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SmartHubs

Smart Mobility Hubs as Game Changers in Transport

WP6. SmartHubs Living Labs

T6.6 Analysis of hubs in the ODP

Deliverable D 6.5

Documentation and analysis of the SmartHubs Open Data Platform

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EXECUTIVE SUMMARY

The SmartHubs project introduces the Open Data Platform (ODP) which aims at collecting data on mobility hubs, allowing comprehensive mobility hub visualization and analysis. This deliverable highlights the key aspects of the ODP in terms of development processes, technical details, functionalities, and showcases the possible usage of the generated data in examples for analysis.

The SmartHubs project deals with mobility hubs in various forms – especially examining their levels of integration (physical, digital, democratic), establishing an ODP to gather data and allowing analysis of these levels. The ODP's objectives include providing a holistic view of existing mobility hubs and facilitating data collection in a multi-relational database. The iterative development of the ODP involved collaboration among project partners and other stakeholders like operators, facilitating the operationalization of SmartHubs integration levels.

The ODP utilizes Semantic Media Wiki and various open-source extensions for user management, visualization, and customization. Its data model is complex, supporting diverse functionalities like user distinction, search, filtering, comparison, submission, and visualization. Data analysis explores mobility hub initiators, types, networks, public transport modes, and integration levels. Comparative analysis with secondary data, such as the SmartHubs Accessibility Tool, enhances insights into hub inclusivity, density, and urbanization effects. The data in the ODP, available to the public through an export function, still offers various possibilities for analysis – especially regarding the spatial context and differences of the mobility hubs.

Developing the ODP revealed the need for documentation enhancements, data visibility improvements, and potential database restructuring. Gaps in available data hinder comprehensive analysis, signalling opportunities for gamification and community engagement. However, the SmartHubs project ODP offers a scalable platform for comprehensive mobility hub analysis, empowering stakeholders with valuable insights for informed decision-making and strategic planning in the transportation sector.

1. INTRODUCTION AND READERS NAVIGATION

The SmartHubs project deals with mobility hubs in various forms – especially examining their levels of integration (physical, digital, democratic – see Deliverable D2.1, Geurs et al. 2022) for more information) as indicators to be a gamechanger in transport. For this purpose, an Open Data Platform (ODP) was set up to (1) provide an overview of the mobility hubs with the four SmartHubs Living Labs and (2) to collect data on the existing mobility hub examples to derive their respective integration levels.

This deliverable should give an overview on the development process, technical details, functionalities, and possible usage of the generated data – each more or less relevant for different interest profiles regarding the ODP – a web-based system that makes a collection of datasets on mobility hubs (among other features) available for users and allows the visualisation of its components. The most important purpose of the ODP is to get a single point of access and overviews of the datasets to the consortium members, which have been and will be collected under common rules (see also Deliverable D2.1, Geurs et al. 2022).

Below you can find a fast-forward "readers navigation" to give you an indication which sections could be of interest depend on your profile.

Table 1 Navigation for interest profiles

Interest profile	**Highly relevant sections for respective profile**	**Page Nr.**
Mobility Hub – Operator: Are you running one or many mobility hubs and want to compare your hubs to other relevant examples?	3.3 Functionalities of the ODP	13
	4.3 Descriptive analysis	19
Mobility Hub – Planner: Are you in charge of designing and adapting new single hubs or hub networks and want to get to know possible configurations, typical service bundles, …?	3.3 Functionalities of the ODP	13
	4.4 Comparative analysis using secondary data	21
Open Source – Expert: Are you interested in open-source technologies, e.g. Semantic media Wiki and Extensions used in the ODP? Do you want to learn more on the data structure behind the ODP?	3.1 Semantic media wiki and extensions	12
	3.2 Data model	12
Mobility Data researcher: Are you used to combine, merge, and analyse different data from various sources? Are you interested in a better understanding of the mobility hubs types, service bundles and relation to their environment?	4 Analysis of ODP data	18
Mobility Hub – Collector: Do you know a lot of great mobility hub examples which you want to share with the world – maybe you even have pictures of it?	3.3 Functionalities of the ODP	13
ODP as a tool – Replicator: Do you want to learn more on the data structure behind the ODP? You are interested in applying the ODP-approach in your own project?	2. Setup process Smarthub Open Data Platform	8
	3.2 Data model	12
	4.5 Need for research and further analysis	25

We hope this navigation helps in finding the most relevant content in this deliverable. If you are reviewing the deliverable step-by-step, the following sections will describe the development process of the ODP (section 2), elaborate on the technical design and structure (section 3), introduce you into the various functionalities of the ODP (section 3.3) and finally also showcase some first exploratory data analyses (section 4).

2. SETUP PROCESS SMARTHUB OPEN DATA PLATFORM

2.1.Objectives

Project related objectives

In the context of the SmartHubs project, the following objectives were defined to be fulfilled by the ODP:

Strategic Sub-objectives (as defined in the proposal for the SmartHubs project):

- provide a comprehensive overview of the characteristics of existing and planned mobility hubs across Europe.

Operative objectives:

- The ODP gives an overview on the case studies within the SmartHubs Living Labs including their respective governance information which allows easy comparison between them.
- The ODP-team builds an online interface which allows a decentral collection of mobility hub learning cases by the whole SmartHubs consortium and external editors.
- The ODP operationalises the SmartHubs integration levels into online-survey-form which is easy to be filled in by relevant stakeholders.
- The ODP gives the possibility to collect data on the single hubs to derive the three integration levels for each hub in the ODP and makes the whole data set accessible as open data.

Overall objectives

In a bigger context beyond the SmartHubs project, following **overall objectives** are defined (which will be followed by the consortium partners after the project end):

- **Standardisation**: the ODP will support the standardisation of research, planning and evaluation of mobility hubs.
- **Variety**: the ODP will give an overview on mobility learning examples with different service combinations in as heterogeneous contexts as possible.
- **Integration**: the ODP will be integrated into other knowledge platforms (e.g. DUT) and open data initiatives (e.g. https://www.mobilitydata.gv.at/).
- **Education:** the ODP will serve as a framework for future student projects (e.g. thesis, seminars) to enable data collection and management.

Partly, there is the need for further technical and design developments on ODP to be able to fulfil the above-mentioned objectives – the SmartHubs team is open for any kind of cooperation (see section 6 for contact details).

2.2.Development steps and involved partners

The development of the ODP was organised in an iterative way (see Figure 1) involving the SmartHubs Living Lab Leaders as early as possible in the process (starting with Phase I). The first design was setup in collaboration between mobyome KG (subcontracted by UT), UT and TUW MOVE (Phase 0). After a first internal collection of examples (Phase II), the ODP was opened to the public for crowd-mappings (Phase III) to collect so called “Learning cases”. These were defined as mobility hub examples which either have a certain USP, reach high integration levels, or are in a certain spatial context. In Phase I and

II, additional data modules were also attached in the ODP to collect governance data related to the different Living Labs for example (see https://data.smartmobilityhubs.eu/wiki/Governance_Survey).

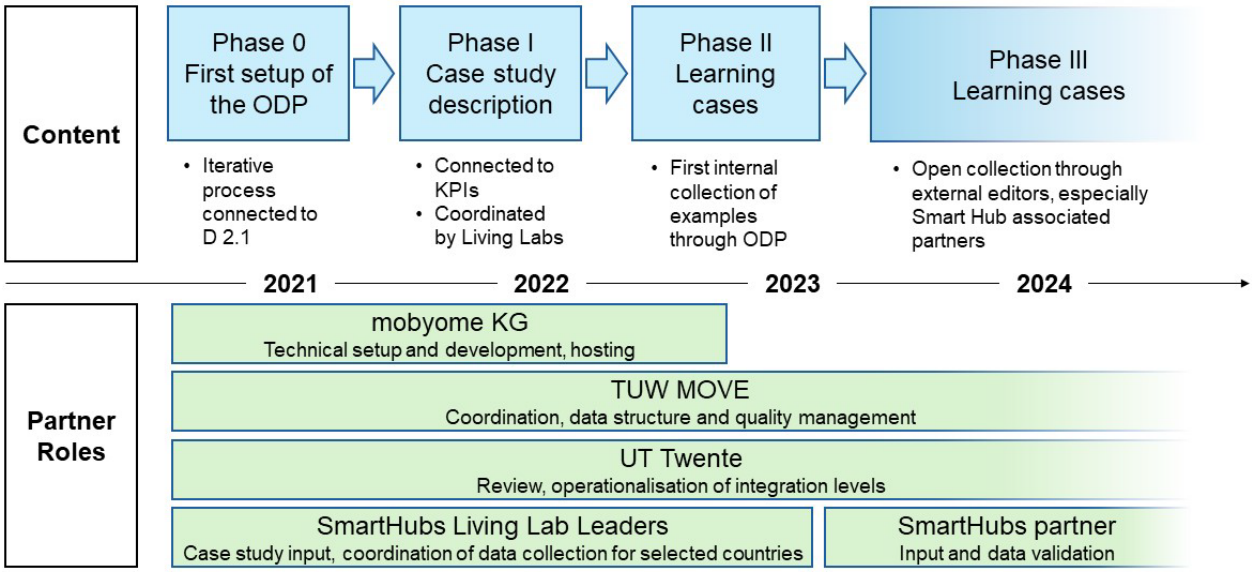


Figure 1 ODP development process

2.3.Operationalisation of SmartHubs Integration Levels

Genesis of the SmartHubs Integration Levels

As a first collective effort from the project team, parallel to the setup of the ODP, the SmartHubs Integration levels were developed and refined further. The first version was still only consisting of keywords to make the differences between the levels clear (see Figure 2), later in the process each pillar (physical, digital, democratic) within the integration levels was further differentiated (see Figure 3). See Geurs et al. 2024a and Deliverable 2.1 (Geurs et al. 2022) for more information on the SmartHubs Integration Levels. An example for the application of the differentiated integration levels can be seen via the handout on mobility hubs published by the province of Noord-Holland with UT and UUM (UUM 2024).

