Approaching a Common Conscious Dataspace from a Data Provider Perspective – Requirements and Perspectives

Markus Jobst[1(✉)] and Tatjana Fischer[2]

[1] Federal Office of Metrology and Surveying, Vienna, Austria
markus@jobstmedia.at

[2] Department of Landscape, Spatial and Infrastructure Sciences, University of Natural Resources and Life Sciences, Vienna, Austria

Abstract. Many use cases give the impression that fundamental spatial data themes could help to bridge the gap of data silos and even approach a common conscious dataspace. Starting from the fundamental data themes of UNGGIM, we evaluate the minimal consensus for spatial data quality and create evidence for a missing common spatial data space by pragmatic examples from a data provider viewpoint. By the hand of given examples, the main challenges to start a common conscious dataspace in terms of the geospatial perspective can be highlighted, which leads to the need for a foundational semantic structure and sustainable persistent information structures. One possible approach to establish the baseline for a common persistent information space are geographical grid systems.

Keywords: Conscious dataspace · Spatial knowledge infrastructure · Map · Grid system · Graph structures

1 Introduction

The more data become available and follow FAIR principles (findable, accessible, interoperable, reusable), the easier gaps or discrepancies can be observed for the different data silos. Different qualities due to various use cases, different velocities and contradicting semantics make it hard to work within a common homogeneous dataspace that establishes a single market for economy and supports data sovereignty.

The combination of geographical grids with fundamental data themes and their foundational geospatial ontology encapsulates semantics by grids [1]. The spatial information space becomes more comparable. Therefore, this grid graph approach creates the ability to persistently compare against spatial phenomena, stays independent from detailed spatial feature changes and their spatial movements throughout time and may offer a spatial storage container. In general, these characteristics are needed for the conscious data space, where consciousness describes some kind of long-term information memory to observe and verify phenomena across different data spaces.

This contribution discusses the situation, gaps and requirements for a common conscious dataspace. We will highlight the need for a foundational semantic structure and

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2022
O. Gervasi et al. (Eds.): ICCSA 2022, LNCS 13376, pp. 333–343, 2022.
https://doi.org/10.1007/978-3-031-10450-3_28

evaluate their implementation by using geographical grids systems [18] as baseline for a common information space. The resulting geographical grid graph approach can highlight characteristics that are needed in a conscious data space, but is also accompanied with restrictions. We will discuss the perspectives and restrictions of the proposed geographic grid graph approach and come to a first assessment for its usability.

2 Fundamental Spatial Data Sources in Action for a Common Conscious Dataspace

A common dataspace is fed with different data sources, which in their complexity are computed according to an occurring use case. The different velocities and contradicting semantics within the common dataspace need to be considered. At least the characteristic of each data source need to be understood in order to reduce incompatibilities. This kind of transparency of the data source supports data sovereighty and brings competences of the data production and its provider into the common data space [15]. This organisational inclusive step becomes an important part of a common conscious dataspace, where a long-term memory within the dataspace is established. This means that specific data (if they are important enough) stay available in the long term for various use cases [3].

Considering the spatial dimension in a common dataspace opens additional possibilities in terms of data linking. This enhanced cross-linking of data and their semantics are a core component of a spatial-driven conscious dataspace, which mainly builds upon spatial knowledge infrastructures and smart environments. An applicable spatial component within the common dataspace requires persistent IDs, a documentation of its lifetime and precise as well as comprehensive semantic anchoring [11]. At least these requirements should be valid for fundamental data themes, a set of spatial core information that initially structures space.

Pragmatic approaches for domain-specific dataspaces highlight the evidence for the importance of spatial information in a common conscious dataspace. A minimum consensus for spatial data quality and structures for the different data providers is needed on one hand. Flexibility and openess for new dynamic information input and semantic structures, like it is produced by self-managing algorithms [16] or citizen science, is needed on the other hand.

2.1 Spatial Knowledge Networks

The spatial knowledge infrastructure (SKI) unites evaluated pieces of information in a network [21]. This is the result of data collection and enrichment processes, feedback of information success and its fitting into the specified knowledge space [17]. The SKI is more than a connected collection and mutual orchestration of microservices that are offered by different providers. It includes intelligent processes of spatial information analysis, transformations and formation of semantic links [12].

A “cartographic added value” within the spatial knowledge infrastructure as part of a conscious dataspace fulfills two tasks. First: the rules of cartography allow for a better perception of retrieved information. Second: cartography embedded as foundational ontology allows to identify topographical relations.

