

# Design of the Data Model for Information Support in the Field of Civil Protection of Municipalities

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*Abstract:* - This article describes the design of a data model for the purposes of civil protection. The objective of the data model is, in particular, to support the planning and preparation of civil protection and sheltering of the population. The article also defines key entities and attributes of the resulting data model (DM). Subsequently, it verifies the proposed DM in practice by implementing it in the real-life conditions of the town of Uherské Hradiště in the Czech Republic. Crucial areas of planning and preparation of civil protection are identified based on the analysis of valid legislation and other materials. In this respect, the article aims to create system support for the processes of civil protection. In order to design the data model an E-R diagram is used and processed in the draw.io diagram editor. The data model is designed using scientific methods of analysis, observation, abstraction, and especially modeling. Not only do these methods serve for the identification of key entities and their attributes but they are also used for creating the conceptual and logical data scheme. Individual entities and their attributes constitute a conceptual data scheme of the civil protection data model. In addition, the article outlines a logical data scheme of the civil protection data model in which formats of individual entities and attributes are indicated. MS Excel was selected for the design of the logical data scheme. By the end of the article the hypothesis of standardization of residential houses when mapping premises for improvised shelters (IS) is presented and verified. This hypothesis was developed during the DM implementation in the town of Uherské Hradiště. The application and usability of the resulting DM were also verified there. Outputs of the implementation confirm the hypothesis of standardization and they also demonstrate the importance of using spatial tools in the planning processes of population sheltering.

*Key-Words:* - Data model, Geographic Information System, Informatics, Information Systems.

## 1 Introduction

Currently, civil protection and namely population sheltering (PoS) within the concept of Smart Cities requires the use of information technologies in order to fulfill the tasks of planning and implementation of civil protection measures. From the perspective of using advanced information technologies, population sheltering has recently been sidelined in the Czech Republic (CR). Several factors were the cause of it being sidelined, the most significant of which were the low priority of the PoS and the absence of system solutions which would allow more extensive use of IT in this field. The low priority of the PoS has been a long-term trend in the CR [1]. However, within the context of the development of global security threats in recent years this trend has been reversing gradually. In addition, the PoS has been incorporated into the legislation of the CR. As a result, the PoS occupies an important position among tasks for civil protection. Another problem is the absence of a system solution for the wider use of IT [2]. This is a

major problem from the perspective of actually using IT and integrating the PoS into the Smart Cities concept. Nevertheless, this problem can be solved by designing a data model (DM) of the PoS that would cover the issues of the PoS by means of IT. Such a data model represents a coherent model of real-life conditions of the PoS. In order for the DM to be designed, it is necessary to carry out a detailed analysis of the PoS in the CR and to define key entities and their attributes [3]. It is possible to proceed from a sufficiently extensive basis of documents of both legislative and non-legislative character. Consequently, the knowledge obtained should be compared with the knowledge acquired from real-life practice. In the CR the PoS is implemented by the staff of the municipalities because they are the most appropriate experts for comparing the findings and implementing any adjustments needed in practice [3]. The design of the data model will therefore contribute to the development of IT applications in the field of civil

protection. This makes it easier for civil protection to be integrated into the concept of Smart Cities.

## 2 Problem Formulation

In order to design the DM of civil protection general methods of analysis, comparison and interviewing are used. These methods are applied when evaluating theoretical foundations of the PoS in order to define the key entities of the DM and their attributes. In addition, methods of analysis and comparison of valid legislation and available professional literature are applied. As there exist a large number of handbooks and instructions for the preparation and construction of the IS in the CR, these also have been included in the research. The interview method is applied to the civil protection professionals. The aim of these interviews is to verify the knowledge acquired through analysis and comparison. The validation of the defined key aspects of the PoS is followed by the design of the data model. The DM is designed using the modeling method by means of which the real-life environment of civil protection is modeled, especially in the field of the permanent shelters (PS) and improvised shelters (IS).