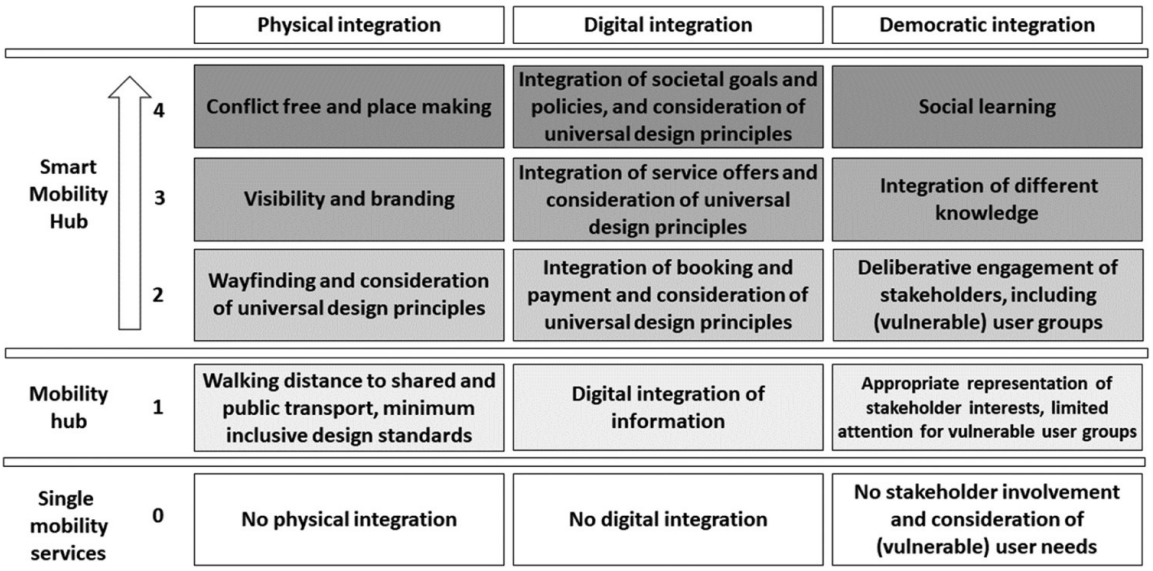


Figure 2 The SmartHubs Integration Ladder – summary, Geurs et al. 2024

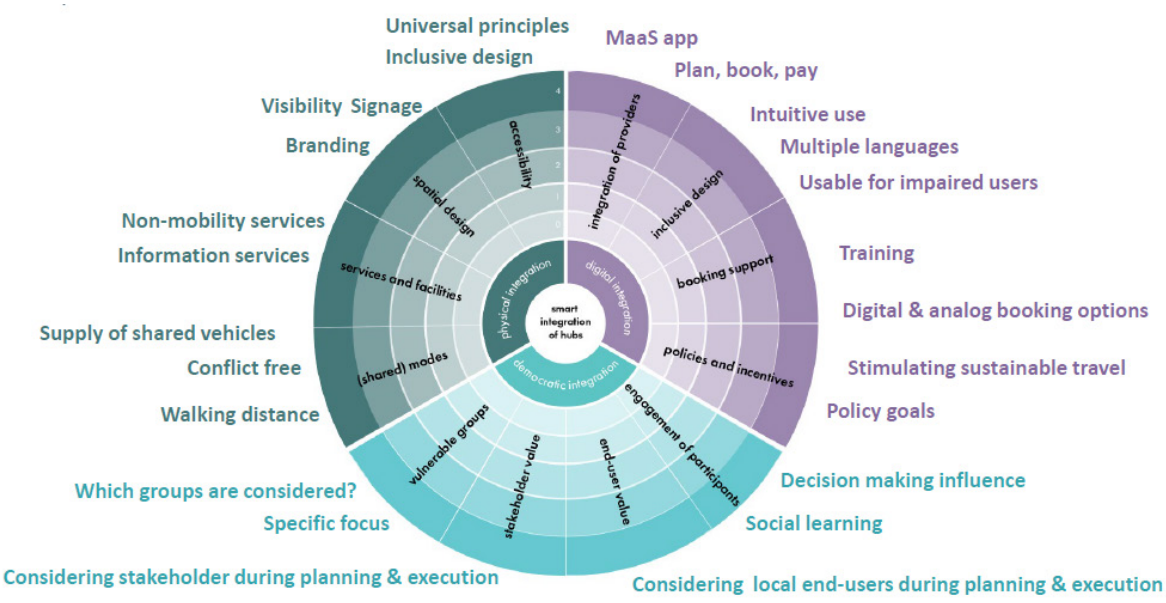


Figure 3 Sublevels for integration levels, developed by University of Twente 2023

Operationalisation in the ODP

In parallel to the process described above, a survey form was developed to be integrated into the ODP. For each pillar, questions were developed to collect the data needed to derive the respective level for a mobility hub. Below some examples for the operationalisation. To view the whole form, go to: https://data.smartmobilityhubs.eu/wiki/Special:FormEdit/semorg-hub-draft (for submitting a hub please use the submit button at the start page of the ODP).

Table 2 Examples for Integration Levels operationalisation

Physical Integration Sub-Level: services and facilities As for level 3 visibility and for level 4 conflict free accessibility needs to be approved for each mobility service at the mobility hub, this part of the survey is more demanding for the respondents.	Are there designated areas for the following **mobility services?** Carsharing ☐ in acceptable walking distance from PT stop (max. 400m) ☐ visible from PT stop ☐ accessible without conflict from PT stop (e.g. no crossing of street necessary)
Digital integration Sub-Level: Intuitive use For the digital integration levels, only a few checkboxes were necessary to indicate the levels.	Planner app ☐ The planner app has a simple and **intuitive design**. ☐ A multimodal travel planner is available with which at least public transport and one shared mode at the hub can be **planned**. ☐ Minimum **support for non-digital users** (trainings, volunteers for guidance, Call-Center, on-site support) is available. ☐ A multimodal travel planner is available with which at least public transport and one shared mode at the hub can be **planned, booked and paid**. ☐ A multimodal travel planner is available with which all modes available at the hub can be **planned, booked and paid**. (e.g. a MaaS app). ☐ **Analogue, on-site booking alternatives** are available for all modes. ☐ Shared mobility and public transport services available at the hub are **bundled**, e.g. through a subscription. ☐ Local, regional and/or national **policies and goals** are integrated into the service.

Democratic integration	How was the input/participation **valued**? ○ unknown ◉ The input of participants was not heard ○ The input of participants was valued ○ The participants who provided input received feedback on how their input was used
Sub-Level: Which groups are considered?	**Vulnerable users** (e.g. People with a low digital skill, reduced mobility, reduced vision and/or reduced cognitive abilities)
Filter questions are used to hide further questions and prevent survey fatigue at this final part of the survey in the ODP.	☐ The needs of vulnerable users were included in the participation process (surveys, interviews of intermediary institutions, ...)

For some parts of the form, explanations were added on not so commonplace or not well-known terms like placemaking, minimum legal inclusive design and universal design principals. This should allow the respondents to easily answer all questions without misunderstanding. A pre-test with the Living Lab Leaders supported in refining the survey. Analysis of the derived integration levels can be found in section 4.3.

3. TECHNICAL DESIGN, STRUCTURE AND FUNCTIONALTIES OF THE ODP

In the following sections, more detailed information will be provided on the backend, powering the entire ODP. The original inspiration and first structural-blueprint was derived from the platform mobil-am-land.at, operated by mobyome KG, an impact oriented company from Austria subcontracted by UT in the course of the SmartHubs project.

3.1.Semantic media wiki and extensions

As described, the technical setup was provided by Tobias Haider and Matteo Stark from mobyome KG. The ODP uses Semantic-media Wiki, a framework for multirelational databases which allows data to be structured and displayed in various forms. This technology is an extension of the MediaWiki, which supports Wikipedia. For a detailed overview on the whole set of technologies used for the ODP see: https://data.smartmobilityhubs.eu/wiki/Special:Version.

Additional open-source extensions are used for the ODP to meet the project requirements, e.g.:

- Semantic Organization (developed by mobyome KG): enables user management
- Semantic Result Formats: adds large number of further result formats
- SmartHubs extension (developed by mobyome KG): specific extension for the SmartHubs project
- LinkLogin (developed by mobyome KG): allows to automatically authenticate users with a hash in a link
- Maps: allows embedding of dynamic maps into wiki pages using Google Maps or Leaflet.

Following so called skins (which are enhancing the design of the frontend) are used for the ODP, e.g.:

- Tweeki (developed by mobyome KG): helps to implement “bootstrap” functionalities
- Vector: modern version of MonoBook with fresh look and many usability improvements

As a “side effect” during setup and further developing the ODP, extensions maintained by mobyome KG also were improved or even new extensions were programmed. Using Open Source software for the ODP brings additional benefits like transparency on the used code or the possibility to easily add new extensions if relevant.

