ACTUAL APPROACHES ON THE WATER UTILITIES DATA MODELS

Ana Cornelia BADEA, Assoc. Prof. PhD. Eng., Technical University of Civil Engineering Bucharest, Faculty of Geodesy, Romania, anacorneliabadea@gmail.com, ana.badea@utcb.ro
Gheorghe BADEA, Prof. PhD. Eng., Technical University of Civil Engineering Bucharest, Faculty of Geodesy, Romania, badeacadastru@gmail.com, gheorghe.badea@utcb.ro

Abstract*: In November 2017 the Technical Normatives about producing spatial datasets on public utility networks was approved and published by National Agency of Cadastre and Land Registration. Romania has undertaken the implementation of INSPIRE, so identifying the best ways to put it into practice is an essential step in the application of these rules. Currently there are developed models for water and sewerage networks, designed both using company software and open source software solutions. From cadastral and urban management viewpoint, it is very important that the utility networks to be correctly and complexly modeled, justifying the importance of presented analysis. Its importance is due to the fact that utilities networks are fundamental parts of the smart city concept, being integrated with the cadastral information. The implementation of concepts that lead to 3D modeling of standards-compliant utilities networks, while also offering open-source access, is a top priority, including at international level. The present article aims to analyze these models by highlighting their current status and defining important aspects.*

Keywords: *INSPIRE, OGC, utility network, CityGML, ArcGIS, CityEngine*

1. Introduction

Public utilities are technical utilities which are serving housing, social-cultural assemblies, institutions, economic agents etc., as well as the industrial technical networks in the urban space. Urban utilities networks can be located both over-ground and underground.

For localities it is necessary to develop a specific informational system to deal with inventory and systematic evidence of underground and over-ground facilities in the perimeter of urban areas, from the technical and quality viewpoint. It is necessary a permanent maintenance and updating them according to the real situation in the field. [6]

2. Correlation between the Informational System of the Municipal Utility Networks with the Real Estate Informational System and Cadastre

The Cadastre deals with the technical aspect and is referring to: evidence of properties which are belonging to this field by measurement of shape, position and their configuration in the purpose of registration in the cadastral documents and in the Land Book; obtaining of the digital cadastral plans.

In a locality, it is advisable to associate the real estate fund with the utility networks in order to provide a good management and an appropriate coordination of activities leading to a high standard of living.

The component of the utility networks evidence [10] is composed by those elements that are belonging to the qualitative aspect as well as by other technical features like the following: keeping records and inventory of municipal networks by types of networks; determination of the position in the plan and the way of laying of the main and of the distribution networks; planimetric determination of urban constructions and urban technical facilities; determining quotas elements or significant points (covers of manholes, odds slab, pipe in a manhole etc.); information sheets (artery sheets, unique sheets, standard sheets); information on the nature of piping construction materials and their diameters; status information about networks; information on debits, capabilities etc.

In November 2017 the technical normatives about producing spatial data sets on public utility networks was approved and published by NACLR. The normatives are based on description of the INSPIRE theme III. 6. - "Public utilities and other public services", which is provided by art. 10 point 6 of Annex 2 of the Government Decision no. 579/2016 and includes public utility facilities. Nomenclatures used to propagate attributes and association roles for spatial object types and data types used will be in accordance with the definitions and values defined in the Annex at http://inspire.ec.europa.eu/codelist/. [11] For each class of objects are mentioned items such as: geometry type (polygon, poline, point), attributes, description attribute, predefined attribute values, value description. (Annex VII for Water supply and Collection, sewerage, sewage treatment and storm water evacuation). (figure 1)

