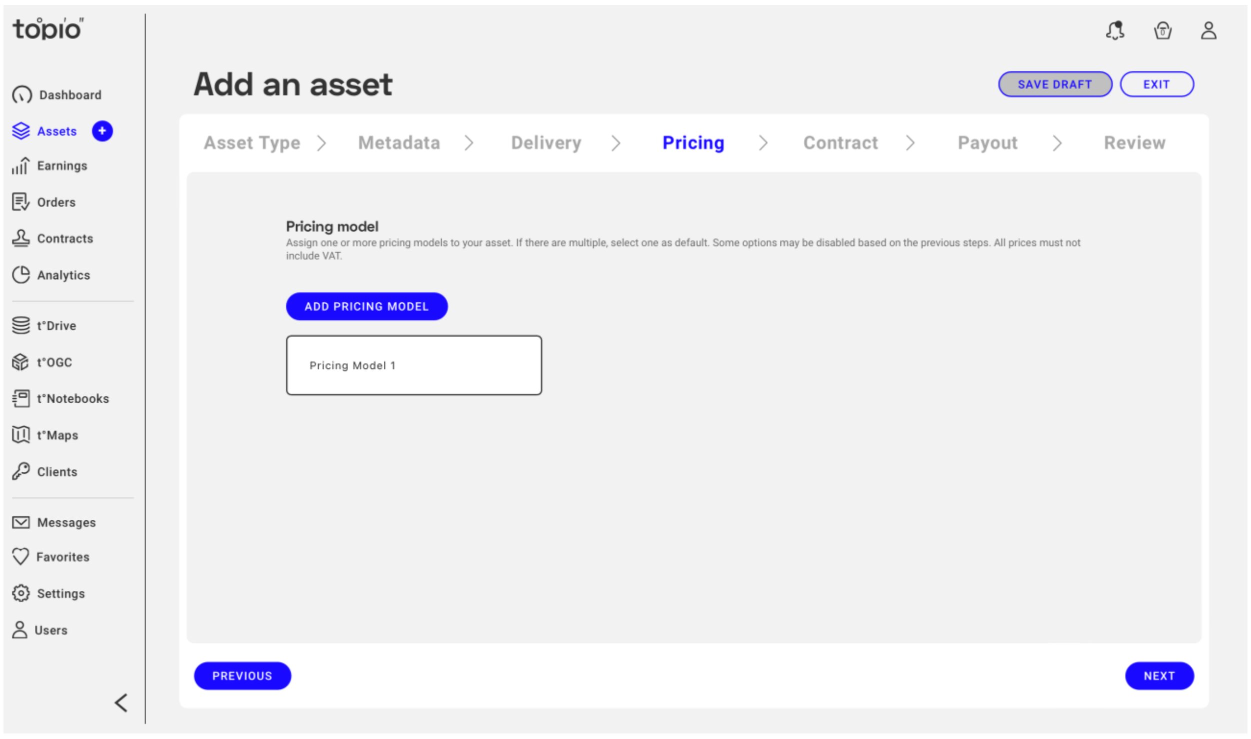
Number of years

This is the period in years during which prospective clients have access to new versions of your product. After the end of this period, they cannot receive any new versions and must purchase the asset again.

☐ Include domain restrictions?
☐ Include coverage restrictions?
☐ Include consumer restrictions?

Figure 7: Setting the price for the “Fixed” pricing model

After creating a pricing model, it is placed below the “Add Pricing Model” button, in a white rectangle, as shown in Figure 8. At this point, the seller can add more pricing models by clicking again on the “Add Pricing Model” button. Doing so, initiates the pricing model selection procedure again.



Pricing model

Assign one or more pricing models to your asset. If there are multiple, select one as default. Some options may be disabled based on the previous steps. All prices must not include VAT.

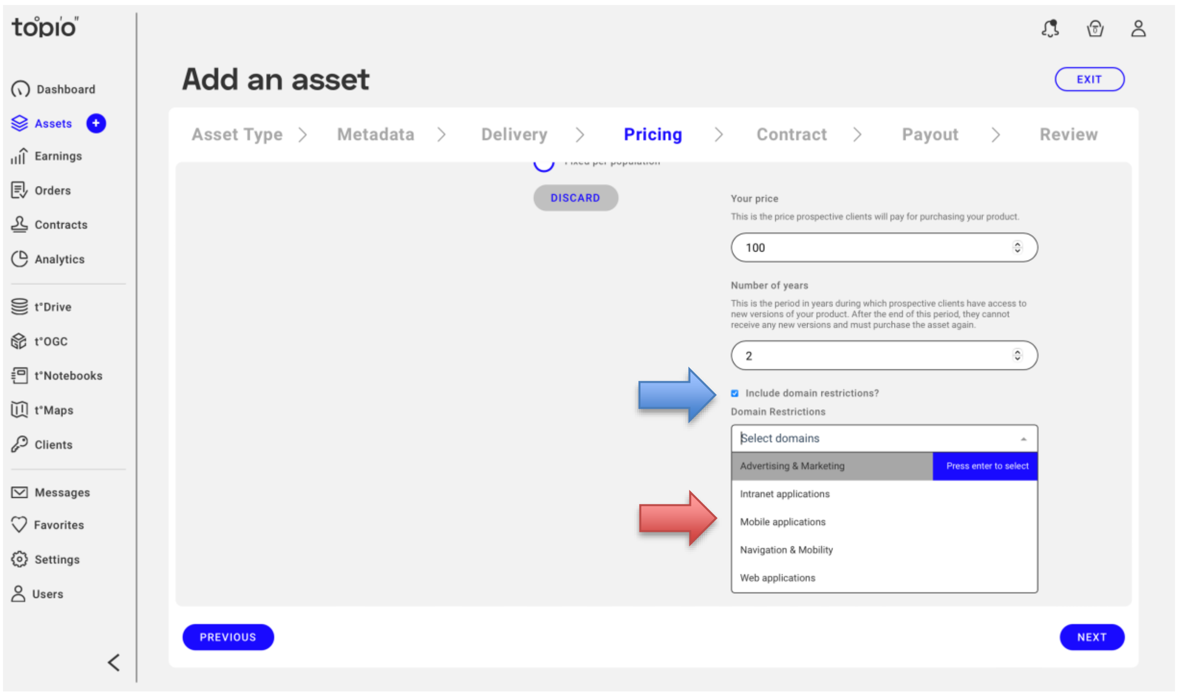
Figure 8: Specifying the pricing model(s) for a new asset

1.2.3.1. Restrictions

The seller can add *domain-, coverage- and consumer-related restrictions* to the data asset that she desires to offer via Topio. These options become available once the user checks one of the corresponding check boxes (green arrow in Figure 7). To add domain restrictions, the user must check the "Include domain restrictions?" check box (blue arrow in Figure 9) and then, the following five options (red arrow in Figure 9) become available:

- **Advertising & Marketing**: This data asset can only be used in advertising- and marketing-related applications.
- **Intranet applications:** This data asset must only be used in intranet applications.
- **Mobile applications**: This data asset must only be used in mobile applications.
- **Navigation & Mobility**: This data asset must only be used in navigation- and mobility-related applications.
- **Web applications**: This data asset can only be used in web applications.

The user can select one or more of these options to apply the corresponding domain descriptions.



Your price
This is the price prospective clients will pay for purchasing your product.
100

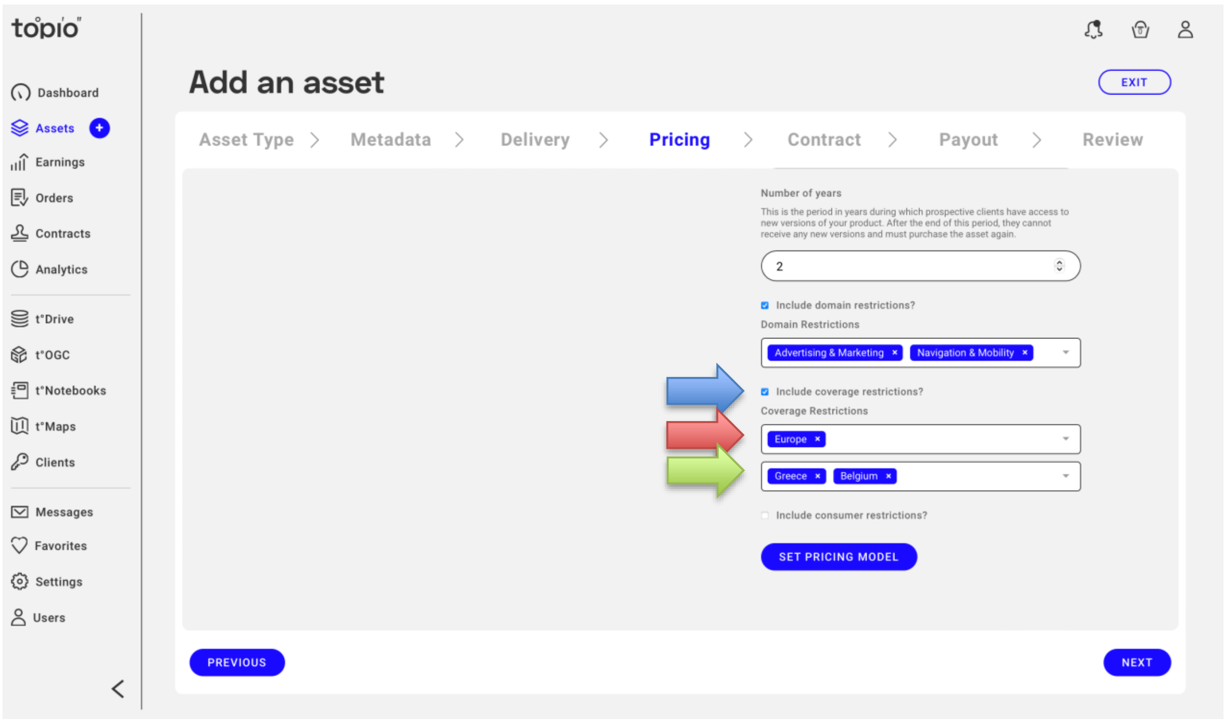
Number of years
This is the period in years during which prospective clients have access to new versions of your product. After the end of this period, they cannot receive any new versions and must purchase the asset again.
2

☑ Include domain restrictions?

Domain Restrictions
Select domains
Advertising & Marketing — Press enter to select
Intranet applications
Mobile applications
Navigation & Mobility
Web applications

Figure 9: Setting domain restrictions for the asset

To enable coverage restrictions regarding the use of the asset, the supplier must check the "Include coverage restrictions?" check box (blue arrow in Figure 10). Indicated with a red arrow in Figure 10 is a list containing the continental regions, on which the seller can allow the use of the asset. If she desires so, she can also select (one or more) specific countries from the list below it (green arrow in Figure 10), to apply coverage restrictions with higher granularity. Doing so, adds the selected country to the list; clicking on the "X" next to each country's or continent's name removes it from the list.



Number of years

This is the period in years during which prospective clients have access to new versions of your product. After the end of this period, they cannot receive any new versions and must purchase the asset again.

2

[✓] Include domain restrictions?

Domain Restrictions: Advertising & Marketing ×, Navigation & Mobility ×

[✓] Include coverage restrictions?

Coverage Restrictions: Europe ×

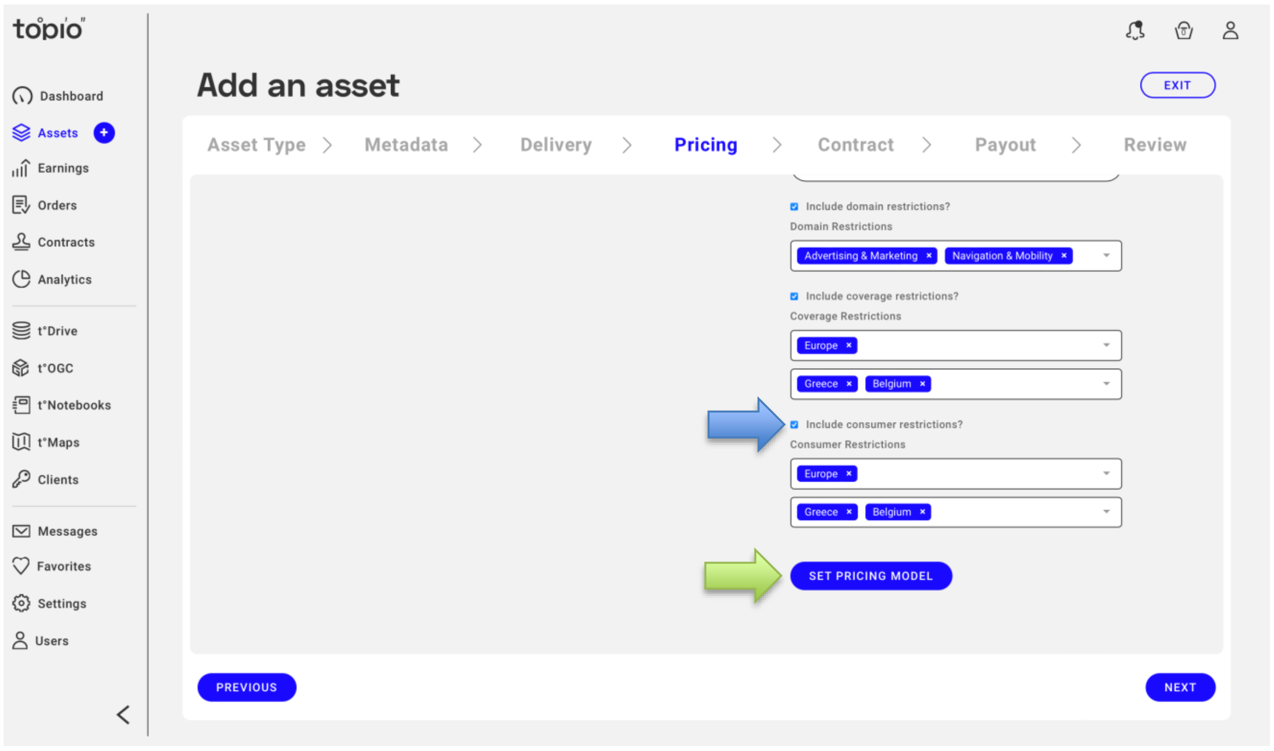
Greece ×, Belgium ×

[ ] Include consumer restrictions?

SET PRICING MODEL

Figure 10: Setting coverage restrictions for the asset

The seller can also enable consumer-related restrictions, according to which, the asset can prohibit sales to clients from specific regions/countries around the world. To do so, she must check the "Include consumer restrictions?" check box (blue arrow in Figure 11). These are applied in the exact same manner as the coverage restrictions.



Include domain restrictions?
Domain Restrictions: Advertising & Marketing, Navigation & Mobility

Include coverage restrictions?
Coverage Restrictions: Europe; Greece, Belgium

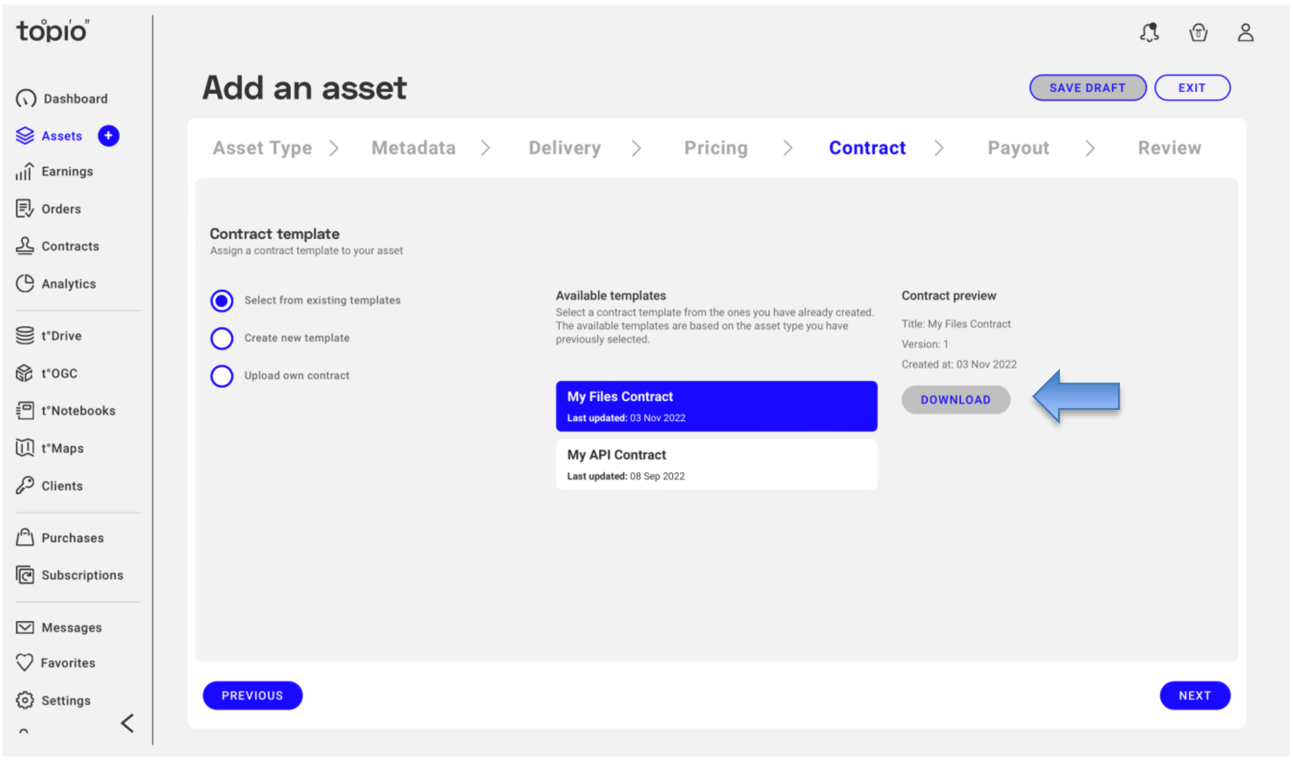
Include consumer restrictions?
Consumer Restrictions: Europe; Greece, Belgium

Figure 11: Setting consumer restrictions for the asset

After filling-in all the required fields and selecting any desired restrictions, the supplier can add the pricing model to the data asset, by clicking on the "Set Pricing Model" button, indicated with a green arrow in Figure 11.

1.2.4. Contract Terms

The next step involves choosing a *contract template* (Figure 12), which specifies the terms and conditions for selling this new data asset. As discussed in D1.5, a supplier can prepare several contract templates. For instance, a contract template may concern the acquisition of vector data assets as files, another one their availability through an API, etc., each one with possibly different conditions. If the supplier wishes to choose an *existing contract template* for the new asset, the list of his previously created contract templates appears so that she can select the one and apply one of the prepared templates. The chosen template is highlighted (in blue background color) and it can be downloaded as a PDF file for preview by clicking on the "Download" button on the right side (blue arrow in Figure 12).



Contract template
Assign a contract template to your asset

[✓ Select from existing templates]
Create new template
Upload own contract

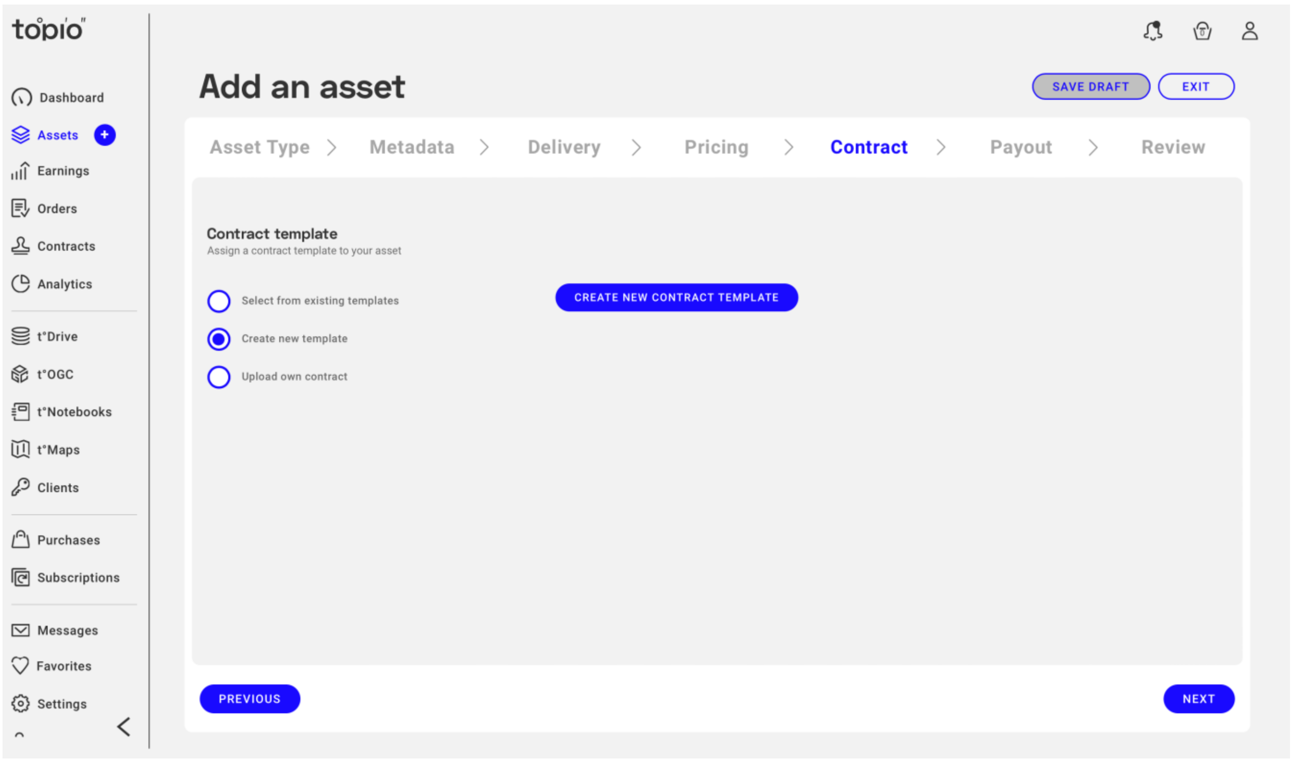
Available templates
Select a contract template from the ones you have already created. The available templates are based on the asset type you have previously selected.

My Files Contract
Last updated: 03 Nov 2022

My API Contract
Last updated: 08 Sep 2022

Contract preview
Title: My Files Contract
Version: 1
Created at: 03 Nov 2022

Figure 12: Specifying a contract template for a new asset



Contract template
Assign a contract template to your asset

Select from existing templates
[✓ Create new template]
Upload own contract

Figure 13: Creating a new contract template

Alternatively, the supplier can create a new contract template. By selecting the “Create new Template” radio button and then clicking on “Create New Contract Template” (Figure 13), a step-by-step wizard is launched and enables the provider to specify all his preferences regarding this new contract template. As shown in Figure 14, the first step involves specification of the type for this template contract, by choosing one of the platform’s master contracts.

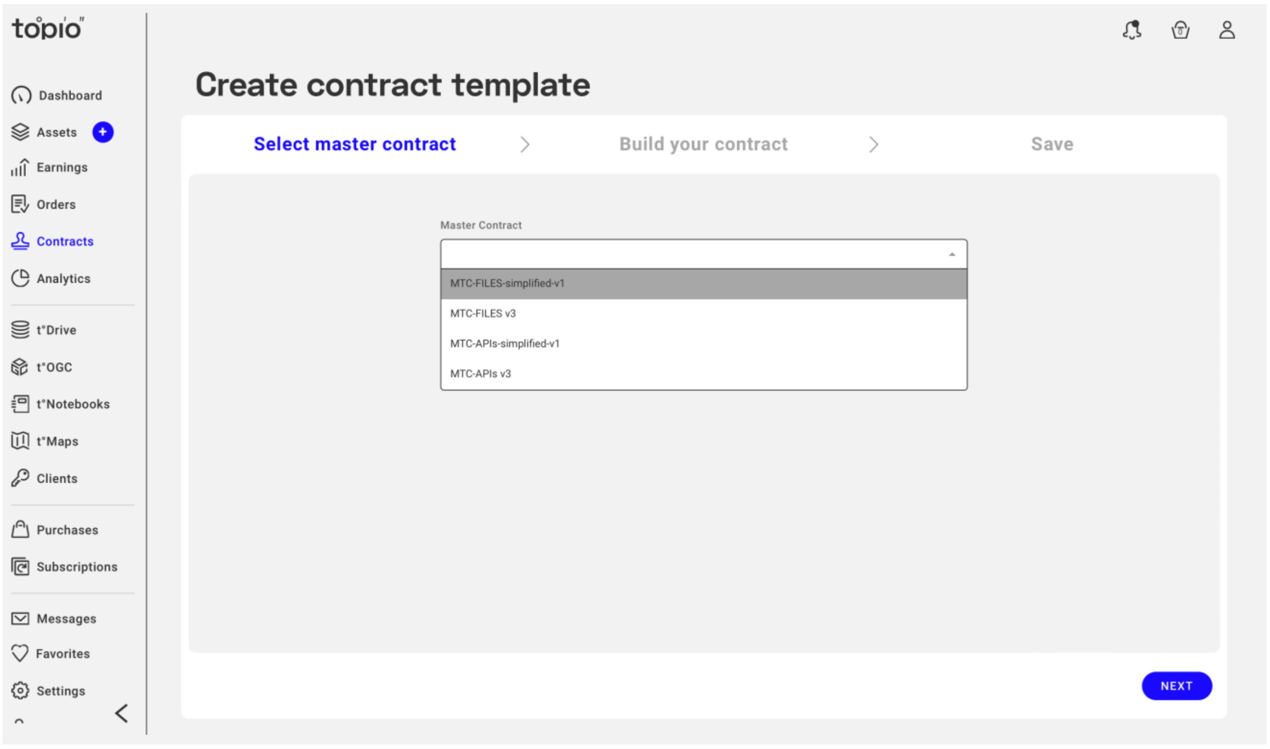
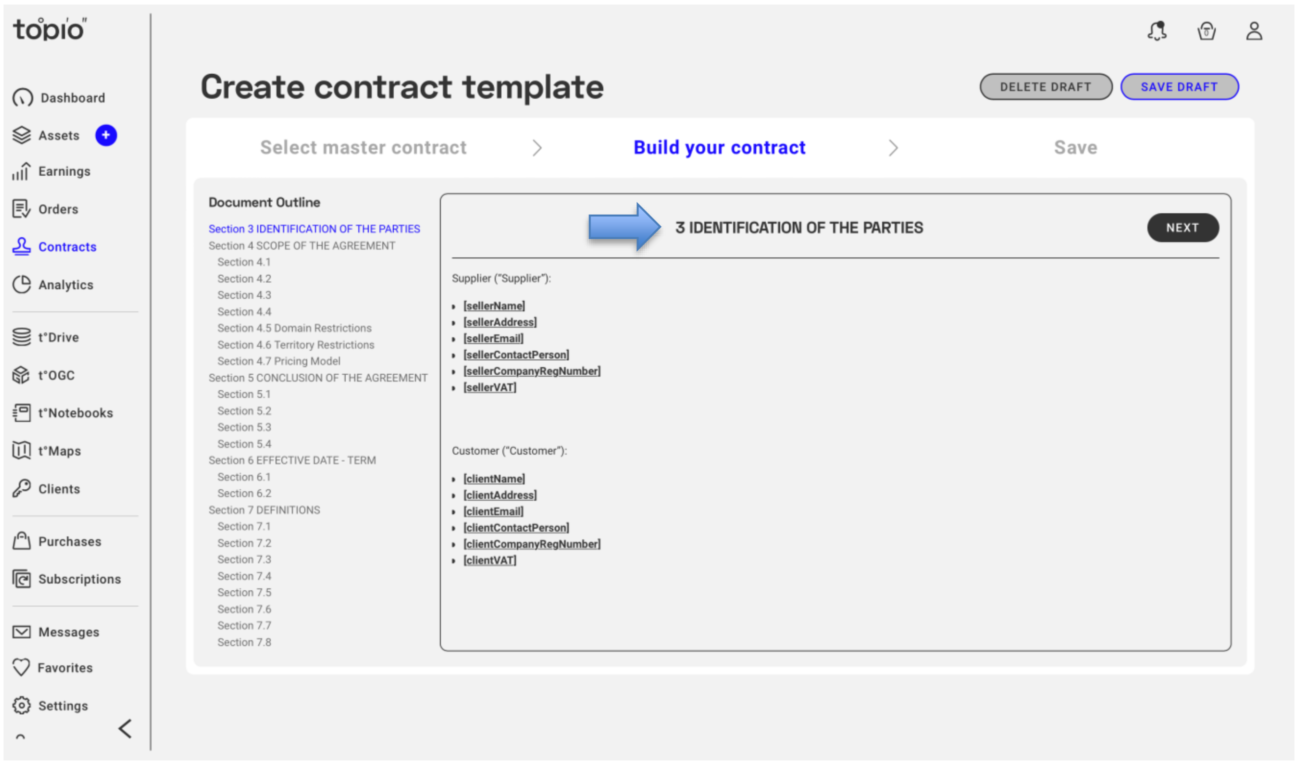


Figure 14: Selecting master contract for a contract template

The next step (Figure 15), enables the supplier to build his contract template section by section, by selecting the terms and conditions of her choice from those specified in the master template. At this stage, the supplier is able to discard non-mandatory terms (blue arrow in Figure 16) and also choose among available options for specific sections (e.g., domain restrictions, as in Figure 17). At some steps, the supplier may be also notified that the respective section cannot change, but she can still view it as it will appear in the template (see Figure 15).



Create contract template

Document Outline

Section 3 IDENTIFICATION OF THE PARTIES
Section 4 SCOPE OF THE AGREEMENT
Section 4.1
Section 4.2
Section 4.3
Section 4.4
Section 4.5 Domain Restrictions
Section 4.6 Territory Restrictions
Section 4.7 Pricing Model
Section 5 CONCLUSION OF THE AGREEMENT
Section 5.1
Section 5.2
Section 5.3
Section 5.4
Section 6 EFFECTIVE DATE - TERM
Section 6.1
Section 6.2
Section 7 DEFINITIONS
Section 7.1
Section 7.2
Section 7.3
Section 7.4
Section 7.5
Section 7.6
Section 7.7
Section 7.8

3 IDENTIFICATION OF THE PARTIES

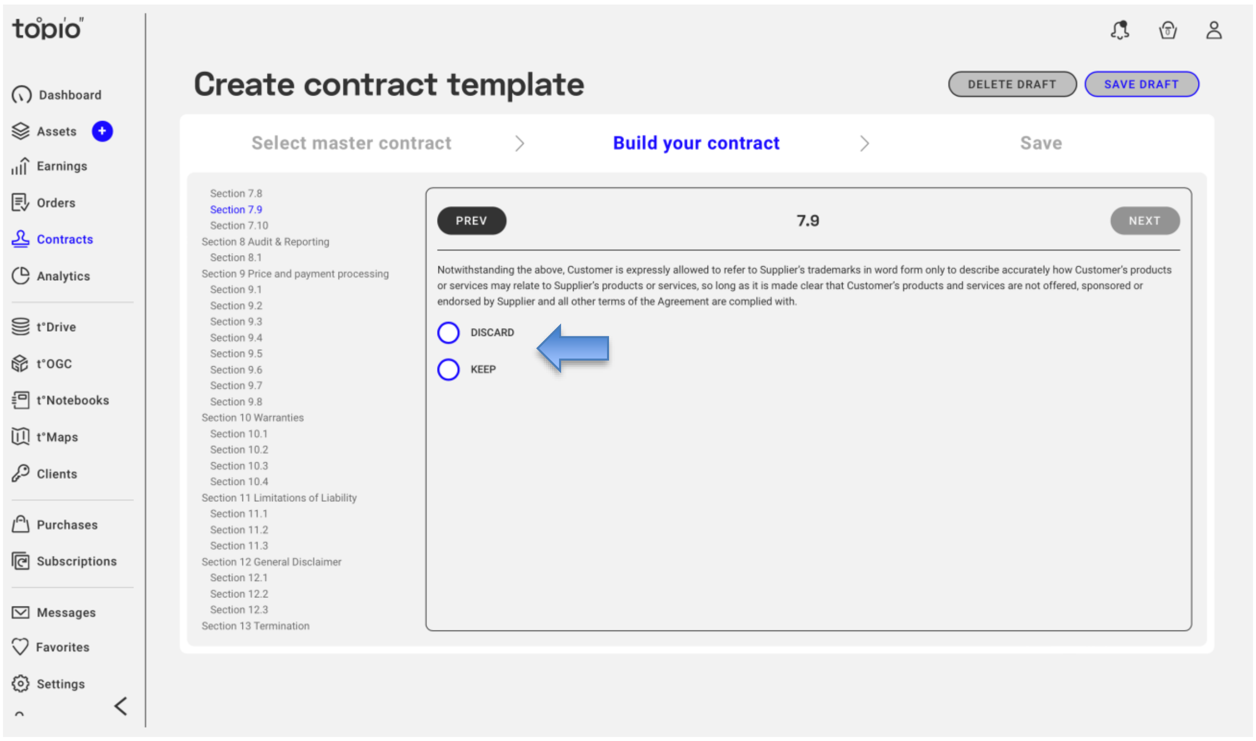
Supplier ("Supplier"):

- [sellerName]
- [sellerAddress]
- [sellerEmail]
- [sellerContactPerson]
- [sellerCompanyRegNumber]
- [sellerVAT]

Customer ("Customer"):

- [clientName]
- [clientAddress]
- [clientEmail]
- [clientContactPerson]
- [clientCompanyRegNumber]
- [clientVAT]

Figure 15: Building a contract template section per section



Create contract template

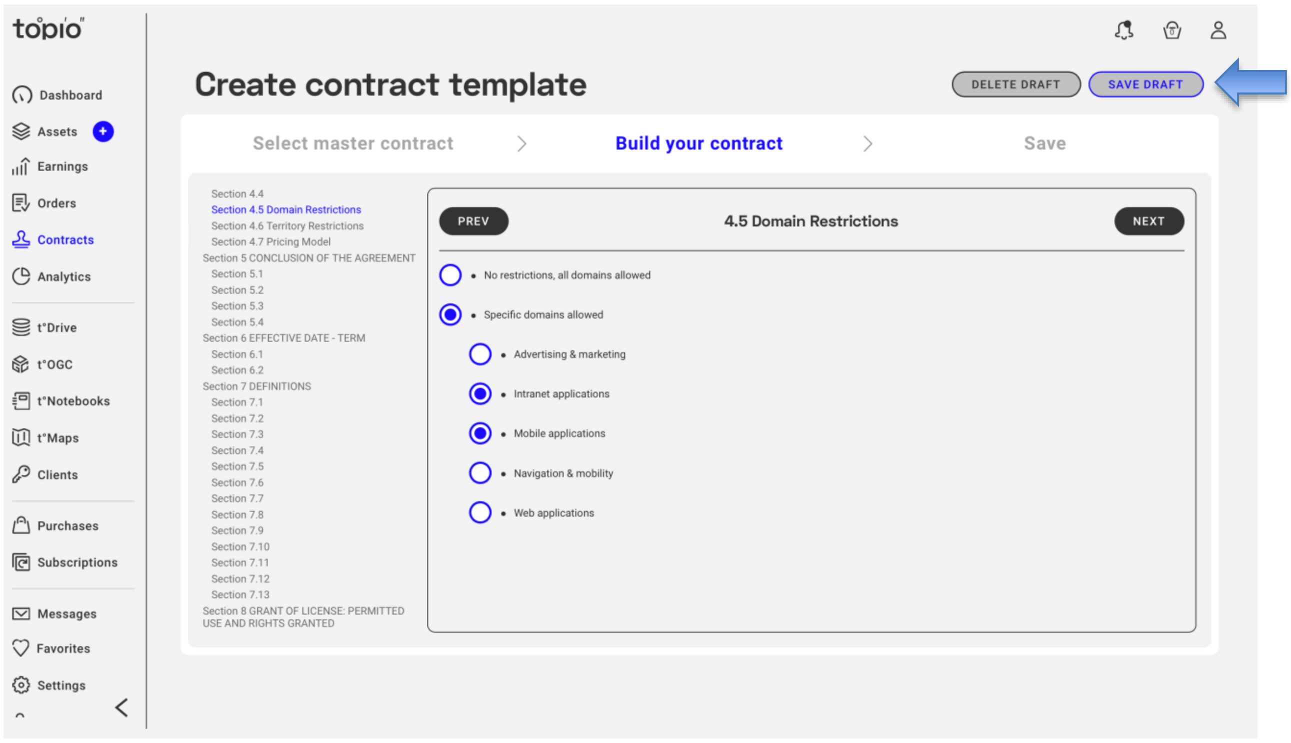
Section 7.8
Section 7.9
Section 7.10
Section 8 Audit & Reporting
Section 8.1
Section 9 Price and payment processing
Section 9.1
Section 9.2
Section 9.3
Section 9.4
Section 9.5
Section 9.6
Section 9.7
Section 9.8
Section 10 Warranties
Section 10.1
Section 10.2
Section 10.3
Section 10.4
Section 11 Limitations of Liability
Section 11.1
Section 11.2
Section 11.3
Section 12 General Disclaimer
Section 12.1
Section 12.2
Section 12.3
Section 13 Termination

7.9

Notwithstanding the above, Customer is expressly allowed to refer to Supplier's trademarks in word form only to describe accurately how Customer's products or services may relate to Supplier's products or services, so long as it is made clear that Customer's products and services are not offered, sponsored or endorsed by Supplier and all other terms of the Agreement are complied with.

○ DISCARD
○ KEEP

Figure 16: Choosing whether to include a non-mandatory term



Create contract template

Section 4.4
Section 4.5 Domain Restrictions
Section 4.6 Territory Restrictions
Section 4.7 Pricing Model
Section 5 CONCLUSION OF THE AGREEMENT
Section 5.1
Section 5.2
Section 5.3
Section 5.4
Section 6 EFFECTIVE DATE - TERM
Section 6.1
Section 6.2
Section 7 DEFINITIONS
Section 7.1
Section 7.2
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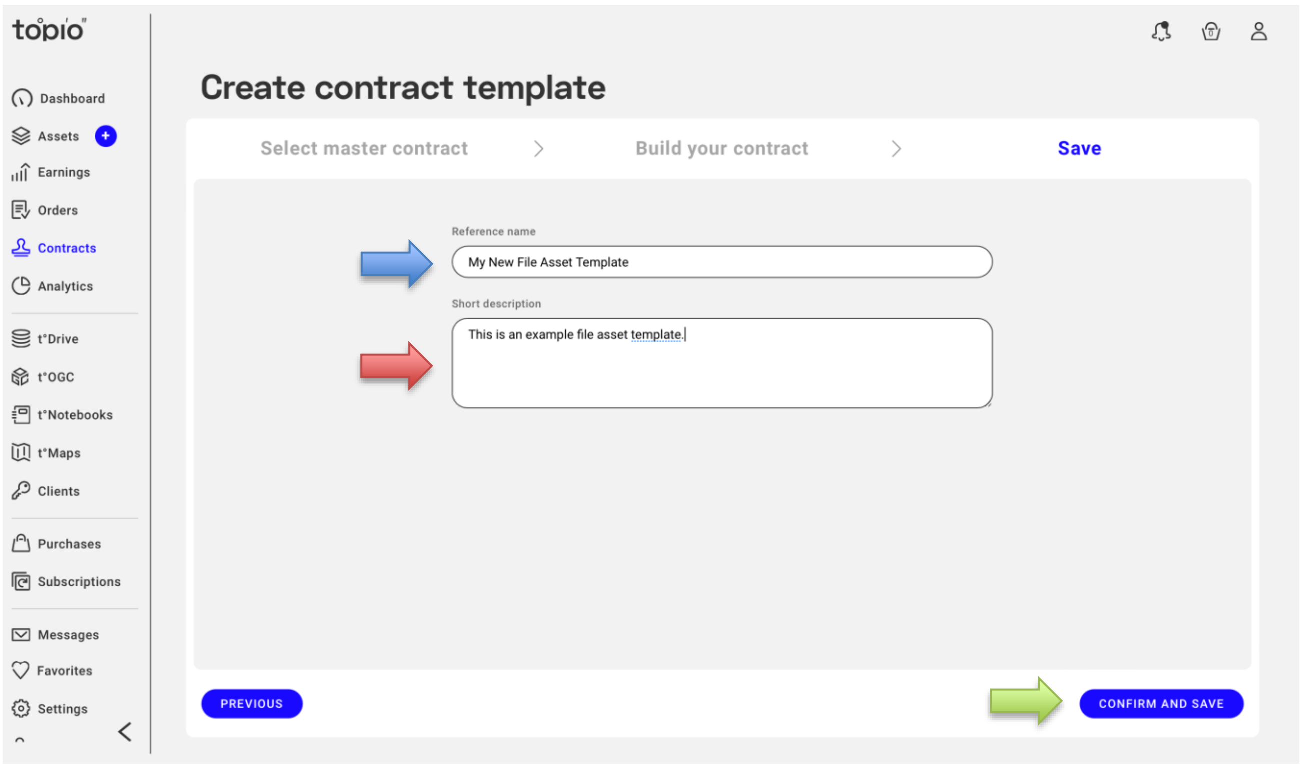
Section 7.4
Section 7.5
Section 7.6
Section 7.7
Section 7.8
Section 7.9
Section 7.10
Section 7.11
Section 7.12
Section 7.13
Section 8 GRANT OF LICENSE: PERMITTED USE AND RIGHTS GRANTED

4.5 Domain Restrictions

- No restrictions, all domains allowed
- [✓ Specific domains allowed]
  - Advertising & marketing
  - [✓ Intranet applications]
  - [✓ Mobile applications]
  - Navigation & mobility
  - Web applications

Figure 17: Choosing a particular option for specific section of a contract template

Once all sections of the template have been compiled and the necessary options of the master template have been specified by the supplier, she is navigated to the last page of the wizard, where she can save and publish her template contract (see Figure 18). At any stage during the process, through the control buttons (blue arrow in Figure 17), the supplier can either save this template as a *draft*, to continue later with its editing, or discard it entirely by clicking on the “Delete Draft” button. At the last wizard step, the supplier can optionally specify a name and a short description for future reference (blue and red arrows in Figure 18). To finalize and store the contract template, the supplier must click on the “Confirm and Save” button (green arrow in Figure 18). Doing so, saves and publishes the template contract and she is redirected to her contract list; there, she can access her newly created template contract (red arrow in Figure 19) which is in a “Published” state. In the case the supplier chooses to save the contract as draft, the template appears in her list of template contracts and is marked as “Draft” (blue arrow in Figure 19).

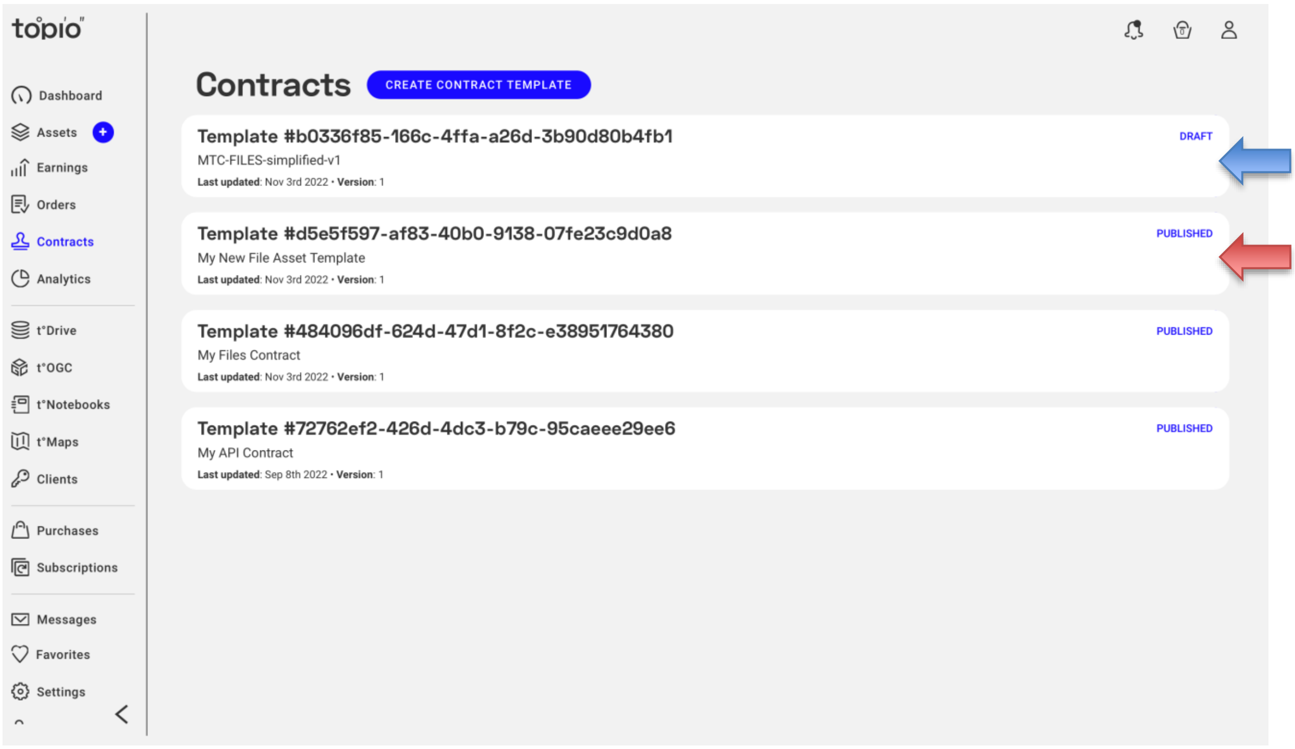


Create contract template

Reference name: My New File Asset Template

Short description: This is an example file asset template.

Figure 18: Save a contract template



Contracts

Template #b0336f85-166c-4ffa-a26d-3b90d80b4fb1 — DRAFT
MTC-FILES-simplified-v1
Last updated: Nov 3rd 2022 • **Version**: 1

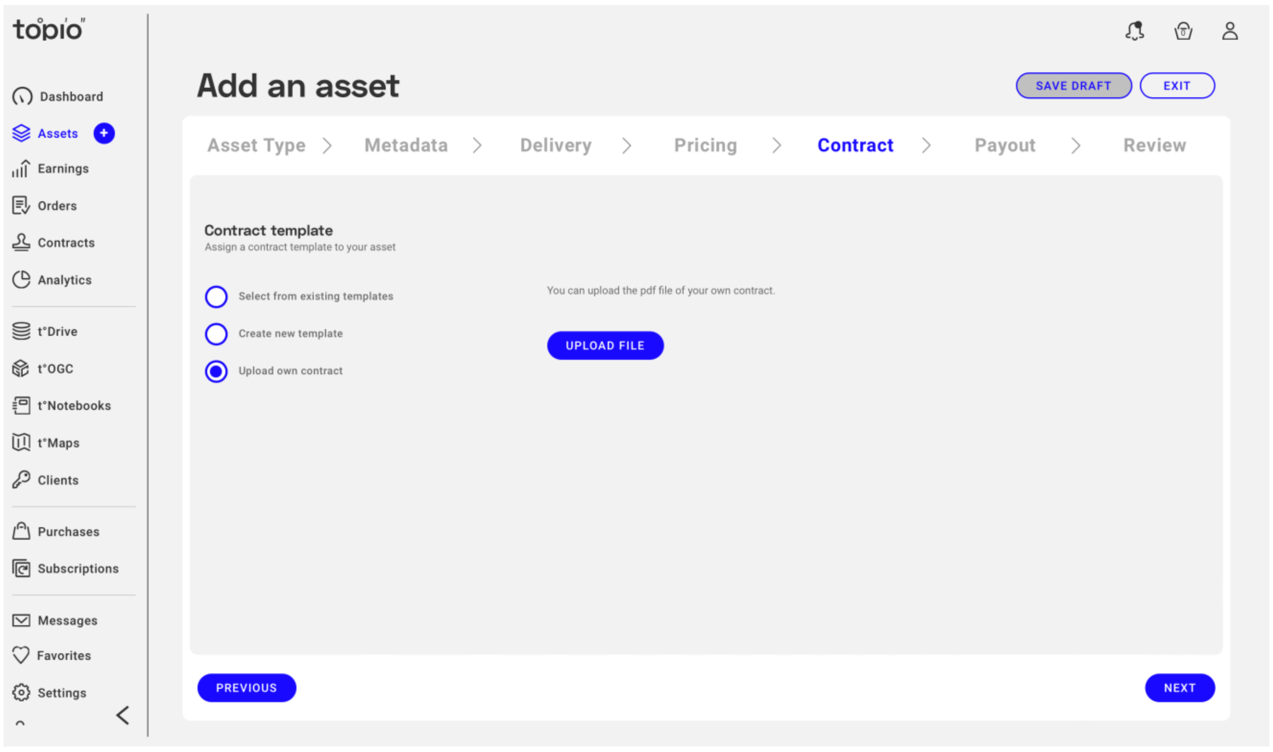
Template #d5e5f597-af83-40b0-9138-07fe23c9d0a8 — PUBLISHED
My New File Asset Template
Last updated: Nov 3rd 2022 • **Version**: 1

Template #484096df-624d-47d1-8f2c-e38951764380 — PUBLISHED
My Files Contract
Last updated: Nov 3rd 2022 • **Version**: 1

Template #72762ef2-426d-4dc3-b79c-95caeee29ee6 — PUBLISHED
My API Contract
Last updated: Sep 8th 2022 • **Version**: 1

Figure 19: Template contract list

Finally, suppliers can upload their own contract by selecting the “Upload Own Contract” radio button (see Figure 20). This essentially bypasses the standard publishing flow; this process has been implemented but *is not currently available for suppliers*. Once a supplier chooses this option, a template contract can be uploaded to the platform in pdf format and will be presented as is to all prospective customers of this asset in the marketplace. This is clearly marked in the wizard, so that the supplier becomes aware that this contract will be visible (and downloadable as pdf) at the View Asset page. Customers will be able to view the proprietary contract terms for this asset; a link is provided for downloading the pdf file.



Add an asset

Contract template

Assign a contract template to your asset

○ Select from existing templates

○ Create new template

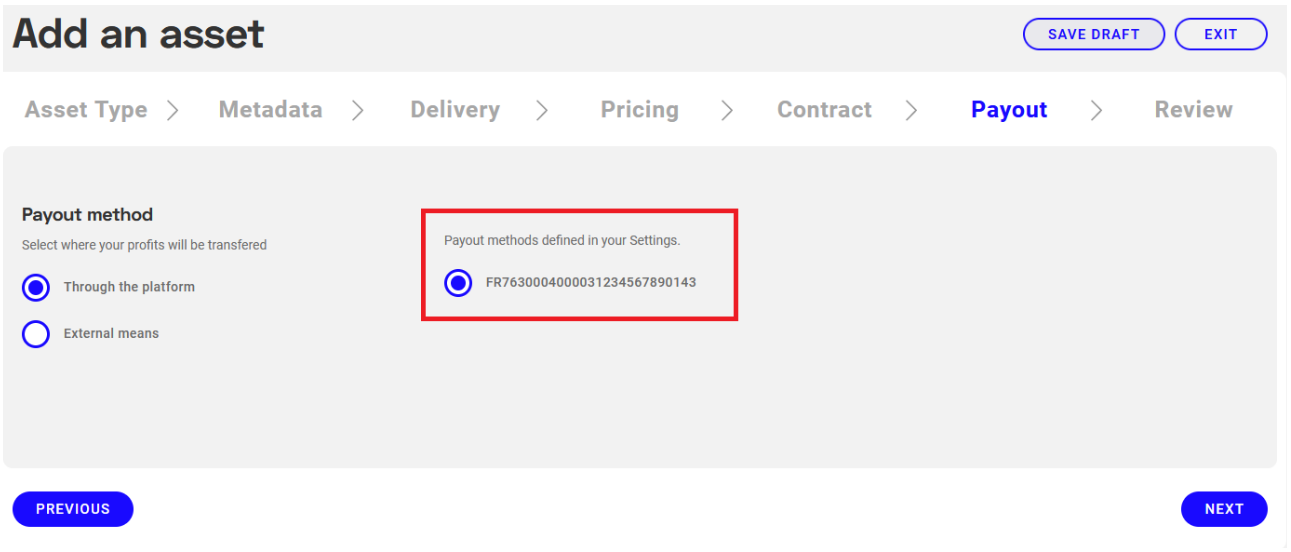
● Upload own contract

You can upload the pdf file of your own contract.

Figure 20: Upload own contract

1.2.5. Payout

The next step concerns payout options for the new asset (Figure 21). In this form, the supplier selects how she will get all payments from future customers of her new asset. Payments may be carried out *through the platform* if the supplier has specified payout methods of her preference, usually an IBAN bank account as specified in her Dashboard Settings. In this case, payments are handled by the marketplace and the supplier's account will be reimbursed with the revenues.


Add an asset

SAVE DRAFT EXIT

Asset Type > Metadata > Delivery > Pricing > Contract > Payout > Review

Payout method

Select where your profits will be transfered

[✓ Through the platform]

External means

Payout methods defined in your Settings.

[✓ FR7630004000031234567890143]

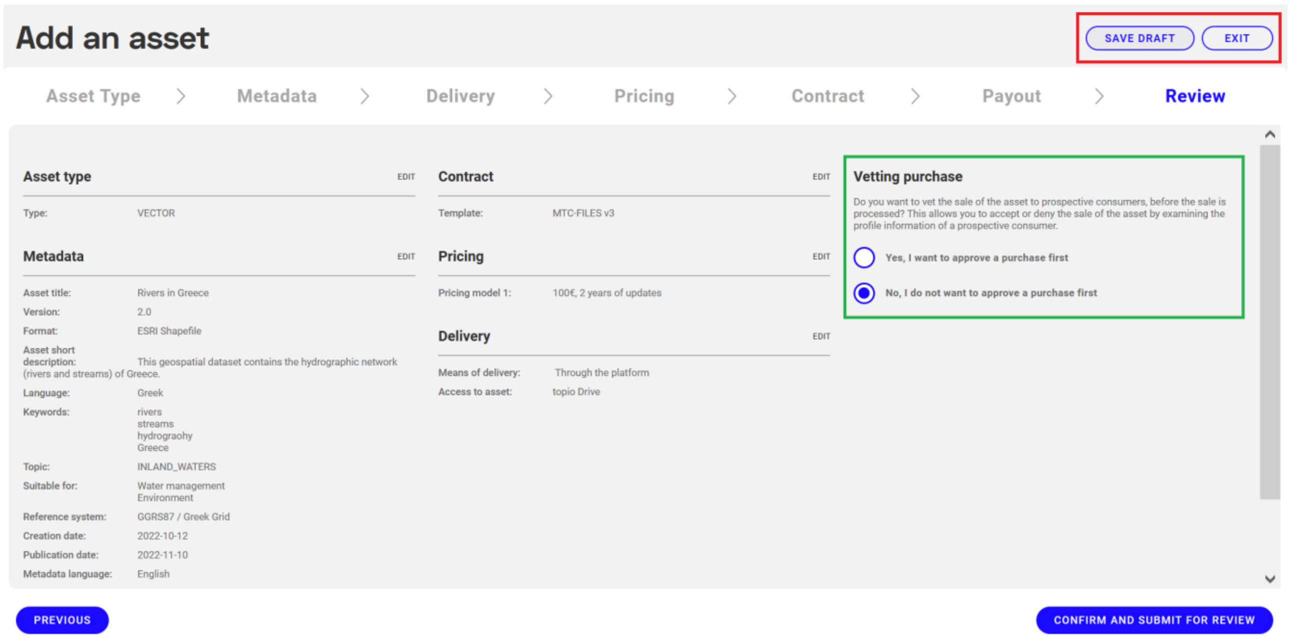
PREVIOUS NEXT

Figure 21: Payout options for a new asset

1.2.6. Review

At the final step, the supplier can check all the options she has made in the previous steps regarding this new asset (Figure 22). Any choices at a particular step can be modified by going back to the respective tab (e.g., pricing). Most importantly, the supplier has also the option to *vet purchases* of assets, as highlighted in the green box. This functionality covers the case where the supplier may wish to approve every purchase of this asset *before* the sale is processed and the asset is delivered to customers. If this vetting option is activated, the supplier must accept or deny each sale by examining the profile information of a prospective customer *prior to every sale*.

Of course, at any stage of the publication process the supplier can save as a *draft asset* all information she has entered, so that she can continue and finish it later. After examining all choices and verifying they are in accordance with her preferences, the supplier can press the *confirmation* button (at the bottom right corner in Figure 22) and submit this asset for *review* by the Helpdesk of the platform.



Asset type

Type:	VECTOR

Metadata

Asset title:	Rivers in Greece
Version:	2.0
Format:	ESRI Shapefile
Asset short description:	This geospatial dataset contains the hydrographic network (rivers and streams) of Greece.
Language:	Greek
Keywords:	rivers streams hydrograohy Greece
Topic:	INLAND_WATERS
Suitable for:	Water management Environment
Reference system:	GGRS87 / Greek Grid
Creation date:	2022-10-12
Publication date:	2022-11-10
Metadata language:	English

Contract

Template:	MTC-FILES v3

Pricing

Pricing model 1:	100€, 2 years of updates

Delivery

Means of delivery:	Through the platform
Access to asset:	topio Drive

Vetting purchase

Do you want to vet the sale of the asset to prospective consumers, before the sale is processed? This allows you to accept or deny the sale of the asset by examining the profile information of a prospective consumer.

Yes, I want to approve a purchase first [✓ No, I do not want to approve a purchase first]

Figure 22: Summary of asset information before submission to the platform

Note that the new asset does not get immediately published, but only if it has been successfully approved by the platform's Helpdesk once all necessary details regarding the asset are considered valid. The supplier is notified accordingly, as shown in Figure 23. The asset is given a persistent identifier (*PID*) for reference in the future, even if the asset does not get finally published for any reason. In case of issues regarding this asset, the supplier is notified by the platform's Helpdesk with a message, so that she can make the necessary changes and resubmit the asset.

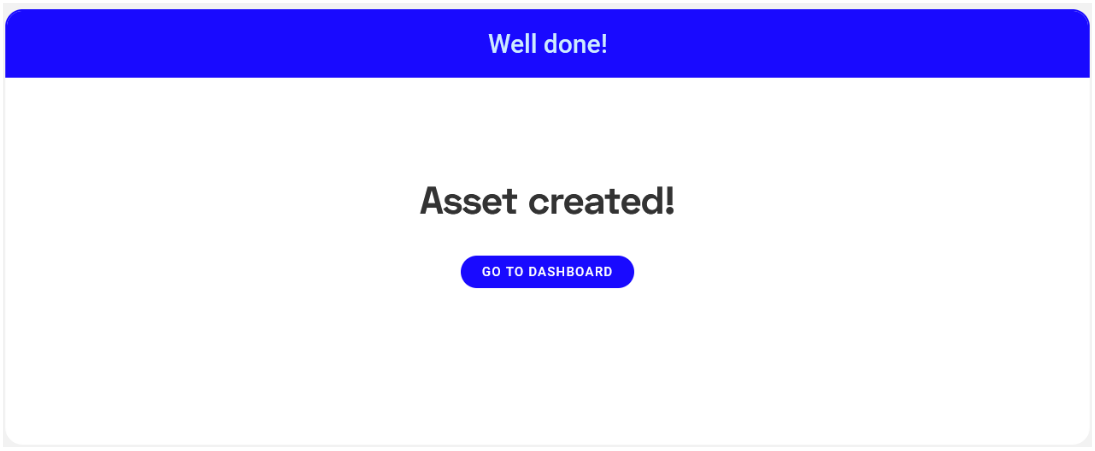


Figure 23: New asset submitted for review by the Helpdesk

1.3. Adding an open file asset

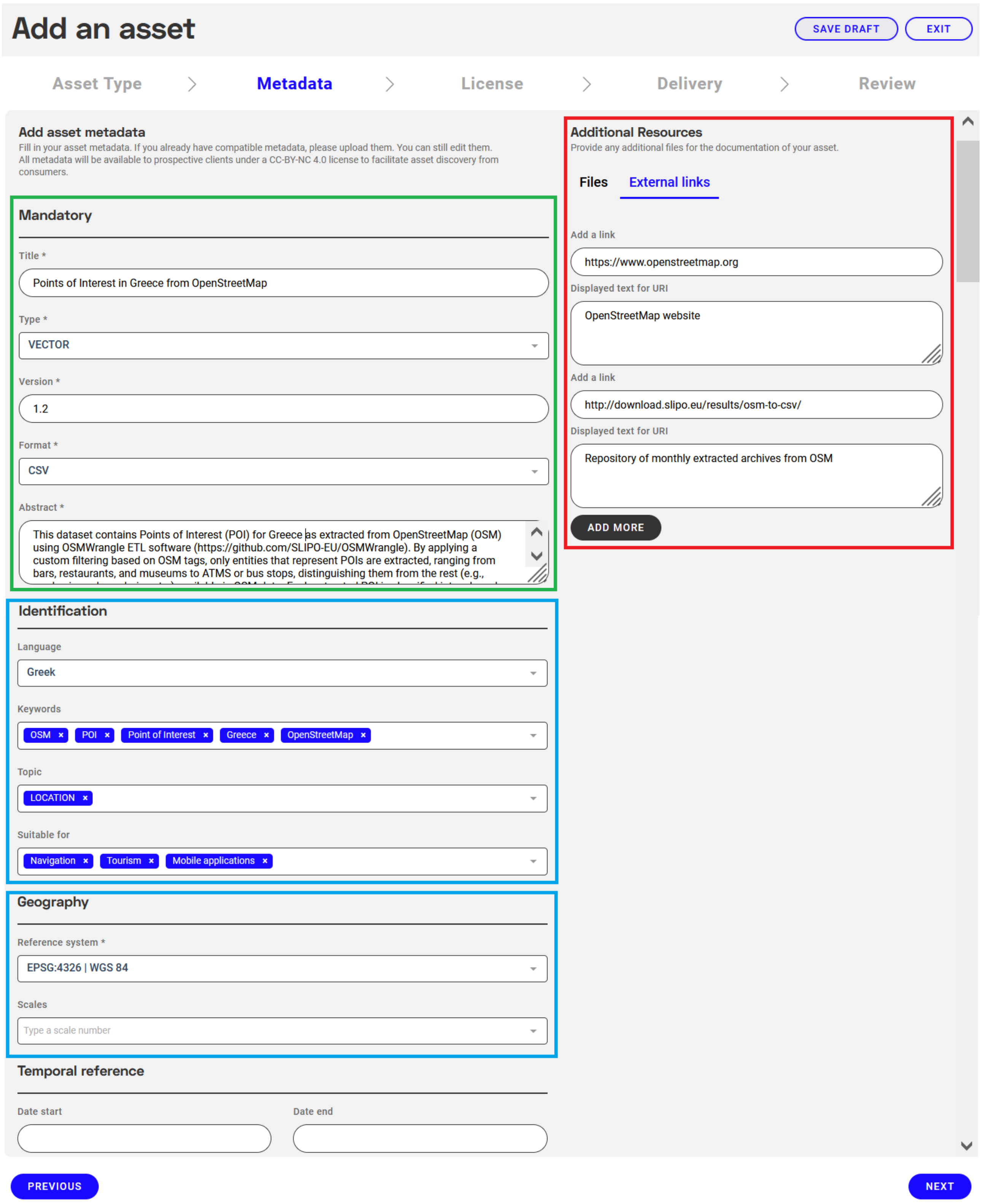
This wizard is reserved for the Topio Admin account only; no other supplier can publish open data assets. In order to add an *open file asset* (from the menu shown in Figure 2), a step-by-step process is applied in a fashion similar to that used for publishing data files (Section 1.2). Again, such open files concern four different types of assets (*vector, tabular, raster, NetCDF*) widely used in geospatial applications and services. However, the wizard is customized specifically for open file assets, which do not include options for pricing, contract, and payout, given that such assets are available for free. Instead, the supplier must specify the type of license applicable for this asset. More specifically, publishing an open asset involves the following stages:

1.3.1. Metadata

This step specifies standard metadata information for the open file asset similar to that for data file assets. As depicted in Figure 24, this form is organized in sections, where the supplier can specify the various metadata elements.

Table 1 lists the various sections of metadata items with the details for each particular element. Note that certain metadata elements are *mandatory* (enclosed in the green box in Figure 24), while the rest are *optional* (highlighted in the blue boxes). However, the more complete metadata is specified, the more chances for this asset to qualify in the various criteria set by users of the platform during search (Section 2.1). This standard metadata are available in the platform under a CC-BY-NC 4.0 license to facilitate asset discovery.

Besides, *additional metadata resources* can be specified (highlighted in the red box in Figure 24). For instance, these may include documents detailing the production process or the specifications of the asset, details on the attribute schema, as well as external links related to the asset, such as webpages with full documentation, use cases, videos, etc., thus offering prospective customers more information about this asset. Note that the platform does not alter or revise any of the specified standard metadata; after publication, these will appear in the asset view page as originally specified (Section 2.2.4).


Add an asset

Add asset metadata

Fill in your asset metadata. If you already have compatible metadata, please upload them. You can still edit them. All metadata will be available to prospective clients under a CC-BY-NC 4.0 license to facilitate asset discovery from consumers.

Mandatory

Title *: Points of Interest in Greece from OpenStreetMap

Type *: VECTOR

Version *: 1.2

Format *: CSV

Abstract *: This dataset contains Points of Interest (POI) for Greece as extracted from OpenStreetMap (OSM) using OSMWrangle ETL software (https://github.com/SLIPO-EU/OSMWrangle). By applying a custom filtering based on OSM tags, only entities that represent POIs are extracted, ranging from bars, restaurants, and museums to ATMS or bus stops, distinguishing them from the rest (e.g.,

Identification

Language: Greek

Keywords: OSM, POI, Point of Interest, Greece, OpenStreetMap

Topic: LOCATION

Suitable for: Navigation, Tourism, Mobile applications

Geography

Reference system *: EPSG:4326 | WGS 84

Scales: Type a scale number

Temporal reference

Date start:

Date end:

Additional Resources

Provide any additional files for the documentation of your asset.

Add a link: https://www.openstreetmap.org

Displayed text for URI: OpenStreetMap website

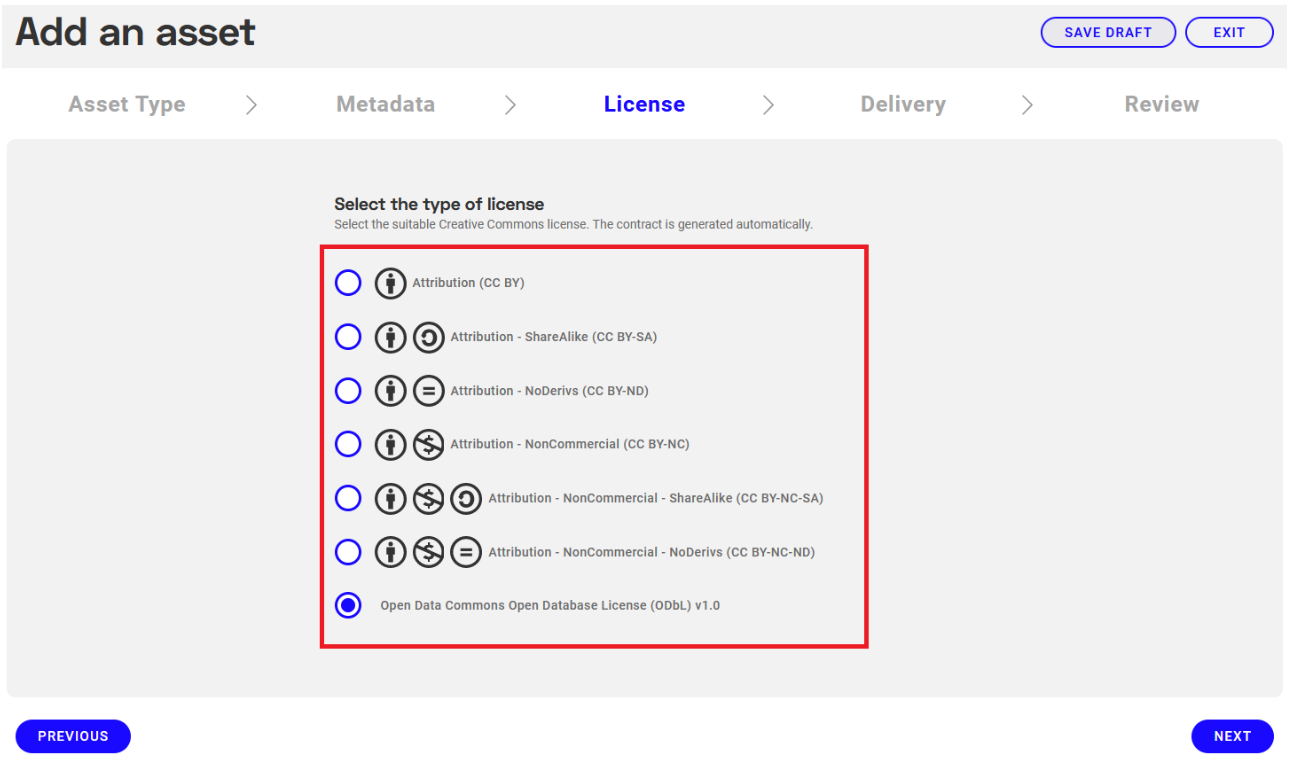
Add a link: http://download.slipo.eu/results/osm-to-csv/

Displayed text for URI: Repository of monthly extracted archives from OSM

Figure 24: Specifying metadata for a new open asset

1.3.2. License

In contrast to proprietary data files that can be purchased under contract terms specified by their supplier (Section 1.2.4), open assets will be available in the marketplace according to standard licenses widely used for such datasets. As shown in Figure 25, the Topio Admin can choose one of the license types in the list applicable to this asset (e.g., one of the Creative Commons licenses), and the respective terms and restrictions will be generated automatically when the asset is purchased.



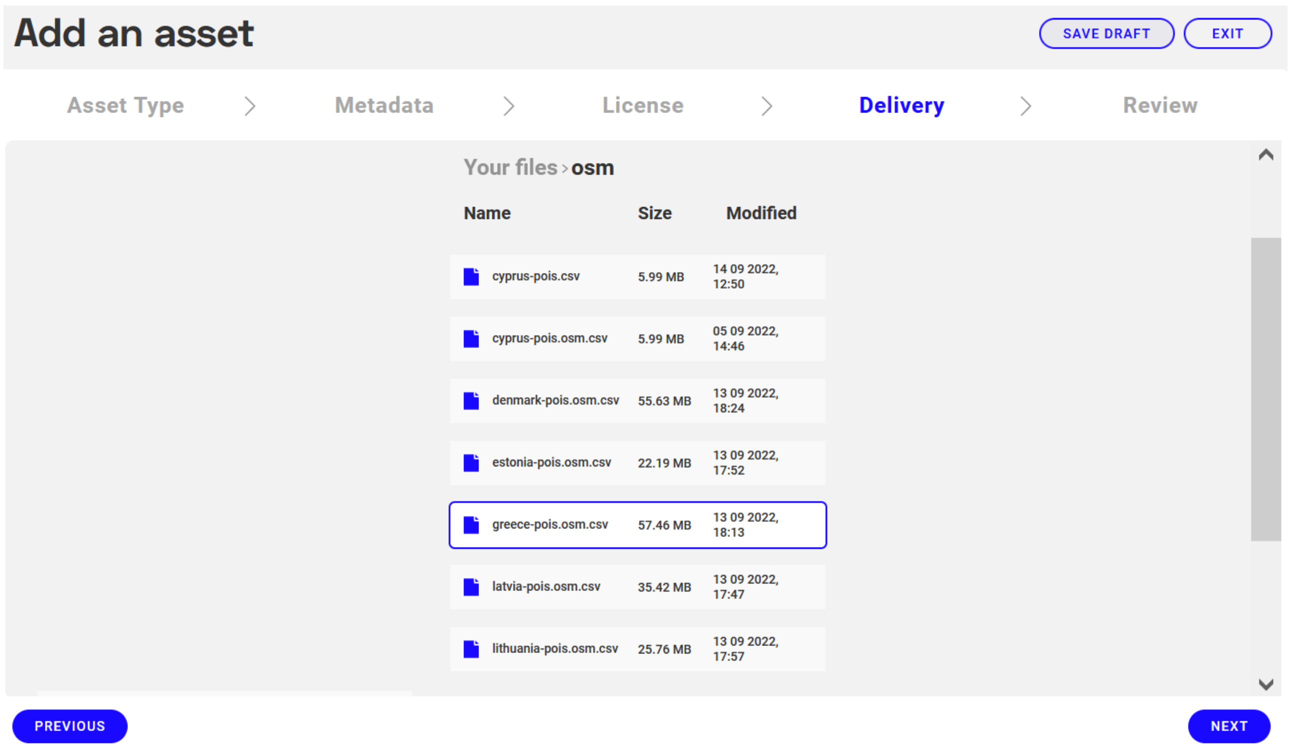
Select the type of license
Select the suitable Creative Commons license. The contract is generated automatically.

- ○ Attribution (CC BY)
- ○ Attribution - ShareAlike (CC BY-SA)
- ○ Attribution - NoDerivs (CC BY-ND)
- ○ Attribution - NonCommercial (CC BY-NC)
- ○ Attribution - NonCommercial - ShareAlike (CC BY-NC-SA)
- ○ Attribution - NonCommercial - NoDerivs (CC BY-NC-ND)
- [✓ Open Data Commons Open Database License (ODbL) v1.0]

Figure 25: Specifying the license for a new open asset

1.3.3. Delivery

In this step, the supplier (i.e., the Topio Admin) must provide the actual data file for this open asset. This file may have been previously uploaded and already available in the Topio Drive, so the supplier can navigate through its directories and specify it as shown in Figure 26. Alternatively, the supplier may enter a URL link (like an https site or Dropbox) where this file is publicly available. Once the asset is submitted to the backend, the publishing workflow will visit this URL, acquire the file and process it.



Your files › osm

Name	Size	Modified
cyprus-pois.csv	5.99 MB	14 09 2022, 12:50
cyprus-pois.osm.csv	5.99 MB	05 09 2022, 14:46
denmark-pois.osm.csv	55.63 MB	13 09 2022, 18:24
estonia-pois.osm.csv	22.19 MB	13 09 2022, 17:52
greece-pois.osm.csv	57.46 MB	13 09 2022, 18:13
latvia-pois.osm.csv	35.42 MB	13 09 2022, 17:47
lithuania-pois.osm.csv	25.76 MB	13 09 2022, 17:57

Figure 26: Specifying the dataset in Topio Drive for a new open asset

1.3.4. Review

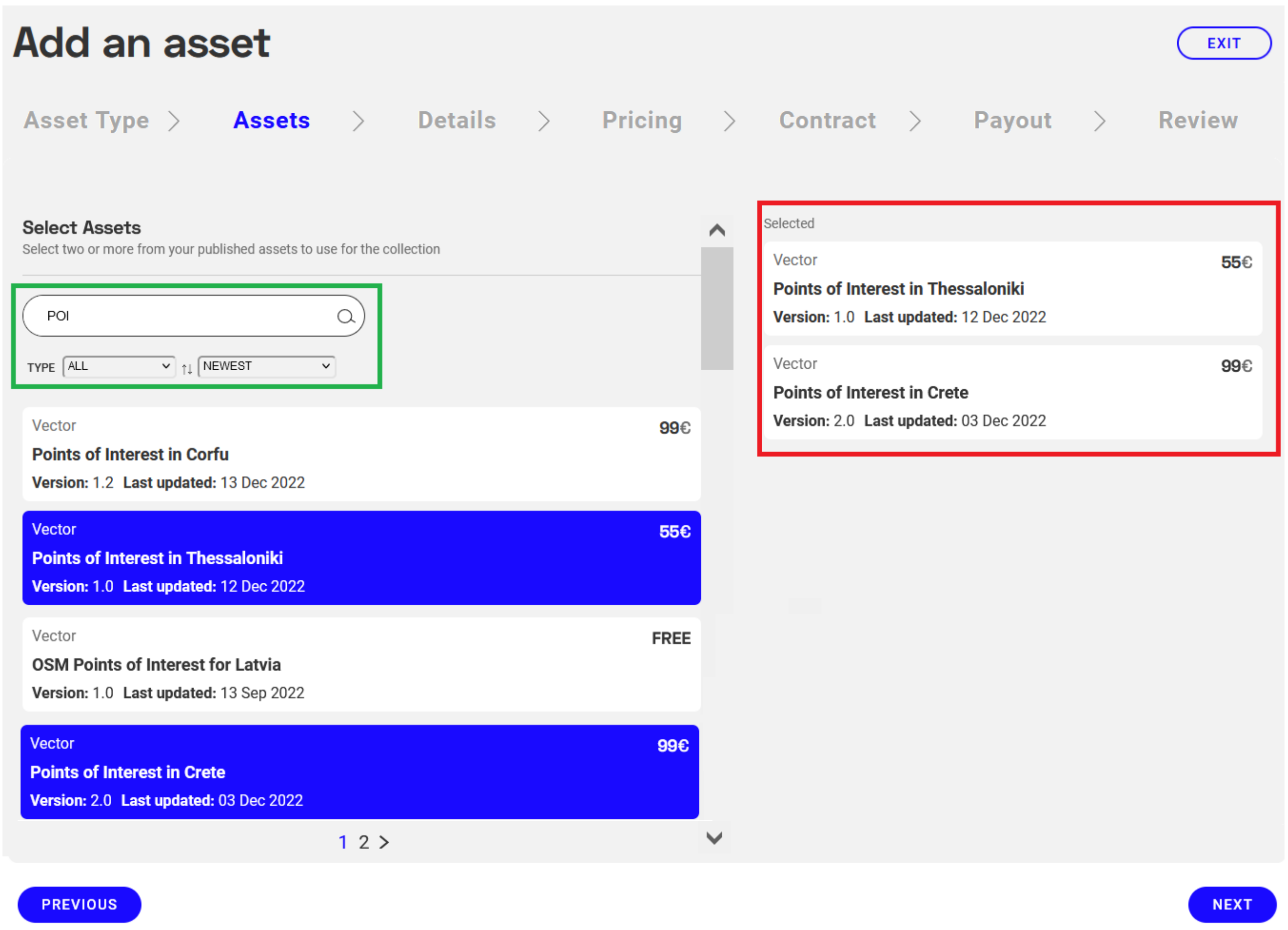
In this final step, the Topio Admin can inspect all settings specified for this open asset. If needed, he can go back to any previous stage and change any setting. In contrast to the review of data file assets (Section 1.2.6), no vetting can be specified for open assets. Once all settings are confirmed, the topio Admin can submit this asset to the backend; from that point, its handling in the backend is similar to that for data files, involving metadata checking and profile computation, review (accept/reject) of its automated metadata, and finally publication in the marketplace. The published asset will be shown to users of the marketplace as *Open* and *Free* of charge (i.e., no price) in the list of available assets.