3.2.Data model

Several lists in the database are used to collect data on the mobility hubs, related networks, and research projects. Some lists are not used anymore as the form design for hubs changed – especially for mobility services which are no longer recorded including the respective operator (see lists on the right side of the data model - Figure 4). The figure also showcases the complexity of the data-set – which makes the analysis partly more complex (see section 5). The data model can only be changed by the IT-development team at mobyome KG – not the Admins from the SmartHubs project.

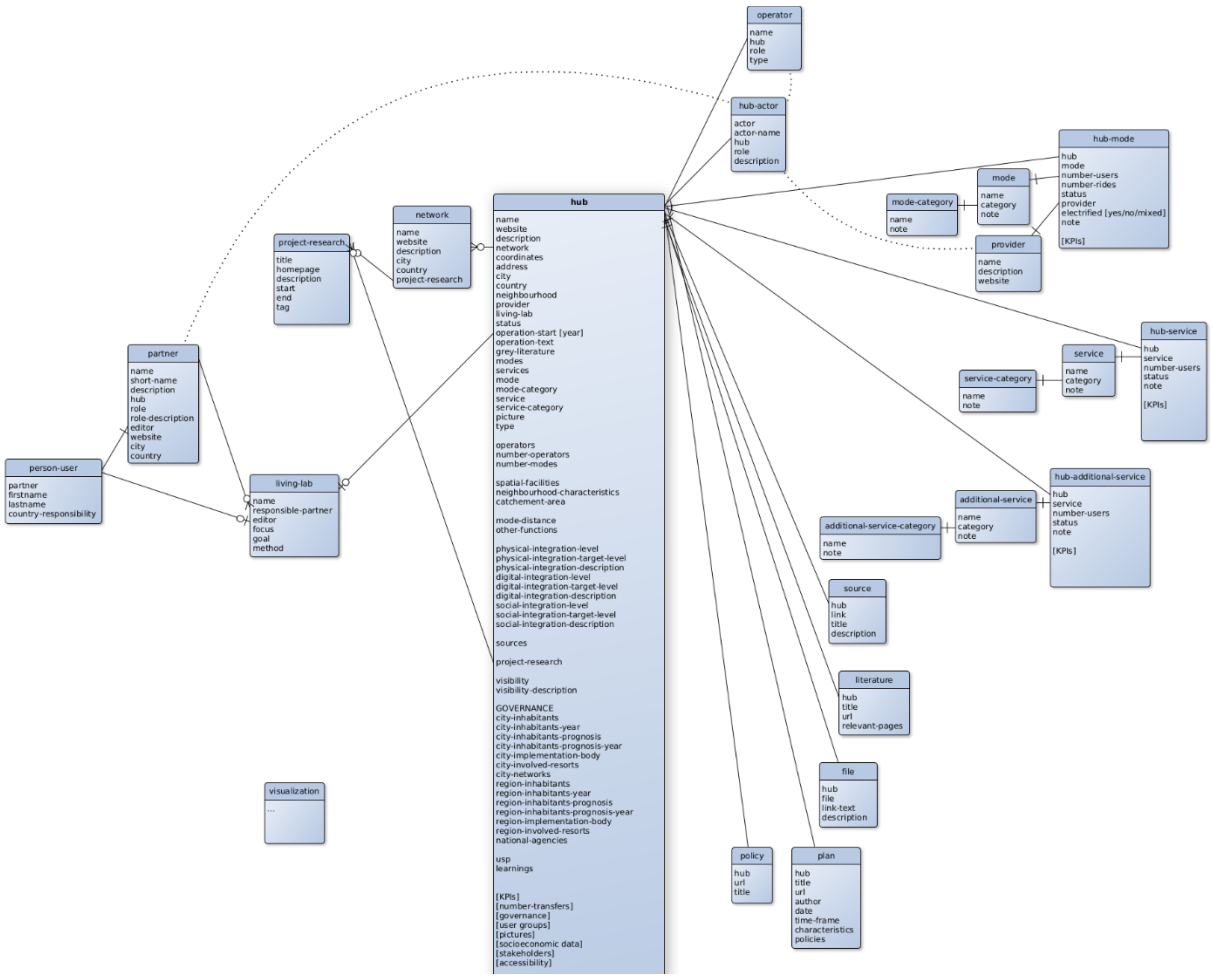


Figure 4 ODP data model

3.3.Functionalities of the ODP

User types

In the ODP, a distinction is made between an internal (with login - editors) and external view. While normal users see all hubs, for the SmartHubs consortium there is a clear distinction between learning cases (collection of well-equipped mobility hubs across Europe) and case studies (single selected hubs in living labs with defined location and more detailed information on the ODP). Also interested persons outside of the SmartHubs project can become editors in the ODP (see section 6 for contact details).

A special form of user is enabled via the LinkLogin feature: selected hubs can be made available for stakeholders like mobility hub operators to be able to edit all data (see Figure 5). Via a dedicated link these stakeholders can directly access their hubs and start editing (see Figure 6).

Figure 5 LinkLogin feature user page

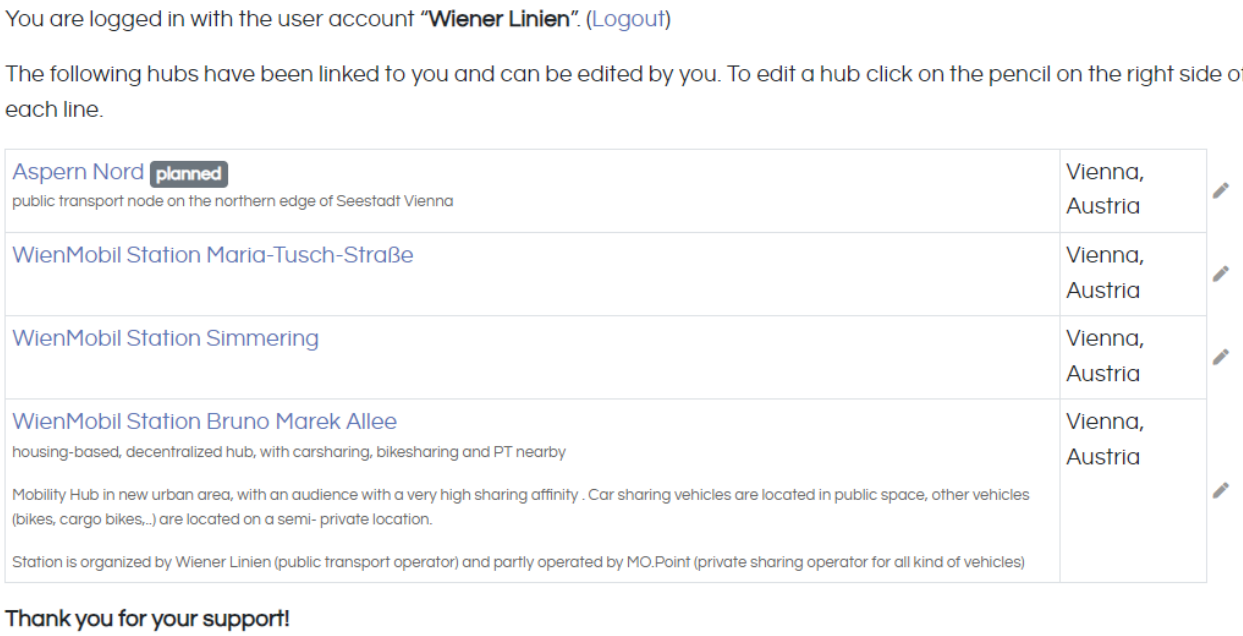


Figure 6 LinkLogin editing page

Search and filtering

As a visitor of the ODP, there are three options to search: (1) by using the search field in the upper right corner (here all pages in the ODP can be found like networks, research projects etc.), (2) by using the map interface and selecting a hub there or (3) by scrolling through the overall list of mobility hubs sorted from A to Z.

Filtering is possible on many ODP - overview pages (like Hubs Integration Levels, Hubs Cards etc.) – and filters can be customized per page depending on the relevant aspects (see Figure 7). The Smartness indicates if a mobility hub reached at least level 1 (="Mobility Hub") or level 2 (="Smart Mobility Hub") for all integration pillars. Entries in the ODP which don't reach Level 1 in any of the pillars, are defined as "Singel Mobility Services". Filters can be combined to find specific combination of features.

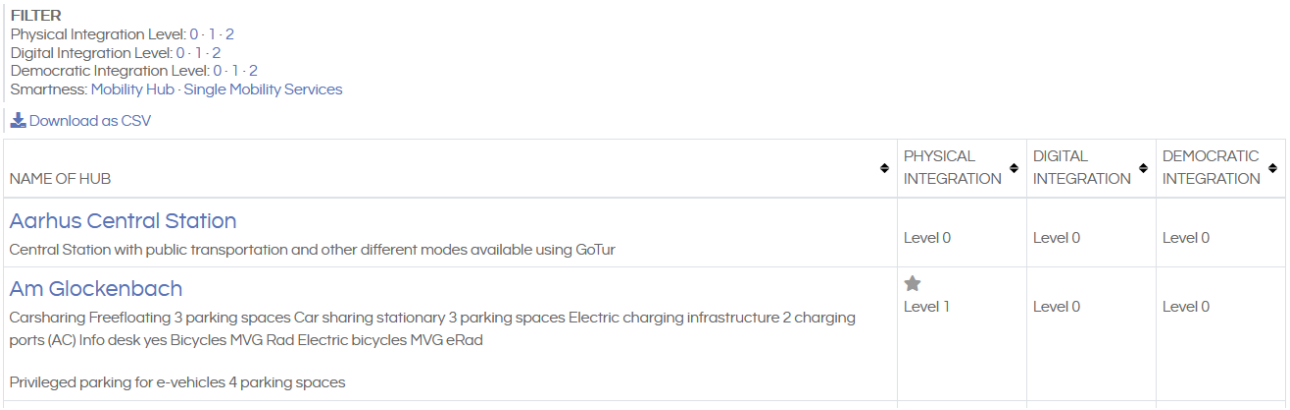


Figure 7 Example for filtering

Comparing hubs

When the user has found a mobility hub of their interest, they can compare the respective hub with other examples in the ODP. As a default, the other hubs are displayed which are the same type, status and integration levels. These comparison filters can be customized depending on your specific interest.