2.2 Smart Environment

Smart environments can be described as small worlds with mutual interacting components, like smart devices, that continuously record, analyse and process to make specialists tasks and even human life more comfortable [23]. Applications fields reach from hazardous work, physical labors to a very general view of automated agents.

The core concept focuses on dynamically created mashups and a high degree of flexibility, instead of statically determined process driven approaches with service-mashups [19]. The most promising approach uses Web patterns with fault-tolerant relations, low-level protocol semantics, information ontologies and a standard Web architecture style [4]. This concept supports the integration of big data and IoT technologies for a variety of application fields.

2.3 Fundamental Spatial Data Themes

A sustainable development of environment and society requires continuous measurements, monitoring and governance according to the results. A common dataspace that includes all relevant information in a flexible but consistent way over time supports evidence-informed policy and decision making [10]. Spatial data and cartography are highly relevant in this information environment because it puts information into spatial context, mutually connects information pieces and brings in scale dependent semantics.

A set of fundamental data themes have been defined by the United Nations Expert Group of Global Geoinformation Management. Theses data themes cover the global geodetic reference frame, orthoimagery, elevation and depth, buildings and constructions, geographical names as identification of places, geology, land cover and its proposed land use, land parcels and land ownership, transport networks and their connectivity, physical infrastructure including public facilities and functional areas of public life that is used for different kind of administration [25].

2.4 The Role of Citizen Science in a Common Dataspace

In a common dataspace as comprehensive information source, information quality (IQ) of its components is of focal interest. The integration of different sources identifies quality concerns and discrepancies [24]. It is therefore a key task to mutually enhance quality within the data. For example, the correlation of administrative units, addresses and geographical names will immediately highlight a non-harmonized naming of the features and call for a common definition and guidance for the naming.

Citizen science with its open, frequently and in general anonymous participation adds further possibilities to the IQ enhancement. In many cases this citizen information can be classified as collective intelligence. In fact, citizen science brings in a user perspective - what is important to a participating user? - and refers to a large application scale. If considered carefully, it is a trigger for quality improvement within a common dataspace.

2.5 Functional Space and Its Impact on a Common Conscious Dataspace

The following pragmatic view on a use case in the field of spatial research and regional planning highlights the requirements for reliant data sources, transparent information quality and the recursive processing in a common conscious dataspace [14].

It is important to understand that functional regions are spatial structures that consist of communities with different characteristics that are in (exchange) relationships with each other [26]. This (exchange) relationship, in turn, must be "significant", i.e. relevant in quantitative terms. To this end, the relationship must be made measurable. In a first step, the characteristics must be defined (e.g. schools, hospitals in central places) and the relationship between the municipalities must be conceptualized (e.g. use of the facility by local residents as well as by and inhabitants of other (neighboring) municipalities). It is then necessary to identify and decide for secondary data that are suitable for calculating a defined indicator (e.g. catchment area of a nursing home). This approach also makes it possible to spatially delimit the functional region on the basis of the a priori defined threshold values for the required minimum strength of the relationship between the municipalities [6].

By taking into account other previously defined relevant boundary conditions such as the reasonable accessibility of the infrastructure and the spatial information required and available for this (e.g. the topology), the calculation model can be refined and more differentiated conclusions can be drawn on infrastructural oversupply and undersupply as well as on (intra-regional) supply rates..

The complex regional problem analysis of the functional space incorporates a diversity of data sources that are not harmonized, but deliver important impact on the analysis model. The recursive approach of regional planning corresponds to a machine learning procedure as long as discrete conclusions are the result of the analysis. Therefore, discretisation of indicators can be seen as core requirement for a common conscious dataspace from a functional space perspective.

3 Initial Challenges to Start a Common Conscious Dataspace

Initial challenges for a common conscious dataspace exist. These challenges mainly concern new roles in a common dataspace [13]. These roles are integrative parts in autonomous data silos, but need to be available and to interact in a common dataspace. Central roles are for example identity management or content brokering [8]. A conscious dataspace requests a full automation of these roles in order to fulfill the requirements of long-term availability.

Any knowledge persistence on the basis of a common dataspace assumes ongoing continuous processes for the fundamental (spatial) data sources, which is supported by a flexible but defined stewardship model and the governance of critical rules. From a geospatial perspective, consciousness within a common dataspace depends on trustworthy spatial data sources that appropriately describe space in an actual way, are historically available, offer an acceptable information quality and bind into a common consensual semantic structure [7].