1.4. Adding a collection of assets

A supplier can create *collections* from her data file assets and trade them as a new asset in the marketplace. Such a collection can include any of the already published data assets of the supplier, typically concerning datasets that are complementary (e.g., a road network dataset with another one concerning Points of Interest in the same area) or have been produced with the same specifications (e.g., digitization from imagery of two datasets concerning rivers and lakes, respectively). The supplier may choose to provide such assets as a collection, possibly at a discount price, by invoking the publishing wizard from her Dashboard.

1.4.1. Asset selection

Once the supplier chooses "*Collection*" as the asset type in the initial step of the publishing wizard (Figure 2), she is shown a list with all her published assets to choose the ones that will be included in the collection. As illustrated in Figure 27, the supplier can filter her assets by type and sort them by various criteria (date, title, type) in the list on the left in order to make her choices. Any items chosen in that list (highlighted in blue color), are shown as *selected* on the right (enclosed in the red box). The chosen assets will be bundled together as the new collection.


Add an asset

Select Assets
Select two or more from your published assets to use for the collection

POI
TYPE ALL ↑↓ NEWEST

Vector
Points of Interest in Corfu 99€
Version: 1.2 Last updated: 13 Dec 2022

Vector
Points of Interest in Thessaloniki 55€
Version: 1.0 Last updated: 12 Dec 2022

Vector
OSM Points of Interest for Latvia FREE
Version: 1.0 Last updated: 13 Sep 2022

Vector
Points of Interest in Crete 99€
Version: 2.0 Last updated: 03 Dec 2022

Selected

Vector
Points of Interest in Thessaloniki 55€
Version: 1.0 Last updated: 12 Dec 2022

Vector
Points of Interest in Crete 99€
Version: 2.0 Last updated: 03 Dec 2022

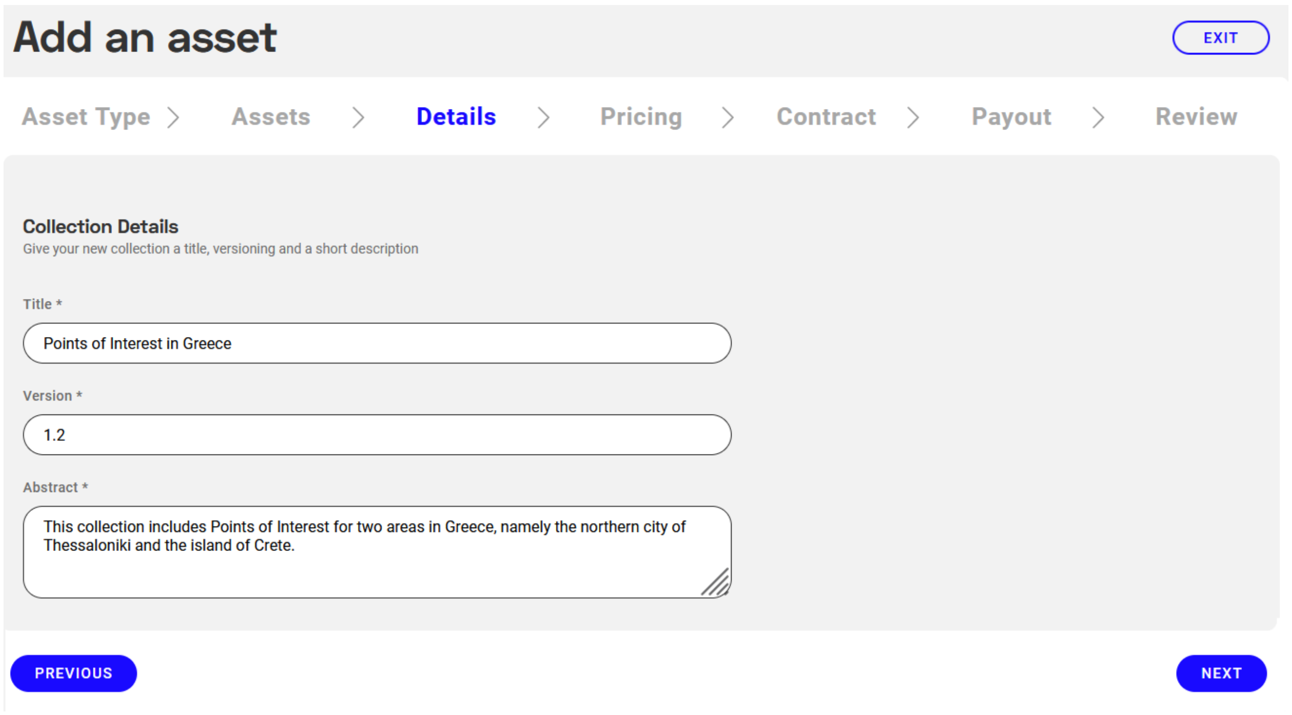
Figure 27: Choosing assets to include in a collection

1.4.2. Collection details

In the second step of the wizard, the supplier must give a few details (Figure 28) about the collection:

1. *Title* of the new collection,
2. *Version*, and
3. *Abstract* with a brief description of its contents.

Note that no other metadata is required for such a collection, given that its constituent assets are already published and each of them includes standard metadata (Section 1.2.1) as well as profiling information (automated metadata).



Collection Details
Give your new collection a title, versioning and a short description

Title *
Points of Interest in Greece

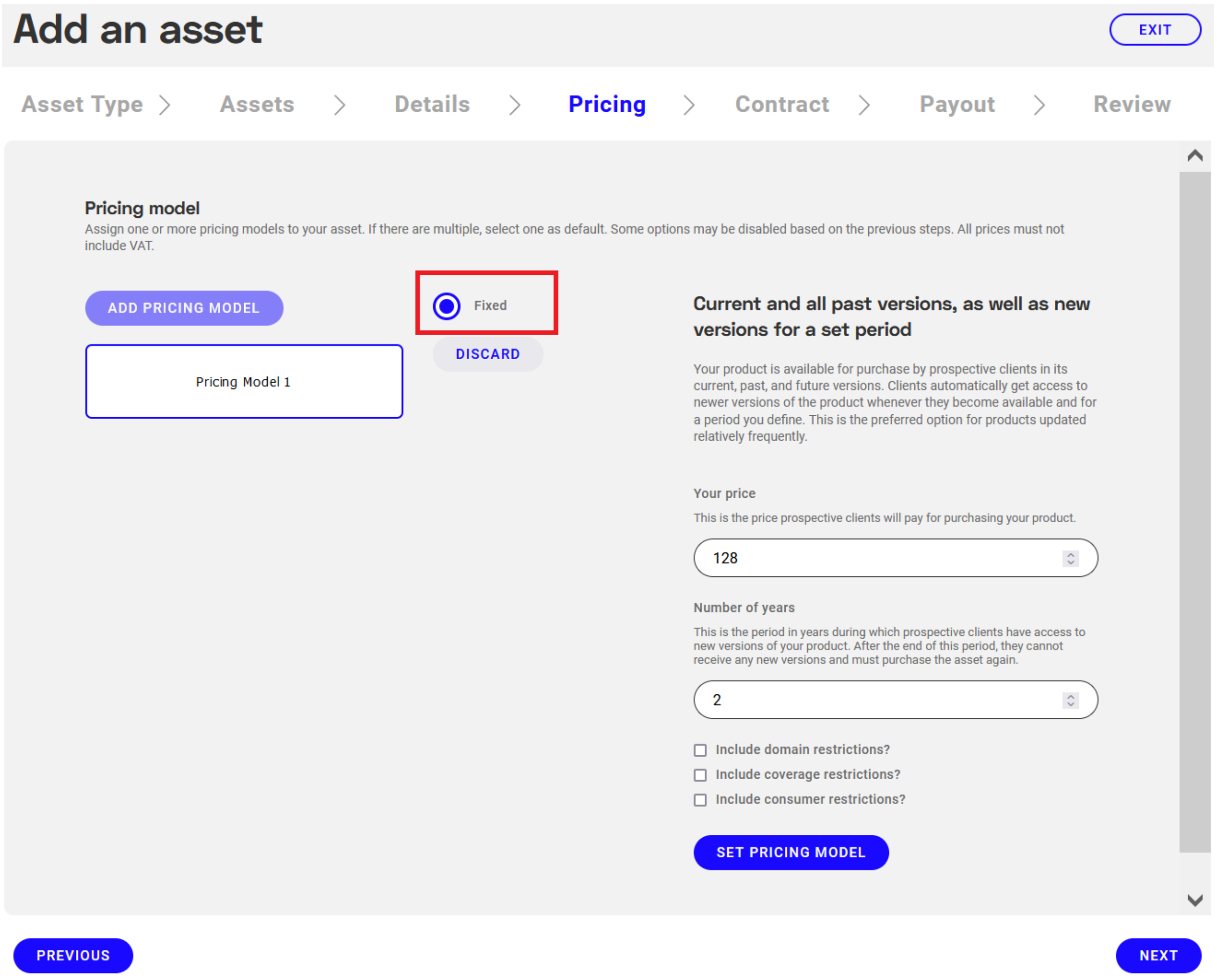
Version *
1.2

Abstract *
This collection includes Points of Interest for two areas in Greece, namely the northern city of Thessaloniki and the island of Crete.

Figure 28: Collection details

1.4.3. Pricing

Next, the supplier must specify the pricing model to be applied when a customer purchases this collection. As depicted in Figure 29, in contrast to data file assets (Section 1.2.3), the only available option is a *fixed price*, which may cover free updates for a specified number of years after purchase. Other models (per number of rows or by population) available for data assets are cumbersome to apply in case of asset collections with varying number of features or different spatial distribution per asset. Of course, the supplier can also specify *domain-, coverage- and consumer-related restrictions* to the provision of this collection through the platform.



Add an asset

Pricing model

Assign one or more pricing models to your asset. If there are multiple, select one as default. Some options may be disabled based on the previous steps. All prices must not include VAT.

Current and all past versions, as well as new versions for a set period

Your product is available for purchase by prospective clients in its current, past, and future versions. Clients automatically get access to newer versions of the product whenever they become available and for a period you define. This is the preferred option for products updated relatively frequently.

Your price

This is the price prospective clients will pay for purchasing your product.

128

Number of years

This is the period in years during which prospective clients have access to new versions of your product. After the end of this period, they cannot receive any new versions and must purchase the asset again.

2

☐ Include domain restrictions?

☐ Include coverage restrictions?

☐ Include consumer restrictions?

Figure 29: Specifying the pricing model of the new collection

1.4.4. Contract

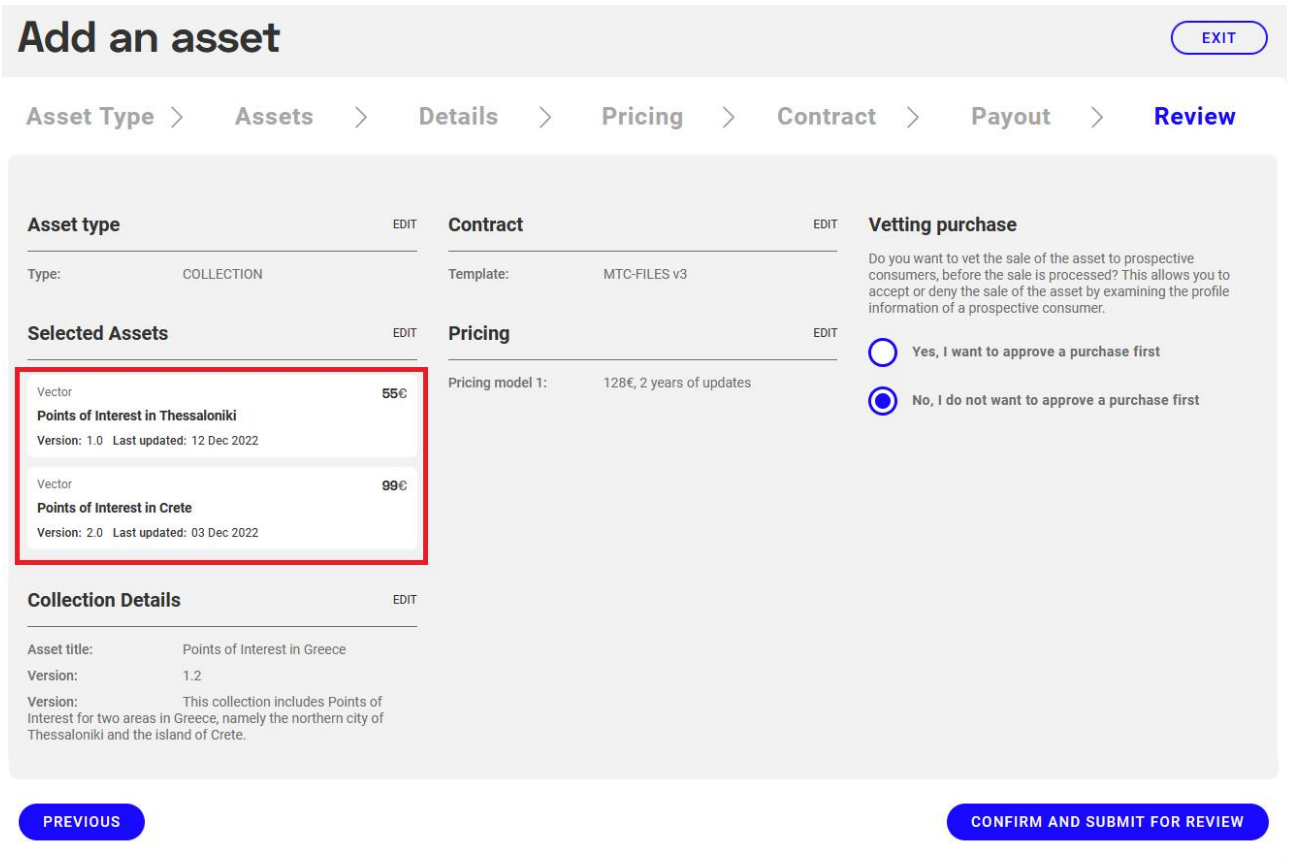
The contract options for a new collection are similar to those for data files (Figure 12) as discussed in Section 1.2.4.

1.4.5. Payout

The payout options for a new API asset are similar to those for data files (Figure 21) as discussed in Section 1.2.5.

1.4.6. Review

This final step enables the supplier to check all specified settings exactly as in the case of data file assets, including the vetting options (Figure 30). Note that the selected assets are shown in the list (enclosed in the red box), so that the supplier is aware which assets will be bundled together in the new collection. Once the supplier submits the collection, no uploading is required, and the collection goes directly for review by the Helpdesk. While the collection is still under review or remains a draft with some steps still incomplete, it is shown with a red notification at the top of the list of assets in the dashboard. Once the Helpdesk approves this draft collection, the supplier can view the draft collection as it will appear in the platform, and accept (or reject) its publication.


Add an asset
EXIT
Asset Type > Assets > Details > Pricing > Contract > Payout > Review
EDIT
PREVIOUS
CONFIRM AND SUBMIT FOR REVIEW

Asset type

Type: COLLECTION

Selected Assets

Vector — 55€
Points of Interest in Thessaloniki
Version: 1.0 Last updated: 12 Dec 2022

Vector — 99€
Points of Interest in Crete
Version: 2.0 Last updated: 03 Dec 2022

Collection Details

Asset title: Points of Interest in Greece
Version: 1.2
Version: This collection includes Points of Interest for two areas in Greece, namely the northern city of Thessaloniki and the island of Crete.

Contract

Template: MTC-FILES v3

Pricing

Pricing model 1: 128€, 2 years of updates

Vetting purchase

Do you want to vet the sale of the asset to prospective consumers, before the sale is processed? This allows you to accept or deny the sale of the asset by examining the profile information of a prospective consumer.

Yes, I want to approve a purchase first [✓ No, I do not want to approve a purchase first]

Figure 30: Review new asset collection before submission

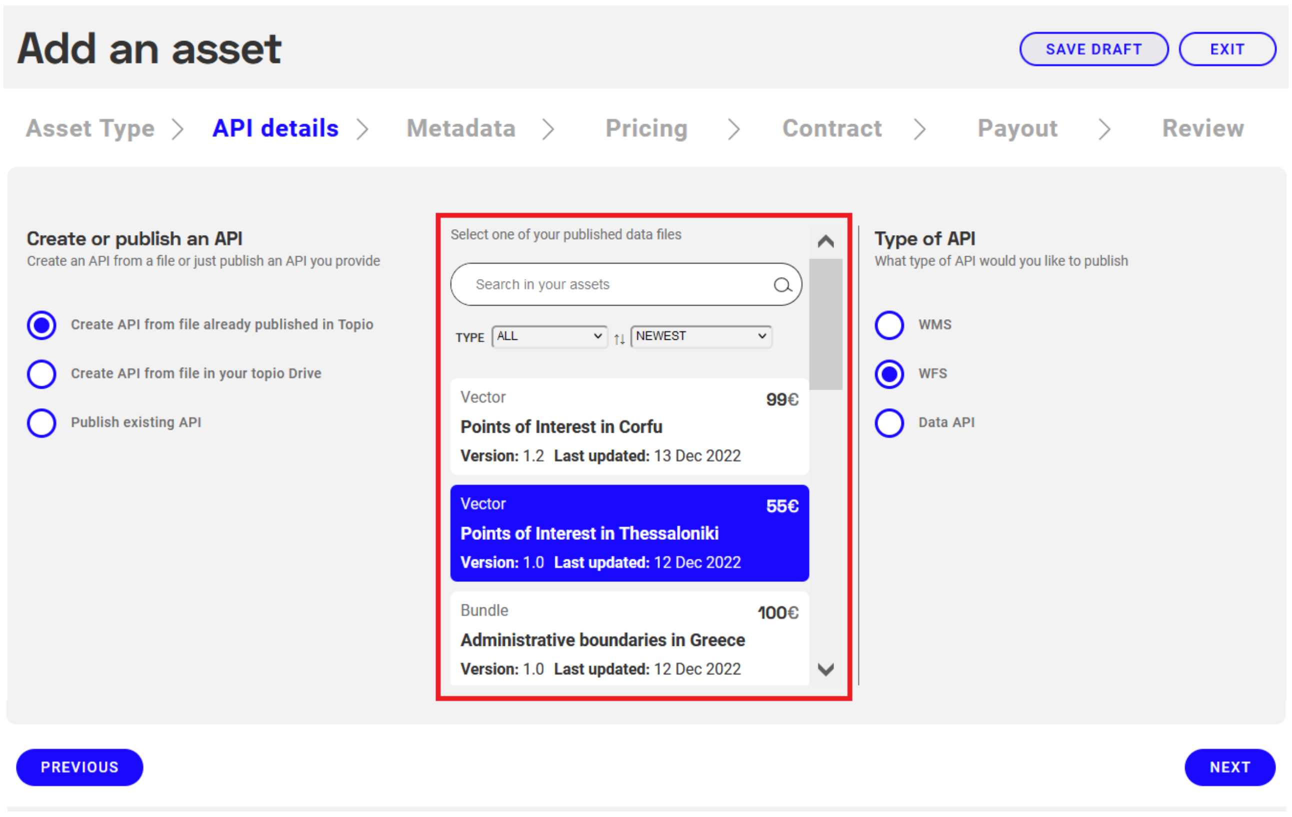
1.5. Adding an API asset

Once the supplier chooses to add an API asset through the publishing wizard (Figure 2), the process proceeds in a step-by-step fashion as detailed next.

1.5.1. API details

This step is only required if the asset is an API and enables the supplier to create an API from a file asset already available in the platform or publish an external API. In particular, the supplier has the following options:

- *Create API from a file already published as an asset in the platform* (Figure 31). In this case, the assets provided by the supplier are shown in a list, which is searchable via the bar on the top. The supplier can also filter her assets by their type, and also sort them by various criteria (such as date, type, or title), using a functionality similar to that used in Asset Search (Section 2.1). Once the supplier picks an asset, the ability to specify the *API type* is enabled.


Add an asset

SAVE DRAFT EXIT

Asset Type > API details > Metadata > Pricing > Contract > Payout > Review

Create or publish an API
Create an API from a file or just publish an API you provide

[✓ Create API from file already published in Topio]
Create API from file in your topio Drive
Publish existing API

Select one of your published data files

Search in your assets

TYPE ALL ↑↓ NEWEST

Vector	99€
Points of Interest in Corfu	
Version: 1.2 **Last updated:** 13 Dec 2022	
Vector	55€
Points of Interest in Thessaloniki	
Version: 1.0 **Last updated:** 12 Dec 2022	
Bundle	100€
Administrative boundaries in Greece	
Version: 1.0 **Last updated:** 12 Dec 2022	

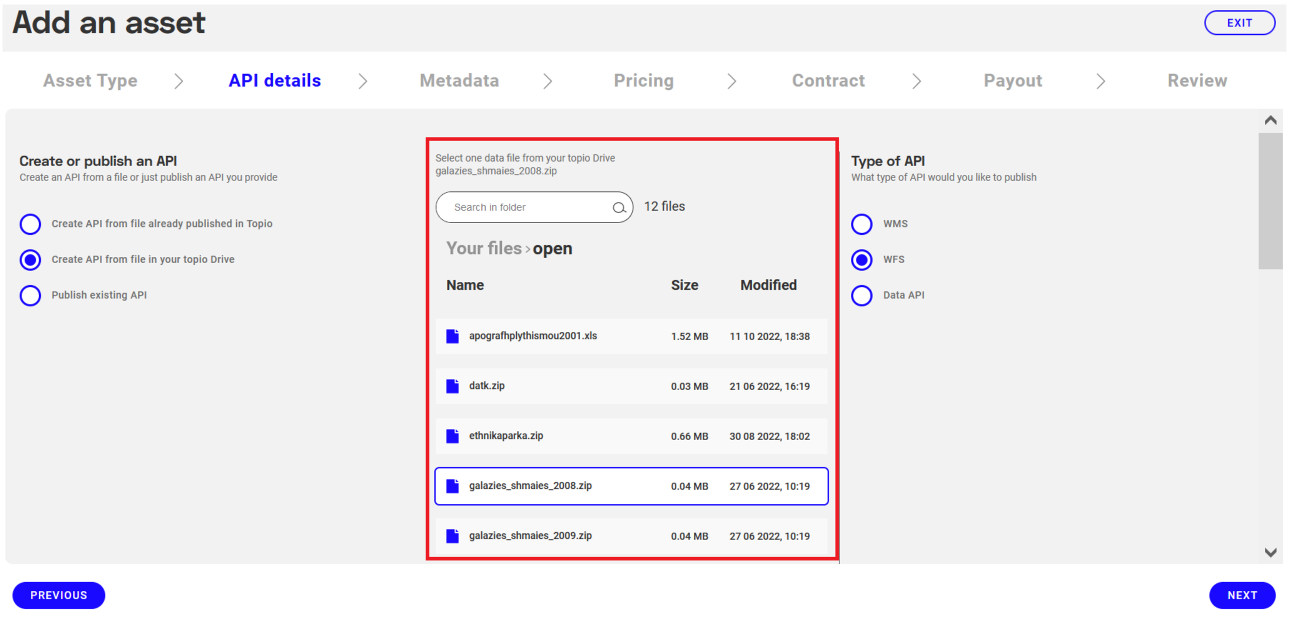
Type of API
What type of API would you like to publish

WMS
[✓ WFS]
Data API

PREVIOUS NEXT

Figure 31: Specifying details for a new API based on a published asset

- *Create API from a file available in Topio Drive* (Figure 32), i.e., a dataset not published as an asset, but uploaded on her own storage space in the platform. In this case, a file explorer is shown in the middle (enclosed in a red box), which lists all directories and files available in the supplier's storage space in Topio Drive. Thus, the supplier can navigate through its contents to identify the file that wishes to use for the API. Once she picks a file (shapefiles should be available in a single .zip file, as in this example), she can specify the *API type* to apply to proceed to the next step.


Add an asset

EXIT

Asset Type > **API details** > Metadata > Pricing > Contract > Payout > Review

Create or publish an API
Create an API from a file or just publish an API you provide

- ○ Create API from file already published in Topio
- ● Create API from file in your topio Drive
- ○ Publish existing API

Select one data file from your topio Drive
galazies_shmaies_2008.zip

Search in folder — 12 files

Your files > **open**

Name	Size	Modified
apografhplythismou2001.xls	1.52 MB	11 10 2022, 18:38
datk.zip	0.03 MB	21 06 2022, 16:19
ethnikaparka.zip	0.66 MB	30 08 2022, 18:02
galazies_shmaies_2008.zip	0.04 MB	27 06 2022, 10:19
galazies_shmaies_2009.zip	0.04 MB	27 06 2022, 10:19

Type of API
What type of API would you like to publish

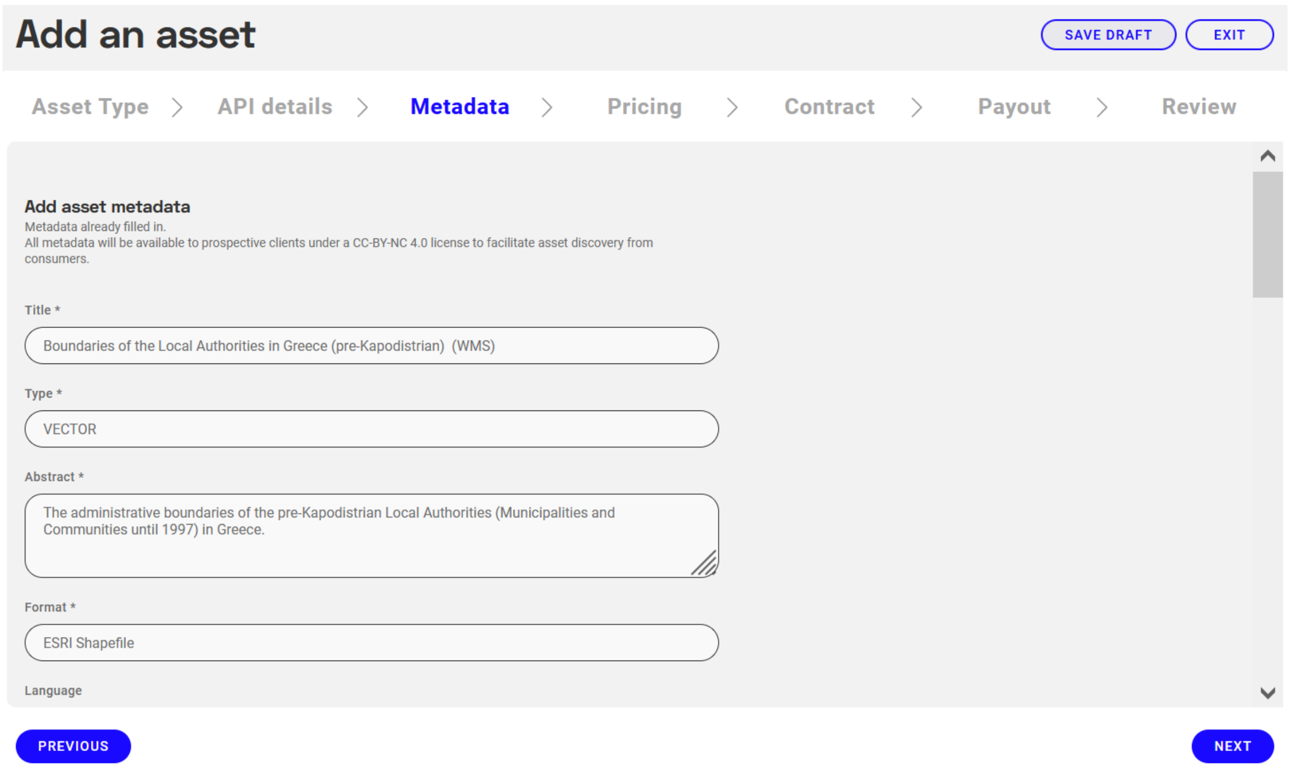
- ○ WMS
- ● WFS
- ○ Data API

PREVIOUS — NEXT

Figure 32: Specifying details for a new API based on a file in the Topio Drive

1.5.2. Metadata

In the case of a new API asset based on a *published file asset*, the whole *Metadata* tab is disabled, since the platform already holds all required metadata. Then, the form is automatically populated with standard metadata information (Figure 33) identical to that of the original file asset.


Add an asset

SAVE DRAFT — EXIT

Asset Type > API details > **Metadata** > Pricing > Contract > Payout > Review

Add asset metadata
Metadata already filled in.
All metadata will be available to prospective clients under a CC-BY-NC 4.0 license to facilitate asset discovery from consumers.

Title *
Boundaries of the Local Authorities in Greece (pre-Kapodistrian) (WMS)

Type *
VECTOR

Abstract *
The administrative boundaries of the pre-Kapodistrian Local Authorities (Municipalities and Communities until 1997) in Greece.

Format *
ESRI Shapefile

Language

PREVIOUS — NEXT

Figure 33: Prefilled metadata for an API based on an existing asset

However, when adding a new API not from an existing asset, but *from an unpublished file uploaded in Topio Drive*, the supplier must provide metadata information (either manually through the form or by uploading a compatible metadata file as in Figure 3.

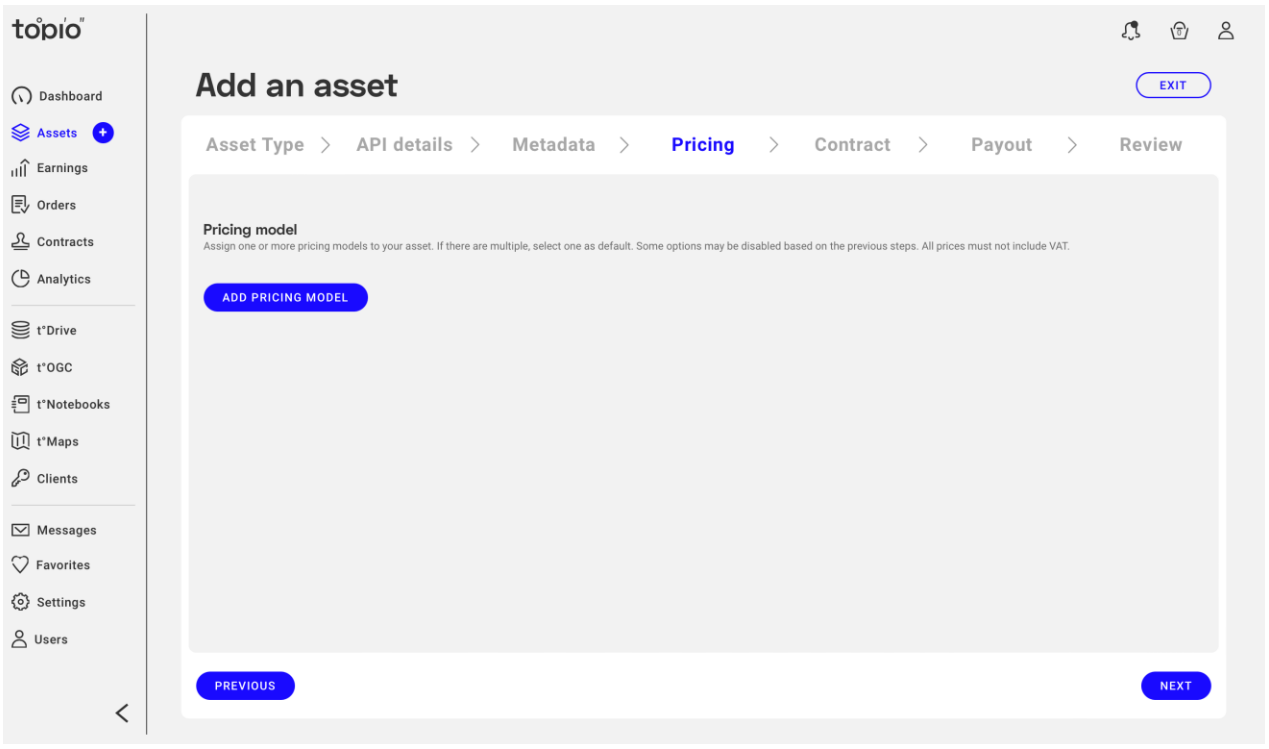
1.5.3. Delivery

The wizard does not include a step for specifying delivery options for API assets, as it did for data files (Section 1.2.2). This step is entirely skipped in the case of an API asset. Indeed, APIs based on assets or data files in Topio Drive will be delivered through the platform. External APIs will be delivered from external means as specified by their supplier.

1.5.4. Pricing

Specifying pricing model(s) for *API assets* works similarly to the case of data files, but it now concerns *subscriptions*. There are two pricing models available for API assets. The supplier can choose either one or both models and specify the parameters of each one (e.g., prices, discount, etc.).

When the user reaches the pricing step for API assets, she is presented with a button titled “Add Pricing Model”, as illustrated in Figure 34. As for the data assets, upon clicking on the button, she is presented with the various pricing model options.



Add an asset

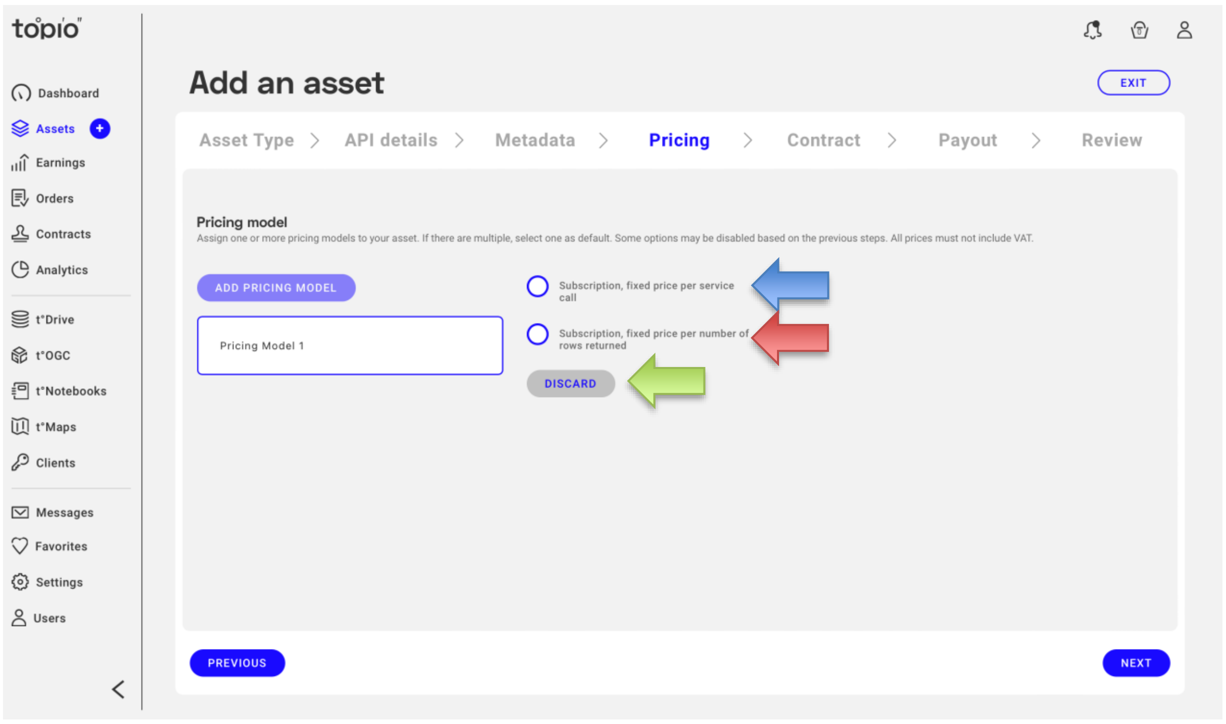
Pricing model

Assign one or more pricing models to your asset. If there are multiple, select one as default. Some options may be disabled based on the previous steps. All prices must not include VAT.

Figure 34: The pricing step of the asset publishing wizard

Figure 35 depicts the available pricing model options to the prospective supplier for API assets. More specifically, the following pricing models for API assets are supported.

- **Subscription, fixed price per service call** (blue arrow in Figure 35): Choosing this pricing model allows customers to subscribe to the service and pay a fixed price per API call, which is set by the seller. Optionally, the supplier can allow consumers to prepay a given number of calls at a discount, via (up to) three discount tiers, with different discount options for each one (blue arrow in Figure 36). There is also the option to set the price per individual call of the service at different block rates, providing increasing discounts the more the service is used, as a reward to the consumers for their loyalty (red arrow in Figure 36). Once a consumer is subscribed, they can purchase additional prepaid calls at any point in time. If their prepaid calls are depleted, then they are charged with the standard price. Topio adds a pre-specified (e.g., 30%) overhead to the price set by the seller, which covers the costs of service provision. Consumers may cancel their subscription at any point time. If they had any prepaid calls still left, they will not be reimbursed.
- **Subscription, fixed price per number of rows returned** (red arrow in Figure 35): This pricing model is similar to the one titled "Subscription, fixed price per service call", but instead of service calls, the consumer is charged based on the number of rows (tiles for WMS) that are returned while using the service.

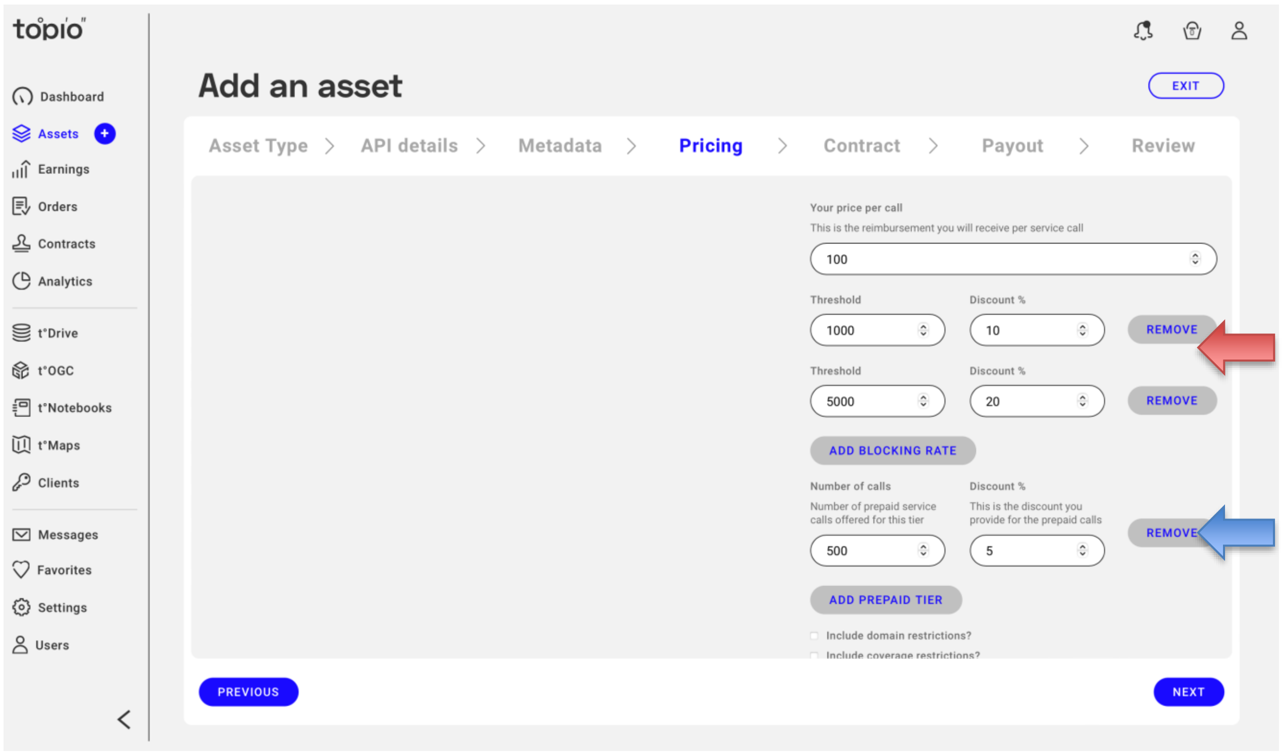


Pricing model

Assign one or more pricing models to your asset. If there are multiple, select one as default. Some options may be disabled based on the previous steps. All prices must not include VAT.

Figure 35: Specifying the pricing model for a new API asset

As in data assets, the user must select one of the pricing models at the middle pane and a new scrollable pane appears on the right of the window (see Figure 7), containing the pricing and various other fields, such as restrictions, discounts and blocking rates that the seller must define to add this pricing model to her API asset.



Add an asset

Your price per call

This is the reimbursement you will receive per service call

100

Threshold	Discount %
1000	10
5000	20

Number of calls	Discount %
Number of prepaid service calls offered for this tier	This is the discount you provide for the prepaid calls
500	5

☐ Include domain restrictions?

☐ Include coverage restrictions?

Figure 36: Specifying details for an API pricing model

Regarding restrictions for API assets, the procedure for defining them is the same as for data assets, as described in Section 1.2.3.1.

1.5.5. Contract terms

The next step involves choosing a *contract* for selling this new API asset. In this case, two options are available, selecting from existing templates and creating a new template contract (blue arrow in Figure 37). In both cases, the procedure is the same as for data assets, as described in Section 1.2.4.

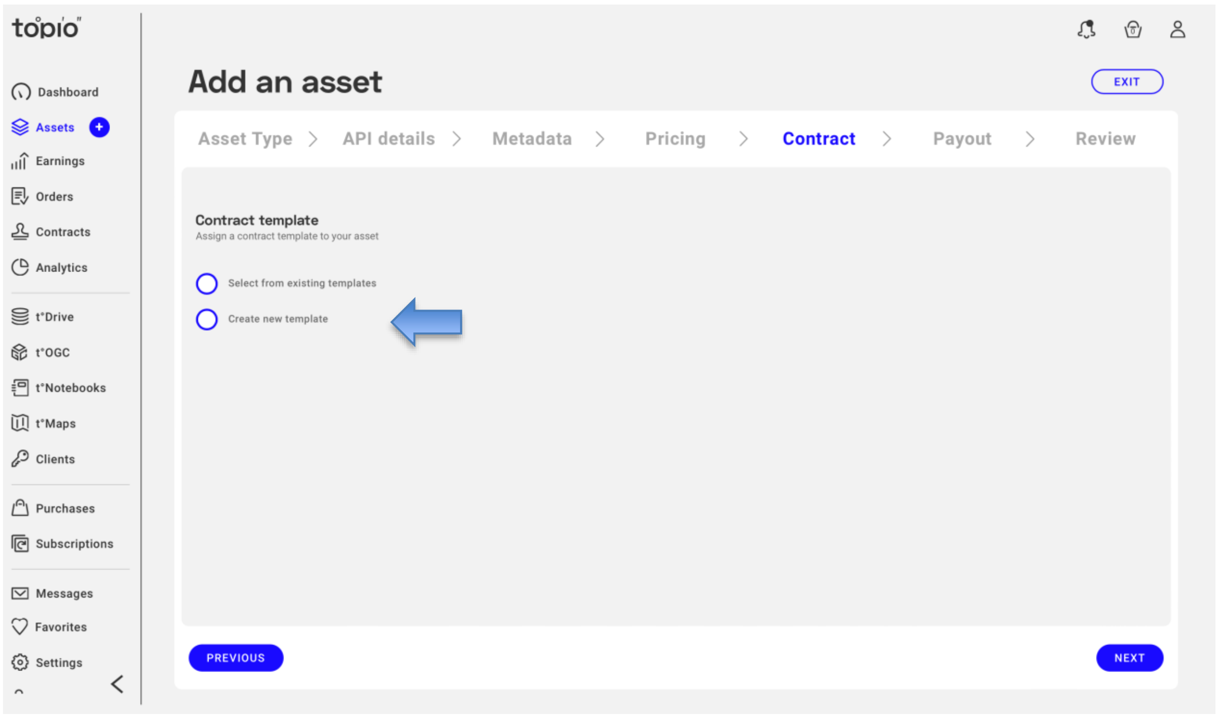


Figure 37: Specifying a contract for a new API asset

1.5.6. Payout

The payout options for a new API asset are similar to those for data files (Figure 21) as discussed in Section 1.2.5.

1.5.7. Review

This final step enables the supplier to check all specified settings exactly as in the case of data file assets, including the vetting options (Figure 22). Once the supplier submits the API asset for review by the Helpdesk, it automatically gets a unique PID for reference; a PID is also assigned for draft API assets. In contrast to a new data file asset, no data uploading is necessary in the case of API assets. While the asset is still under review or remains a draft with some steps still incomplete, it is shown with a red notification at the top of the list of assets in the dashboard.

1.6. Adding an Earth Observation asset

Adding an Earth Observation (EO) asset is reserved to Topio Admin only and concerns EO collections from Sentinel Hub; no other supplier can currently publish EO collections. The publishing wizard includes two steps only: (i) *Asset Type* for choosing “Sentinel Hub” as the source of EO collections, and (ii) *Metadata* with information about a particular EO collection. One of the available EO collections may be chosen (like Sentinel 1 GRD, Sentinel 2 L1C, Landsat 8, etc.) and its respective metadata (title, abstract, keywords, additional resources, etc.) can be specified, exactly as in the case of data file assets (Section 1.2.1). Once the Topio Admin submits the new asset to the backend, the respective workflow will establish a connection to the Sentinel Hub API and will make this EO collection available in the marketplace. Users can search, view, and purchase such EO assets as further detailed in Section 2.2.1.5.

1.7. Managing Assets

Through the dashboard, the supplier has complete control over her assets. This concerns not only those assets already published in the marketplace but also saved draft assets, which are not yet submitted for review, are awaiting the review, or still missing some steps before submission. If a red notification is shown next to the Assets option in the dashboard, it indicates that there are assets unpublished or under review, which require some action from the supplier (e.g., some steps in the publishing wizard have not been performed yet). Such assets are also shown on the top of the assets list with a notification in red. In this case, the supplier may carry out several actions, as detailed next.

1.7.1. Edit an asset

In this case, the publishing wizard opens, which allows the supplier to edit any information previously specified regarding the asset (metadata, contract, pricing, delivery, payout). This follows most of steps already presented when adding an asset; however, at each step the supplier can now examine her previously defined settings and modify them.

For example, a supplier can upload extra resources regarding metadata for this asset or add external links, and edit any of the metadata elements specified previously (during the publish asset stage as detailed in Sections 1.2 and 1.5). Similar edits (add/remove certain options, change values in certain properties or options) can be done in any of the successive steps of the wizard. At the last step in this wizard, the supplier is prompted to *review* all specifications and confirm them before submitting the asset to the Helpdesk for review (similar to the form shown in Figure 22). Of course, the supplier can save a draft of this asset and revisit all settings later; in such case, the asset will appear on his list of assets with a red dot to clearly mark that some necessary actions are still pending.

1.7.2. Create API

These options are available for published assets only and allow the supplier to create:

- a *Web Map Service* (WMS);
- a *Web Feature Service* (WFS); and

based on the contents of this asset.

In each case, the flow is similar to the one used for adding a new API asset. In the first three steps (*Asset type, API details, Metadata*) of the wizard, the supplier can only view but cannot change the settings, i.e., that this will be an API and concerns the specified data asset. In API details, she can only change the API type (e.g., from switch from WMS to WFS). The metadata specification is as shown in Figure 33, since metadata for this asset is already available and is shown for information only. The next steps in the wizard are exactly as detailed in Section 1.5, enabling the supplier to choose pricing model(s), contract, payout method(s), and finally review all settings before submitting the new API asset for check by the Helpdesk.

1.7.3. Delete an asset

Once the supplier clicks on the *Delete* option of an asset, the warning in Figure 38 pops up and prompts her either to delete the asset or cancel the operation. If the asset is deleted, it will be no longer traded through the marketplace and will not be available to future customers. However, it will be retained in the platform (if it is a data file uploaded by the supplier) for reference, as it may have been already sold to consumers.

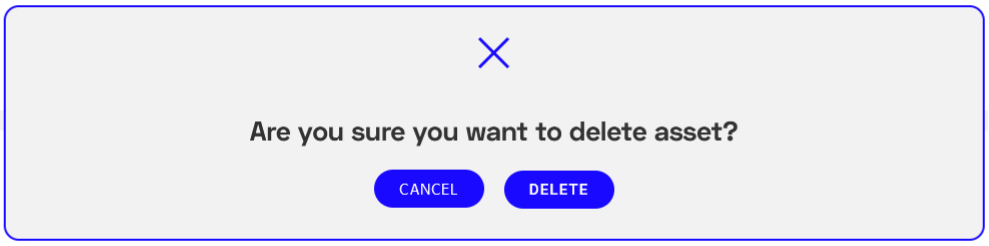
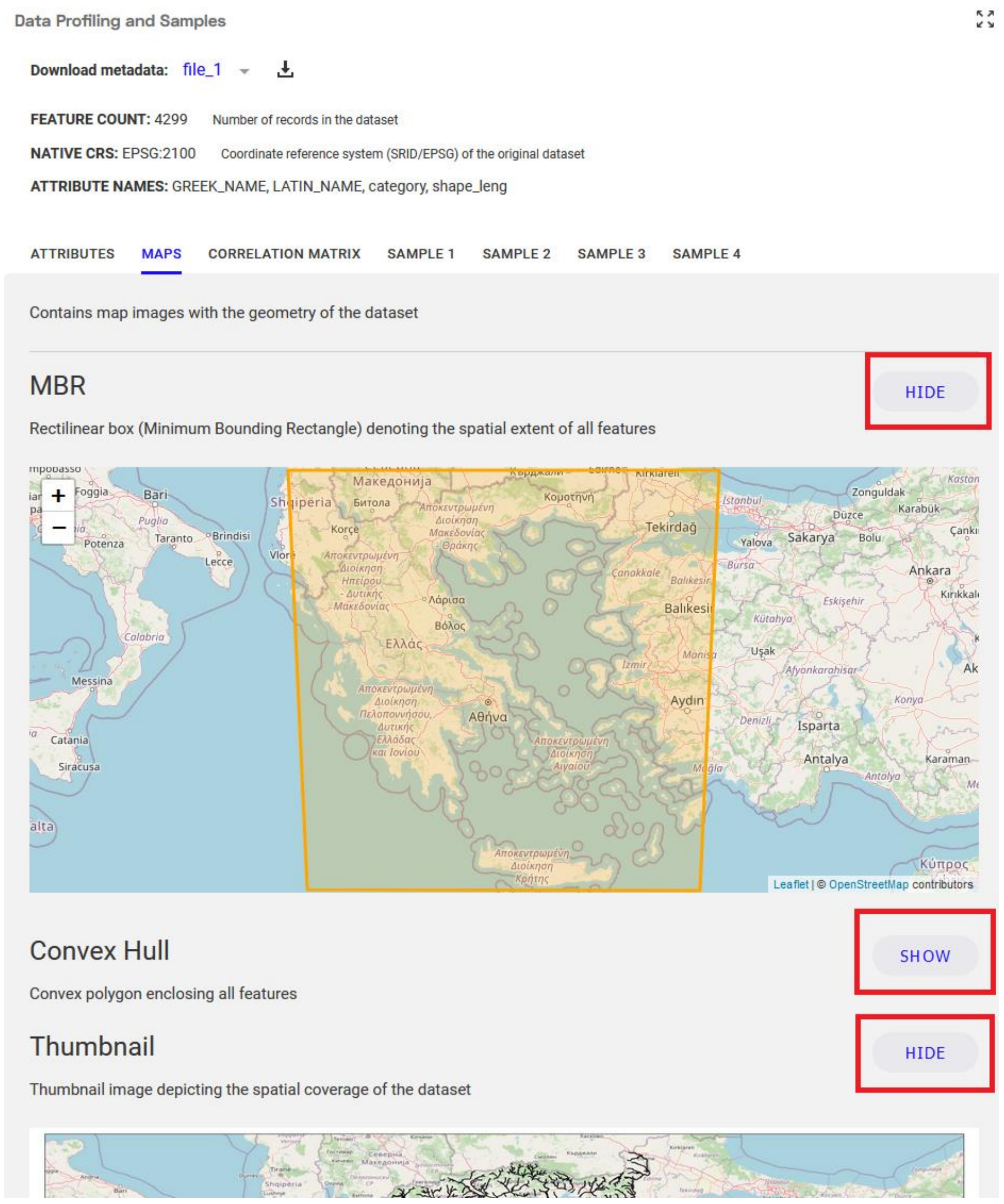

Are you sure you want to delete asset?

Figure 38: Warning prior to asset deletion

1.7.4. Approve profile of data asset

Soon after a data asset is submitted to the Helpdesk, the platform in the backend automatically invokes a profiling service that computes automated metadata and samples from this dataset. Once this process terminates, the supplier receives a notification to view its calculated profile (i.e., automated metadata and samples). Such profiles will be shown to prospective customers (as will be discussed in Section 2.2.3) offering them a wide range of statistics, charts, maps, samples, etc. over the data for better assessing its quality and suitability for their needs. Suppliers are not involved in how such profiles are computed, to avoid any bias. However, since profiles serve as an important quality indicator of assets, a supplier can choose which profile elements will be made visible in the platform and which should be hidden before the asset is published.

More specifically, the supplier is shown the section of the Asset View concerning profiles, exactly as it will be presented to customers once published in the marketplace. However, for select items she can toggle its visibility (*Show*/*Hide*). This applies on every map displaying spatial features and aggregates (e.g., heatmaps as in Figure 39), the correlation matrix, and automatically created samples (Figure 40).


Data Profiling and Samples

Download metadata: file_1

FEATURE COUNT: 4299 Number of records in the dataset

NATIVE CRS: EPSG:2100 Coordinate reference system (SRID/EPSG) of the original dataset

ATTRIBUTE NAMES: GREEK_NAME, LATIN_NAME, category, shape_leng

Contains map images with the geometry of the dataset

MBR

Rectilinear box (Minimum Bounding Rectangle) denoting the spatial extent of all features

Convex Hull

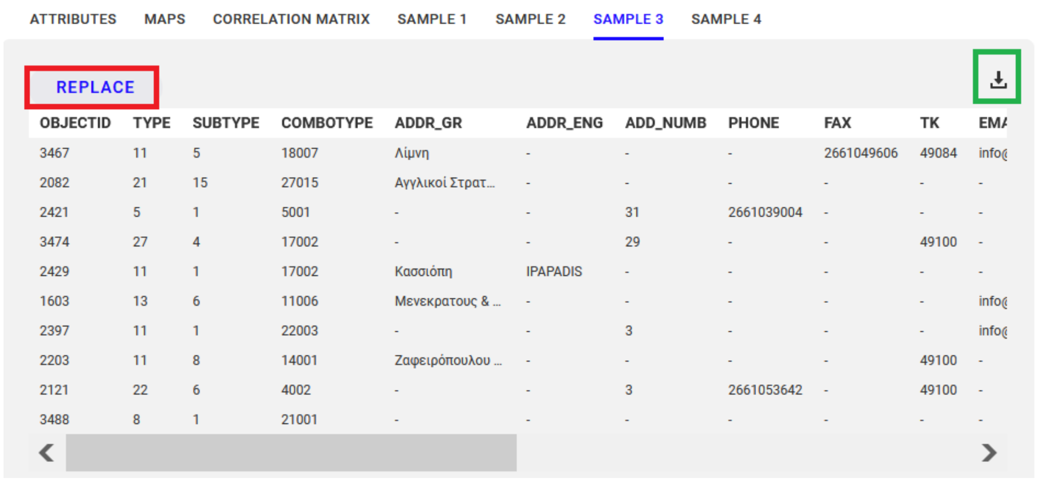
Convex polygon enclosing all features

Thumbnail

Thumbnail image depicting the spatial coverage of the dataset

Figure 39: Choosing which spatial profiles to display for an asset

Especially for *samples*, the platform offers suppliers the capability to *replace* any of those automatically computed by their own samples. For instance, the automatically extracted sample shown in Figure 40 happens to contain many NULL values as it randomly picks rows from the file. As this may have a negative impact on consumers, the supplier may change it with another, more representative sample. The supplier may download this sample (using the button highlighted in the green box) and closely inspect it, e.g., using a GIS software. If the supplier clicks on button *Replace*, she is prompted to upload a file that will be checked by the Helpdesk before becoming available. In each case, the supplier has the flexibility to choose which and how many samples to offer, even none.



OBJECTID	TYPE	SUBTYPE	COMBOTYPE	ADDR_GR	ADDR_ENG	ADD_NUMB	PHONE	FAX	TK	EMA
3467	11	5	18007	Λίμνη	-	-	-	2661049606	49084	info@
2082	21	15	27015	Αγγλικοί Στρατ...	-	-	-	-	-	-
2421	5	1	5001	-	-	31	2661039004	-	-	-
3474	27	4	17002	-	-	29	-	-	49100	-
2429	11	1	17002	Κασσιόπη	IPAPADIS	-	-	-	-	-
1603	13	6	11006	Μενεκρατους & ...	-	-	-	-	-	info@
2397	11	1	22003	-	-	3	-	-	-	info@
2203	11	8	14001	Ζαφειρόπουλου ...	-	-	-	-	49100	-
2121	22	6	4002	-	-	3	2661053642	-	49100	-
3488	8	1	21001	-	-	-	-	-	-	-

Figure 40: Specifying samples of an asset that will be available to registered users

1.8. Creating a private OGC service

In contrast to assets published by suppliers and traded in the marketplace, consumers can also create and use *private APIs* through the platform. More specifically, a consumer can create private APIs that offer OGC services (WMS, WFS) based on her data files or assets. Users have to pay a subscription in order to use the platform's infrastructure and create such a service. Such OGC services are not publicly available, but only the user can invoke them through other value-added services in the platform (e.g., Topio Notebooks, Topio Maps). In her Dashboard, by clicking on menu *Topio OGC* from the sidebar, the user can list all the OGC services she has created and can use (Figure 41). Also, by clicking on the *Delete* button that appears next to such an item in the list, she can delete the service.

By clicking on button "*Create Service*", a user-friendly wizard opens and guides the user to provide some information about the service, as detailed next.

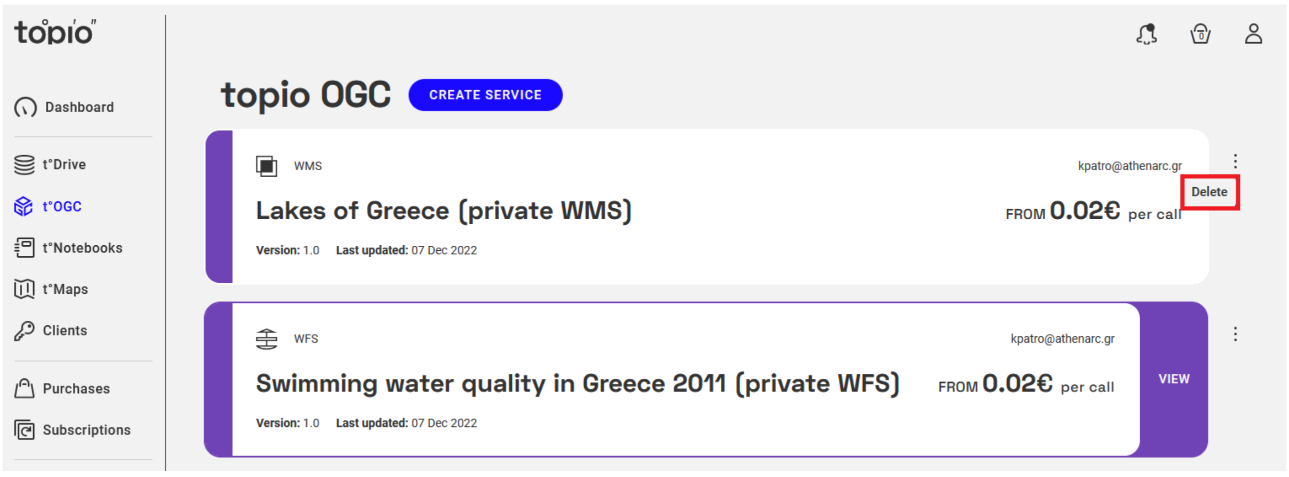
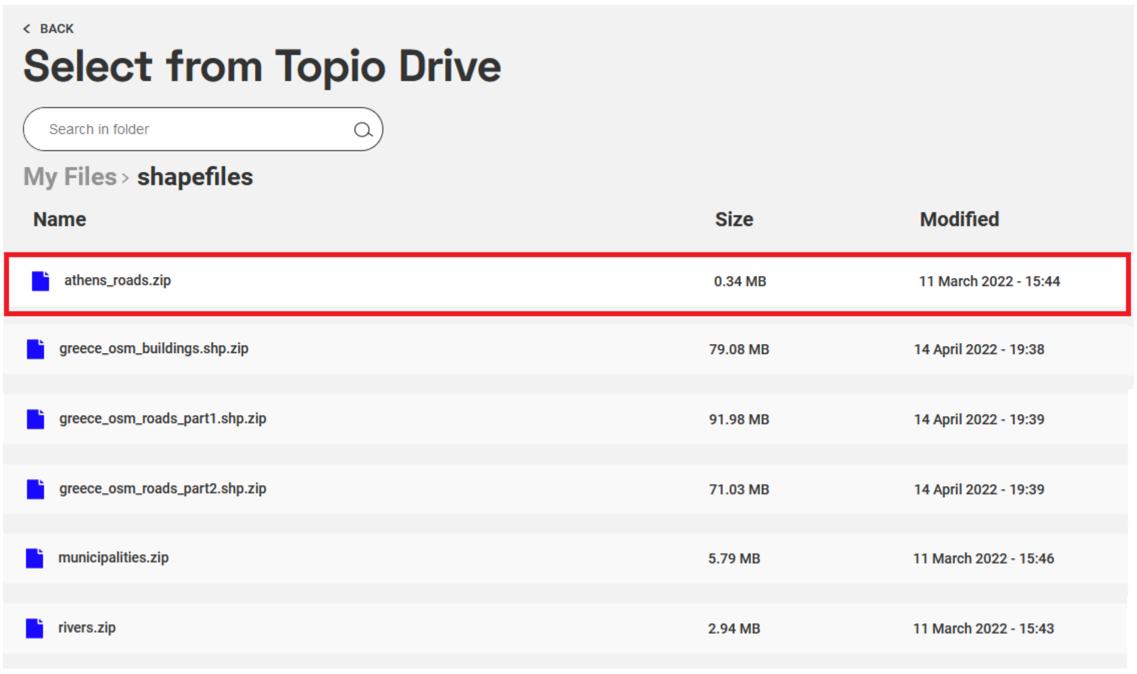


Figure 41: Private OGC services

1.8.1. Select data file from Topio Drive

Before creating the service, the user must specify the data file on which this service will be based. As shown in Figure 42, the wizard invokes the file explorer of her Topio Drive storage, enabling the user to pick one of her datasets. This can be one of her own datasets or one that she has purchased from the platform and stored in her Topio Drive.



Name	Size	Modified
athens_roads.zip	0.34 MB	11 March 2022 - 15:44
greece_osm_buildings.shp.zip	79.08 MB	14 April 2022 - 19:38
greece_osm_roads_part1.shp.zip	91.98 MB	14 April 2022 - 19:39
greece_osm_roads_part2.shp.zip	71.03 MB	14 April 2022 - 19:39
municipalities.zip	5.79 MB	11 March 2022 - 15:46
rivers.zip	2.94 MB	11 March 2022 - 15:43

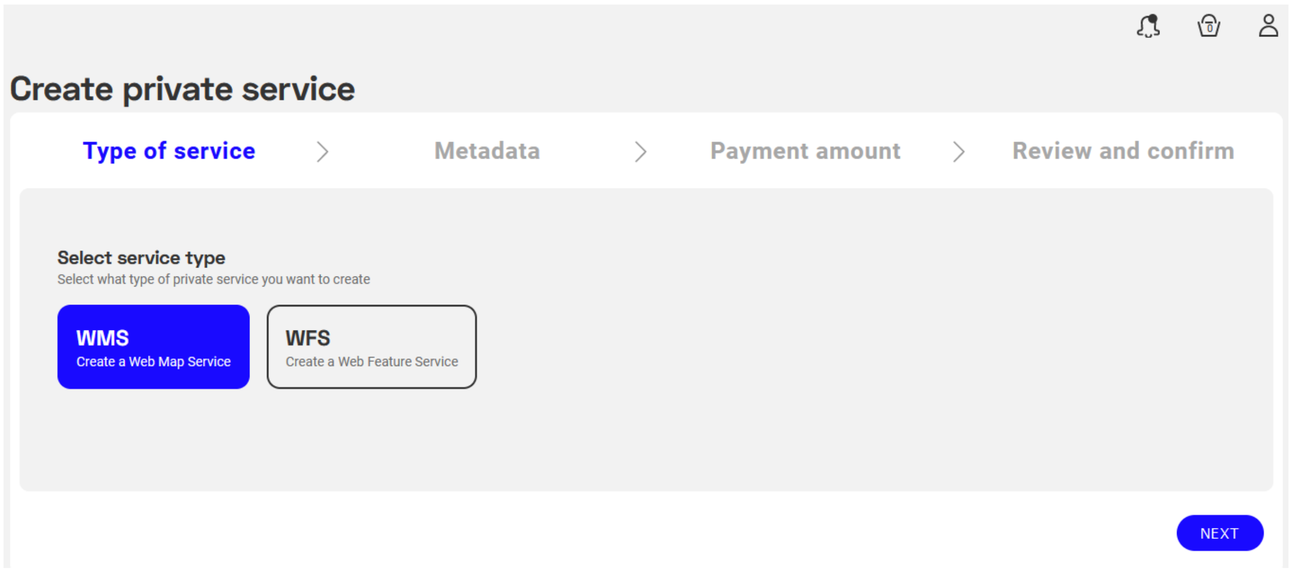
Figure 42: Selecting data file from Topio Drive

1.8.2. Select service type

Next, the user must specify one of the two types of OGC services available in the platform (Figure 43):

- WMS: a *Web Map Service* is a standard protocol developed by the Open Geospatial Consortium for serving georeferenced map images as tiles (e.g., in PNG format).
- WFS: a *Web Feature Service* provides interfaces for describing data manipulation operations of geographic features, such as querying features based on spatial and non-spatial constraints and receiving the results in a standard format (e.g., GML, JSON).

Once created, such services are available through API requests.


Create private service

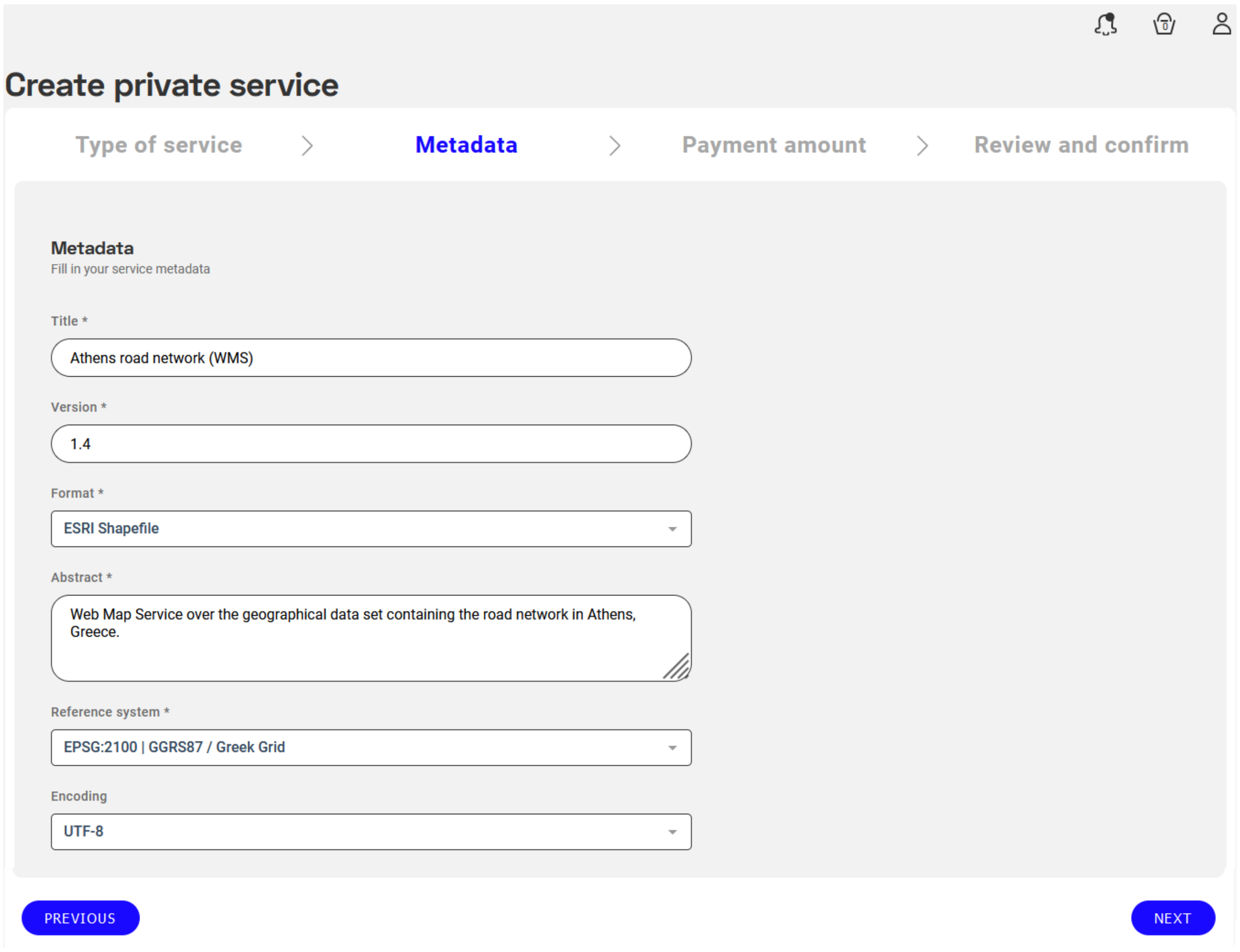
Type of service > Metadata > Payment amount > Review and confirm

Select service type

Select what type of private service you want to create

Figure 43: Selecting service type

1.8.3. Metadata


Create private service

Type of service > Metadata > Payment amount > Review and confirm

Metadata

Fill in your service metadata

Title *	Athens road network (WMS)
Version *	1.4
Format *	ESRI Shapefile
Abstract *	Web Map Service over the geographical data set containing the road network in Athens, Greece.
Reference system *	EPSG:2100 | GGRS87 / Greek Grid
Encoding	UTF-8

Figure 44: Metadata on the new private OGC service

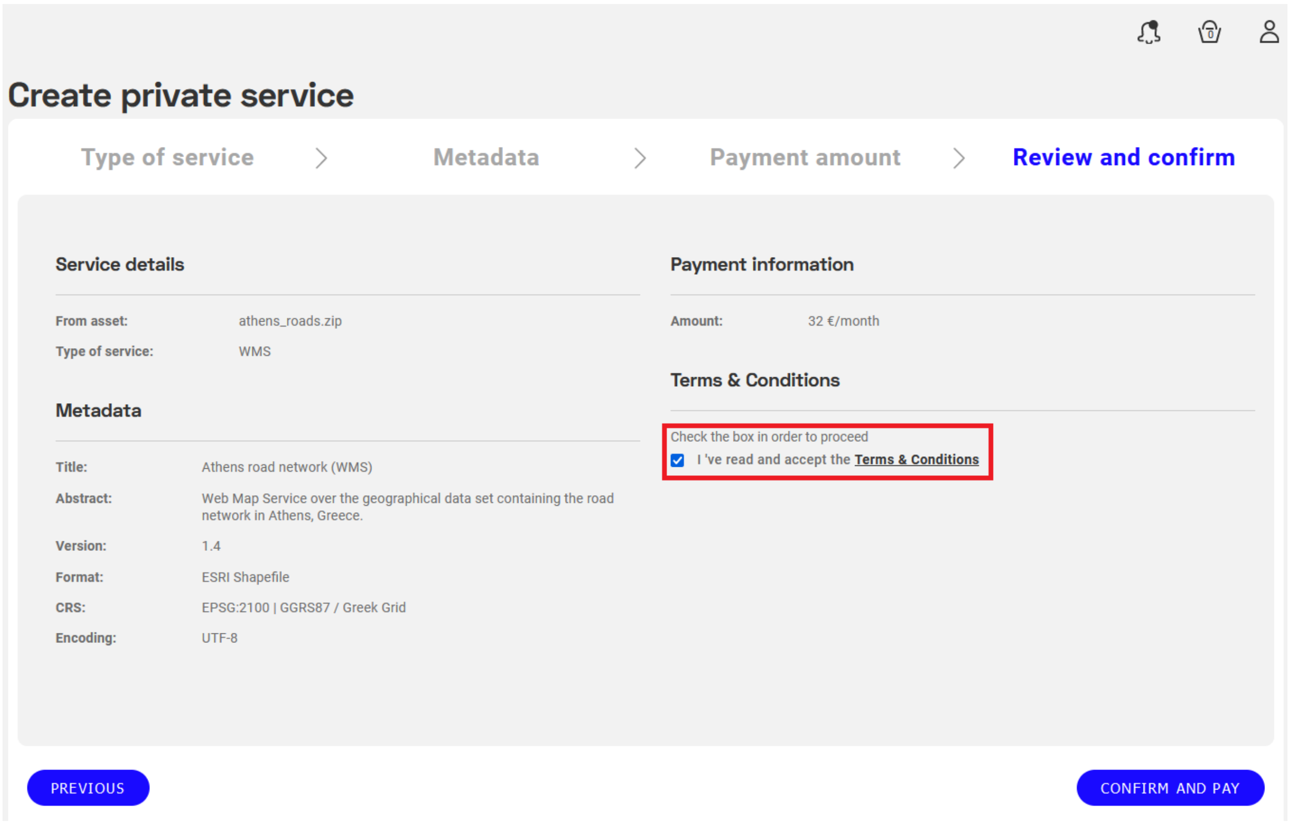
In the next step, the user must enter a few metadata regarding the new service as shown in Figure 44. This includes a title, the version, a short description (abstract), the format of the dataset that will be used in the service, as well as its spatial reference system and the string encoding. This metadata will be used to automatically operationalize the service.

1.8.4. Payment

Since this service will be available through the platform and will be based on its infrastructure and resources, the user must subscribe and pay a fixed amount per month. Billing will be effectuated every 1st working day of the month.

1.8.5. Review and confirm to create service

Finally, the user is shown all the settings that she has specified for the new service as listed in Figure 45. She must explicitly agree to the Terms and Conditions under which this service from Topio will be provided (highlighted in the red box). Once she clicks on button "*Confirm and Pay*", the user is notified that the request for this new service is submitted to the backend. Soon afterwards, after confirming the payment and availability of the data, the new service is created.