For the needs of the design, the E-R diagram is used to implement a conceptual data model. The conceptual model using the E-R diagram is designed in the draw.io environment. For better clarity the resulting logical scheme is processed using MS Excel.

The hypothesis of using standardized residential buildings was applied in the research in order to select premises suitable for IS. This hypothesis was used in a case study in the territory of the town of Uherské Hradiště in which individual construction series of concrete blocks of flats were identified. For the implementation into the GIS, SW tools QGIS version 2.18.17 and QGIS Browser version 2.18.17 were used. These served to create a physical data model and to spatially present the identified buildings of the individual construction series and other entities and attributes of the DM. In addition, the demographic database OpenStreetMap (OSM) was used, which served as a source of reference for the data.

The DM design was based on the hypothesis of standardization of the premises for IS located in blocks of flats. This hypothesis assumes consistency in structure types/subtypes of the individual blocks of flats. Here again, the design consistency of the individual buildings included in the given design

series is assumed. Therefore, the implementation of the DM for every block of flats of a given series is not necessary. The DM can only be implemented to the whole design series. Using this hypothesis saves the time required to implement the DM.

## 3 Problem Solution

The main task of the data model (DM) is to enable the use of SW applications as tools for information support of civil protection (CP), especially for administration and record keeping of data on improvised shelters and permanent shelters. In addition, the DM is required to be used for data analyses. The designed model is also to be used across several departments and workplaces. Therefore, the model includes only information that is crucial for record keeping, management and designing of shelters. Some information is not entered into the DM and it can be kept in a different manner, e.g. by means of “shelter tabs” [2].

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### 3.1 Conceptual Design of a Data Model

In order to design the DM, a scheme of a conceptual DM was created, which was subsequently converted into a logical DM. The creation of the conceptual DM included the following steps [2]:

- specification of types of objects and their characteristics,
- defining entities,
- assigning attributes,
- defining relationships and their attributes,
- integration of the DM components.

#### a) Specification of Types of Objects and their Characteristics

In order to ensure that the DM is applicable to the project focused on the IS, individual shelters were categorized according to the types of emergency events (EE) and the types of negative effects against which shelters protect.

This attribute divides the EE into four basic categories [3]:

- natural floods and floods caused by accidents,
- EE of a natural character,
- chemical, biological, radiological and nuclear EE (CBRN) of a military and non-military character,
- other types of EEs.

In addition, the attribute operates with a mathematical apparatus that serves to determine a protective coefficient for the building against the effects of penetrating radiation. This apparatus allows selecting the most suitable shelter in the event of radiation and nuclear EE. The algorithm for calculating the protection properties depends on the type of shelter.

### b) Defining Entities

For the purposes of the DM entities were designed based on specific types of objects and their characteristics. The most important entities were buildings of the CP which included PS and IS together with their equipment, construction series and characteristics. These entities were converted into a graphical format [2].

### c) Assigning Attributes

The list of attributes of the chosen entities was obtained by analyzing characteristics of the types of objects selected for construction of the IS. Besides the attributes there are also abbreviations that will be used when creating the DM and during its implementation into the SW application. The primary keys were simultaneously assigned to the selected attributes.

The key attribute was also selected within the entity of permanent shelters; this attribute is an identification component (i.e. ID). Furthermore, the selected attributes were notionally categorized as follows [3]:

- identification component,
- record keeping (registration number),
- location (address and position coordinates),
- ownership and management,
- key information about the given shelter (types of EEs for which the shelter is intended, attraction zone, time of operation and putting into operation, capacity, etc.),
- informative attribute (status, other purposes of the shelter, etc.).

Similar to the PS the identification component with almost identical attributes was chosen as the primary attribute of the improvised shelters. Again, these were notionally categorized as follows [3]:

- record keeping,
- location,
- ownership and management,
- key information about using the shelter,
- informative attribute.

In the category of informative attributes, the status of the shelter was altered based on the fact if it was used as the permanent shelter.

