URBAN ROAD INVENTORY - CHALLENGES AND SOLUTIONS – TIMIȘOARA CASE STUDY

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***Abstract**: Present article examines the Urban Road Inventory, a much-needed data infrastructure required for good local governance, right of way, traffic studies, urban development, asset management, etc. Raised challenges are examined and solutions are suggested starting from an ongoing project for road inventory of Timișoara municipality. A technology mix of mobile mapping, very high-resolution satellite imagery, open data and Geographic Information Systems is considered and assessed for producing data with high density and quality.*

***Keywords:** Road Inventory; Mobile mapping; Remote sensing; open data; Geographic Information System*

1. Introduction

In august 2022 Timișoara City Hall has awarded Gauss SRL a contract for a Study regarding the measurement of the streets in the Municipality of Timișoara and the determination of the length, width and surface needed to establish the street cleaning areas. The main objective of the study was to provide a correct and necessary source of information for determining the surfaces of streets proposed for cleaning, for drawing up schedules with the frequency of execution and determining the annual volume of works.

The challenges met during the execution of this contract are, probably, the same in every Romanian city or town.

The diversity of geospatial data acquisition technologies available today, as well as their productivity in the rapid acquisition of a huge volume of geospatial information, ensure the premises for increased efficiency in road infrastructure management, starting from the inventory of the current situation, the detection of changes over time, monitoring current events, increasing operational safety, providing adequate information for development decision-making and enhancing transparency. Present article traces the advantages and disadvantages of the various technologies available and presents concrete ways of correlating their use for the generation of spatial data with a sufficient degree of precision for the purposes pursued and in an economically efficient way of collecting them. Relevant examples are presented from the study performed in Timișoara.

Spatial data (also called geospatial) represents "any data having a direct or indirect connection with a location or a specific geographical area" (Government Ordinance no. 4/2010 regarding the establishment of the National Infrastructure for Spatial Information in Romania). Geospatial data is the basis for relevant and critical information used in planning, design, asset management and operations associated with infrastructure in general, and road infrastructure in particular, at all levels of government and administration. The sources of spatial data can be existing cartographic materials, topographic measurements, remote sensing or smart terminals such as phones, tablets and IoT sensors (Internet of Things).

Geospatial data and their management and processing technologies have a major impact on the judicious management of transport infrastructure. Their importance is recognized internationally, for example, in The National Academies of Sciences, Engineering, and Medicine in Transportation Research Board Conference Proceedings 31, published in 2004, it is stated that "extracting these data, transforming them and putting them to the disposition of decision makers have grown dramatically in importance as all modes and levels of government face an increasing responsibility to improve efficiency while maintaining mobility, improving safety and anticipating and addressing security threats." (*** 2004)

2. Acquisition Methods of Geospatial Data for Road Infrastructure

Urban road infrastructure has several key characteristics:

Table 1. Road infrastructure key characteristics

No	Characteristic	Impact on survey	Timișoara case study
1	Regular geometry of the road components	+	Over 95% or roads are geometrically regular
2	High density of road infrastructure – high volume of survey	-	~10km of roads per km^2
3	Heavy traffic	-	in Timiș county, at 31st December 2021, were registered 296,116 cars 1,515 busses and 39,947 vehicles for transports of goods - a sizeable part of these are located in Timișoara
4	Traffic further crowded by cars from other counties	-	Timișoara is an urban pole of attraction (especially Hunedoara, Caraș Severin, Mehedinți, or Gorj)
5	High usage of carriage way for parking	-	lack of proper parking places
6	Street names are not clearly marked and defined	-	There are situations where a part of the road is unclear to which is the street name or where a particular street is situated
7	Roads property status	-	There are private streets that are not in City Hall administration Lack of land book registration for majority streets.
8	Streets in new development areas are not yet built	-	Streets that are listed in the public domain are not yet built

Timișoara road network aspect, in particular, is heavily influenced by the presence of a military fortification in the middle of the city up to 1892. This led to a concentric radial network of streets. The Bega canal, which crosses the city from East to South West it separates the city into its Norther part and Southern part connected by 9 road bridges and 4 foot bridges.

The mentioned characteristics raise the following challenges (C) and opportunities (O):

1. (O) The obscured road elements limits can be reconstructed using geometry tools.
2. (C) The duration of survey has to be reasonable.
3. (C) Traffic must not be interrupted.

4. (C) Health and safety issued.
5. (C) Identification of all streets mentioned in the City Street Names List.
6. (C) Delineation of streets according to names.