Service details

From asset:	athens_roads.zip
Type of service:	WMS

Metadata

Title:	Athens road network (WMS)
Abstract:	Web Map Service over the geographical data set containing the road network in Athens, Greece.
Version:	1.4
Format:	ESRI Shapefile
CRS:	EPSG:2100 | GGRS87 / Greek Grid
Encoding:	UTF-8

Payment information

Amount:	32 €/month

Terms & Conditions

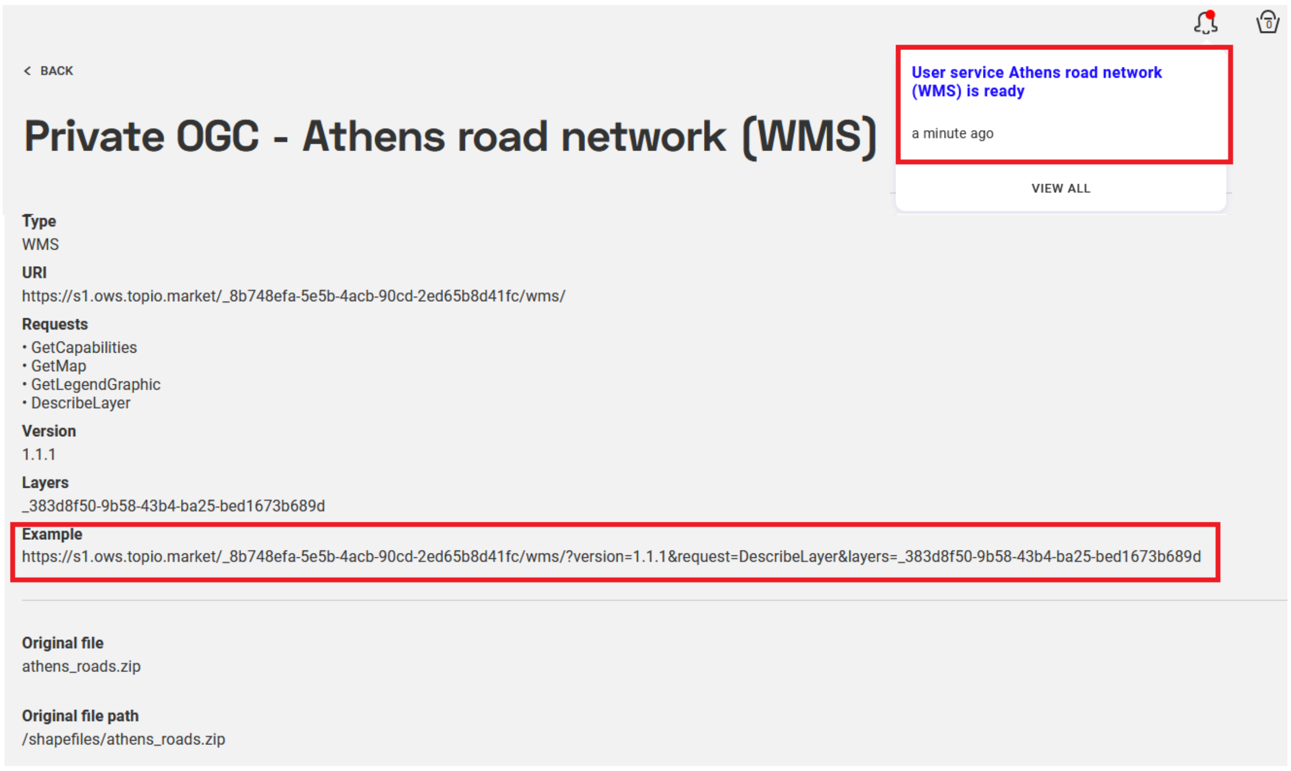
Check the box in order to proceed

✓ I 've read and accept the **Terms & Conditions**

Figure 45: Review settings and create the OGC service

1.8.6. Details of an OGC service

Once the service is launched, the user gets a notification that this is available for use. The new service then appears on the list of her OGC services (Figure 41). When the user clicks on one of these services in the list, she can view all its details, as shown in Figure 46. This provides the full information on the URI where this OGC service is accessible, the supported requests, the type and version of the services, as well as the name of the layer (type name), the original file name and its path on her Topio Drive storage (as specified by the user in the wizard). An example request is also given, so that the user can directly invoke it and verify the status of the service. Note that in order to use such a service, the user must create access credentials and then provide them to the applications (e.g., Topio Notebooks) that will make API requests on behalf of the user.



Private OGC - Athens road network (WMS)

User service Athens road network (WMS) is ready

a minute ago

Type
WMS

URI
https://s1.ows.topio.market/_8b748efa-5e5b-4acb-90cd-2ed65b8d41fc/wms/

Requests
- GetCapabilities
- GetMap
- GetLegendGraphic
- DescribeLayer

Version
1.1.1

Layers
_383d8f50-9b58-43b4-ba25-bed1673b689d

Example
https://s1.ows.topio.market/_8b748efa-5e5b-4acb-90cd-2ed65b8d41fc/wms/?version=1.1.1&request=DescribeLayer&layers=_383d8f50-9b58-43b4-ba25-bed1673b689d

Original file
athens_roads.zip

Original file path
/shapefiles/athens_roads.zip

Figure 46: Details of a private OGC service (WFS)

2. Asset Discovery

In this Section, we present how a prospective consumer's experience is augmented by the integration of contract, terms, and pricing information for asset discovery. First, we showcase the catalog's search and filtering facilities, and specifically how this additional metadata can be applied in asset search. Next, we present and discuss the framing of this information in the standard asset's view, thus allowing its assessment and comparison with similar assets. Finally, we present how dynamic pricing models are delivered to prospective consumers, exploring their options and considerations.

Please note that all screenshots and descriptions are correct as of the time of this writing and are expected to be modified in the future, as the platform continues to be in development, even after the end of the OpertusMundi project. Further, the platform's messages, labels, and assets (data, services) presented in the screenshots that follow are integrated for testing and illustration purposes only and hence may not correspond to actual commercial/proprietary geospatial assets. As such: (a) the same assets may appear multiple times, (b) the content of assets is derived from open licensed assets, (c) the provided metadata (e.g., pricing, terms, profiling) may not be accurate.

2.1. Search

The platform offers rich search capabilities with a wide range of optional filtering criteria so that prospective consumers can quickly identify assets of their interest. All search operations are powered by indexing all assets and their metadata in the backend and thus supporting various search conditions (textual, numerical, spatial, temporal, etc.) for exploring the Asset Catalog.

2.1.1. Search from the landing page

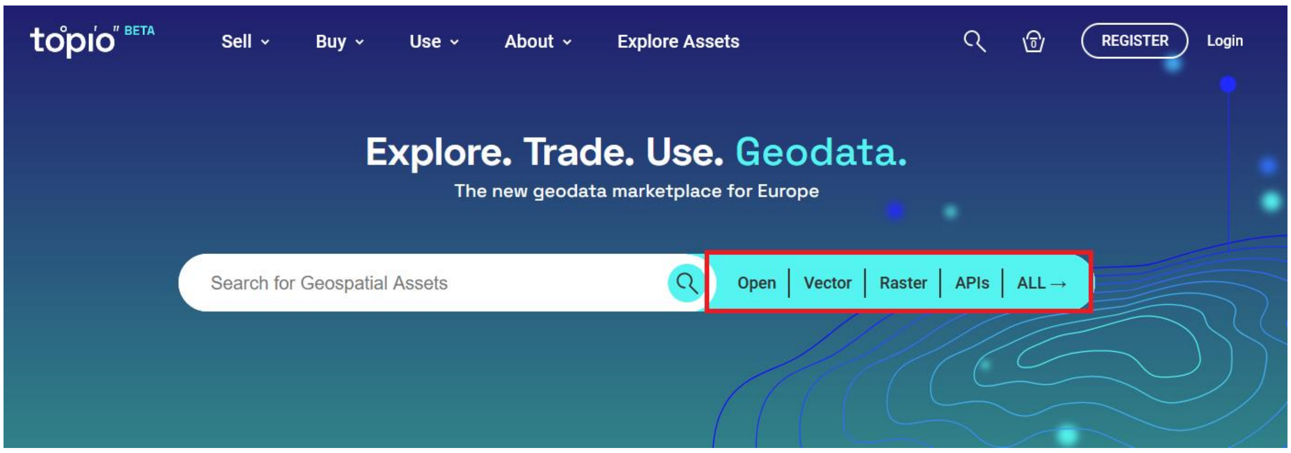
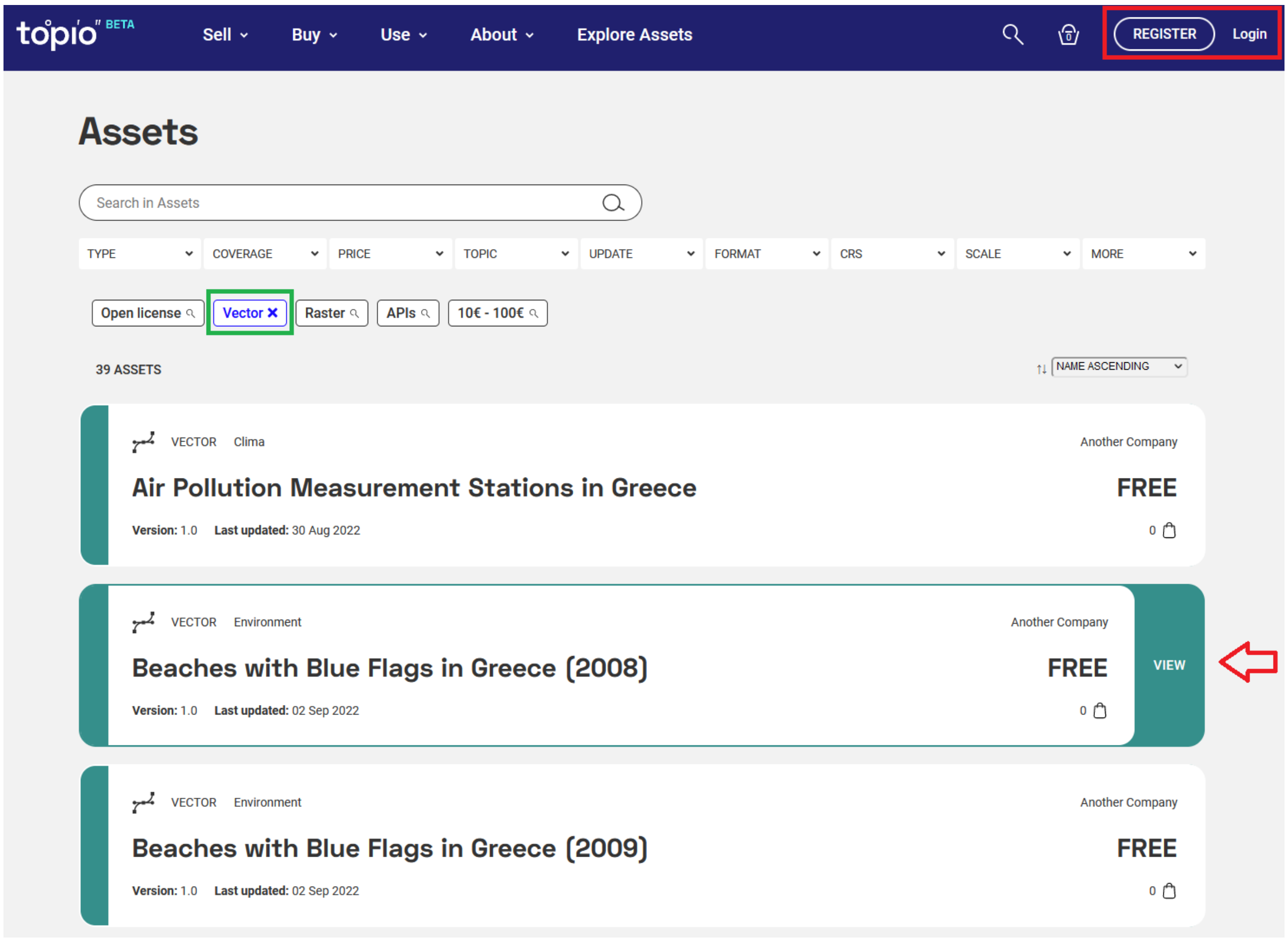

topio BETA
Sell
Buy
Use
About
Explore Assets
REGISTER
Login
Explore. Trade. Use. Geodata.
The new geodata marketplace for Europe
Search for Geospatial Assets
Open
Vector
Raster
APIs
ALL →

Figure 47: Search assets bar

From the landing page of the marketplace, a user can search for geospatial data assets through the "*Search for Geospatial Assets*" bar (Figure 47). The search bar combines two search operations concerning *assets* and terms (i.e., *keywords*) characterizing the marketed assets. In addition, several *frequently used filters* (*Open license, Vector, Raster, APIs, ALL*) are readily available next the search bar (shown enclosed in the red box) that offer a handy shortcut to quickly specify such the respective filter over the catalog. For instance, when clicking on "*Vector*", the catalog opens and shows vector file assets only (Figure 48). Then, she can further filter them with additional search criteria as discussed next. Any applied filters are clearly marked (green box), so that the user can easily remove them. Note that full search capabilities are available even to unregistered users, who can discover any type of assets available in the marketplace. However, they can only view certain details for each one (hover on an asset and click on *View*, as illustrated with the arrow in Figure 48), unless they register to the marketplace or login with their credentials (for already registered users), highlighted with the buttons in the red box.



Assets

39 ASSETS

VECTOR Clima — Another Company
Air Pollution Measurement Stations in Greece — FREE
Version: 1.0 Last updated: 30 Aug 2022 — 0

VECTOR Environment — Another Company
Beaches with Blue Flags in Greece (2008) — FREE
Version: 1.0 Last updated: 02 Sep 2022 — 0

VECTOR Environment — Another Company
Beaches with Blue Flags in Greece (2009) — FREE
Version: 1.0 Last updated: 02 Sep 2022 — 0

Figure 48: Asset Catalog available for search

Of course, the *search bar* in the landing page allows users to look for assets in a fashion typical for web browsers. Before even typing any character in the search bar, the list under "*Recent Searches*" is populated with *terms* in the user's search history (Figure 49), provided that she has logged in the marketplace.

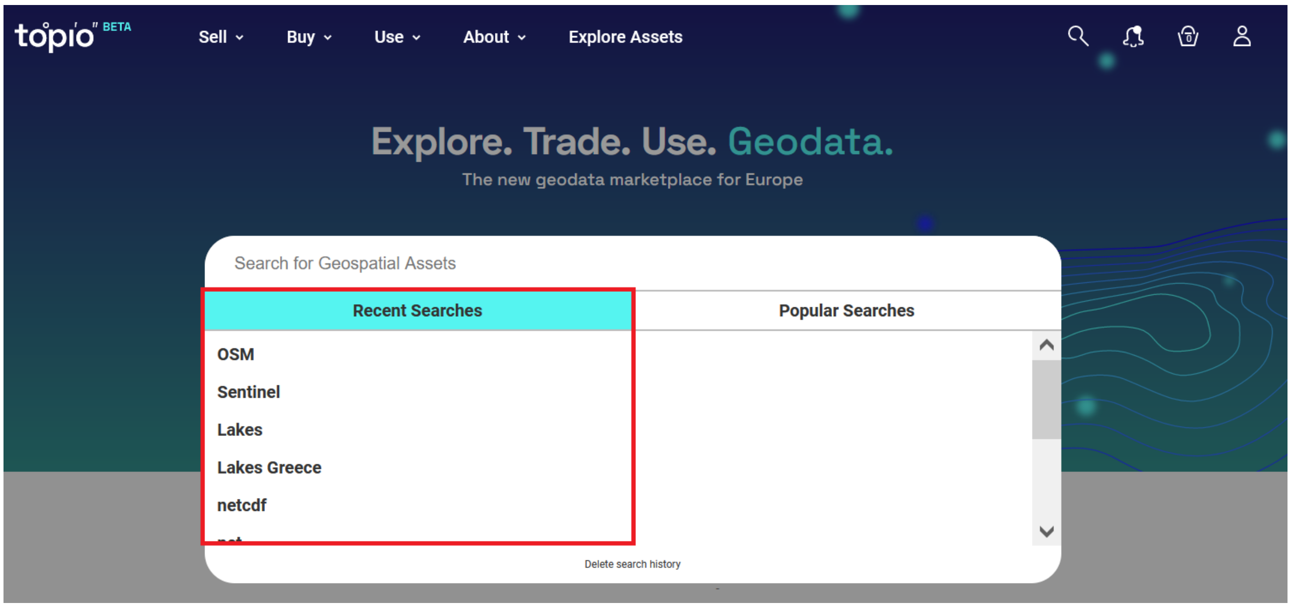


Figure 49: List of recently searched assets under the search bar

As shown in Figure 50, upon *typing* on the search bar, users can write any *terms* of their own choice and search for assets with matching tags. To facilitate searching and filtering, an autocomplete feature is available in the search bar. Soon after the user types a few letters, suggested *assets* mostly similar with the specified term(s) appear below the bar in descending relevance, so that the user can quickly identify something close to what she searches for. If she clicks on a suggested asset from this list, she can directly display all its details in the Asset View page as discussed in Section 2.2.

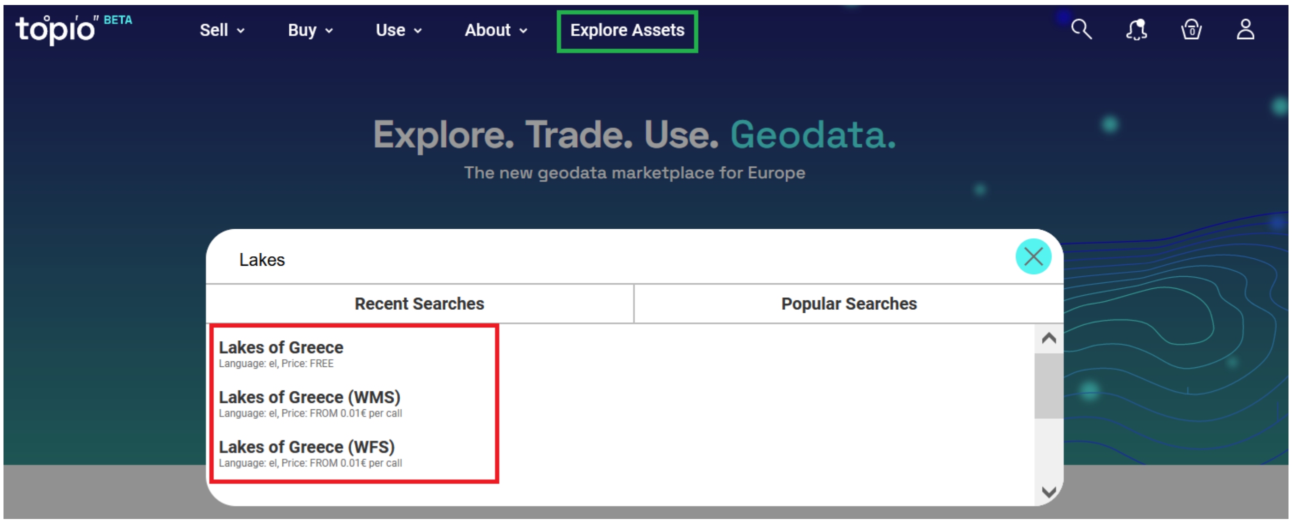
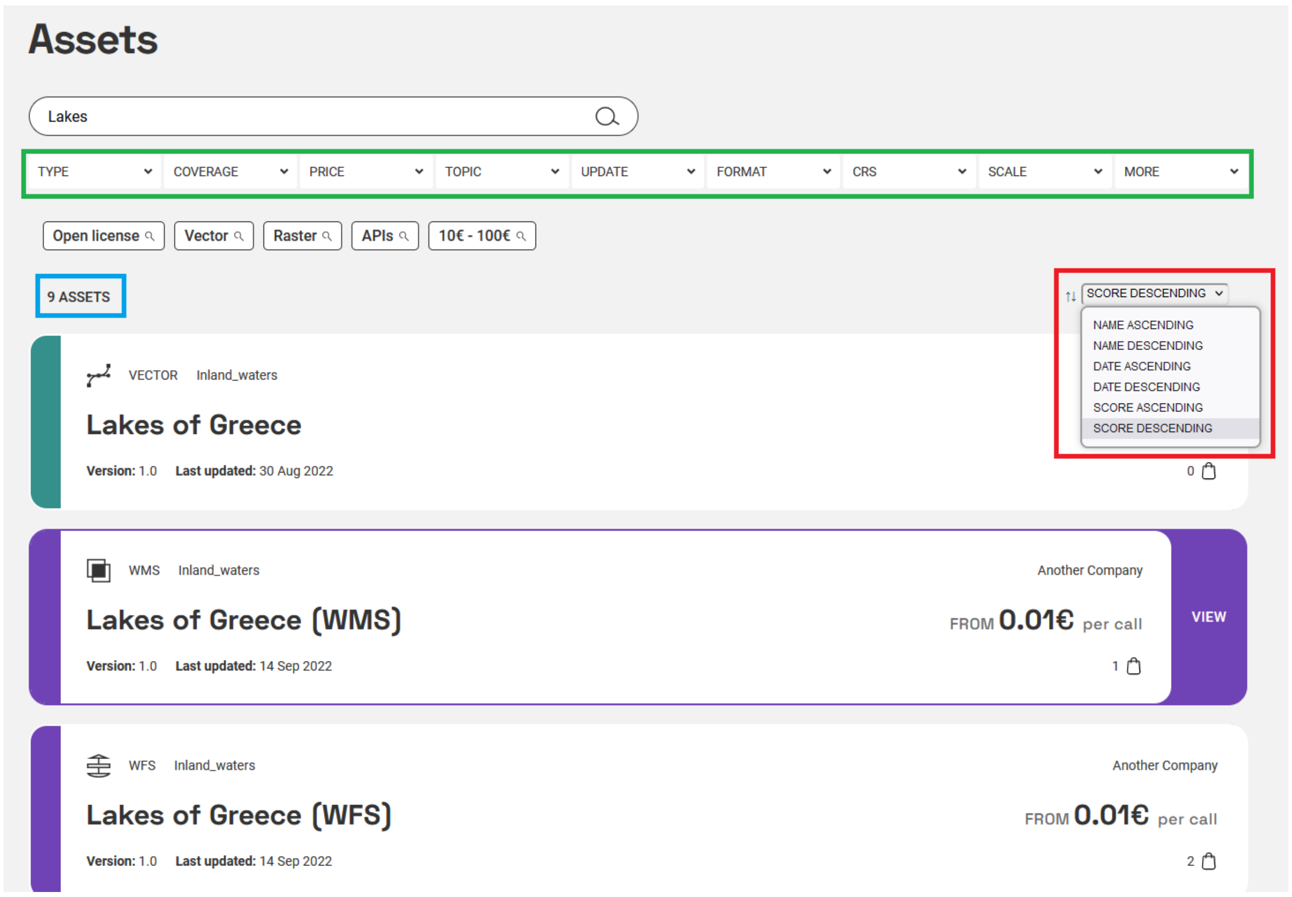

topio BETA
Sell
Buy
Use
About
Explore Assets
Explore. Trade. Use. Geodata.
The new geodata marketplace for Europe
Lakes
Recent Searches
Popular Searches
Lakes of Greece
Language: el, Price: FREE
Lakes of Greece (WMS)
Language: el, Price: FROM 0.01€ per call
Lakes of Greece (WFS)
Language: el, Price: FROM 0.01€ per call

Figure 50: Indicative list of assets matching the search terms

Instead, if the user presses *Enter* in the search bar, she is directed to a more detailed list of assets qualifying to her search term(s), as depicted in Figure 51. This list allows the user to inspect all information about the returned assets, and most importantly to explore the catalog of assets available in the marketplace, as detailed next.

2.1.2. Explore assets

The list of assets in Figure 51 can be accessed directly from the landing page, by clicking on the Explore Assets menu (in the green box in Figure 50); in this case, *the full catalog of available assets* is displayed, since no search conditions are applied. However, once the user submits a search request with specific terms in the search bar, this list only includes assets that are characterized by similar terms. The number of qualifying assets is clearly indicated on top of the list (enclosed in blue box in Figure 51). Then, the user can further refine the search results by extra criteria of even revise the search with other conditions. Note that summary information is shown per asset, allowing users to easily find whether something in the list is relevant to their needs. Each asset in the list is shown with a different background color to indicate its type (data file, API, etc.). By hovering the mouse over an asset, a "*View*" button is shown; upon clicking on it, the *Asset View* page opens to show all information available for the corresponding asset (see Section 2.2). Further, the resulting assets can be *sorted* according to the user's preferences: lexicographically *by name*, by ascending or descending *date*, as well as *by relevance* (similarity score) to the search term(s). These sorting options are listed in the red box in Figure 51.


Assets

Lakes

VECTOR Inland_waters
Lakes of Greece
Version: 1.0 **Last updated:** 30 Aug 2022
0

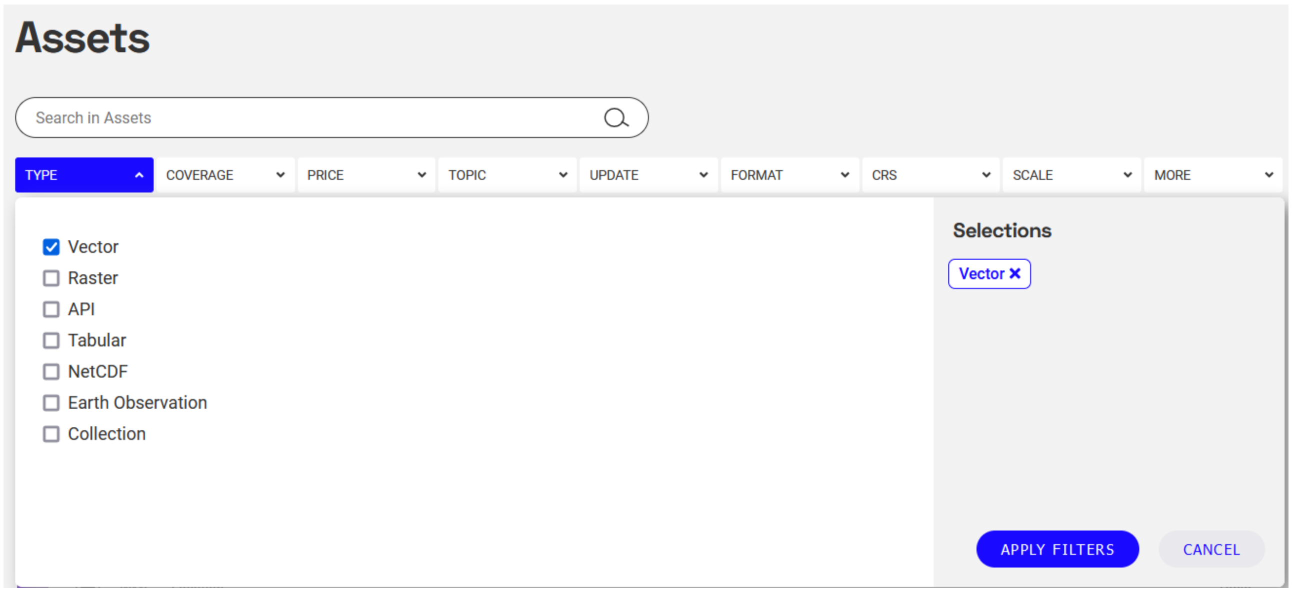
WMS Inland_waters
Another Company
Lakes of Greece (WMS)
FROM 0.01€ per call
Version: 1.0 **Last updated:** 14 Sep 2022
1
VIEW

WFS Inland_waters
Another Company
Lakes of Greece (WFS)
FROM 0.01€ per call
Version: 1.0 **Last updated:** 14 Sep 2022
2

Figure 51: Exploring the list of assets qualifying to search criteria

Optionally, this list of assets can be further *filtered* by several extra options (in the green box in Figure 51), each of them with its own conditions. These filtering criteria include:

- *Asset type*. The user can choose one or multiple types of geospatial assets supported in the marketplace: *Vector, Raster, API, Tabular, NetCDF, Earth Observation, Collection* (Figure 52).
- *Coverage*. The user can pick a particular country of interest from a dropdown list, thus specifying her interest on assets that cover this region. Alternatively, the user can draw a rectangle on an interactive map and specify that her assets of interest should *topologically overlap* with this rectangular region. This region (Figure 53) will then be used as a spatial criterion against the spatial extents of the assets in the Catalogue.
- *Price*. The user can specify her preferred minimum price, maximum price, or both (i.e., range of cost) for the sought assets. Besides, the user can specify her interest on assets available for free, by simply specifying "*Free*" on the minimum price.
- *Topic*. Each asset traded in the marketplace may be intended by its supplier for use in one or multiple broad application domains, e.g., *Environment, Farming, Transportation, Health*, etc. The user can pick one or more of these topics from this tab and find related assets.
- *Time of update*. The user can pick one or two dates from a calendar widget, depending on her preferences: (i) she may only look for assets updated after a date; (ii) she can search for assets updated no later than a cut-off date; or (iii) she may specify both dates to find assets updated during this time interval.
- *Format*. The user may wish to identify assets of a specific format, which also depends on its type. For example, *vector* data assets may be available as ESRI shapefiles, GeoJSON, CSV, etc., *raster* data as GeoTIFF, PNG, etc., whereas *APIs* may concern WMS, WFS. In case that the user has already picked asset type(s) from previous tab, she can only choose from the respective formats.
- *CRS*. This option concerns the original *Coordinate Reference System* of the asset, e.g., a global system like EPSG:4326, EPSG:3807 or other, even a national CRS like EPSG:2100 (GreekGrid87). Some popular CRS are shown as possible choices, but the user can also search for a particular reference system in a list of known CRSs and specify it for filtering.
- *Scale*. Scale is important for vector assets, as it conveys their accuracy. The user can specify a minimum scale, a maximum scale, or both, in order to find qualifying assets according to their original metadata as published by the suppliers. Besides, a few common scales are also listed (e.g., 1:10000, 1:50000, 1:100000, etc.) to allow the user to directly specify them.
- *More filters*. The last tab offers some extra filtering options, like type of *license*, *language*(s) used in thematic attributes of the dataset, *number of features* (distinguished in small, medium, or large size of the dataset), *attributes* that must exist in the dataset schema, or the name of the *supplier*. The user can specify her preference in any of these options to further refine the search results.


Assets

Search in Assets

TYPE | COVERAGE | PRICE | TOPIC | UPDATE | FORMAT | CRS | SCALE | MORE

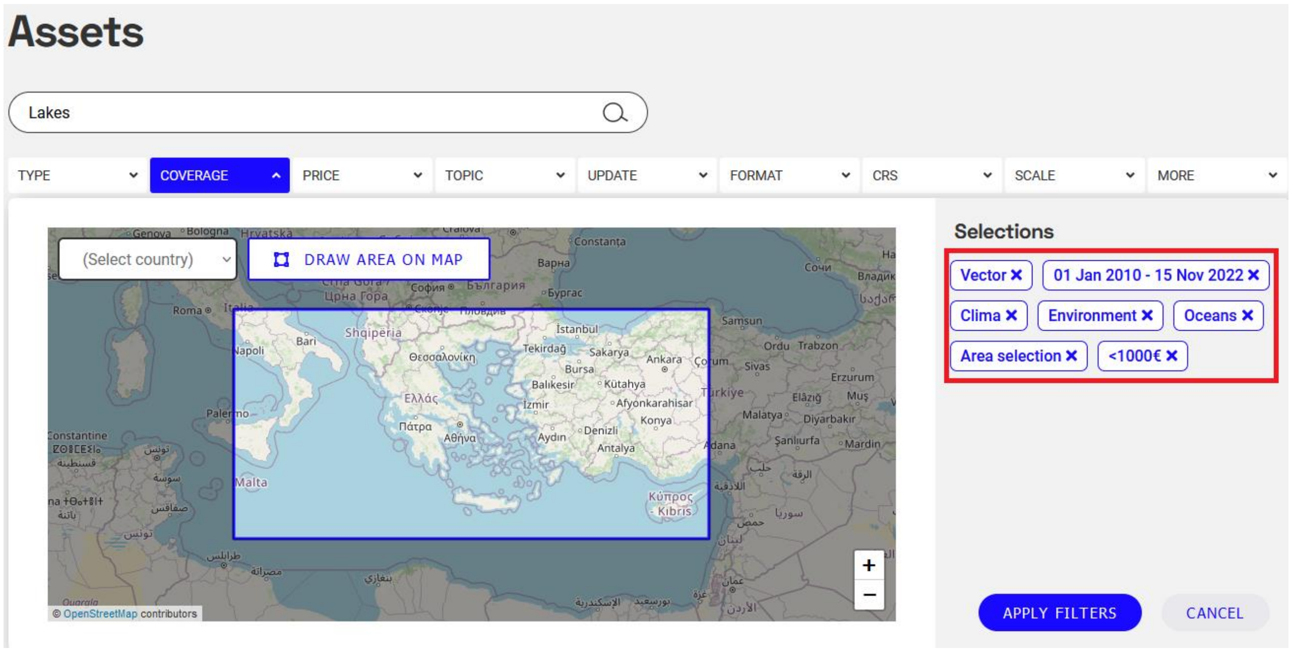
- [x] Vector
- [ ] Raster
- [ ] API
- [ ] Tabular
- [ ] NetCDF
- [ ] Earth Observation
- [ ] Collection

Selections

Vector ✕

APPLY FILTERS CANCEL

Figure 52: Applying different types of filters in asset search


Assets

Lakes

TYPE | COVERAGE | PRICE | TOPIC | UPDATE | FORMAT | CRS | SCALE | MORE

(Select country) DRAW AREA ON MAP

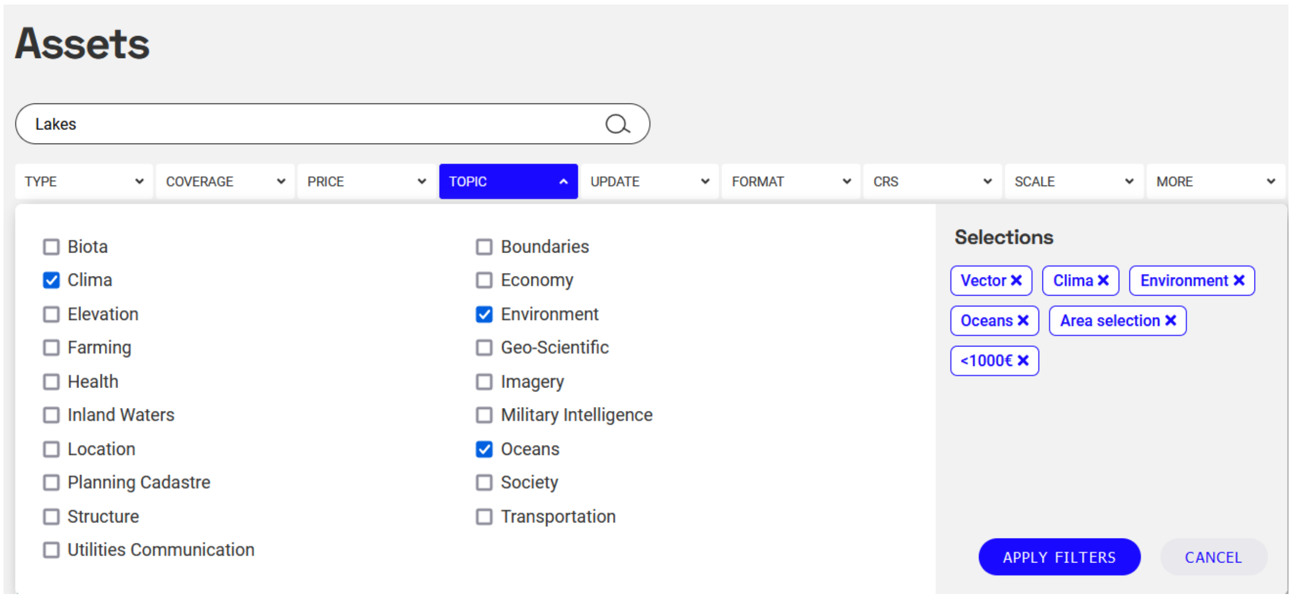
Selections

Vector ✕ | 01 Jan 2010 - 15 Nov 2022 ✕ | Clima ✕ | Environment ✕ | Oceans ✕ | Area selection ✕ | <1000€ ✕

APPLY FILTERS CANCEL

Figure 53: Filtering with a region of interest through an interactive map

The applied conditions from all tabs are visible in the *Selections* panel of the form (highlighted in the red box in Figure 53). Some of the filtering conditions may come from a *closed dictionary* (e.g., asset types, file formats, or topics as depicted in Figure 54), but others can be *user-specified* (e.g., price range). This enables prospective customers to narrow down their selection to assets that mostly match their preferences based on multiple filtering criteria.


Assets

Lakes

TYPE | COVERAGE | PRICE | TOPIC | UPDATE | FORMAT | CRS | SCALE | MORE

- [ ] Biota
- [x] Clima
- [ ] Elevation
- [ ] Farming
- [ ] Health
- [ ] Inland Waters
- [ ] Location
- [ ] Planning Cadastre
- [ ] Structure
- [ ] Utilities Communication
- [ ] Boundaries
- [ ] Economy
- [x] Environment
- [ ] Geo-Scientific
- [ ] Imagery
- [ ] Military Intelligence
- [x] Oceans
- [ ] Society
- [ ] Transportation

Selections

Vector ✕ Clima ✕ Environment ✕ Oceans ✕ Area selection ✕ <1000€ ✕

Figure 54: Several filtering criteria applied for refined search

By clicking on button "*Apply Filters*", the previously obtained search results are filtered with the chosen conditions and the list is refreshed with those qualifying to the actual filters. Of course, users can always add extra filtering conditions, modify those filters already applied (e.g., increase the price range, or add extra file formats), or even *cancel* some or all of them (by clicking on the × symbol next to each filter under *Selections*), thus triggering an update in the listed assets.

As already mentioned, at any step during this search the user can click on any of the listed assets and view all related information as detailed next in Section 2.2.

2.2. Asset View

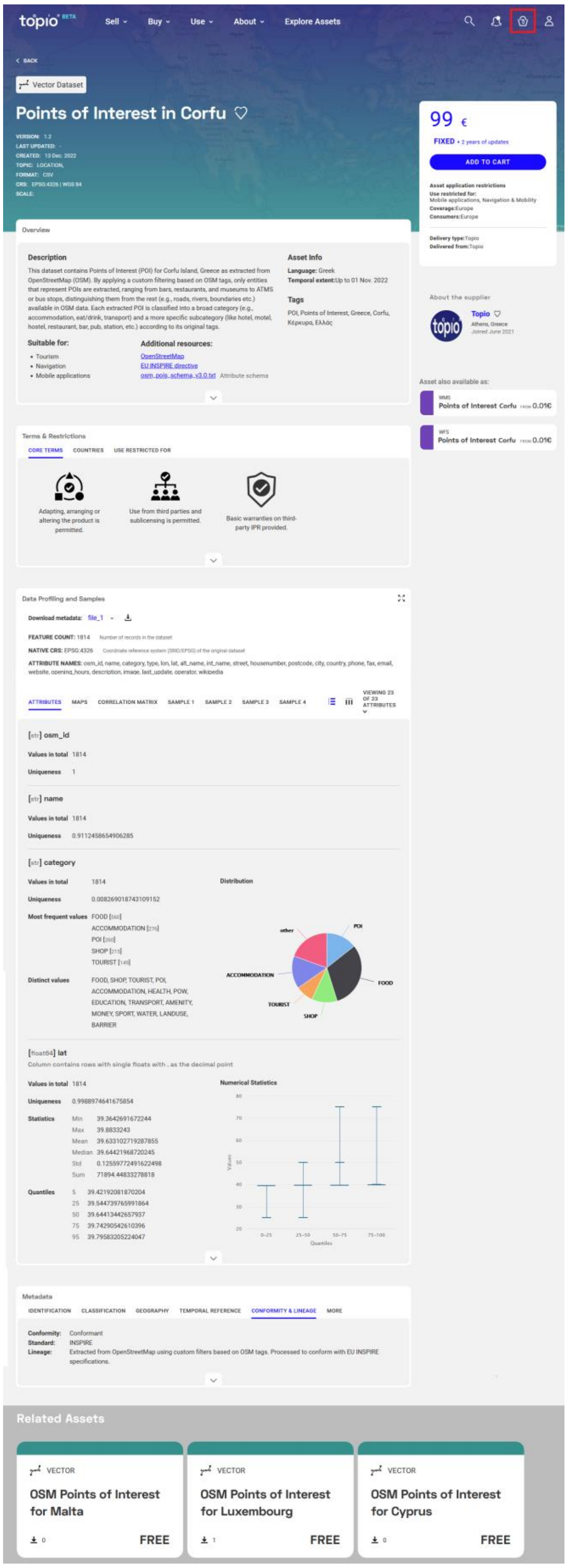
Browsing the list of assets qualifying to a search request with filtering criteria as discussed in Section 2.1, the user can click on any asset to view all available details about it. This *Asset View* (Figure 55) provides *complete information* about this particular asset, enabling a prospective customer to inspect its characteristics, examine the terms and conditions regarding its acquisition, assess its suitability for her needs through intuitive data profiling with visualizations and statistics, get samples and complete metadata for closer inspection, and of course purchase the asset under one of the offered pricing models.

For all asset types, this View Asset page maintains a common layout, like the one shown in Figure 55. In particular, this page consists of the following main blocks as detailed in the next subsections:

- Overview (Section 2.2.1);
- Purchase options (Section 2.3);
- Terms and Conditions (Section 2.2.2);
- Data profiling / EO Explorer (Section 2.2.3).
- Standard metadata (Section 2.2.4).

- Alternative offerings for asset (Section 2.2.5).
- Related assets (Section 2.2.6).

Note that depending on the asset type, this view is adjusted accordingly. For example, profiling information for data assets is precomputed and can be viewed on interactive maps, whereas this section for Earth Observation (EO) assets (i.e., satellite imagery) enables the user to search for available images with specific filters (like area and date of interest, cloud coverage, etc.), as detailed next. Displayed metadata may also differ by asset type, e.g., band information is also shown for raster data, service specifications of an API asset (e.g., WMS, WFS), etc.



Vector Dataset

Points of Interest in Corfu

VERSION: 1.2
LAST UPDATED: -
CREATED: 13 Dec. 2022
TOPIC: LOCATION,
FORMAT: CSV
CRS: EPSG:4326 | WGS 84
SCALE:

99 €
FIXED + 2 years of updates

Asset application restrictions
Use restricted for:
Mobile applications, Navigation & Mobility
Coverage: Europe
Consumers: Europe

Delivery type: Topio
Delivered from: Topio

About the supplier
Topio
Athens, Greece
Joined June 2021

Asset also available as:
WMS Points of Interest Corfu FROM 0.01€
WFS Points of Interest Corfu FROM 0.01€

Overview

Description
This dataset contains Points of Interest (POI) for Corfu Island, Greece as extracted from OpenStreetMap (OSM). By applying a custom filtering based on OSM tags, only entities that represent POIs are extracted, ranging from bars, restaurants, and museums to ATMS or bus stops, distinguishing them from the rest (e.g., roads, rivers, boundaries etc.) available in OSM data. Each extracted POI is classified into a broad category (e.g., accommodation, eat/drink, transport) and a more specific subcategory (like hotel, motel, hostel, restaurant, bar, pub, station, etc.) according to its original tags.

Asset Info
Language: Greek
Temporal extent: Up to 01 Nov. 2022

Tags
POI, Points of Interest, Greece, Corfu, Κέρκυρα, Ελλάς

Suitable for:
- Tourism
- Navigation
- Mobile applications

Additional resources:
OpenStreetMap
EU INSPIRE directive
osm_pois_schema_v3.0.txt Attribute schema

Terms & Restrictions
CORE TERMS | COUNTRIES | USE RESTRICTED FOR

Adapting, arranging or altering the product is permitted.
Use from third parties and sublicensing is permitted.
Basic warranties on third-party IPR provided.

Data Profiling and Samples

Download metadata: file_1

FEATURE COUNT: 1814 Number of records in the dataset
NATIVE CRS: EPSG:4326 Coordinate reference system (SRID/EPSG) of the original dataset
ATTRIBUTE NAMES: osm_id, name, category, type, lon, lat, alt_name, int_name, street, housenumber, postcode, city, country, phone, fax, email, website, opening_hours, description, image, last_update, operator, wikipedia

ATTRIBUTES | MAPS | CORRELATION MATRIX | SAMPLE 1 | SAMPLE 2 | SAMPLE 3 | SAMPLE 4 | VIEWING 23 OF 23 ATTRIBUTES

[str] osm_id
Values in total 1814
Uniqueness 1

[str] name
Values in total 1814
Uniqueness 0.9112458654906285

[str] category
Values in total 1814
Uniqueness 0.008269018743109152
Most frequent values FOOD [560]
ACCOMMODATION [276]
POI [260]
SHOP [215]
TOURIST [149]
Distinct values FOOD, SHOP, TOURIST, POI, ACCOMMODATION, HEALTH, POW, EDUCATION, TRANSPORT, AMENITY, MONEY, SPORT, WATER, LANDUSE, BARRIER
Distribution

[float64] lat
Column contains rows with single floats with . as the decimal point
Values in total 1814
Uniqueness 0.9988974641675854
Statistics
Min 39.3642691672244
Max 39.8833243
Mean 39.633102719287855
Median 39.64421968720245
Std 0.12559772491622498
Sum 71894.44833278818
Quantiles
5 39.42192081870204
25 39.544739765991864
50 39.64413442657937
75 39.74290542610396
95 39.79583205224047
Numerical Statistics

Metadata
IDENTIFICATION | CLASSIFICATION | GEOGRAPHY | TEMPORAL REFERENCE | CONFORMITY & LINEAGE | MORE

Conformity: Conformant
Standard: INSPIRE
Lineage: Extracted from OpenStreetMap using custom filters based on OSM tags. Processed to conform with EU INSPIRE specifications.

Related Assets

VECTOR
OSM Points of Interest for Malta
0 FREE

VECTOR
OSM Points of Interest for Luxembourg
1 FREE

VECTOR
OSM Points of Interest for Cyprus
0 FREE

Figure 55: Asset View for a data file (vector)

2.2.1. Overview

The *identity* of this asset is shown at the top of the web page, offering concise information about its contents and purpose. This summary highlights the *type* of the asset and informs about the *version(s)* available for purchase. A *topic* that suggests the spatial data category where this asset has been assigned to by its supplier, indicates its main purpose and broader application domain (e.g., geomarketing, transportation). Other important metadata describe timeliness (*last update*, *creation date*) of this asset, its original *format* (for file data assets), as well as spatial properties (*CRS*, original *scale*, area of *coverage*). A registered user can also mark a data asset as *favorite* by clicking on the heart button ♥ next to this asset's name (Figure 55). Then, this asset is added to the list of this user's favorites, which can be viewed at her dashboard. In addition, the rating of this asset is adjusted accordingly.

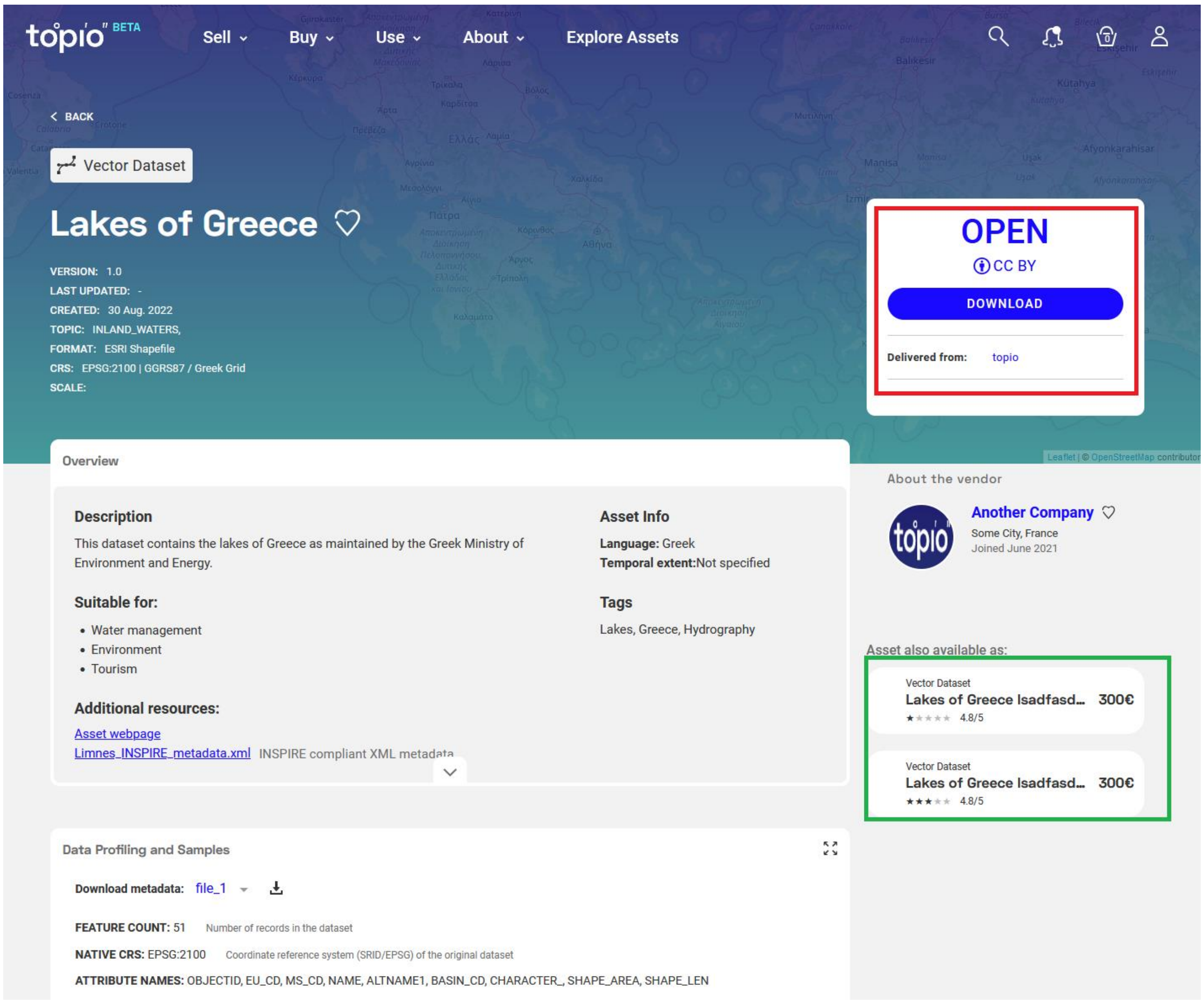
An *overview* of this asset's contents as provided by the supplier are shown below its basic identification. This summary includes a short description (abstract) of the asset, one or multiple application domains where the supplier considers that this asset is mostly suitable for use, asset information (language, temporal extent, etc.), as well as a collection of *tags* (i.e., keywords) that characterize this asset and can greatly facilitate search requests, i.e., when users search for assets to their keywords of interest. *Additional resources* about this asset (e.g., detailed documentation of its contents or its production process, description of the attributes, exemplary use cases) can also be provided as links to external files or webpages (e.g., at the supplier's website). All this information comes from the asset metadata as specified by the supplier in the publishing wizard.

2.2.1.1. Asset View for data files

The Asset View page for vector, raster, or tabular file datasets displays all available information as in Figure 55. It should be noted that specific elements may vary depending on the asset type, e.g., *scale* (e.g., 1:5000) is shown for vector assets. In contrast, tabular data may not explicitly contain geographical reference, hence scale or CRS may not be applicable. The listed *file format(s)* may also differ, e.g., vector datasets can be available as shapefiles, GeoJSON, raster data can be offered in TIFF, GeoTIFF, MrSID, etc., whereas tabular data may be available in CSV or XLS.

2.2.1.2. Asset View for open data files

The Asset View for open data files generally resembles the one shown for paid file assets, with a few important differences, as illustrated in Figure 56. First, the fact that the asset is *Open* and offered for *free download* is clearly marked, as highlighted with the red box in the same place where the pricing models are shown for paid assets. A registered consumer can *directly download* the asset; the process of adding assets to her cart, accepting the contract, and placing an order is not applied for open assets, thus simplifying their acquisition and use. Note that the applied license is clearly visible (e.g., CC BY) and by downloading such an asset, the consumer accepts the terms of this license. Thus, the entire section regarding Terms and Conditions (used for commercial data files as shown in Figure 55 and detailed in Section 2.2.2) is no longer necessary. All other sections of this page are similar to other assets, including data profile and samples, full metadata, as well as alternate offerings (e.g., WMS, WFS) of this open asset (highlighted in the green box). However, note that any services (WMS, WFS) over open assets offered by Topio require a paid subscription, thus they are not offered for free as the original open data file.


topio BETA | Sell | Buy | Use | About | Explore Assets

BACK

Vector Dataset

Lakes of Greece

VERSION: 1.0
LAST UPDATED: -
CREATED: 30 Aug. 2022
TOPIC: INLAND_WATERS,
FORMAT: ESRI Shapefile
CRS: EPSG:2100 | GGRS87 / Greek Grid
SCALE:

OPEN
CC BY
DOWNLOAD
Delivered from: topio

Overview

Description
This dataset contains the lakes of Greece as maintained by the Greek Ministry of Environment and Energy.

Asset Info
Language: Greek
Temporal extent:Not specified

Suitable for:
- Water management
- Environment
- Tourism

Tags
Lakes, Greece, Hydrography

Additional resources:
Asset webpage
Limnes_INSPIRE_metadata.xml INSPIRE compliant XML metadata

About the vendor
Another Company
Some City, France
Joined June 2021

Asset also available as:
Vector Dataset
Lakes of Greece lsadfasd... 300€ 4.8/5
Vector Dataset
Lakes of Greece lsadfasd... 300€ 4.8/5

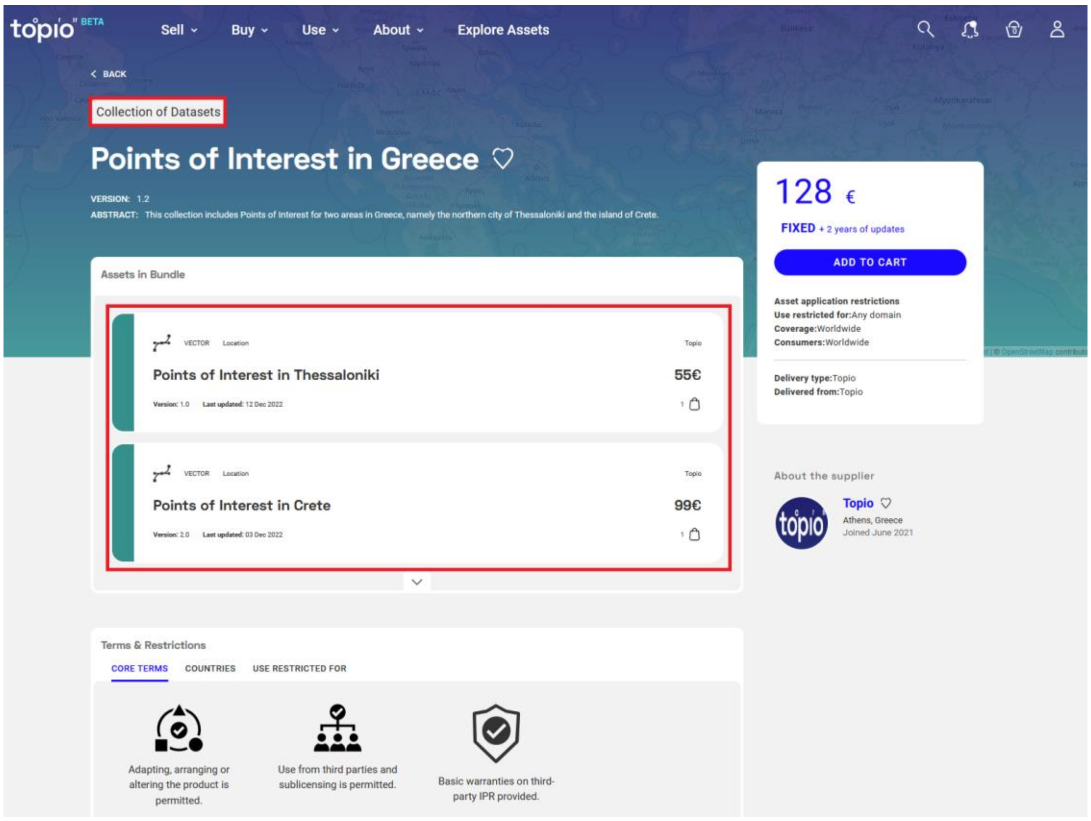
Data Profiling and Samples
Download metadata: file_1

FEATURE COUNT: 51 Number of records in the dataset
NATIVE CRS: EPSG:2100 Coordinate reference system (SRID/EPSG) of the original dataset
ATTRIBUTE NAMES: OBJECTID, EU_CD, MS_CD, NAME, ALTNAME1, BASIN_CD, CHARACTER_, SHAPE_AREA, SHAPE_LEN

Figure 56: Asset View for open data files

2.2.1.3. Asset View for collections

The Asset View page for collection of assets enables consumers to inspect the general information, the basic characteristics, and purchase this collection *as a whole*. If the customer needs further details for each asset in the collection, she has to visit its own Asset View page. As illustrated in Figure 57, the user can view the list of its constituent assets (enclosed in the red box). Upon clicking on any of these items, she is redirected to its corresponding Asset View page, which shows the complete details about it, including its data profile, samples, full metadata, etc.



Collection of Datasets

Points of Interest in Greece

VERSION: 1.2

ABSTRACT: This collection includes Points of Interest for two areas in Greece, namely the northern city of Thessaloniki and the island of Crete.

Assets in Bundle

VECTOR Location Topio
Points of Interest in Thessaloniki 55€
Version: 1.0 Last updated: 12 Dec 2022 1

VECTOR Location Topio
Points of Interest in Crete 99€
Version: 2.0 Last updated: 03 Dec 2022 1

Terms & Restrictions

CORE TERMS COUNTRIES USE RESTRICTED FOR

Adapting, arranging or altering the product is permitted.

Use from third parties and sublicensing is permitted.

Basic warranties on third-party IPR provided.

128 €

FIXED + 2 years of updates

ADD TO CART

Asset application restrictions
Use restricted for: Any domain
Coverage: Worldwide
Consumers: Worldwide

Delivery type: Topio
Delivered from: Topio

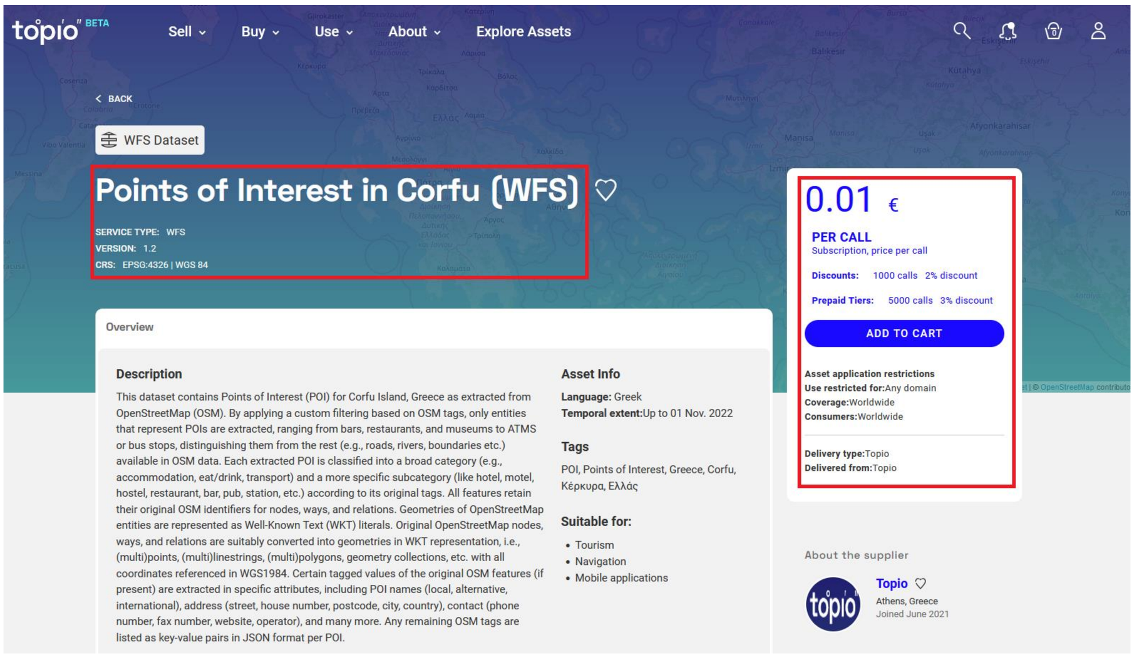
About the supplier

Topio
Athens, Greece
Joined June 2021

Figure 57: Standard Asset view page for collections

2.2.1.4. Asset View for APIs

The Asset View page for APIs enables customers to examine details about them. Basic information about the API is shown below its title (enclosed in a red box in Figure 58), but the particular elements depend on its type.



WFS Dataset

Points of Interest in Corfu (WFS)

SERVICE TYPE: WFS
VERSION: 1.2
CRS: EPSG:4326 | WGS 84

Overview

Description

This dataset contains Points of Interest (POI) for Corfu Island, Greece as extracted from OpenStreetMap (OSM). By applying a custom filtering based on OSM tags, only entities that represent POIs are extracted, ranging from bars, restaurants, and museums to ATMS or bus stops, distinguishing them from the rest (e.g., roads, rivers, boundaries etc.) available in OSM data. Each extracted POI is classified into a broad category (e.g., accommodation, eat/drink, transport) and a more specific subcategory (like hotel, motel, hostel, restaurant, bar, pub, station, etc.) according to its original tags. All features retain their original OSM identifiers for nodes, ways, and relations. Geometries of OpenStreetMap entities are represented as Well-Known Text (WKT) literals. Original OpenStreetMap nodes, ways, and relations are suitably converted into geometries in WKT representation, i.e., (multi)points, (multi)linestrings, (multi)polygons, geometry collections, etc. with all coordinates referenced in WGS1984. Certain tagged values of the original OSM features (if present) are extracted in specific attributes, including POI names (local, alternative, international), address (street, house number, postcode, city, country), contact (phone number, fax number, website, operator), and many more. Any remaining OSM tags are listed as key-value pairs in JSON format per POI.

Asset Info

Language: Greek
Temporal extent: Up to 01 Nov. 2022

Tags

POI, Points of Interest, Greece, Corfu, Κέρκυρα, Ελλάς

Suitable for:

- Tourism
- Navigation
- Mobile applications

0.01 €

PER CALL
Subscription, price per call

Discounts: 1000 calls 2% discount

Prepaid Tiers: 5000 calls 3% discount

ADD TO CART

Asset application restrictions
Use restricted for: Any domain
Coverage: Worldwide
Consumers: Worldwide

Delivery type: Topio
Delivered from: Topio

About the supplier

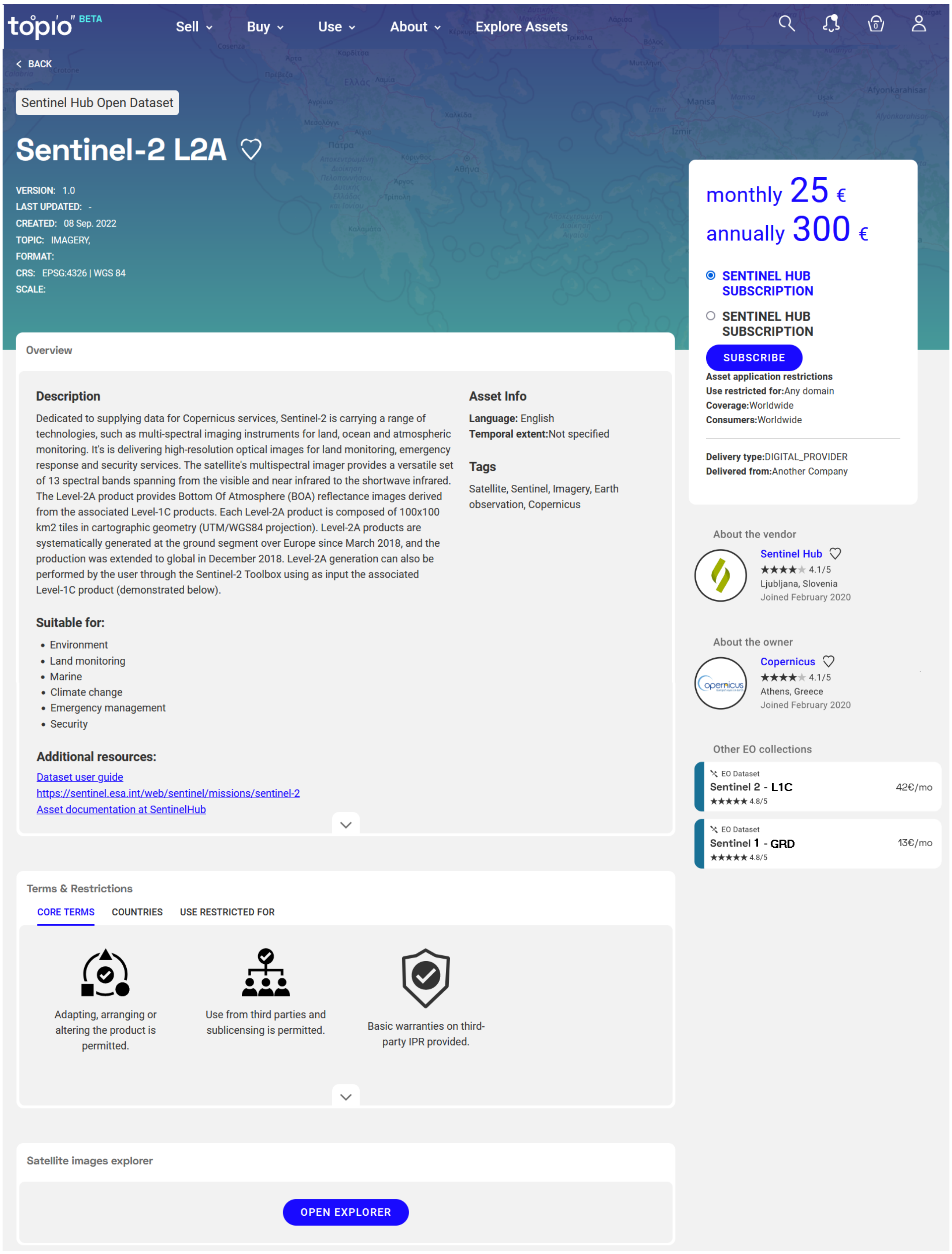
Topio
Athens, Greece
Joined June 2021

Figure 58: Overview of a typical API asset (WFS)

2.2.1.5. Asset View for EO collections

The Asset View for Earth Observation (EO) collections enables consumers to get information about collections of EO assets, inspect their characteristics, explore their coverage, and even view thumbnails of images. As shown in Figure 59, the layout of the page almost looks like the one used for other types of assets, including basic information about the collection, its supplier, related assets (other EO collections available, as marked in the blue box).

When the user clicks on the *Open Explorer* button, a panel is displayed allowing users of the platform explore what is offered by this EO collection. Based on their own assessment, customers may subscribe to OGC-compliant services from *open EO collections* that offer such imagery. For each open EO collection, they can search its contents with user-specified preferences (like area of interest, time period, or maximum cloud coverage allowed) depending on the EO collection), and preview metadata regarding its available images. Regarding *proprietary EO collections*, the platform enables users to search for available images that qualify to similar user-specified preferences (e.g., area of interest, time period, maximum cloud coverage allowed, etc.) and order such images through the marketplace. This Image Explorer panel is further discussed in Sections 2.2.3.4 (open EO collections) and 2.2.3.5 (proprietary collections).



Sentinel Hub Open Dataset

Sentinel-2 L2A

VERSION: 1.0
LAST UPDATED: -
CREATED: 08 Sep. 2022
TOPIC: IMAGERY,
FORMAT:
CRS: EPSG:4326 | WGS 84
SCALE:

monthly 25 €
annually 300 €

[✓ SENTINEL HUB SUBSCRIPTION]
SENTINEL HUB SUBSCRIPTION

SUBSCRIBE

Asset application restrictions
Use restricted for: Any domain
Coverage: Worldwide
Consumers: Worldwide

Delivery type: DIGITAL_PROVIDER
Delivered from: Another Company

Overview

Description

Dedicated to supplying data for Copernicus services, Sentinel-2 is carrying a range of technologies, such as multi-spectral imaging instruments for land, ocean and atmospheric monitoring. It's is delivering high-resolution optical images for land monitoring, emergency response and security services. The satellite's multispectral imager provides a versatile set of 13 spectral bands spanning from the visible and near infrared to the shortwave infrared. The Level-2A product provides Bottom Of Atmosphere (BOA) reflectance images derived from the associated Level-1C products. Each Level-2A product is composed of 100x100 km2 tiles in cartographic geometry (UTM/WGS84 projection). Level-2A products are systematically generated at the ground segment over Europe since March 2018, and the production was extended to global in December 2018. Level-2A generation can also be performed by the user through the Sentinel-2 Toolbox using as input the associated Level-1C product (demonstrated below).

Suitable for:

- Environment
- Land monitoring
- Marine
- Climate change
- Emergency management
- Security

Additional resources:

Dataset user guide
https://sentinel.esa.int/web/sentinel/missions/sentinel-2
Asset documentation at SentinelHub

Asset Info

Language: English
Temporal extent: Not specified

Tags

Satellite, Sentinel, Imagery, Earth observation, Copernicus

About the vendor

Sentinel Hub
★★★★ 4.1/5
Ljubljana, Slovenia
Joined February 2020

About the owner

Copernicus
★★★★ 4.1/5
Athens, Greece
Joined February 2020

Other EO collections

EO Dataset	Sentinel 2 - L1C	42€/mo
★★★★★ 4.8/5		
EO Dataset	Sentinel 1 - GRD	13€/mo
★★★★★ 4.8/5		

Terms & Restrictions

CORE TERMS   COUNTRIES   USE RESTRICTED FOR

Adapting, arranging or altering the product is permitted.

Use from third parties and sublicensing is permitted.

Basic warranties on third-party IPR provided.

Satellite images explorer

OPEN EXPLORER

Figure 59: Asset View for open EO collections

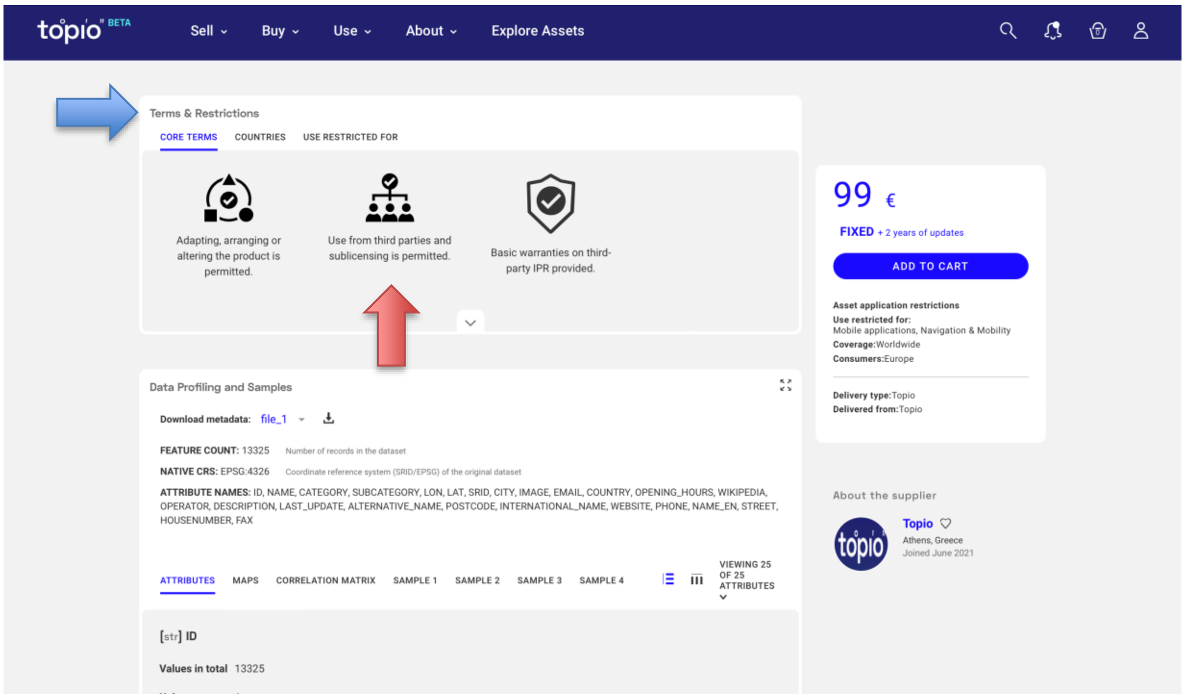
2.2.2. Terms and restrictions

Upon visiting the "Asset View" page of an asset, a prospective customer is provided with information regarding the license terms and restrictions that accompany the asset. The license terms are placed in the "Terms & Restrictions" frame, located below the overview of each asset, as indicated with a blue arrow in Figure 60.

The license terms frame is consisted of the following three tabs:

- Core terms
- Countries
- Use restricted for

The "Core Terms" tab, shown in Figure 60, contains details regarding terms and conditions for using the asset, which correspond to the optional terms selected by the supplier while creating the template contract for this asset. To keep things simple, each term is consisted of a small but comprehensive sentence that clearly describes each term, e.g., "Use from third parties and sublicensing is permitted" (red arrow in Figure 60). Each term is also accompanied by a simple, monochrome, intuitive icon that represents its directive.



Adapting, arranging or altering the product is permitted.

Use from third parties and sublicensing is permitted.

Basic warranties on third-party IPR provided.

Download metadata: file_1

FEATURE COUNT: 13325 Number of records in the dataset

NATIVE CRS: EPSG:4326 Coordinate reference system (SRID/EPSG) of the original dataset

ATTRIBUTE NAMES: ID, NAME, CATEGORY, SUBCATEGORY, LON, LAT, SRID, CITY, IMAGE, EMAIL, COUNTRY, OPENING_HOURS, WIKIPEDIA, OPERATOR, DESCRIPTION, LAST_UPDATE, ALTERNATIVE_NAME, POSTCODE, INTERNATIONAL_NAME, WEBSITE, PHONE, NAME_EN, STREET, HOUSENUMBER, FAX

VIEWING 25 OF 25 ATTRIBUTES

[str] ID

Values in total 13325

99 €

FIXED + 2 years of updates

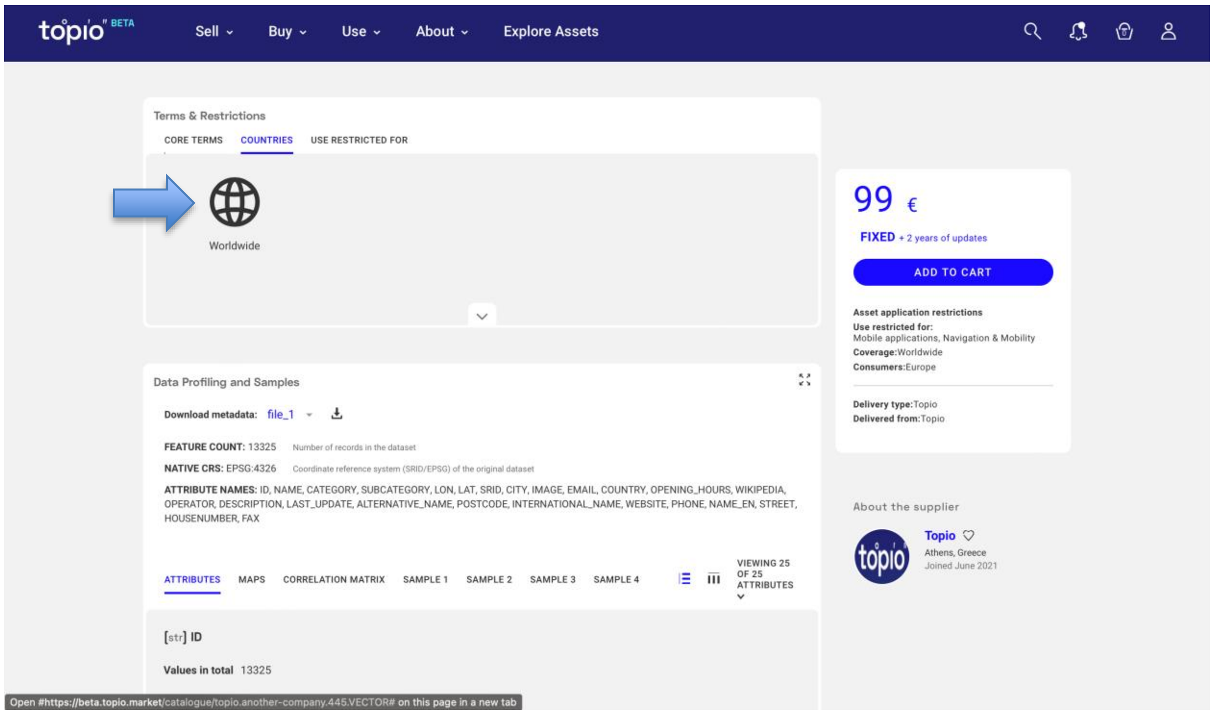
Asset application restrictions
Use restricted for:
Mobile applications, Navigation & Mobility
Coverage: Worldwide
Consumers: Europe

Delivery type: Topio
Delivered from: Topio

Topio
Athens, Greece
Joined June 2021

Figure 60: "Core terms" tab of the license terms

The "Countries" tab in the "Terms & Restrictions" frame contains the list of countries or regions that the use of this asset is restricted for. In the example depicted in Figure 61, the asset is available for use everywhere in the world, which is indicated using a corresponding icon (blue arrow in Figure 61).



