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FORMATION OF ATTRIBUTABLE DATA OF THE THEMATIC LAYER OF "UNDERGROUND SEWAGE PIPES" AND INTEGRATION INTO THE SINGLE GEOSPATIC INFORMATION BASE

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Abstract: This article outlines key tasks related to the formation of attribute data for the thematic layer "Underground Sewer Pipelines" on the basis of legal, economic management, and architectural-construction status indicators of underground sewer systems. It discusses the procedures for formalizing these data within spatial database tables and visualizing them on a 1:2000 scale land cadastre map using ArcGIS 9.3. Additionally, the article highlights the importance of submitting this information to the National Geographic Information System aimed at ensuring the operational support of the Specialized Geographic Information System for the Unified State Cadastre System (SGIS-USC). The focus is on facilitating the integration of state cadastre systems.

Keywords: Buildings, underground sewage pipes, structure, property, economy, list, mapping, law, protection, historical, cultural, technical, economic, indicator, area, account, attributive, system, quality, quantity

Introduction: It is necessary to develop a computerized database of cadastral information regarding underground sewage pipelines in the region, based on the data recorded in the cadastral register concerning the legal, economic, and architectural-construction status of these facilities. This information should be consolidated on a national, regional, and local (settlement-level) basis quarterly and annually, systematized, and published accordingly [1; 2].

These data, based on a computerized database, are intended for the creation and management of a specialized Geographic Information System (GIS) designed to solve the issues of the Unified State Cadastre System (USCS). This system is developed with the purpose of integrating the thematic cadastral information into a unified geospatial information database [3;4].

Thematic layer formation within GIS for underground sewer pipelines, the necessity of collecting and processing information on underground sewer pipelines based on the State Cadastre, as well as ensuring their timely and regulated submission, highlights the relevance of this research.

Research methodology and methods. The object of the study is the results of an inventory conducted on types of underground sewer pipelines within the designated area. **The subject of the research** is the development of a procedure for generating attribute data for the thematic layer of underground sewer pipelines based on indicators of their legal, operational, and architectural-construction status within the area. During the research process, the following methods were employed: statistical analysis, field surveying, classification, systematization, and statistical re-verification to ensure the reliability of the results.

Reliability and Discussion of Research Findings:

The computer database is structured according to a unified system, which is based on the classification of underground sewer pipelines by the following characteristics and groupings:

- Category of use (industrial facilities, multi-storey buildings, or private residential houses);

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- Intended purpose;
- Ownership or other real rights;
- Construction and technical characteristics
- Location
- Material and diameter
- Protection zone
- Distance from the pipeline axis to adjacent structures

A database (DB) is a collection of data organized according to defined rules and adhering to general principles of description, storage, and management.

This database forms the core of an automated system known as a Geographic Information System (GIS), which is designed to collect, process, analyze, model, and visualize information on geographic features. It also utilizes digital cartographic, textual, and related data to solve information and analytical tasks of national (intersectoral) or sectoral importance [5; 6; 7].

Since the emergence of GIS, it has become possible to integrate not only geographic data, but also tables, diagrams, and various economic and legal datasets. The primary focus in this context is on the types of data represented in the database and the methods used for their presentation. This type of data is generally referred to as attribute data.

After mapping the underground sewer pipeline in GIS, it is typically displayed as a polygon. However, detailed information about the pipeline may still be required. This is where the concept of attribute data becomes essential. An attribute database contains comprehensive data about the underground sewer pipeline, including:

– Legal documentation
– Total length
– Area covered
– Geographical location
– Type and distance of connection (left or right)
– Materials used
– Diameter of the pipe
– Year of construction
– Usage category (enterprise, multi-storey, or private residential building), and more.

Analysis: Based on their functional characteristics, the facilities are classified into two main groups: "Main Underground Sewer Pipelines" and "Auxiliary Connected Underground Sewer Pipelines." Taking into account their legal, operational, and construction statuses [8; 9; 10], the attribute data for the "Underground Sewer Pipelines" thematic layer is developed (see Figure 1).