Within the entity of shelter equipment the selected attributes were notionally categorized as follows [3]:

- equipment identification (ID),
- communication and information equipment (telephone, internet connection, warning and notification systems in close proximity, etc.),
- energies (water, electricity and gas supplies),
- technical equipment and sanitary facilities (sewerage, filter-ventilation, etc.),
- other (for additional information).

Attributes assigned to the construction entity were notionally divided into the following categories [3]:

- construction (types of construction, number of floors, sections, etc.),
- location,
- materials,
- dimensions,
- protective elements and calculations.

Owing to the selected format of the conceptual DM using the E-R diagram, it is not necessary to define classes, which can be used to create a class diagram if it is applied to this DM [2].

### d) Defining Relationships and their Attributes

Upon defining the given entities and attributes the strong and weak relationships of individual entities were specified. In order to maintain clarity of a graphic depiction within the attribute definition only some attributes were included. Other attributes were based on the attribute tables mentioned in the previous section. The defined relationships are shown in figure 1 [2].

### e) Integration of the DM Components

Prior to the actual integration of DM components into the conceptual model it is necessary to assign and define domains for individual attributes. Domains constrain the values that the attributes may acquire. These domains are specified together with individual attributes of the given entities.

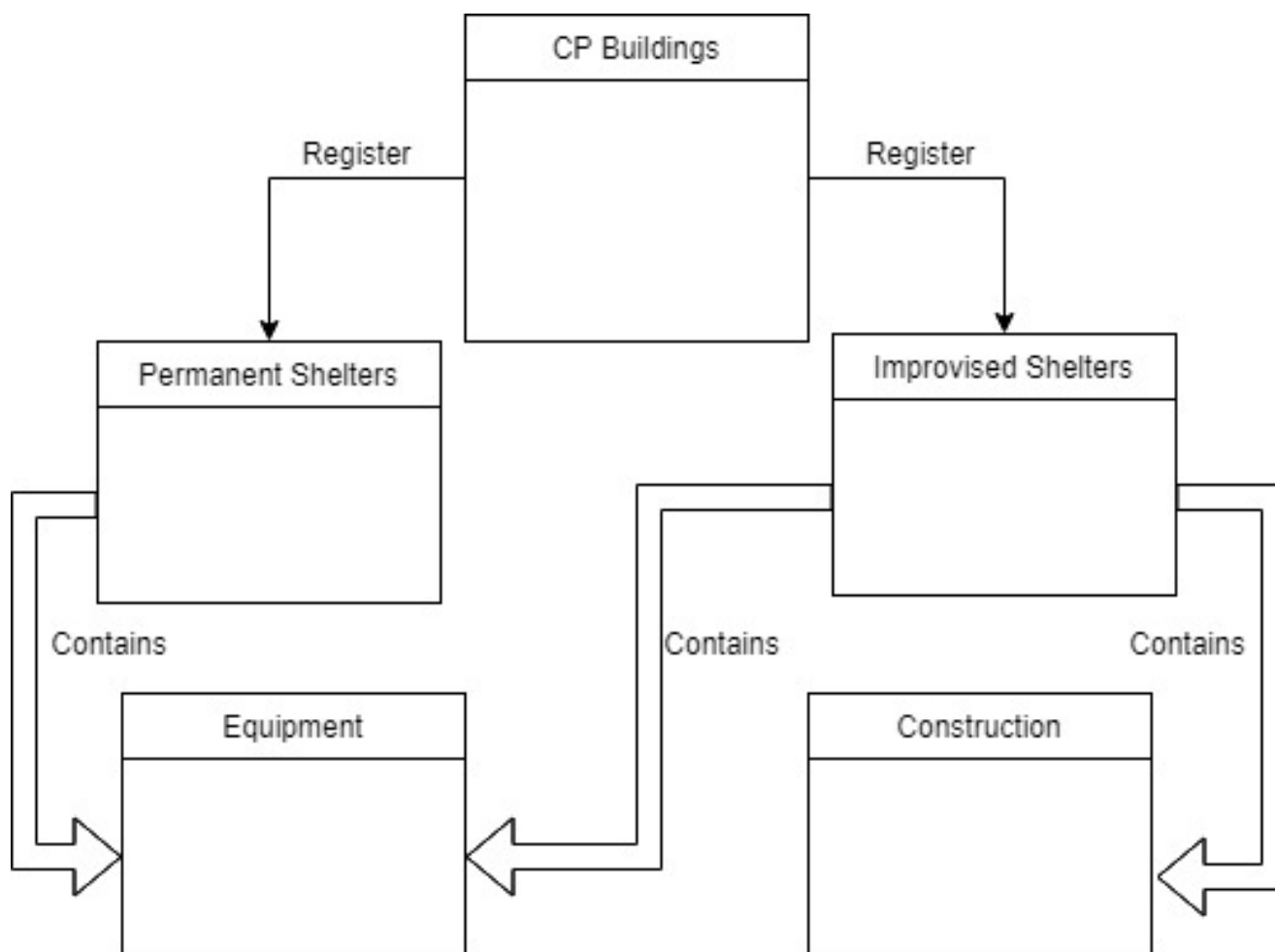


Fig. 1: Conceptual data model [2,4].

Upon defining the domains the E-R diagram was completed with a legend chart containing relevant attributes and their domains.

### 3.2 The Logic Design of the Data Model

Upon defining the necessary entities, attributes and domains, a simplified scheme of the logical DM was created. This scheme is based on the previous design of the conceptual DM. The logical model combines entities, attributes and domains for which it subsequently sets the format. A detail of the logical DM is not presented at the paper but were used the domains: string, integer and list (too extensive format).