3.1 A Shared Understanding of the Term "Common Dataspace"

A common dataspace is not only a collection of microservices or data sources. It is a network of reliable and self-determined exchange of information among known or unknown partners. The level of trusting available information in the dataspace can be

defined by the stewardship of participating parties and their core competencies, which at least refer to “data sovereignty” [27].

3.2 The Conscious Framework from a Geospatial Perspective

A conscious framework within a common dataspace requests a historicized understanding of space. The description of space and its understanding is permanently changing. Due to legal frameworks or organizational collaboration the imagery and meaning of information evolves, which again influences a persistent semantic structuring of space [9]. The geospatial perspective helps to understand spatial related situations, where e.g. topography impacts a sustainable delivery of professional care for the elderly. In this context, it can be assumed that spatial-related challenges such as overcoming geographical distances in alpine areas are likely to fuel the reflection on whether to decide for a job in mobile care or nursing… The creation of a foundational semantic structure of space is a first step to persist the understanding of a geospatial imagery.

3.3 The Need for a Foundational Ontology

A universal topographic semantic structure across different scales, cartographic simplifications and spatial structures creates a foundational topographic ontology that helps to connect existing structures of meaning by its spatial characteristic [20]. It verifies another role of modern maps: a universal semantic structure of topographic content.

The need for a foundational topographic ontology can be anticipated, whenever semantic interoperability and efficient knowledge transmission on the basis of modern SDI lacks [21].

The foundational topographic ontology enhances a cross-domain networking of information structures. It therefore prevents spatial information spoofing and thus ‘fake facts’. This can be achieved by cross-correlation of information, clear responsibilities of definitions and its universal semantic thesaurus of geographies.

Given by the aspects of initial challenges, a common conscious dataspace envisages a collaborative information landscape with enabled trust, mutual understanding, comprehensive knowledge, informed decisions, full automation of spatial data integration and adaptive analytics for knowledge expansion.

4 Geographic Grids Establishing the Baseline for a Common Information Space

In the recent years the integration of thematic and spatial information, especially concerning the UN sustainable development goals indicators, led to the realization that common geographies and geocoding are of high importance. Within the GSGF (Global Statistical Geospatial Framework) evidence has been built to move to gridded data delivery.

Gridded data are in use for the statistical domain for decades [1]. These statistical grid systems have regional restrictions. There are national and regional definitions. Some use cases call for global coverages. Therefore, a discrete global grid system (DGGS) has been developed under the auspices of the Open Geospatial Consortium (OGC). The main

aim of a grid system is to provide a geospatial reference frame and establish persistent location for spatial values measured. As consequence the grid enables comparison in time and space. Values are bound to a location on one hand, the size of the grid cell and its value is comparable throughout the defined grid on the other hand. The grid is a multiscale definition which establishes a discrete hierarchical tessellation of progressively finer resolution cells. The numbering of cells follows a unique and multiple scale spanning index that facilitates rapid computation.

A common conscious dataspace could benefit from the comparable and timelessness characteristic of a grid system. Its geospatial reference and multiscale index hierarchy establish a baseline for a common conscious dataspace, at least for specific analysis and cross-domain-linking.

5 A Geographical Grid Graph Approach (GGGA)

Many use cases in spatial-related planning require a persistent framework of information structuring on one hand, but also call for flexibility for data structures on the other hand. From the viewpoint of the authors, a geographical grid graph approach (GGGA) could fulfill both requirements. In pragmatic use cases of regional planning this approach has been established and delivered first comparable results.

The GGGA is an established geographical grid and combines the functionalities and characteristics of space within a graph database. The geographical grid discretizes space into comparable tiles. The graph database introduces flexibility for data structures. In addition, the graph points to original geometries in a spatial index for deep learning procedures.

5.1 Encapsulating Semantics by Grids

The meaning of a spatial situation is defined by an ontology based spatial structure [28], something like a foundational topographic ontology combined with thematic classifications. Thematic classifications depend on the given use case and help to identify “important” information [29]. A graph describes this spatial semantic, whereas geographical features represent natural objects as geometries [30]. These geometries may change during time and often can hardly be compared. For example, a forest area will change its shape, but still stays the same semantic object. As described in the previous section, the relation of the spatial semantic to a grid establishes a baseline for a continuous comparison.