Terms & Restrictions

CORE TERMS COUNTRIES USE RESTRICTED FOR

Worldwide

Data Profiling and Samples

Download metadata: file_1

FEATURE COUNT: 13325 Number of records in the dataset

NATIVE CRS: EPSG:4326 Coordinate reference system (SRID/EPSG) of the original dataset

ATTRIBUTE NAMES: ID, NAME, CATEGORY, SUBCATEGORY, LON, LAT, SRID, CITY, IMAGE, EMAIL, COUNTRY, OPENING_HOURS, WIKIPEDIA, OPERATOR, DESCRIPTION, LAST_UPDATE, ALTERNATIVE_NAME, POSTCODE, INTERNATIONAL_NAME, WEBSITE, PHONE, NAME_EN, STREET, HOUSENUMBER, FAX

ATTRIBUTES MAPS CORRELATION MATRIX SAMPLE 1 SAMPLE 2 SAMPLE 3 SAMPLE 4 VIEWING 25 OF 25 ATTRIBUTES

[str] ID

Values in total 13325

Open #https://beta.topio.market/catalogue/topio.another-company.445.VECTOR# on this page in a new tab

99 €

FIXED + 2 years of updates

ADD TO CART

Asset application restrictions
Use restricted for:
Mobile applications, Navigation & Mobility
Coverage:Worldwide
Consumers:Europe

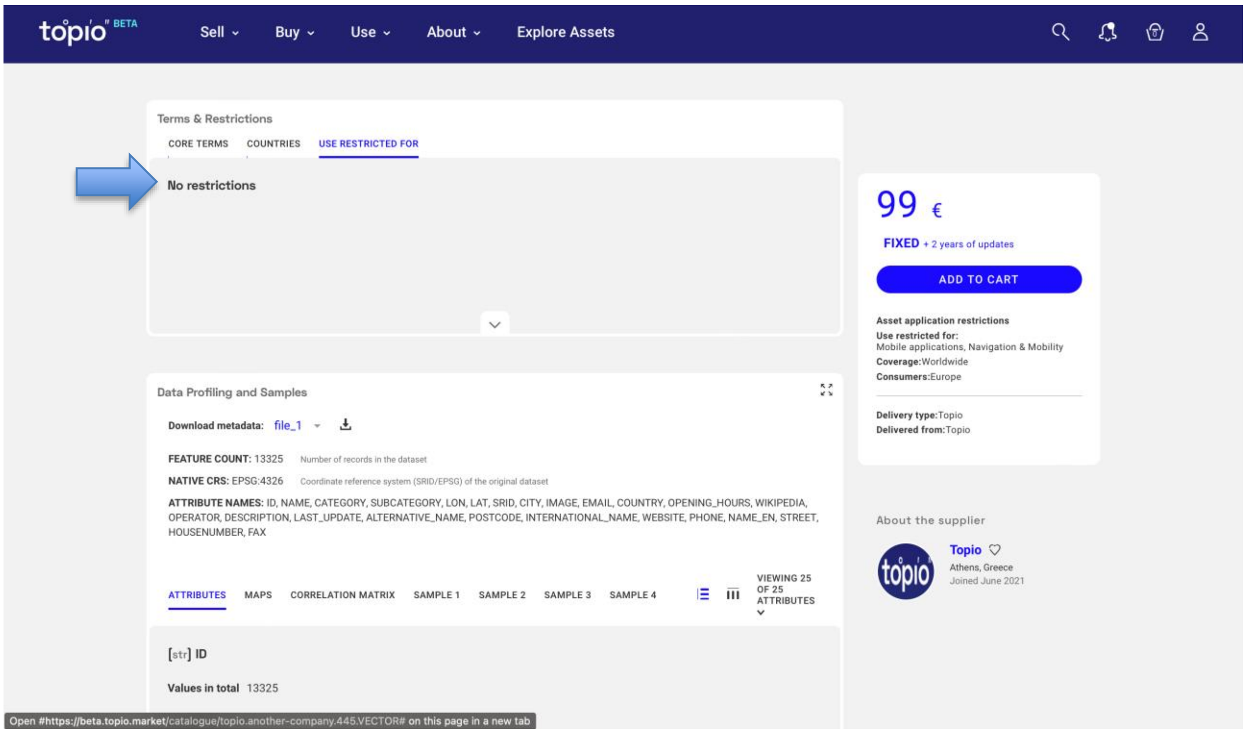
Delivery type:Topio
Delivered from:Topio

About the supplier

Topio
Athens, Greece
Joined June 2021

Figure 61: “Countries” tab of the license terms

Finally, the “Use Restricted For” tab contains information regarding restrictions on the domain where the asset can be used. For example, in Figure 62, the asset has no domain restrictions and is available for all applications (blue arrow in Figure 62). As in the previous tabs, any restrictions that appear here are accompanied with a monochrome, intuitive icon representing the directive.



Terms & Restrictions

CORE TERMS COUNTRIES USE RESTRICTED FOR

No restrictions

Data Profiling and Samples

Download metadata: file_1

FEATURE COUNT: 13325 Number of records in the dataset

NATIVE CRS: EPSG:4326 Coordinate reference system (SRID/EPSG) of the original dataset

ATTRIBUTE NAMES: ID, NAME, CATEGORY, SUBCATEGORY, LON, LAT, SRID, CITY, IMAGE, EMAIL, COUNTRY, OPENING_HOURS, WIKIPEDIA, OPERATOR, DESCRIPTION, LAST_UPDATE, ALTERNATIVE_NAME, POSTCODE, INTERNATIONAL_NAME, WEBSITE, PHONE, NAME_EN, STREET, HOUSENUMBER, FAX

ATTRIBUTES MAPS CORRELATION MATRIX SAMPLE 1 SAMPLE 2 SAMPLE 3 SAMPLE 4 VIEWING 25 OF 25 ATTRIBUTES

[str] ID

Values in total 13325

Open #https://beta.topio.market/catalogue/topio.another-company.445.VECTOR# on this page in a new tab

99 €

FIXED + 2 years of updates

ADD TO CART

Asset application restrictions
Use restricted for:
Mobile applications, Navigation & Mobility
Coverage:Worldwide
Consumers:Europe

Delivery type:Topio
Delivered from:Topio

About the supplier

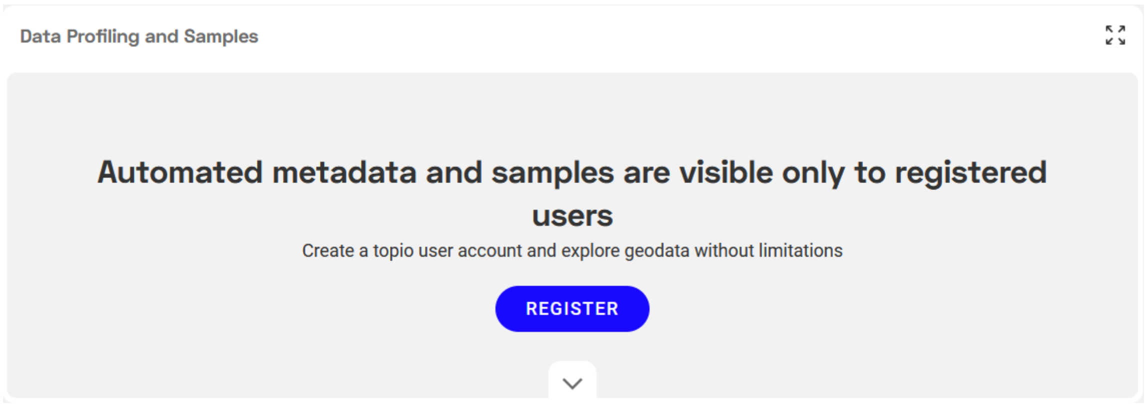
Topio
Athens, Greece
Joined June 2021

Figure 62: “Use restricted for” tab of the license terms

2.2.3. Profiling and samples

Providing prospective customers with comprehensive and intuitive information that reveals important aspects of each asset before purchase is a key marketplace offering to increase transparency and trust. For *data assets* (e.g., vector, raster), this profiling information concerns *automated metadata*, such as coverage, timeliness, quality, spatial distribution, etc., as well as *samples* which are calculated by the platform before an asset gets publicly available. Similar profile information also applies to *open* file assets. For *APIs* like WMS or WFS, this section displays metadata extracted from the respective service. For *Earth Observation assets* (i.e., satellite imagery) this section is adjusted to enable users to search for available images with specific filters (area and date of interest, cloud coverage, etc.).

It is important to note that *unregistered visitors* of the marketplace can neither view any such information nor can they download any samples. As illustrated in Figure 63, such visitors are shown "greyed out" panel with no decipherable metadata information and they are urged to register or sign in the platform to explore the profile of each data asset in full. This is a deliberate decision, because such data profiles are expected to offer in-depth information about each asset, and we consider them as a non-invasive and simple nudge for users to register in the platform.


Data Profiling and Samples

Automated metadata and samples are visible only to registered users

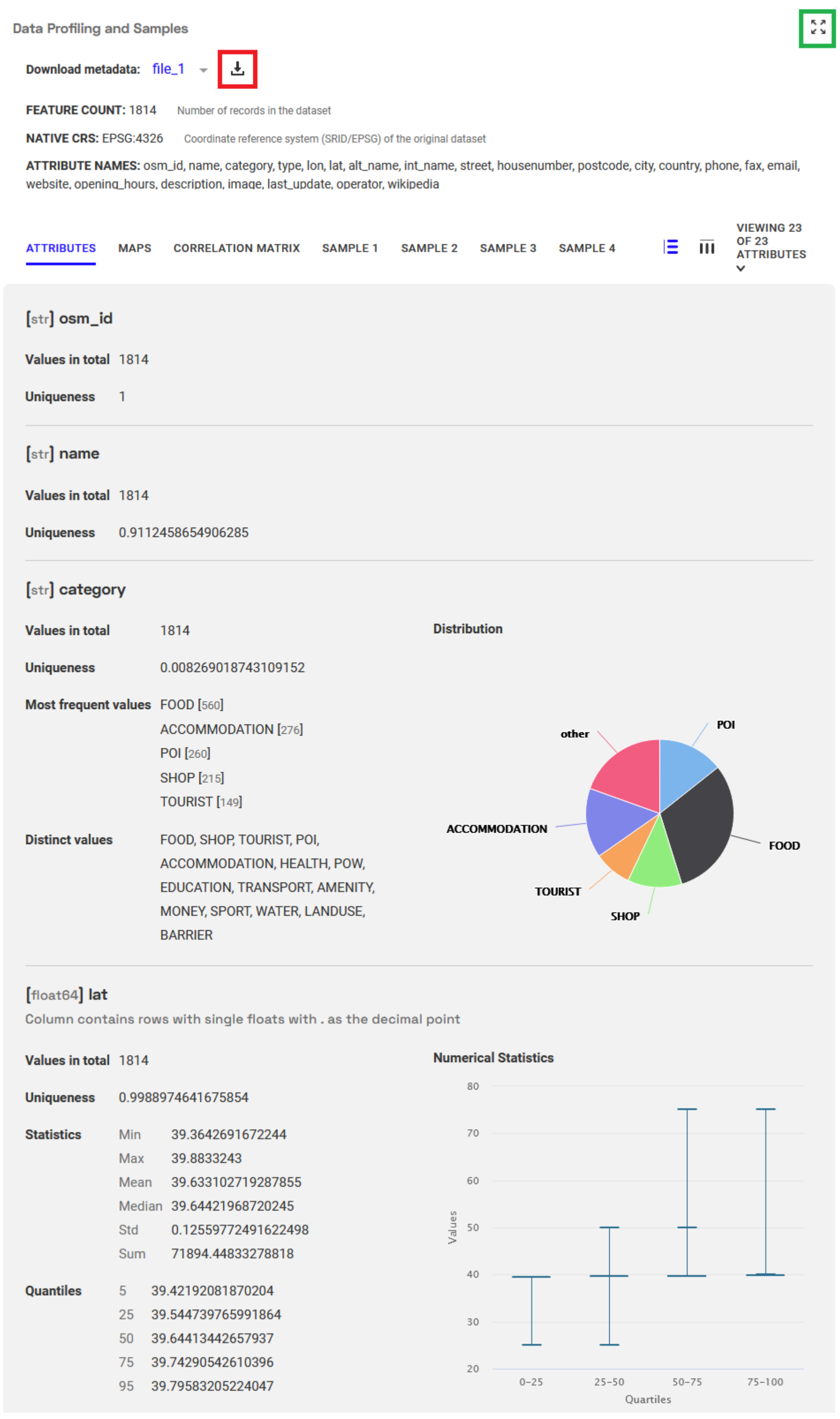
Create a topio user account and explore geodata without limitations

Figure 63: Profiling information and samples are not accessible by unregistered users

In the following sections we discuss the differing profiling views offered per asset type, effectively helping customers to compare assets and assess their suitability for their own needs.

2.2.3.1. Profiling and samples for data assets

Registered users who have signed in the platform are presented with a comprehensive *profile* of each *data asset*, i.e., a wide range of automated metadata computed by the platform as depicted in Figure 64. This panel can be *maximized* to full screen by clicking on the expand button (shown in the red box on the top right).



Data Profiling and Samples

Download metadata: file_1

FEATURE COUNT: 1814 Number of records in the dataset

NATIVE CRS: EPSG:4326 Coordinate reference system (SRID/EPSG) of the original dataset

ATTRIBUTE NAMES: osm_id, name, category, type, lon, lat, alt_name, int_name, street, housenumber, postcode, city, country, phone, fax, email, website, opening_hours, description, image, last_update, operator, wikipedia

ATTRIBUTES MAPS CORRELATION MATRIX SAMPLE 1 SAMPLE 2 SAMPLE 3 SAMPLE 4 VIEWING 23 OF 23 ATTRIBUTES

[str] osm_id

Values in total 1814

Uniqueness 1

[str] name

Values in total 1814

Uniqueness 0.9112458654906285

[str] category

Values in total 1814

Uniqueness 0.008269018743109152

Most frequent values FOOD [560], ACCOMMODATION [276], POI [260], SHOP [215], TOURIST [149]

Distinct values FOOD, SHOP, TOURIST, POI, ACCOMMODATION, HEALTH, POW, EDUCATION, TRANSPORT, AMENITY, MONEY, SPORT, WATER, LANDUSE, BARRIER

Distribution

[float64] lat
Column contains rows with single floats with . as the decimal point

Values in total 1814

Uniqueness 0.9988974641675854

Statistics	
Min	39.3642691672244
Max	39.8833243
Mean	39.633102719287855
Median	39.64421968720245
Std	0.12559772491622498
Sum	71894.44833278818

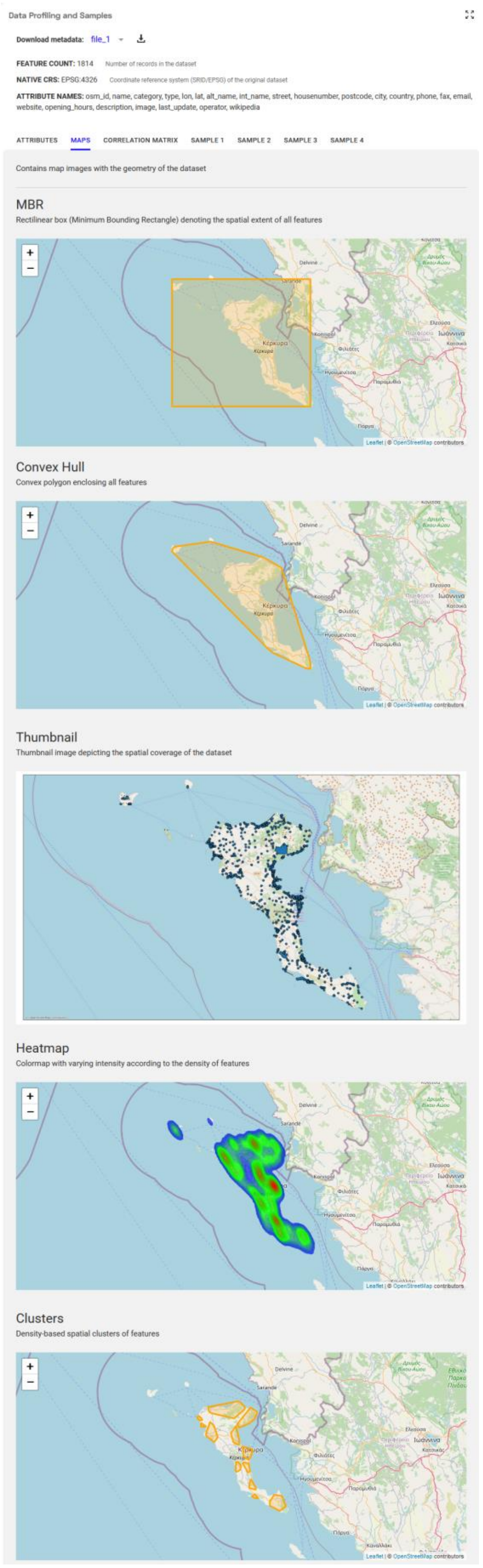
Quantiles	
5	39.42192081870204
25	39.544739765991864
50	39.64413442657937
75	39.74290542610396
95	39.79583205224047

Numerical Statistics

Figure 64: Full range of automated thematic metadata available to registered users

More specifically, such a profile includes information concerning the entire asset, such as the native CRS, the number of features, etc., as detected by the platform for data assets that have been uploaded to the repository. Most importantly, for *vector data assets* there is detailed information per thematic attribute, which includes pie charts or histograms for its own distribution of values, lists of distinct and most frequent values, as well as statistics (e.g., quartiles for numerical values). For inspecting vector datasets with many attributes, users are also able to choose which attributes are of interest and display this information only (either side-by-side as in Figure 64 or as a vertical list with one attribute below the other).

Regarding spatial information, users can also browse several types of *map-based plots*, as illustrated in Figure 65. Such plots may include the spatial extent (MBR) of features, the convex hull, a thumbnail image, as well as heatmaps and clusters that are very informative of the spatial distribution of the geometric entities contained in the dataset. Such plots have been prepared in advance when an asset is under review. Some plots are rendered as high-resolution images and users can magnify each one for more detail. Further, certain elements can also be also viewed on interactive maps (e.g., clusters, MBRs). The user can pan, zoom in, or zoom out the map and inspect those plots in more detail.


Data Profiling and Samples

Download metadata: file_1

FEATURE COUNT: 1814 Number of records in the dataset

NATIVE CRS: EPSG:4326 Coordinate reference system (SRID/EPSG) of the original dataset

ATTRIBUTE NAMES: osm_id, name, category, type, lon, lat, alt_name, int_name, street, housenumber, postcode, city, country, phone, fax, email, website, opening_hours, description, image, last_update, operator, wikipedia

ATTRIBUTES MAPS CORRELATION MATRIX SAMPLE 1 SAMPLE 2 SAMPLE 3 SAMPLE 4

Contains map images with the geometry of the dataset

MBR

Rectilinear box (Minimum Bounding Rectangle) denoting the spatial extent of all features

Convex Hull

Convex polygon enclosing all features

Thumbnail

Thumbnail image depicting the spatial coverage of the dataset

Heatmap

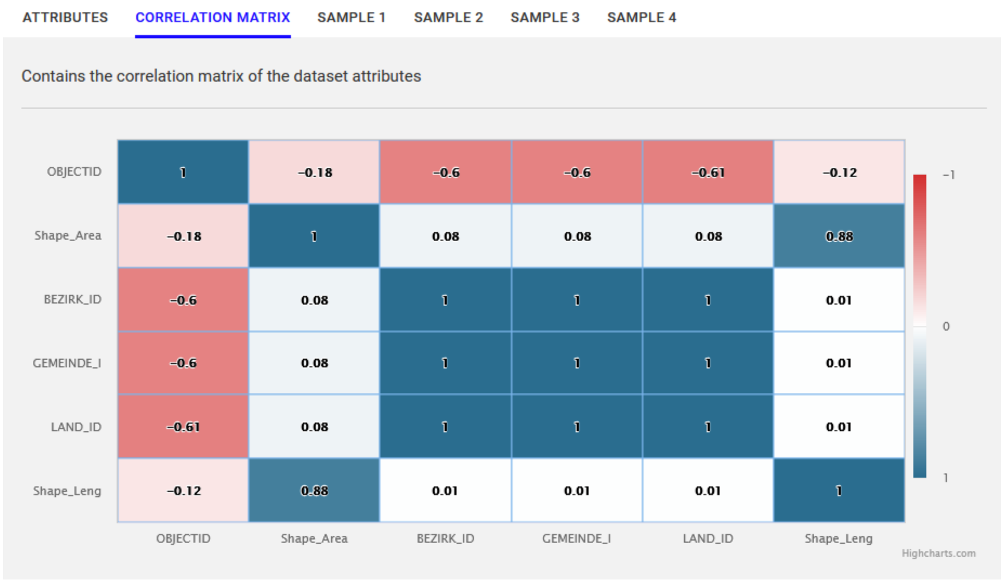
Colormap with varying intensity according to the density of features

Clusters

Density-based spatial clusters of features

Figure 65: Automated spatial metadata in interactive maps available to registered users

In addition, any correlations between attributes in a *vector* or *tabular* file asset are shown in a *correlation matrix* as illustrated in Figure 66. Highly correlated pairs of attributes have a positive correlation value and are depicted in dark green color (obviously each attribute is shown correlated with itself). Instead, no (zero) correlation is shown white, whereas anti-correlated attributes are shown in red-colored shades.

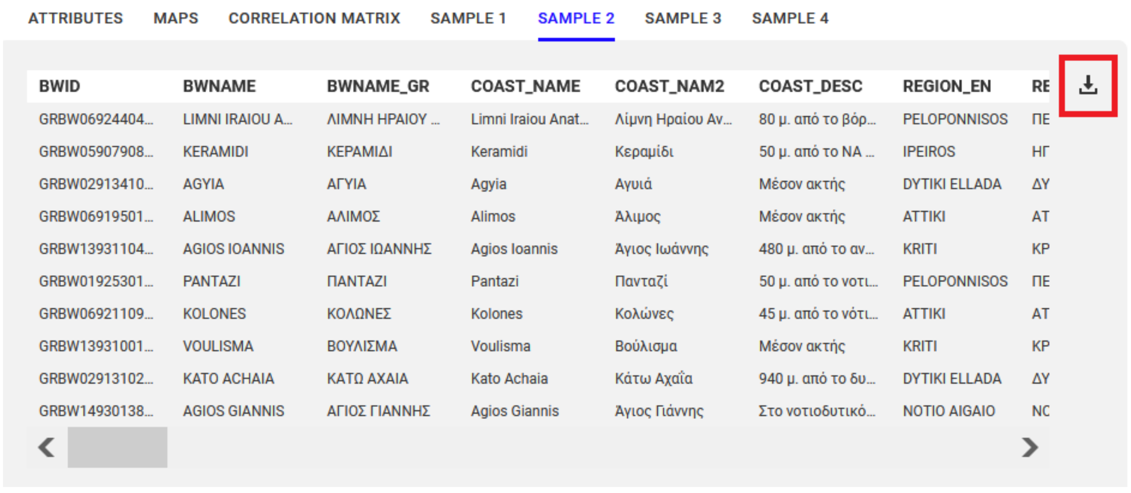


Contains the correlation matrix of the dataset attributes

	OBJECTID	Shape_Area	BEZIRK_ID	GEMEINDE_I	LAND_ID	Shape_Leng
OBJECTID	1	-0.18	-0.6	-0.6	-0.61	-0.12
Shape_Area	-0.18	1	0.08	0.08	0.08	0.88
BEZIRK_ID	-0.6	0.08	1	1	1	0.01
GEMEINDE_I	-0.6	0.08	1	1	1	0.01
LAND_ID	-0.61	0.08	1	1	1	0.01
Shape_Leng	-0.12	0.88	0.01	0.01	0.01	1

Figure 66: Matrix showing pairwise correlation of all attributes

Finally, prospective customers are offered with one or more data *samples*, i.e., small subset(s) of the original dataset, as shown in Figure 67. These samples may be provided by the suppliers, but they can be also extracted by the platform when the asset is under review before publication. Each available sample can be viewed directly through the platform, but it is also possible to download it (with the button highlighted in the red box) for display on the user's own machine with a suitable software (e.g., GIS for geographical files).



BWID	BWNAME	BWNAME_GR	COAST_NAME	COAST_NAM2	COAST_DESC	REGION_EN	RE
GRBW06924404...	LIMNI IRAIOU A...	ΛΙΜΝΗ ΗΡΑΙΟΥ ...	Limni Iraiou Anat...	Λίμνη Ηραίου Αν...	80 μ. από το βόρ...	PELOPONNISOS	ΠΕ
GRBW05907908...	KERAMIDI	ΚΕΡΑΜΙΔΙ	Keramidi	Κεραμίδι	50 μ. από το ΝΑ ...	IPEIROS	ΗΓ
GRBW02913410...	AGYIA	ΑΓΥΙΑ	Agyia	Αγυιά	Μέσον ακτής	DYTIKI ELLADA	ΔΥ
GRBW06919501...	ALIMOS	ΑΛΙΜΟΣ	Alimos	Άλιμος	Μέσον ακτής	ATTIKI	ΑΤ
GRBW13931104...	AGIOS IOANNIS	ΑΓΙΟΣ ΙΩΑΝΝΗΣ	Agios Ioannis	Άγιος Ιωάννης	480 μ. από το αν...	KRITI	ΚΡ
GRBW01925301...	PANTAZI	ΠΑΝΤΑΖΙ	Pantazi	Πανταζί	50 μ. από το νοτι...	PELOPONNISOS	ΠΕ
GRBW06921109...	KOLONES	ΚΟΛΩΝΕΣ	Kolones	Κολώνες	45 μ. από το νότι...	ATTIKI	ΑΤ
GRBW13931001...	VOULISMA	ΒΟΥΛΙΣΜΑ	Voulisma	Βούλισμα	Μέσον ακτής	KRITI	ΚΡ
GRBW02913102...	KATO ACHAIA	ΚΑΤΩ ΑΧΑΙΑ	Kato Achaia	Κάτω Αχαΐα	940 μ. από το δυ...	DYTIKI ELLADA	ΔΥ
GRBW14930138...	AGIOS GIANNIS	ΑΓΙΟΣ ΓΙΑΝΝΗΣ	Agios Giannis	Άγιος Γιάννης	Στο νοτιοδυτικό...	NOTIO AIGAIO	NC

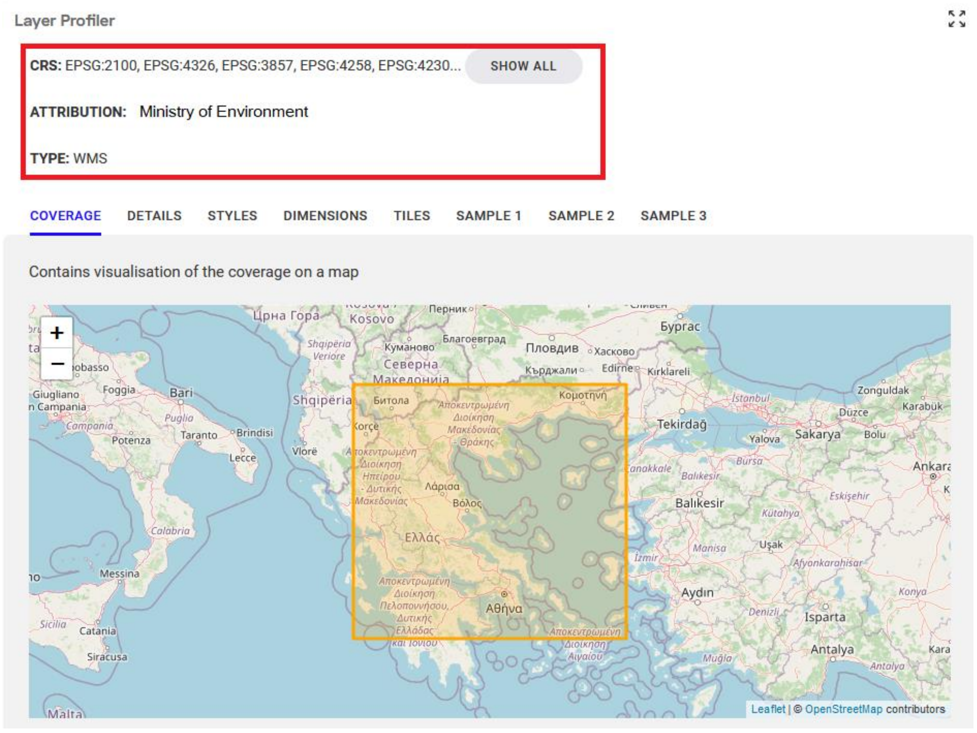
Figure 67: Viewing samples of data assets

2.2.3.2. Profiling for collections

Profiling cannot be available for a collection as a whole, as explained in Section 2.2.1.3. However, if the customer needs further details for each asset in this collection, she can visit its own Asset View page by clicking on the respective item in the list of its assets.

2.2.3.3. Profiling for API assets

In case of *APIs or services*, profiling provides metadata available from the suppliers, e.g., through a *GetCapabilities* request to the corresponding WMS or WFS service. For such assets, the profiler provides information about the *layer(s)* accessible through this API, e.g., map tiles from a WMS or features from a WFS concerning a dataset (road network, protected areas, points of interest, etc.). As illustrated in Figure 68 regarding a WMS available through this service, the user can display all its available *metadata* (type, attribution, CRS, description, keywords, etc.). Moreover, a map illustrates the spatial extent (bounding box, BBOX) of the layer, which conveys the *coverage* of this layer. Other tabs in this panel give more metadata *details* (thorough standardized metadata, list of features represented in the layer, output formats, etc.), and information about the *styles* used for the depicted features in map tiles.


Layer Profiler

CRS: EPSG:2100, EPSG:4326, EPSG:3857, EPSG:4258, EPSG:4230... SHOW ALL

ATTRIBUTION: Ministry of Environment

TYPE: WMS

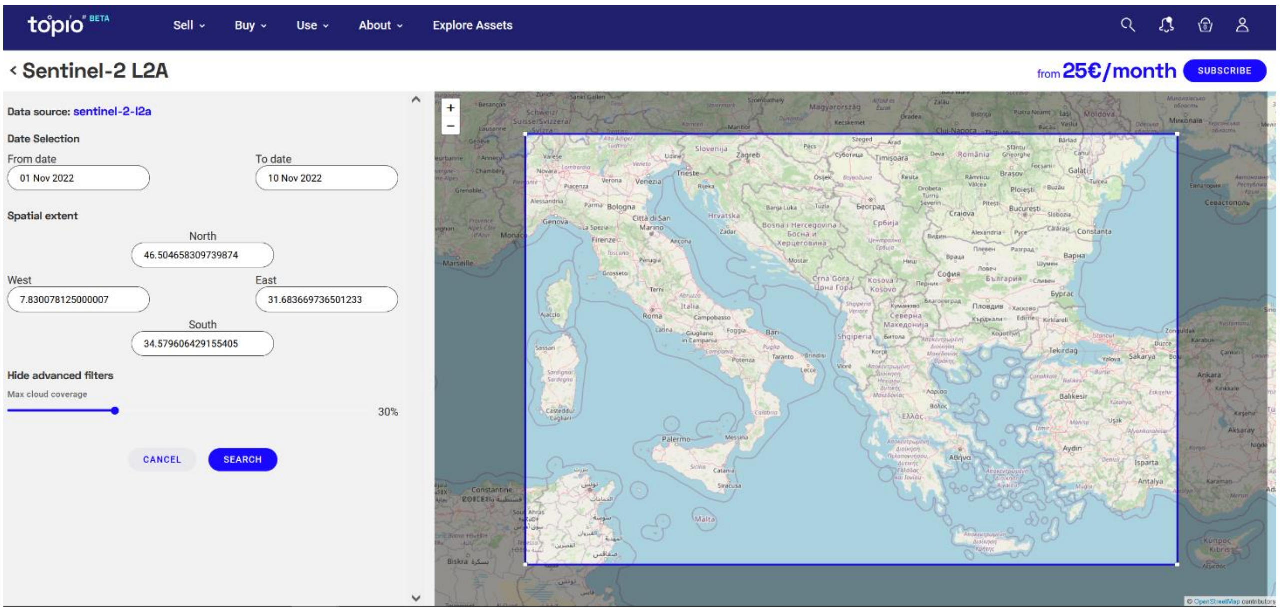
COVERAGE DETAILS STYLES DIMENSIONS TILES SAMPLE 1 SAMPLE 2 SAMPLE 3

Contains visualisation of the coverage on a map

Figure 68: Overview of a typical API asset (WMS)

2.2.3.4. Image Explorer for Open Earth Observation collections

Once the user launches the Image Explorer for an open EO collection (e.g., Copernicus Sentinel-2 L2A), an interface appears like the one shown in Figure 69. Through this customized view, the user can specify several types of filters and search for the availability of such imagery through services offered by the provider. On the top right of this form, the *Subscribe* button allows the user to examine the subscription options available for the EO collection.



Data source: sentinel-2-l2a

Date Selection

From date: 01 Nov 2022

To date: 10 Nov 2022

Spatial extent

North: 46.504658309739874

West: 7.830078125000007

East: 31.683669736501233

South: 34.579606429155405

Hide advanced filters

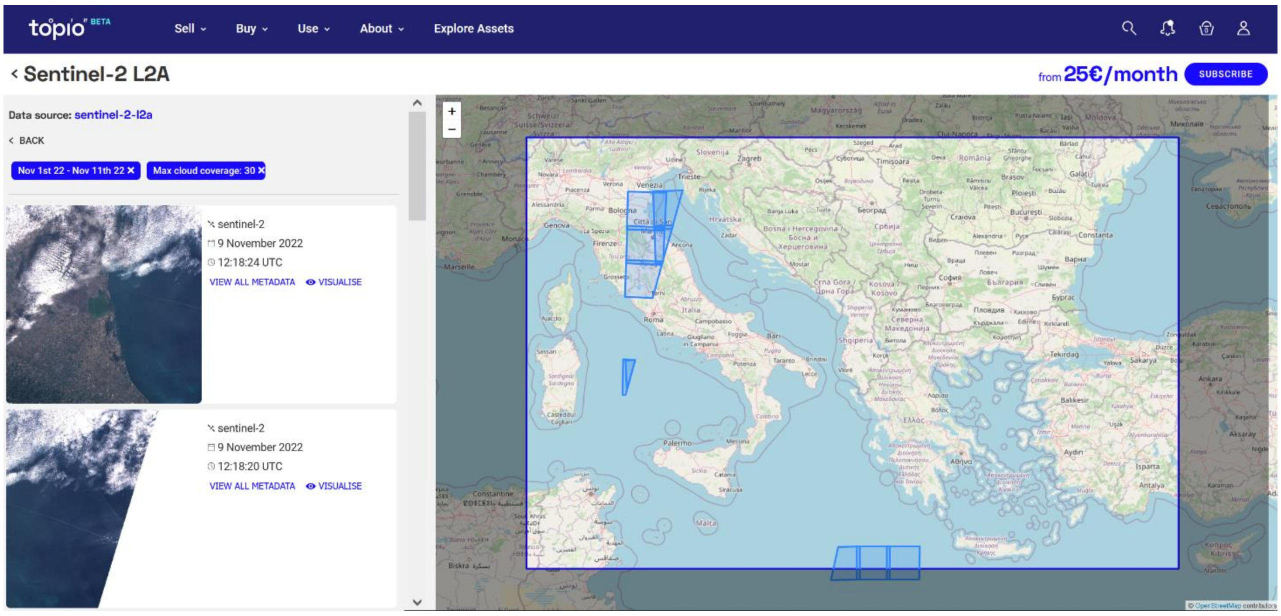
Max cloud coverage: 30%

Figure 69: Specifying filters to search for images of interest from an open EO collection

In particular, the *mandatory filters* are:

- *Area of interest*, either specified with the visible map extent of the interactive map or by drawing a rectangle on this map. This specifies that the user is interested in imagery the (at least partially) overlaps with the specified area.
- *Time reference*: the user can pick either a single date from the calendar widget or two dates to specify a period of interest. This filter will search for availability of images taken at that date or during this period.

In addition, the user can *optionally* specify *advanced filters* (depending on what is enabled by each EO collection) to refine her preferences, such as *Maximum cloud coverage* (a percentage between 0% and 100% that indicates the portion of the image that may be covered by cloud).



Data source: sentinel-2-l2a

Nov 1st 22 - Nov 11th 22 ✕ Max cloud coverage: 30 ✕

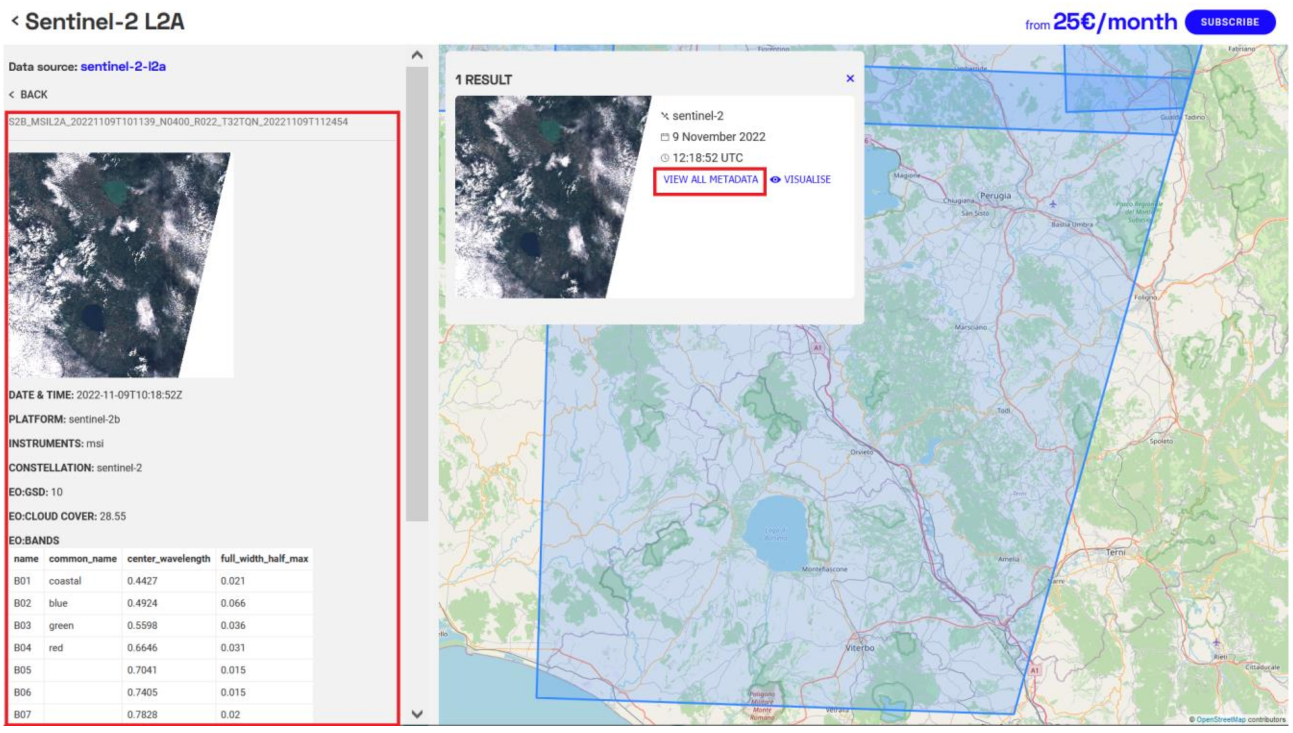
sentinel-2
9 November 2022
12:18:24 UTC

sentinel-2
9 November 2022
12:18:20 UTC

Figure 70: Exploring search results from open EO collections

As the user specifies more preferences in the various filters, the number of qualifying results should be narrowed. If she clicks on the *Search* button, a search request is sent to the Sentinel Hub API and the list of resulting images qualifying to the filters is displayed, as shown in the left side of Figure 70. Of course, the user can remove any filter or clear them all, thus triggering an update in the list, or even go back to the filtering criteria to modify them.

For each image in the list of current search results, the interactive map shows their respective spatial extents, which may be overlapping polygons. If the user clicks on such a polygon on the map, a popup is shown (in the green rectangle in Figure 71) with the subset of images from the list that correspond to this spatial extent. The user can choose to *View All Metadata* about an image, and then its details are listed as in the left side of the map. This metadata includes all available information about the image, including the date/time it was taken, its geographical reference, its area, the cloud coverage, etc., as well as the bands for multi-band images.



Data source: sentinel-2-l2a

S2B_MSIL2A_20221109T101139_N0400_R022_T32TQN_20221109T112454

DATE & TIME: 2022-11-09T10:18:52Z

PLATFORM: sentinel-2b

INSTRUMENTS: msi

CONSTELLATION: sentinel-2

EO:GSD: 10

EO:CLOUD COVER: 28.55

EO:BANDS

name	common_name	center_wavelength	full_width_half_max
B01	coastal	0.4427	0.021
B02	blue	0.4924	0.066
B03	green	0.5598	0.036
B04	red	0.6646	0.031
B05		0.7041	0.015
B06		0.7405	0.015
B07		0.7828	0.02

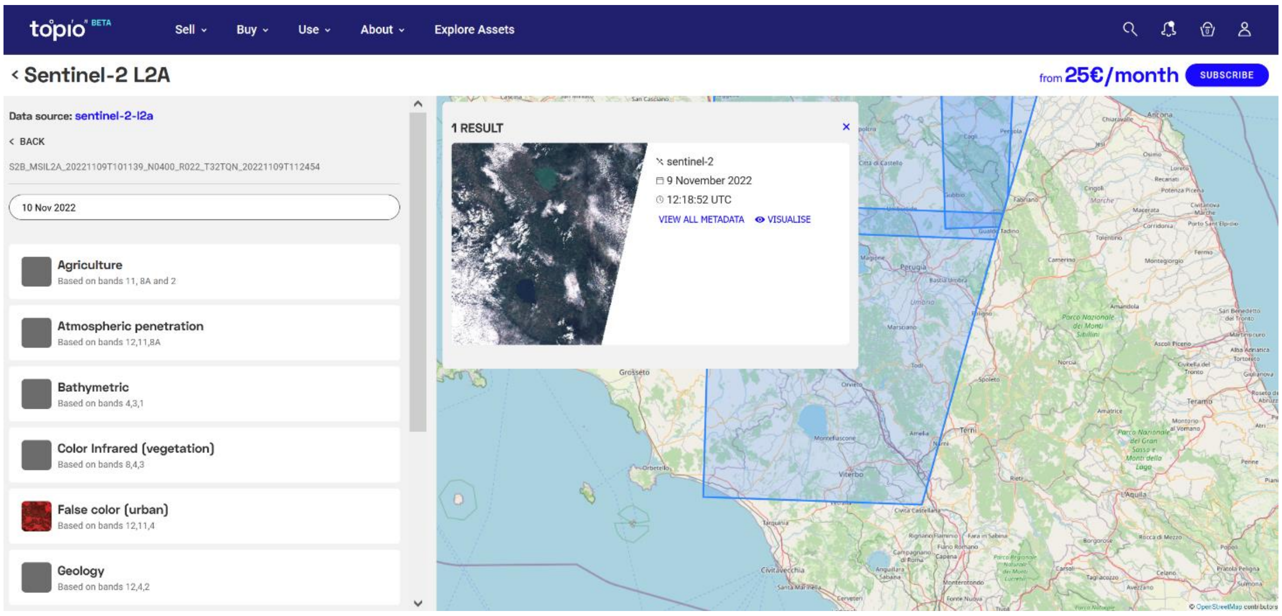
sentinel-2

9 November 2022

12:18:52 UTC

Figure 71: Detailed metadata for a selected image from open EO collections

Once the user clicks on the thumbnail, she can *visualize* the various alternative representations of this image, such as true-color, false-color, vegetation index, short-wave infrared, etc. as depicted in Figure 72. All images shown in this interface are low-resolution *thumbnails* as provided by the respective EO collection; the users can get access to the respective EO services offered by the supplier only after they subscribe.



Sentinel-2 L2A

from 25€/month

Data source: sentinel-2-l2a

S2B_MSIL2A_20221109T101139_N0400_R022_T32TQN_20221109T112454

10 Nov 2022

Agriculture
Based on bands 11, 8A and 2

Atmospheric penetration
Based on bands 12,11,8A

Bathymetric
Based on bands 4,3,1

Color Infrared (vegetation)
Based on bands 8,4,3

False color (urban)
Based on bands 12,11,4

Geology
Based on bands 12,4,2

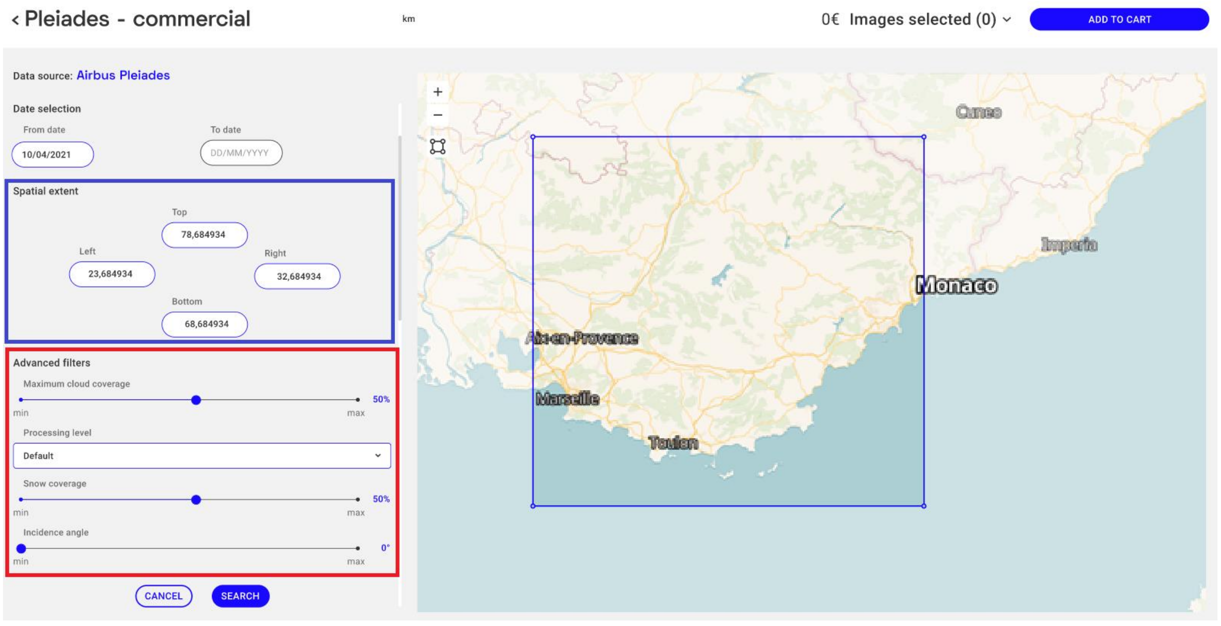
1 RESULT

sentinel-2
9 November 2022
12:18:52 UTC

Figure 72: Displaying various representations for a selected image from open EO collections

2.2.3.5. Image Explorer for proprietary Earth Observation collections[2]

Launching the Image Explorer for *proprietary* (i.e., commercial) EO collections, allows users to identify availability of images with respect to their own preferences, subscribe to the collection, but also to *individually* order images through the marketplace. The user interface shares some similarity with the one discussed for open EO collections, but the objective differs: in open EO collections the user may only *subscribe* to a service, whereas from proprietary EO collections she can also buy an arbitrary number images (note that supplier-side minimum may apply).



Pleiades - commercial

0€ Images selected (0)

Data source: Airbus Pleiades

Date selection
From date: 10/04/2021
To date: DD/MM/YYYY

Spatial extent
Top: 78,684934
Left: 23,684934
Right: 32,684934
Bottom: 68,684934

Advanced filters
Maximum cloud coverage: 50% (min – max)
Processing level: Default
Snow coverage: 50% (min – max)
Incidence angle: 0° (min – max)

Figure 73: Identifying images of interest from commercial EO collections

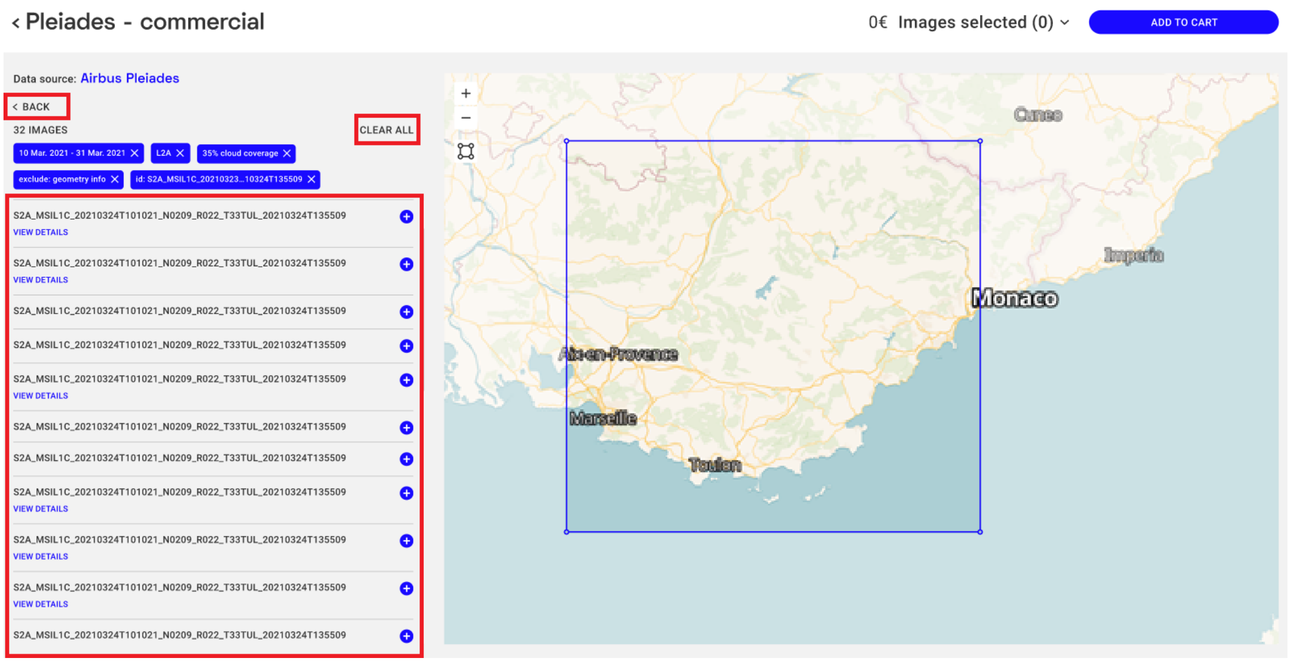
[2] Please note that this functionality is not currently available in the beta due to the pending licensing agreements with their providers.

The basic interface is shown in Figure 73. On the left side, several filters are available. As in open EO collections, the mandatory filters include:

- *Area of interest*, either specified with the visible map extent of the interactive map or by drawing a rectangle on this map. This specifies that the user is interested in imagery the (at least partially) overlaps with the specified area.
- *Time reference*: the user can pick either a single date from the calendar widget or two dates to specify a period of interest. This filter will search for images taken at that date or during this period.

However, *advanced filters* depend on what is supported by the search API of the provider and the specifications of the respective satellites. For example, Airbus Pléiades enables preferences regarding maximum cloud coverage, snow coverage, or incidence angle (as shown in Figure 73). In contrast, MAXAR allows extra filters on min/max off nadir and min/max sun elevation.

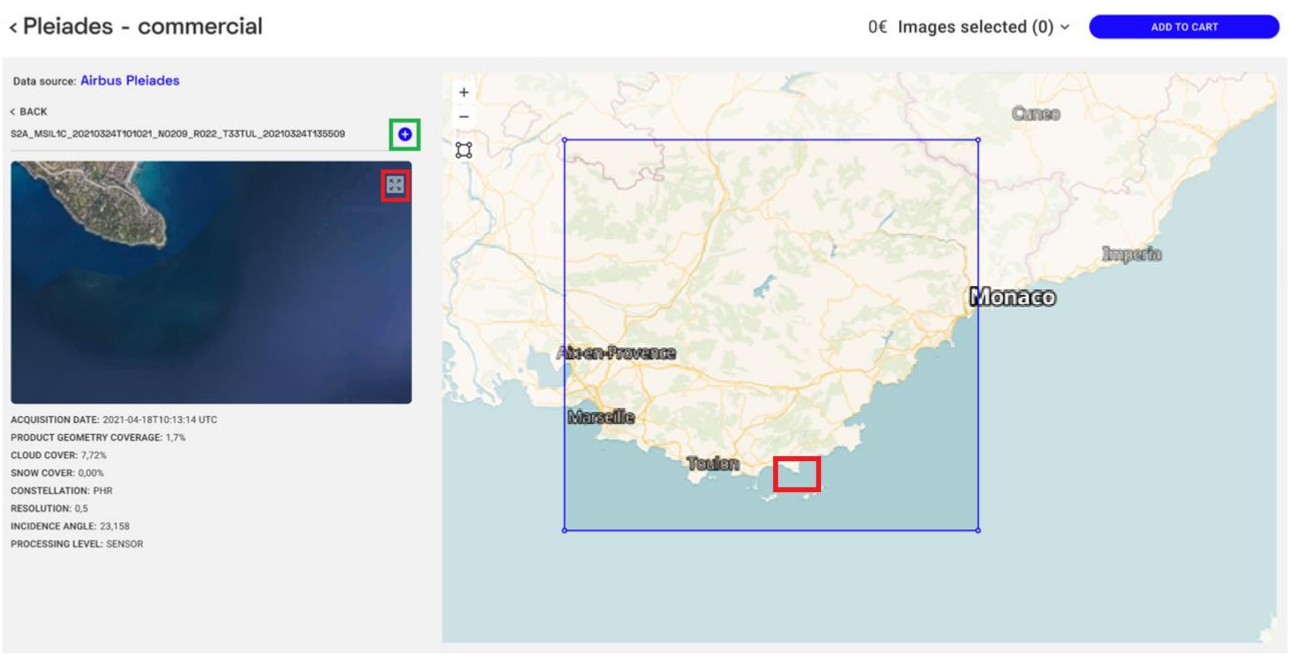
Once the user hits search, the qualifying images are listed on the left, as shown in Figure 74. Again, the user is reminded of the applied filters, she can remove any or all of them or go back and modify them in the search form. She can *View Details* for any of the listed images, in which case all available metadata about the chosen image appears as in Figure 75.



S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
VIEW DETAILS
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
VIEW DETAILS
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
VIEW DETAILS
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
VIEW DETAILS
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
VIEW DETAILS
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
VIEW DETAILS
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509

Figure 74: List of images from commercial EO collections qualifying to search criteria

For the chosen image (Figure 75), the user can view all its available metadata (may differ according to the provider), a thumbnail, as well as the spatial extent of this image on map (red rectangle) superimposed on her specified area of interest for comparison. The thumbnail can be magnified, but this is certainly of much lower resolution than the original image. If the user wishes to *acquire* this image, she can add it to her selection through the + button next to its identifier (shown in the green box).

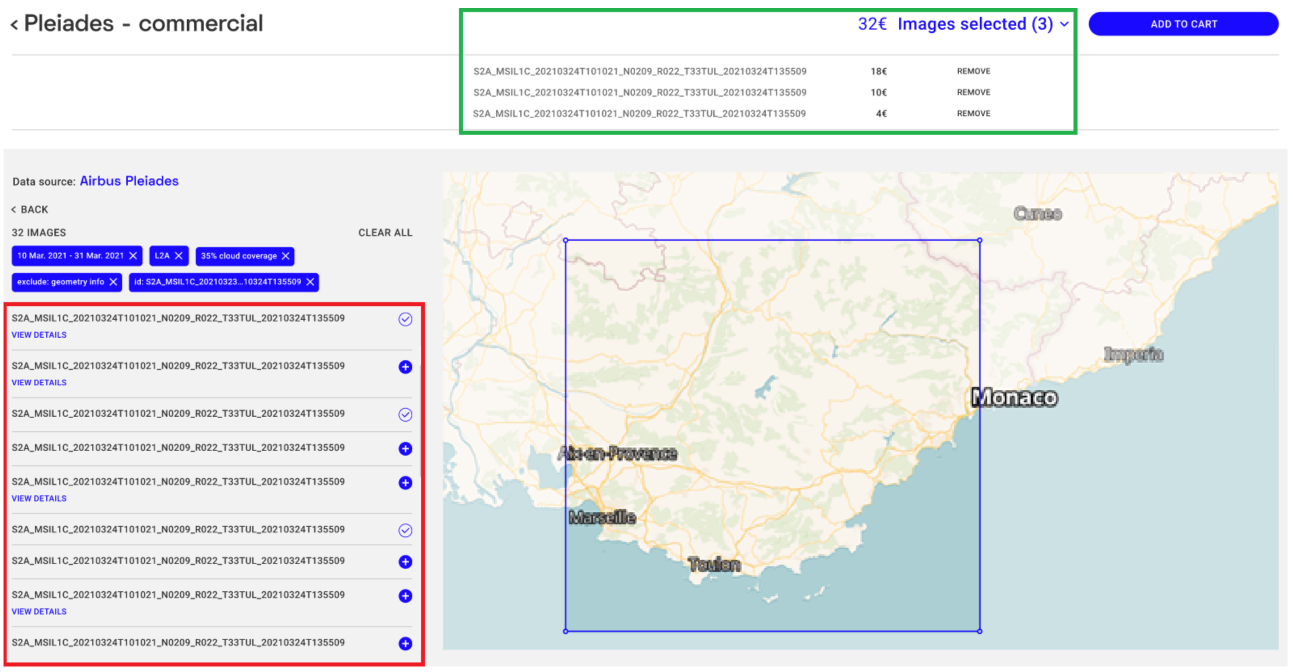


S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509

ACQUISITION DATE: 2021-04-18T10:13:14 UTC
PRODUCT GEOMETRY COVERAGE: 1,7%
CLOUD COVER: 7,72%
SNOW COVER: 0,00%
CONSTELLATION: PHR
RESOLUTION: 0,5
INCIDENCE ANGLE: 23,158
PROCESSING LEVEL: SENSOR

Figure 75: View details of an image from commercial EO collections

This way, the user can pick one or multiple images of her interest and add them to her collection. The compiled list is shown on the top of the form (enclosed in a green box in Figure 76), so that the user can examine their cost before proceeding to make an order. Note that the cost may differ, depending on the pricing models applied by the provider, e.g., based on area in sq.km., as detailed in Section 2.3. At this stage, she can remove any of the chosen images or go back to search to add more. The list is always refreshed with the currently chosen images. Once the user hits the button Add to Cart, she can proceed to order the chosen image(s) through the marketplace.



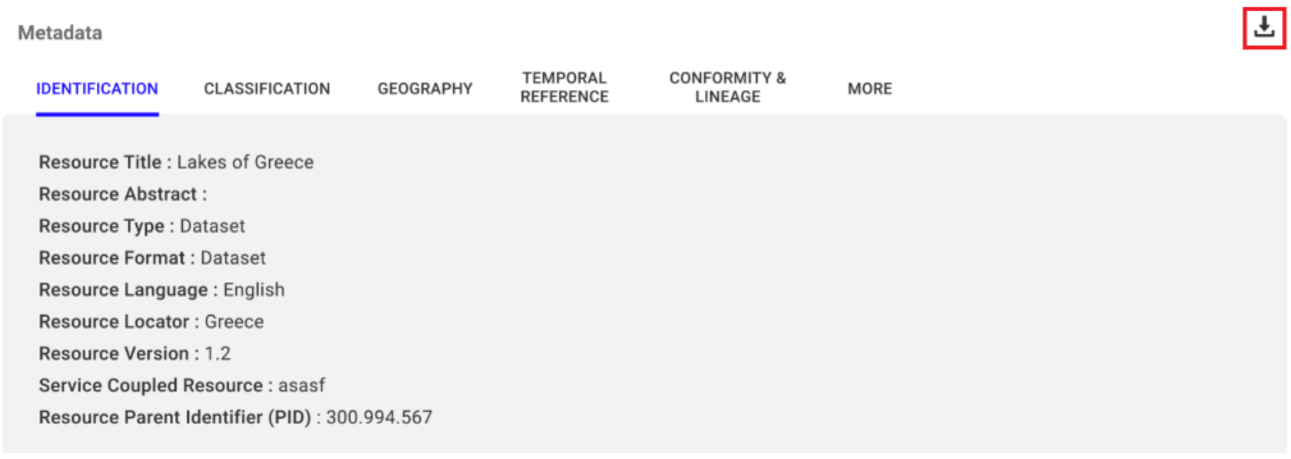
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509	18€	REMOVE
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509	10€	REMOVE
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509	4€	REMOVE

S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509 ✓
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509 ✓
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509 ✓
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509

Figure 76: Selecting images to order from commercial EO collections

2.2.4. Standard Metadata

Before an asset becomes available in the marketplace, its supplier must provide its *metadata* (as discussed in the publishing wizard in Section 1.2.1). This metadata will be also displayed through the asset view page, organized is several categories as illustrated in Figure 77. Clicking on each tab, the user can get detailed information about the identification of this asset, its classification, its geographical properties (e.g., scale), temporal reference, conformity, and lineage (e.g., if this asset was produced from another dataset), and more.



Resource Title : Lakes of Greece
Resource Abstract :
Resource Type : Dataset
Resource Format : Dataset
Resource Language : English
Resource Locator : Greece
Resource Version : 1.2
Service Coupled Resource : asasf
Resource Parent Identifier (PID) : 300.994.567

Figure 77: Standard metadata for an asset as specified by its supplier

2.2.5. Alternate Offerings

Below the pricing and purchase options, alternate types of the currently viewed asset are listed (Figure 78), e.g., via *web services* (WMS, WFS). This is important, as different pricing models may refer to these related assets, which may be of interest to the user to examine before purchasing the current asset. In this same list, users can also view relevant assets that are sold as a *collection* and can be used together with the currently visited asset. For instance, a dataset containing rivers may be used for analyses along a dataset regarding lakes in the same region. Those two assets come from the same supplier, and they are probably produced with similar specifications, so they can be seamlessly combined in maps and applications. In case these relevant assets are provided together as a collection, a discount may be offered on their total price.

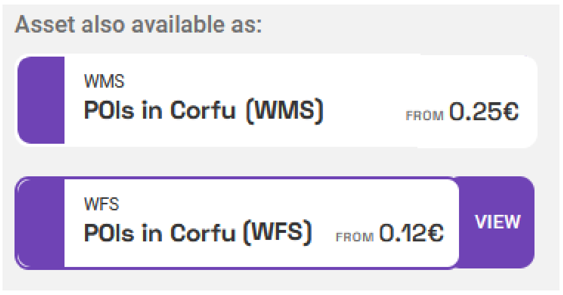


Figure 78: An asset available in alternative types or in collections with other related assets

2.2.6. Related Assets

At the bottom of an asset's view page, users are informed of assets *related* to the one currently viewed. For example, the list may include assets with the same spatial coverage (i.e., referring to the same region), assets offered by the same supplier, assets usually bought together by customers (e.g., a road network dataset with its recent traffic statistics), etc.

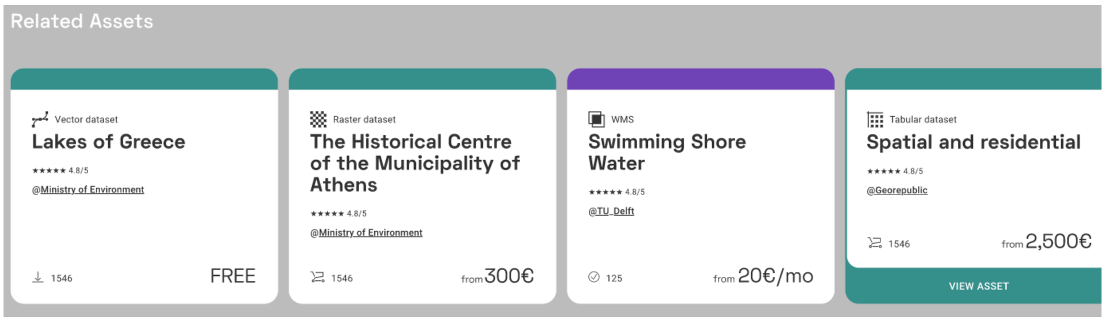


Figure 79: Assets related to the one currently viewed

2.3. Purchase options

As mentioned in Section 2.1, the Topio platform offers numerous options for a prospective user to search, filter and view an asset or assets she is interested in. To proceed with purchasing a particular asset, *regardless of the asset's type*, the user must visit its "Asset View" (e.g., as illustrated in Figure 55), select one of the available pricing options, add it to her shopping cart and, finally, proceed with the checkout. The pricing options that the purchaser is presented with, correspond to the pricing models the supplier selected for a particular asset at the "Pricing" step of the publishing wizard. The "Asset View" page contains the respective price along with any extra costs (e.g., for delivery with physical means). Depending on the user's chosen options on pricing, the final cost gets updated. A summary of the shipping information, along with the expected delivery date are also indicated, as well as the payment methods specified by the supplier. To add the asset to the shopping cart, the user must click on the corresponding button, which differs according to the asset type, e.g., "Add to Cart" for a fixed price, or "Select Areas" for per population pricing). By clicking on the cart icon (enclosed in a red box in Figure 55), the list of assets currently in the user's cart is displayed. If the user is not signed in the marketplace, she is prompted to sign in before proceeding. In the following, we will describe all the various pricing options available to prospective purchasers, depending on the type of asset.

2.3.1. Purchase Options for Data Files

Figure 80 depicts the purchase options for data file assets, contained within a white frame in the *Asset View* page. The frame contains the following elements:

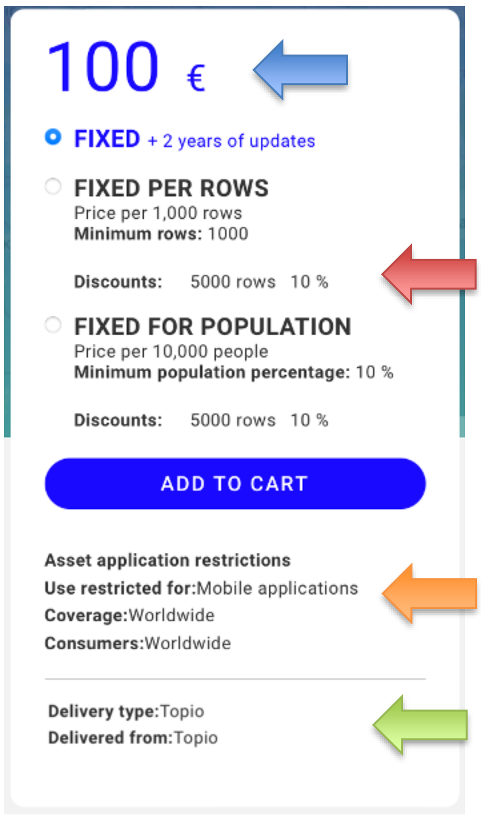
- The various **pricing options** available for each asset (list indicated with a red arrow in Figure 80).

- The **price** for the selected pricing option (blue arrow in Figure 80).
- Any applied **domain** and **location restrictions** for this asset (orange arrow in Figure 80).
- A list of **more information** regarding this asset, such as the supplier's name and whether the asset is delivered digitally (green arrow in Figure 80), or physically (green arrow in Figure 81).

The pricing options available for a certain asset correspond to the pricing model that was selected and defined during the asset publishing procedure by the supplier. In the data file asset example shown in Figure 80 there are three pricing options available, which will be described in the following.

2.3.1.1. Fixed

This is the default pricing option and its radio button in the pricing options list is pre-selected when the user visits the data file asset's "Asset View" page, as depicted in Figure 80. This is the simplest purchase option available to prospective purchasers. It regards the latest version of the data file asset plus any additional years of updates, if provided by the supplier. In the example, the customer pays once to buy the asset and can receive updates for 2 years.


100 €

● FIXED + 2 years of updates

○ FIXED PER ROWS
Price per 1,000 rows
Minimum rows: 1000

Discounts: 5000 rows 10 %

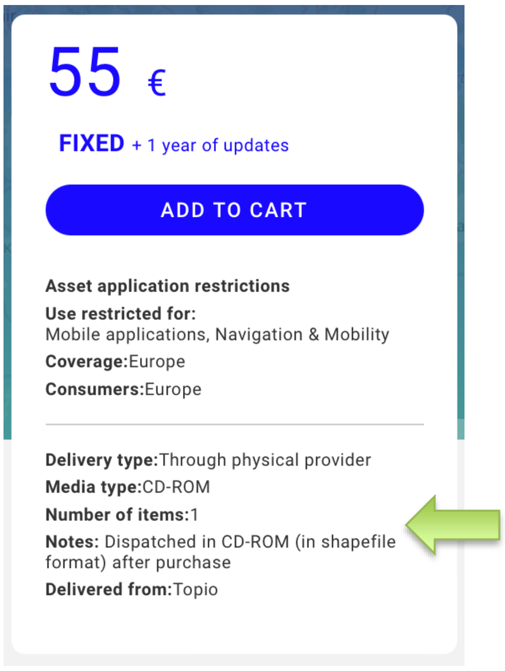
○ FIXED FOR POPULATION
Price per 10,000 people
Minimum population percentage: 10 %

Discounts: 5000 rows 10 %

Asset application restrictions
Use restricted for: Mobile applications
Coverage: Worldwide
Consumers: Worldwide

Delivery type: Topio
Delivered from: Topio

Figure 80: Purchase options for data file assets


55 €

FIXED + 1 year of updates

ADD TO CART

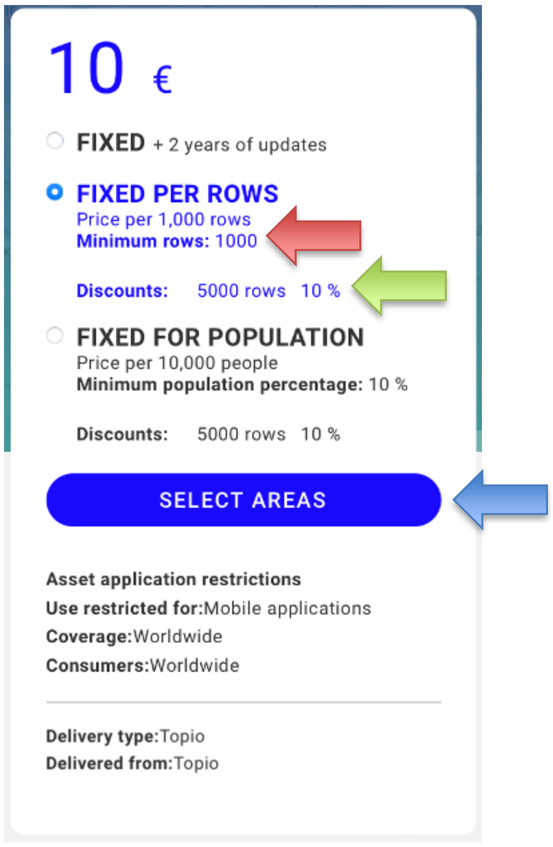
Asset application restrictions
Use restricted for:
Mobile applications, Navigation & Mobility
Coverage: Europe
Consumers: Europe

Delivery type: Through physical provider
Media type:CD-ROM
Number of items:1
Notes: Dispatched in CD-ROM (in shapefile format) after purchase
Delivered from: Topio

Figure 81: Physical asset delivery

2.3.1.2. Fixed per Rows

This pricing option can be enabled by a supplier only when the asset is made available for delivery via the platform. The prospective customer can select and purchase only a subset of the data file asset, by defining an area of interest (e.g., country, city) she is interested in. The final price is based on the *number of rows* that the selected subset of the asset will contain. Of course, there is a mandatory *minimum* number of rows contained in the subset that the purchaser selects to buy. As illustrated in Figure 82, the price for this option starts from a certain amount, depending on the minimum possible number of rows that can be selected (red arrow in the figure). Any additional discount options are also displayed under the pricing option (green arrow in the figure), e.g., a 10% discount if more than 5000 rows are purchased. To select the areas she desires, the purchaser must click on the “Select Areas” button, indicated with a blue arrow in Figure 82.



10 €

FIXED + 2 years of updates

FIXED PER ROWS
Price per 1,000 rows
Minimum rows: 1000

Discounts: 5000 rows 10 %

FIXED FOR POPULATION
Price per 10,000 people
Minimum population percentage: 10 %

Discounts: 5000 rows 10 %

Asset application restrictions
Use restricted for: Mobile applications
Coverage: Worldwide
Consumers: Worldwide

Delivery type: Topio
Delivered from: Topio

Figure 82: Subset priced per row option for data file assets

Clicking on the button opens the corresponding "Select Areas" window, shown in Figure 83. Here, the purchaser can easily select the areas she is interested in, which are clearly indicated in the map contained in the window. More specifically, the areas in the "Select Areas" window are partitioned based on the *European NUTS 1 and 2 classification*[3] and they can be browsed and selected in the following two ways:

- From the list on the left (blue arrow in Figure 83). Each item in the list represents a separate country and it is collapsible and expandable, revealing the NUTS-2-based basic regions that can be selected for this data asset.
- By clicking on a particular country or region on the map. The user can pan the map around and zoom-in/out using the mouse. If she desires so, she can zoom-in/out using the buttons at the bottom right part of the map (red arrow in Figure 83).

[3] https://ec.europa.eu/eurostat/web/nuts/background

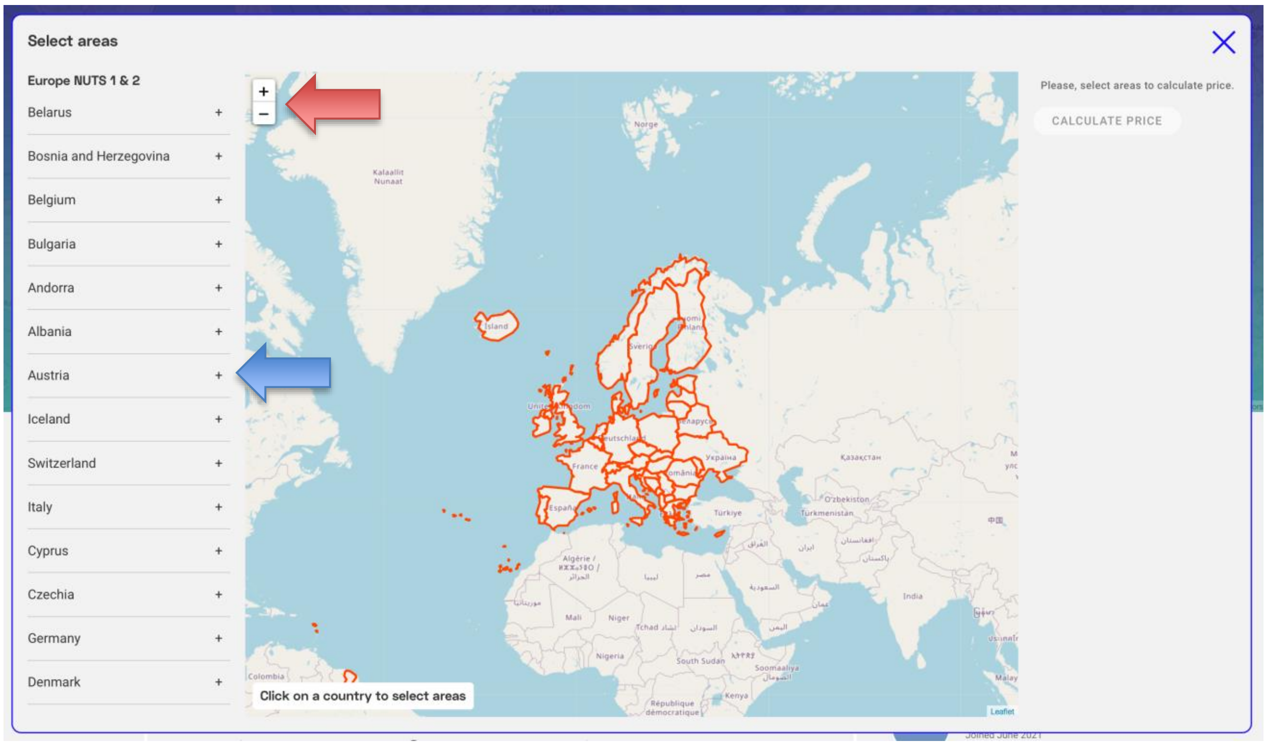


Figure 83: Popup window to select areas for the subset to be purchased

After detecting her country or region of interest, the purchaser must click on it on the map, to select it before adding it to the subset she is about to purchase. Doing so, draws the corresponding NUTS polygons on the map using blue colored lines and lists the regions in the list on the left. This is demonstrated in Figure 84. Selecting a country triggers a small informative box to appear on the top right of the map (blue arrow in Figure 84), which contains the total number of rows for that country and an "Add Country" button to add them to the selected subset. After selecting the desired subset, the user must click on the "Calculate Price" button (red arrow in Figure 84) to see its final price before adding it to the card for purchase.