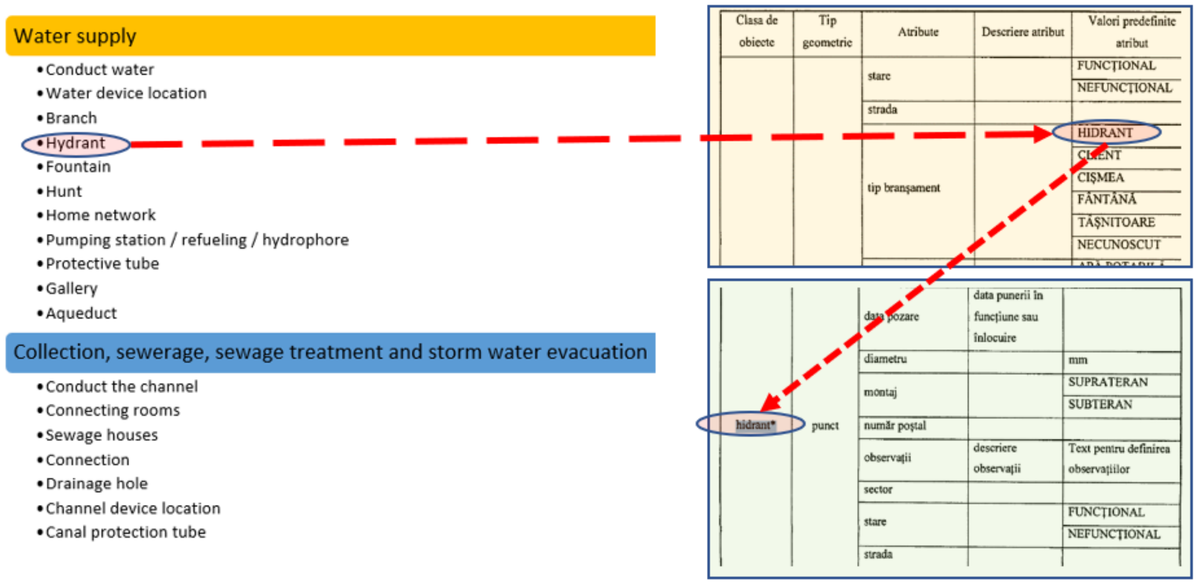


Figure 1 – Example of attributes, description attribute, predefined attribute values for Hydrant (according with [11])

3. Different Approaches of the Water Utilities Data Models

A network is a collection of NetworkElements that is the superclass for elements like Area, Node, and some special classes. INSPIRE developed an application schema called "Utility Networks" which are including schemas for different utility networks as Electricity, Oil, Gas, Sewer, Telecommunications, Water. [4]

ISO developed a standard containing the rules for application schema, called ISO 19109:2015. This ISO standard includes the conceptual modelling of features and their properties, definition of application schemas, use of the conceptual schema language for application schemas, transition from the concepts in the conceptual model to the data types in the application schema and integration of standardized schemas from other ISO geographic information standards with the application schema. [14]