In this regard, information about the legal status of underground sewer pipelines includes the location of the underground sewer pipelines, their ownership rights or other property rights with legal entities and individuals, the grounds and terms of the emergence of these rights, the terms of their termination, conditions of limitation of property rights and other material rights, information about the rights of third parties to these objects are considered as [9;10].

The value of the “underground sewer pipelines,” the specifics of their usage, the purposes of these facilities in production, their use for designated purposes, and other related information constitute the basis of the economic status of the “underground sewage pipelines” [5; 6].

The architectural and construction status of an “Underground Sewer Pipeline” is determined based on its compliance with land use planning schemes, city master plans, settlement placement projects, as well as urban planning norms and regulations. This status includes various parameters of the pipeline such as construction material, diameter, total length, total

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occupied area, connection distance and type (right or left), usage category (industrial, multi-storey or single residential housing), date of construction, designation of the pipeline's protection zone, distance from the pipeline axis to nearby buildings, and other technical details [6;8;9]. In the database of the Geographic Information System (GIS), one of the main forms of describing attribute data is the tabular format.

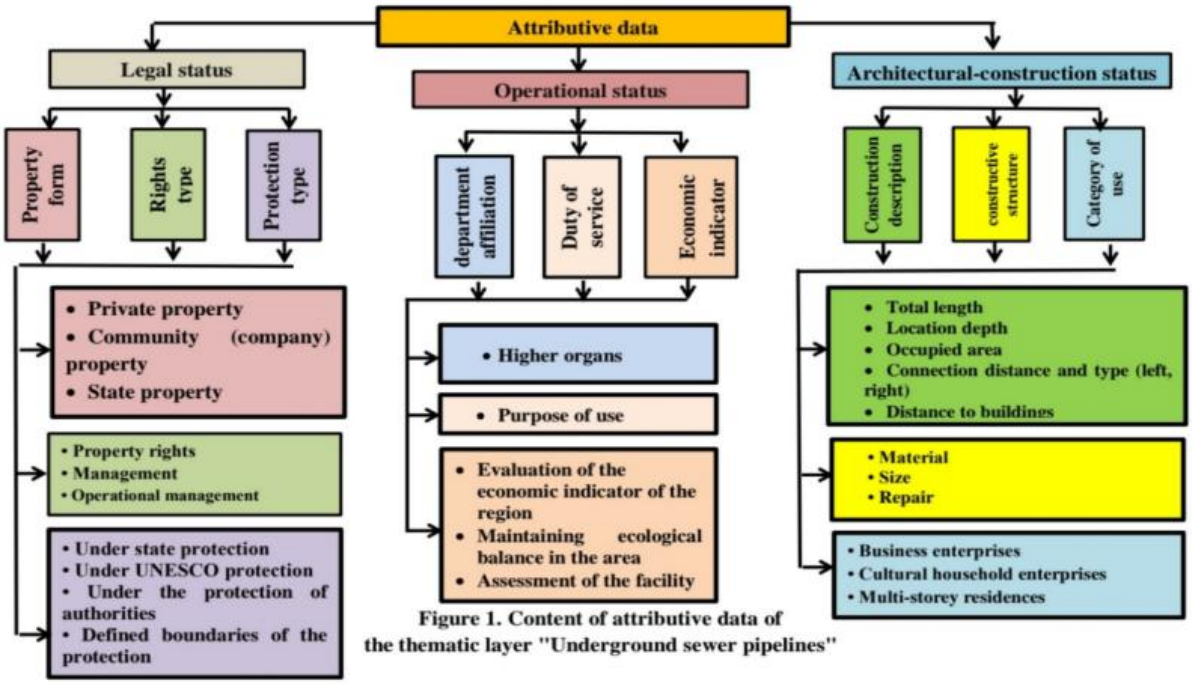

Figure 1. Content of attributive data of the thematic layer "Underground sewer pipelines"

Attributes that define the characteristics of an object and correspond to the thematic structure of the data are stored in table format. In this structure, each object is placed in a row, while its attribute data is arranged in columns (see Figure 2). Once the thematic attribute data of the "Underground Sewer Pipelines" has been collected and officially registered, they are marked on the cadastral plans of buildings or structures.