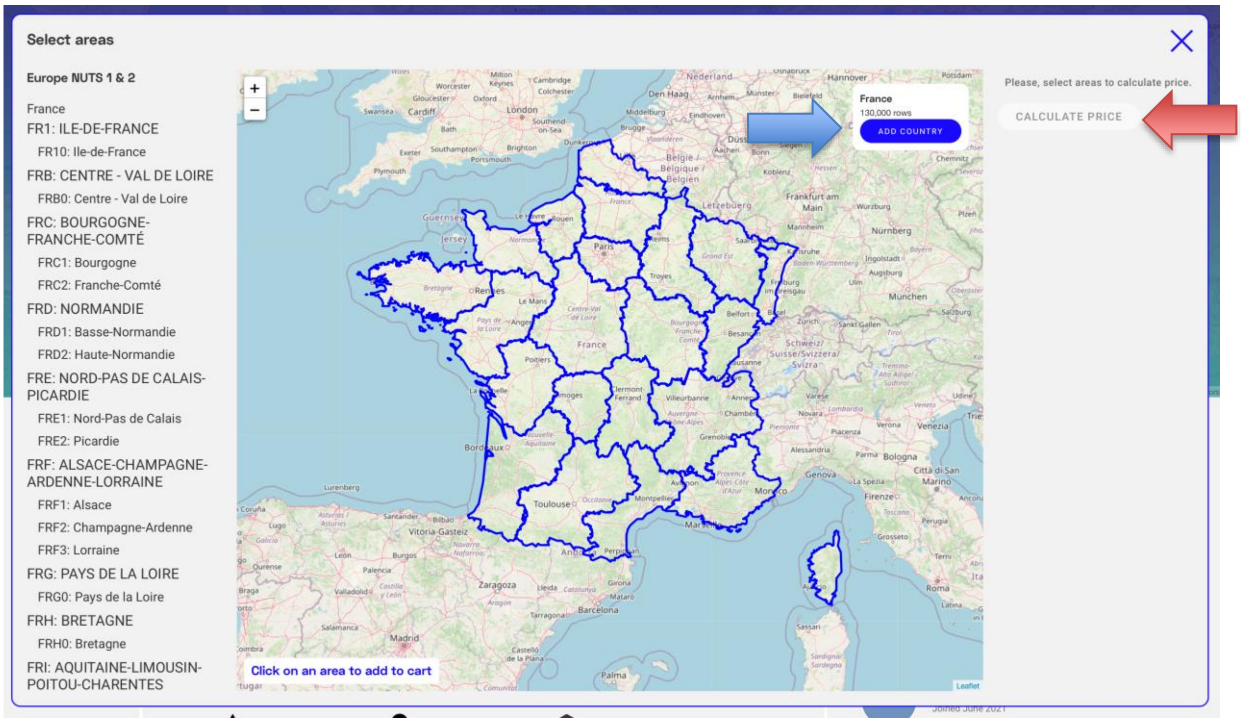
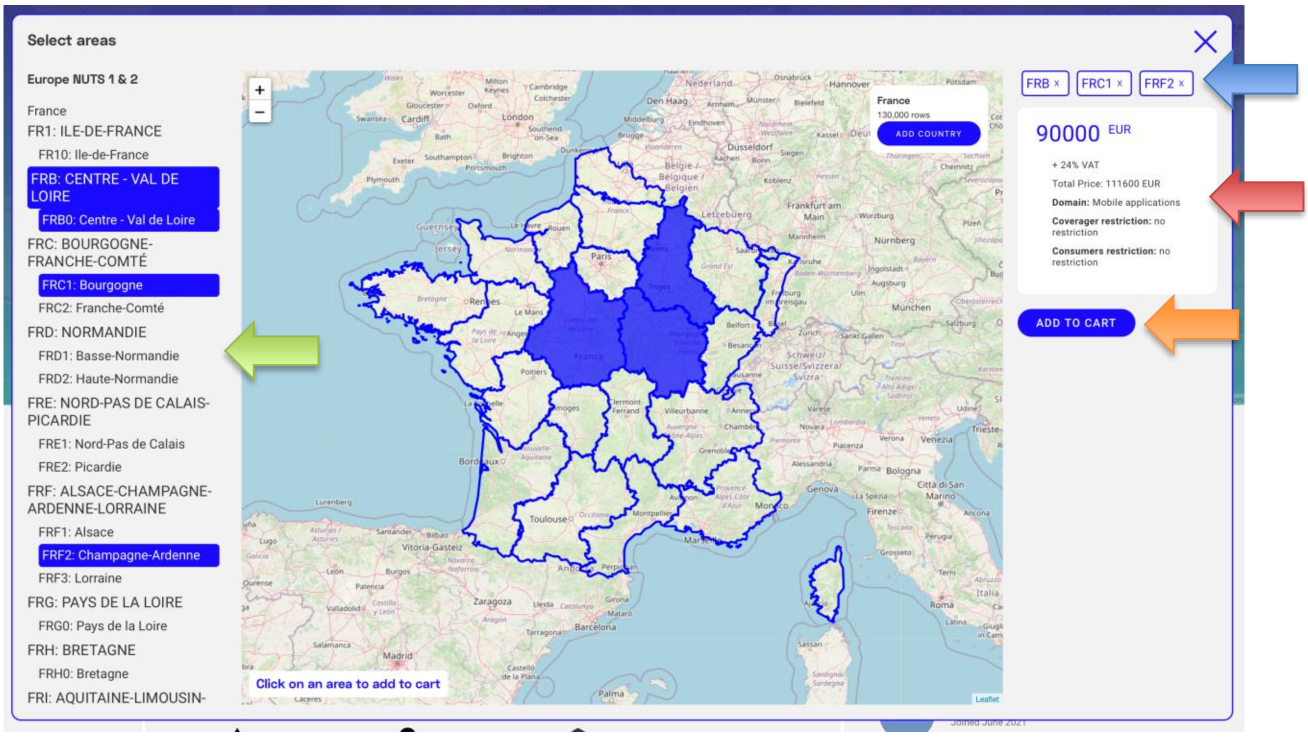


Figure 84: Selecting some regions to purchase

In the example illustrated in Figure 85, the user has selected three NUTS-2-based regions of France, added them to the subset she desires to purchase, and clicked on the “Calculate Price” button. The added regions are highlighted in blue on the list on the left part of the window (red arrow in Figure 85); they are also added as dismissible boxes on the right (green arrow in Figure 85). The price before and after taxes is shown in a white rectangle on the right part of the window (red arrow in Figure 85). Any domain, coverage and consumers restrictions are also contained therein. Finally, the purchaser must click on the “Add to Cart” button (orange arrow in Figure 85) to add the selected subset to the shopping cart and proceed to the checkout.

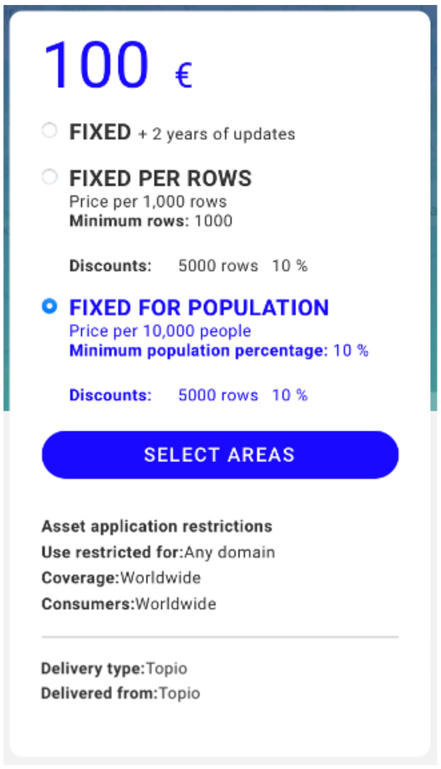


90000 EUR
+ 24% VAT
Total Price: 111600 EUR
Domain: Mobile applications
Coverager restriction: no restriction
Consumers restriction: no restriction

Figure 85: Adding selected regions to the subset to be purchased

2.3.1.3. Fixed for Population

This is the final pricing option for data file assets (Figure 86) and it operates similarly to the per row option. The prospective client must click on the “Select Areas” button to select the (partitioned according to NUTS 1 and 2) regions she wants to add to the subset. Doing so, triggers the “Select Areas” window to appear. The selection and final addition of regions to the subset to be purchased is performed exactly as in the per row case; the only difference lies in the way the pricing is applied; instead of per row contained in the subset, the purchaser is charged according to the total population density of the selected regions.


100 €

FIXED + 2 years of updates

FIXED PER ROWS
Price per 1,000 rows
Minimum rows: 1000

Discounts: 5000 rows 10 %

[✓ FIXED FOR POPULATION]
Price per 10,000 people
Minimum population percentage: 10 %

Discounts: 5000 rows 10 %

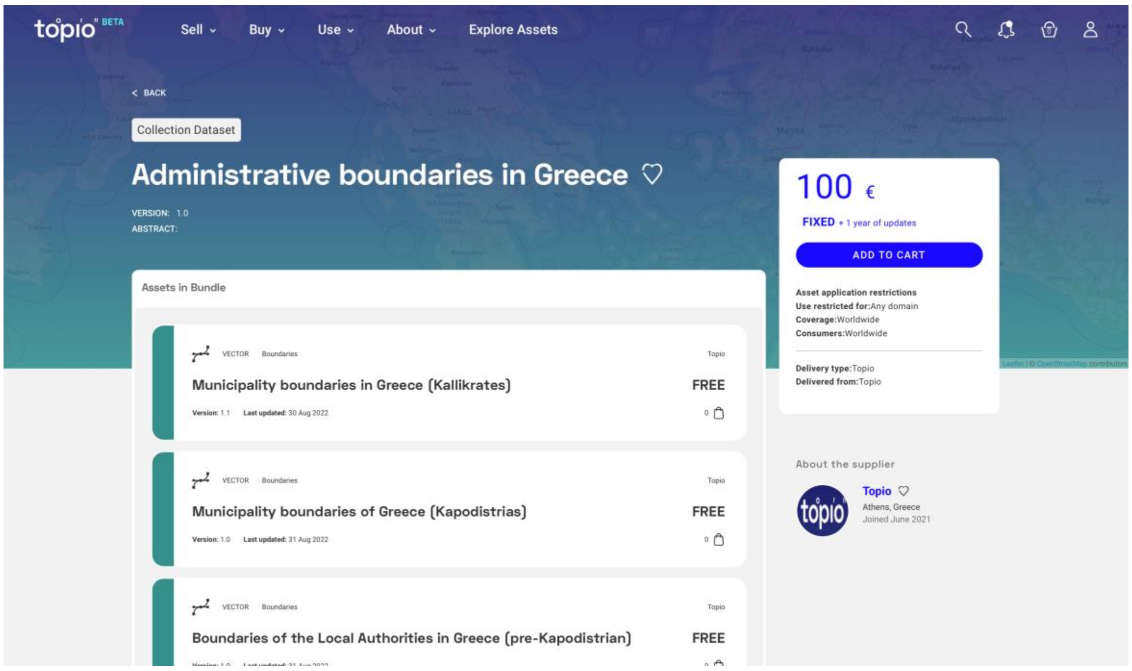
Asset application restrictions
Use restricted for: Any domain
Coverage: Worldwide
Consumers: Worldwide

Delivery type: Topio
Delivered from: Topio

Figure 86: Per population coverage pricing

2.3.2. Purchase Options for Collections

Through *collections* of assets, the supplier can offer more than one data file assets for sale bundled together. As illustrated in Figure 87, there is a single pricing option that corresponds to the total price of all the assets contained in the collection. As in every case, the purchaser must click on the “Add to Cart” button to forward the asset collection to her shopping cart and proceed to the checkout from there.



Administrative boundaries in Greece

VERSION: 1.0
ABSTRACT:

Assets in Bundle

VECTOR Boundaries		Topio
Municipality boundaries in Greece (Kallikrates)		FREE
Version: 1.1	Last updated: 30 Aug 2022	0
VECTOR Boundaries		Topio
Municipality boundaries of Greece (Kapodistrias)		FREE
Version: 1.0	Last updated: 31 Aug 2022	0
VECTOR Boundaries		Topio
Boundaries of the Local Authorities in Greece (pre-Kapodistrian)		FREE

100 €

FIXED + 1 year of updates

Asset application restrictions
Use restricted for: Any domain
Coverage: Worldwide
Consumers: Worldwide

Delivery type: Topio
Delivered from: Topio

About the supplier
Topio
Athens, Greece
Joined June 2021

Figure 87: Collection of assets pricing

2.3.3. Purchase Options for APIs

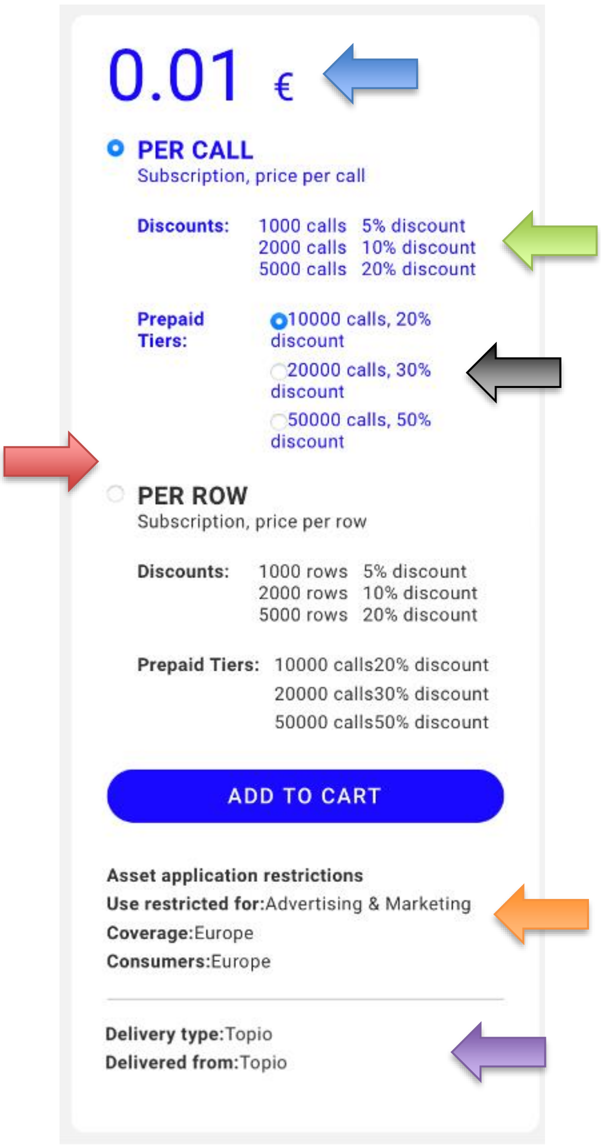
Figure 88 depicts the purchase options for API assets available from the *Asset View* page. As in the case for data file assets and collections, they are contained within a white rectangle. The white rectangle in the case of API assets contains the following elements:

- The various **pricing options** available for each asset (list indicated with a red arrow in Figure 88).
- The **pricing** for the selected pricing option (blue arrow in Figure 88).
- The available **discount** tiers for each pricing option (green arrow in Figure 88).
- A list of the available prepaid tiers for each pricing option (black arrow in Figure 88).
- Any applied **domain** and **location restrictions** for this asset (orange arrow in Figure 88).
- A list of **more information** regarding this asset, such as the supplier's name (purple arrow in Figure 88).

The pricing options available for a certain asset correspond to the pricing model(s) that was selected and defined during the asset publishing procedure by the supplier. In the API asset example shown in Figure 88 there are two pricing options available, which will be described next.

2.3.3.1. Fixed Price / Call

This pricing option applies a fixed price per service call. To keep the customers engaged, the supplier can optionally select up to three discount tiers, based on the number of service calls, as indicated with a green arrow in Figure 88. Furthermore, the supplier can allow the customer *pre-pay* several service calls via a tiered scheme offering incremental discounts depending on the number of pre-paid calls. There can be up to three such discount tiers. To select the discount tier of her preference, the purchaser must select the corresponding radio button (black arrow in Figure 88). For each tier, the number of calls to be pre-paid is indicated, along with the corresponding discount. To add the API asset to the cart and proceed with the subscription the user must click on "Add to Cart" and proceed to checkout as in the data assets.


0.01 €

● PER CALL

Subscription, price per call

Discounts:	1000 calls	5% discount
	2000 calls	10% discount
	5000 calls	20% discount

Prepaid Tiers: [✓ 10000 calls, 20% discount] 20000 calls, 30% discount 50000 calls, 50% discount

○ PER ROW

Subscription, price per row

Discounts:	1000 rows	5% discount
	2000 rows	10% discount
	5000 rows	20% discount

Prepaid Tiers: 10000 calls20% discount
20000 calls30% discount
50000 calls50% discount

Asset application restrictions
Use restricted for: Advertising & Marketing
Coverage: Europe
Consumers: Europe

Delivery type: Topio
Delivered from: Topio

Figure 88: Fixed price per service call pricing option

2.3.3.2. Fixed Price / Row

This pricing option applies a fixed price per row returned. Its functionality is the same as in the fixed price per row pricing option. The difference lies in the fact that all pricing, discount, and pre-paid tiers are now applied per row.

2.3.4. Purchase Options for open EO Collections

A consumer may subscribe to an *open* Earth Observation (EO) collection by directly clicking on the "*Subscribe*" button in its corresponding "Asset View" page, as shown in Figure 59. However, before subscribing to the service, she can preview a collection of images and explore their metadata through the "Image Explorer" by clicking on "Open Explorer" (blue button in Figure 59), as described in Section 2.2.3.5. Figure 89 illustrates an example from the Sentinel1-GRD collection provided by Sentinel Hub. The user has selected to view tiles from 8th November to 10th November

2022 (blue arrow in Figure 89) in the United Kingdom (enclosed in the cyan rectangle). The resulting images along with links to their metadata have appeared in the list on the left (green arrow in Figure 89) and their corresponding bounding boxes are drawn on the map.

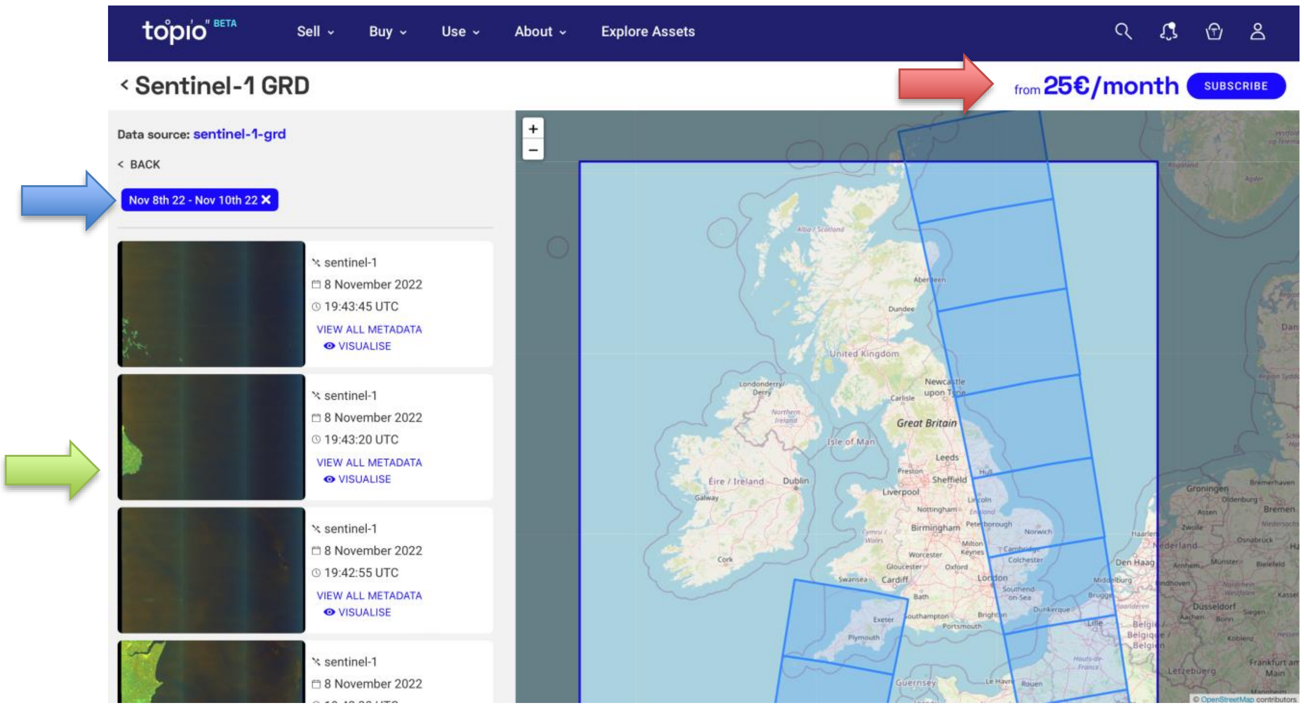
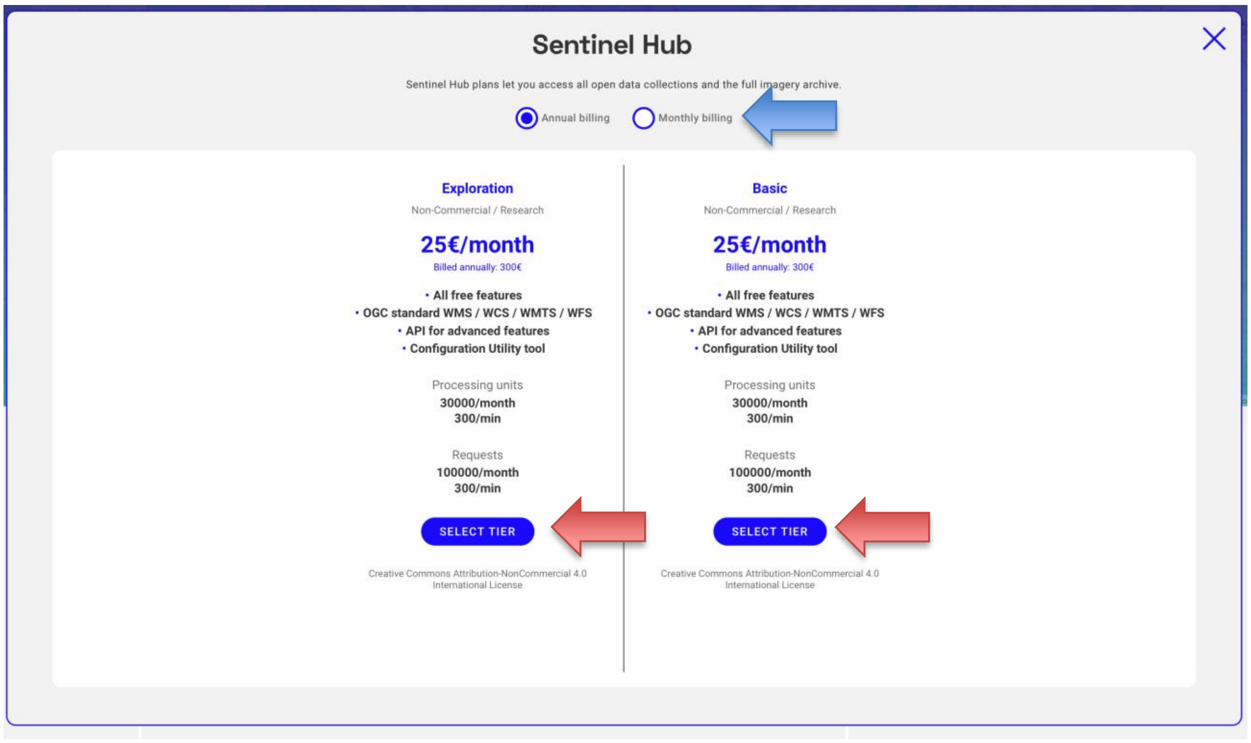


Figure 89: Image explorer for open EO collections

After previewing an open EO collection, the user may be interested to subscribe and have access to the actual imagery. To select a subscription tier, the user must click on the “Subscribe” button (red arrow in Figure 89). Doing so, triggers a pop-up window containing the available tiers for this EO dataset, as illustrated in Figure 90, for the case of the EO data provided by Sentinel Hub. The purchaser has the option to select among monthly or annual (with an extra discount) billing, as indicated with a blue arrow in Figure 90. In this example, the selected billing is annual. There are two separate tiers available (“Exploration”, “Basic”), each offering additional features, processing units and maximum allowed requests. When the customer decides on which tier she wants to subscribe to, she must click on the corresponding “Select Tier” button (red arrows in Figure 90). This adds the selected tier on her shopping cart, from where she can proceed to checkout.


Sentinel Hub

Sentinel Hub plans let you access all open data collections and the full imagery archive.

Annual billing [✓] Monthly billing

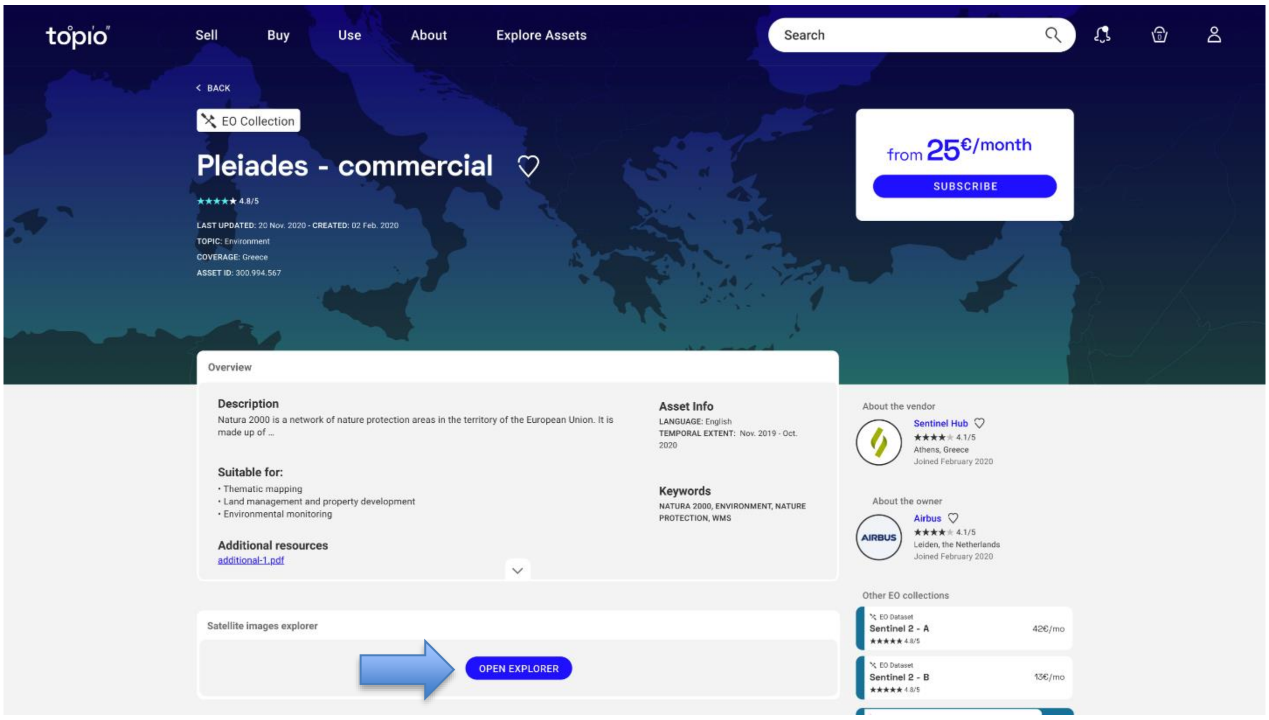
Exploration	Basic
Non-Commercial / Research	Non-Commercial / Research
25€/month	25€/month
Billed annually: 300€	Billed annually: 300€
• All free features • OGC standard WMS / WCS / WMTS / WFS • API for advanced features • Configuration Utility tool	• All free features • OGC standard WMS / WCS / WMTS / WFS • API for advanced features • Configuration Utility tool
Processing units 30000/month 300/min	Processing units 30000/month 300/min
Requests 100000/month 300/min	Requests 100000/month 300/min
SELECT TIER	SELECT TIER
Creative Commons Attribution-NonCommercial 4.0 International License	Creative Commons Attribution-NonCommercial 4.0 International License

Figure 90: Subscription tiers for open EO collections

2.3.5. Purchase Options for proprietary EO Collections[4]

In the case of commercial EO collections a customer can purchase a collection of images, which can be priced according to the number of selected images, or area covered, depending on the provider. The user must first open the *Image Explorer* for proprietary EO collections by clicking on the "Open Explorer" button (blue arrow in Figure 91) and select a set of images to purchase, as described in Section 2.2.3.5. Figure 89 illustrates an example of three images selected for purchase from the Pléiades commercial dataset provided by Sentinel Hub. To proceed with the transaction, the user must click on the "Add to Cart" button (blue arrow in Figure 89), in order to add the selected images to her shopping cart and proceed with the checkout.

[4] Please note that this functionality is not currently available in the beta due to the pending licensing agreements with their providers.



EO Collection

Pleiades - commercial

★★★★★ 4.8/5

LAST UPDATED: 20 Nov. 2020 - CREATED: 02 Feb. 2020
TOPIC: Environment
COVERAGE: Greece
ASSET ID: 300.994.567

from 25€/month

Overview

Description
Natura 2000 is a network of nature protection areas in the territory of the European Union. It is made up of ...

Suitable for:
• Thematic mapping
• Land management and property development
• Environmental monitoring

Additional resources
additional-1.pdf

Asset Info
LANGUAGE: English
TEMPORAL EXTENT: Nov. 2019 - Oct. 2020

Keywords
NATURA 2000, ENVIRONMENT, NATURE PROTECTION, WMS

About the vendor
Sentinel Hub ★★★★ 4.1/5
Athens, Greece
Joined February 2020

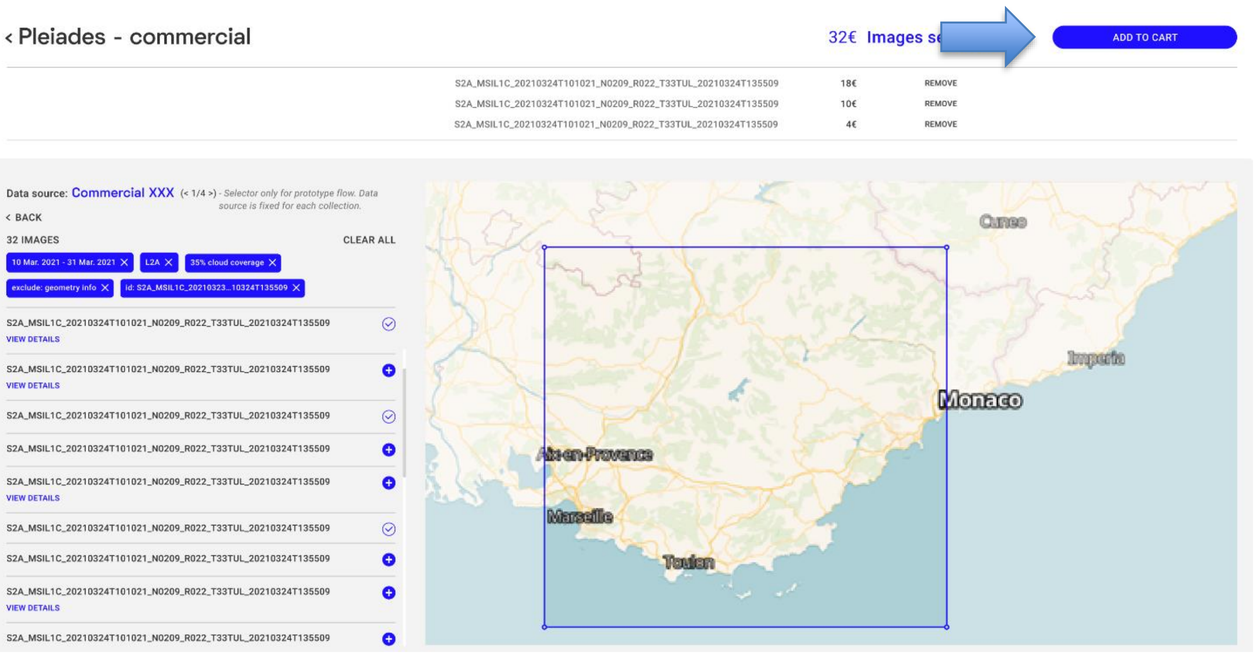
About the owner
Airbus ★★★★ 4.1/5
Leiden, the Netherlands
Joined February 2020

Other EO collections

EO Dataset	Sentinel 2 - A ★★★★★ 4.8/5	42€/mo
EO Dataset	Sentinel 2 - B ★★★★★ 4.8/5	13€/mo

Satellite images explorer

Figure 91: Open explorer for commercial EO collections



Pleiades - commercial — 32€ Images se

S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509	18€	REMOVE
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509	10€	REMOVE
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509	4€	REMOVE

Data source: Commercial XXX (< 1/4 >) - *Selector only for prototype flow. Data source is fixed for each collection.*

32 IMAGES

10 Mar. 2021 - 31 Mar. 2021 · L2A · 35% cloud coverage · exclude: geometry info · id: S2A_MSIL1C_20210323...10324T135509

S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509
S2A_MSIL1C_20210324T101021_N0209_R022_T33TUL_20210324T135509

Figure 92: Purchase images for commercial EO collections

3. Transaction Manager

In this section, we present how asset transactions are modelled, instantiated, and monitored in the marketplace in accordance with our established business models, offerings, and workflows. First, we provide an overview of the workflow engine applied in the OpertusMundi marketplace, and offer examples of how workflows are authored, invoked, and monitored. Next, we discuss the core modelling concepts and decisions regarding the lifecycle of asset transactions within the broader operation of the marketplace, as well as the corresponding components providing them. Finally, we present how payments are received and processed by the platform's payment provider.

3.1. Workflow Engine

In the next sections, we present the workflow engine applied in the OpertusMundi marketplace and the facilities it provides for authoring, invoking, and monitoring workflows.

3.1.1. Integration

In OpertusMundi, all **asset transactions** such as asset **publishing**, **purchasing**, and **provisioning** are managed by **workflows**. Although a workflow dictates how data flows through several platform modules to accomplish a specific task, the implementation details are decoupled from the workflow itself. Hence, a workflow orchestrates the steps required by a complex task, while external services implement them.

Workflows are executed via a Business Process Management (BPM) engine. In our implementation, we use the Camunda BPM engine for authoring, invoking, and monitoring workflows. The integration of Camunda in the OpertusMundi marketplace is displayed in Figure 93.

Users and external services interact with the platform through the API and Admin Gateway Services. These services are responsible for enforcing security constraints and performing validation checks. Moreover, the API Gateway is exclusively handling marketplace requests, while the Admin Gateway is responsible for administrative tasks and is accessible only to platform accredited personnel.

Both Gateway Services interact with the Camunda engine using the Camunda REST API[5], for initiating, querying, and updating workflow instances. To decouple workflows from business logic implementation, Camunda is using the notion of *External Tasks*. An External Task is a unit of work that is executed by another application, namely, the External Task Service Worker and which is identified by a unique name referred to as the *topic*. During its initialization, a Worker may subscribe for multiple *topics* to one or more BPM engine instances. Whenever the execution of a workflow instance reaches an External Task, Camunda queues the task to a list and waits until the first available Worker, which has a subscription for the specific *topic*, picks and executes the task.

[5] https://docs.camunda.org/manual/latest/reference/rest/

Once the task is completed, the workflow execution resumes, and the Worker fetches the next available task for execution. An example of an external task execution is shown in Figure 94.

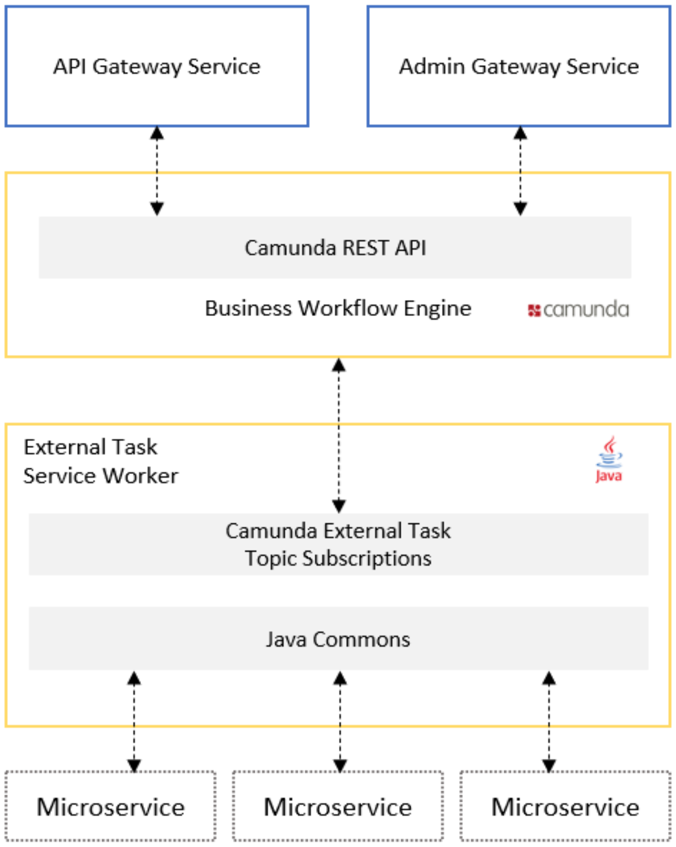


Figure 93: Camunda integration in OpertusMundi platform

In OpertusMundi, Workers are implemented as Java service applications and are deployed using Docker containers. Moreover, there is a single Worker implementation[6], which subscribes for all *topics* required by the platform. On a production deployment, multiple instances are created for better performance and resilience. Moreover, to keep Worker implementation as simple as possible, the business logic is implemented in a separate module, the OpertusMundi Java Commons[7]. This module contains the core of the OpertusMundi business logic, data repositories for accessing external data sources, and HTTP clients for connecting to other OpertusMundi microservices.

[6] https://github.com/OpertusMundi/bpm-worker-service
[7] https://github.com/OpertusMundi/java-commons

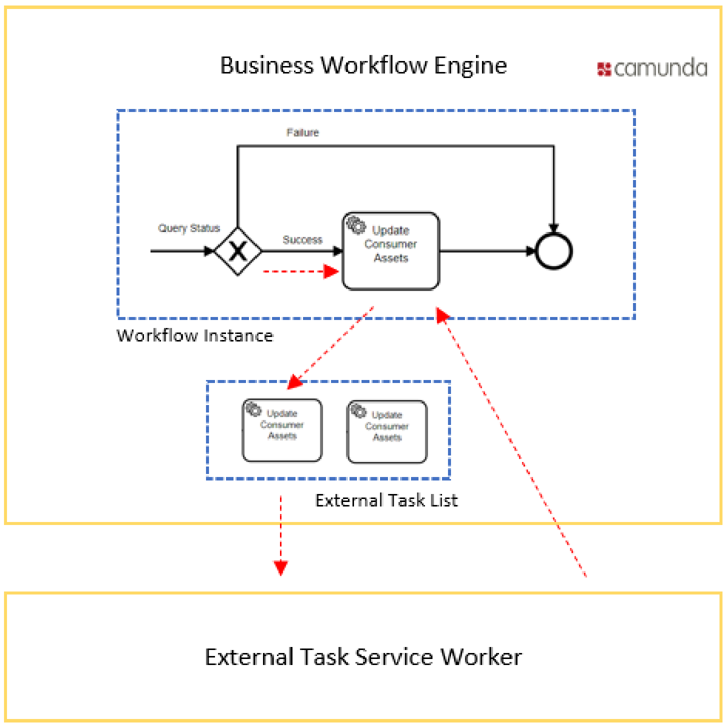


Figure 94: Externa Task execution

3.1.2. Workflow Design and Management

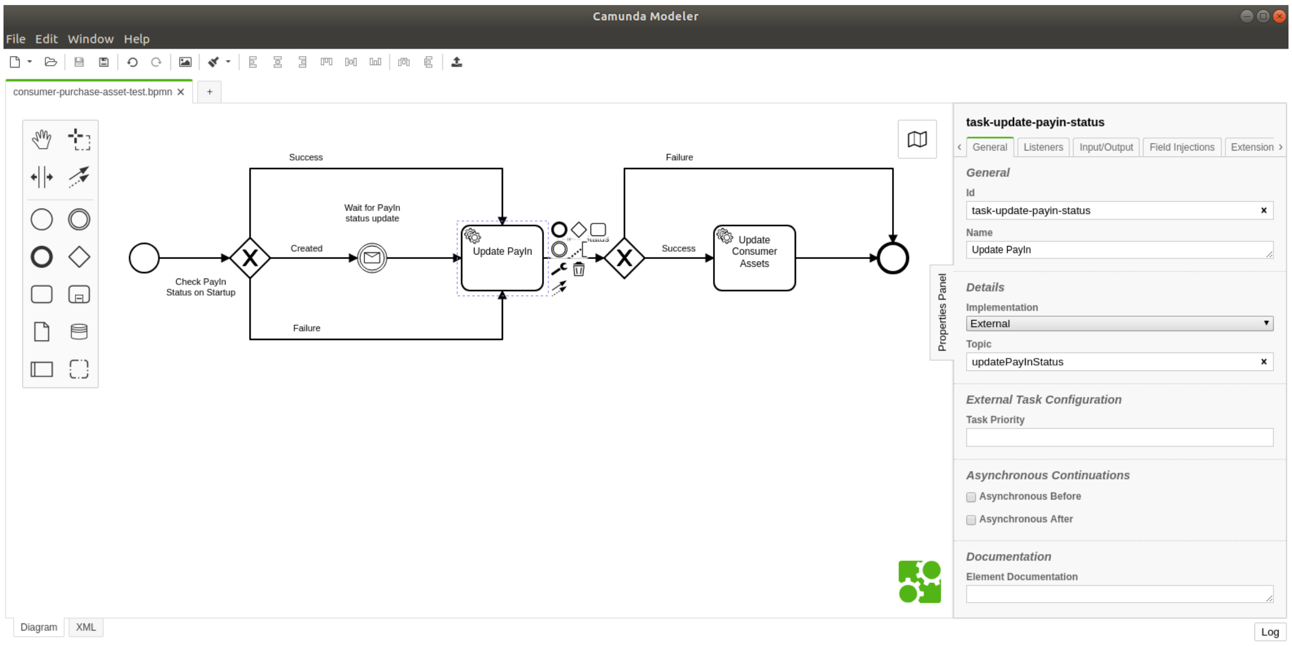
In this section, we present the applications used for the design of workflows and the management of process instances, namely, the Camunda Modeler[8] and the Camunda Cockpit[9] applications.

Camunda uses the Business Process Model and Notation (BPMN) 2.0 representation for defining workflows. To simplify workflow authoring, we are using the Camunda Modeler application, which provides a GUI to easily specify workflow definitions. An example of such a workflow is shown in Figure 95. Once a workflow is created, it can be either uploaded to an existing BPM engine instance using the Modeler application or packaged with the BPM engine distributable. In OpertusMundi, use the latter solution since include workflow definitions in our code versioning system.

After a workflow definition is deployed, it can be instantiated either through the Cockpit application or the REST API. In OpertusMundi, workflow instances are always created by the Gateway Services either *synchronously* (due to a user request) or *asynchronously* (due to a scheduler event).

Starting a workflow, creates a new process instance. The Cockpit application allows administrators to (a) monitor the status of all active process instances, (b) detect any runtime errors (also named incidents), (c) retry failed instances, thus resolving errors, (d) query runtime variables, and (e) manually terminate the execution of an instance.

[8] https://camunda.com/download/modeler/
[9] https://camunda.com/products/camunda-platform/cockpit/



task-update-payin-status

General | Listeners | Input/Output | Field Injections | Extension

General

Id: task-update-payin-status

Name: Update PayIn

Details

Implementation: External

Topic: updatePayInStatus

External Task Configuration

Task Priority:

Asynchronous Continuations

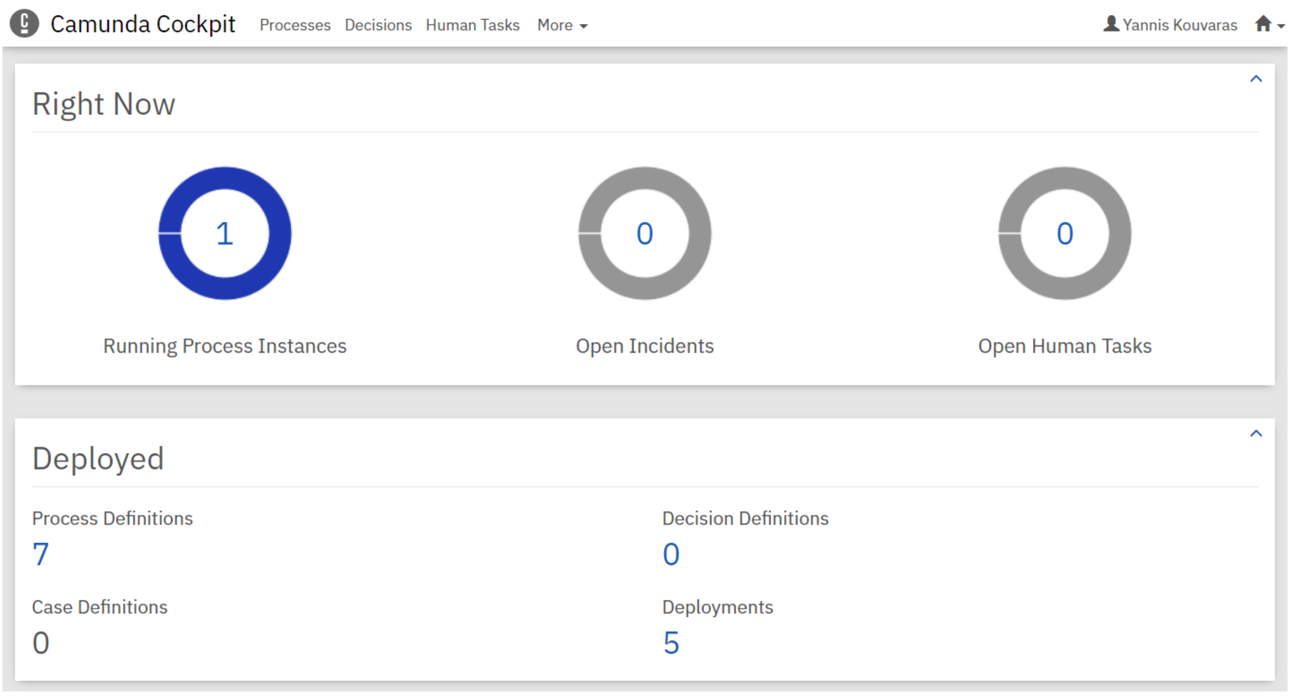
- [ ] Asynchronous Before
- [ ] Asynchronous After

Documentation

Element Documentation:

Figure 95: Camunda Modeler example

Camunda Cockpit presents process instance information at several levels of detail. At the topmost level, an overview of all running workflow instances is presented as shown in Figure 96.



Right Now

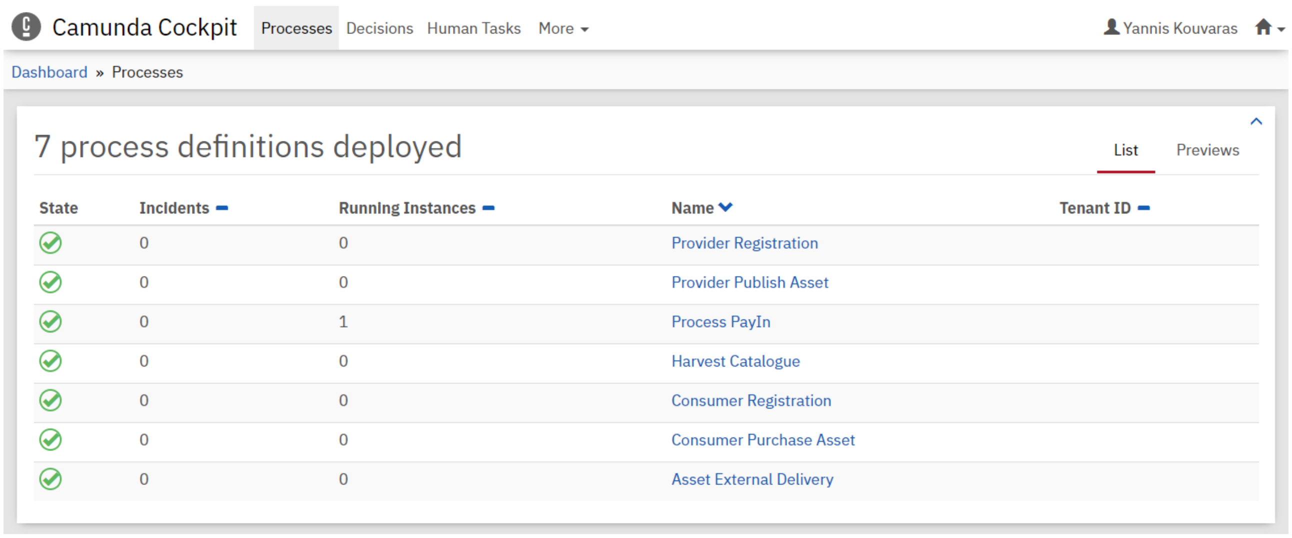
Running Process Instances	Open Incidents	Open Human Tasks
1	0	0

Deployed

Process Definitions	Decision Definitions
7	0
Case Definitions	Deployments
0	5

Figure 96: Camunda Cockpit overview

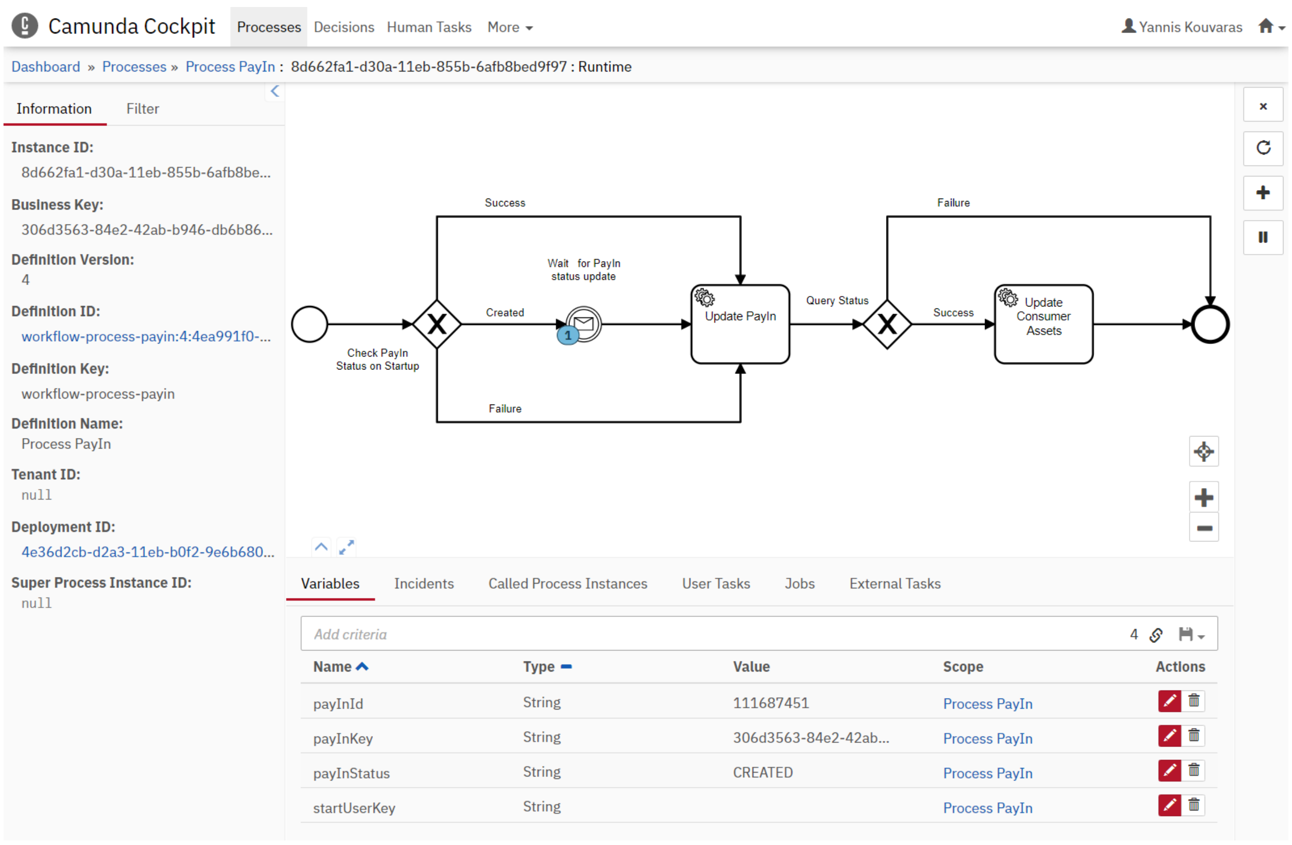
Users can also select to view details about running instances grouped per workflow definition as illustrated in Figure 97. Finally, the application allows to view all executions for a specific workflow definition as displayed in Figure 98. This is the most useful view since it provides the most details about the exact state of every process instance, including any unresolved incidents and variables values.



7 process definitions deployed

State	Incidents	Running Instances	Name	Tenant ID
✓	0	0	Provider Registration	
✓	0	0	Provider Publish Asset	
✓	0	1	Process PayIn	
✓	0	0	Harvest Catalogue	
✓	0	0	Consumer Registration	
✓	0	0	Consumer Purchase Asset	
✓	0	0	Asset External Delivery	

Figure 97: Process instances per workflow definition



Instance ID:
8d662fa1-d30a-11eb-855b-6afb8be...

Business Key:
306d3563-84e2-42ab-b946-db6b86...

Definition Version:
4

Definition ID:
workflow-process-payin:4:4ea991f0-...

Definition Key:
workflow-process-payin

Definition Name:
Process PayIn

Tenant ID:
null

Deployment ID:
4e36d2cb-d2a3-11eb-b0f2-9e6b680...

Super Process Instance ID:
null

Name	Type	Value	Scope	Actions
payInId	String	111687451	Process PayIn	
payInKey	String	306d3563-84e2-42ab...	Process PayIn	
payInStatus	String	CREATED	Process PayIn	
startUserKey	String		Process PayIn	

Figure 98: Process instances for a specific workflow definition

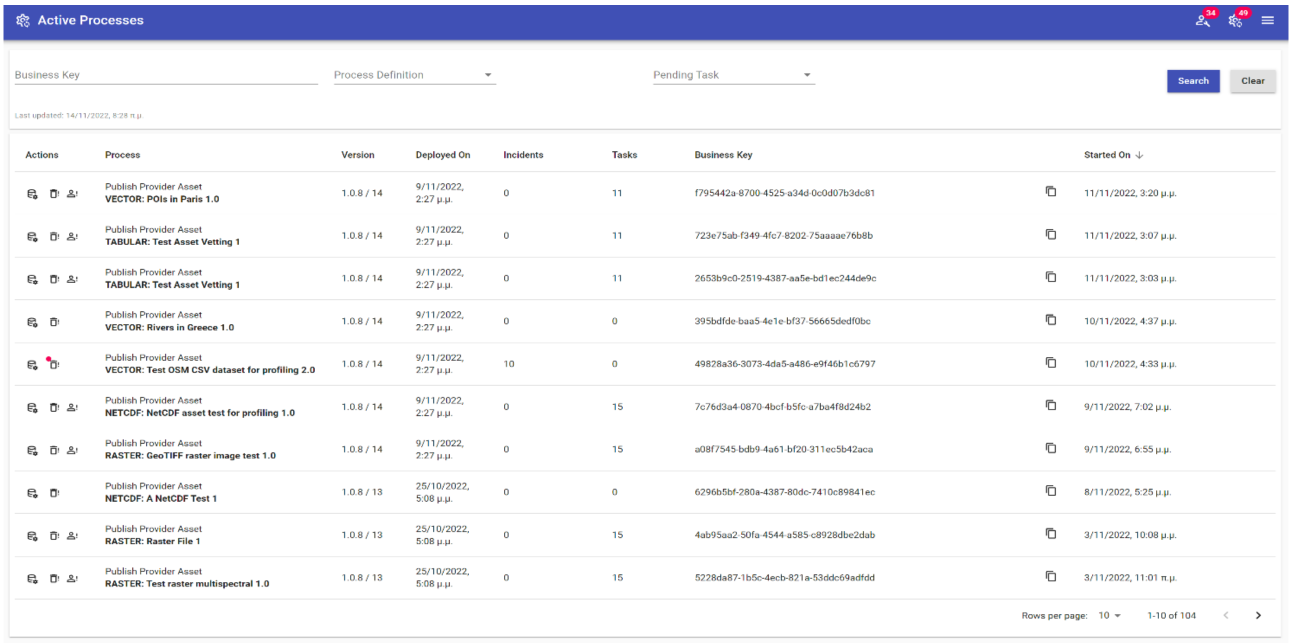
Camunda Cockpit is accessible *only to the platform administrators* and is used primarily for debugging workflow definitions during development. As discussed in the next sections, the Admin Gateway Service, is using the REST API to expose part of this information in a manner more suitable for the OpertusMundi business model.

3.2. Workflow Monitoring

In the previous section, we presented the Camunda BPM engine, the service used for executing workflows and the Camunda Cockpit, the application used for monitoring process instances. The latter presents and manages workflow information from the perspective of software developers and system administrators.

Next, we present the features provided by the Transaction Manager UI client for monitoring process instances. Details about the actual implementation of the UI client, as well as the service handling client requests are available in Section 5.3.

Whenever a new process instance is started, a unique identifier, namely the *business key*, is assigned to it by the platform. The business key is always coupled to a distinct entity of the OpertusMundi business model such as an asset publish operation, a customer order, or a payment. Transaction Manager allows users to search running process instances by their business key from the *Active Process*es view shown in Figure 99. This view provides a concise snapshot of the status of all running process instances. Users can easily view the type of a process, the deployed version and whether the execution has errors.



Last updated: 14/11/2022, 8:28 π.μ.

Actions	Process	Version	Deployed On	Incidents	Tasks	Business Key	Started On ↓
	Publish Provider Asset **VECTOR: POIs in Paris 1.0**	1.0.8 / 14	9/11/2022, 2:27 μ.μ.	0	11	f795442a-8700-4525-a34d-0c0d07b3dc81	11/11/2022, 3:20 μ.μ.
	Publish Provider Asset **TABULAR: Test Asset Vetting 1**	1.0.8 / 14	9/11/2022, 2:27 μ.μ.	0	11	723e75ab-f349-4fc7-8202-75aaaae76b8b	11/11/2022, 3:07 μ.μ.
	Publish Provider Asset **TABULAR: Test Asset Vetting 1**	1.0.8 / 14	9/11/2022, 2:27 μ.μ.	0	11	2653b9c0-2519-4387-aa5e-bd1ec244de9c	11/11/2022, 3:03 μ.μ.
	Publish Provider Asset **VECTOR: Rivers in Greece 1.0**	1.0.8 / 14	9/11/2022, 2:27 μ.μ.	0	0	395bdfde-baa5-4e1e-bf37-56665dedf0bc	10/11/2022, 4:37 μ.μ.
	Publish Provider Asset **VECTOR: Test OSM CSV dataset for profiling 2.0**	1.0.8 / 14	9/11/2022, 2:27 μ.μ.	10	0	49828a36-3073-4da5-a486-e9f46b1c6797	10/11/2022, 4:33 μ.μ.
	Publish Provider Asset **NETCDF: NetCDF asset test for profiling 1.0**	1.0.8 / 14	9/11/2022, 2:27 μ.μ.	0	15	7c76d3a4-0870-4bcf-b5fc-a7ba4f8d24b2	9/11/2022, 7:02 μ.μ.
	Publish Provider Asset **RASTER: GeoTIFF raster image test 1.0**	1.0.8 / 14	9/11/2022, 2:27 μ.μ.	0	15	a08f7545-bdb9-4a61-bf20-311ec5b42aca	9/11/2022, 6:55 μ.μ.
	Publish Provider Asset **NETCDF: A NetCDF Test 1**	1.0.8 / 13	25/10/2022, 5:08 μ.μ.	0	0	6296b5bf-280a-4387-80dc-7410c89841ec	8/11/2022, 5:25 μ.μ.
	Publish Provider Asset **RASTER: Raster File 1**	1.0.8 / 13	25/10/2022, 5:08 μ.μ.	0	15	4ab95aa2-50fa-4544-a585-c8928dbe2dab	3/11/2022, 10:08 μ.μ.
	Publish Provider Asset **RASTER: Test raster multispectral 1.0**	1.0.8 / 13	25/10/2022, 5:08 μ.μ.	0	15	5228da87-1b5c-4ecb-821a-53ddc69adfdd	3/11/2022, 11:01 π.μ.

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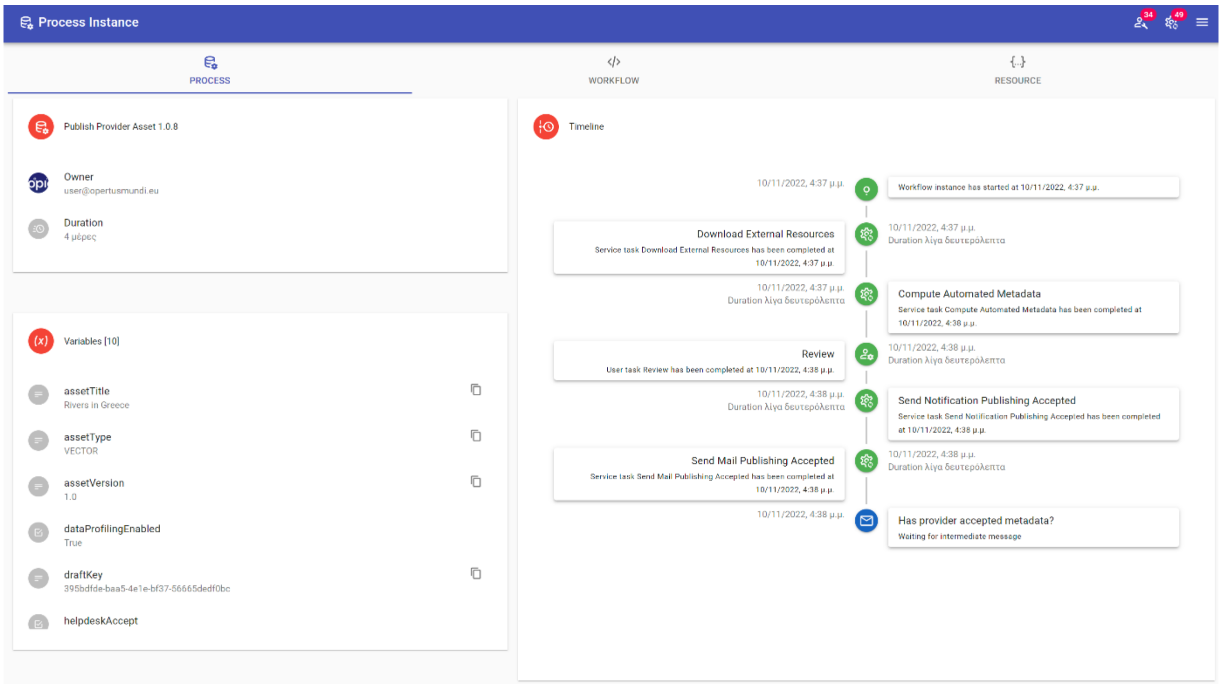
Figure 99: Active process instances

A user may select to view details about the execution of a specific process instance as displayed in Figure 100. In contrast to the Camunda Cockpit view shown in Figure 98, information is presented in a less technical manner. Hence, instead of the BPMN diagram, an event timeline is rendered that includes the following:

- Start and end events.

- Messages exchanged by the process instance.
- External tasks executed.
- User tasks completed (these are tasks that require external user interaction).
- Incidents and optionally details about when the error was resolved.
- Process instance variables.



Publish Provider Asset 1.0.8

Owner
user@opertusmundi.eu

Duration
4 μέρες

Variables [10]

assetTitle
Rivers in Greece

assetType
VECTOR

assetVersion
1.0

dataProfilingEnabled
True

draftKey
395bdfde-baa5-4e1e-bf37-56665dedf0bc

helpdeskAccept

Timeline

10/11/2022, 4:37 μ.μ.
Workflow instance has started at 10/11/2022, 4:37 μ.μ.

Download External Resources
Service task Download External Resources has been completed at 10/11/2022, 4:37 μ.μ.
10/11/2022, 4:37 μ.μ.
Duration λίγα δευτερόλεπτα

10/11/2022, 4:37 μ.μ.
Duration λίγα δευτερόλεπτα
Compute Automated Metadata
Service task Compute Automated Metadata has been completed at 10/11/2022, 4:38 μ.μ.

Review
User task Review has been completed at 10/11/2022, 4:38 μ.μ.
10/11/2022, 4:38 μ.μ.
Duration λίγα δευτερόλεπτα

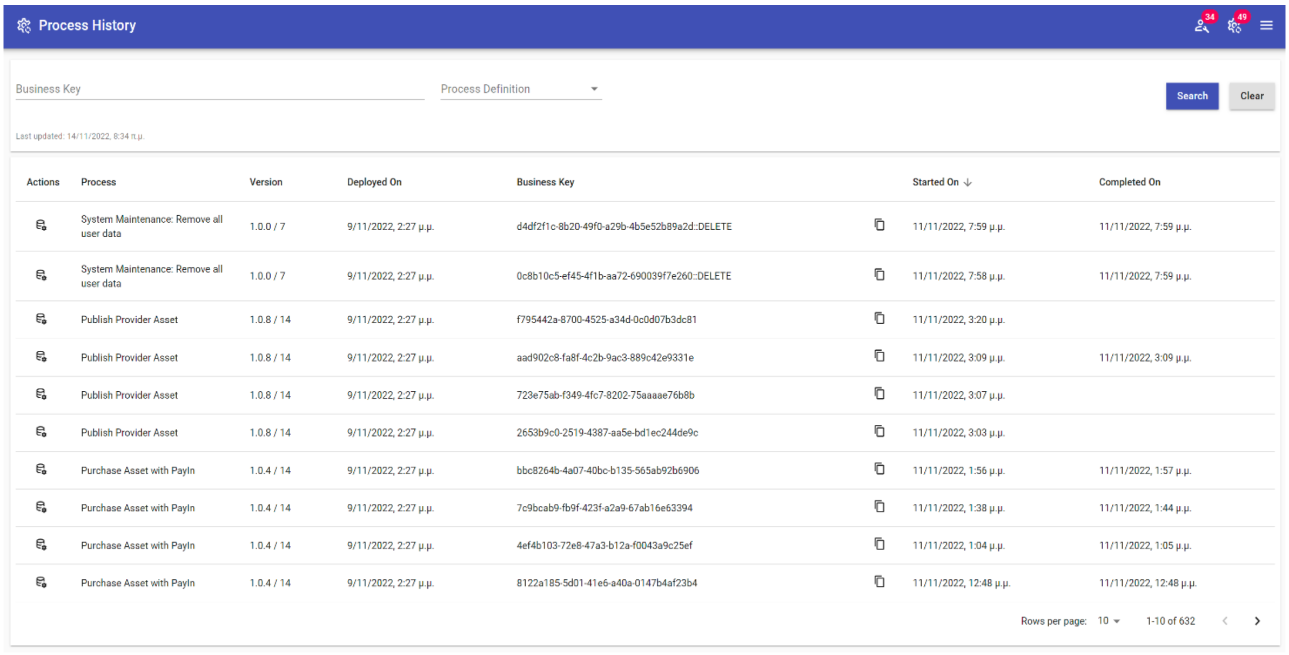
10/11/2022, 4:38 μ.μ.
Duration λίγα δευτερόλεπτα
Send Notification Publishing Accepted
Service task Send Notification Publishing Accepted has been completed at 10/11/2022, 4:38 μ.μ.

Send Mail Publishing Accepted
Service task Send Mail Publishing Accepted has been completed at 10/11/2022, 4:38 μ.μ.
10/11/2022, 4:38 μ.μ.
Duration λίγα δευτερόλεπτα

10/11/2022, 4:38 μ.μ.
Has provider accepted metadata?
Waiting for intermediate message

Figure 100: Process instance execution details

For performance reasons, once an active process instance is completed, Camunda BPM engine archives all related information. The Camunda Cockpit Community edition used by the OpertusMundi marketplace, does not have support for displaying archived data. To make such historical data available to the client, we have implemented the *Process History* view shown in Figure 101.



Last updated: 14/11/2022, 8:34 π.μ.

Actions	Process	Version	Deployed On	Business Key		Started On	Completed On
	System Maintenance: Remove all user data	1.0.0 / 7	9/11/2022, 2:27 μ.μ.	d4df2f1c-8b20-49f0-a29b-4b5e52b89a2d::DELETE		11/11/2022, 7:59 μ.μ.	11/11/2022, 7:59 μ.μ.
	System Maintenance: Remove all user data	1.0.0 / 7	9/11/2022, 2:27 μ.μ.	0c8b10c5-ef45-4f1b-aa72-690039f7e260::DELETE		11/11/2022, 7:58 μ.μ.	11/11/2022, 7:59 μ.μ.
	Publish Provider Asset	1.0.8 / 14	9/11/2022, 2:27 μ.μ.	f795442a-8700-4525-a34d-0c0d07b3dc81		11/11/2022, 3:20 μ.μ.	
	Publish Provider Asset	1.0.8 / 14	9/11/2022, 2:27 μ.μ.	aad902c8-fa8f-4c2b-9ac3-889c42e9331e		11/11/2022, 3:09 μ.μ.	11/11/2022, 3:09 μ.μ.
	Publish Provider Asset	1.0.8 / 14	9/11/2022, 2:27 μ.μ.	723e75ab-f349-4fc7-8202-75aaaae76b8b		11/11/2022, 3:07 μ.μ.	
	Publish Provider Asset	1.0.8 / 14	9/11/2022, 2:27 μ.μ.	2653b9c0-2519-4387-aa5e-bd1ec244de9c		11/11/2022, 3:03 μ.μ.	
	Purchase Asset with PayIn	1.0.4 / 14	9/11/2022, 2:27 μ.μ.	bbc8264b-4a07-40bc-b135-565ab92b6906		11/11/2022, 1:56 μ.μ.	11/11/2022, 1:57 μ.μ.
	Purchase Asset with PayIn	1.0.4 / 14	9/11/2022, 2:27 μ.μ.	7c9bcab9-fb9f-423f-a2a9-67ab16e63394		11/11/2022, 1:38 μ.μ.	11/11/2022, 1:44 μ.μ.
	Purchase Asset with PayIn	1.0.4 / 14	9/11/2022, 2:27 μ.μ.	4ef4b103-72e8-47a3-b12a-f0043a9c25ef		11/11/2022, 1:04 μ.μ.	11/11/2022, 1:05 μ.μ.
	Purchase Asset with PayIn	1.0.4 / 14	9/11/2022, 2:27 μ.μ.	8122a185-5d01-41e6-a40a-0147b4af23b4		11/11/2022, 12:48 μ.μ.	11/11/2022, 12:48 μ.μ.

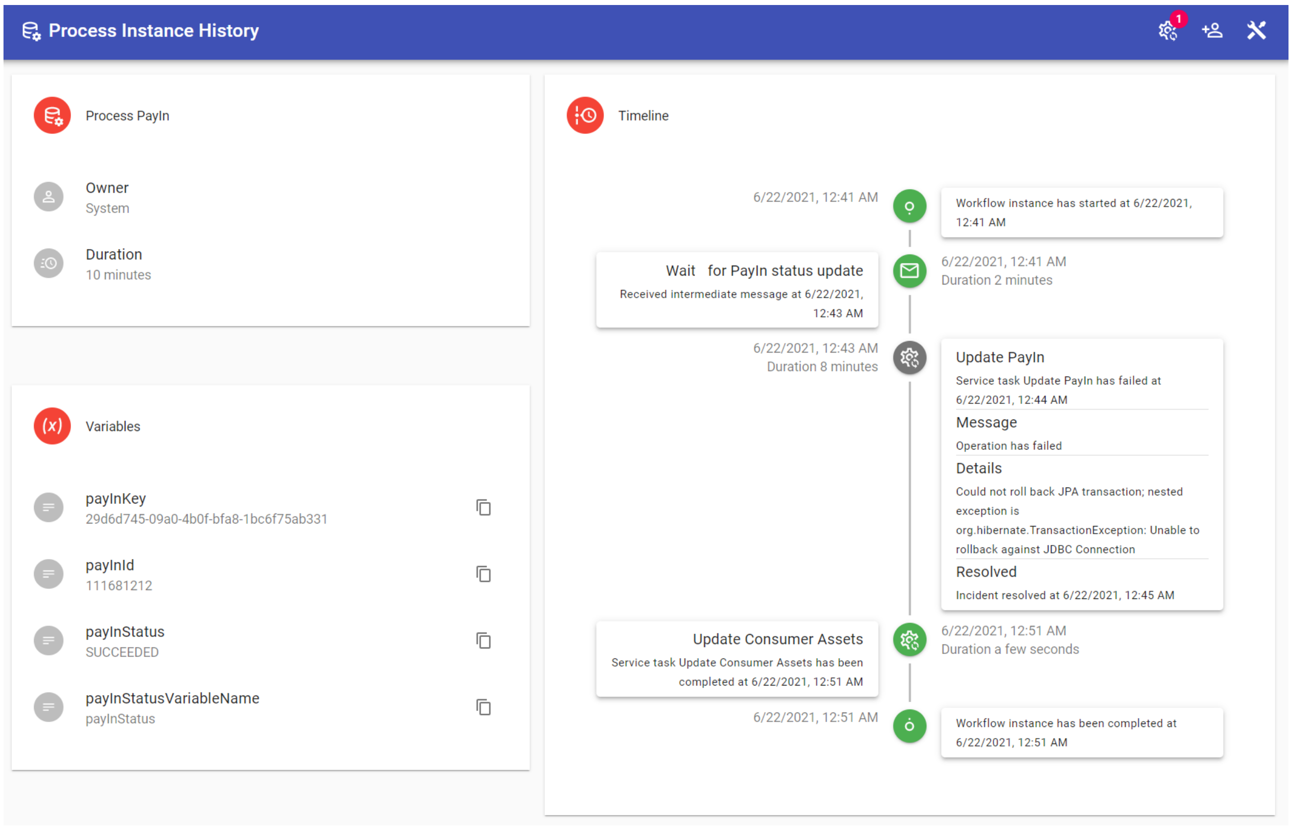
Rows per page: 10 1-10 of 632

Figure 101: Process instance history

This view aggregates data from several Camunda REST API methods and allows users to (a) view summarized process instance historical data and (b) drill down to the details of a specific instance. An example of the latter option is shown in Figure 102. In this example, the process instance refers to a customer payment and the following events are highlighted:

- A start event has initialized the process instance execution.
- A message was received by the process instance that reports a change to the status of the payment by the Payment provider.
- The payment has been updated. Moreover, the update has initially failed once, but eventually the error was resolved successfully.
- The consumer profile has been updated with any assets or subscriptions referred by the specific payment record.
- An end event signaling the end of the process instance execution.

In the previous example, the payment was referring to an asset purchased with platform digital delivery. If physical delivery were selected, additional events would have been included in the timeline, such as a consumer delivery confirmation message.