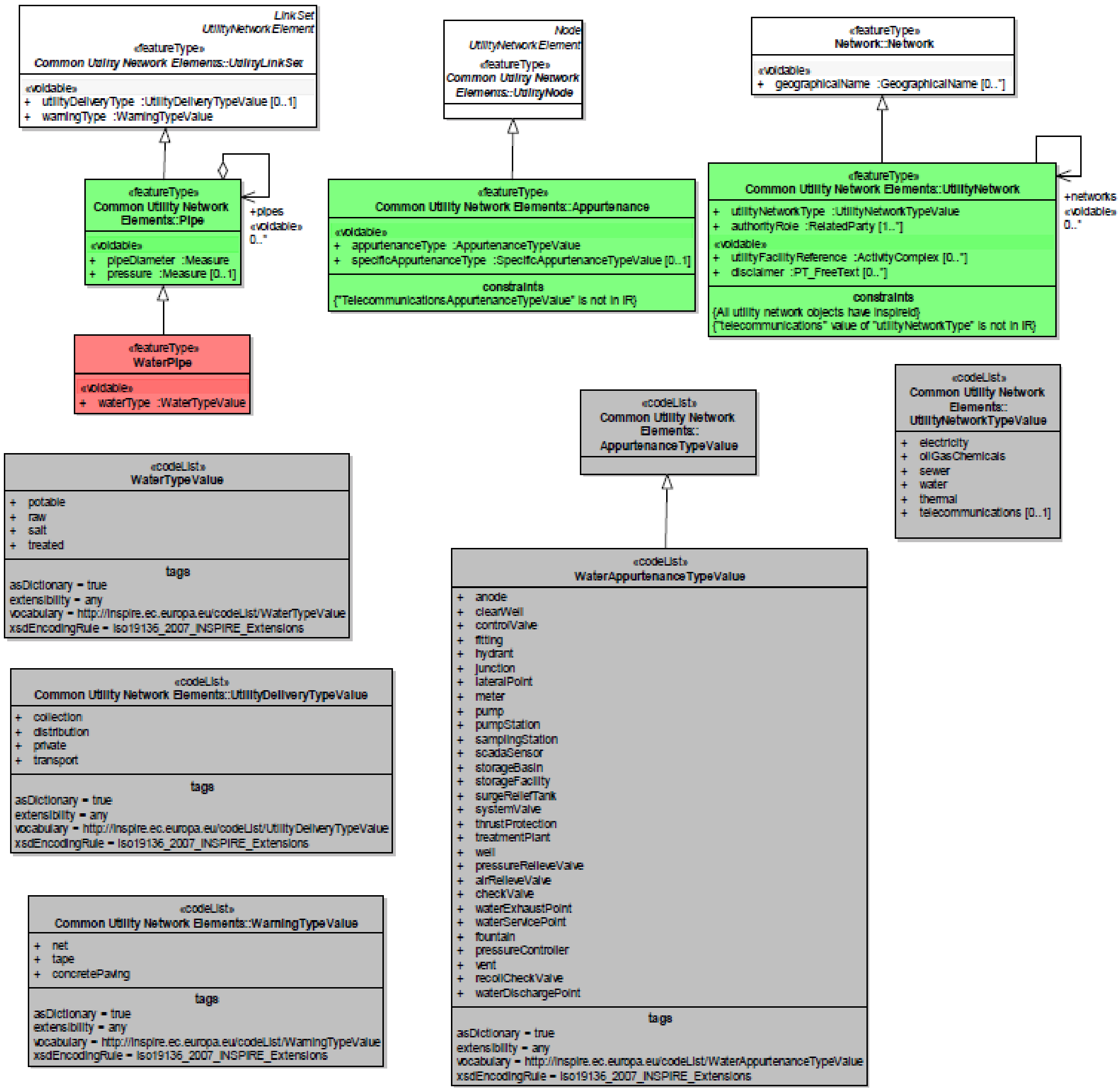


Fig. 1 – Extract - INSPIRE Class Water Network (according with [17])

The Local Government Information Model was developed to be used for managing geospatial information, designing the ArcGIS for Local Government maps and apps. Starting with 2017, according with [1], Local Government Information Model, which was the basis of utility networks using Esri technology was changed.

The Water Utility Network Editing and Analysis was removed from LocalGovernment.gdb configuration and was replaced with WaterUtilities.gdb and RefrenceData.gdb. It exists a similarity between these two versions, so the feature datasets for water, wastewater, and stormwater are almost the same. These models are designed for a utility's mapping technicians to manage water, sewer, and stormwater network data.

In the following figures, there are emphasized examples of geospatial databases for different water networks which were developed using Microsoft Visio and ArcGIS Pro. (figures 2 – 7) ESRI technology offers high possibilities for workflow automatization. [8]

Fig. 2 – Defining Domains for Sewer Network in MS Visio (according with [15])

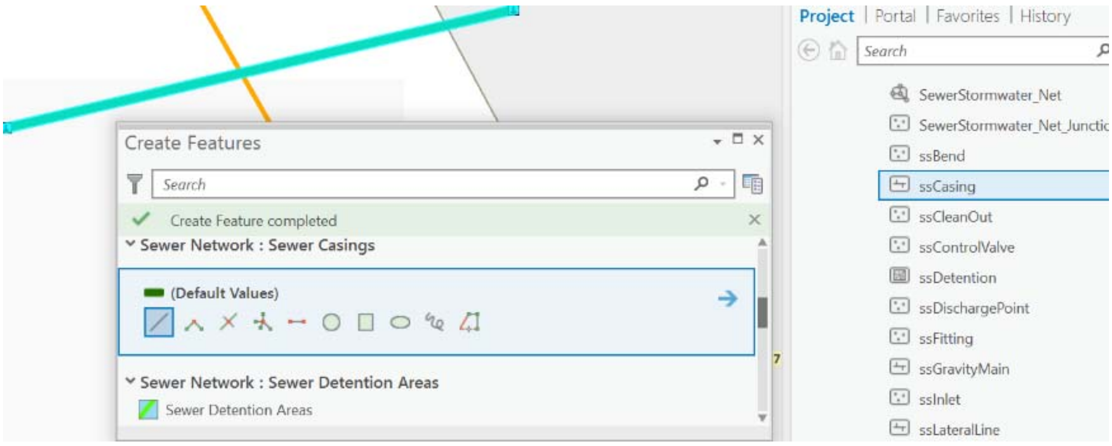


Fig. 3 –Subtypes Defined for Sewer Stormwater Network in ArcGIS Pro (according with [15], [16])