### 3.3 Creating a Physical Data Model

The open source SW QGIS version 2.18.17 was used to convert the logical data model into the physical form. The actual physical model was then created by the transformation of the target structures of the geographical database and file systems; physical layers and attributes were also created.

First of all, the system of layers was created; this file was created in ESRI shapefile format with .shp extension. For work purposes and for the sake of better analytical work in the GIS, a vector data model with a "point" as the topology type was chosen. Subsequently, the individual attributes were implemented and their structures were slightly modified for the needs of the DM. The ESRI shapefile format has been chosen primarily for its ease of portability among various GIS applications and great possibilities for additional extensions. In addition, it is compatible with the licensed tools ArcGIS that are the most frequently used by villages and municipal authorities.

### 3.4 Implementation of the DM in Uherské Hradiště - The Case Study

The physical DM was implemented in the territory of Uherské Hradiště in the Czech Republic. A case study for the implementation of the DM was performed there.

An example of the implementation of the DM into QGIS 2.18.4 is shown in the following figure. The figure depicts a map of the given DM area, and there is also a list of created layers of permanent

shelters (PS) and IS on the left. For the purposes of better spatial clarity, a raster map of the area is also represented. This map was obtained from the OpenStreetMap server and it fulfills the function of the overview map. In addition, the attribute tables of the layers for both PS and IS are also represented.

For these buildings, the non-specification of a particular series is also stated.

A preview of the database of mapped residential buildings is shown in Tab. 1. In the first stage, a simple database was processed in MS Excel. This SW was selected for its case of use and sharing.