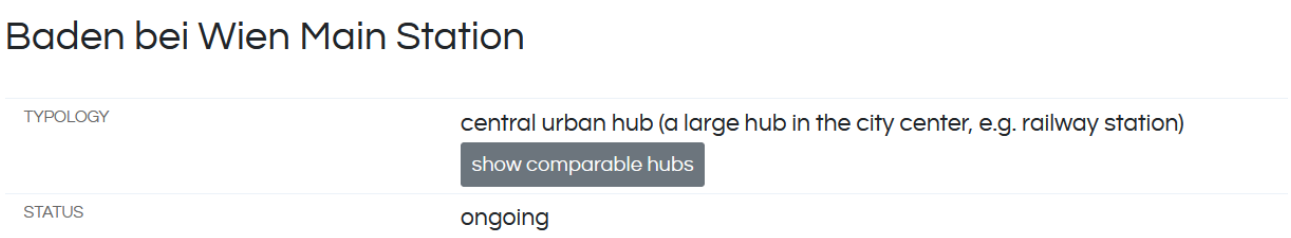


Figure 8 Comparing function

Creating or editing a hub / network / research project

As editor, you can directly create a hub, mobility hub network or research project (without the need to wait for a submission check by an admin user) and create links between the aforementioned elements. The displayed form is the same as when editing a hub example.

Figure 9 Network - hub links

Submitting a hub

If you are missing a relevant learning case on the ODP, as a visitor you can submit your example through the submit button on the ODP-start page (https://data.smartmobilityhubs.eu/wiki/Main_Page). For your submission, you should have information on the status, location, operator, available information / booking channels, participation measures implemented and mobility (related) services available at the hub. But also if you only have parts of the information needed, we are happy to get informed about new examples for further research – with information on the operator it is more easy then to collect the data needed. Finally, a picture of the hub can help to give visual inspiration on the design of mobility hubs.

Admin users can then review the submitted data (see Figure 10) and if provided contact the submitter for further information on the example.

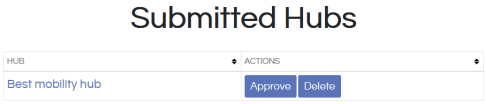
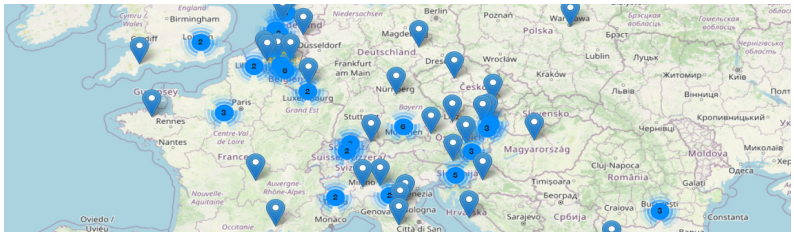
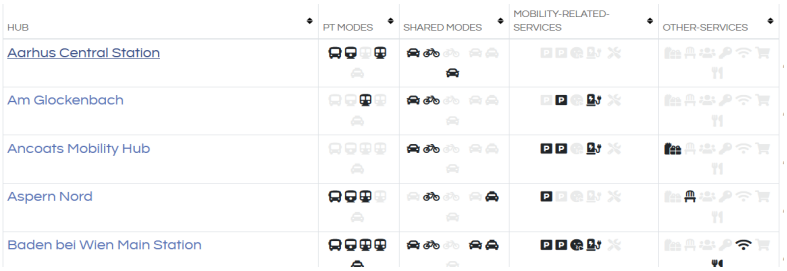
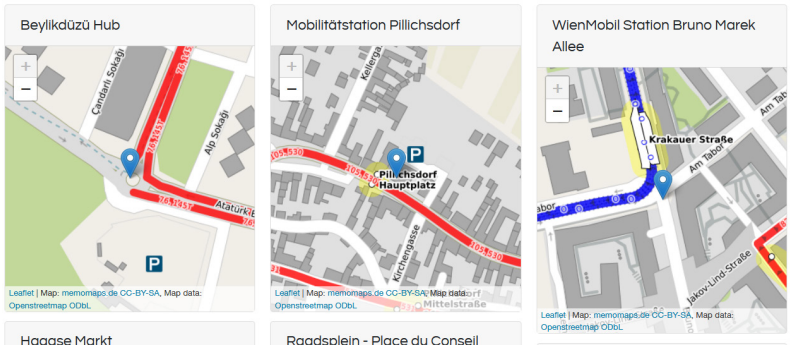
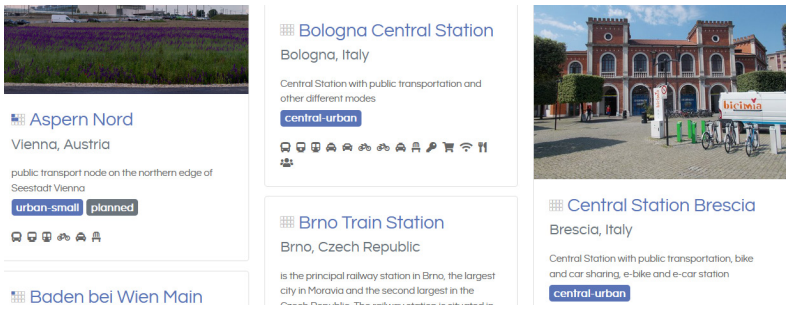
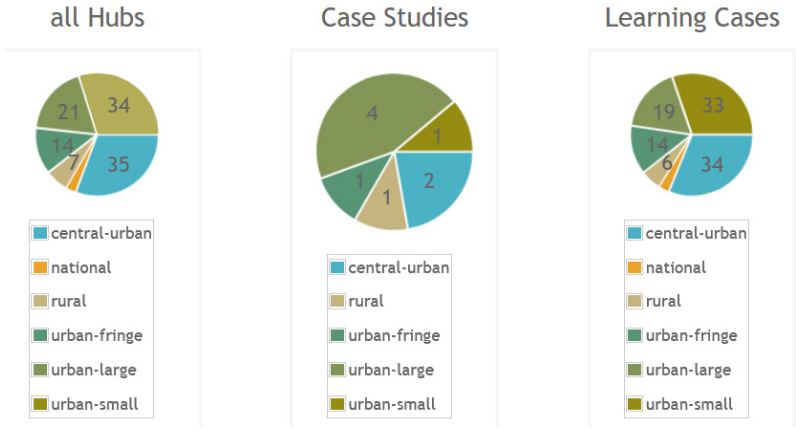


Figure 10 Admin view on submitted hubs

Visualising hub data

As stated above, thanks to the open-source community, various visualisation types are possible within the Semantic Media Wiki extension (and the possibilities are steadily evolving). Table 3 below shows some examples used and indicates links to view the visualisation in the ODP.

Table 3 Examples for visualisation types

Map overview	Main Page	
Using leaflet, a fast overview can be given on the distribution of hub locations across countries – and after zooming in also on local level.		
Service overview	Modes and Services	
To give a fast visual impression on the overall service offer at the hub examples, icons are used in a table view. Also, service bundles can be identified in this view.		
Hub context maps	Case Studies Maps	
To get an impression on the various spatial context the hubs are located in, small maps, which are generated automatically based on the indicated locations, are displayed next to each other.		
Hub cards	Main Page	
The cards include the most relevant information on the hub, including a picture if uploaded and icons for available services. Filters can be applied to show hubs with specific features.		
Pie charts	Hub Typologies	
Different kind of diagrams can be produced and updated automatically (pie charts, car charts etc.). Partly interactive elements can be included (like filtering in the diagram).		

Quality management

As admin, several options exist per default in the semantic media wiki extensions to ensure good data quality. First, admins will receive an email containing any changes made in the ODP – this can help identify bots active on the platform. Users with unusual behaviour can be blocked by admins. Furthermore, after changes have been made, admins can see all changes made by users, and duplicate users can also be recognized automatically. As additional measure within the SmartHubs project, a list with all hubs with integration levels 0 were exported and checked again regarding data availability (to be able to exclude hubs from analysis where data is just not accessible).

Export

One central aspect of the ODP is the possibility to export all datasets available. On the export page (https://data.smartmobilityhubs.eu/wiki/Data_Export) different levels of details are available to be exported in CSV format. If users are missing a certain dataset (see Figure 4 ODP data model to view all datasets and their relations), the SmartHubs team is happy to support by creating a custom export depending on your needs. Basically, also an API can be offered (please reach out the team for support). For the following analysis, a combination of exports was used and integrated into one table.