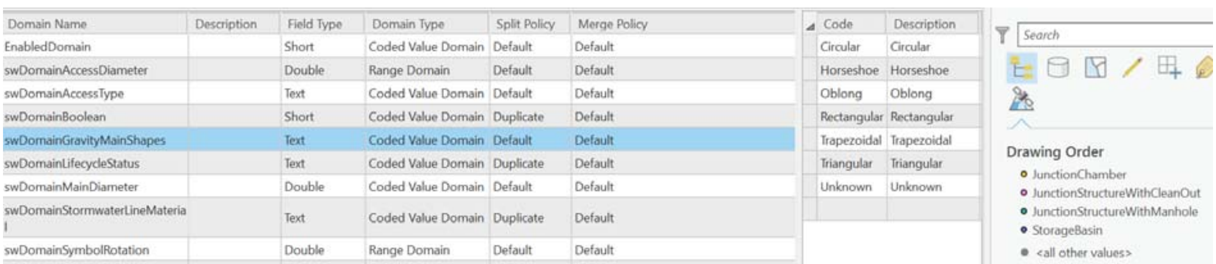


Fig. 4 – Defining Domains for Stormwater Gdb in ArcGIS Pro (according with [15])

The water supply network can be composed by: drinking water supply network; water supply network for maintenance of green areas, streets etc.; industrial water supply network. The water supply network generally refers to: capture, pumping, quality improvement water in storage systems and water transport systems from tanks or pumping stations at consumer outlets. The sewer network system comprises an assembly of pipelines and devices that collects, transports, purify and evacuate wastewater and stormwater in an emissary.

Regarding the water supply network, there are needed at least the elements concerning the following features [10]: capture of water (from underground or from the surface); construction and treatment facilities to improve water quality; water transport network for treatment and storage tanks; treatment and storage tanks (underground, ground or above ground), clearing or pumping tanks of water; pumping stations; the water distribution network from storage tanks to consumers' outlets.

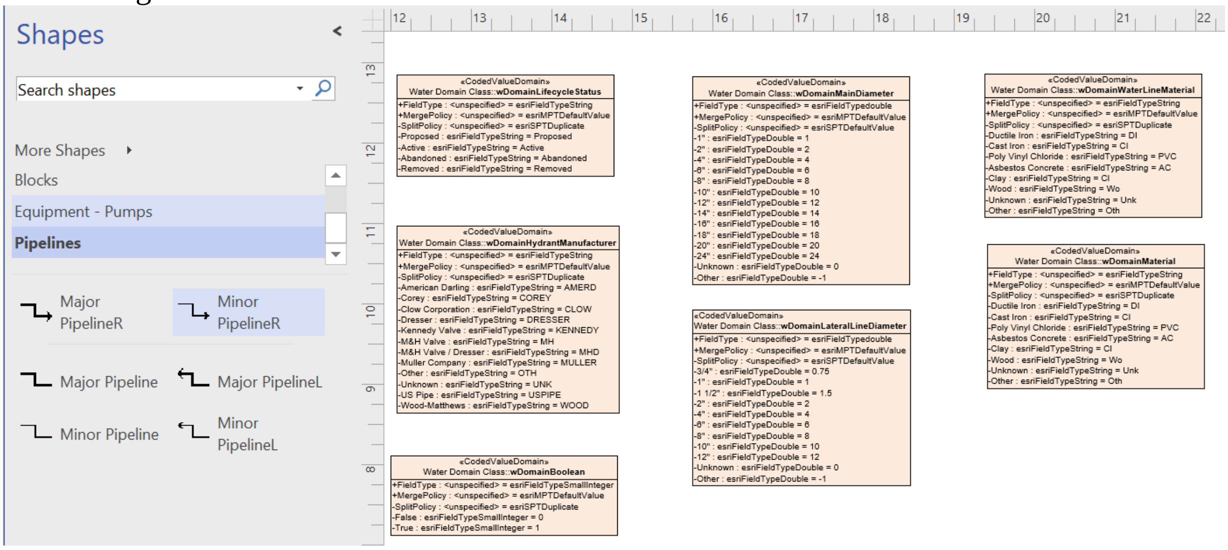


Fig.5 – Defining Domains for Water Network in MS Visio (according with [15])