Two relations have to be established for a GGGA:

(1) the information of geographical features has to be related to one or more specified grids. This is done by georeferencing, a dataintegration method by space: in which grid cell is the geographical feature located? The persistent identifier (PID) of the geographical feature then becomes part of the grid cell as "consist of" relation. In addition, the PID of the grid cell could become part of the geographical feature as “refers to” relation.

(2) the grid has to be connected to the spatial semantic. This connection to spatial semantic is done with the help of all the information of geographical features within the grid cell.

The spatial semantic could evolve with research questions and a proposed analysis. Changes also occur with new insights. Then relations between the grid and a new semantic have to be modified or extended.

5.2 Observations in a Regional Planning Use Case

In our use case of regional planning and the analysis of functional space, we identified several datasources, created a thematic semantic for the functional space, considered the foundational topographic ontology and established a semantic grid by a standardized regional statistical raster grid.

The open dataspace for the analysis of functional space is increasing, but inhomogeneous. Authoritative sources and volunteered geographic information mix up, which delivers a good variety. Reliance of the different sources differs:

Authoritative data seem to be complete depending to the meaning of data. For example, one source will embed all childcare facilities run by public authorities, others will list all childcare facilities including private ones, but exclude church-affiliated and other confessional institutions. Given a varying georeference (location) and a missing feature identifier accross all data sources, one may easily step into the trap of "counting too much".

Volunteered geographic information includes a diverse but consistent semantic. Functional description like childcare facilities, hospitals, police stations or museums exist. But the information only exists if it was interesting for the volunteer. Therefore, a lot of information is missing. Often authoritative feature identifiers, if they exist, are not considered. The volunteered geographic sources within the common dataspace for a functional analysis could extend authoritative collections and but could not be reliably considered for the categorisation of municipalities in our use case.

The thematic semantic for the functional space has been designed according to different scientific publications. This means that the thematic semantic structure is flexible and may change according to new insights.

The chosen "standardized regional statistical raster grid" has been designed in a way that it is compatible with the European statistical grid system based on the coordinate reference system (CRS) epsg: 3035 with 100 m grid cells. 100 m seems to be a rough resolution for geographical features, but it is a microscale for statistical themes, which may call for statistical disclosure control [22].

This setting of the grid allows for the integration of a lot more statistical data, such as demographic characteristics, health status and labor market structure.

6 Requirements, Perspectives and Restrictions of the Proposed Geographic Grid Graph Approach (GGGA)

Our ongoing work on approaching a common conscious dataspace with the proposed geographic grid graph approach from a data provider perspective exposes some requirements, perspectives and restrictions. In general, graph structures and their ontologies, combined with discrete and comparable spatial cells, could establish a sustainable structure for a common conscious dataspace. The main characteristics of this GGGA approach are the persistence of spatial discretisation with the grid and the flexibility of information structures with the graph.

The spatial discretisation with the grid supports a massive integration with time- and information layers, which then will lead to a so-called datacube [2]. The datacube as multidimensional data container has specific performance characteristics and owns specific operations to extract data. The connection to spatial data on the web is supported by a RDF data cube vocabulary (ref: RDF data cube vocabulary).

In this section we highlight the most important requirements and restrictions according to our observations.

6.1 Requirements

The main observed requirements for a common conscious dataspace are quality governance and a common understanding.

Quality Governance. Information sources within a common conscious dataspace consist of differing qualities that may not match or even create wrong results. A quality categorization for information chunks or geographic features has to be embedded in addition to the time stamp and persistent identifier in order to characterize this piece of information and differentiate its importance within a given use case. The quality categorization could be issue to modification if integration procedures can improve precision, reliability, coverage, completeness or conformance [5].

Foundational Ontology. The common understanding for spatial structures in a common conscious dataspace is driven by ontologies, a categorization and linking of information taxonomy [31]. In general, these ontologies are driven by applications fields and use cases and may differ in a single common dataspace. Therefore, the common understanding has to be supported by a foundational ontology for spatial components, which connect spatial information to a common knowledge base.

6.2 Restrictions

The grid within GGGA is accompanied by some restrictions. The discretisation of space enables timelessness comparison, but it depends on its specification. Grids with different specifications (e.g. starting point, grid cell size), geographical projections or cell geometries (e.g. square, hexagon) cannot be compared, because the information content of the cell will differ. This means that the specification of the grid as vehicle for stability

is an apriori task that considers the scale, density, regional- and global needs of any approaching use case in future.