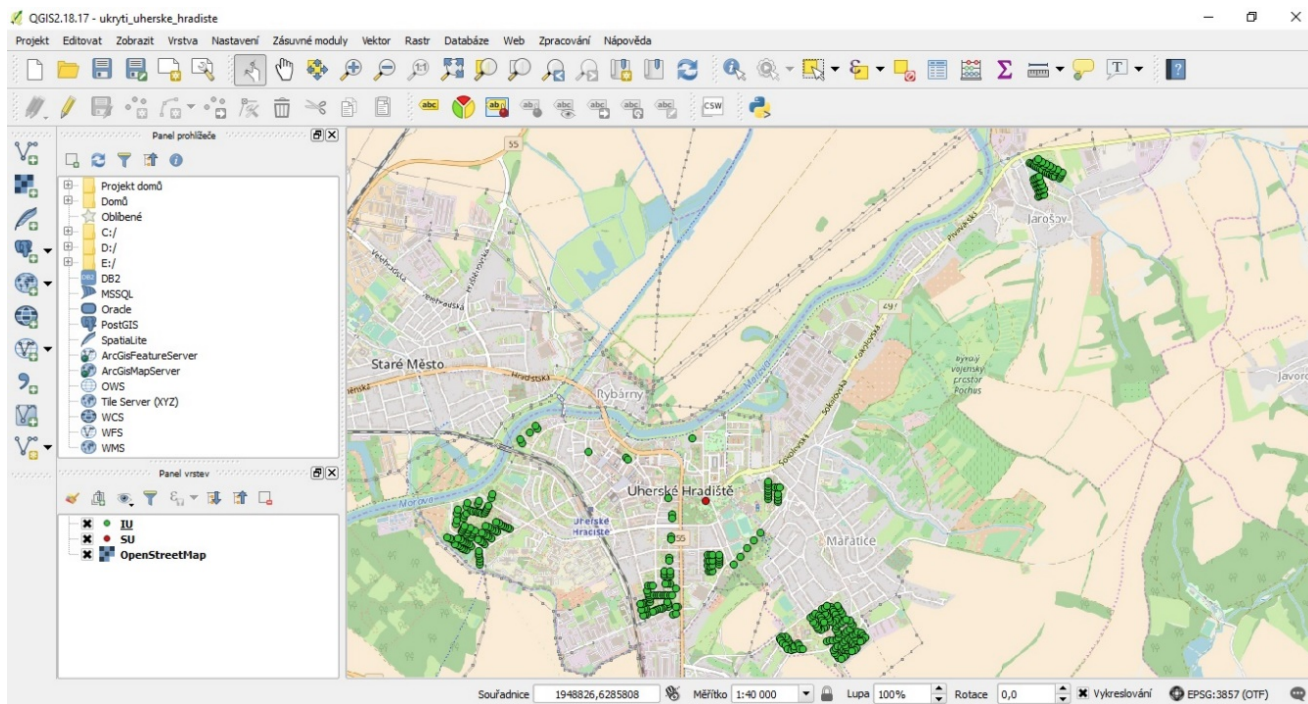


Fig. 2: Example of the output from QGIS version 2.18.4 with DM implementation completed with a background map from OpenStreetMap server [4].

SW QGIS was consequently used for testing the implemented DM in laboratory conditions during which actual available information was used and the basic operation of the model was tested; in addition, possibilities for using the model for spatial analyzes associated with the population sheltering were verified.

On the basis of laboratory testing the implementation of buildings with PS and premises for IS in Uherské Hradiště was performed. Also the hypothesis of standardization of premises for IS was applied. By means of the data obtained, the physical survey and the spatial data evaluation, several basic design series of residential building structures were identified. From the perspective of block of flats these are series OP 1.11., OP 1.31 and G32 [12]. Moreover, several residential houses with possible brick construction were identified. However, this piece of information could not be verified and thus, it is labeled as unidentified in the overall database and the detected assumption is mentioned. Similar to these buildings, it was not possible to verify the type of construction for some of the blocks of flats.

The database contains a total of 364 records, some of which are physically connected to each other and, according to the Decree of the Ministry of the Interior No. 326/2000 Sb. [16], they have been assigned more numbers. For this reason, they are listed as two separate buildings in the database. This may be changed in the future by the decision of the municipality to renumber the buildings.