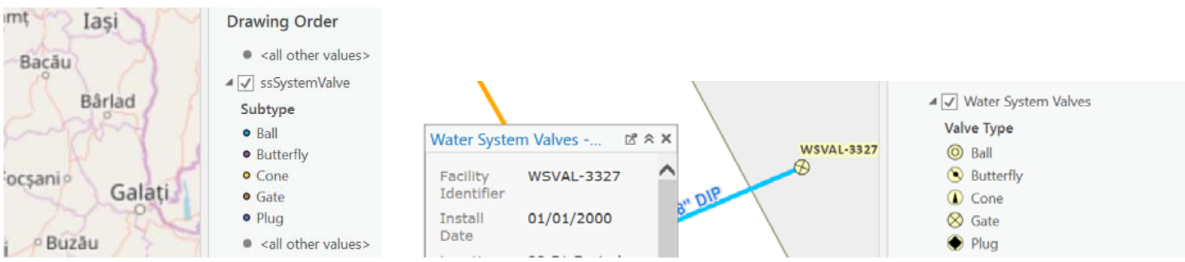
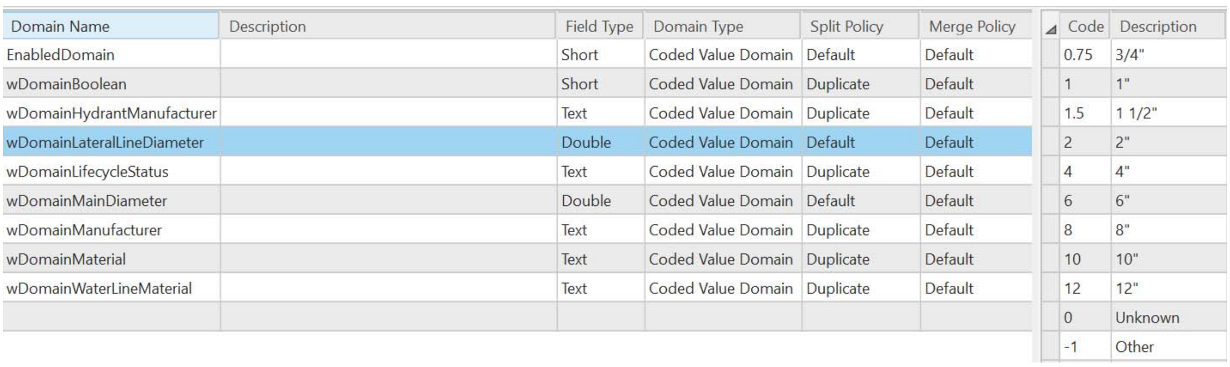


Fig. 6 –Subtypes Defined for Water Network in ArcGIS Pro (according with [15], [16])



Domain Name	Description	Field Type	Domain Type	Split Policy	Merge Policy
EnabledDomain		Short	Coded Value Domain	Default	Default
wDomainBoolean		Short	Coded Value Domain	Duplicate	Default
wDomainHydrantManufacturer		Text	Coded Value Domain	Duplicate	Default
wDomainLateralLineDiameter		Double	Coded Value Domain	Default	Default
wDomainLifecycleStatus		Text	Coded Value Domain	Duplicate	Default
wDomainMainDiameter		Double	Coded Value Domain	Default	Default
wDomainManufacturer		Text	Coded Value Domain	Duplicate	Default
wDomainMaterial		Text	Coded Value Domain	Duplicate	Default
wDomainWaterLineMaterial		Text	Coded Value Domain	Duplicate	Default

Code	Description
0.75	3/4"
1	1"
1.5	1 1/2"
2	2"
4	4"
6	6"
8	8"
10	10"
12	12"
0	Unknown
-1	Other

Fig. 7 – Defining Domains for Water Gdb in ArcGIS Pro (according with [15])

The main elements of the sewerage system that are the subject of the public networks evidence are the following: external sewerage network (street and collector network);

pumping or refilling stations; pre-treatment and purification installations; discharge collector and discharge hole.

City Geography Markup Language (CityGML) is an international standard of the Open Geospatial Consortium. CityGML is an international OGC standard, being used free of charge. Using CityGML can be represented 3D geometry, 3D topology and semantics, as well as the appearance in 5 discrete scales (Levels of Detail, LOD). These levels of detail are the following [5]: LOD0 - regional landscape - can be draped with an aerial image or a map ; LOD1 - city, region - includes prismatic buildings with flat roofs; LOD2 - neighborhoods, residential projects - includes the structure of the roof and the outside of buildings, such as attics or chimneys, as well as the vegetation; LOD3 - architectural models for exterior - architectural models with detailed walls and roof structures, balconies, hollows and projections, high resolution textures can be printed on these structures and can contain detailed vegetation or transport elements; LOD4 - Architectural Interior Designs - contains the interior structures of buildings: rooms, furniture and interior fittings.