In our presented example the use case is restricted to a regional bounding box. In order to consume official European data sources, the regional grid has been specified according to the official statistical grid of Europe. An extension to the discrete global grid system is not possible, because the shape and projection of both grids does not match and therefore the information value cannot be compared.

A conceivable approach to overcome the incompatibility of different grid specifications could make use of the original spatial source data and rebuild the information grid. The most critical point here is, that any location modification within the data source will lead to an information change in the grid. These location modifications often come along with quality improvements.

7 Concluding Remarks

As we understand it, a common conscious dataspace is an extended concept of a common dataspace that establishes long-term memory with spatial relevance. From the perspective of a data provider and the application field of regional planning a common conscious dataspace is of "extreme" high value.

This paper tells about our work in progress and the observed difficulties to approach a common conscious dataspace that could be used for cross-sectoral spatial-related planning. In this paper we focused on spatial requirements and perspectives. We did not go into details on the new roles, like broker or identity manager in common dataspaces. We highlighted our approach to introduce stability in space and time with a geographical grid graph approach and resulted in its main requirements and restrictions.

Further actions of our work concern the embedding of statistical evaluations and derivation of effective geo-visualisations on the basis of the geographical grid graph.

References

1. Sato, A.-H., Nishimura, S., Namiki, T., Makita, N., Tsubaki, H.: World grid square data reference framework and its potential applications. In: 2018 IEEE 42nd Annual Computer Software and Applications Conference (COMPSAC), pp. 398–409 (2018), https://doi.org/10.1109/COMPSAC.2018.00062
2. Baumann, P., Team, R.: The EarthServer global datacube federation. In: IEEE, pp.3192–3194 (2020). https://ieeexplore.ieee.org/abstract/document/9324386
3. Bensmann, F., et al.: An infrastructure for spatial linking of survey data. Data Sci. J. **19**(19). https://datascience.codata.org/articles/https://doi.org/10.5334/dsj-2020-027/
4. Berners-Lee, T.: Linked data design issues. [online] W3C (2021). https://www.w3.org/DesignIssues/LinkedData. Accessed 25 Mar 2021
5. Döllner, J.: Geospatial artificial intelligence: potentials of machine learning for 3D point clouds and geospatial digital twins. PFG. J. Photogram. Remote Sens. Geoinform. Sci. **88,** 15–24 (2020). https://link.springer.com/article/10.1007%2Fs41064-020-00102-3
6. Dunford, M.: Area definition and classification and regional development finance: the European Union and China. In: Pike, A., Rodriguez-Pose, A., Tomaney, J. (eds.) Routledge Handbook of Local and Regional Development. Routledge, pp. 527–548 (2010). https://doi.org/10.4324/9780203842393.CH44