4. ANALYSIS OF ODP DATA

The data available in the ODP was collected by a continuous effort coordinated by the core partners in the SmartHubs project as editors (responsibilities for dedicated countries were defined) and the living lab leaders which especially added data on their selected case studies. Online-Datathons to support and motivate the editors and presentations of the ODP at the regular SmartHubs symposia generated attention for the ODP.

The exported CSV data allows users the ability to analyse hubs in more detail. For first insights, an exploratory approach was chosen to examine and explore the data to understand its structure, identify patterns, and (re-)formulate hypotheses for further investigation. Some findings are showcased in chapter 4.3 and 4.4.

4.1.Data preparation and workflow

The ODP data sets are available for download from the website. As several data sheets are created, it is important to get an understanding of the structure and content of each CSV sheet (e.g. identify common fields), cleaning the data from inconsistencies (e.g. spelling errors) and standardize column headers before merging the sheets.

After creating a merged dataset, it was crucial to validate the data, so each hub contains its correct information. The dataset contains 154 hubs and description in 106 columns in main categories:

- Location
- Hub description
- Services
- Information on physical, digital and demographic integration

Specific data depending on needs in the analysis was split in separated sheets. This helped organizing the data and made it easier to analyse.

4.2.Goals and research questions of the analysis

The goal of the analysis was to showcase the potentials of the data and collect ides for visualisation which could be automated in the ODP. A complete analysis of the dataset would have been too extensive for the project lifetime. We chose two directions of analysis:

a. Descriptive analysis of the ODP dataset
b. Intersecting of the ODP dataset with other data (e.g. GIS data, data from the Accessibility Tool)

Before analysing the data, several research questions were formulated, e.g.:

- Who initiated the hubs?
- What hub types are collected on the ODP?
- How many hubs are part of a hub network? What modes do they contain?
- Do hubs which are part of network have higher integration levels than “single” hubs?
- How is the accessibility of the hubs types in terms of walking and cycling?

4.3.Descriptive analysis

A first analysis shows the initiators of the mobility hubs. 93 from 140 hubs (66%) were initiated by the government, 28 (20%) by public transport providers and 14 (10%) by private companies. Only two were initiated by the local community.

Figure 12 shows the types of hubs within the ODP. More than half of the hubs are urban-small and central-urban, One third urban-large and urban fringe. The least are the types rural and national (e.g. a port).

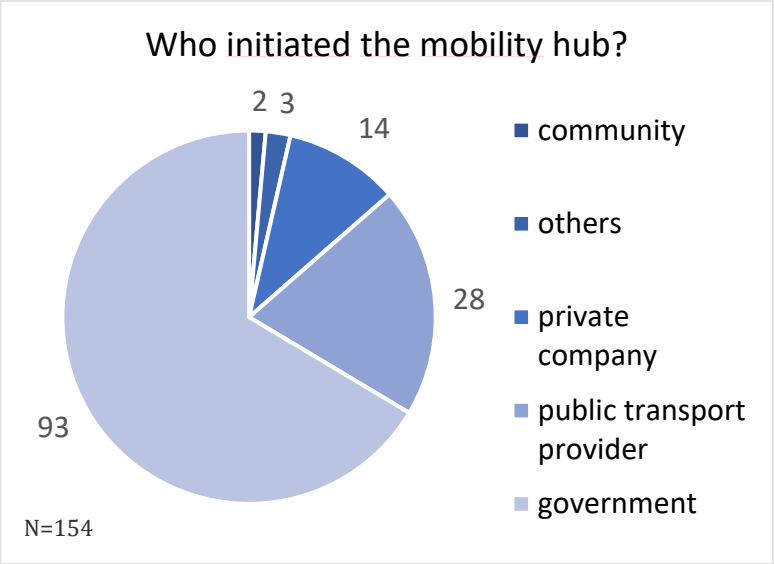


Figure 11 Initiators of hubs

The types were derived from an extensive collection of typologies in Deliverable 2.1 (Geurs et al. 2022, page 13-14) and can be described as follows:

- central urban hub - a large hub in the city centre, e.g. railway station
- urban neighbourhood hub – small (a couple of shared vehicles)
- urban neighbourhood hub – large (a substantial number of shared vehicles)
- suburban / urban fringe hub - a hub at a motorway and/or railway near a city
- rural hub - a hub in a rural area
- (inter)national hub – airport
- Other, e.g. business park hub

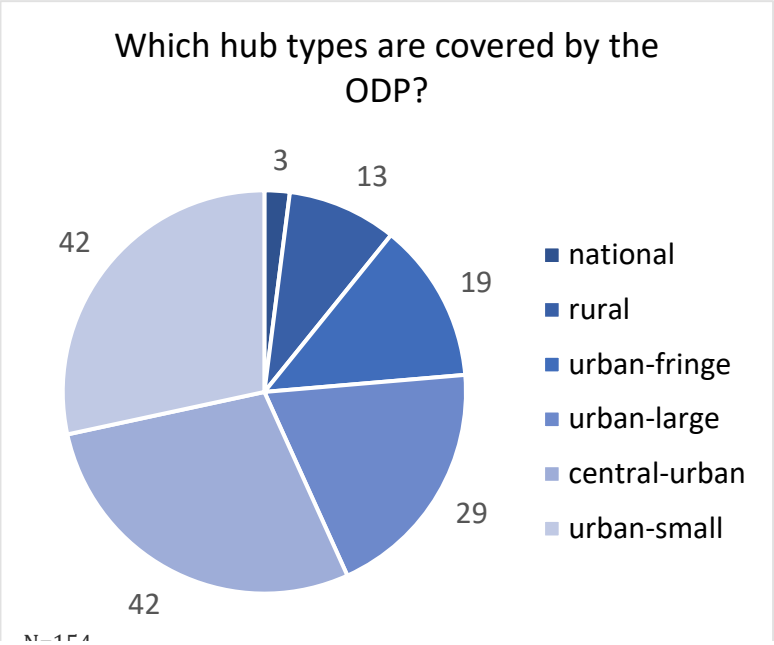


Figure 12 Types of hubs within ODP

A mobility hub network refers to a system of interconnected transportation hubs designed to facilitate seamless and efficient travel within a city or region. The most hubs are part of the Hoppin network (Belgium) with 20 hubs, Mobipoint (Belgium and France) with 16 hubs and eHubs with 10 (see Figure 13). Most of the networks showcased on the ODP contain only one hub. It should be noted here that this does not reflect reality, but only the hubs that have been entered in the database. WienMobil, for example, has more than 100 stations with several combined mobility services (carsharing, bikesharing, bike service etc. – see https://www.wienerlinien.at/wienmobil/stationen).

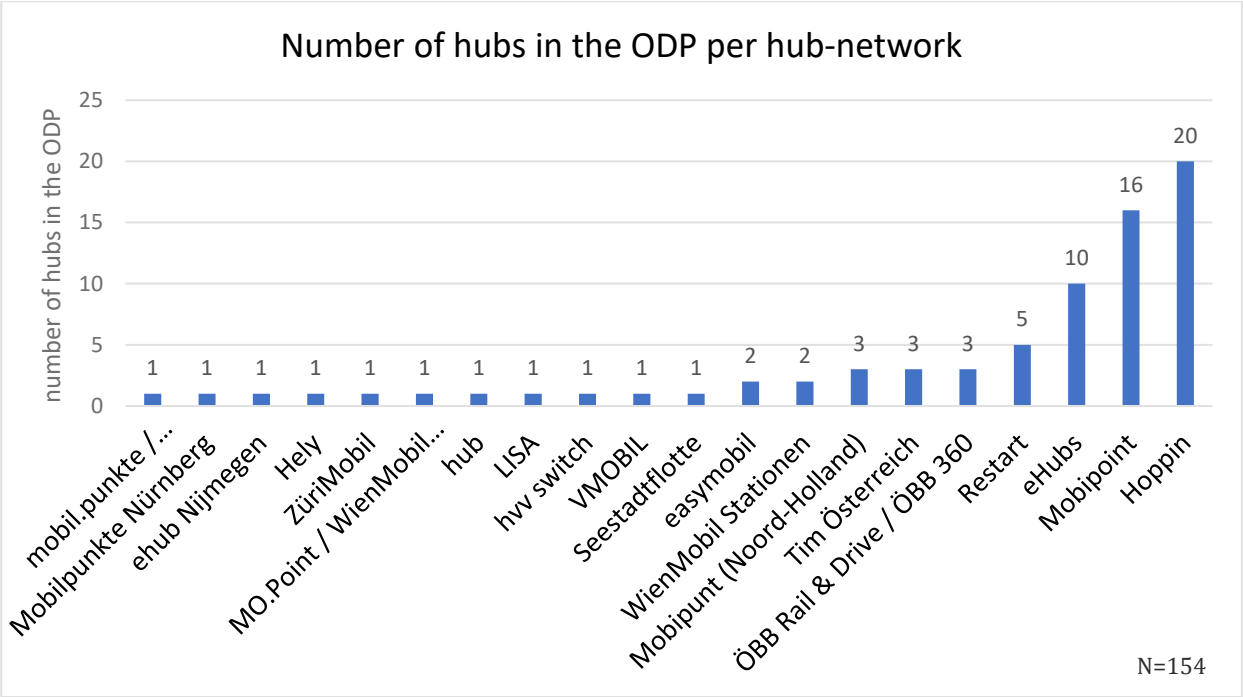


Figure 13: Number of hubs per hub-network

A hub can contain different modes of public transportation. Figure 14 shows the availability of modes at the hub. From 154 hubs, 136 (88%) provide a bus, 60 (38%) a train connection, 39 (25%) a tram and 30 (19%) a metro line. Demand transportation is the least offered mode at hubs with only 9 (5%) out of 154.