In a CityGML dataset, the same object can be represented in multiple layers simultaneously, for analyzing and viewing the same object at different resolution levels. Two CityGML datasets containing the same object in different levels of detail can be combined and integrated. CityGML data model is composed by different classes that belong to the most important types of objects in the 3D virtual models city. [9]

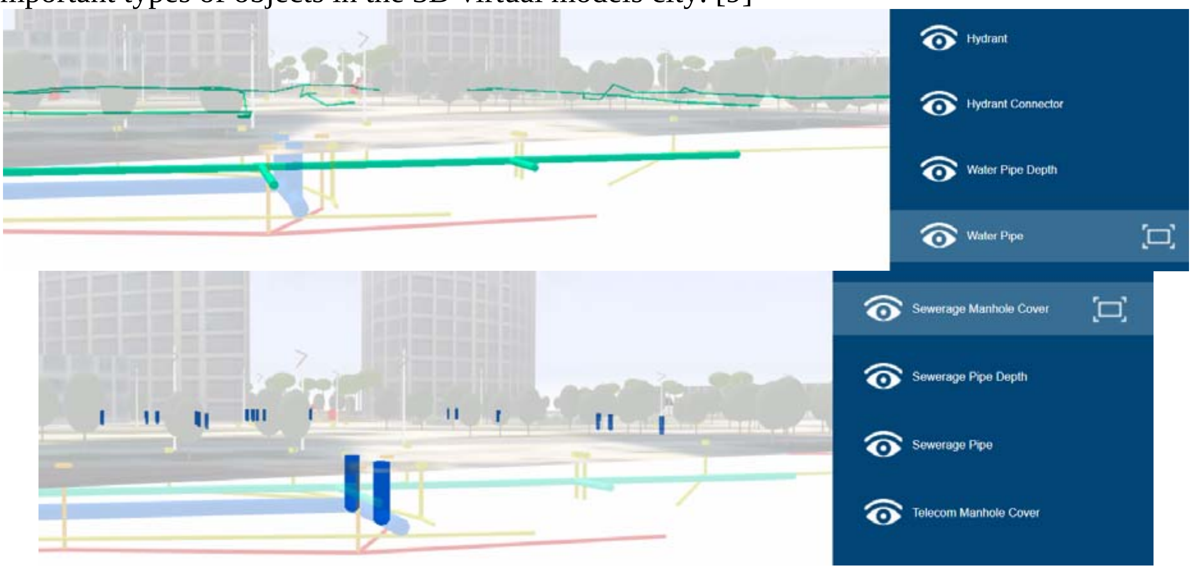


Fig. 8 –Utilities in ESRI CityEngine (example from [18])

According with [7], using UtilityNetworkADE, a utility network can be modeled in CityGML. The UtilityNetworkADE defines a topological network model facilitating sophisticated analyses and simulations on utility networks and supplying infrastructures. Included are, amongst others, network hierarchies of arbitrary depth, nesting of network components, and modelling of multi-modal networks. [13] In fact, ADE (Application Domain Extension) represents CityGML systematic extension mechanism, allowing to extend each CityGML object type by additional attributes, the result being the introduction of new object types. [3]