7. European Commission, J.: Guidelines for the RDF encoding of spatial data (2017). Github.io. http://inspire-eu-rdf.github.io/inspire-rdf-guidelines/. Accessed 8 Apr 2021
8. European Commission: Policy: Destination earth (DestinE). [online] European Commission (2020). https://ec.europa.eu/digital-single-market/en/destination-earth-destine
9. Gould, N., Mackaness, W.: From taxonomies to ontologies: formalizing generalization knowledge for on-demand mapping. Cartogr. Geogr. Inf. Sci. **43**(2016), 208–222 (2016). https://www.tandfonline.com/doi/abs/https://doi.org/10.1080/15230406.2015.1072737
10. Hadley, C.: The global fundamental geospatial data themdes journey. United Nations Committee of Experts on Global Geospatial Information Management (2018). https://ggim.un.org/documents/Fundamental%20Data%20Publication.pdf
11. Haldorson, M., Moström, J.: Developing a statistical geospatial framework for the European statistical system. In: Service-Oriented Mapping. Springer, pp.185–206. https://link.springer.com/chapter/https://doi.org/10.1007/978-3-319-72434-8_9
12. Hyvönen, E.: Linked open data infrastructure for digital humanities in Finland. In: Proceedings of Digital Humanities in Nordic Countries (DHN 2020) (2020). https://helda.helsinki.fi/bitstream/handle/10138/320220/hyvonen_lodi4dh_dhn_2020.pdf?sequence=1
13. International Data Spaces Association: IDSA rule book. Internationaldataspaces.org (2019). https://internationaldataspaces.org/download/19008/
14. ISO - International Organization for Standardization: ISO 37120:2014, Sustainable development of communities — Indicators for city services and quality of life ISO (2017). https://www.iso.org/standard/62436.html
15. ISO - International Organization for Standardization: ISO/IEC JTC 1/SC 41, Internet of things and digital twin. ISO (2020b). https://www.iso.org/committee/6483279.html
16. ISO - International Organization for Standardization: ISO/IEC JTC 1/SC 42Artificial intelligence. ISO (2020c). https://www.iso.org/committee/6794475.html
17. Janowicz, K., Scheider, S., Pehle, T., Hart, G.: Geospatial semantics and linked spatiotemporal data–past, present, and future. Semantic Web **3**, 321–332 (2012). https://content.iospress.com/articles/semantic-web/sw077. Accessed 8 Apr 2021
18. Sahr, K., White, D., Jon Kimerling, A.: Geodesic discrete global grid systems. Cartogr. Geogr. Inf. Sci. **30**(2), 121–134 (2003). https://doi.org/10.1559/152304003100011090
19. Mohammadi, H., Rajabifard, A., Williamson, I.P.: Development of an interoperable tool to facilitate spatial data integration in the context of SDI. Int. J. Geogr. Inf. Sci. **24**, 487–505 (2010). https://www.tandfonline.com/doi/abs/https://doi.org/10.1080/13658810902881903. Accessed 8 Apr 2021
20. Partridge, C., Mitchell, A., Cook, A., Sullivan, J., West, M.: A survey of top-level ontologies-to inform the ontological choices for a foundation data model. Cambridge University Research Outputs (2020). https://www.repository.cam.ac.uk/handle/1810/313452. Accessed 8 Apr 2021
21. Rieke, M., et al.: Geospatial IoT—the need for event-driven architectures in contemporary spatial data infrastructures. ISPRS Int. J. Geo-Inf. **7,** 385 (2018). https://www.mdpi.com/2220-9964/7/10/385. Accessed 8 Apr 2021
22. Ritchie, F.: Disclosure detection in research environments in practice. Paper presented at UNECE/Eurostat Work Session on Statistical Data Confidentiality (2007). https://doi.org/10.2901/Eurostat.C2007.004
23. Mayer, S., Verborgh, R., Kovatsch, M., Mattern, F.: Smart configuration of smart environments. IEEE Trans. Autom. Sci. Eng. **13**(3), 1247–1255 (2016). https://doi.org/10.1109/TASE.2016.2533321
24. Schade, S., Granell, C., Diaz, L.: Augmenting SDI with linked data. In: Citeseer. (2010). http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.414.9301&rep=rep1&type=pdf

25. Scott, G.P.: A national strategic geospatial information framework to support the implementation of the sustainable development goals (SDGs) (2020). https://minerva-access.unimelb.edu.au/handle/11343/243052
26. Statistics Austria (Ed.): Urban-Rural Typology of Statistics Austria. Information on Methodology in German Language. https://www.statistik.at/web_en/classifications/regional_breakdown/urban_rural/index.html. Accessed 8 May 2022
27. Taneski, N., Petrovski, A., Bogatinov, D.: Geography in geospatial intelligence-C4IRS and cyber security. Security and crisis management–theory and practice, Regional Association for Security and Crisis Management S4 GLOSEC Global , pp. 65–73 (2019)
28. vd Brink, L., et al.: Best practices for publishing, retrieving, and using spatial data on the web. Semantic Web **10**, 95–114 (2019). https://content.iospress.com/articles/semantic-web/sw305. Accessed 8 Apr 2021
29. W3C: Spatial data on the web working group. W3.org (2015). https://www.w3.org/2015/spatial/wiki/Main_Page. Accessed 8 Apr 2021
30. W3C: DCAP AP. W3.org (2020). https://www.w3.org/ns/dcat. Accessed 8 Apr 2021
31. Wang, T.D., Parsia, B., Hendler, J.: A survey of the web ontology landscape. In: Cruz, et al. (eds.) The Semantic Web - ISWC 2006 ISWC 2006 5th International Semantic Web Conference, ISWC 2006, Athens, GA, USA, 5–9 November 2006, LNCS 4273, pp. 682–694. Springer, Heidelberg (2006). https://doi.org/10.1007/11926078_49