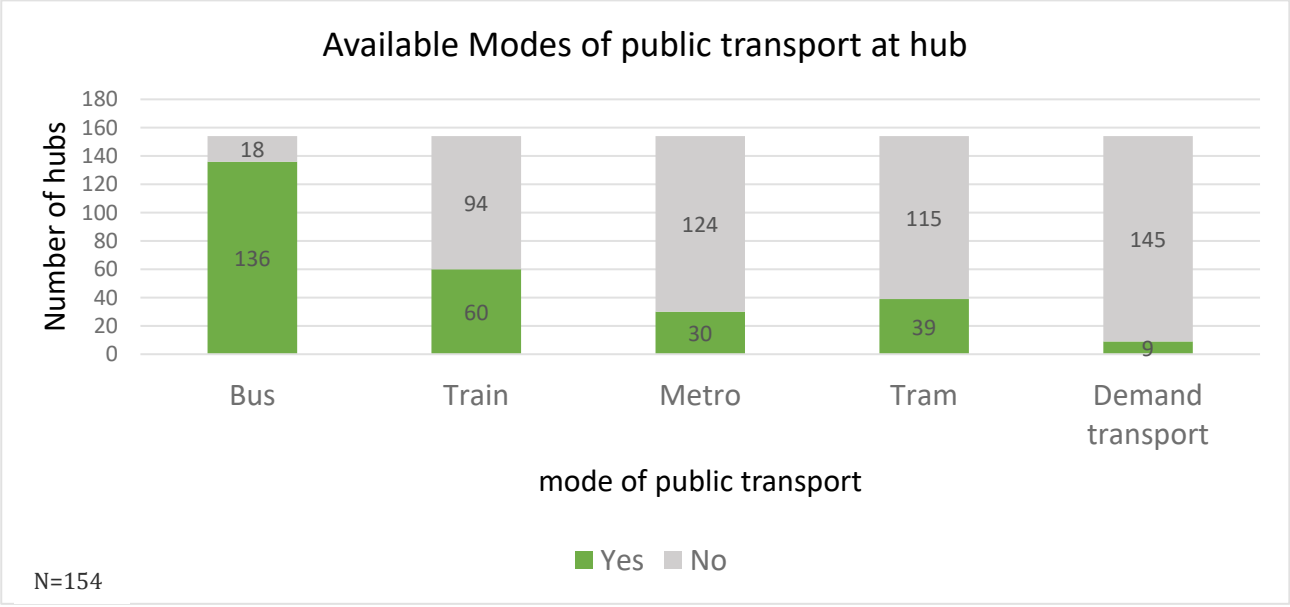


Figure 14: Modes of public transport available at the hub

Figure 15 shows the number of available public transport modes. This shows that at most of the hubs at least one or two PT services (the most occurring ones are: bus, train, tram – see Figure 14) were available. Only in the 10 of the hubs 4 PT services are available.

Figure 15 Number of PT-modes at hubs

Looking at the analysis of the Integration Levels in Figure 16 (originally from the SmartHubs Final Report, Geurs 2024b) it can be seen that at least level 1 regarding physical integration is achieved by 35% of the hubs. For digital and democratic integration there seem to be less examples in the ODP which manage to reach at least level 1. The data on hubs with a 0 for all levels were double checked by the SmartHubs team by involving stakeholders and operators.

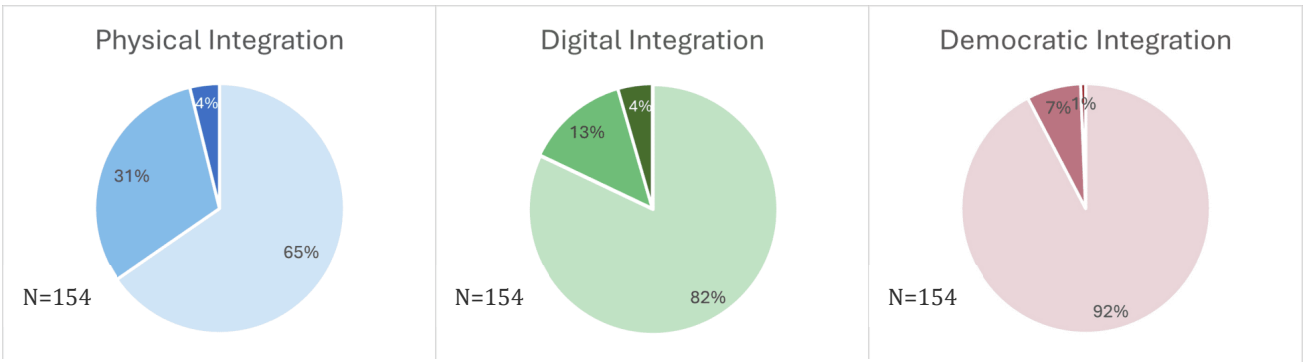


Figure 16 Analysis of integration levels

4.4.Comparative analysis using secondary data

Application of SmartHubs Accessibility tool

See Deliverable 5.2 (Nichols et al. 2023) for documentation and detailed analyses for SmartHubs Living Labs using the SmartHubs Accessibility Tool. For the ODP-analysis, the geolocation of the mobility hubs in the database were uploaded into the SmartHubs Accessibility Tool, which allows then to download the POI data within a defined time range per mode for multiple hubs (=geolocations) at once. For each mode, settings can be defined regarding travel time and speed. For the data used later, the defined settings for all modes where: 15min, slow, as shown in Figure 17.

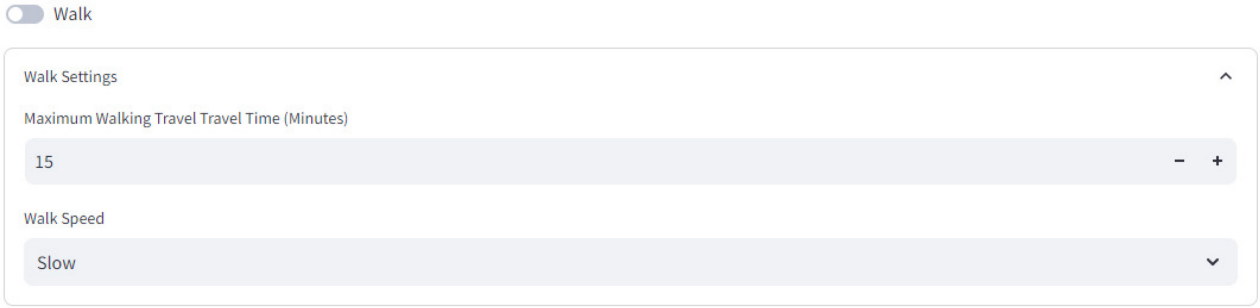
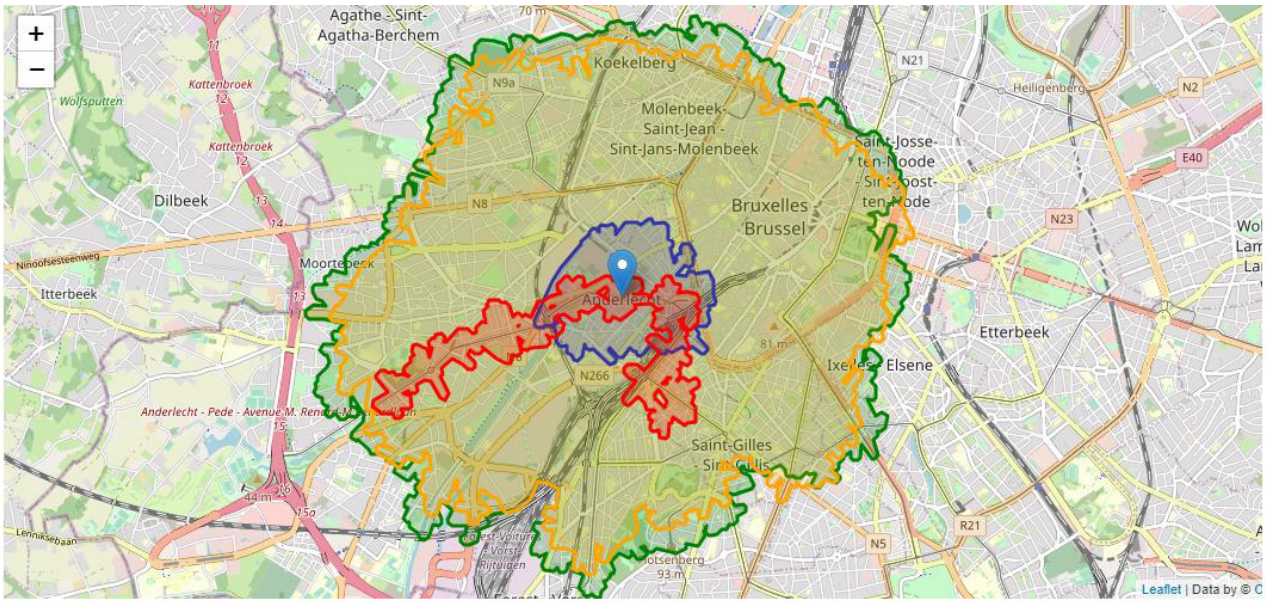


Figure 17: Example for modification in the Accessibility tool

The following figures show a comparison of a base scenario (walking and public transport) to a potential future scenario where shared bike and e-scooter are also available. The integration of additional modes might lead to better access to more amenities (e.g., restaurant, education, healthcare).



	id	mode	Restaurant/Cafe/Bar	Education	Service	Healthcare	Supermarket	Entertainment
0	hub1	Walk	74	5	20	19	6	1
1	hub1	Bike	1731	64	213	228	71	10
2	hub1	E-Scooter	1638	58	202	201	65	9
3	hub1	Public Transport	83	1	24	21	6	1

Figure 18 Place du Conseil - After Scenario

Combining the data from the Accessibility Tool with the dataset from the ODP, additional analysis can be accomplished. The following Figure 19 and Figure 20 illustrate the relationship between available amenities around the mobility hub and its physical integration level. Looking at the average sum per each integration level, for both accessibility by cycling and walking, higher numbers of integration levels also come up with higher average numbers of amenities.