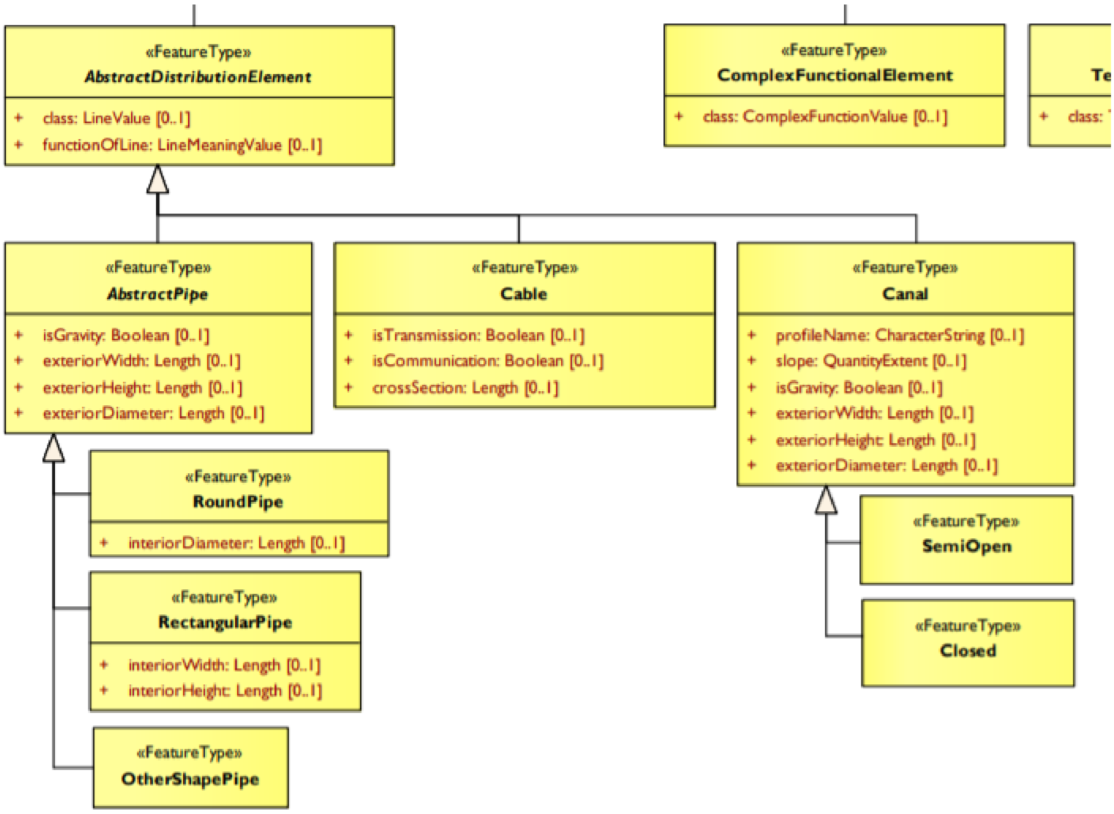


Fig. 9 - Extract from UtilityNetwork ADE – UML Model (according with [21])

CityGML Utility Network ADE can be implemented as a geodatabase model for ESRI ArcGIS. [4] The ArcGIS utility models are very popular GIS-based utility solutions. In ESRI CityEngine has been developed some posibilities for 3D modeling of utility networks. (figure 8).

The Geometric Networks is the basic structure used to represent different types of utility networks. A network is composed by edges (2D line features) and junctions (2D point features). According with [4], the ArcGIS utility model is useful for documentation and planning support in utility companies and city administrations, but a 3D geometry representation can be made just for 3D visualization.

IFC (Industry Foundation Classes) represents an important standard for buildings data exchange in interdisciplinary domains. [7] The IFC model is appropriate for building wide supply system. INSPIRE network model is considered being a good approach for a city or country wide supply system. [4] In the IFC model can be represented logical building structures, their attributes, being also associated with 2D and 3D geometry as well as utilities.

Table 1 –Differences in the Main Utility Modeling Approaches (adapted from [3])

Criteria	*INSPIRE Utility Networks*	*IFC*	*ArcGIS Utility Networks*	*CityGML Utility Network ADE*
Representation of heterogeneous networks	✓	basic	basic	✓✓
Dual representation	✓	✓✓	✓	✓✓
Topographic/graphic aspects	✓✓	✓✓	✓✓	✓✓
3D geometries		✓✓		✓
Functional aspects				basic
Hierarchical modelling				
• networks/ subnetworks	✓✓			✓✓
• components/ subcomponents	✓✓	✓✓	basic	✓✓
Interdependencies between				
• network features and city objects		basic		✓✓
• network features of different network types		✓✓		✓✓

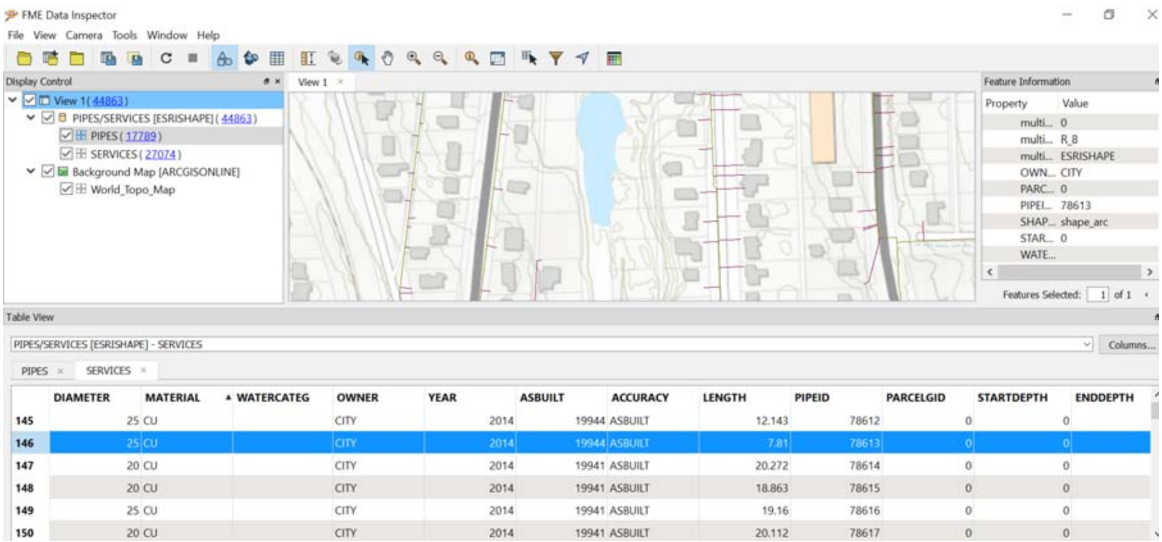


Fig. 10 – Open Data Catalogue Water Utilities Datasource investigated with FME Data Inspector (data downloaded from [19])

4. Conclusions

The paper investigates the current state of the main possibilities for modeling utility networks in general and water utility networks in particular. The main approaches can be divided into company software solutions and open source software solutions. Following a background literature review, the paper presents the main approaches for defining the spatial model. There have been mentioned the principal aspects regarding utility networks. It can be noticed that the interest in implementing open source standards is increasing.