The cadastral plan consists of a series of maps and plans with scales ranging from 1:100 to 1:10,000, which must clearly depict the location and main parameters of the registered objects in a schematic drawing [6;9;10], that is, on the current land cadastre map of the area.

The depiction of the thematic attribute data of the "Underground Sewer Pipelines" and the land plot where these pipelines are located is carried out on a base cartographic map at a scale of 1:2000 using ArcGIS 9.3 software [6;7;10] (see Picture 1).

Figure 2. Arrangement of Attribute Data of Objects into Columns

ATTRIBUTE DATA OF THE "UNDERGROUND SEWER PIPELINE"		
1. Legal Status		
Name:	1.01	**Sewer pipeline located at the intersection of Amir Temur and Great Silk Road streets, Samarkand city.**
Certificate Registration Number for State Registration	1.02	**SM 0269385 18.02.2017 y**

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Date of State Registration	1.03	**18.02.2017 y № 263-376-188**
Details of the document confirming ownership: when and by whom it was issued	1.04	**Decision No. 663-Q of the Mayor of Samarkand City dated October 1, 1982**
Type of Right to the "Underground Sewer Pipeline"	1.05	**Economic Management**
Cadastral Number	1.06	**14:16:03:36:04:0773:004**
Information about the Protection Zone	1.07	**Under the Protection of the Local Government**
Information about the Servitude	1.08	**Not Specified**
Information on Restrictions and Prohibitions Related to the Right to the "Underground Sewer Pipeline"	1.09	**Protocol No. 2 dated October 10, 1982, of the Regional Inspectorate for Supervision in the Field of Construction and Housing and Communal Services of Samarkand Region**
Cadastral Plan	1.10	**M.1:500**
Region	1.11	**Samarkand**
District	1.12	**-**
City	1.13	**Samarkand**
Settlement	1.14	**-**
Address	1.15	**Located on Great Silk Road Street, from the intersection of Amir Temur and Great Silk Road streets, Samarkand City**
2. Economic Management Status		
Name and address of the legal or natural person who owns, possesses, uses, or rents the property	2.01	**JSC "Uzsuvtaminot", Samarkand City, Ministry of Construction and Housing and Communal Services of the Republic of Uzbekistan**
Departmental Affiliation of the Object	2.02	**Ministry of Construction and Housing and Communal Services of the Republic of Uzbekistan**
Purpose of Use of the "Underground Sewer Pipeline"	2.03	**Transportation of Wastewater from Residential, Industrial, and Communal Facilities**
Usage Category of the Sewer Pipeline (industrial facility, multi-storey or single residential housing)	2.04	**Residential, Industrial, and Communal Facilities**
Repair Work (general description, cost, date, author, location of related documents)	2.05	**No Repair Work Has Been Carried Out**
3. Architectural and Construction Status		
Technical Condition	3. 01	**Satisfactory**
Total Area of the "Underground Sewer Pipeline" (ha)	3.02	**2269.1 *1.5 = 3403.65 sq.m**

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Length of the "Underground Sewer Pipeline" (m)	3.03	**2269.1 m**
Connection Distance and Type of the Sewer Pipeline (right, left)	3.04	**Right and left**
Material and Diameter of the Sewer Pipeline (mm)	3.05	**Reinforced concrete, diameter – 1000**
Installation Depth of the Sewer Pipeline (m)	3.06	**1-4**
Protection System	3.07	**Under the protection of the local government**
Date and Registration Number of the Document Confirming Protection Status	3.08	**Decision No. 663-Q of the Mayor of Samarkand City dated October 1, 1982**
Designation of Protection Zone Boundaries	3.09	**Protocol No. 3 dated October 20, 1982, of the Regional Inspectorate for Supervision in the Field of Construction and Housing and Communal Services of Samarkand Region**
Distance from the Sewer Pipeline Axis to Buildings (m)	3.10	**5-10 m.**
Balance Ownership Affiliation	3.11	**JSC "Uzsuvtaminot", Samarkand City**
Technical Condition: good, average, poor, emergency condition	3.12	**good**
Assessment Date	3.13	**Not Evaluated**
Type of Valuation	3.14	**Not Evaluated**
Date of Valuation Report	3.15	**Not Evaluated**
Value (thousand soums)	3.16	**Not Evaluated**
Economic or Tax Zone	3.17	**First zone**