The following acquisition methods for Geospatial Data were considered for use in Timișoara project.

Table 2. Technologies for geospatial data acquisition

Technology	Advantages	Limitations
GNSS Surveys	Very high precision Independ on the weather Operators can be trained quickly for data acquisition Productivity 300 points/ day/ team	Average costs for processing equipment and software Requires highly skilled users for processing Short mobilization time In the case of RTK measurements it requires a data link or radio link Low data traceability
Tachymetric Surveys	Very high precision Productivity 200 points/ day/ team	Average costs for processing equipment and software Average mobilization time Dependent on weather Requires highly skilled users for processing It requires the determination of points by GNSS or points with known coordinates Low data traceability
Satellite photogrammetry	Acquisition over large areas (typically at least 100 km^2) Resolutions down to 30 cm Very good data traceability Reduced costs with the purchase of frames	High mobilization time Average costs for processing equipment and software It depends on the weather Requires highly skilled users for processing It requires determining the coordinates of some control points (GCP)
Satellite SAR	Sentinel-1 data freely available It does not depend on the weather/time - active lighting Wide coverage High return frequency	Complex processing of primary data Requires very highly skilled users for processing The presence of so-called artifacts after processing - false data
Aerial photogrammetry (UAV)	Acquisition on medium surfaces (typically at least 2 km^2) The digital model of the surface flown over can be extracted with a precision corresponding to the 1:500 scale Resolutions up to 2 cm Very good data traceability	Significant drone costs High mobilization time Average costs for processing equipment and software Existing areas restricted for overfly It depends on the weather Requires highly skilled users for processing operation It requires determining the coordinates of some control points (GCP)
Aerial Lidar (UAV)	Acquisition on medium surfaces (typically at least 2 km^2) The digital model of the surface/land flown over can be extracted with a precision corresponding to the 1:500 scale through semi-automatic filtering Densities of 50 points/m^2 Very good data traceability	Significant drone costs High mobilization time Average costs for processing equipment and software Existing areas restricted for overfly It depends on the weather. Requires highly skilled users for processing operation It requires determining the coordinates of

Technology	Advantages	Limitations
		some control points (GCP)
Terrestrial Mobile Lidar	High precision The highest productivity among the presented methods Very good data traceability	High equipment costs Very large volume of information to be stored - 50 Tb for 100 km of road
Terrestrial Static Lidar static	Very high precision Very good data traceability	High equipment costs Low productivity Very large volume of information to be stored

In the end, after a cost benefit analysis, Mobile LiDAR Surveys combined with GNSS surveys and satellite photogrammetry were selected as methods of acquiring data.

3. Progress of Works

Lidar surveys were performed during 7 days in august- September 2022. In total it were surveyed 594.909 km – an average of 84.987 km per day.

Later, during vectorisation phase, it was determined that several additional areas need to me surveyed. These surveys totalled 141.442 km and were performed in 6 days – an average of 23.573 km per day

Fig. 1. Lidar road surveys calendar

GNSS surveys were performed in 10 days, for areas where the access of mobile mapping system was not feasible.

Photograms were used for evaluating and confirmation of the type of object.

Sentinel 2 images were used for calculation several vegetation indices: NDVI. These indices were used for a coarse quality check of the digitization.

In order to identify the correspondence between the digitised carriageway of the road with the list of streets, available in excel format on the City hall website (https://www.primariatm.ro/file_uploads/nomenclatorul-stardal/Nomenclator-stradal-Timisoara-ACTUALIZAT-HCL-582-2019.xls), the following methods were used:

- direct data extraction from video images
- OpenStreetMap data (available at https://download.geofabrik.de/)
- Local people knowledge

Nevertheless, there were 83 streets that were not identified. These were later identified with the aid of the City Hall.

Fig. 2. Stret name indicator

There were digitised the following classes:

Table 3. Classes of obejctes identified

Object class	**Number of polygons**	**Area [ha]**
the carriageway of the road	2,088	426.69
parking lots (along the streets and in residential areas)	1,928	79.08
passages	5	0.70
bicycle paths	485	11.68
bridges	17	2.35
embankments of the tram lines	1	20.93
sidewalks	6,565	189.09