Today is a real emergency to make many systems interoperable - for example: emergency response systems utility GIS systems SCADA systems. Unfortunately, the use of OGC standards is not established very well in the utilities domain, most of European utilities have adopted a service-oriented architecture (SOA). [20] The activity of the OGC is very important because it designs a process in which different organizations can work together to create international standards, the main purpose being to get their systems to communicate geoprocessing service requests in the same way.

5. References

1. Crothers, H., The Evolving Local Government Information Model and its Impact on Water Utilities, https://www.esri.com/arcgis-blog/;
2. Grise, S., Idolyantes, E., Brinton, E., Booth, B., Zeiler, M., ArcGIS Water Utilities Data Model, Esri, 2001;
3. Kutzner, T., Kolbe, T. H., CityGML Utility Network ADE – Scope, Concepts, and Applications, Underground Infrastructure Mapping and Modeling Workshop, New York City, April 24-25, 2017;
4. Becker, T., Nagel, C., Kolbe, T. H., Semantic 3D modeling of multi-utility networks in cities for analysis and 3D visualization, 3D GeoInfo Conference, Quebec, 2012;
5. Badea, A. C., Badea, G., Cadastru, bănci de date și aplicații GIS în zone urbane, Editura Conspress, 2013, ISBN 978-973-100-310-8, http://www.agir.ro/carte/cadastru-banci-de-date-si-aplicatii-gis-in-zone-urbane-121878.html;
6. Badea, G., Badea, A. C., Aplicaţii Sisteme informaţionale specifice domeniilor de activitate – îndrumător de lucrări practice, Editura Conspress, 2014, ISBN 978-973-100-309-2, http://www.agir.ro/carte/aplicatii-sisteme-informationale-specifice-domeniilor-de-activitate-indrumator-122244.html;
7. Hijazi, I., Ehlers, M., Zlatanova, S., Becker, T., Berlo, L. van, Initial investigations for modeling interior Utilities within 3D Geo Context: Transforming IFC- interior utility to CityGML/UtilityNetworkADE, 45th International 3D GeoInfo Conference, 2010, Berlin, Germany;
8. Badea, A. C., Badea, G., The Advantages of Creating Compound GIS Functions for Automated Workflow, pp. 943 – 949, INFORMATICS, GEOINFORMATICS AND REMOTE SENSING, Conference Proceedings, vol. I, ISBN 978-954-91818-9-0, DOI:10.5593/SGEM2013/BB2.V1/S11.043
9. Badea, G., Badea, A. C., Considerations Regarding the Implementation of the Technical Specifications in the Urban Information System, pages 23 – 32, RevCAD 15/2013, http://revcad.uab.ro/index.php?pagina=pg&id=3&rev=da&id_rev=34&modul=rev;
*10. ***, Metodologie privind executarea lucrărilor de introducere a cadastrului reţelelor edilitare în localităţi, Of.N. Cad. şi Cartografie, O.M.L.P.A.T. nr. 91/N/02.06.1997, B.C. nr.7/1997*
*11. ***, Ordin 1523 din 29.11.2017 pentru aprobarea Normelor Tehnice pentru realizarea seturilor de date spatiale privind retelele de utilităiţi publice, ANCPI, http://www.ancpi.ro*
12. https://3d.bk.tudelft.nl/ken/files/17_geobim.pdf (last accessed April 2018)
13. http://www.citygmlwiki.org (last accessed March 2018)
14. https://www.iso.org/standard/59193.html (last accessed February 2018)
15. www.esri.com (last accessed March 2018)

16. https://pro.arcgis.com (last accessed March 2018)
17. https://inspire.ec.europa.eu/id/document/tg/us (last accessed February 2018)
18. http://www.arcgis.com/apps/CEWebViewer (last accessed April 2018)
19. https://www.nanaimo.ca/open-data-catalogue (last accessed March 2018)
20. http://www.opengeospatial.org/domain/EnergyUtilities (last accessed March 2018)
21. https://github.com/ (last accessed April 2018)