Table 1. A preview of the residential building database.

id.	H.N.	Street	Construction Type Line
1	969	Na rybníku	OP 1.31
2	970	Na rybníku	OP 1.31
3	971	Na rybníku	OP 1.31
4	974	Na rybníku	OP 1.31
5	975	Na rybníku	OP 1.31
6	976	Na rybníku	OP 1.31
7	977	Na rybníku	OP 1.31
8	978	Na rybníku	OP 1.31
9	979	Na rybníku	OP 1.31
10	980	Na rybníku	OP 1.31

11	981	Na rybníku	OP 1.31
12	965	Na rybníku	OP 1.31
13	966	Na rybníku	OP 1.31
14	967	Na rybníku	OP 1.31
15	968	Na rybníku	OP 1.31
16	984	28. října	Was not Determined
17	985	28. října	Was not Determined
18	986	28. října	Was not Determined
19	987	28. října	Was not Determined
20	988	28. října	Was not Determined
21	989	Pod Svahy	OP 1.11
22	990	Pod Svahy	OP 1.11
23	991	Pod Svahy	OP 1.11
24	992	Pod Svahy	OP 1.11
25	993	Pod Svahy	OP 1.11
26	994	Pod Svahy	OP 1.11
27	995	Pod Svahy	OP 1.11

Out of the total number of buildings there are 271 buildings of OP 1.11 series, 33 of G32 series and 15 of OP 1.31 series. For 45 buildings the construction type was not identified; however, 16 of them are probably made of bricks. When compared to the total number of buildings, the prevalence of buildings of OP 1.11 series verified the hypothesis based on unification, or rather standardization of premises for IS according to their construction types.

The figure presents the localization of individual database objects (the layer of residential buildings). Buildings of OP 1.11 series are marked in green, buildings of G32 series are yellow and those of OP 1.31 are blue. Buildings of undefined construction type are marked in red. The database remains open for the continuity of adding unmapped buildings and the eventual adjustment of unidentified data.

#### 4 Discussion and Conclusion

The design of the data model is the basis for introducing a systematic approach to civil protection in the field of sheltering. The data model forms the foundation for the use of information support tools.