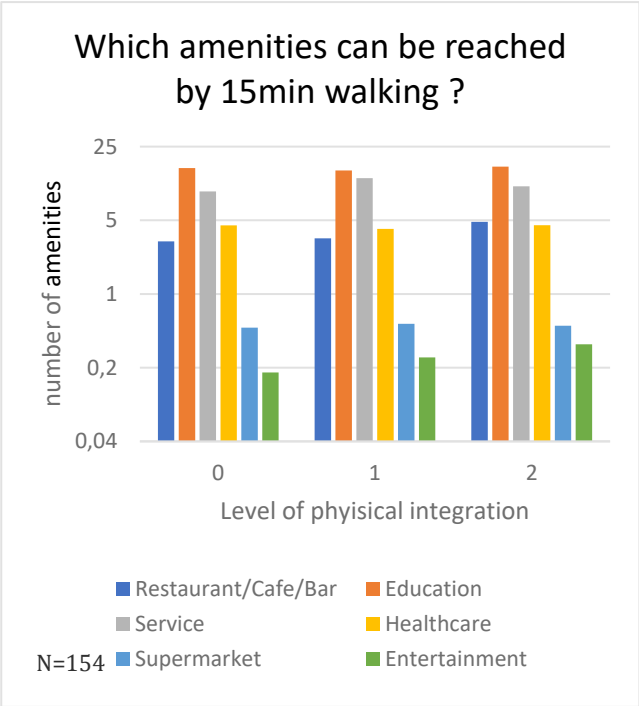


Figure 20 Services reached within 15 minutes of walking by integration levels

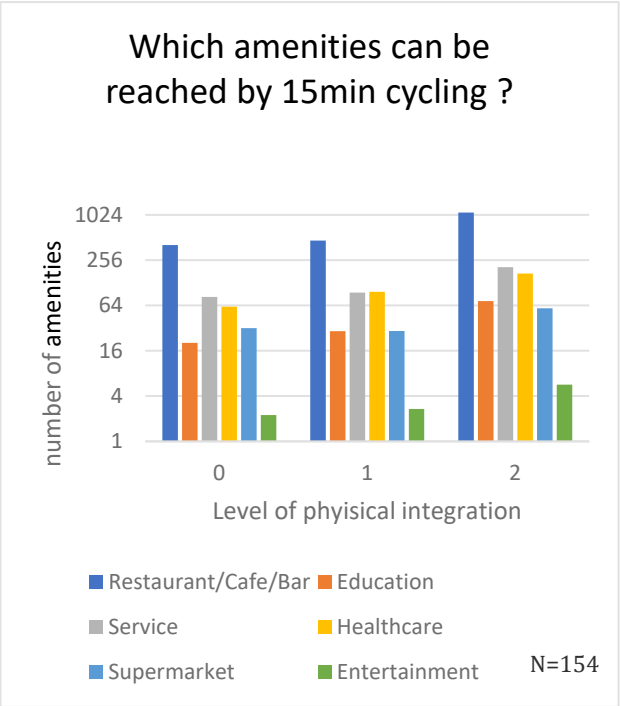


Figure 19 Services reached within 15 minutes of cycling by integration levels

The following Figure 22 shows the accessibility of the two amenities "Education" and "Supermarket" and the hub type. It becomes clear that in the urban context (urban-large, urban-small and central-urban) more amenities can be reached by 15 minutes cycling than on the urban fringe or in the rural areas. This seems logical as the density of supermarkets and educational amenities is higher in urban areas. The difference between rural and urban hubs becomes even clearer when it comes to walking modes. Here, only very few facilities can be reached on foot in 15 minutes (see Figure 21).

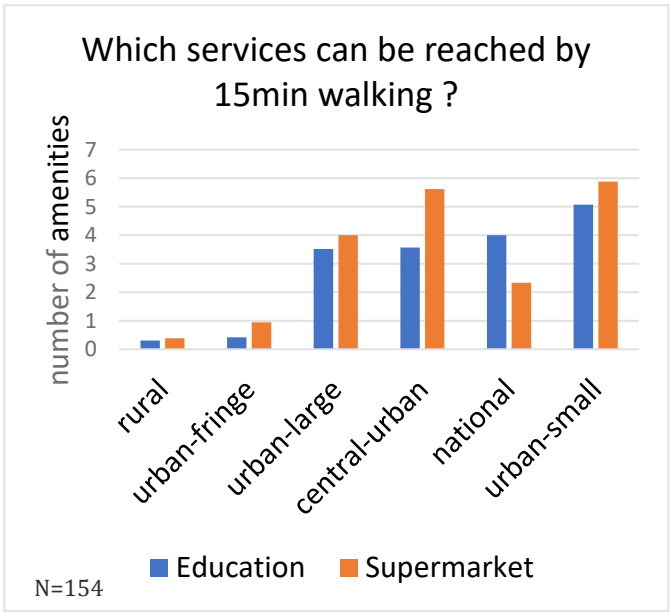


Figure 22 Amenities reached within 15 minutes of walking

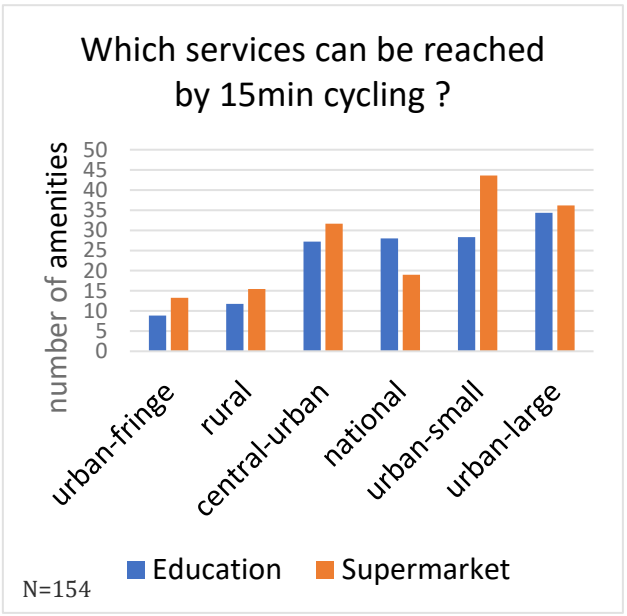


Figure 21 Amenities reached within 15 minutes of cycling

Based on the data from the SmartHubs Accessibility Tool, type of hubs where clustered following the number of health care facilities in 15min walking time around the hub (see text box in Figure 22 for definition).

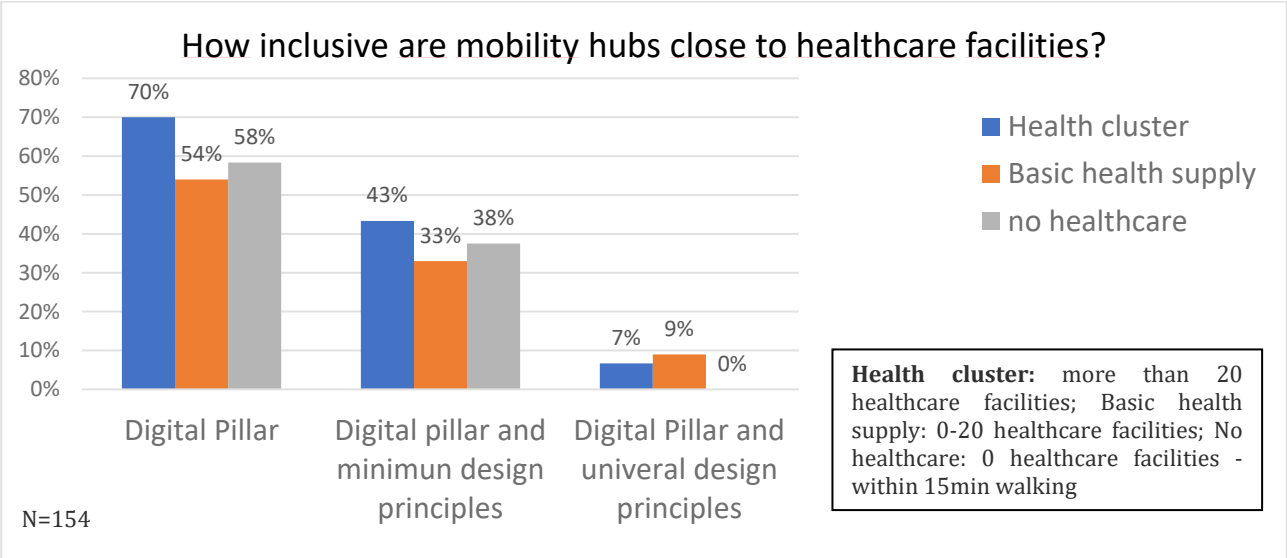


Figure 23 Inclusiveness of mobility hubs close to healthcare facilities by 15 min. walking;

The inclusiveness by digital offers is an important aspect especially close to healthcare facilities since these locations see a high number of visitors who are vulnerable-to-exclusion (e.g., without possibilities for booking via smartphone). Figure 23 shows that digital offers vary but are quite similar in the context of provided healthcare. Slightly more inclusivity in health clusters can be recognized when 70% provide digital pillars, 43% provide digital pillars and minimum design principles. This slightly higher number could be a coincidence and can be interpreted as the planning of hubs in the vicinity of healthcare facilities does not pay particular attention to the design of the digital offering.