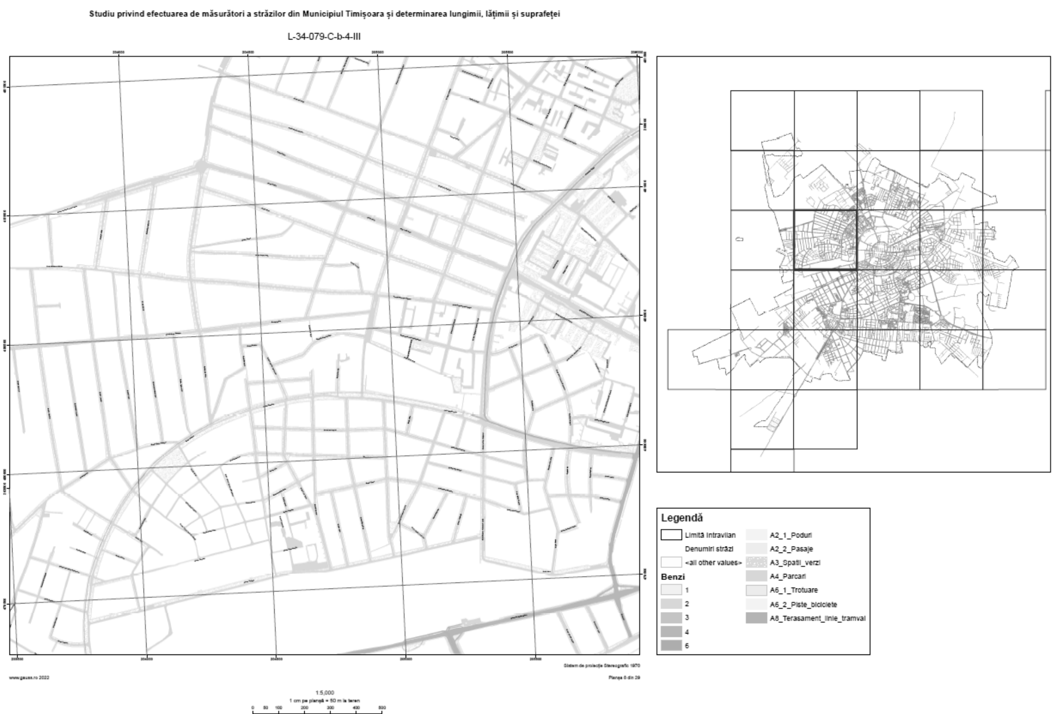

Fig. 3. 1: 5000 Map with digitised elements

4. Conclusions

One important issue, regarding the city built area (*rom. intravilan*), is the availability of the latest digital version. The city built area was established by the General Urbanistic Plan approved in 14.09.1999. This limit is available in digital format at Cadastre and Land Registration Office (OCPI - Oficiul de Cadastru și Publicitate Imobiliară (rom.)) Timiș. This limit is, unfortunately, not updated by Zonal Urbanistic Plans. This happens to the fact that the approval loop is missing a stage, after the adoption of the Zonal Urbanistic Plan in the local council, in which the limit modified (if applicable) through the Zonal Urbanistic Plan is formally received by OCPI.

From the surveying point of view, LIDAR surveys proved to be the most efficient technology for gathering geospatial data – in Timișoara case it allowed the covering of over 95% of the road infrastructure. It allowed data collection in a very short time, in conditions of heavy traffic. Laser point data, combined with panoramic images allowed the digitization of the elements in the office by a team of 5 persons during 2 months.

5. References

1. **** (2004) - The National Academies of Sciences, Engineering, and Medicine in Transportation Research Board Conference Proceedings 31*
2. *Aurelia Junia, Mihai Opriș, Mihai Botescu, Loredana Brihac - Studiu de fundamentare zone construite protejate – Timișoara 2011*
3. *Andreas Hartmann, Florence Yeang Yng Ling, Value creation of road infrastructure networks: A structural equation approach, Journal of Traffic and Transportation Engineering (English Edition), Volume 3, Issue 1, 2016, Pages 28-36, ISSN 2095-7564,*
4. *STOCK, Kristin, GUESGEN Hans (2016) - Geospatial Reasoning With Open Data in Automating Open Source Intelligence*
5. *MASSER, Ian (2009)- Changing Notions of a Spatial Data Infrastructure*
6. *NISTORESCU, Marius, DOBA, Alexandra, SÎRBU, Ioana, MOȚ, Radu, REMUS, Cristian, ANDRÁS, Papp, NAGY Attila, SOS, Tibor (2016) - Ghid de bune practici pentru planificarea şi implementarea investițiilor din sectorul infrastructură rutieră, București*
7. *GUO, Xiaoqin, LI, Boye, and LI, Xiang (2022) - A Study on Synergistic Development of Innovative Public Management and Economic Growth Based on Big Data in Mobile Information Systems Volume 2022, Article ID 9906507,*