Process Instance History

Process PayIn

Owner
System

Duration
10 minutes

Variables

payInKey	29d6d745-09a0-4b0f-bfa8-1bc6f75ab331
payInId	111681212
payInStatus	SUCCEEDED
payInStatusVariableName	payInStatus

Timeline

6/22/2021, 12:41 AM
Workflow instance has started at 6/22/2021, 12:41 AM

Wait for PayIn status update
Received intermediate message at 6/22/2021, 12:43 AM
6/22/2021, 12:41 AM
Duration 2 minutes

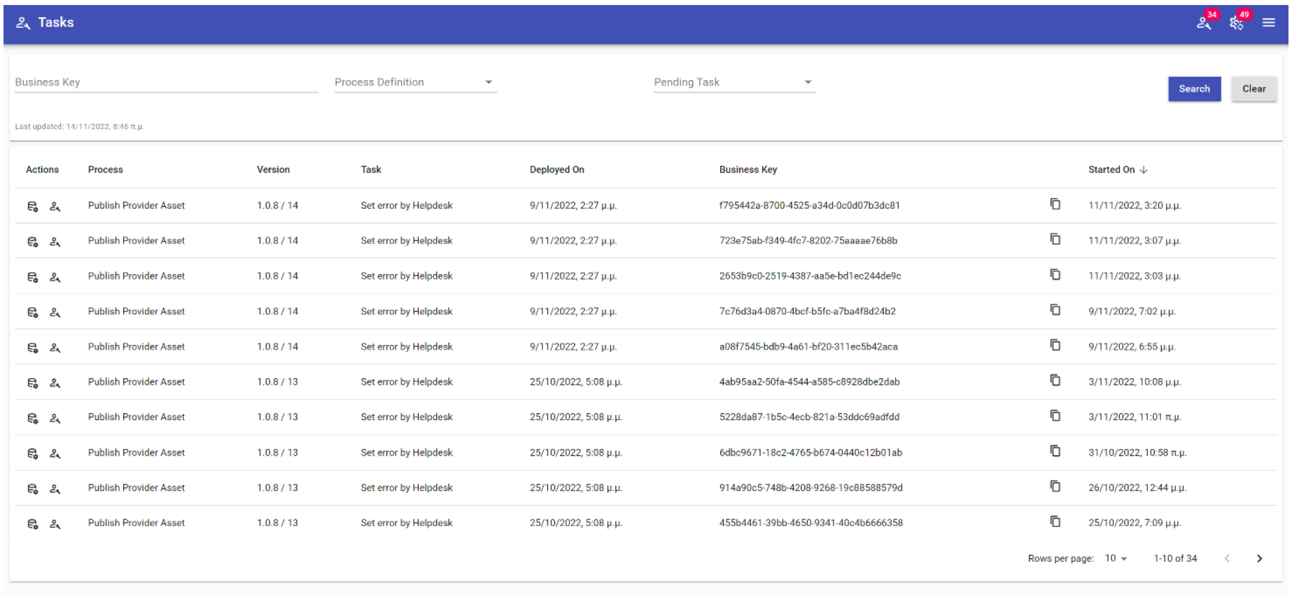
6/22/2021, 12:43 AM
Duration 8 minutes
Update PayIn
Service task Update PayIn has failed at 6/22/2021, 12:44 AM
Message
Operation has failed
Details
Could not roll back JPA transaction; nested exception is org.hibernate.TransactionException: Unable to rollback against JDBC Connection
Resolved
Incident resolved at 6/22/2021, 12:45 AM

Update Consumer Assets
Service task Update Consumer Assets has been completed at 6/22/2021, 12:51 AM
6/22/2021, 12:51 AM
Duration a few seconds

6/22/2021, 12:51 AM
Workflow instance has been completed at 6/22/2021, 12:51 AM

Figure 102: Process instance historical data

During the execution of a workflow instance, the system may require input by a Topio user e.g., a Topio user may review and approve an asset to publish or send an error message to a marketplace user for a failed transaction. The Transaction manager UI implements the *Tasks* view for handling such cases, shown in Figure 103.


Tasks

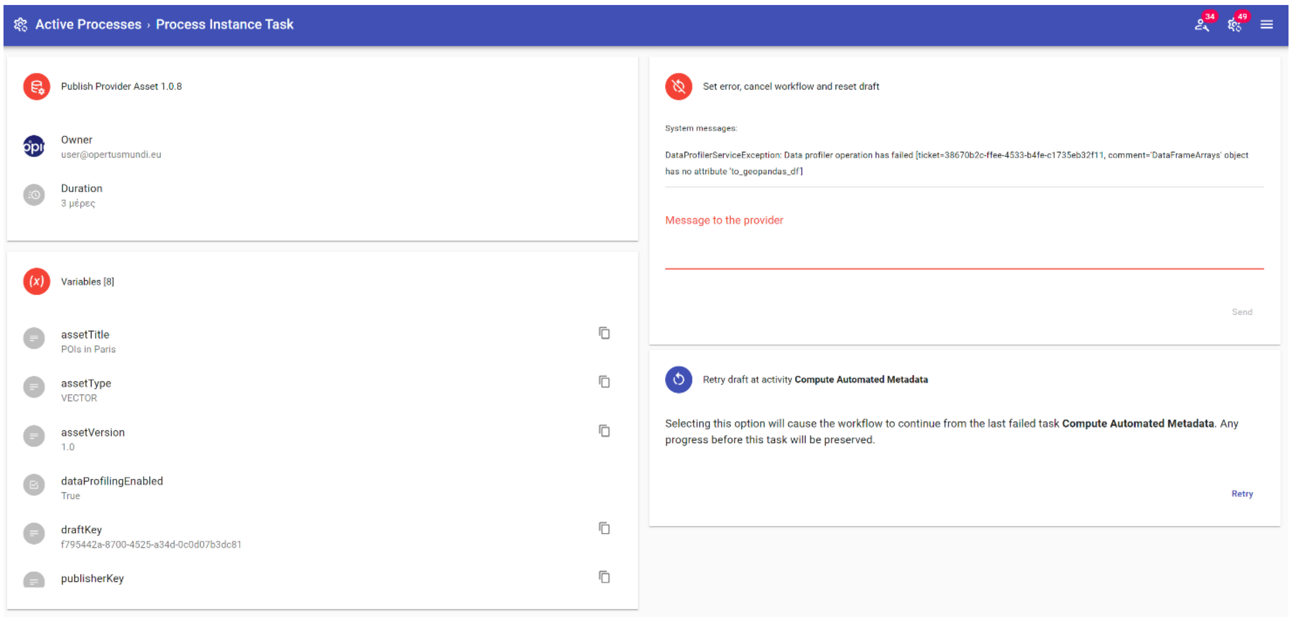
Last updated: 14/11/2022, 8:46 π.μ.

Actions	Process	Version	Task	Deployed On	Business Key	Started On ↓
	Publish Provider Asset	1.0.8 / 14	Set error by Helpdesk	9/11/2022, 2:27 μ.μ.	f795442a-8700-4525-a34d-0c0d07b3dc81	11/11/2022, 3:20 μ.μ.
	Publish Provider Asset	1.0.8 / 14	Set error by Helpdesk	9/11/2022, 2:27 μ.μ.	723e75ab-f349-4fc7-8202-75aaaae76b8b	11/11/2022, 3:07 μ.μ.
	Publish Provider Asset	1.0.8 / 14	Set error by Helpdesk	9/11/2022, 2:27 μ.μ.	2653b9c0-2519-4387-aa5e-bd1ec244de9c	11/11/2022, 3:03 μ.μ.
	Publish Provider Asset	1.0.8 / 14	Set error by Helpdesk	9/11/2022, 2:27 μ.μ.	7c76d3a4-0870-4bcf-b5fc-a7ba4f8d24b2	9/11/2022, 7:02 μ.μ.
	Publish Provider Asset	1.0.8 / 14	Set error by Helpdesk	9/11/2022, 2:27 μ.μ.	a08f7545-bdb9-4a61-bf20-311ec5b42aca	9/11/2022, 6:55 μ.μ.
	Publish Provider Asset	1.0.8 / 13	Set error by Helpdesk	25/10/2022, 5:08 μ.μ.	4ab95aa2-50fa-4544-a585-c8928dbe2dab	3/11/2022, 10:08 μ.μ.
	Publish Provider Asset	1.0.8 / 13	Set error by Helpdesk	25/10/2022, 5:08 μ.μ.	5228da87-1b5c-4ecb-821a-53ddc69adfdd	3/11/2022, 11:01 π.μ.
	Publish Provider Asset	1.0.8 / 13	Set error by Helpdesk	25/10/2022, 5:08 μ.μ.	6dbc9671-18c2-4765-b674-0440c12b01ab	31/10/2022, 10:58 π.μ.
	Publish Provider Asset	1.0.8 / 13	Set error by Helpdesk	25/10/2022, 5:08 μ.μ.	914a90c5-748b-4208-9268-19c88588579d	26/10/2022, 12:44 μ.μ.
	Publish Provider Asset	1.0.8 / 13	Set error by Helpdesk	25/10/2022, 5:08 μ.μ.	455b4461-39bb-4650-9341-40c4b6666358	25/10/2022, 7:09 μ.μ.

Rows per page: 10 1-10 of 34

Figure 103: Tasks view

For error handling tasks, the user may decide to either retry the task or cancel the workflow instance and send a message to the owner as shown in Figure 104.


Active Processes › Process Instance Task

Publish Provider Asset 1.0.8

Owner
user@opertusmundi.eu

Duration
3 μέρες

Variables [8]

assetTitle
POIs in Paris

assetType
VECTOR

assetVersion
1.0

dataProfilingEnabled
True

draftKey
f795442a-8700-4525-a34d-0c0d07b3dc81

publisherKey

Set error, cancel workflow and reset draft

System messages:

DataProfilerServiceException: Data profiler operation has failed [ticket=38670b2c-ffee-4533-b4fe-c1735eb32f11, comment='DataFrameArrays' object has no attribute 'to_geopandas_df']

Message to the provider

Send

Retry draft at activity **Compute Automated Metadata**

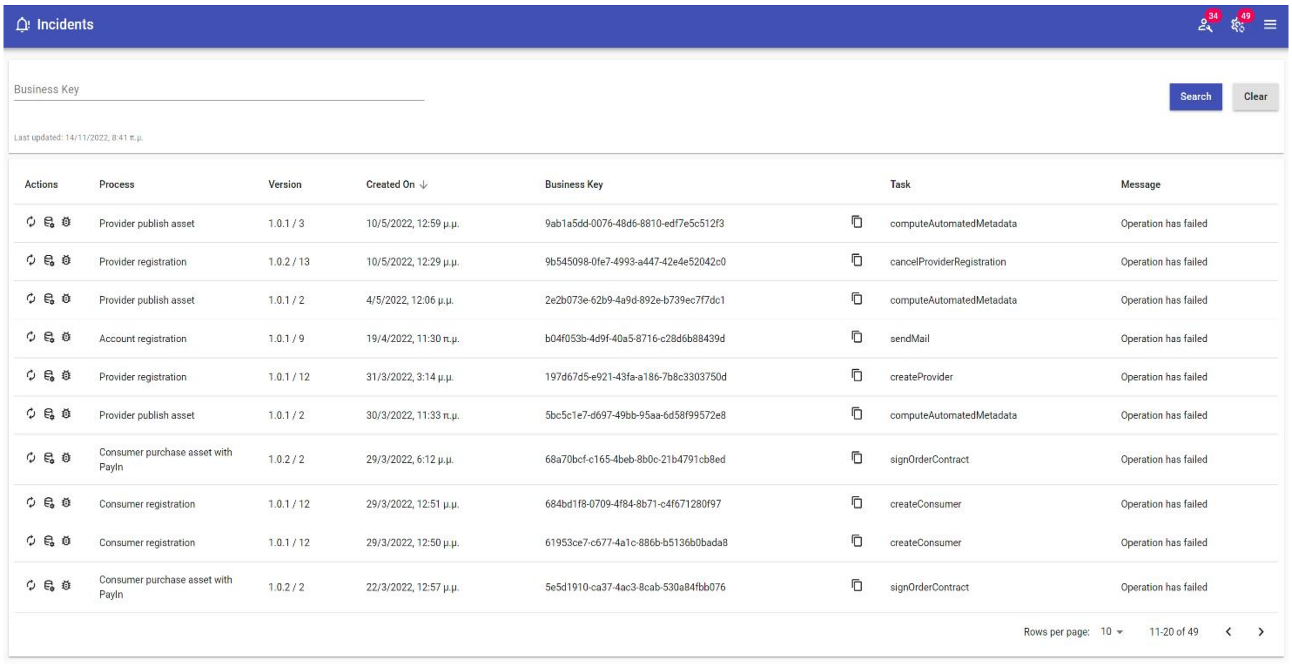
Selecting this option will cause the workflow to continue from the last failed task **Compute Automated Metadata**. Any progress before this task will be preserved.

Retry

Figure 104: Set error or retry task

Finally, Transaction Manager UI implements the *Incidents* view, shown in Figure 105, for monitoring failed process instances. The view displays information about the type of a process, the failed task, and the associated error message. Moreover, the following actions are supported:

- Retry a failed task. This option allows users to resume process instance execution. For instance, if the error was caused by a service outage, retrying a task after a while may resolve the incident.
- View process instance details as discussed above.
- View error details for a specific error message. Error details may contain additional information about the service that caused the error.


Incidents

Business Key

Search Clear

Last updated: 14/11/2022, 8:41 π.μ.

Actions	Process	Version	Created On ↓	Business Key		Task	Message
	Provider publish asset	1.0.1 / 3	10/5/2022, 12:59 μ.μ.	9ab1a5dd-0076-48d6-8810-edf7e5c512f3		computeAutomatedMetadata	Operation has failed
	Provider registration	1.0.2 / 13	10/5/2022, 12:29 μ.μ.	9b545098-0fe7-4993-a447-42e4e52042c0		cancelProviderRegistration	Operation has failed
	Provider publish asset	1.0.1 / 2	4/5/2022, 12:06 μ.μ.	2e2b073e-62b9-4a9d-892e-b739ec7f7dc1		computeAutomatedMetadata	Operation has failed
	Account registration	1.0.1 / 9	19/4/2022, 11:30 π.μ.	b04f053b-4d9f-40a5-8716-c28d6b88439d		sendMail	Operation has failed
	Provider registration	1.0.1 / 12	31/3/2022, 3:14 μ.μ.	197d67d5-e921-43fa-a186-7b8c3303750d		createProvider	Operation has failed
	Provider publish asset	1.0.1 / 2	30/3/2022, 11:33 π.μ.	5bc5c1e7-d697-49bb-95aa-6d58f99572e8		computeAutomatedMetadata	Operation has failed
	Consumer purchase asset with PayIn	1.0.2 / 2	29/3/2022, 6:12 μ.μ.	68a70bcf-c165-4beb-8b0c-21b4791cb8ed		signOrderContract	Operation has failed
	Consumer registration	1.0.1 / 12	29/3/2022, 12:51 μ.μ.	684bd1f8-0709-4f84-8b71-c4f671280f97		createConsumer	Operation has failed
	Consumer registration	1.0.1 / 12	29/3/2022, 12:50 μ.μ.	61953ce7-c677-4a1c-886b-b5136b0bada8		createConsumer	Operation has failed
	Consumer purchase asset with PayIn	1.0.2 / 2	22/3/2022, 12:57 μ.μ.	5e5d1910-ca37-4ac3-8cab-530a84fbb076		signOrderContract	Operation has failed

Rows per page: 10 11-20 of 49

Figure 105: Workflow incidents

3.3. Asset Publishing

OpertusMundi models asset publishing using the **entity 'Asset'**. The *Asset entity* contains all the required information for publishing and trading an asset on the marketplace's catalogue. This information is initially inserted by the provider and later, during the execution of the asset publish workflow, is augmented with additional data generated by the Profiler[10] and Ingest[11] services.

When a new Asset is created, it is assigned a status of value *Draft*. While in this state, a provider can freely review and update it. Once the Asset is ready for publishing, the provider submits it for further processing and its status is updated to *Submitted*. A submitted Asset becomes read-only, and an instance of the asset publish workflow is initialized.

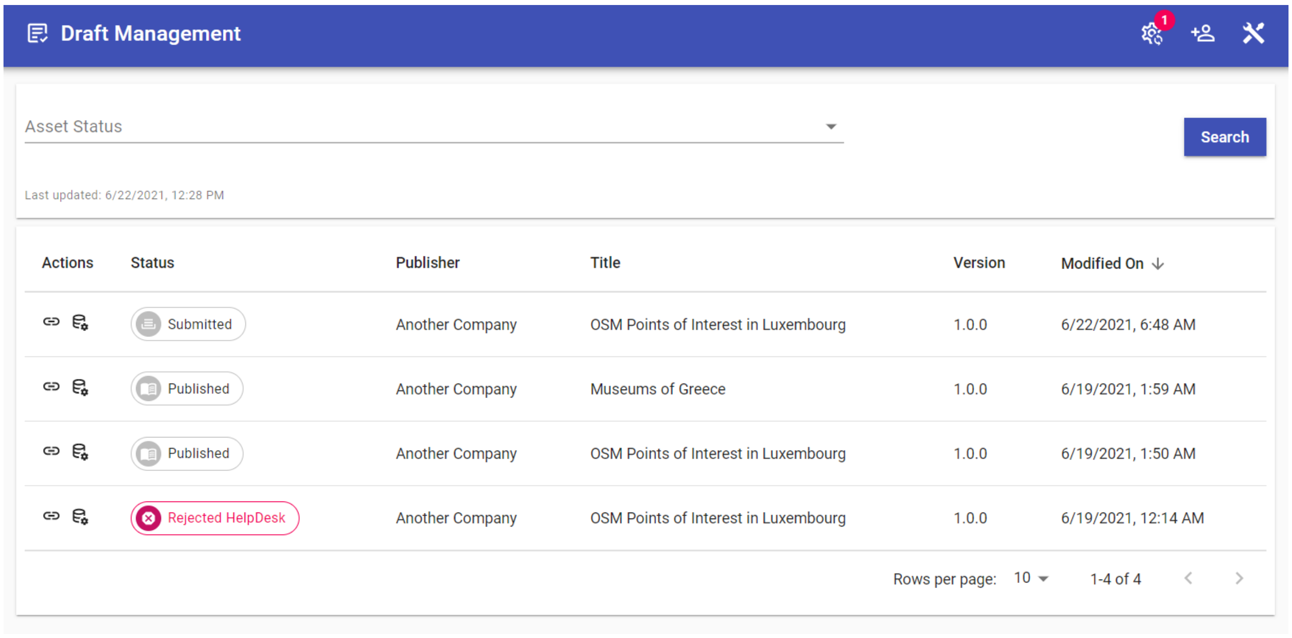
During the asset publishing process, the status of a draft may have one of the following values:

- *Draft*: Initial Asset status. Providers are allowed to edit Assets in this state.
- *Submitted*: Asset has been submitted for review and publication. After this point, the Asset becomes read-only. OpertusMundi platform may update the Asset with additional data. Moreover, the provider may have restricted options for editing the asset i.e., removing automated generated metadata from the final asset.
- *Helpdesk Pending Review*: The Asset must be reviewed by an OpertusMundi platform user before processing can be resumed.
- *Helpdesk Rejected*: If the Helpdesk rejects the Asset, the publishing workflow instance terminates.
- *Provider Pending Review*: The Asset must be reviewed by the provider. The provider may select to delete automated generated metadata computed by the platform.
- *Provider Rejected*: The provider has rejected the metadata of the Asset and the publishing workflow instance terminates.
- *Post-Processing*: Additional processing is performed such as ingesting data to the data store.
- *Embargo*: (Optional) If the provider has set an embargo period, the Asset will remain in this state for the duration set by the provider.
- *Published*: The Asset has been published to the catalogue and can be purchased by potential consumers.

The Transaction Manager allows Helpdesk users to view all Assets and their status using the *Draft Management* view shown in Figure 106.

[10] https://github.com/OpertusMundi/profile

[11] https://github.com/OpertusMundi/ingest



Draft Management

Asset Status

Search

Last updated: 6/22/2021, 12:28 PM

Actions	Status	Publisher	Title	Version	Modified On
	Submitted	Another Company	OSM Points of Interest in Luxembourg	1.0.0	6/22/2021, 6:48 AM
	Published	Another Company	Museums of Greece	1.0.0	6/19/2021, 1:59 AM
	Published	Another Company	OSM Points of Interest in Luxembourg	1.0.0	6/19/2021, 1:50 AM
	Rejected HelpDesk	Another Company	OSM Points of Interest in Luxembourg	1.0.0	6/19/2021, 12:14 AM

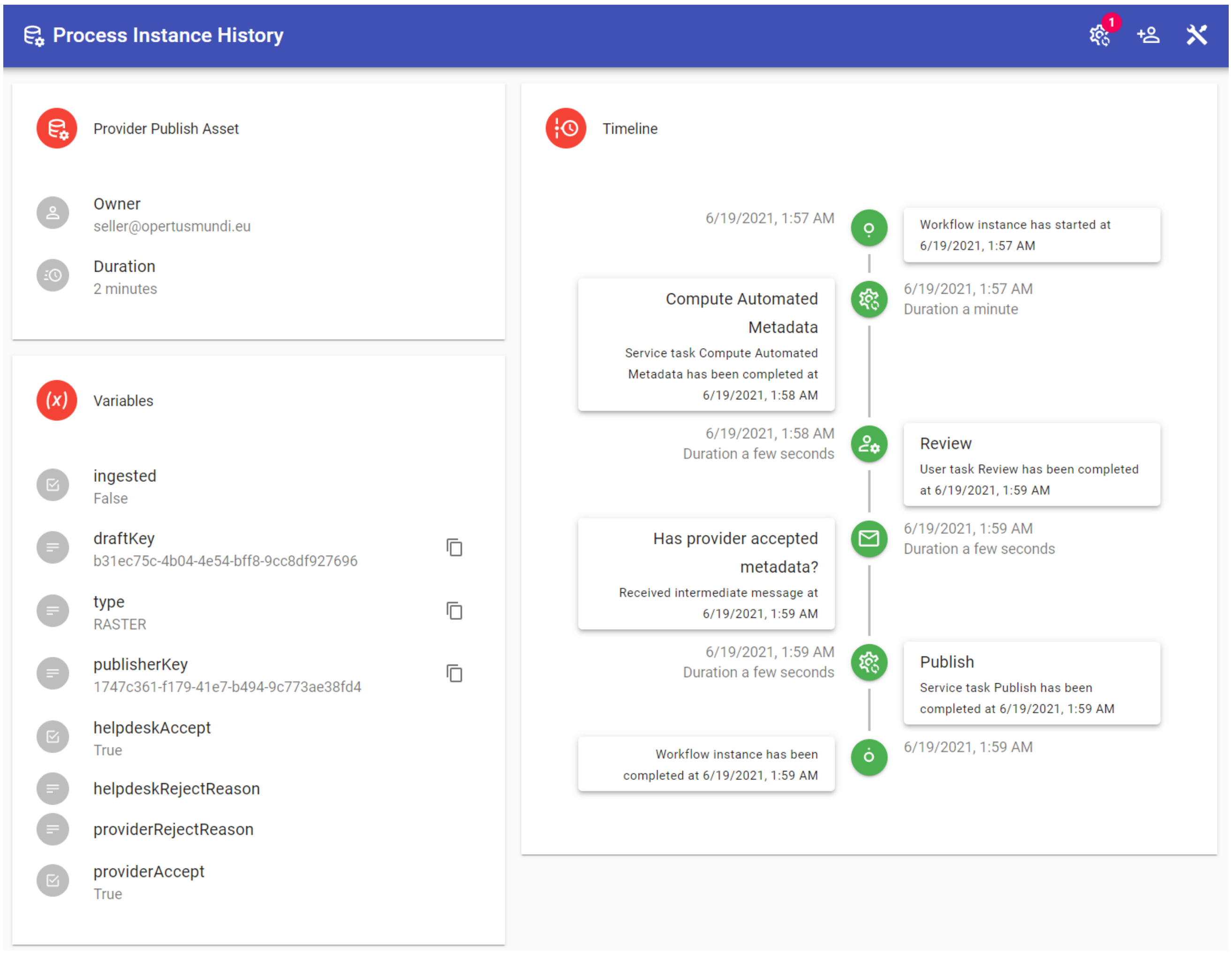
Rows per page: 10 1-4 of 4

Figure 106: Draft Management

For each Asset, a user has the following options:

- Preview the asset in the marketplace.
- View the process instance of the publishing workflow associated with a specific Asset.
- Accept or reject an Asset with status *Helpdesk Pending Review*. If the user accepts or rejects the Asset, its status is updated to *Provider Pending Review* or *Helpdesk Rejected,* respectively.

An example of a publish workflow instance is depicted in Figure 107.


Process Instance History

Provider Publish Asset

Owner
seller@opertusmundi.eu

Duration
2 minutes

Variables

ingested
False

draftKey
b31ec75c-4b04-4e54-bff8-9cc8df927696

type
RASTER

publisherKey
1747c361-f179-41e7-b494-9c773ae38fd4

helpdeskAccept
True

helpdeskRejectReason

providerRejectReason

providerAccept
True

Timeline

6/19/2021, 1:57 AM — Workflow instance has started at 6/19/2021, 1:57 AM

Compute Automated Metadata
Service task Compute Automated Metadata has been completed at 6/19/2021, 1:58 AM
6/19/2021, 1:57 AM
Duration a minute

6/19/2021, 1:58 AM
Duration a few seconds
Review
User task Review has been completed at 6/19/2021, 1:59 AM

Has provider accepted metadata?
Received intermediate message at 6/19/2021, 1:59 AM
6/19/2021, 1:59 AM
Duration a few seconds

6/19/2021, 1:59 AM
Duration a few seconds
Publish
Service task Publish has been completed at 6/19/2021, 1:59 AM

Workflow instance has been completed at 6/19/2021, 1:59 AM
6/19/2021, 1:59 AM

Figure 107: Publish asset process instance.

3.4. Payment Processing

Next, we present how the marketplace handles payment processing. The OpertusMundi platform defers financial transactions to an external payment provider, namely, the MANGOPAY[12] payment provider. First, we introduce several terms used by the MANGOPAY platform and then enumerate the provided functionality.

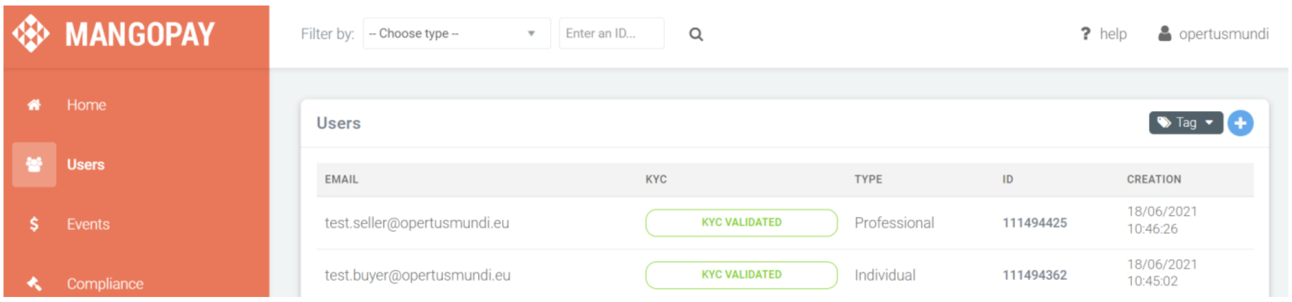
The most important terms used by MANGOPAY payment provider are:

- **User**: Any customer registered to MANGOPAY, either an individual or professional entity, is mapped to a platform user. OpertusMundi registers a new MANGOPAY user for every consumer and provider. If a marketplace user is both a consumer and a provider, then two users are registered at the MANGOPAY platform.

[12] https://www.mangopay.com/

- **Wallet**: Each user may have one or more wallets. Wallets are used for receiving payments from consumers and sending payments to providers. OpertusMundi creates a single wallet for each registered MANGOPAY user linked to a marketplace account.
- **Pay-in**: A Pay-in is any transaction that transfers funds from an external source to a users' wallet. A Pay-In may be a credit card payment or a bank transfer.
- **Transfer**: A transaction that transfers funds from one wallet to another. Usually, during a transfer, the MANGOPAY platform may subtract marketplace i.e., OpertusMundi, fees. The charged fees are added to the marketplace wallet. OpertusMundi initiates a transfer once an order is fulfilled, and assets have been delivered or service subscriptions have been registered.
- **Payout**: A transaction that transfers funds from a user's wallet to one of her registered bank accounts. OpertusMundi creates Payout transactions for transferring funds to providers.
- **Event**: Any financial transaction in the platform, e.g., a Pay-in, a Transfer, etc, is mapped to an event. Events allow marketplace users to query transactions consistently.

When a new User is registered to MANGOPAY, she must submit several Know-Your-Customer (KYC) documents to be verified by the platform. Depending on the verification status of a User, a KYC level is assigned to her. There are two levels, namely *LIGHT* and *REGULAR*. Upon registration the User is assigned *LIGHT* KYC level. To perform any transactions over a specific monetary limit the user must be verified and get a KYC level of *REGULAR*. All users with their KYC level can be browsed using the Users view shown in Figure 108.



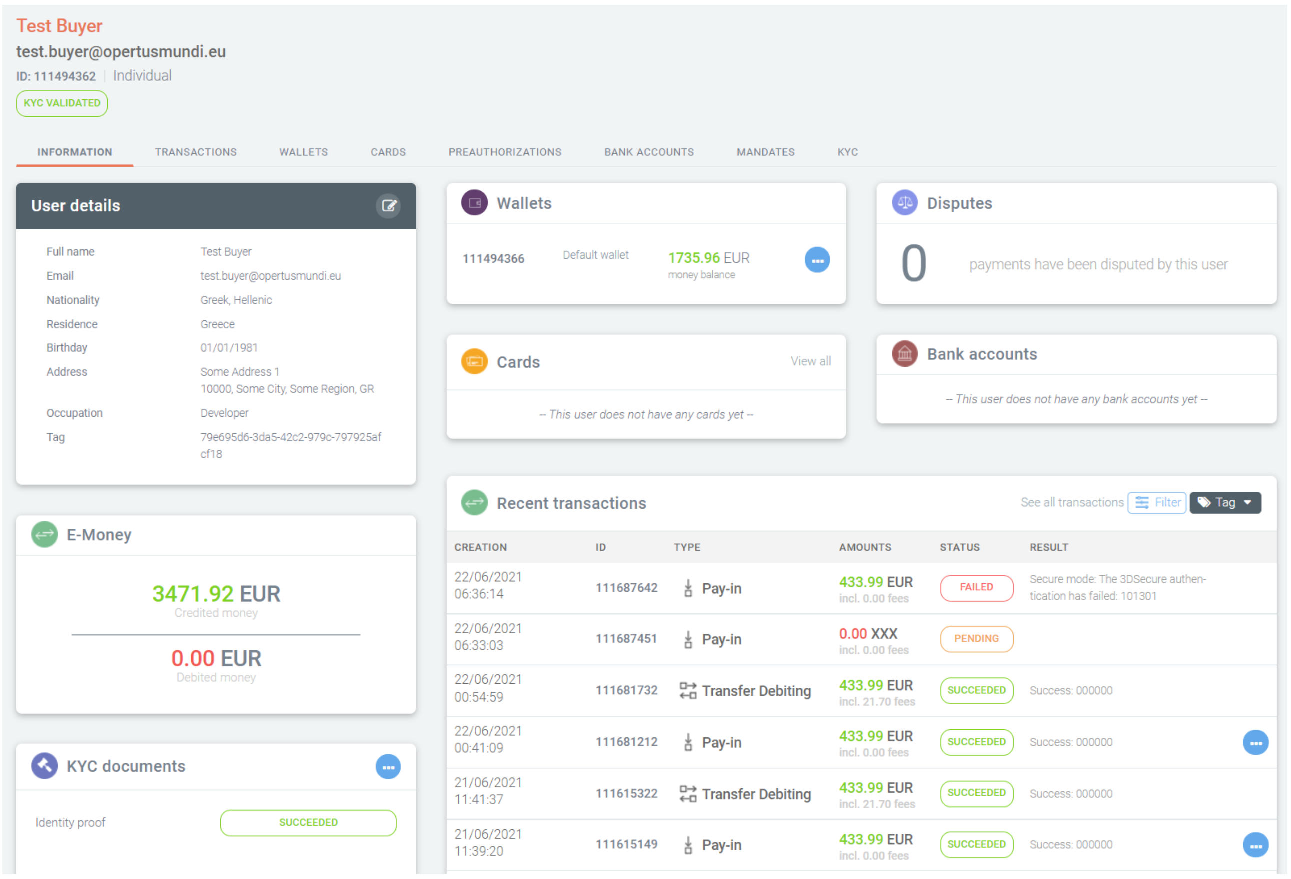
Users

EMAIL	KYC	TYPE	ID	CREATION
test.seller@opertusmundi.eu	KYC VALIDATED	Professional	111494425	18/06/2021 10:46:26
test.buyer@opertusmundi.eu	KYC VALIDATED	Individual	111494362	18/06/2021 10:45:02

Figure 108: MANGOPAY users

Platform users can select any User to view additional information about her account status. Examples of individual and professional Users are shown in Figure 109 and Figure 110 respectively. For each account, the following information is available:

- User details such as the full name and address of an individual User or the company representative and headquarters address of a processional User.
- Registered wallets with their balance and currency.
- Registered cards that can be used for creating new Pay-in transactions.
- Registered bank accounts for creating new Pay-in or Payout transactions.
- A list with all recent event / transactions for the selected User.


Test Buyer
test.buyer@opertusmundi.eu
ID: 111494362 | Individual
KYC VALIDATED

INFORMATION | TRANSACTIONS | WALLETS | CARDS | PREAUTHORIZATIONS | BANK ACCOUNTS | MANDATES | KYC

User details

Full name	Test Buyer
Email	test.buyer@opertusmundi.eu
Nationality	Greek, Hellenic
Residence	Greece
Birthday	01/01/1981
Address	Some Address 1 10000, Some City, Some Region, GR
Occupation	Developer
Tag	79e695d6-3da5-42c2-979c-797925af cf18

Wallets

111494366 Default wallet 1735.96 EUR money balance

Disputes

0 payments have been disputed by this user

Cards View all

-- This user does not have any cards yet --

Bank accounts

-- This user does not have any bank accounts yet --

E-Money

3471.92 EUR Credited money

0.00 EUR Debited money

KYC documents

Identity proof SUCCEEDED

Recent transactions See all transactions Filter Tag

CREATION	ID	TYPE	AMOUNTS	STATUS	RESULT
22/06/2021 06:36:14	111687642	Pay-in	433.99 EUR incl. 0.00 fees	FAILED	Secure mode: The 3DSecure authentication has failed: 101301
22/06/2021 06:33:03	111687451	Pay-in	0.00 XXX incl. 0.00 fees	PENDING	
22/06/2021 00:54:59	111681732	Transfer Debiting	433.99 EUR incl. 21.70 fees	SUCCEEDED	Success: 000000
22/06/2021 00:41:09	111681212	Pay-in	433.99 EUR incl. 0.00 fees	SUCCEEDED	Success: 000000
21/06/2021 11:41:37	111615322	Transfer Debiting	433.99 EUR incl. 21.70 fees	SUCCEEDED	Success: 000000
21/06/2021 11:39:20	111615149	Pay-in	433.99 EUR incl. 0.00 fees	SUCCEEDED	Success: 000000

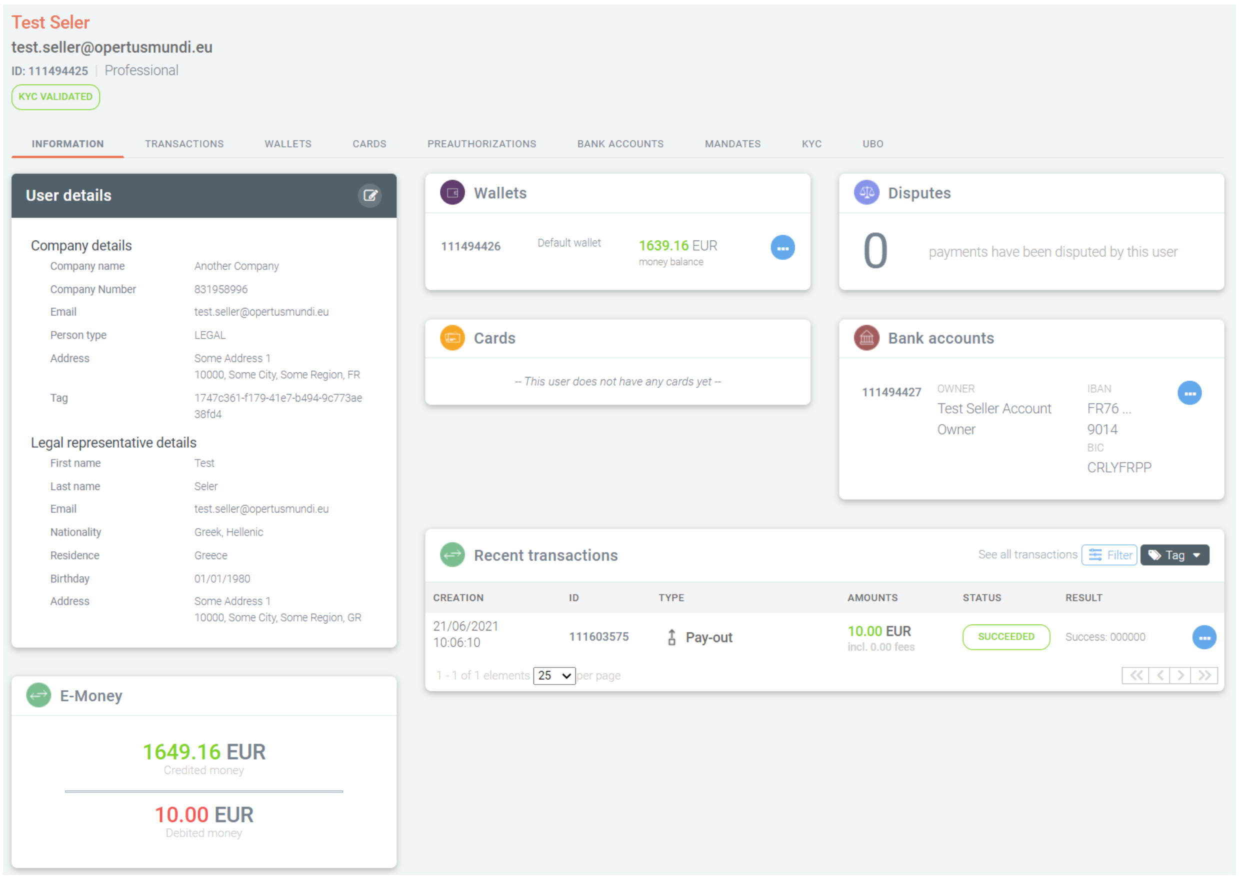
Figure 109: MANGOPAY individual user

Users can transfer funds to their wallet by creating a Pay-in transaction. The payment can be executed either by charging a registered card or by transferring funds from a bank account. Once the funds are received by the MANGOPY platform, they are added to the User's wallet.

Next, funds can be transferred between wallets by creating a Transfer transaction. In Opertusmundi, Transfers are created *from consumer to provider wallets*. Transfers are automatically created during the execution of the order fulfillment workflow. Once the assets of an order are delivered and registered to the consumer's account or any referred subscription billing records are paid, the workflow process instance creates a Transfer transaction for every asset or subscription billing record.

Finally, Payout transactions are created for transferring funds from a provider's wallet to one of her registered accounts. Currently, OpertusMundi creates Payout transactions manually to achieve better control over how funds are distributed to providers. In general, an erroneous Pay-in or Transfer transaction can be refunded or reverted easily through the MANGOPAY platform. Nevertheless, once funds have been successfully debited to a bank account, cancelling the transaction is more complicated.

Examples of Pay-in, Transfer and Payout transactions are shown in Figure 111, Figure 112, and Figure 113 respectively.


Test Seler
test.seller@opertusmundi.eu
ID: 111494425 | Professional

User details

Company details

Company name	Another Company
Company Number	831958996
Email	test.seller@opertusmundi.eu
Person type	LEGAL
Address	Some Address 1 10000, Some City, Some Region, FR
Tag	1747c361-f179-41e7-b494-9c773ae38fd4

Legal representative details

First name	Test
Last name	Seler
Email	test.seller@opertusmundi.eu
Nationality	Greek, Hellenic
Residence	Greece
Birthday	01/01/1980
Address	Some Address 1 10000, Some City, Some Region, GR

E-Money

1649.16 EUR
Credited money

10.00 EUR
Debited money

Wallets

111494426 Default wallet 1639.16 EUR money balance

Disputes

0 payments have been disputed by this user

Cards

-- This user does not have any cards yet --

Bank accounts

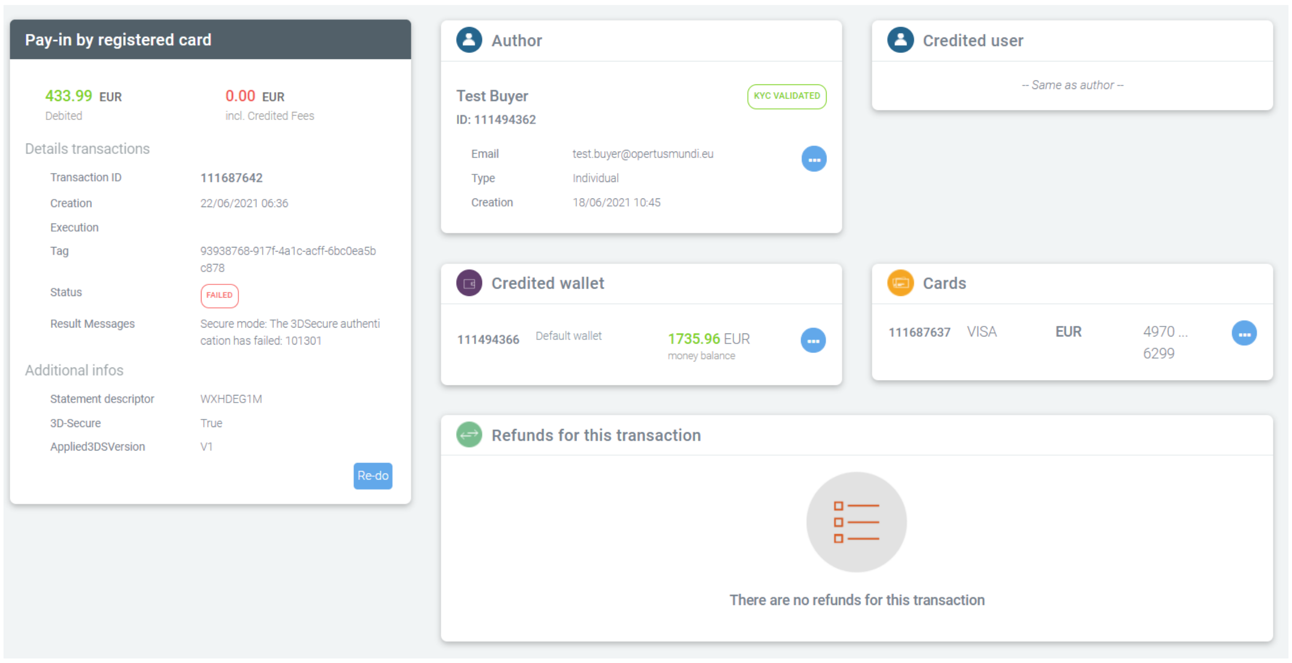
111494427 OWNER Test Seller Account Owner IBAN FR76 ... 9014 BIC CRLYFRPP

Recent transactions

CREATION	ID	TYPE	AMOUNTS	STATUS	RESULT
21/06/2021 10:06:10	111603575	Pay-out	10.00 EUR incl. 0.00 fees	SUCCEEDED	Success: 000000

1 - 1 of 1 elements 25 per page

Figure 110: MANGOPAY professional user


Pay-in by registered card

433.99 EUR
Debited

0.00 EUR
incl. Credited Fees

Details transactions

Transaction ID	111687642
Creation	22/06/2021 06:36
Execution	
Tag	93938768-917f-4a1c-acff-6bc0ea5bc878
Status	FAILED
Result Messages	Secure mode: The 3DSecure authentication has failed: 101301

Additional infos

Statement descriptor	WXHDEG1M
3D-Secure	True
Applied3DSVersion	V1

Author

Test Buyer
ID: 111494362

Email	test.buyer@opertusmundi.eu
Type	Individual
Creation	18/06/2021 10:45

Credited user

-- Same as author --

Credited wallet

111494366 Default wallet 1735.96 EUR money balance

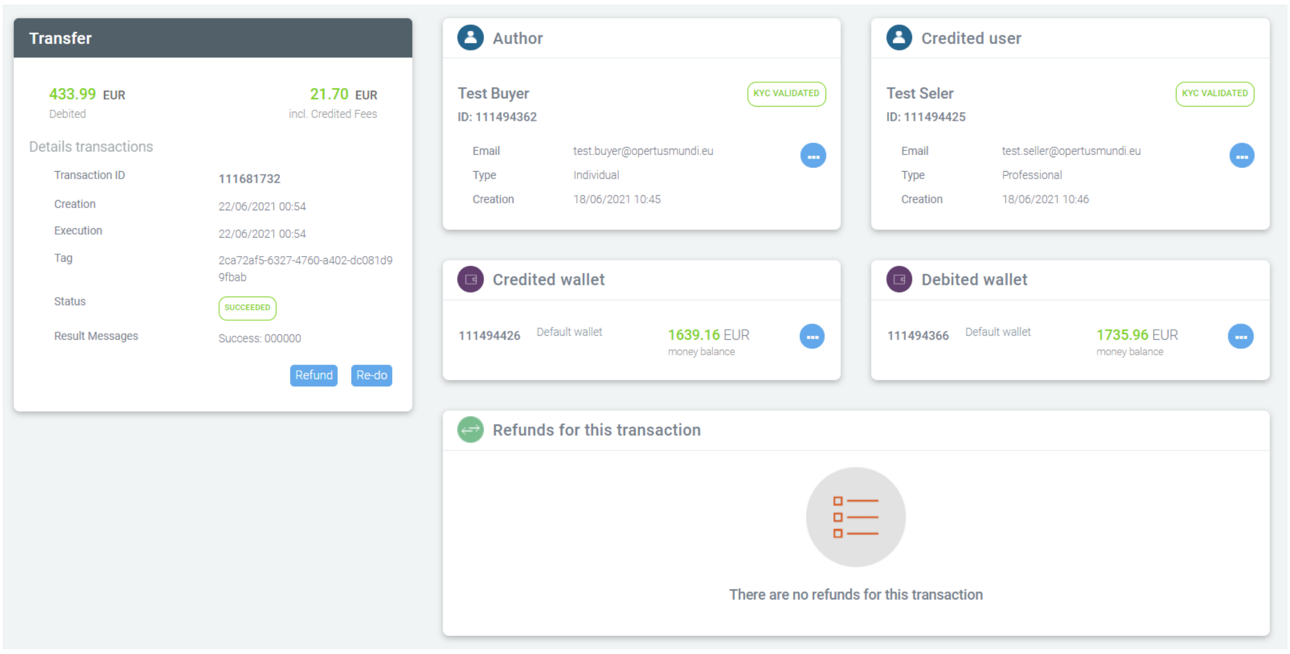
Cards

111687637 VISA EUR 4970 ... 6299

Refunds for this transaction

There are no refunds for this transaction

Figure 111: MANGOPAY Pay-in


Transfer

433.99 EUR
Debited

21.70 EUR
incl. Credited Fees

Details transactions

Transaction ID	111681732
Creation	22/06/2021 00:54
Execution	22/06/2021 00:54
Tag	2ca72af5-6327-4760-a402-dc081d9 9fbab
Status	SUCCEEDED
Result Messages	Success: 000000

Author

Test Buyer KYC VALIDATED
ID: 111494362

Email	test.buyer@opertusmundi.eu
Type	Individual
Creation	18/06/2021 10:45

Credited user

Test Seler KYC VALIDATED
ID: 111494425

Email	test.seller@opertusmundi.eu
Type	Professional
Creation	18/06/2021 10:46

Credited wallet

111494426 Default wallet 1639.16 EUR money balance

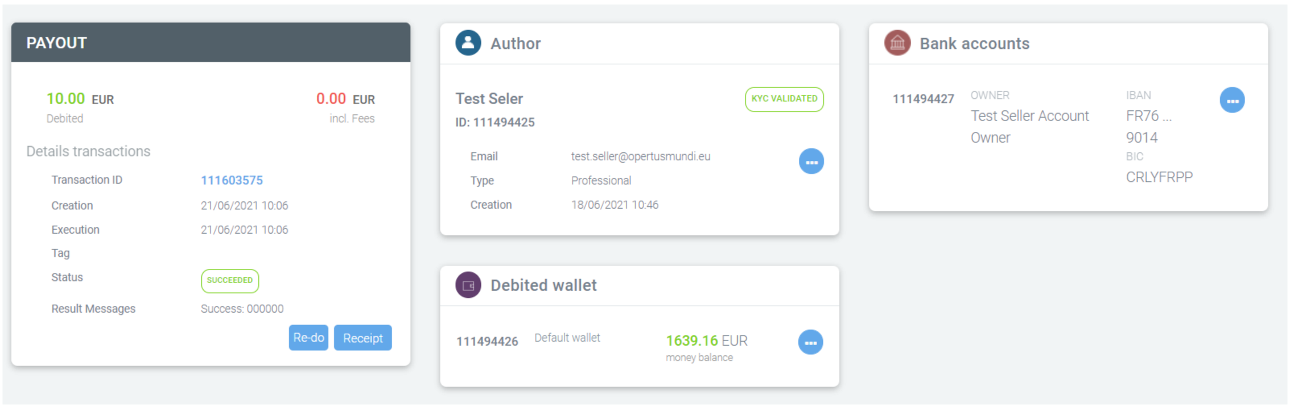
Debited wallet

111494366 Default wallet 1735.96 EUR money balance

Refunds for this transaction

There are no refunds for this transaction

Figure 112: MANGOPAY Transfer


PAYOUT

10.00 EUR
Debited

0.00 EUR
incl. Fees

Details transactions

Transaction ID	111603575
Creation	21/06/2021 10:06
Execution	21/06/2021 10:06
Tag	
Status	SUCCEEDED
Result Messages	Success: 000000

Author

Test Seler KYC VALIDATED
ID: 111494425

Email	test.seller@opertusmundi.eu
Type	Professional
Creation	18/06/2021 10:46

Debited wallet

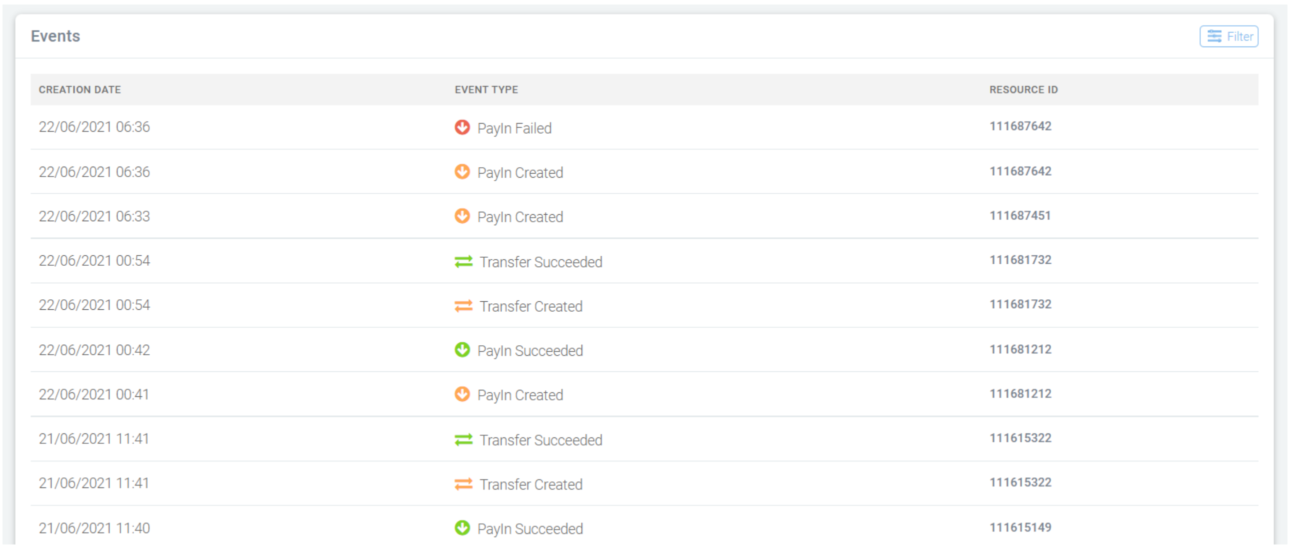
111494426 Default wallet 1639.16 EUR money balance

Bank accounts

111494427 OWNER Test Seller Account Owner IBAN FR76 ... 9014 BIC CRLYFRPP

Figure 113: MANGOPAY Payout

Finally, the *Events* page, shown in Figure 114, can be used for browsing and querying all transactions executed in the marketplace.


Events

CREATION DATE	EVENT TYPE	RESOURCE ID
22/06/2021 06:36	PayIn Failed	111687642
22/06/2021 06:36	PayIn Created	111687642
22/06/2021 06:33	PayIn Created	111687451
22/06/2021 00:54	Transfer Succeeded	111681732
22/06/2021 00:54	Transfer Created	111681732
22/06/2021 00:42	PayIn Succeeded	111681212
22/06/2021 00:41	PayIn Created	111681212
21/06/2021 11:41	Transfer Succeeded	111615322
21/06/2021 11:41	Transfer Created	111615322
21/06/2021 11:40	PayIn Succeeded	111615149

Figure 114: MANGOPAY events

3.5. Asset Purchase and Delivery

In Section 3.4, we presented the features of the MANGOPAY provider used by the OpertusMundi marketplace. Next, we present how the MANGOPAY payment provider is integrated with the Transaction Manager UI to implement and monitor asset purchase and delivery workflows.

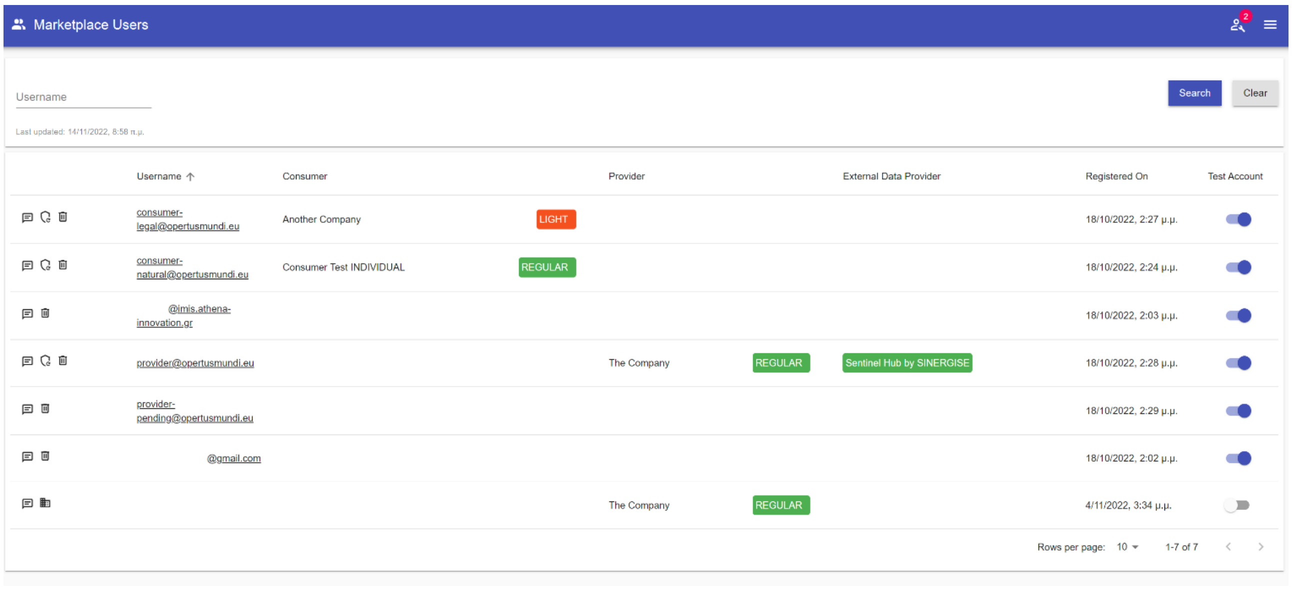
The OpertusMundi marketplace communicates with MANGOPAY either synchronously using the MANGOPAY API[13] or asynchronously by registering listeners to specific web hook[14] events. The former allows the marketplace to register users, create transactions and query existing data on demand by invoking the API. The latter, allows MANGOPAY to inform the marketplace about updates to existing users or transactions. For instance, the marketplace may create a bank transfer Pay-in using the API and MANGOPAY may inform the marketplace about the transfer success or failure using a web hook.

The Transaction Manager maintains partial copies of MANGOPAY entities locally and updates them using web hook events. The reason that we store only *part* of the information locally is due to legal constraints i.e., data like KYC documents and credit cards *are now allowed to be stored by the OpertusMundi platform*.

When a marketplace user appeals for becoming either a consumer or a provider, a new User is created at the MANGOPAY, and the KYC verification process is started. The marketplace is informed about the KYC level of a consumer or a provider through web hooks. Transaction Manager users can browse the marketplace users and view their KYC status by using the *Marketplace Users* view depicted in Figure 115.

[13] https://docs.mangopay.com/
[14] https://docs.mangopay.com/endpoints/v2.01/hooks#e246_the-hook-object

Once a consumer is verified i.e., her KYC level is *REGULAR*, she can purchase assets or subscriptions by placing an order. Every order has a unique reference number and is associated to a Pay-in transaction. After the successful creation of the Pay-In transaction, an instance of the asset purchase workflow is initialized.



Last updated: 14/11/2022, 8:58 π.μ.

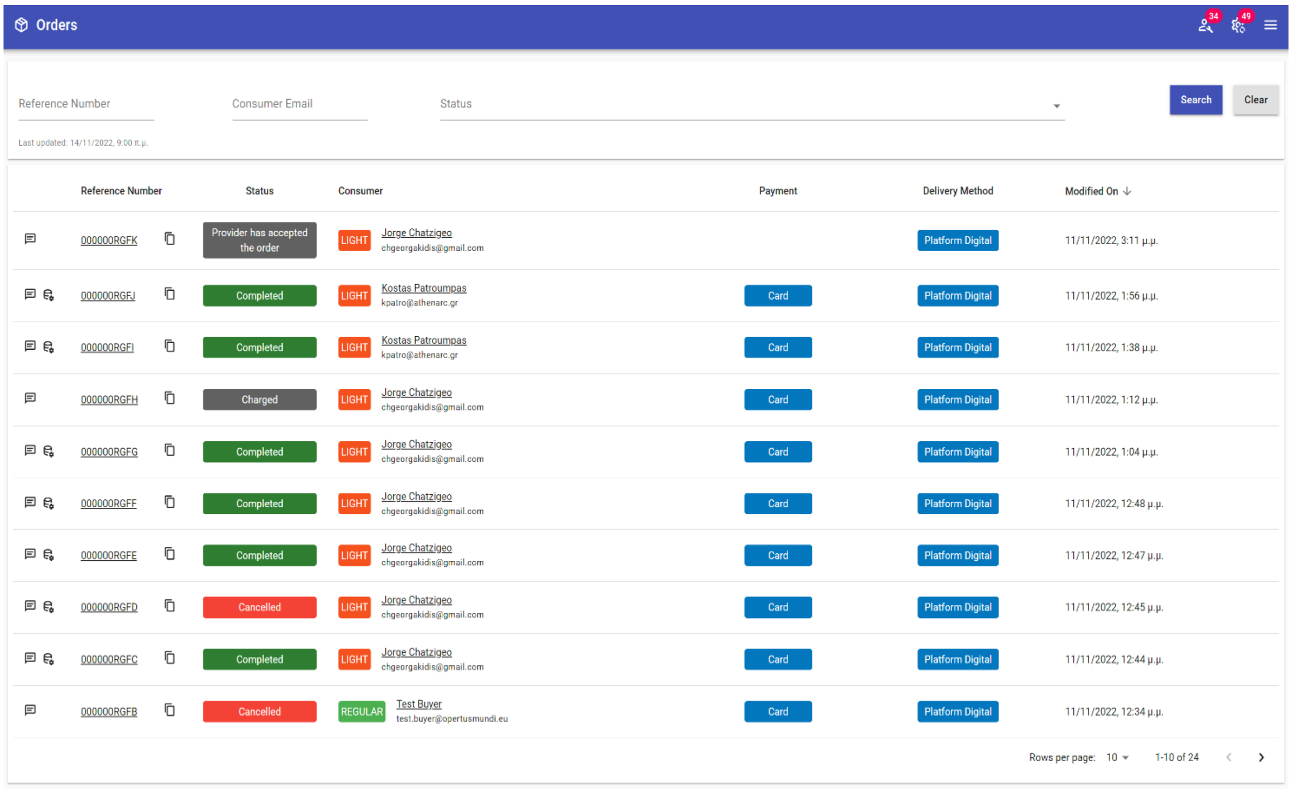
Username	Consumer		Provider		External Data Provider	Registered On	Test Account
consumer-legal@opertusmundi.eu	Another Company	LIGHT				18/10/2022, 2:27 μ.μ.	●
consumer-natural@opertusmundi.eu	Consumer Test INDIVIDUAL	REGULAR				18/10/2022, 2:24 μ.μ.	●
@imis.athena-innovation.gr						18/10/2022, 2:03 μ.μ.	●
provider@opertusmundi.eu			The Company	REGULAR	Sentinel Hub by SINERGISE	18/10/2022, 2:28 μ.μ.	●
provider-pending@opertusmundi.eu						18/10/2022, 2:29 μ.μ.	●
@gmail.com						18/10/2022, 2:02 μ.μ.	●
			The Company	REGULAR		4/11/2022, 3:34 μ.μ.	○

Rows per page: 10 1-7 of 7

Figure 115: Transaction Manager marketplace users

Transaction Manager users can browse all orders using the *Orders* view shown in Figure 116. For each order, users can perform the following actions:

- Send a message to the consumer about her order e.g., informing her about possible delays in the case of physical asset delivery.
- View details about the order and the linked Pay-in transaction.
- View the process instance of the asset purchase workflow.



Orders

Reference Number | Consumer Email | Status | Search | Clear

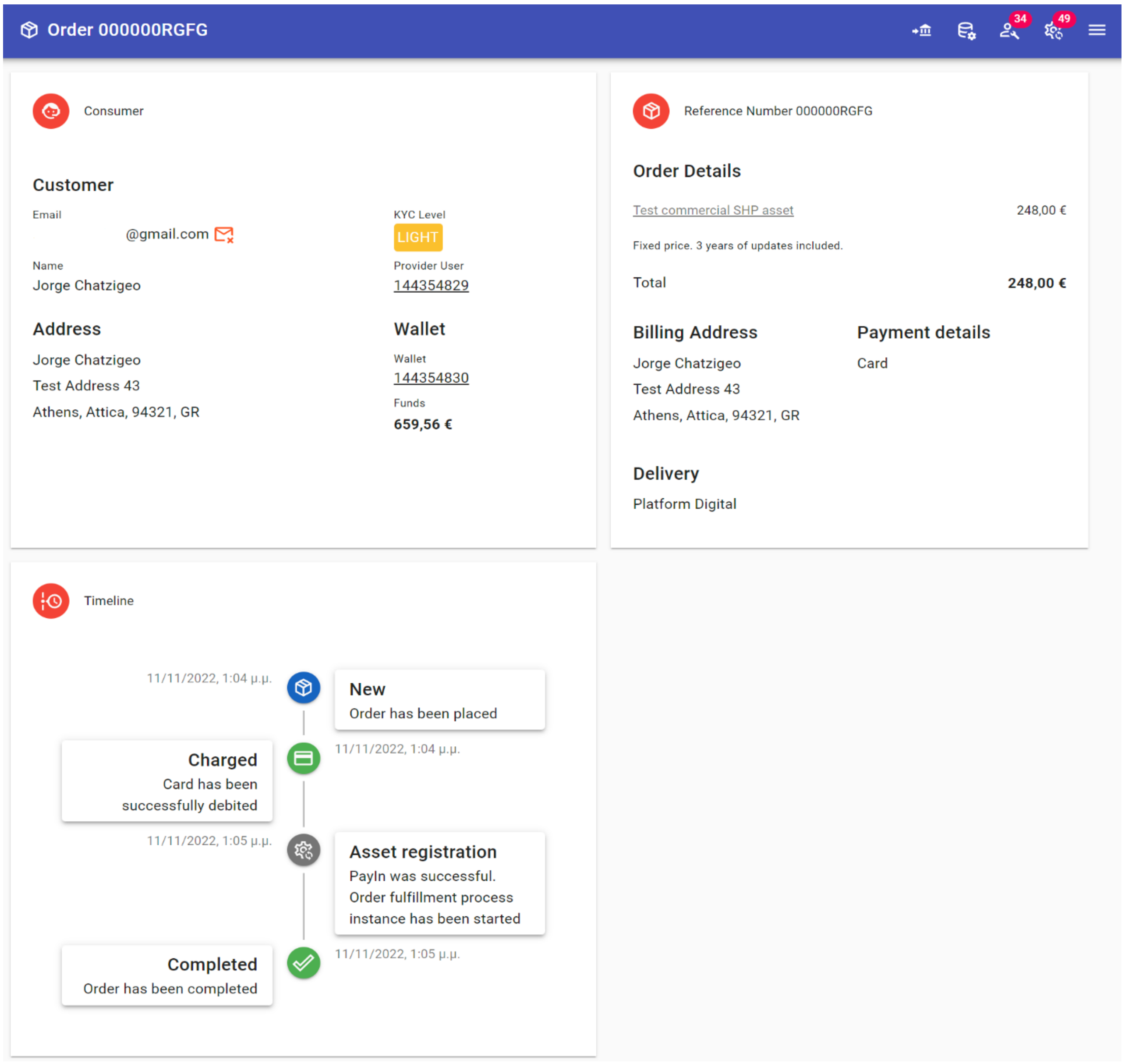
Last updated: 14/11/2022, 9:00 π.μ.

Reference Number	Status	Consumer		Payment	Delivery Method	Modified On
000000RGFK	Provider has accepted the order	LIGHT	Jorge Chatzigeo chgeorgakidis@gmail.com		Platform Digital	11/11/2022, 3:11 μ.μ.
000000RGFJ	Completed	LIGHT	Kostas Patroumpas kpatro@athenarc.gr	Card	Platform Digital	11/11/2022, 1:56 μ.μ.
000000RGFI	Completed	LIGHT	Kostas Patroumpas kpatro@athenarc.gr	Card	Platform Digital	11/11/2022, 1:38 μ.μ.
000000RGFH	Charged	LIGHT	Jorge Chatzigeo chgeorgakidis@gmail.com	Card	Platform Digital	11/11/2022, 1:12 μ.μ.
000000RGFG	Completed	LIGHT	Jorge Chatzigeo chgeorgakidis@gmail.com	Card	Platform Digital	11/11/2022, 1:04 μ.μ.
000000RGFF	Completed	LIGHT	Jorge Chatzigeo chgeorgakidis@gmail.com	Card	Platform Digital	11/11/2022, 12:48 μ.μ.
000000RGFE	Completed	LIGHT	Jorge Chatzigeo chgeorgakidis@gmail.com	Card	Platform Digital	11/11/2022, 12:47 μ.μ.
000000RGFD	Cancelled	LIGHT	Jorge Chatzigeo chgeorgakidis@gmail.com	Card	Platform Digital	11/11/2022, 12:45 μ.μ.
000000RGFC	Completed	LIGHT	Jorge Chatzigeo chgeorgakidis@gmail.com	Card	Platform Digital	11/11/2022, 12:44 μ.μ.
000000RGFB	Cancelled	REGULAR	Test Buyer test.buyer@opertusmundi.eu	Card	Platform Digital	11/11/2022, 12:34 μ.μ.

Rows per page: 10 1-10 of 24

Figure 116: Transaction Manager Orders

An example of an order view is shown in Figure 117. The view consists of two sections, one for the order and another for the execution timeline of the linked Pay-in. The order section includes information about all the assets along with their selected pricing model at the time of purchase, the billing address, payment details, and the delivery method. The Pay-In section presents information about the transaction status and the asset purchase workflow process instance status.



Order 000000RGFG

Consumer

Customer

Email
@gmail.com

KYC Level
LIGHT

Name
Jorge Chatzigeo

Provider User
144354829

Address

Jorge Chatzigeo
Test Address 43
Athens, Attica, 94321, GR

Wallet

Wallet
144354830

Funds
659,56 €

Reference Number 000000RGFG

Order Details

Test commercial SHP asset	248,00 €
Fixed price. 3 years of updates included.	
Total	**248,00 €**

Billing Address

Jorge Chatzigeo
Test Address 43
Athens, Attica, 94321, GR

Payment details

Card

Delivery

Platform Digital

Timeline

11/11/2022, 1:04 μ.μ. — **New** Order has been placed

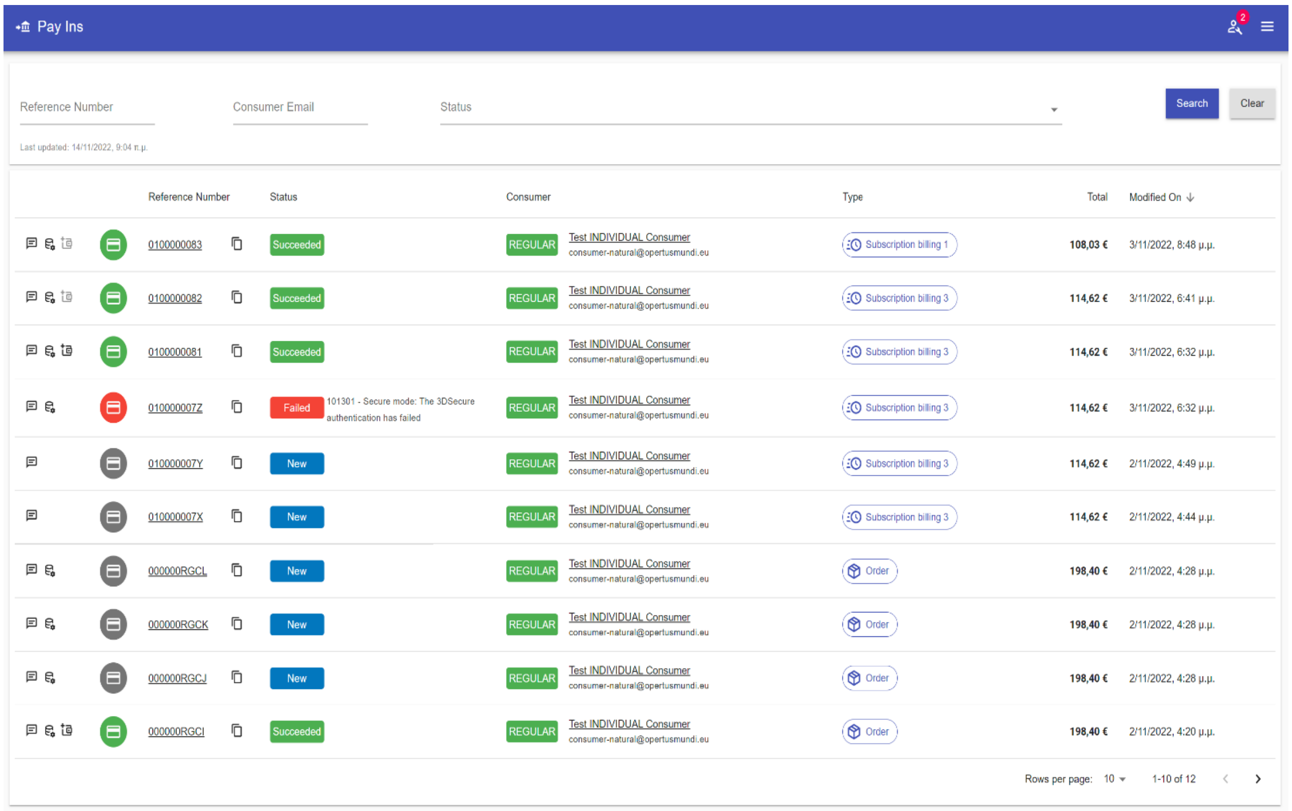
11/11/2022, 1:04 μ.μ. — **Charged** Card has been successfully debited

11/11/2022, 1:05 μ.μ. — **Asset registration** PayIn was successful. Order fulfillment process instance has been started

11/11/2022, 1:05 μ.μ. — **Completed** Order has been completed

Figure 117: Transaction Manager Order

Although an order will always be linked to a Pay-In to get completed, not all Pay-in transactions will have a corresponding order. For instance, a Pay-in may be created for paying subscription billing records. Hence, the Transaction Manager implements the *Pay-ins* view for browsing and searching all marketplace Pay-in transactions as depicted in Figure 118.



Pay Ins

Reference Number | Consumer Email | Status | Search | Clear

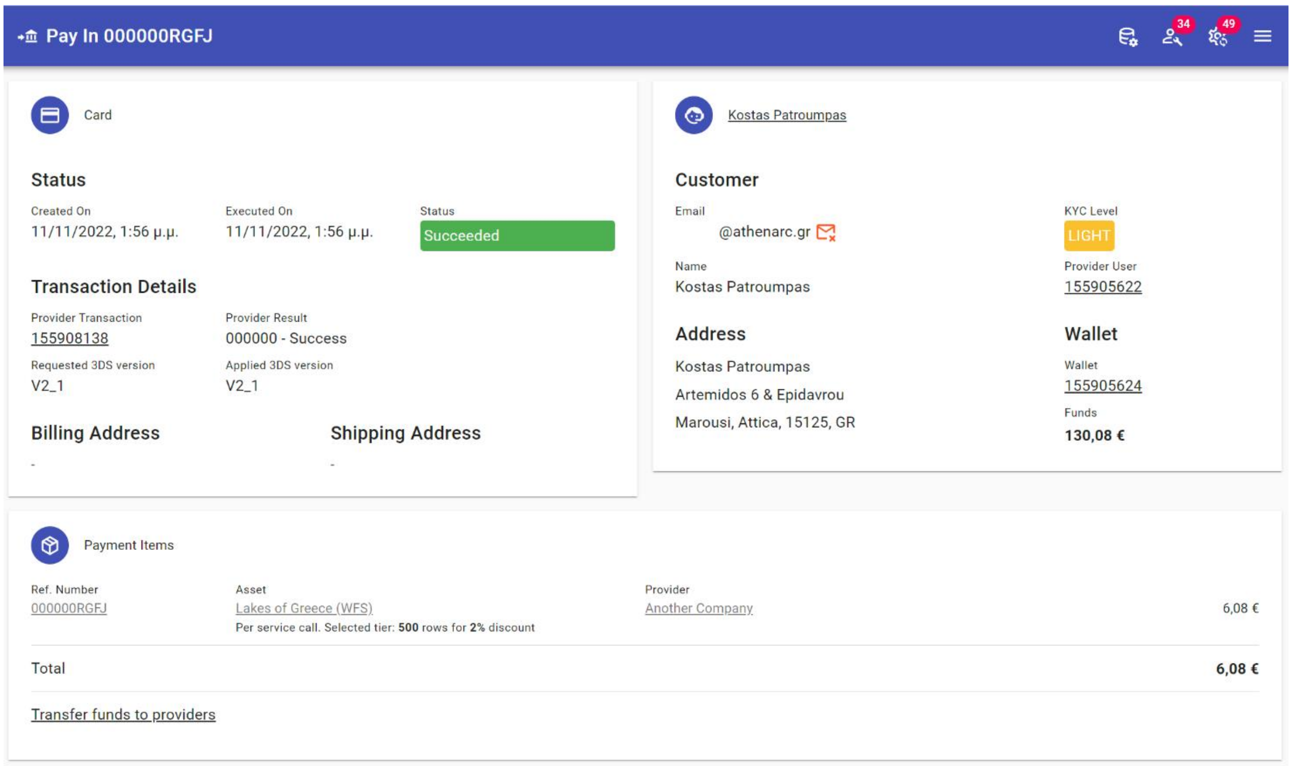
Last updated: 14/11/2022, 9:04 π.μ.

Reference Number	Status	Consumer	Type	Total	Modified On
0100000083	Succeeded	REGULAR Test INDIVIDUAL Consumer consumer-natural@opertusmundi.eu	Subscription billing 1	108,03 €	3/11/2022, 8:48 μ.μ.
0100000082	Succeeded	REGULAR Test INDIVIDUAL Consumer consumer-natural@opertusmundi.eu	Subscription billing 3	114,62 €	3/11/2022, 6:41 μ.μ.
0100000081	Succeeded	REGULAR Test INDIVIDUAL Consumer consumer-natural@opertusmundi.eu	Subscription billing 3	114,62 €	3/11/2022, 6:32 μ.μ.
010000007Z	Failed 101301 - Secure mode: The 3DSecure authentication has failed	REGULAR Test INDIVIDUAL Consumer consumer-natural@opertusmundi.eu	Subscription billing 3	114,62 €	3/11/2022, 6:32 μ.μ.
010000007Y	New	REGULAR Test INDIVIDUAL Consumer consumer-natural@opertusmundi.eu	Subscription billing 3	114,62 €	2/11/2022, 4:49 μ.μ.
010000007X	New	REGULAR Test INDIVIDUAL Consumer consumer-natural@opertusmundi.eu	Subscription billing 3	114,62 €	2/11/2022, 4:44 μ.μ.
000000RGCL	New	REGULAR Test INDIVIDUAL Consumer consumer-natural@opertusmundi.eu	Order	198,40 €	2/11/2022, 4:28 μ.μ.
000000RGCK	New	REGULAR Test INDIVIDUAL Consumer consumer-natural@opertusmundi.eu	Order	198,40 €	2/11/2022, 4:28 μ.μ.
000000RGCJ	New	REGULAR Test INDIVIDUAL Consumer consumer-natural@opertusmundi.eu	Order	198,40 €	2/11/2022, 4:28 μ.μ.
000000RGCI	Succeeded	REGULAR Test INDIVIDUAL Consumer consumer-natural@opertusmundi.eu	Order	198,40 €	2/11/2022, 4:20 μ.μ.