This perspective opens opportunities for the specialization of hubs based on the needs of specific user groups. By identifying areas with a higher concentration of certain demographics or health concerns, practitioners can tailor the services offered at each hub to better meet the needs of the local community.

Density

Population density can be derived from EUROSTAT data on population (status 2021, not available for UK and Turkey) at the 1km grid level (EUROSTAT 2024). Combined with the location of the mobility hubs in the ODP, a distribution of densities around the hubs can be visualized. Roughly 30% of hubs are located in areas with less than 2000 inhabitants / km2 – which for areas within cities can be called low density areas (see Figure 23).

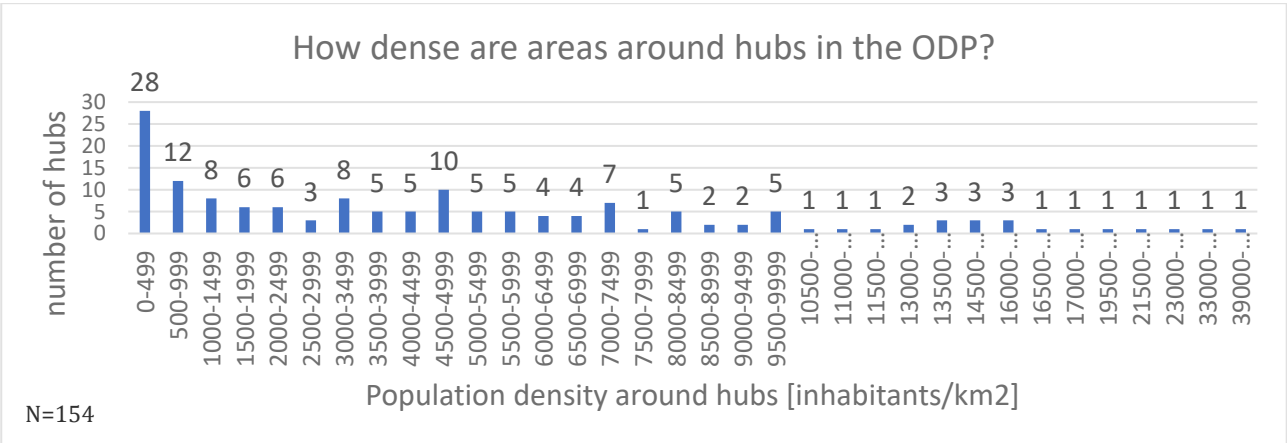


Figure 24 Density around hubs

If we have a look at the average density per hub type (see Figure 24), clear tendencies for lower values for rural and urban-fringe hubs can be seen, as is expected. Comparing urban-small with urban-large hubs, it seems there is no direct link between the size/offer at the hub and the population density around (as many other types of users are using urban large hubs as well).

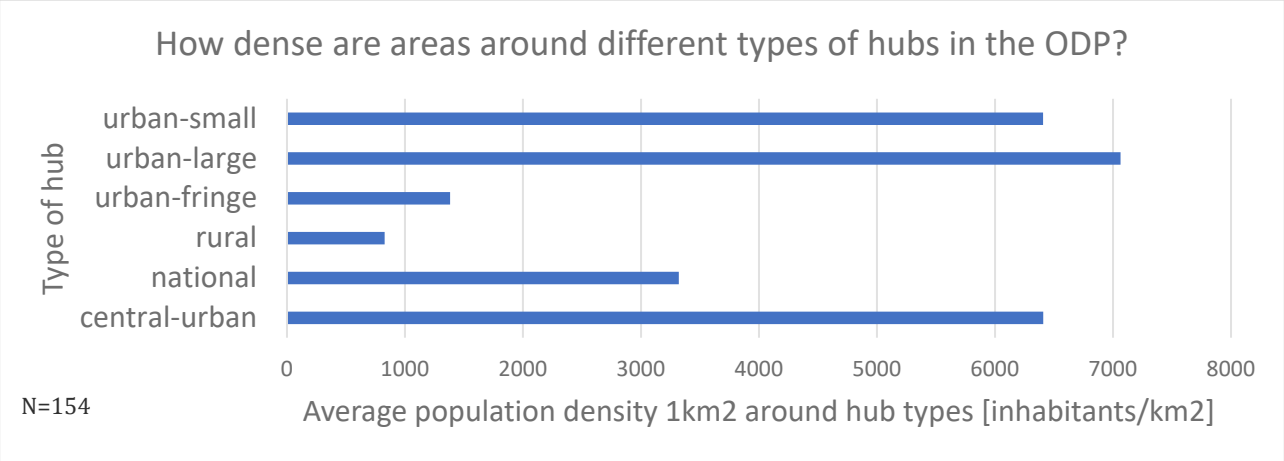


Figure 25 Average density per hub type

4.5.Need for research and further analysis

The ODP-dataset offers different types of data (geolocation, stakeholder-related data, service quality etc.) which allows many further analysis and research approaches.

Starting with the ODP data itself, especially the types of service bundles was not analysed in a structured manor yet (which mobility service bundle often comes together with which non-mobility service? – e.g. car sharing is often combined with E-charging for private uses). Also, it is unclear which mobility services are often not accessible without conflict (e.g., it is easier to have bike sharing close to the public transport stop as public space can be used, but carsharing comes along with a dedicated parking spot which is often still a challenge). Finally, especially the learning cases on level 0 in all pillars could be further explored regarding their most common last barrier to reach the next level (e.g. no minimum design requirements), in other words: which quick wins can potentially be performed to make hubs smarter?

When it comes to combine the ODP data with additional datasets, a wide range of sources could be relevant. Building on the analysis on density, the urbanisation classification (EUROSTAT 2024) could be linked to the hub-locations. A more challenging analysis would be the calculation of public transport level of service at the hubs using the ÖV-Güteklassen (Public transport quality classes, Plan4Better 2024) approach (which would have to be calculated first for all relevant public transport systems, starting with the data output from the SmartHubs Accessibility Tool using GTFS data). This would allow to compare hubs also more in detail on which level of service often comes with the availability of other modes. Finally, the SmartHubs Accessibility Tool offers an interesting database which could help to automatically propose measures to improve mobility hubs and display them in the ODP) based on the type of amenities (derived by the SmartHubs Accessibility tool) in their surroundings. This could help in the prioritisation of investments around mobility hubs.

5. LEARNINGS AND OUTLOOK

There are several learnings from developing the ODP and needs of ODP adaptions and changes which could not be fully realized within the project. These shortcomings should be explained transparently here. Firstly, there is a need for further documentation accompanying the ODP export feature to ensure ease of use. Clear and comprehensive documentation will enable users to effectively utilize exported data for their specific needs. Making ODP data visible in Open Data inventories would promote transparency and accessibility. Exploring the use of a different tool to "rebuild" the multi-relational database within the ODP can potentially improve efficiency and performance for analysis. An API could also be used to automatically update data from the ODP in this analysis environment. Additionally, checking the use of data via a direct data interface in Geographic Information Systems (GIS) can enhance ease of use and streamline data analysis processes. Overall, these potential changes aim to enhance the usability, accessibility, and functionality of the ODP, ultimately improving its effectiveness in supporting data-driven decision-making and analysis.

In the process of the ODP development, aspects were identified which need to be improved or can be removed totally, e.g. granting ODP editor rights to operators may not be realistic in this field, as the value gained from such permissions is relatively low. Further, while community mapping is valuable, a higher level of gamification may be necessary to engage users and intensify participation. By introducing more interactive and rewarding elements, such as incentives, challenges, or rewards, the level of engagement and contributions from the community can be significantly enhanced. There are still gaps in the available data within the ODP, which hinders the generation of more relevant analysis. Critical data elements such as usage data and micro-level data on nearby inhabitants are missing, limiting the depth and accuracy of the analyses conducted using the platform. Addressing these data gaps is essential to unlock the full potential of the ODP and enabling more comprehensive and insightful analysis. Some of this data could be directly integrated (also through external APIs) or just be used outside of the ODP in the analysis process.

The ODP demonstrates remarkable scalability, making it easy to adapt and expand as needed. This scalability ensures that the platform can grow alongside evolving demands and requirements on the collection of mobility hubs. The implementation of multi-level user management within ODP enhances its usability and functionality. This feature enables efficient administration and access control, accommodating diverse user roles and permissions. The ODP contains a high number of hub-locations, which can be comprehensively analysed in a single run using the Accessibility Tool. This efficiency streamlines the analysis process, allowing for thorough examination and evaluation of numerous hub locations simultaneously. Through analysis, ODP illuminates the important role of mobility hubs within their spatial context. This understanding of complexity enables stakeholders to make informed decisions and develop strategic initiatives that effectively address the multifaceted challenges and opportunities associated with mobility hubs.

6. CONTACTS

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