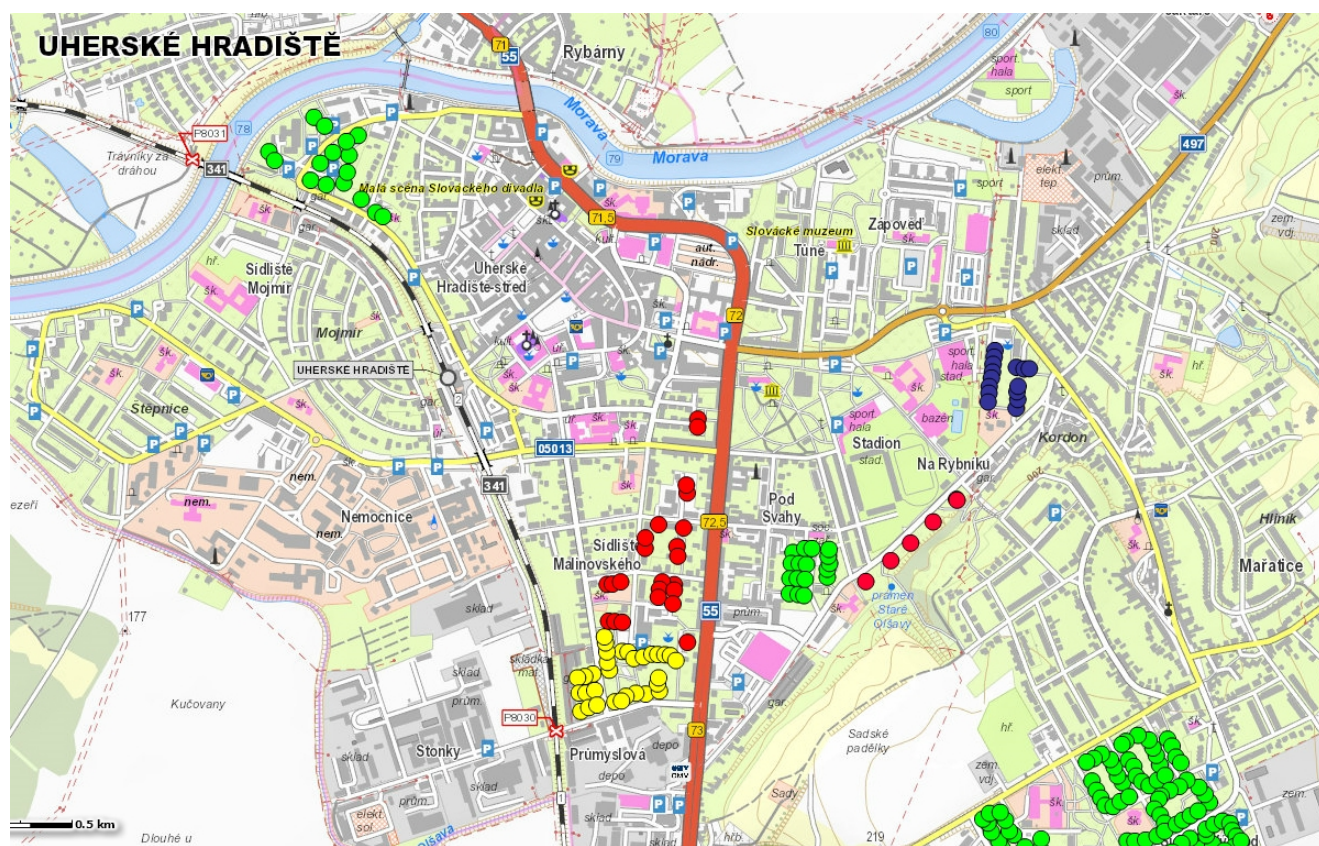


Fig. 3: Preview of a section of a residential buildings database [6,5, 3].

Therefore, it helps to unify the approach of municipalities in the CR towards civil protection. A unified approach can predominantly be achieved by the possible use of a web application, which is easily accessible to the population. Therefore, the designed data model used in web applications seems ideal if used as a support for civil protection. Another SW application, which can be used within information support of civil protection, is the geographic information system (GIS) [1]. GIS applications allow processing spatial information that is contained in locations of individual shelters, building materials, evacuation routes, attraction zones, etc. The DM is not specifically designed to be used in the GIS. Nevertheless, for the purposes of possible future development and different priorities of any future users, the model is designed to be open, which allows easy modification, such as the removal of any arbitrary attribute. At the same time, it includes the "location" attribute that allows using spatial information. It is also possible to select a point as the type of geometry and use this DM as the spatial DM. In addition, the GIS can be used within the web application and this option seems to be an appropriate solution. GIS web applications are also used in related areas of civil protection in which they play a significant role. The choice of a suitable SW application is the topic for further research which will follow the designed DM. Together with the choice of the appropriate SW application (probably the GIS application), the goal of the further research will be testing of the implemented data model in a case study and its possible optimization and adjustments. The possibility of optimization and adjustment was taken into consideration during the actual designing process and therefore, it does not pose a major problem.

The implementation of the proposed DM in the town of Uherské Hradiště has verified the efficiency of the whole model. Testing of the actual model occurred at a selected location in which buildings suitable for PS and IS were mapped. The principle for standardization was used for mapping. Standardization facilitates the planning for population sheltering. The whole method of standardization of the premises for the IS is based on the assumption of structural conformity of residential buildings. Due to the unification of the construction in previous years, this consistency is evident in a larger number of series of residential buildings. Moreover, there are always several buildings of each individual series in the territory of the town. The hypothesis of standardization of the premises for IS has facilitated work in this research.

For instance, 271 buildings of the same construction type were found for OP 1.11 series.

Moreover, the modularity of the DM made up of PS and IS entities enables optimization of the model depending on the current developments in civil protection or possible sidelining of the PS. The DM allows simple deletion of the entity, including its attributes, or the entity of the IS can be changed into the database record with the attribute of the former PS. In conclusion, it was proven that the DM fulfills the main objective of this article, which was creating a tool for the needs of information support of civil protection, and a tool for a systematic approach to the population sheltering in the CR.

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