Rows per page: 10 1-10 of 12

Figure 118: Transaction Manager Pay-ins

For every Pay-in instance, the user may view additional details as show in Figure 119.



Pay In 000000RGFJ

Card

Status

Created On	Executed On	Status
11/11/2022, 1:56 μ.μ.	11/11/2022, 1:56 μ.μ.	Succeeded

Transaction Details

Provider Transaction	Provider Result
155908138	000000 - Success
Requested 3DS version	**Applied 3DS version**
V2_1	V2_1

Billing Address

-

Shipping Address

-

Kostas Patroumpas

Customer

Email	@athenarc.gr
KYC Level	LIGHT
Name	Kostas Patroumpas
Provider User	155905622

Address

Kostas Patroumpas
Artemidos 6 & Epidavrou
Marousi, Attica, 15125, GR

Wallet

Wallet	155905624
Funds	130,08 €

Payment Items

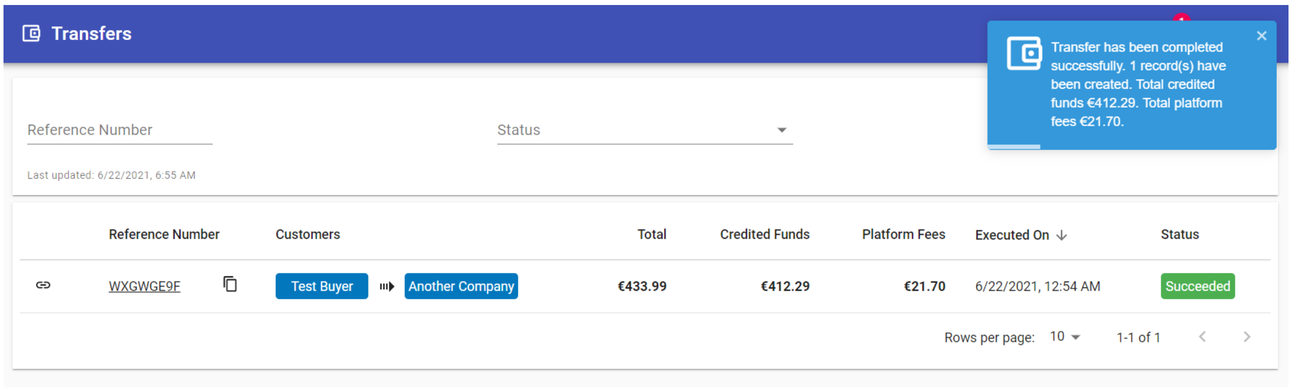
Ref. Number	Asset	Provider	
000000RGFJ	Lakes of Greece (WFS) Per service call. Selected tier: 500 rows for 2% discount	Another Company	6,08 €
Total			6,08 €

Transfer funds to providers

Figure 119: Pay-in view

Using this view, a transfer operation can be initialized for a successful Pay-in. The transfer operation will create one or more Transfer transactions on the MANGOPAY platform, one for each provider referred by the selected Pay-In. For instance, if the Pay-in was created for paying two subscription billing records for services published by two separate providers, each provider will get the appropriate amount of funds to her wallet.

The generated transfers can be browsed using the *Transfers* view shown in Figure 120.



Transfers

Transfer has been completed successfully. 1 record(s) have been created. Total credited funds €412.29. Total platform fees €21.70.

Reference Number | Status

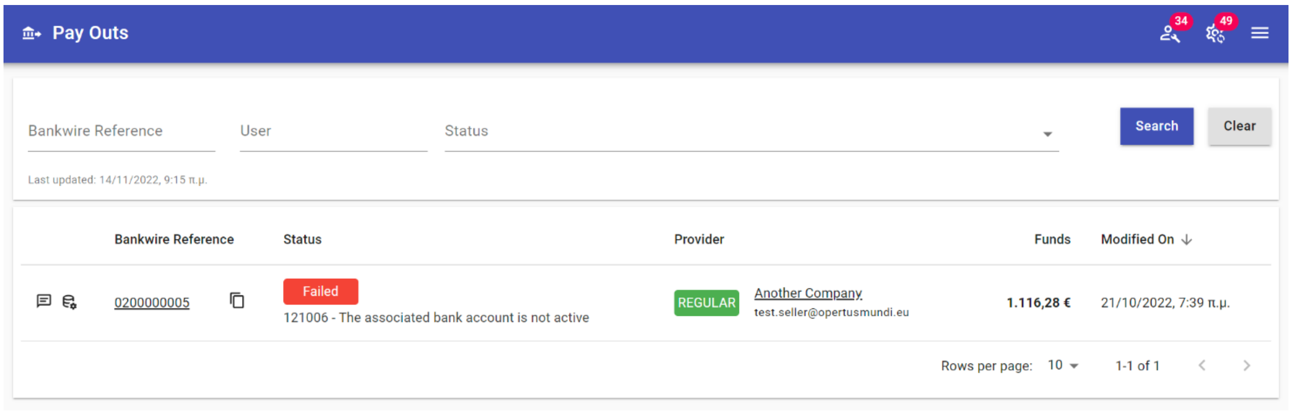
Last updated: 6/22/2021, 6:55 AM

Reference Number	Customers	Total	Credited Funds	Platform Fees	Executed On	Status
WXGWGE9F	Test Buyer → Another Company	€433.99	€412.29	€21.70	6/22/2021, 12:54 AM	Succeeded

Rows per page: 10 1-1 of 1

Figure 120: Transaction Manager Transfers

Finally, after funds have been transferred to a provider’s wallet, a Payout can be executed to transfer funds from MANGOPAY to the provider’s bank account as shown in Figure 121 and Figure 122.



Pay Outs

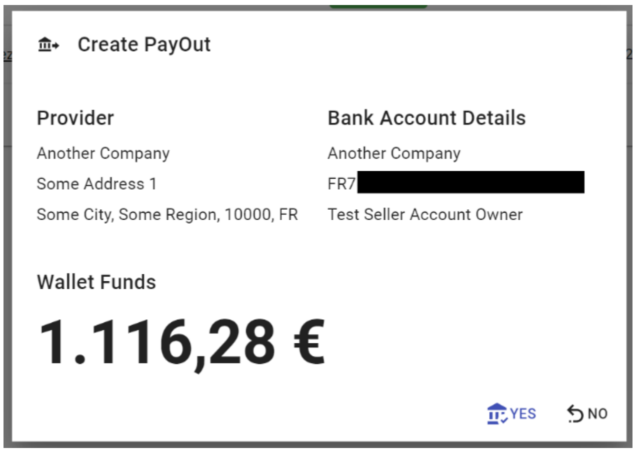
Bankwire Reference | User | Status | Search | Clear

Last updated: 14/11/2022, 9:15 π.μ.

Bankwire Reference	Status	Provider	Funds	Modified On
0200000005	Failed 121006 - The associated bank account is not active	REGULAR Another Company test.seller@opertusmundi.eu	1.116,28 €	21/10/2022, 7:39 π.μ.

Rows per page: 10 1-1 of 1

Figure 121: Payouts view


Create PayOut

Provider

Another Company

Some Address 1

Some City, Some Region, 10000, FR

Bank Account Details

Another Company

FR7[redacted]

Test Seller Account Owner

Wallet Funds

1.116,28 €

Figure 122: Create payout popup

4. Sales Manager

In this Section, we detail the interface and all analytics facilities developed for asset owners, which provide them with comprehensive view and insights over asset transactions. These services are fully integrated in the marketplace's dashboard, offering timely and actionable information for all related steps of asset transactions. Towards this, our presentation follows the purchase of an asset from the viewpoints of both the supplier and consumer, exploring the different options available to them. Finally, we present the analytics services developed specifically for asset suppliers, which provide both a high-level and detailed view of asset transactions, their performance, as well as broader insights related to the marketplace.

Please note that all screenshots and descriptions are correct as of the time of this writing and are expected to be modified in the future, as the platform continues to be in development, even after the end of the OpertusMundi project. Further, the platform's messages, labels, and assets (data, services) presented in the screenshots that follow are integrated for testing and illustration purposes only and hence may not correspond to actual commercial/proprietary geospatial assets. As such: (a) the same assets may appear multiple times, (b) the content of assets is derived from open licensed assets, (c) the provided metadata (e.g., pricing, terms, profiling) are not accurate (e.g., identical entries), (d) entries in analytics sections may be synthetically generated for testing purposes.

4.1. Overview

Once an asset supplier signs in the platform, the main dashboard page shows an updated overview of the latest developments regarding her assets. As exemplified in Figure 123, the supplier can be informed about her total profits, a breakdown of her assets (data files, APIs, etc.) offered through the marketplace, along with charts that reflect the trend of her earnings and evolution of her sales in various market segments. She can choose the *time period* of reference for the displayed figures, e.g., last month, last year, etc. as indicated with the options in the red box. Upon changing the time reference in a panel, the respective contents get updated accordingly.

On the sidebar menu of the dashboard, several options offer more detailed information:

- The *Earnings* option offers a detailed view of revenues (Section 4.1.1) and actual *payments* made by the platform to the owner (Section 4.1.2). Thus, she can examine how her assets have been trading in the marketplace, her revenues for each type of assets, the transactions and payments concerning completed orders of her assets, as well as any due payments.
- The *Orders* option lists all kinds of orders received for assets offered by this owner (Section 4.1.3). This list includes not only completed orders, but also orders still pending (e.g., the

owner has activated his vetting option and must approve the sale of a specific asset) or even rejected.

- The *Analytics* option (Section 4.3) provides a wide range of charts, statistics, and diagrams along with several filtering and sorting options that enable the owner to assess the trend of his assets in the marketplace generally and more specifically (e.g., per application domain, time period).

Note that all this information is confidential and available only to the specific owner concerning his own assets in the marketplace.

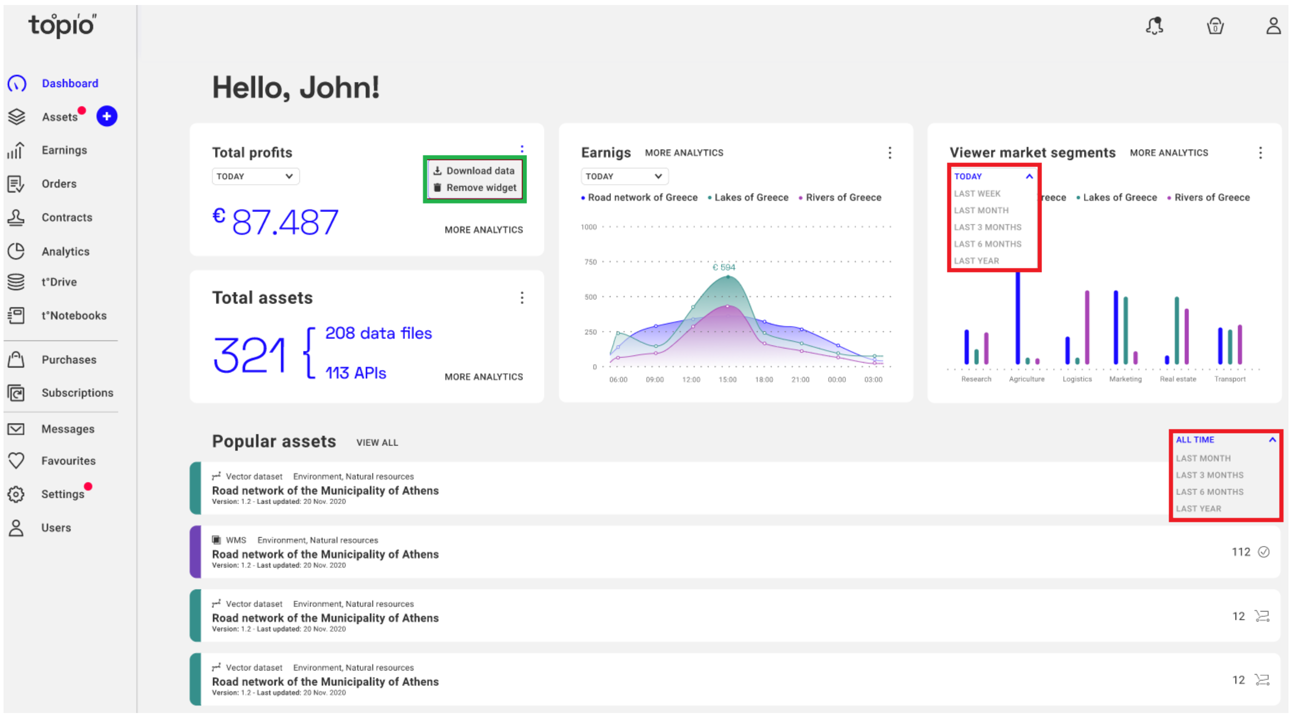
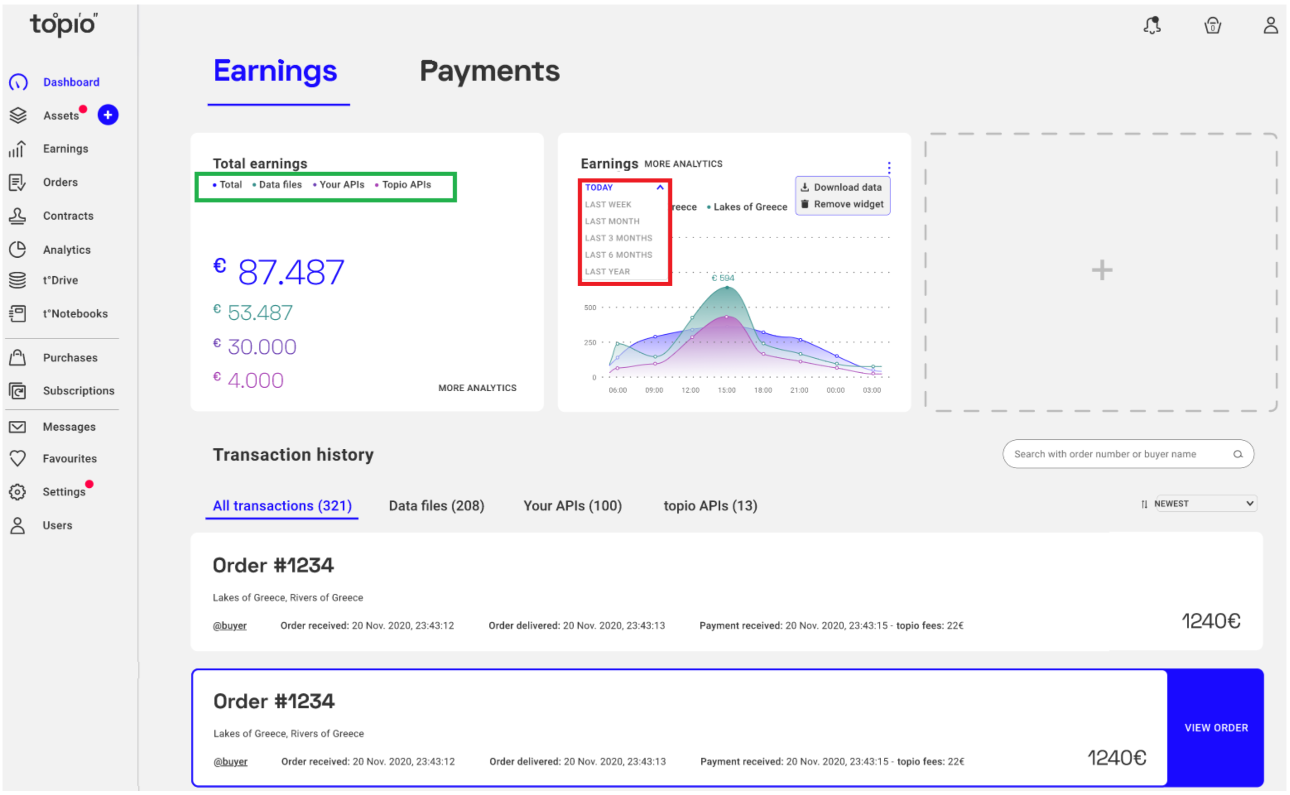


Figure 123: Asset owner's Dashboard

4.1.1. Earnings

With the *Earnings* option in his dashboard, a provider can obtain a detailed view of his revenues, examine how his turnover evolves over time, and inspect the complete history of transactions involving orders placed by customers of his own assets (Figure 124). Note that amounts shown in the earnings tab represent (i) orders that have been completed and their *payments* received, as well as (ii) due amounts to be received by the platform. For instance, revenues from API assets based on number of requests may be collected and reimbursed periodically (e.g., every month) or when they exceed a significant amount (e.g., €100) to avoid bank surcharges.

The supplier may choose to view the total amount or specify a particular type of assets (e.g., Data files, APIs) as indicated in the green box; this view is then refreshed accordingly. Also, the provider can specify the *time period* of reference (indicative options shown in the red box) for calculating the related trends and statistics. By clicking on button "*More Analytics*", she can get a more detailed analysis of his earnings as discussed next in Section 4.3. In the *transaction history*, she gets a list of all transactions concerning her assets. Upon clicking a particular item in the list, the order details are displayed as in Figure 127 and the supplier can examine the full history of this transaction as discussed in Section 4.2.



Order #1234
Lakes of Greece, Rivers of Greece
@buyer Order received: 20 Nov. 2020, 23:43:12 Order delivered: 20 Nov. 2020, 23:43:13 Payment received: 20 Nov. 2020, 23:43:15 - topio fees: 22€
1240€

Order #1234
Lakes of Greece, Rivers of Greece
@buyer Order received: 20 Nov. 2020, 23:43:12 Order delivered: 20 Nov. 2020, 23:43:13 Payment received: 20 Nov. 2020, 23:43:15 - topio fees: 22€
1240€

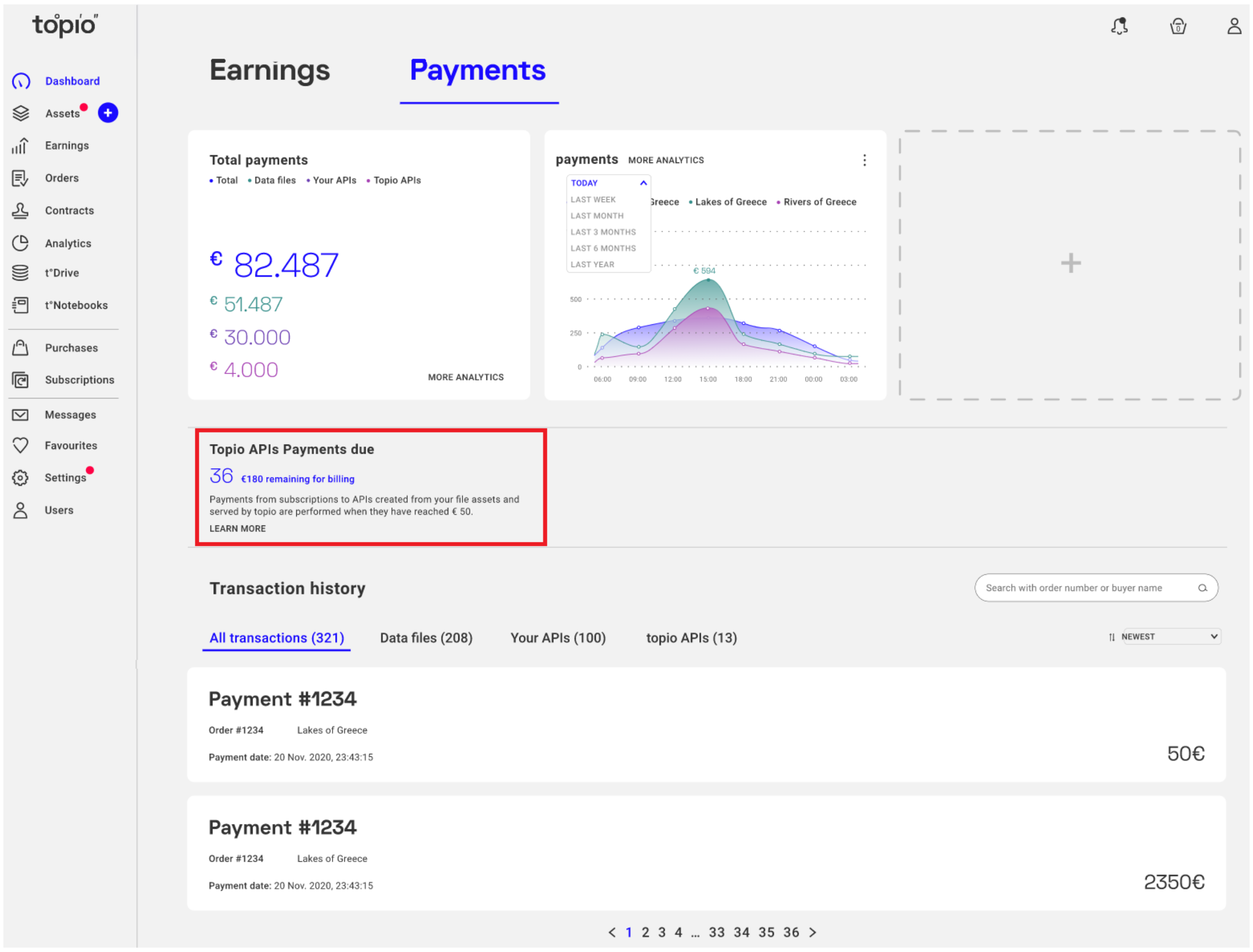
Figure 124: Earnings and transaction history of an asset owner

4.1.2. Payments[15]

If the supplier clicks on the *Payments* tab, she will be only shown amounts actually reimbursed, as well as any due payments (Figure 125). At first glance, this may seem similar to Earnings discussed above, but actually concerns only cleared payments that have been reimbursed to the supplier. This payment information may be used by the accounting department of the supplier.

As in the case of Earnings, similar functionality is regarding filtering by asset type (data file, API, etc.) or time period, with one extra feature (shown in the red box), which indicates the *due payments*. E.g., this may concern payments from subscriptions to APIs based on this supplier's assets. Displayed information includes the number of such owing payments, the total amount, as well as any related notifications (e.g., when the payment can be effectuated).

[15] Please note that this section is not available in the beta as payment processing is not enabled during the beta; all testing has been performed on MangoPay's sandbox environment, which replicates the exact operation of its production payment processing environment.



Total payments
• Total • Data files • Your APIs • Topio APIs

€ 82.487
€ 51.487
€ 30.000
€ 4.000

MORE ANALYTICS

payments MORE ANALYTICS
TODAY
LAST WEEK
LAST MONTH
LAST 3 MONTHS
LAST 6 MONTHS
LAST YEAR
Greece • Lakes of Greece • Rivers of Greece
€ 594

Topio APIs Payments due
36 €180 remaining for billing
Payments from subscriptions to APIs created from your file assets and served by topio are performed when they have reached € 50.
LEARN MORE

Transaction history
Search with order number or buyer name

All transactions (321) Data files (208) Your APIs (100) topio APIs (13) NEWEST

Payment #1234
Order #1234 Lakes of Greece
Payment date: 20 Nov. 2020, 23:43:15
50€

Payment #1234
Order #1234 Lakes of Greece
Payment date: 20 Nov. 2020, 23:43:15
2350€

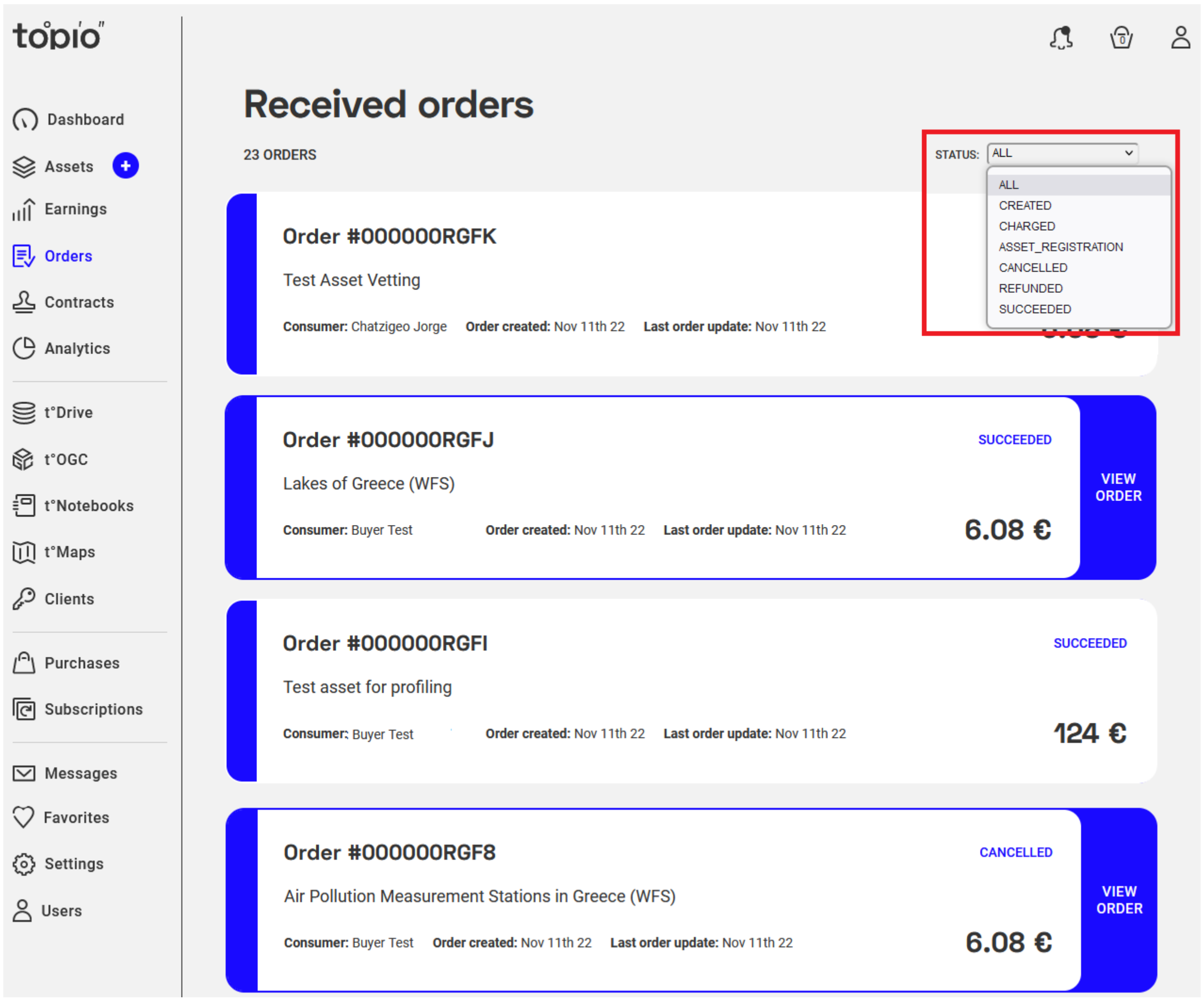
< 1 2 3 4 … 33 34 35 36 >

Figure 125: Payments made to the asset owner

4.1.3. Orders

The option *Orders* in the sidebar of the dashboard presents the supplier with the complete list of all orders placed for her assets (Figure 126). Thus, she can filter these orders by their *status* as shown with the options in the red box: e.g., whether they are received, cancelled, under processing for payment, or succeeded, and the list gets updated accordingly. By default, the supplier can view all orders by reverse chronological order.

Note that some orders may still *require some action* from the supplier; such orders may be listed on the top with a red notification next to them as a reminder that something is pending about them. For example, if the vetting option had been activated by the supplier when the asset was published, then she must approve each individual sale before it proceeds for dispatch and payment. She may also reject a sale of such an asset if she wishes, in which case this order is cancelled; although not effectuated, such rejected orders will still be listed for her records.


topio

Dashboard
Assets
Earnings
Orders
Contracts
Analytics
t°Drive
t°OGC
t°Notebooks
t°Maps
Clients
Purchases
Subscriptions
Messages
Favorites
Settings
Users

Received orders

23 ORDERS

STATUS: ALL

ALL
CREATED
CHARGED
ASSET_REGISTRATION
CANCELLED
REFUNDED
SUCCEEDED

Order #000000RGFK
Test Asset Vetting
Consumer: Chatzigeo Jorge **Order created:** Nov 11th 22 **Last order update:** Nov 11th 22

Order #000000RGFJ SUCCEEDED
Lakes of Greece (WFS)
Consumer: Buyer Test **Order created:** Nov 11th 22 **Last order update:** Nov 11th 22
6.08 €
VIEW ORDER

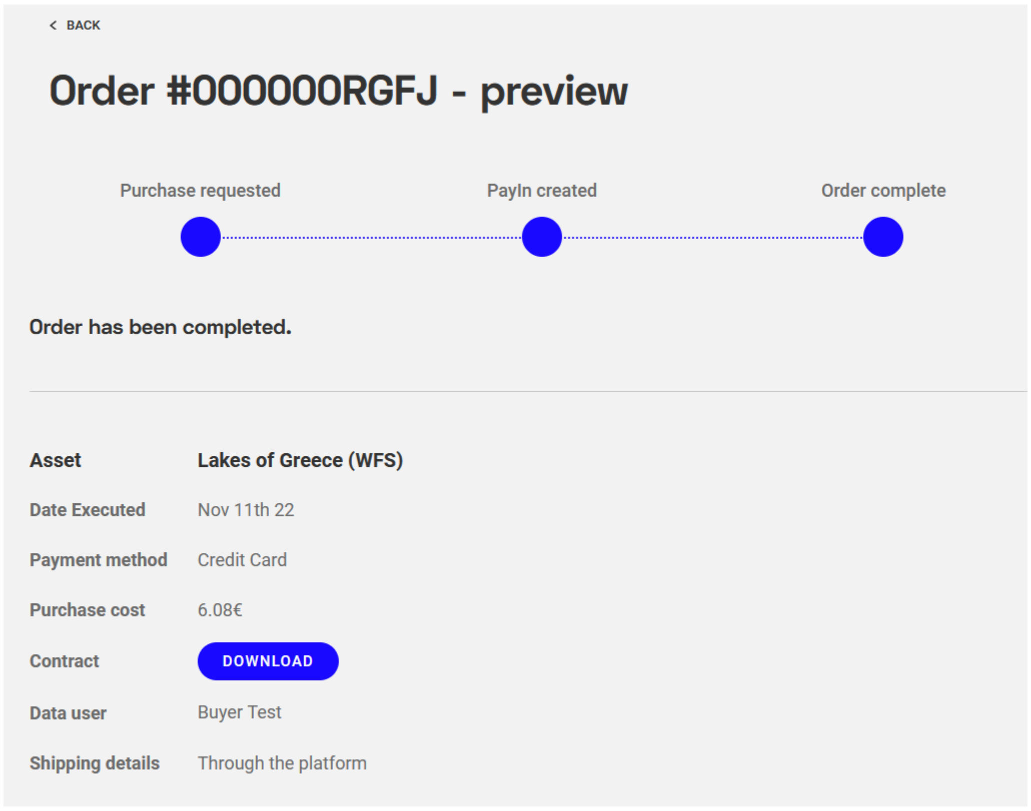
Order #000000RGFI SUCCEEDED
Test asset for profiling
Consumer: Buyer Test **Order created:** Nov 11th 22 **Last order update:** Nov 11th 22
124 €

Order #000000RGF8 CANCELLED
Air Pollution Measurement Stations in Greece (WFS)
Consumer: Buyer Test **Order created:** Nov 11th 22 **Last order update:** Nov 11th 22
6.08 €
VIEW ORDER

Figure 126: Orders received by a supplier

Orders can be also distinguished by the *type of asset* they concern, as indicated with the tabs above the list. By default, the supplier can view all orders by reverse chronological order in the list. However, she can also view only those concerning data file assets, or those based on her own APIs provided externally of the marketplace, or those APIs powered through the platform and based on her assets or files.

By clicking on a particular order in this list, the provider can *view* its status all along its life cycle. When an order arrives (Figure 127), the provider is informed about the asset(s) involved, the customer, the date of the order, the contract details (available for download), as well as the purchase cost. If the supplier has activated the vetting option, she must accept or reject this particular sale. If accepted, the order will be completed once the asset is delivered and the payment is done, as detailed next in Section 4.2.



< BACK

Order #000000RGFJ - preview

Order has been completed.

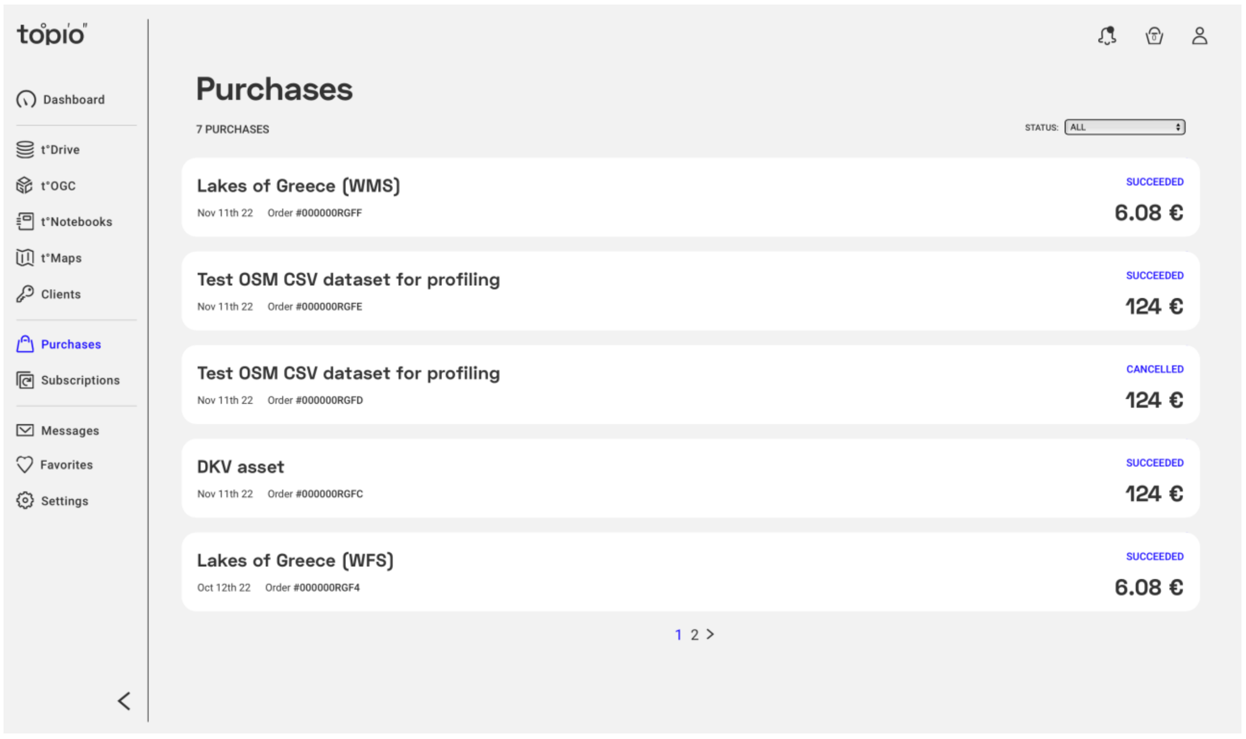
Asset	Lakes of Greece (WFS)
Date Executed	Nov 11th 22
Payment method	Credit Card
Purchase cost	6.08€
Contract	DOWNLOAD
Data user	Buyer Test
Shipping details	Through the platform

Figure 127: Full details of the lifecycle for a completed order

4.2. Asset Transactions

In the following, we focus on tools available to both suppliers and consumers regarding asset transactions. We present the viewpoints of both the owner and consumer and explore the different options available to them via the Topio platform. As mentioned previously, Figure 126 depicts the dashboard's "Orders" page for suppliers, used for viewing and managing the orders they receive via Topio. From the perspective of a purchaser, all the asset transactions and orders can be accessed via the "Purchases" tab at her dashboard, illustrated in Figure 128. The API subscriptions can be also accessed and managed via the "Subscriptions" tab (see Figure 129).

In the following subsections, we will go through all the available functionalities for viewing and managing orders and transactions, from the perspective of both the supplier and the consumer.



Purchases

7 PURCHASES

STATUS: ALL

Lakes of Greece (WMS)
Nov 11th 22 Order #000000RGFF
SUCCEEDED
6.08 €

Test OSM CSV dataset for profiling
Nov 11th 22 Order #000000RGFE
SUCCEEDED
124 €

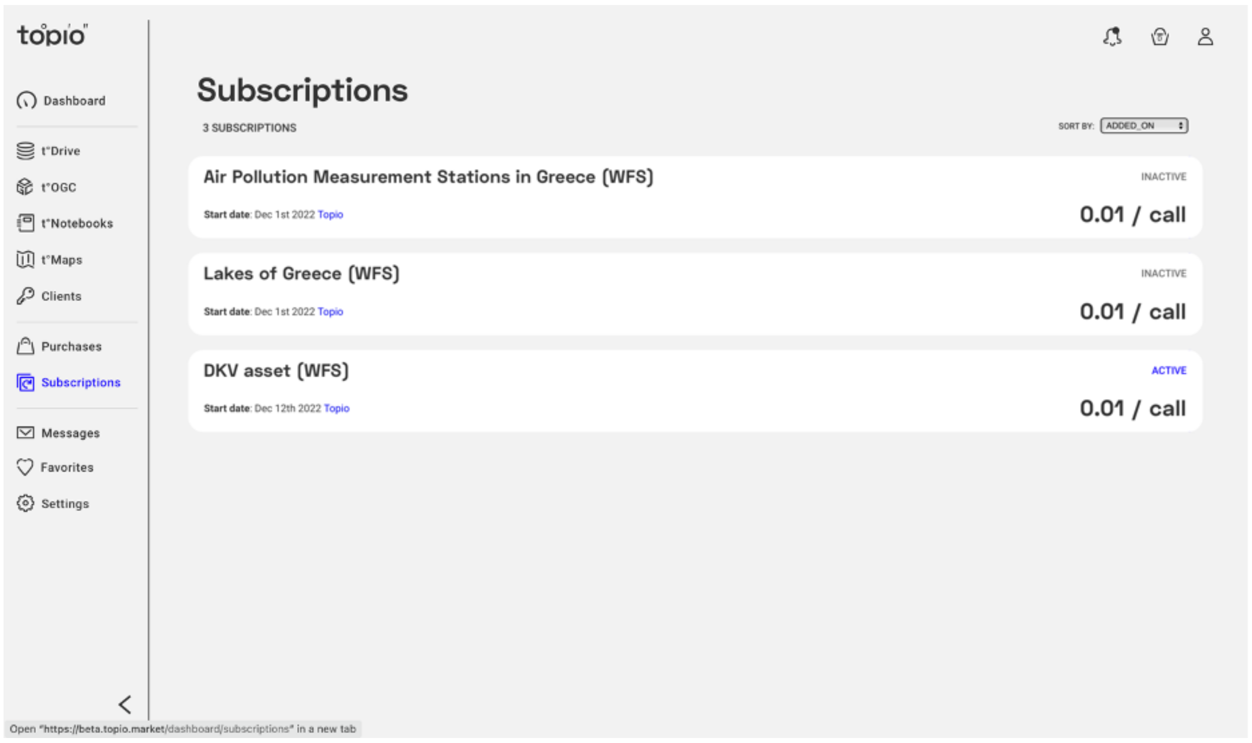
Test OSM CSV dataset for profiling
Nov 11th 22 Order #000000RGFD
CANCELLED
124 €

DKV asset
Nov 11th 22 Order #000000RGFC
SUCCEEDED
124 €

Lakes of Greece (WFS)
Oct 12th 22 Order #000000RGF4
SUCCEEDED
6.08 €

1 2 >

Figure 128: A consumer's purchases



Subscriptions

3 SUBSCRIPTIONS

SORT BY: ADDED_ON

Air Pollution Measurement Stations in Greece (WFS)
Start date: Dec 1st 2022 Topio
INACTIVE
0.01 / call

Lakes of Greece (WFS)
Start date: Dec 1st 2022 Topio
INACTIVE
0.01 / call

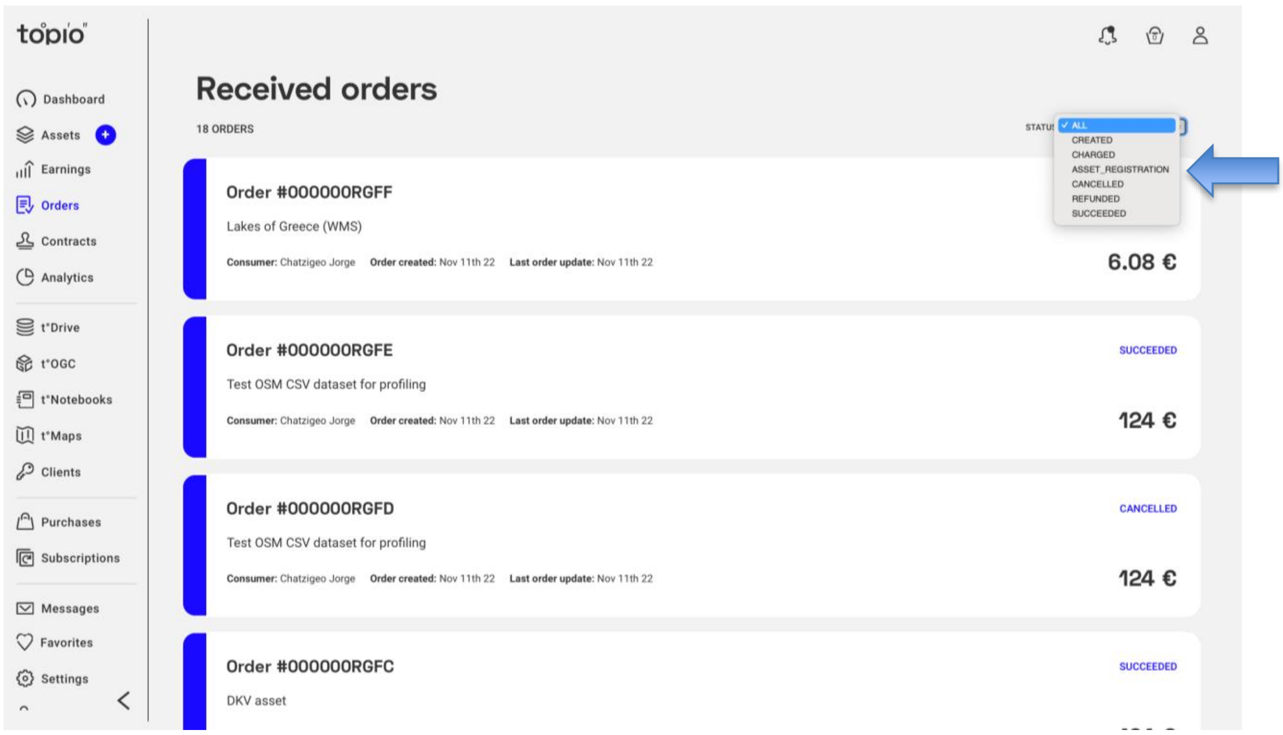
DKV asset (WFS)
Start date: Dec 12th 2022 Topio
ACTIVE
0.01 / call

Open "https://beta.topio.market/dashboard/subscriptions" in a new tab

Figure 129: A consumer's subscriptions

4.2.1. Automated delivery

When a customer purchases a data file asset, if it is set to be delivered by the platform, the transaction is completed automatically. The supplier receives a notification in the form of in-platform message and email, prompting her to view the transaction at her "Dashboard" page. Initially, the order receives a "Charged" status, until the transaction is finalized by the platform. After the transaction is completed, the order status changes to "Succeeded". Upon visiting the "Orders" tab, the supplier can browse the order list to find a specific order. She can also user the various available filters accessible via the "Status" drop-down menu, as shown with a blue arrow in Figure 130.



Received orders

18 ORDERS

Order #000000RGFF
Lakes of Greece (WMS)
Consumer: Chatzigeo Jorge **Order created:** Nov 11th 22 **Last order update:** Nov 11th 22
6.08 €

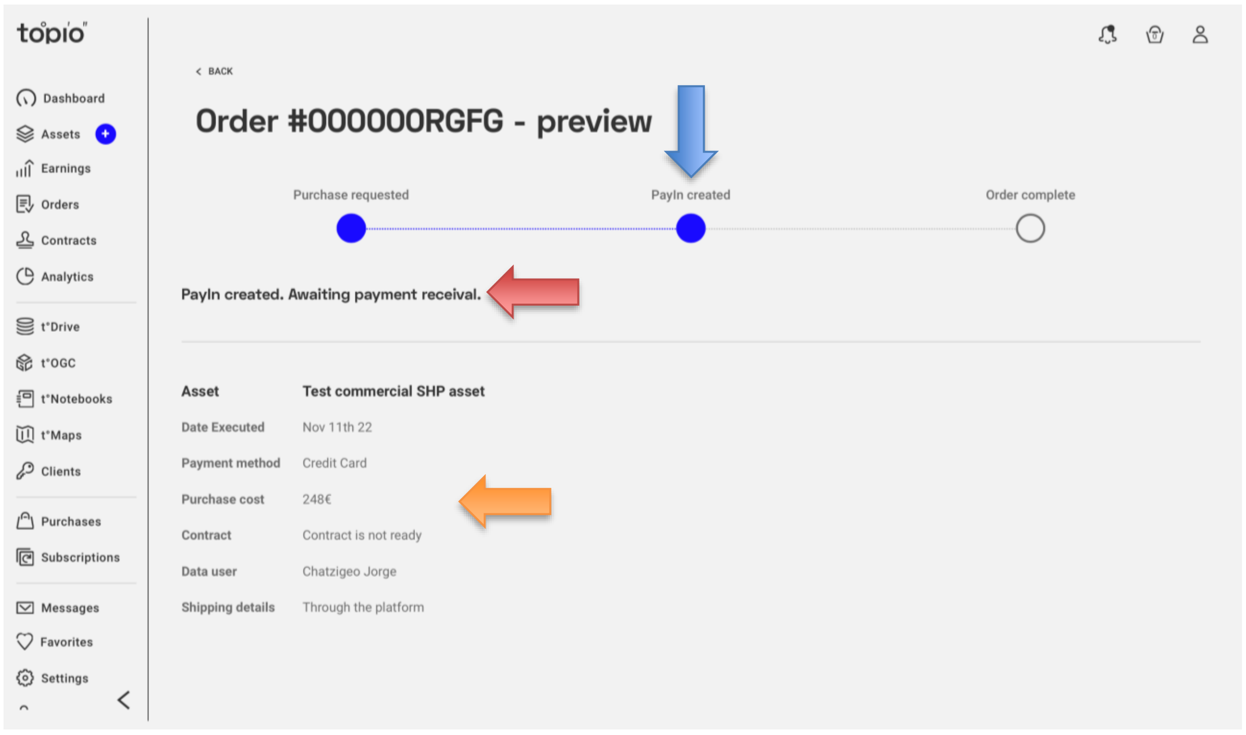
Order #000000RGFE
SUCCEEDED
Test OSM CSV dataset for profiling
Consumer: Chatzigeo Jorge **Order created:** Nov 11th 22 **Last order update:** Nov 11th 22
124 €

Order #000000RGFD
CANCELLED
Test OSM CSV dataset for profiling
Consumer: Chatzigeo Jorge **Order created:** Nov 11th 22 **Last order update:** Nov 11th 22
124 €

Order #000000RGFC
SUCCEEDED
DKV asset

Figure 130: Accessing orders from the supplier's perspective

After clicking on a pending order to access more details, the supplier is redirected to the corresponding page containing details regarding the transaction, as depicted in Figure 131. The order status is indicated using a *line* containing all the remaining steps for it to be completed. In this example, the order is at the "PayIn created" status, waiting for payment retrieval (blue arrow in Figure 131). A more detailed description of the order's status is available below the status line (red arrow in Figure 131). In the figure, the order is being processed by the platform. The supplier can view more details regarding the order (orange arrow in Figure 131), such as the asset's name, the date the order was placed, the total cost, the signed contract (not available yet in the example as the purchase is still being processed) the purchaser name, and any possibly available shipping details (there can be none in this case, since the asset is delivered by the platform).



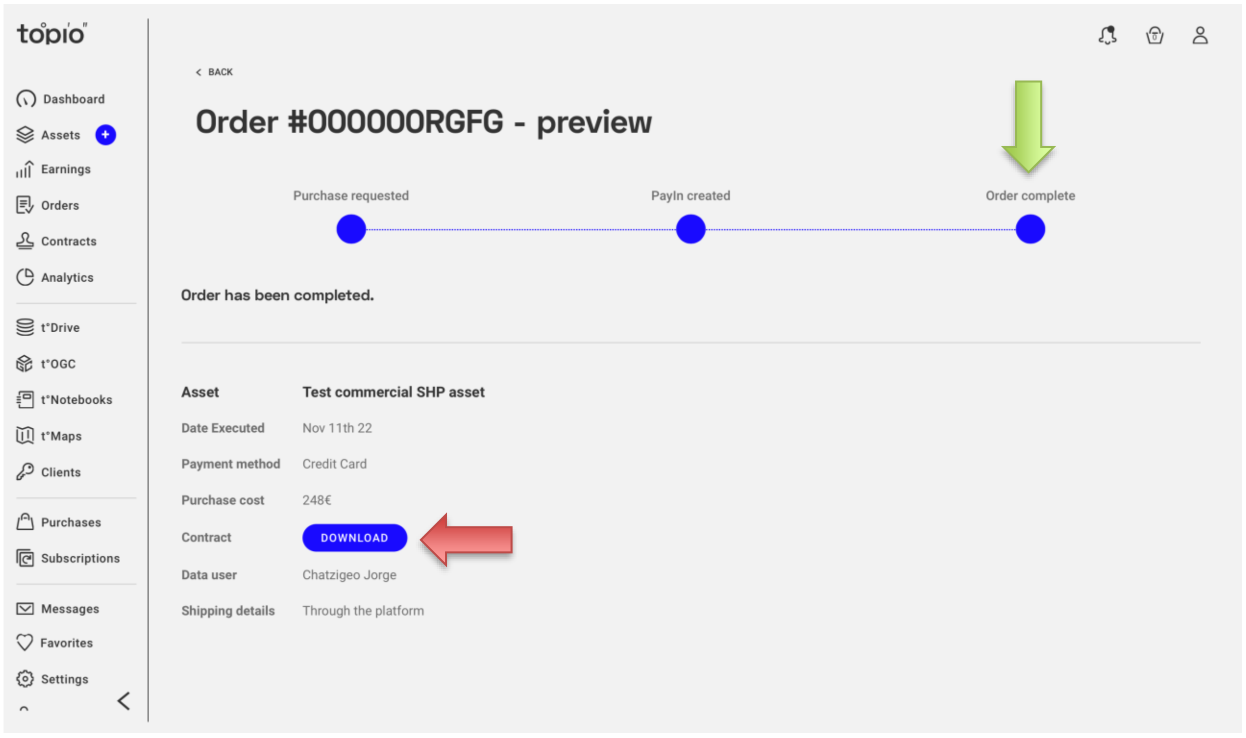
Order #000000RGFG - preview

PayIn created. Awaiting payment receival.

Asset	Test commercial SHP asset
Date Executed	Nov 11th 22
Payment method	Credit Card
Purchase cost	248€
Contract	Contract is not ready
Data user	Chatzigeo Jorge
Shipping details	Through the platform

Figure 131: Viewing a delivered by the platform order from the supplier's perspective

When the order is completed, the corresponding step is annotated at the status line (green arrow in Figure 132. The supplier now can download the signed contract (red arrow in Figure 132).



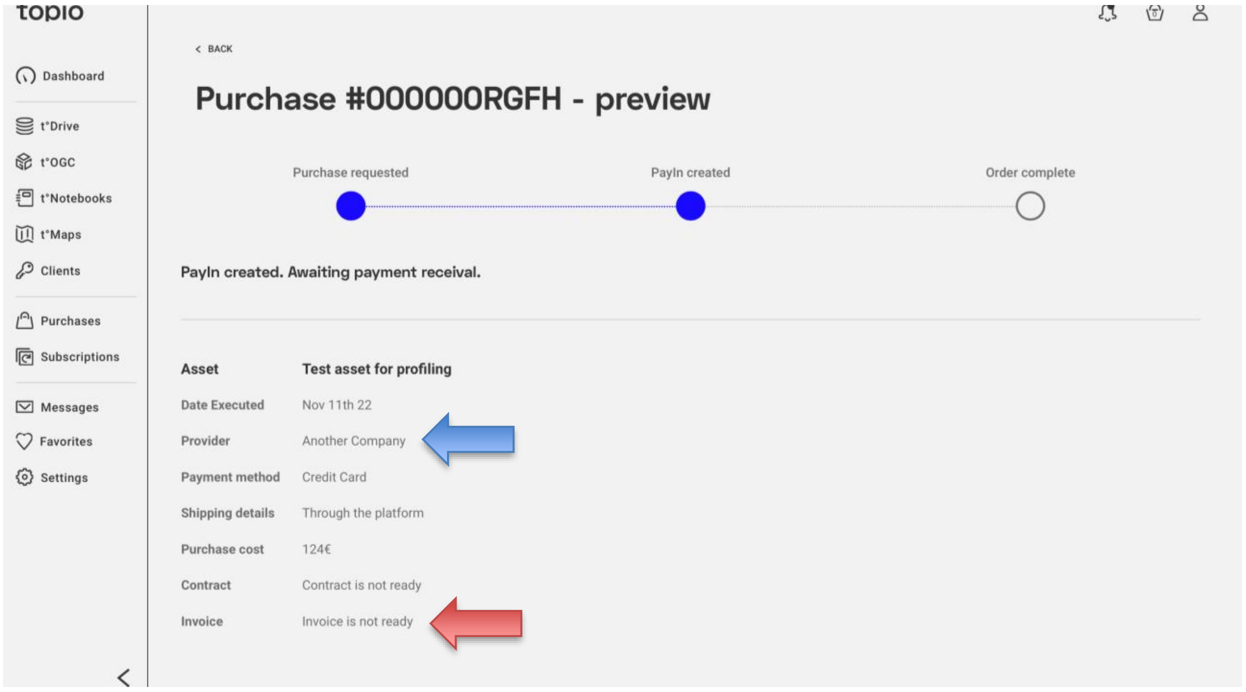
Order #000000RGFG - preview

Order has been completed.

Asset	Test commercial SHP asset
Date Executed	Nov 11th 22
Payment method	Credit Card
Purchase cost	248€
Contract	DOWNLOAD
Data user	Chatzigeo Jorge
Shipping details	Through the platform

Figure 132: Delivered by the platform order completed from the supplier's perspective

From the perspective of the purchaser, to view the status of a transaction upon completing it, she must visit the "Purchases" tab at her dashboard (as shown in Figure 128) and click on the corresponding "View Purchase" button. She will, then, be redirected to the order view page, which is almost identical to the supplier's order view page, as shown in Figure 133; except two minor details: (i) the supplier username is shown this time (blue arrow in Figure 133) and there is a field that will link to the invoice of the purchase, once it's ready (red arrow in Figure 133).



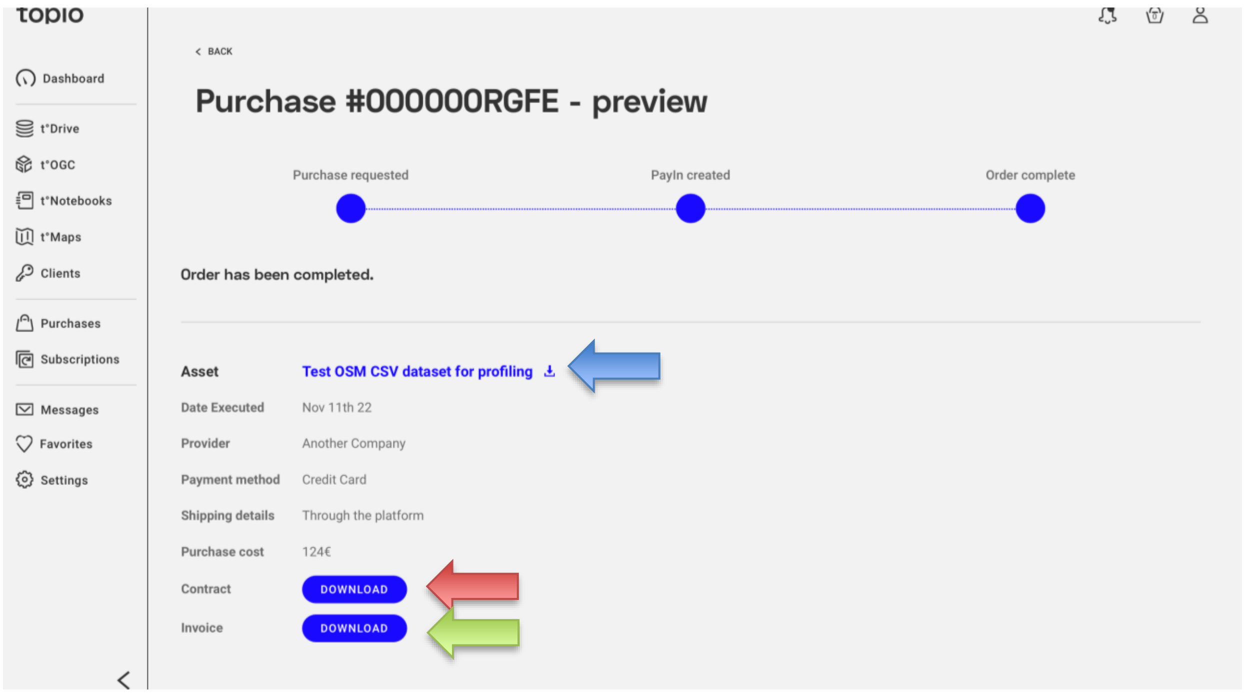
Purchase #000000RGFH - preview

PayIn created. Awaiting payment receival.

Asset	Test asset for profiling
Date Executed	Nov 11th 22
Provider	Another Company
Payment method	Credit Card
Shipping details	Through the platform
Purchase cost	124€
Contract	Contract is not ready
Invoice	Invoice is not ready

Figure 133: Viewing a delivered by the platform order from the purchaser's perspective

When the order is completed, the order view page for the purchaser is also updated accordingly, as illustrated in Figure 134. The name of the asset is now a link (blue arrow in Figure 134), which downloads the purchased data file. Finally, the signed contract and invoice are new ready and there are two available links to download them in PDF format (red and green arrows in Figure 134).



Purchase #000000RGFE - preview

Order has been completed.

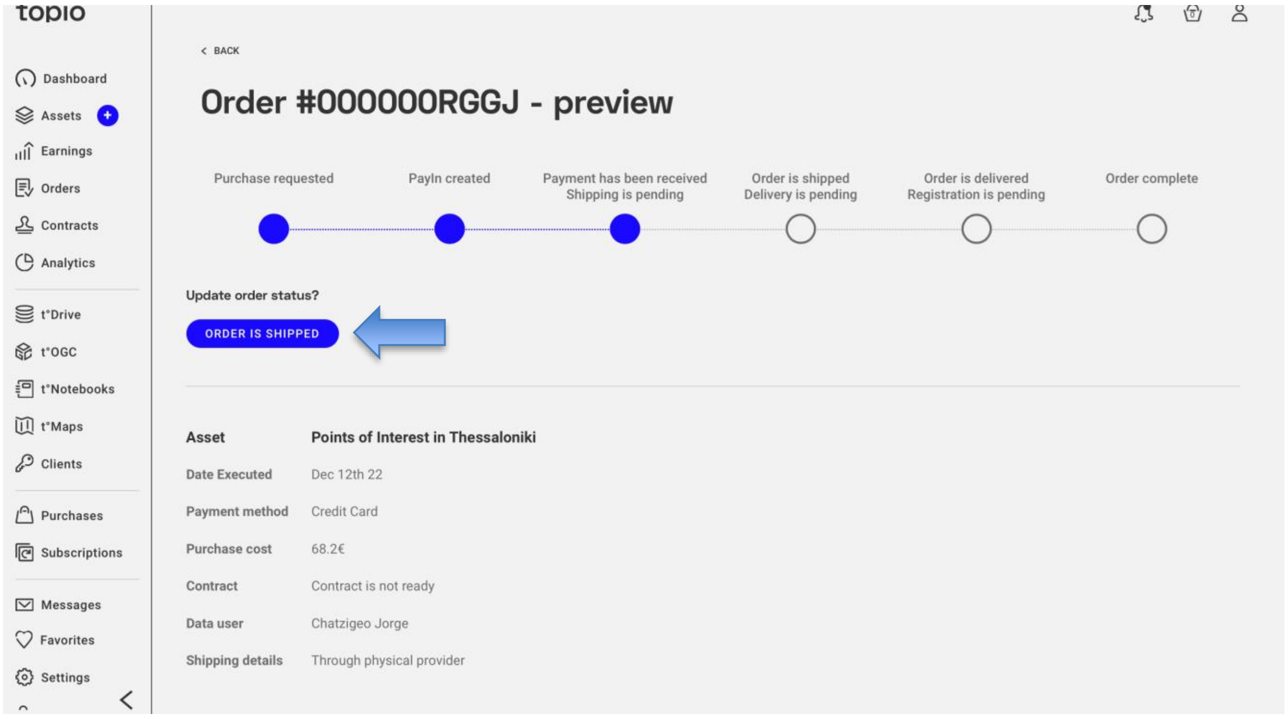
Asset	Test OSM CSV dataset for profiling
Date Executed	Nov 11th 22
Provider	Another Company
Payment method	Credit Card
Shipping details	Through the platform
Purchase cost	124€
Contract	DOWNLOAD
Invoice	DOWNLOAD

Figure 134: Delivered by the platform order completed from the from the purchaser's perspective

4.2.2. Delivery by Physical Means

If a data file asset is delivered by physical means, the supplier is initially notified about the order via an in-platform message and email, prompting her to view the transaction by visiting the "Orders" tab of her dashboard. The list "Received Orders" on top of the "Orders" tab gives the provider the complete list of all the orders placed for her assets (Figure 126). Then, she can filter these orders by their *status*, i.e., whether they are received, dispatched, under processing for payment, or complete, and the list gets updated accordingly.

After visiting the order, the supplier can inspect its status all along its lifetime, indicated with a *status line*. Figure 127 depicts the first step of the process. The information available to the supplier at this point are the same as in the case for the automatically delivered assets, described above. The supplier must now proceed with *shipping* the asset to the customer. After doing so, she must click on "Order is Shipped" button (blue arrow in Figure 135) for the transaction to continue.



Order #000000RGGJ - preview

Purchase requested — PayIn created — Payment has been received Shipping is pending — Order is shipped Delivery is pending — Order is delivered Registration is pending — Order complete

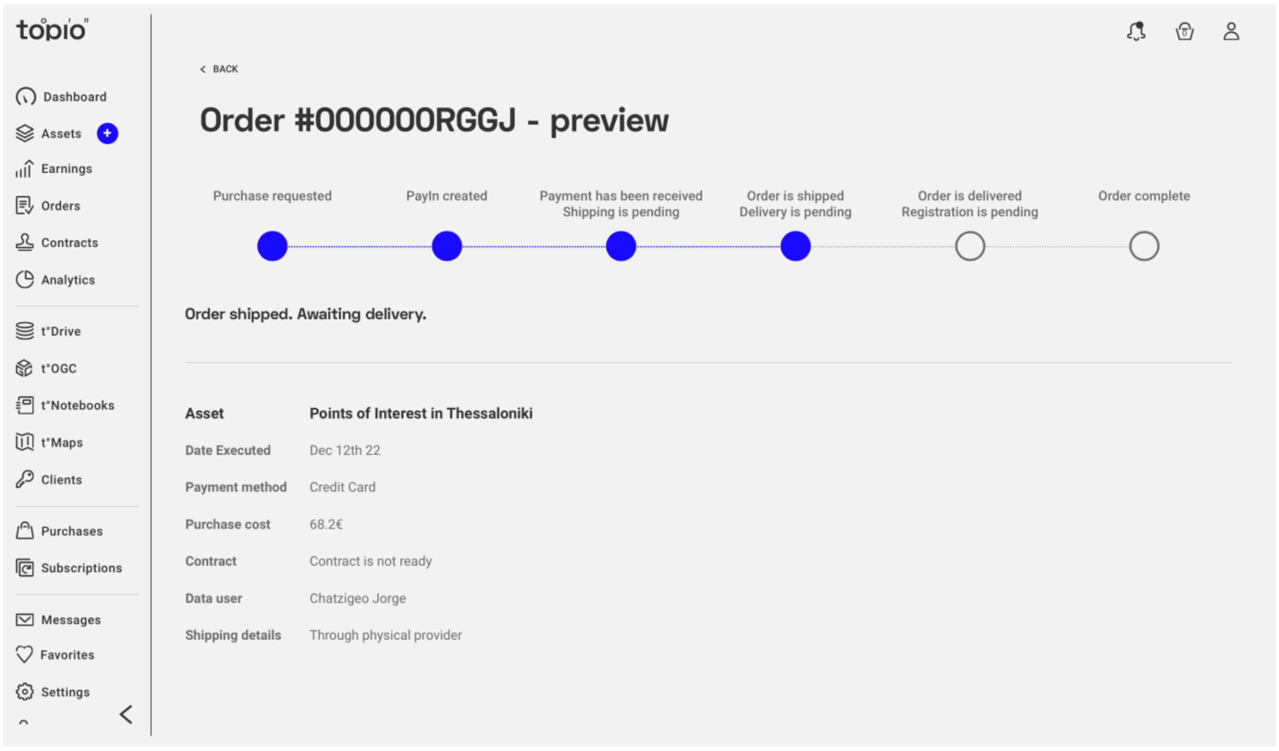
Update order status?

ORDER IS SHIPPED

Asset	Points of Interest in Thessaloniki
Date Executed	Dec 12th 22
Payment method	Credit Card
Purchase cost	68.2€
Contract	Contract is not ready
Data user	Chatzigeo Jorge
Shipping details	Through physical provider

Figure 135: Supplier - New order received

As soon as the asset(s) in the order have been dispatched, the status of the order is updated with information about the delivery (Figure 136). The customer has been accordingly notified that the asset is being delivered.



Order #000000RGGJ - preview

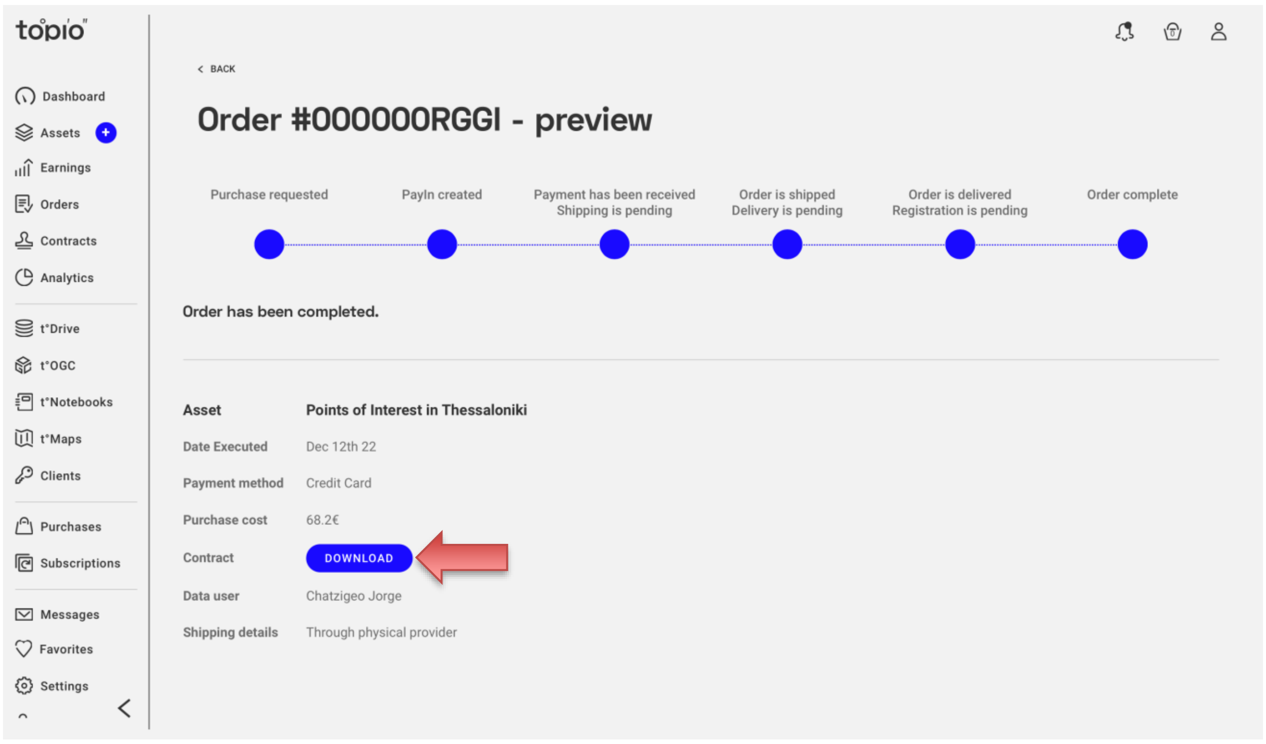
Purchase requested — PayIn created — Payment has been received Shipping is pending — Order is shipped Delivery is pending — Order is delivered Registration is pending — Order complete

Order shipped. Awaiting delivery.

Asset	Points of Interest in Thessaloniki
Date Executed	Dec 12th 22
Payment method	Credit Card
Purchase cost	68.2€
Contract	Contract is not ready
Data user	Chatzigeo Jorge
Shipping details	Through physical provider

Figure 136: Supplier - Asset delivery status

Finally, the status of the order will change to "Complete" (Figure 137) as soon as the customer acknowledges delivery of the ordered asset(s), and the payment has been processed. The supplier now has access to the signed contract between the two parties in PDF form (red arrow in Figure 137).



Order #000000RGGI - preview

Purchase requested — PayIn created — Payment has been received Shipping is pending — Order is shipped Delivery is pending — Order is delivered Registration is pending — Order complete

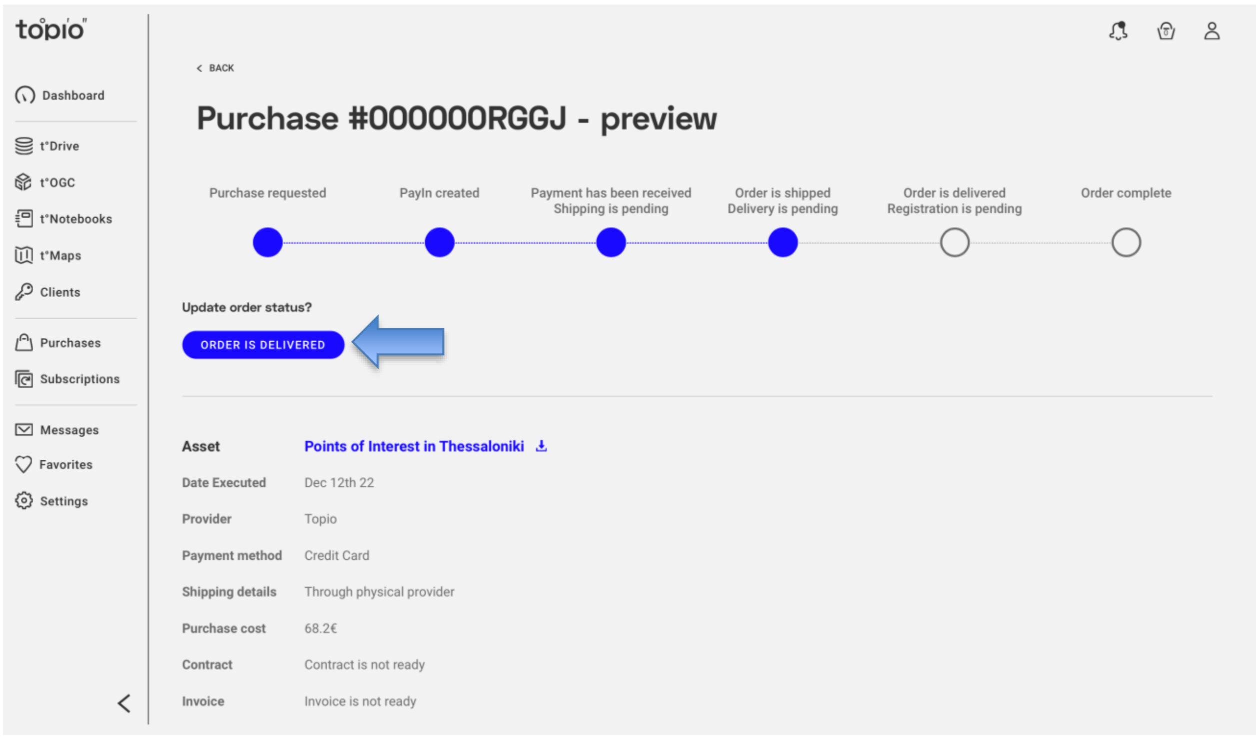
Order has been completed.

Asset	Points of Interest in Thessaloniki
Date Executed	Dec 12th 22
Payment method	Credit Card
Purchase cost	68.2€
Contract	DOWNLOAD
Data user	Chatzigeo Jorge
Shipping details	Through physical provider

Figure 137: Supplier - Order complete

From the perspective of the purchaser, after placing an order for an asset that is physically delivered, she can view and manage it by visiting her dashboard at the "Purchases" tab (shown in Figure 128) and selecting it from the list. She will then be redirected to the corresponding order's view page, where she can view the progress of her order. As in all the cases presented above, the order progress is indicated using a status line. After placing an order for an asset delivered by physical means, the purchaser must wait for the supplier to dispatch the asset before continuing the process.

When the supplier dispatches the asset, the status of the order and the progress line are updated accordingly, as depicted in Figure 138. When the purchaser receives the asset via physical means, an action is required by her in order for the process to continue: She must visit the order's view page and click on the "Order is Delivered" button, shown with a blue arrow in Figure 138. The purchaser is notified about dispached assets via email and in-platform notifications.



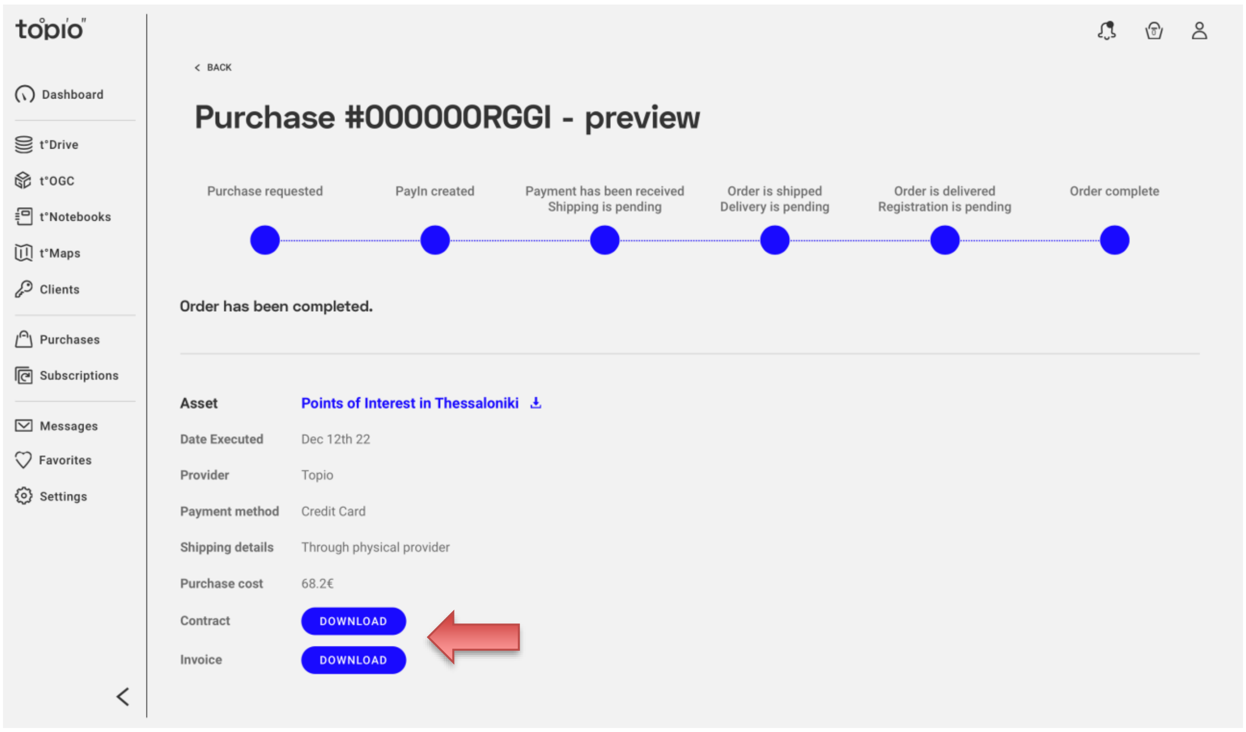
Purchase #000000RGGJ - preview

Update order status?

Asset	Points of Interest in Thessaloniki
Date Executed	Dec 12th 22
Provider	Topio
Payment method	Credit Card
Shipping details	Through physical provider
Purchase cost	68.2€
Contract	Contract is not ready
Invoice	Invoice is not ready

Figure 138: Purchaser – Asset Dispatched

After clicking on the “Order is Delivered” button, the payment to the supplier is processed and the order is completed (Figure 139). As previously, the purchaser can now download the signed contract and invoice for the purchase from the order’s view page (red arrow in Figure 139).



Purchase #000000RGGI - preview

Order has been completed.

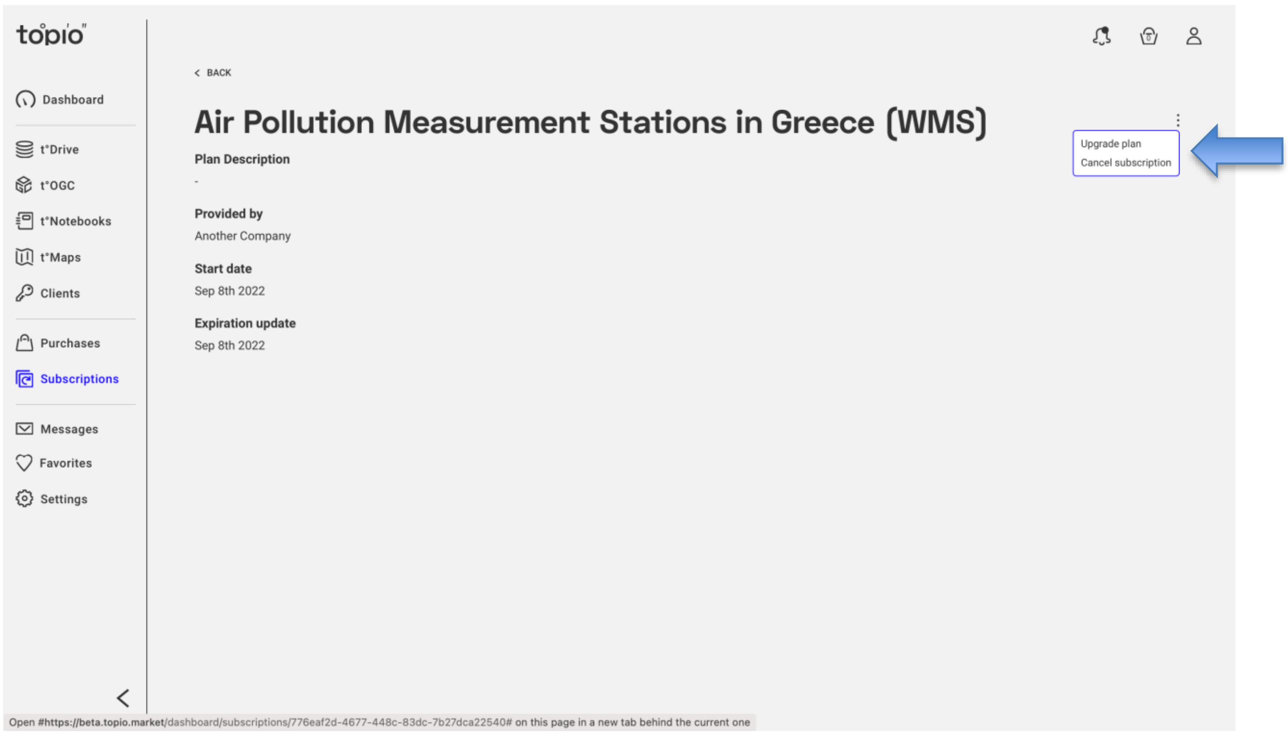
Asset	Points of Interest in Thessaloniki
Date Executed	Dec 12th 22
Provider	Topio
Payment method	Credit Card
Shipping details	Through physical provider
Purchase cost	68.2€
Contract	DOWNLOAD
Invoice	DOWNLOAD

Figure 139: Purchaser - Order complete

4.2.3. Service Subscriptions

Since subscriptions to services are handled by Topio, from the perspective of the supplier, the process is the same as in automated delivery for data file assets: When a customer subscribes to a service, the supplier can view the transaction at the "Orders" tab of her dashboard. The supplier can then click on the corresponding subscription to view and manage the order, which is done as in automated delivery for data file assets (Figure 131 and Figure 132).

From the customer's perspective, when a subscription to a service is requested, the corresponding order can be located at the "Purchases" tab at the dashboard (see Figure 128). The process of a subscription purchase is the same as in data file assets, described in Section 4.2.1 and illustrated in Figure 133 and Figure 134. To view and manage her subscriptions, a customer must visit the "Subscriptions" tab at dashboard, shown in Figure 129. Clicking on one of the subscriptions therein, the user is redirected to the corresponding "Subscription View" page (Figure 140). To upgrade or cancel her subscription, the customer must click on the three dots at the top right of the page and choose one of the available options in the drop-down list (blue arrow in Figure 140).



Air Pollution Measurement Stations in Greece (WMS)

Plan Description

-

Provided by

Another Company

Start date

Sep 8th 2022

Expiration update

Sep 8th 2022

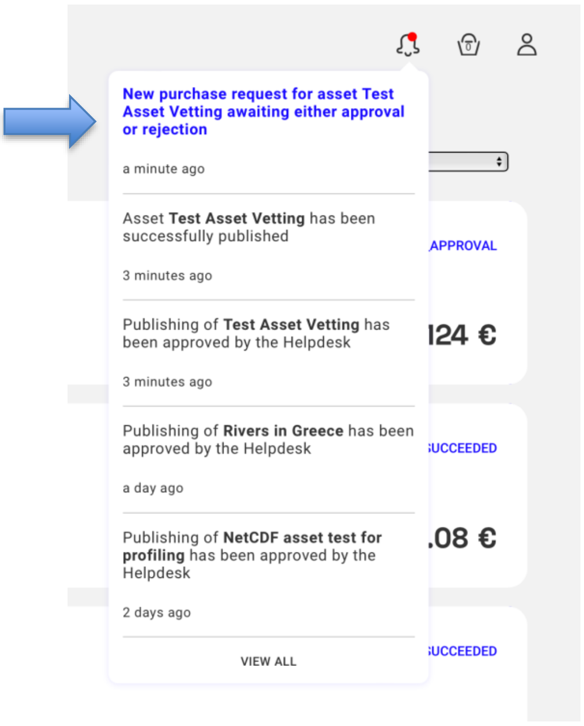
Open #https://beta.topio.market/dashboard/subscriptions/776eaf2d-4677-448c-83dc-7b27dca22540# on this page in a new tab behind the current one

Figure 140: Subscription view page

4.2.4. Seller vetting

During publishing an asset, a supplier must choose whether she wants to approve purchases of the asset that is being published, by selecting the corresponding option at the *Review* step of the publishing wizard (for more details, please refer to Section 1.2.6 of D3.3). If this option is selected, the asset transaction process involves one extra step, both for the purchaser and the supplier.

In the case of the supplier, when a customer requests to buy an asset for which she has enabled vetting, she must first accept, or reject the request. First of all, she is informed about the request via the platform's notification system, as indicated with a blue arrow in Figure 141. Then, the supplier must visit the "Orders" tab of her dashboard in order to access the requested order. An order that must be approved by the supplier is appropriately annotated with "Pending Provider Approval" in the received orders list, as shown with a blue arrow in Figure 142.


New purchase request for asset Test Asset Vetting awaiting either approval or rejection

a minute ago

Asset **Test Asset Vetting** has been successfully published

3 minutes ago

Publishing of **Test Asset Vetting** has been approved by the Helpdesk

3 minutes ago

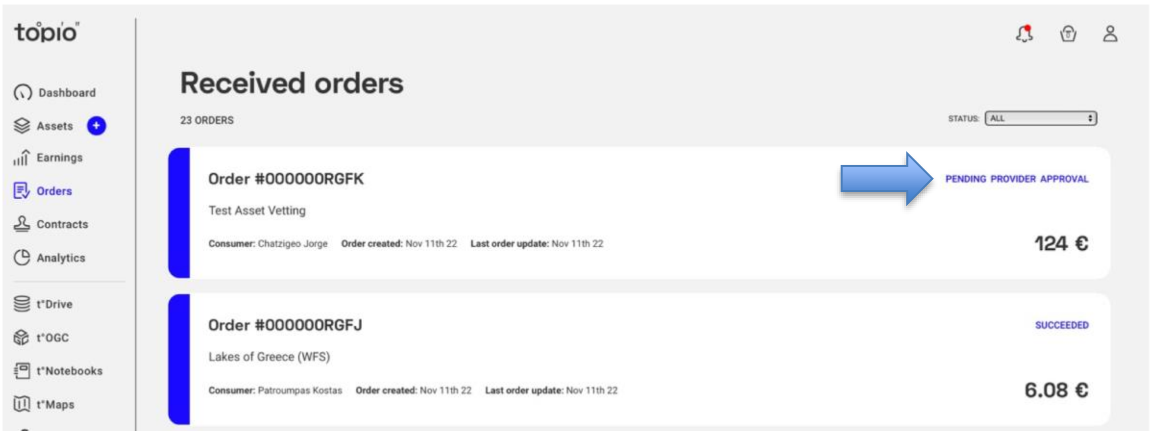
Publishing of **Rivers in Greece** has been approved by the Helpdesk

a day ago

Publishing of **NetCDF asset test for profiling** has been approved by the Helpdesk

2 days ago

Figure 141: Approve order notification



Received orders

23 ORDERS

STATUS: ALL

Order #000000RGFK — PENDING PROVIDER APPROVAL

Test Asset Vetting

Consumer: Chatzigeo Jorge Order created: Nov 11th 22 Last order update: Nov 11th 22

124 €

Order #000000RGFJ — SUCCEEDED

Lakes of Greece (WFS)

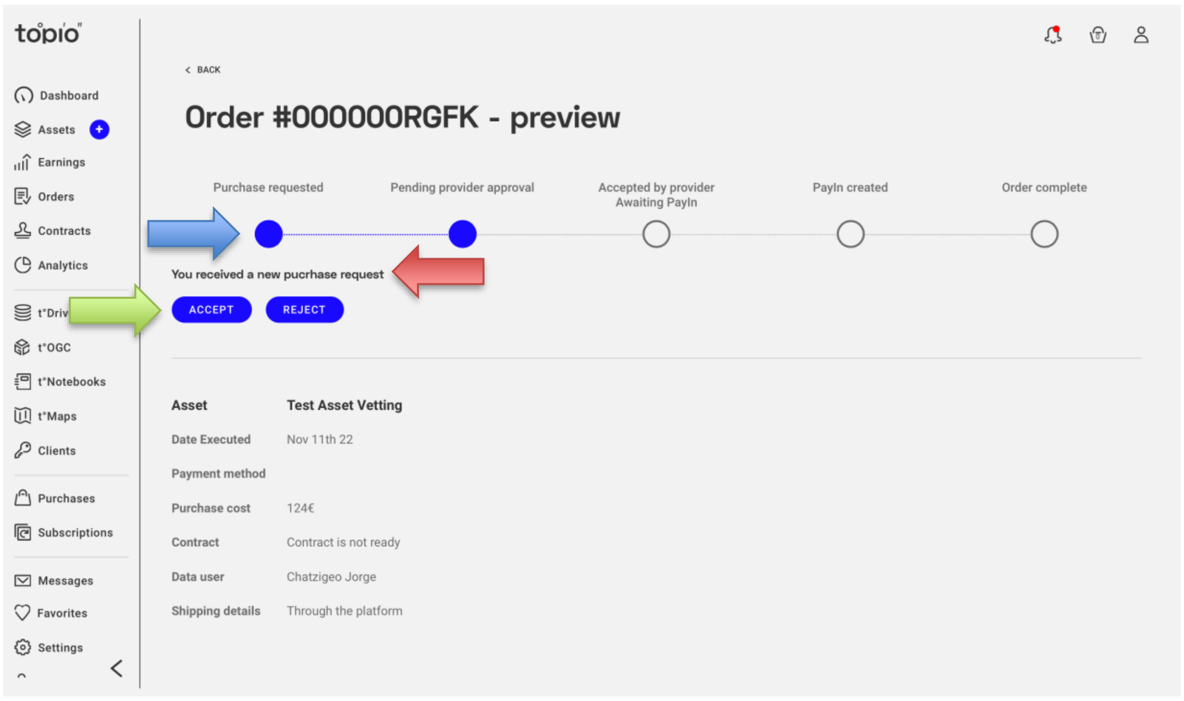
Consumer: Patroumpas Kostas Order created: Nov 11th 22 Last order update: Nov 11th 22

6.08 €

Figure 142: Pending approval

To accept or reject the request, the supplier must click on the order to enter its view page. The order status line now has an extra step at its left-most edge, titled "Purchase requested", accompanied with the appropriate message (blue and red arrows in Figure 143). The supplier must then accept or reject the transaction by clicking on the corresponding buttons (green arrow in

Figure 143). If the supplier accepts, the consumer is notified via notification and email and she can continue the purchase process. If she rejects the transaction, the order is completed and receives a "Rejected" status. The purchaser is informed regarding the rejection via email and notification.



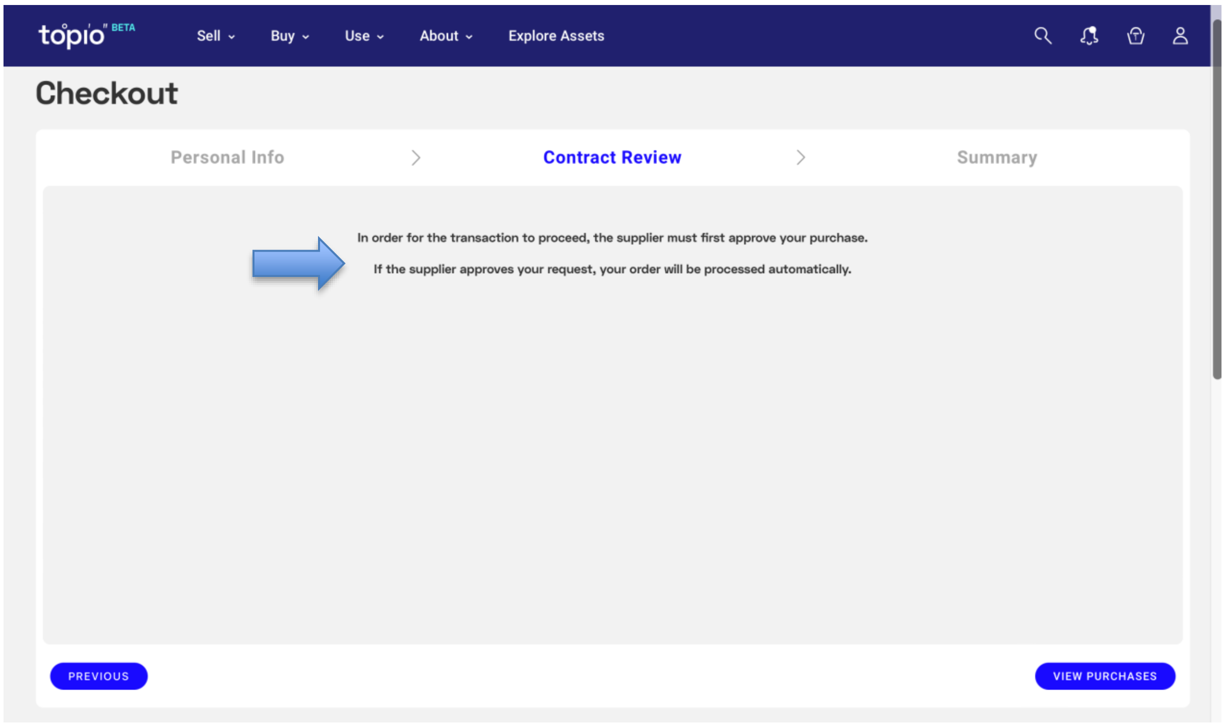
Order #000000RGFK - preview

You received a new pucrhase request

Asset	Test Asset Vetting
Date Executed	Nov 11th 22
Payment method	
Purchase cost	124€
Contract	Contract is not ready
Data user	Chatzigeo Jorge
Shipping details	Through the platform

Figure 143: Accept or reject order

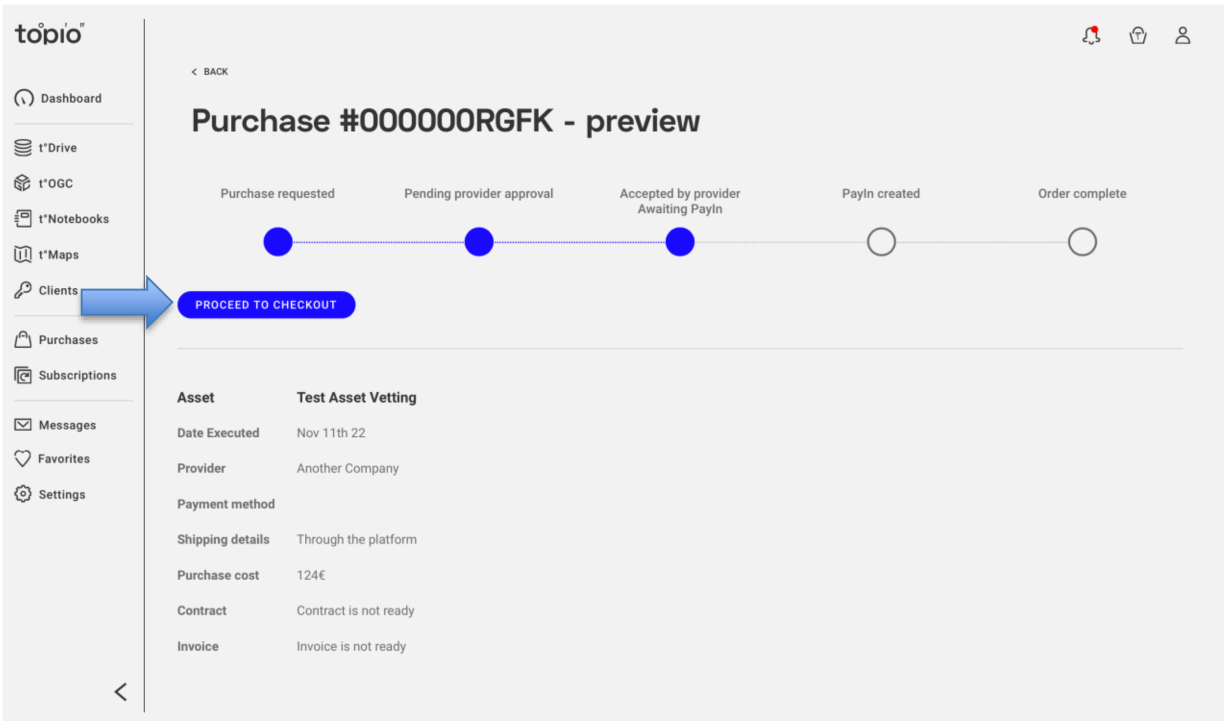
From the perspective of a purchaser, if buying an asset requires approval from the supplier, the order process is halted at the corresponding step until approval, as indicated with a blue arrow in Figure 144. If the supplier accepts, the consumer receives a notification and email prompting her to visit her dashboard, track her order from the "Purchases" tab and proceed to checkout normally, as indicated with a blue arrow in Figure 145. Otherwise, the order is rejected, and the purchaser is informed via email and in-platform notification.



In order for the transaction to proceed, the supplier must first approve your purchase.

If the supplier approves your request, your order will be processed automatically.

Figure 144: Awaiting supplier's approval



Purchase #000000RGFK - preview

Asset	Test Asset Vetting
Date Executed	Nov 11th 22
Provider	Another Company
Payment method	
Shipping details	Through the platform
Purchase cost	124€
Contract	Contract is not ready
Invoice	Invoice is not ready

Figure 145: Proceeding to checkout after approval

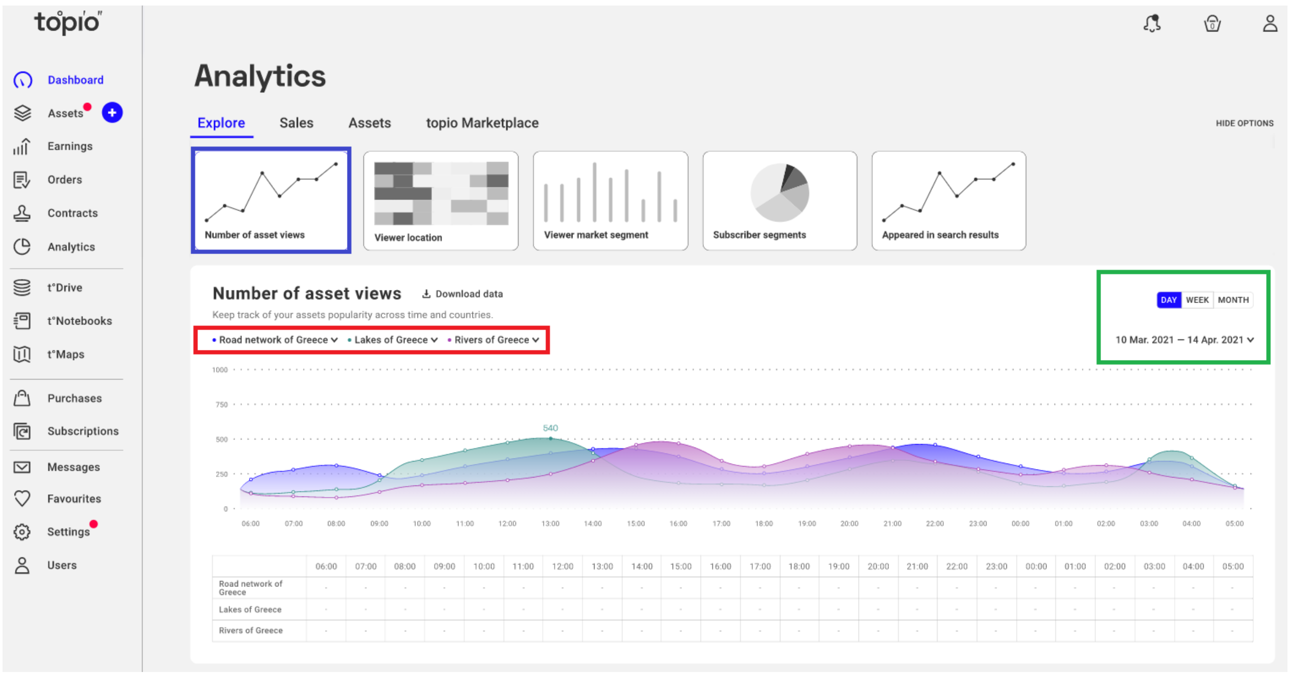
4.3. Analytics

4.3.1. Overview

The *Analytics* option in the dashboard offers to the supplier a wide range of statistics, charts, and diagrams (including line or bar plots, pie charts, heatmaps, and choropleth maps) about her standing in the marketplace. Overall, several *categories* of analytics are available, as indicated with the four tabs in Figure 146:

- *Explore*: displays analytics based on logs of search requests from visitors that involve her assets (Section 4.3.2);
- *Sales*: enables the supplier to monitor the evolution of sales and compare her revenues from selected asset(s) for a chosen time period and asset type(s) (Section 4.3.3);
- *Assets*: visualizes the popularity of assets and detailed analytics for purchased ones (Section 4.3.4); and
- *topio Marketplace*: allows the supplier to assess her overall performance in the marketplace (Section 4.3.5).

All such analytics are accompanied with several *filtering* and *aggregation* options that enable the owner to assess the trend of her assets and monitor the progress of her sales in the marketplace (e.g., per application domain, time period, country, etc.).



Number of asset views   Download data

Keep track of your assets popularity across time and countries.

	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	00:00	01:00	02:00	03:00	04:00	05:00
Road network of Greece	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lakes of Greece	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rivers of Greece	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure 146: Analytics regarding number of asset views

Filters can be applied to such analytics and may involve:

- *Asset(s) of interest*: the supplier can specify one or some of her own assets in order to compare their popularity amongst users or their actual sales in the marketplace. In most cases, the supplier can pick up to 3 assets; specifically for asset insights, she can compute analytics involving up to 10 of her assets.

- *Asset type*: this is mostly used in breaking down earnings per type (*data file, API, total*).

Aggregates can be computed for asset views and sales revenues on three possible *dimensions*:

- *Temporal*: the supplier can specify the time granularity of interest (day, week, or month);
- *Spatial*: the supplier can specify whether she wants a breakdown of the aggregated values by EU country;
- *Segment*: the supplier can display aggregates per market segment, i.e., broader application domains (like marketing, logistics, real estate, transport, environment, government, healthcare, etc.) where geospatial data assets are typically used.

Depending on the specified dimension(s), the underlying data is summarized at the specified granularity.

4.3.2. Explore analytics

Visitor statistics regarding their *search requests* and *asset views* involving products offered by this supplier are aggregated in order to offer insight about their appeal to potential customers. Table 2 lists the types of such analytics, along with their respective visualization, aggregation view, dimensions, and applicable filters that are available under the tab *Explore*.

Table 2: Analytics on asset exploration

Analytics	Visualization	Aggregate By	Dimensions	Filters
Number of Asset Views	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Appeared in search results	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Viewer location	Choropleth map	Day, week, month	(location)	single asset
Viewer market segment	Bar chart		(segments)	1 – 3 assets for comparison

For example, the supplier can pick up to three of her assets (indicated in the red box in Figure 146) and compare their popularity amongst visitors of the marketplace over a period of interest at the granularity of day (specified in the green box). This specific aggregation concerns number of visits of the pages of these assets in the marketplace and results are plotted as line charts, but they are also available in tabular format and can be downloaded.

4.3.3. Sales analytics

As listed in Table 3, this tab offers various visualizations on analytics regarding the various types of assets (data files, APIs, all) offered by this supplier. These include the number of transactions for file assets, number of subscriptions to APIs, actual earnings per asset type, breakdown of sales by customer location or market segment, etc. In addition, the supplier can examine the overall trend of her sales per asset type and by time of interest or country.

Table 3: Sales analytics

Analytics	Visualization	Aggregate By	Dimensions	Filters
		File assets		
Number of transactions	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Earnings	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Purchaser location	Choropleth map		(time)	
Purchaser segments	Bar chart			1 – 3 assets for comparison
		APIs		
Number of subscribers	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Number of calls	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Earnings	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Subscriber location	Choropleth map		(time)	single asset
Subscriber segments	Pie chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
		All		
Asset type earnings	Line chart	Day, week, month; EU country	(time)	3 lines: total, files, APIs

For instance, Figure 147 illustrates the market segmentation of subscribers for three selected APIs (enclosed in the red box) by their industrial domain. Each pie chart concerns a specific asset and shows the percentage of subscribers per market segment (logistics, marketing, research, transport, etc.) for the selected period and time granularity (indicated in the green box).

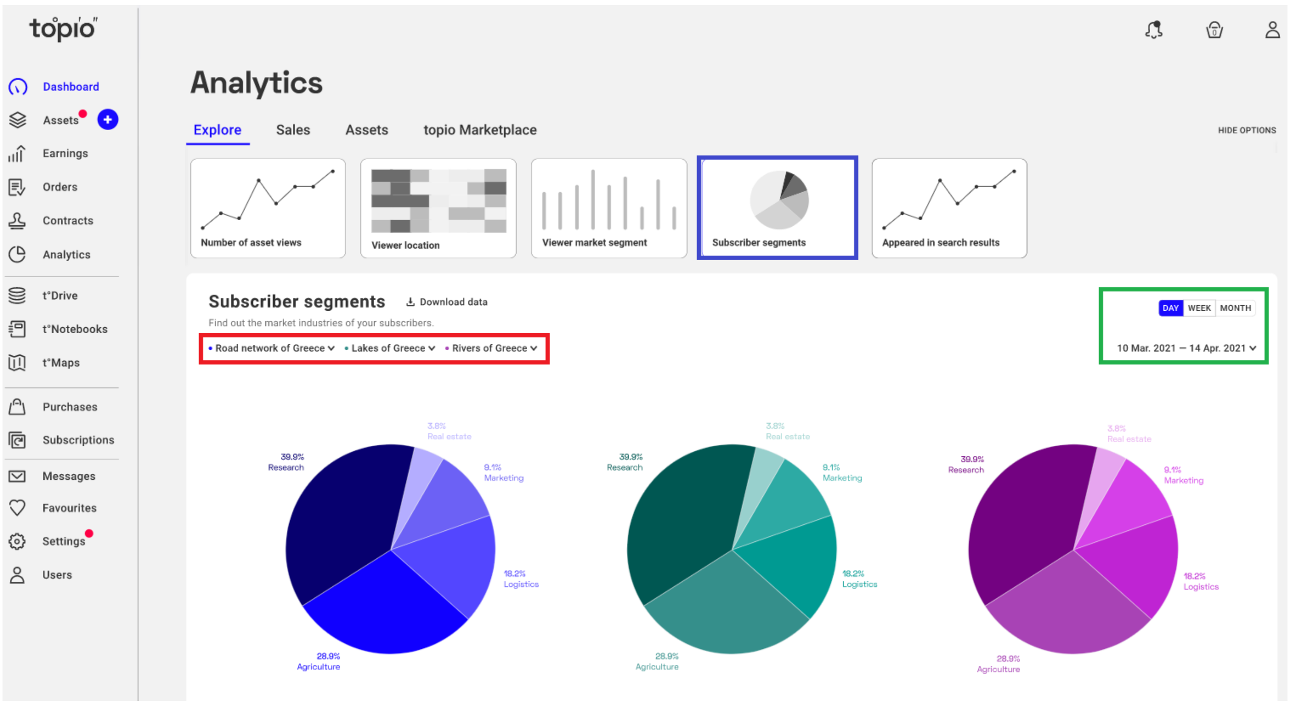


Figure 147: Segmentation of asset subscribers by industrial domain

4.3.4. Asset analytics

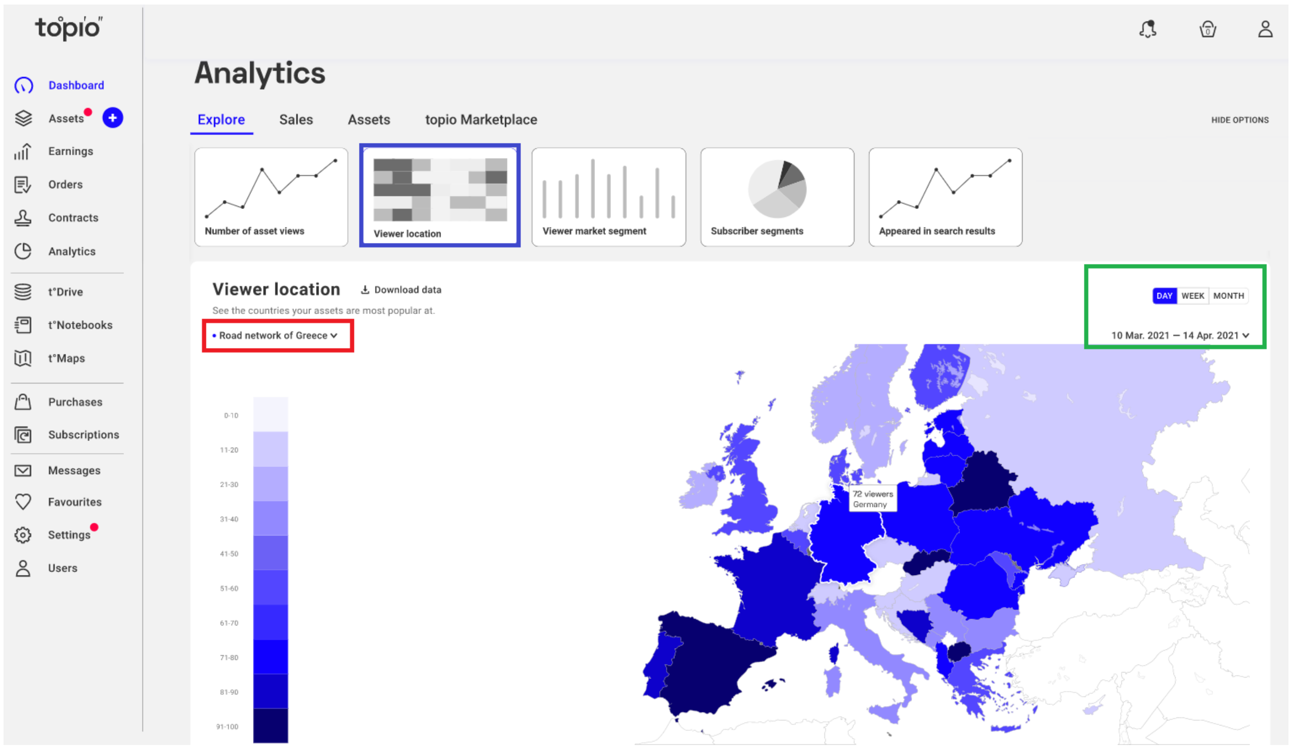
Tab *Assets* offers to the supplier in-depth insight of trends in popularity and sales of specific assets. As detailed in Table 4, she can inspect how (up to 10 of) her assets trend among search results returned to visitors in the marketplace and examine the number, country, and market segment of visitors who have actually viewed their respective Asset View page.

Table 4: Asset analytics

Analytics	Visualization	Aggregate By	Dimensions	Filters
Asset insights				
Number of Asset Views	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Appeared in search results	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Viewer location	Choropleth map		(time)	
Viewer market segment	Bar chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
File assets				

Analytics	Visualization	Aggregate By	Dimensions	Filters
Number of transactions	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Earnings (and cumulative)	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Purchaser location	Choropleth map		(time)	single asset
Purchaser segments	Bar chart			single asset
APIs				
Number of subscribers	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Number of calls	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Earnings (per day)	Line chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
Subscriber location	Choropleth map		(time)	single asset
Subscriber segments	Pie chart	Day, week, month; EU country	(time)	1 – 3 assets for comparison
All				
Asset type earnings	Line chart	Day, week, month; EU country	(time)	3 lines: total, files, APIs

For example, the supplier can visualize in a choropleth map the number of viewers per country for a particular asset of interest (Figure 148) or the market segment of viewers for three of her traded assets (Figure 149). Moreover, she can view charts and heatmaps regarding sales of chosen asset(s) across time.



Analytics

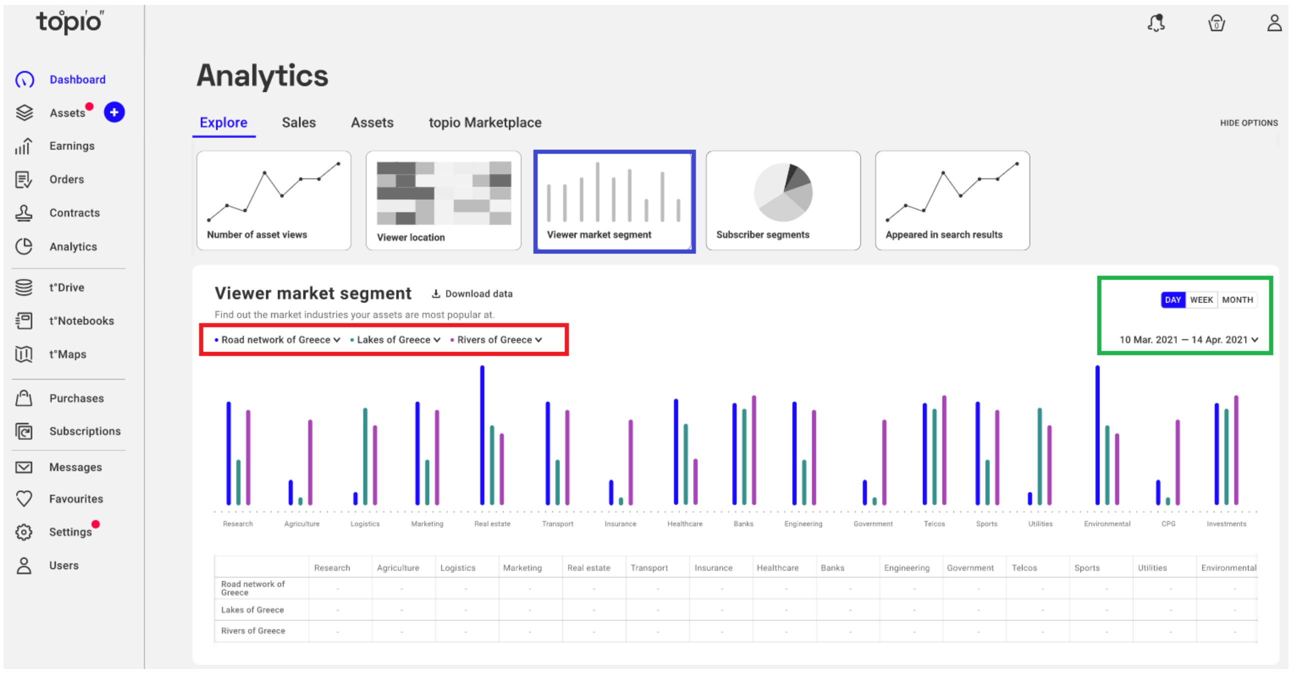
Viewer location

See the countries your assets are most popular at.

• Road network of Greece

10 Mar. 2021 — 14 Apr. 2021

Figure 148: Analytics on viewer locations for a specific asset



Analytics

Viewer market segment

Find out the market industries your assets are most popular at.

• Road network of Greece • Lakes of Greece • Rivers of Greece

10 Mar. 2021 — 14 Apr. 2021

	Research	Agriculture	Logistics	Marketing	Real estate	Transport	Insurance	Healthcare	Banks	Engineering	Government	Telcos	Sports	Utilities	Environmental
Road network of Greece	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lakes of Greece	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rivers of Greece	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure 149: Market segmentation of viewers of specific assets offered by a supplier

4.3.5. Market analytics

Tab *topio Marketplace* allows the supplier to assess the overall visibility and appeal of her assets across the marketplace. As listed in Table 5, she can visually display her top viewed assets, those that most frequently appear among search results, and examine the terms mostly involved in visitors' search requests. She can also inspect her overall performance in the marketplace in terms of number of visitors to her assets, number of subscribers to her APIs, transactions, value of file assets, etc. She can also visualize choropleth concerning the geographical coverage of her assets, the location of viewers, and the location of her customers.

Table 5: Market analytics

Analytics	Visualization	Dimensions	Filters
Top viewed assets	Bar chart	(time; EU Area)	1 – 3 assets for comparison
Top assets appeared in search results	Bar chart	(time; EU Area)	1 – 3 assets for comparison
Top search terms	Bar chart	(time; EU Area)	
Marketplace visitors	Line chart	(time; EU Area)	
Marketplace suppliers	Line chart	(time; EU area)	
Marketplace transactions	Line chart	(time; EU area)	
Subscribers to Topio APIs	Line chart	(time; EU area)	
Number of assets (*total*)	Line chart	(time)	
Value of file assets	Line chart	(time)	
Coverage of assets	Choropleth map	(time)	market segments
Viewer locations	Choropleth map	(time)	
Purchaser locations	Choropleth map	(time)	

5. Implementation

In this section, we provide implementation details for all software components presented, i.e., the publishing wizards, search facilities, Transaction Manager Sales Manager of OP Core//Operations. As these components extend, reuse, and are integrated to, other components of the catalog and OpertusMundi platform, our discussion similarly builds upon this output and the corresponding deliverables to avoid verbosity and maintain the focus of this report.

The source code of the software is available in our public source code repository and similarly to all software developed in the project (a) it is licensed under an open-source license (Apache 2.0), (b) it applies exclusively open-source software for its development and operation.

- https://github.com/OpertusMundi/frontend-marketplace (Wizards and asset view)
- https://github.com/OpertusMundi/java-commons (Search)
- https://github.com/OpertusMundi/java-commons (Code shared among Sales Manager Service, Transaction Manager Service, and External Task Services)
- https://github.com/OpertusMundi/bpm-engine-service (Workflow Engine)
- https://github.com/OpertusMundi/bpm-worker-service (External Task Services)
- https://github.com/OpertusMundi/admin-gateway-service (Transaction Manager Service)
- https://github.com/OpertusMundi/frontend-admin (Transaction Manager UI)
- https://github.com/OpertusMundi/api-gateway-service (Sales Manager Service)
- https://github.com/OpertusMundi/frontend-marketplace (Sales Manager UI)

5.1. Publishing Wizard

The component implements the web-based front-end and UI elements presented in Section 1 and Section 2 and is mainly implemented using the Vue.js[16] JavaScript framework.

5.1.1. Overview

The component implements the web-based front-end and UI elements presented in Section 1 and Section 2 and is mainly implemented using the Vue.js[17] JavaScript framework. The implementation is based on a multistep form pattern by grouping multiple required fields that an asset consists of. Each step is individually validated using dynamic validation patterns based on predefined Typescript types of the corresponding API. The component does not contain any business logic, but instead invokes the appropriate APIs of the API Gateway, which among others, manage the various publishing flows, purchases, and business models supported by the marketplace.

[16] https://vuejs.org/

[17] https://vuejs.org/

The User Interface consists of *components* and *views*. Components are reusable UI elements implemented using the Vue.js framework that can be composed to implement more complex UI structures. Views are components too but are also used by the *router* for navigation. Application data is managed by the store component implemented by the Vuex[18] state management library. The UI interacts with the API Gateway using *services* and by raising *events*. Both UI components and services, may update the application state through store mutating methods, namely, actions. Finally, the router renders the appropriate views either when a user requests a new view (e.g., selects a link) or a service updates the application state (e.g., after a successful login operation).

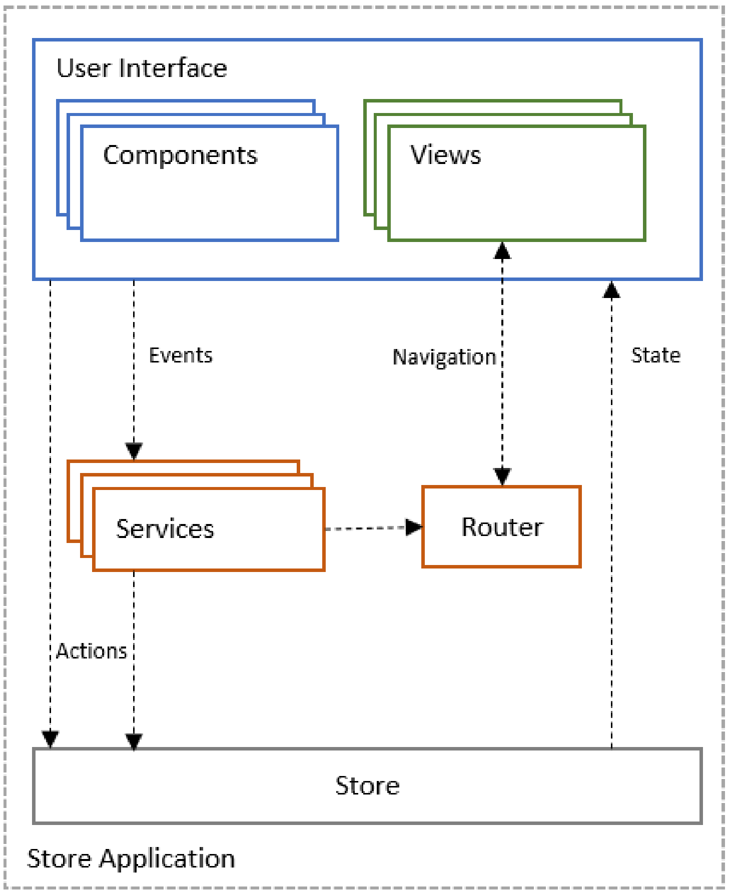


Figure 150: Application architecture

5.1.2. Features

UI elements were built using SAAS[19] as a stylesheet language that is compiled to CSS. SAAS is a stylesheet language allowing developers you to use variables, nested rules, mixins, functions, and more, all with a fully CSS-compatible syntax. Sass helps keep large stylesheets well-organized and makes it easy to share design within and across projects. In addition, the BEM [20] naming methodology is used across all UI elements. BEM (Block, Element, Modifier) is a highly useful, powerful, and simple naming convention that makes front-end code easier to read and

[18] https://vuex.vuejs.org/
[19] https://sass-lang.com/
[20] http://getbem.com/

understand, easier to work with, easier to scale, more robust and explicit, and a lot more strict. By implementing the above, we have been able to make all UI components easily customizable and achieve an easy reusability across multiple scenarios.

5.1.3. Architecture

The application structure of D2.2 has been extended with the following:

- *Services related to pricing models*
    - **Spatial service**: Specific pricing models require area selection by prospective clients. To implement a User Interface (UI) for area selection, a service for fetching areas is created. The service requests spatial data from an implemented WFS, which responds with a GeoJSON of Nomenclature of Territorial Units for Statistics (NUTS), i.e., the official division of the EU and the UK for regional statistics.
    - **Quotation service**: Returns a price quotation as a response to a request, containing the selected pricing model and relevant parameters (e.g., selected areas if required, prepaid tier if supported by the pricing model).
- *Services related to defining and managing license, price models and contracts*
    - **Create Asset Draft**: Provider creates a draft item containing metadata of the asset. Metadata include information about resource licensing and provided pricing models. Information is stored as draft until submission.
    - **Submit Asset Draft**: Submission of asset draft item.
- *Models (client-based types in Typescript, describing the API)*
    - Pricing Models
    - Catalogue
    - Draft
    - Sentinel Hub

For filtering assets by coverage, searching Earth Observation assets or selecting areas for purchase when specific pricing models are chosen, interactive maps are implemented. Some technical details regarding these maps are the following:

- **Coverage filter map**: When the user selects an area, an *MBR* (Minimum Bounding Rectangle) -also known as BBOX (Bounding Box)- is produced. The coordinates of the MBR are included as parameters in the filtering request. The countries-dropdown menu is populated with an MBR for each country.
- **Select areas map**: In the initial map state, a GeoJSON of European Countries is rendered on the map. By clicking on a country, the areas of higher NUTS levels (NUTS-1 & NUTS-2) are requested. The response contains a GeoJSON of these sub-areas; when it is received, these are rendered on the map.

- **Earth Observation (EO) map**: In the initial map state, the user sets a Bounding Box, as well as other filtering parameters which are included in the request for fetching EO Data. Server response includes a list of Satellite Images and the properties of each one, all of which are displayed in the User Interface. In addition, each collection can be visualized on map using WMS.

Both maps are implemented using Leaflet.js & Vue2Leaflet wrapper while OpenStreetMap tiles are currently used for basemaps.

5.1.4. Deployment

The component extends the *Asset Publishing and Discovery* component presented in D2.2 and is thus deployed in way prescribed in D2.2 (see Section 3.4.1).

5.1.5. Frameworks

5.1.5.1. TypeScript

JavaScript is the most well-known scripting language for web pages. Despite its popularity, JavaScript does not support strong typing which results to problems that are hard to trace at runtime. TypeScript is a superset of JavaScript that introduces types. The use of types is optional and TypeScript code can coexist with JavaScript one. Still, using types and type inference, TypeScript allows developers to use static checking and detect possible bugs before executing their code. Moreover, by using modern development tools, they can perform tasks such as code refactoring and be more productive.

5.1.5.2. Vue.js[21]

Vue.js is a JavaScript framework for building interactive User Interfaces. Vue.js can be thought as the View in the MVC pattern that allows building reusable UI components and promotes composition of existing ones. Each component maintains its internal state which controls the rendering process. It is also possible to create stateless components that inherit state information from parent components using properties, resulting in pure presentational components. Whenever state (or a property) changes, only the parts of the DOM that are affected are updated. This is achieved by using a virtual representation of the DOM that efficiently detects changes to the actual DOM. The latter feature makes Vue.js interoperability with other UI libraries more challenging. Vue.js adopts a declarative model for creating views with the help of a HTML-based template syntax with a smooth learning curve for developers who are familiar with HTML5 and CSS3.

5.1.5.3. Vuex[22]

Vuex is a state management library for Vue.js applications that stores application state for all components and ensures that it can only be changed through predictable actions. Modern Single

[21] https://vuejs.org/

[22] https://vuex.vuejs.org/

Page Applications (SPA) have increased requirements for handling application logic. In such applications, the state management becomes increasingly harder since various user interactions – which quite often involve asynchronous requests – result in state changes. Vuex attempts to manage state in a predictable way by imposing specific restrictions on how and when state updates can occur. Vuex makes a perfect match to Vue.js by deferring component state management to Vuex. Vuex keeps the state in a single store (following a Single source of Truth principle), instead of multiple stores. The single application state maps at any moment to its view representation via Vue.js UI components. User actions such as clicks may dispatch actions that change the state in a predefined way using appropriate handlers that dictate how a specific action modifies the application state. In this manner, a one-way flow is achieved, making the application easy to reason about, debug and scale.

The core parts of a Vuex implementation are enumerated next.

- **State**: Vuex uses a state tree that holds the entire application state, which is the representation of the application at any given time. State is an object containing any number of valid JS data types, such as numbers, strings, boolean values, arrays, or other objects. A key concept is that the state object cannot be mutated directly, but only by committing actions.
- **Getters**: Getters implement computed properties whose values can be computed from the state. Instead of duplicating the code that computes a property in multiple places, a getter makes a property accessible from the store. Moreover, getter results are cached and refreshed only when any of their dependencies is updated.
- **Mutations**: Mutations can be triggered by user interactions and cause the state to change. Mutations are like events and consist of a type and a handler synchronous function. Handlers are not directly invoked, but instead they are committed to the store. Optionally, arguments can be passed when committing a mutation.
- **Actions**: Actions are like mutations, but they offer more flexibility for updating state. Actions can be asynchronous, invoke other actions and commit mutations. Actions do not directly update state but instead they commit mutations.
- **Modules**: Having a single state tree may be problematic for big applications where the state object may become too complex. Modules allow the separations of state in several parts, each one containing its own state, getters, mutations and actions.

5.1.5.4. Vue.js Router[23]

Vue Router is a JavaScript library for managing routing in applications implemented using Vue.js. Vue Router offers a rich set of features including route/view mapping, routing parameter management, navigation control using guards, module lazy loading using routes and view transition effects triggered by navigation events.

[23] https://router.vuejs.org/

5.1.5.5. Leaflet, Vue2Leaflet

Leaflet[24] is an open-source JavaScript library, built with simplicity, performance, and usability in mind. It works efficiently across all major desktop and mobile platforms while being light and extendable. *Vue2Leaflet* is a wrapper library for Leaflet, designed for the Vue framework. It encapsulates most of the functionality of the Leaflet library and provides a series of composable Vue components. It also adds reactivity to maps.

5.2. Search

5.2.1. Overview

The OpertusMundi search engine provides users with the capability to search for assets (data and services) via optional filters applied to their descriptive information (standard and automated metadata). The engine has been developed using Elasticsearch to support the following three key capabilities.

- **Be fast**: Search results should be returned almost instantly to provide a responsive user experience.
- **Be full text**: Searches should not be limited to specific matching keywords, but to the entire datastore.
- **Be forgiving**: If a search contains a typo, relevant results for what the user might have been trying to search for should be returned.

5.2.2. Features

The default behavior of a search when searching for a phrase using Elasticsearch, is that the phrase terms must appear in the datastore in the *exact* same order for a document to match, with no typos as well. This is a strict requirement and the implementation of the our search engine aims to relax it as much as possible. To achieve this, we have used two main search capabilities provided by Elasticsearch:

- The **slop** option, that handles the terms ordering by setting the corresponding variable. The slop parameter significantly helps in proximity searches, as it represents how far a term may be moved in any direction, to satisfy a phrase.
- The **fuzziness** option, that handles typos by setting the corresponding variable. The fuzziness parameter allows several characters in all terms of a given phrase to be inserted, deleted, or substituted, turning them into other possible terms. In other words, it creates a set of all possible variations or expansions of the search terms within the specified *edit distance* (variable value). We have followed the Elasticsearch best practices and set fuzziness value to *AUTO*. According to this value:
    - If a term consists of at most two characters, it must exactly match with a term in the datastore.

[24] https://leafletjs.com

    - If a term consists of three, four or five characters, it must exactly match with a term in the datastore modified by one edit.
    - If a term consists of at least 6 characters, it must exactly match with a term in the datastore modified by two edits.

All the above refer to the free-text search capability via the search bar. A user can also combine the free-text search with optional filters to narrow their search results. All filters are applied to the appropriate index fields.

Regarding the search results presentation, all search results are sorted by their *score* in descending order. *Score* is an Elasticsearch internal variable that indicates how relevant a match is to the query. This way, the most relevant results are returned at the top of the result set.

Finally, the entire implementation is based on the Java High REST Level Client for Elasticsearch[25] which concretes request classes for all the different endpoints and contains builders for all the various needed queries and aggregations that Elasticsearch supports.

5.2.3. Architecture

All search requests are performed using an index, which is the base unit of storage in Elasticsearch. Every asset that needs to be searched must be stored in that index. Therefore, apart from the search operation, the configuration and the structure of the index are of paramount importance as well. The index consists of two main sections of information, *settings*, and *mappings*.

The settings section contains the implementation of the custom-made analyzer, needed mainly for the free-text search capability. This analyzer is an algorithm that determines how the value of a text field is transformed into terms and is tightly coupled to the free-text search, as it performs the same text analysis in both insertion of a new asset into the index and execution of a free-text search. While inserting new assets or executing free-text search, all values of text fields and the text that the user is searching for, are analyzed. Implementation-wise, the analyzer consists of the following.

- A **tokenizer** that receives a **stream** of characters, breaks it up into individual tokens/words and outputs a stream of tokens. In our case, the tokenizer breaks text into tokens whenever it finds any whitespace, new line characters, or special characters, such as "-" and "_".
- A **filter** that performs **stemming**. Stemming is the process of reducing a word into its root form. For example, the words "searching" and "searched" will both be stemmed to the same root word "search". That ensures that variants of the word will match during a search request.
- A **filter** that performs **possessive stemming** to remove apostrophes from all words, e.g., the word "car's" will be transformed to "car".
- A **filter** that **lowercases** all tokens for the search operation not to be case sensitive.

[25] https://www.elastic.co/guide/en/elasticsearch/client/java-rest/master/java-rest-high.html

- A **filter** that removes the default English **stop-words** from the token stream. Stop-words in computing are words which are filtered out before, or after processing of natural language data such as "and", "a", "an" and "or".

In the mappings section, the index fields, their datatypes, and optional parameters per field are defined, if needed. Moreover, the parameter *dynamic* that applies to the entire index is set to *false*, so as only the specified fields of an asset to be indexed and not the entire asset. Regarding the structure, the fields that have been decided to be indexed are: (i) those that are related to the front-end filters, (ii) all text fields that contain information that could be helpful for the free-text search and, (iii) the asset id that uniquely identifies each asset in the index.

As in the search operation, all needed operations to create and drop an index, as well as insert and delete documents are implemented based on the Java High REST Level Client for Elasticsearch.

5.2.4. Deployment

The component is packaged as a Docker image[26] and deployed independently as a Kubernetes deployment at the Kubernetes environment of the platform. The search component is a microservice standing behind the Store API Gateway service. Since all web applications are tightly coupled to the API Gateway, the search microservice acts as a *backend* service to the API Gateway, thus it is agnostic of authentication and authorization logic. The web application and internal components invoke the search exclusively via the API Gateway services.

5.2.5. Frameworks

5.2.5.1. ELK stack

The ELK stack is an acronym used to describe a stack that comprises three popular open-source projects: *Elasticsearch*, *Logstash*, and *Kibana*. Often referred to as Elasticsearch, the ELK stack gives you the ability to aggregate logs from all your systems and applications, analyze these logs, and create visualizations for application and infrastructure monitoring, faster troubleshooting, security analytics, and more.

- **Elasticsearch** is an open-source, RESTful, distributed search, and analytics engine, built on Apache Lucene. Its support for various programming languages, high performance, and schema-free JSON documents, makes Elasticsearch an ideal choice for various log analytics and search use cases.
- **Logstash** is an open-source data ingestion tool that allows you to collect data from a variety of sources, transform them, and send them to a desired destination. With pre-built filters and support for over 200 plugins, Logstash allows users to easily ingest data, regardless of the data source or type.
- **Kibana** is an open-source data visualization and exploration tool for reviewing logs and events. Kibana's easy-to-use interactive charts, pre-built aggregations/filters, and geospatial support, make it the preferred choice for visualizing data stored in Elasticsearch.

[26] https://github.com/OpertusMundi/catalogue-service/blob/master/Dockerfile

5.2.5.2. Java High Level REST Client

The Java High Level REST Client for Elasticsearch works on top of the Java Low Level REST client. Its main goal is to expose API specific methods that accept request objects as an argument and return response objects, so that request marshalling and response un-marshalling are handled by the client itself.

Each API can be called synchronously or asynchronously. The synchronous methods return a response object, while the asynchronous methods -whose names end with the “async” suffix- require a listener argument that is notified -on the thread pool managed by the low-level client- once a response or an error is received.

5.3. Transaction Manager

5.3.1. Overview

OP Core//Operations consists of two groups of software artifacts, UI components used for implementing the client-side applications and service components used for implementing the business logic at the sever-side. Hence, Transaction Manager implementation spans several projects, each of which implements a specific slice of the Transaction Manager functionality. The projects that include part of the Transaction Manager implementation are:

- **Admin Frontend**: This is the client application used by OpertusMundi platform personnel. All examples and figures presented in Sections 3.2, 3.3, and 3.5 are part of this application.
- **Marketplace (Store) Frontend**: This is the client application used by OpertusMundi consumers and providers. It implements the components for authoring and reviewing asset drafts discussed in Section 3.3.
- **Admin API Gateway**: The service that handles Admin Frontend requests. Workflow monitoring, asset publishing, and provider payment processing is handled by this service.
- **Marketplace (Store) API Gateway**: The service that handles Marketplace Frontend requests. Draft authoring and consumer payment processing is handed by this service.
- **External Task Service Worker**: The service that implements external tasks required by the BPM engine. Most of the business logic for asset publishing and order fulfillment is implemented by this service.
- **Java Commons Library**: A library that contains code shared by the Admin API Gateway, Store API Gateway, and External Task Service Worker.

5.3.2. Architecture

A high-level overview of the OP Core//Operations architecture is presented in Figure 151. It consists of two web client applications and two services. In this section, we will focus on the admin client application and the Admin API Gateway service. Details on the store client application are presented in Section 5.4. The Store API Gateway service implementation has the same architecture and design with the Admin API Gateway service. Hence, it is not included in this presentation.

The client application is a Single Page Application (SPA) developed using the React[27] JavaScript UI library and TypeScript[28], a super set of JavaScript language that provides strong typing and compile-time code checks. An expanded view of the client application architecture is shown in Figure 152. The application is using the Redux[29] state container for managing application data. Using React in combination with Redux enforces a unidirectional flow of data and commands inside the application which simplifies both implementation and error tracing. The main components of the application are:

1. **UI Components**: The React components used for building the application UI. Components receive data from the **Store** and handle user requests using either **Actions** or **Thunks**.
2. **Actions**: Synchronous commands that cause updates to the data stored in a Redux **Store**.
3. **Thunks**: Asynchronous commands that update the data stored in the Redux **Store**. **Thunks** usually invoke the remote Admin service.
4. **Reducers**: Methods used for updating the application state. After the execution of Actions or Thunks, one or more reducers decide the new application state. A reducer may update the whole application state or only a part of it.
5. **Store**: The store used by Redux library for handling application data.
6. **Services**: Classes that wrap the implementation of remote Admin Service calls. Thunks are using services for interaction with the OP Core//Operations Service and more specifically, with the Transaction Manager.
7. **Model**: Application model implemented using TypeScript interfaces and shared by all client application components.

[27] https://reactjs.org/
[28] https://www.typescriptlang.org/
[29] https://redux.js.org/

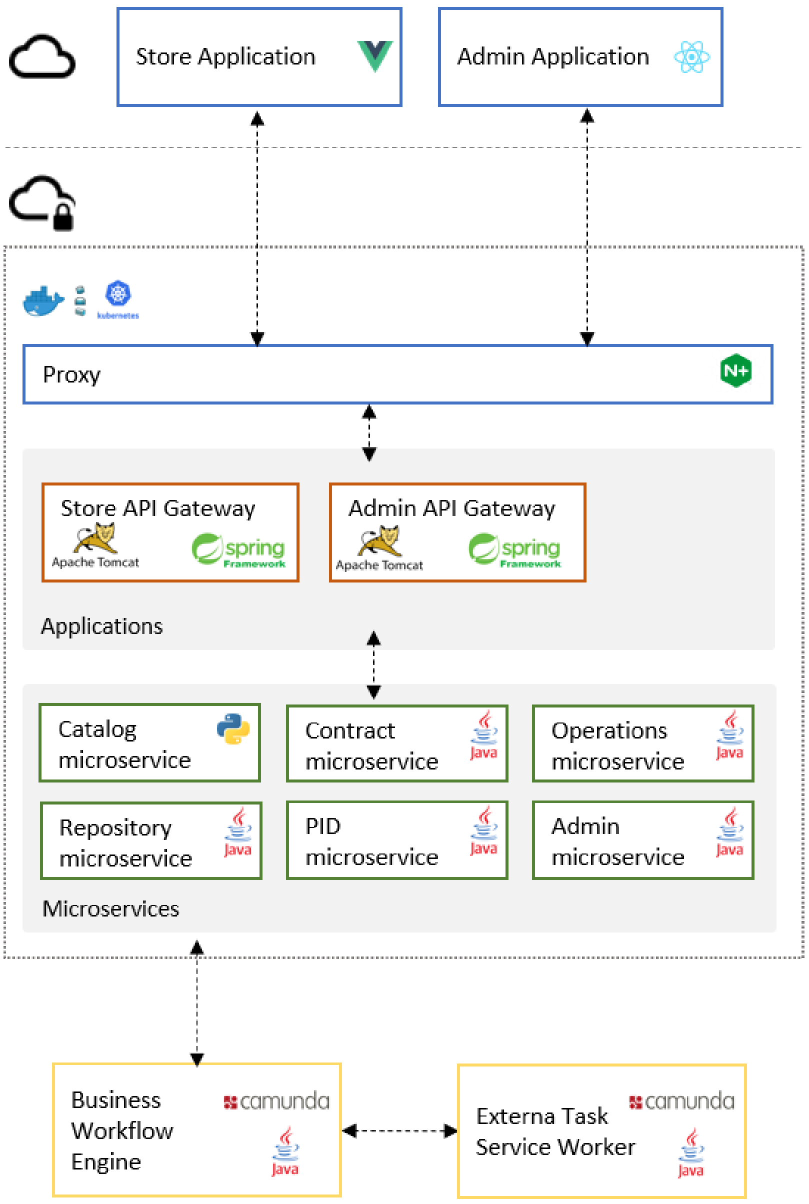


Figure 151: OP Core//Operations architecture

The design of the OP Core//Admin Service is an adaptation of the Model-View-Controller (MVC) pattern where the View is replaced by a SPA client application. The Service is implemented using the Spring Boot[30] Java framework, configures and runs an embedded Tomcat[31] web application server at runtime and is deployed as a Docker[32] container.

[30] https://spring.io/projects/spring-boot
[31] http://tomcat.apache.org/
[32] https://www.docker.com/

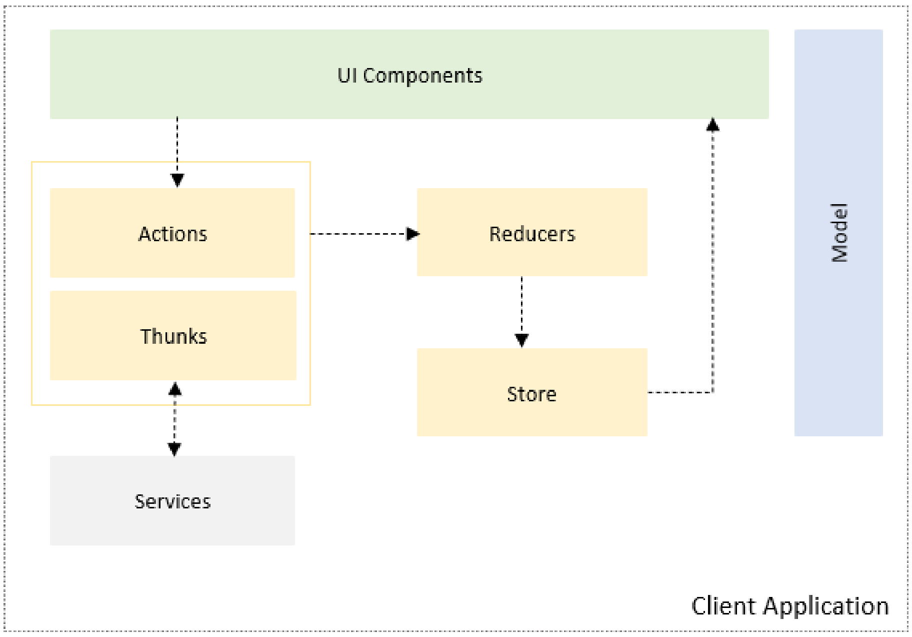


Figure 152: Admin client application architecture

The main components of the Admin Service are:

1. **Controllers**: Controllers are the entry points to the service functionality. They are responsible for enforcing security constraints and invoking the appropriate services for implementing the requested operations.
2. **Services**: Services implement most of the application business logic. Each service is focused to a single aspect of the application functionality, e.g., the catalogue service handles all catalogue related requests while the workflow service manages application workflows.
3. **Repositories**: Repositories handle data access to external data sources. Admin Service repositories connect to two relational databases, the OpertusMundi shared database and the Camunda[33] workflow engine one.
4. **Feign Clients**: Feign clients implement HTTP clients for accessing external services required by the Admin Service such as the catalogue and the BPM engine services. They are used to decouple **Services** from network connection management and data serialization.

[33] https://camunda.com/

5.3.3. Frameworks

5.3.3.1. Spring

Spring[34] is one of the most popular and mature application development frameworks for Java, featuring a vast ecosystem of projects for developing applications from the mobile to the enterprise and cloud. Spring's vertical tool stack handles almost any programmatic task like security, data access, transaction management, social service provider integration, etc. Yet, its modular architecture allows using only the features required by the solution being developed. Despite its complex architecture, Spring's extensive documentation and supreme extensibility features allow developers to easily configure Spring to their needs.

The Spring Framework consists of several core modules that offer the basic building blocks for developing any kind of application. The features provided by the Spring Framework include:

- Inversion of Control (IoC) and Dependency Injection (DI) features for configuring the creation and managing the lifecycle of objects.
- Aspect-Oriented Programming (AOP) features for cleanly decoupling shared functionality such as transaction management and logging.
- Data Access features, including integration with object relation mapping APIs such as Java Persistence API [35] (JPA) or Hibernate [36]. Moreover, Spring Framework allows the combination of these APIs with features such as declarative transaction management using AOP as mentioned earlier.
- Spring MVC web application and RESTful Web Service framework for easily building web application and services.

5.3.3.2. Spring Boot

When developing an application using the Spring Framework many configuration options must be set either using external configuration files or programmatically. Spring Boot takes an opinionated view of the Spring platform by promoting convention over configuration and selecting sensible default values for most configuration settings. Thus, an application requires minimum configuration. At the same time, whenever the default values are not appropriate to the requirements of the application, they can easily be replaced with custom configuration options.

5.3.3.3. TypeScript

JavaScript is the most well-known scripting language for web pages. Despite its popularity, JavaScript does not support strong typing which results to problems that are hard to trace at runtime. TypeScript is a superset of JavaScript that introduces types. The use of types is optional and TypeScript code can coexist with JavaScript one. Still, using types and type inference, TypeScript allows developers to use static checking and detect possible bugs before executing

[34] https://spring.io/

[35] https://www.oracle.com/java/technologies/persistence-jsp.html

[36] https://hibernate.org/

their code. Moreover, by using modern development tools, they can perform tasks such as code refactoring and be more productive.

5.3.3.4. React

React is a JavaScript framework for building interactive User Interfaces. React can be thought as the View in the MVC pattern that allows building reusable UI components and promotes composition of existing ones. Each component maintains its internal state which controls the rendering process. It is also possible to create stateless components that inherit state information from parent components using properties, resulting in pure presentational components. Whenever state (or a property) changes, only the parts of the DOM that are affected are updated. This is achieved by using a virtual representation of the DOM that efficiently detects changes to the actual DOM. The latter feature makes React interoperability with other UI libraries more challenging. React adopts a declarative model for creating views with the help of JSX, an XML-like syntax with a smooth learning curve for developers who are familiar with HTML5 and CSS3.

5.3.3.5. React Redux

Redux is a predictable state container for JavaScript applications that is very popular for handling the increased application logic complexity that arises in Single Page Applications. In such applications, the state management becomes increasingly harder since various user interactions – which quite often involve asynchronous requests – result in state changes. Redux attempts to manage state in a predictable way by imposing specific restrictions on how and when state updates can occur. Redux makes a perfect match to React by deferring component state management to Redux. It was based on the principal ideas of Flux[37] for making the flow of an application unidirectional. The main difference Redux introduced is the core idea of keeping the state in a single store (following a Single source of Truth principle), instead of multiple stores. The single application state maps at any moment to its view representation via React UI components. User actions such as clicks may dispatch actions that change the state in a predefined way with the help of reducers that dictate how a specific action modifies the application state. In this manner, a one-way flow is achieved, making the application easy to reason about, debug and scale. The main components of the Redux pattern are:

- **Store**: In Redux the store holds the entire application state, which is the representation of the application at any given time. It is an object containing any number of valid JS data types, such as numbers, strings, boolean values, arrays, or other objects. A key concept is that the state object cannot be mutated directly, but only by emitting actions.
- **Actions**: Actions can be dispatched by user interactions or other actions and cause the state to change. There are two types of actions, simple and complex actions that execute with the help of a special middleware. Simple actions are plain objects containing the unique action type and any data that needs to be passed to the store. Complex actions are functions that get access to the state and can perform asynchronous operations (such as fetching data from a remote service) and/or orchestrate multiple simple action dispatches.

[37] https://facebook.github.io/flux/

- **Reducers**: Reducers are pure functions that determine how an action modifies the state. Multiple reducers can be combined, each responsible for mutating a specific part of the state. Reducers do not mutate the state, but instead return a new state object, which allows easy recognition of any changes so that the view can be updated.

5.3.3.6. React Router[38]

React Router is a JavaScript library that allows an application implemented using React and Redux to keep the application state in sync with routing information. This feature is achieved by automatically storing additional data about the current URL inside the state. This information is then propagated to React which can in turn suitably change the component tree rendering process.

5.4. Sales Manager

The component implements the web-based front-end and UI elements presented in Section 4 and is mainly implemented using the Vue.js[39] JavaScript framework. All other frameworks used are presented in Section 5.4.3.

5.4.1. Overview

The implementation follows the same principles presented in Section 5.1.1

5.4.2. Architecture

The architecture is based on the Vuex state management pattern, which provides a centralized store for all the components in the application, with rules ensuring that the state can only be mutated in a predictable fashion, thus helping code maintenance and reusability. The application structure of D2.2 has been extended with the following:

- Model: All the client-based types in TypeScript types describing the API:
  - Pricing Models
  - User Account
  - User Roles
  - Auth-specific values (CSRF[40])
  - Shopping Cart – checkout
  - Various configuration options (login type, language, etc.)
  - Assets (assets fields)
  - Server responses

[38] https://reactrouter.com/

[39] https://vuejs.org/

[40] https://en.wikipedia.org/wiki/Cross-site_request_forgery

    - Server requests
    - Errors
- Service: Various functions describing the business model
    - User
        - login: attempt to login user with provided credentials
        - logout: logout user
        - getUserData: retrieves all the user specific data
        - setProfile: updates user data
        - register: create new user account
    - Catalogue
        - find: catalogue search functionality
        - findOne: catalogue search functionality
        - create: create a catalogue item (asset)
    - Configuration
        - getConfiguration: get global configuration data
    - Cart
        - getCart: fetch all the user items on cart
        - addItem: add an item to cart
        - removeItem: remove item from cart
        - clear: remove all cart items
- Store: The part of the application which is responsible to manage the central state of the application. The store consists of multiple actions and mutators to help retrieve and store data from and to the central state.
- Components: Custom UI elements that can be reused in HTML composing the application UI (Footer, Header, Buttons, Search-field, Asset Card, Input field, etc.)
- Router: All application routes are defined here. The routing system is based on Vue-router implementation which is offering the following features:
    - Nested route/view mapping
    - Modular, component-based router configuration
    - Route params, query, wildcards
    - View transition effects powered by Vue.js' transition system
    - Fine-grained navigation control
    - Links with automatic active CSS classes
    - HTML5 history mode or hash mode, with auto-fallback in IE9
    - Customizable Scroll Behavior
- Views: Application single pages; each one is a composition of predefined components and corresponds to one or multiple routes in the Router definitions.

The component is packaged and deployed as part of the Store API Gateway service. Since all web applications are tightly coupled to the API Gateway due to API versioning, this is the preferred approach. Packaging is handled automatically during the build phase. Further, the application invokes all platform services *exclusively* via the API Gateway services, which is available behind a proxy service, allowing for simpler configuration, increased security, and a richer set of configuration options. The application is *agnostic* in terms of the actual back-end implementation, scheduling, and error-handling. In this setting, the API Gateway is responsible for scheduling and invoking backend micro-services and applications in response to the prototype's request, hence ensuring the platform's business logic is decoupled from the frontend. This greatly facilities the rapid development and alteration of business logic (expressed as workflows) with no changes required from the frontend.

In Figure 153, we provide a simple example showcasing how the front-end invokes the backend of the OpertusMundi platform via the API Gateway presented in D1.2.

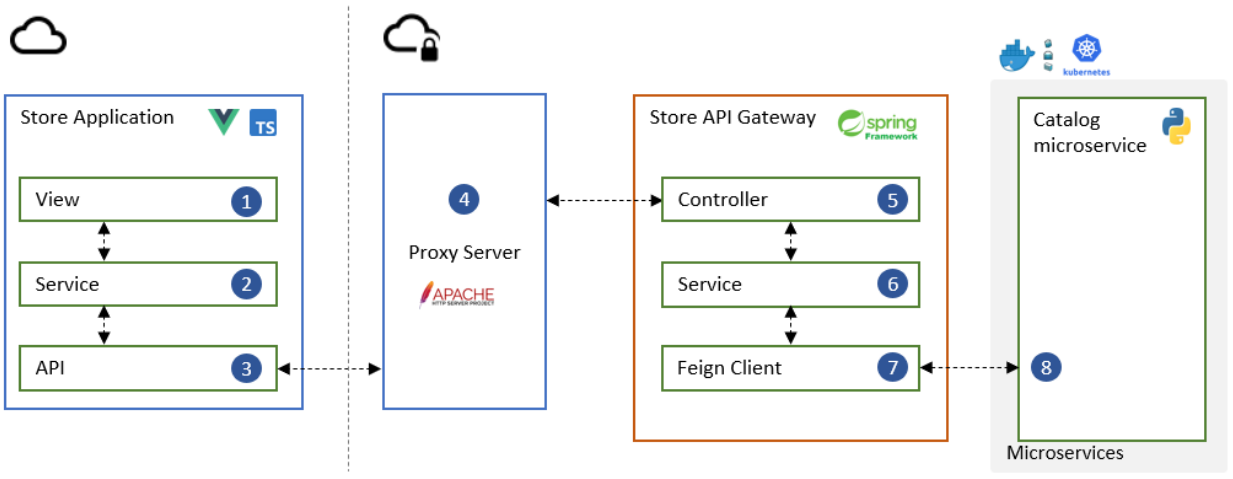


Figure 153: Backend invocation from front-end

A request to the backend is initiated by an event triggered either from a user interaction with a UI component or a scheduler. More specifically, the following steps are executed:

- *UI components are organized in views.* A user interacts with a view and triggers an event e.g., she requests a catalogue search operation.
- *The event handler invokes a service method.* Each service implements a specific segment of application functionality, e.g., the catalogue service is responsible for handling all catalogue related requests. The service creates a new request.
- *All services use the API utility service for submitting requests to the server.* API utility service is agnostic in terms of request payload and semantics and only implements generic HTTP methods[41] such as POST, GET, etc. The service sends the request to the Proxy server.
- *The proxy server routes the request to the appropriate application* i.e., the API Gateway.

[41] https://www.w3.org/Protocols/rfc2616/rfc2616-sec5.html

- All requests are handled by controllers. The API Gateway is implemented using the MVC[42] pattern. A controller receives the request, enforces security constraints, applies validation rules and optionally enriches the request with additional context data e.g., user authorization context. If the request is valid and access control is passed, the appropriate service is invoked.
- *A service implements the core business logic of the OpertusMundi platform*. To execute an operation, a service may invoke several other services, locally or remotely.
- *Remote services (e.g., the catalogue microservice), are invoked using a Feign[43] client instance*. A Feign client is implemented for each service and encapsulates the security requirements and API signatures of the service.

5.4.3. Frameworks

The implementation applies the same frameworks with those presented in Section 5.1.5.

[42] https://en.wikipedia.org/wiki/Model%E2%80%93view%E2%80%93controller
[43] https://spring.io/projects/spring-cloud-openfeign