Topographic Survey of the "Underground Sewer Pipeline" Network Located in the Territory of Samarkand City

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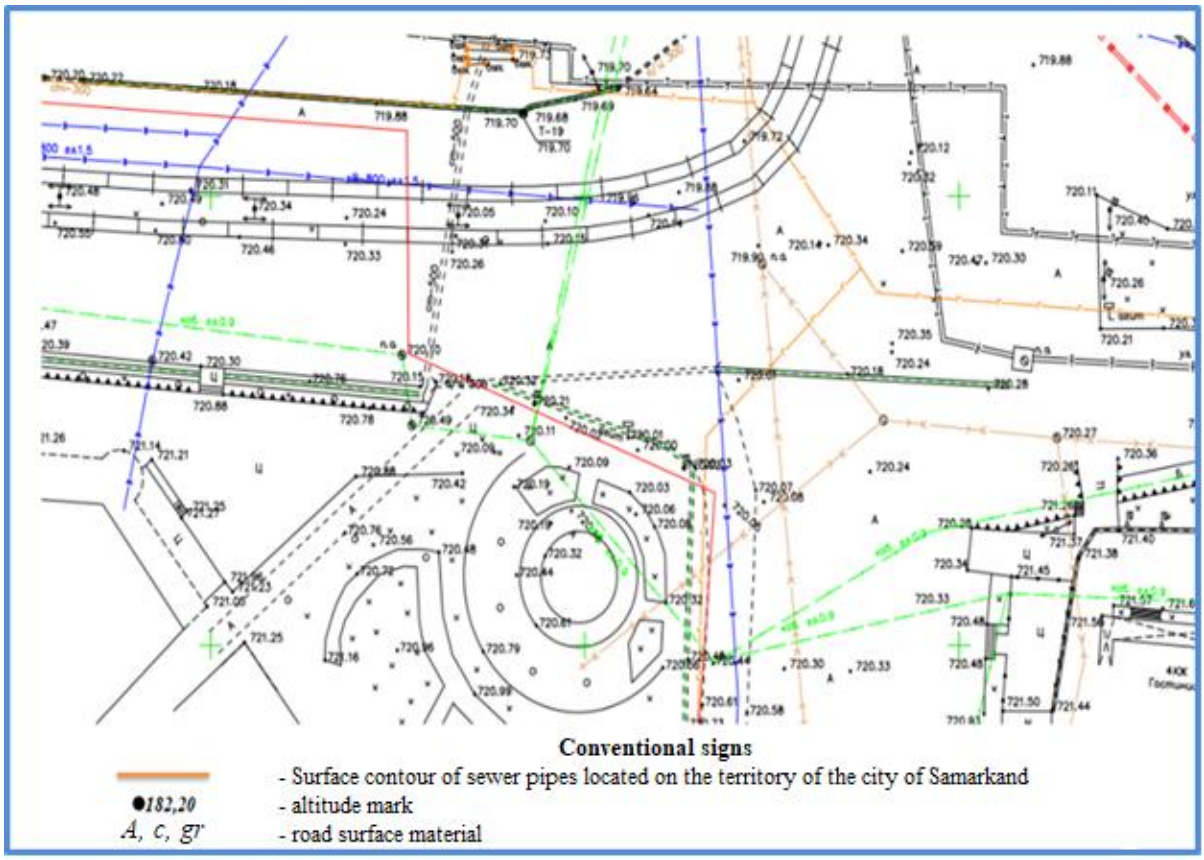

Picture 1. Depiction of "Underground Sewer Pipelines" on the Map

District and city geofunds are maintained based on the thematic attribute data of the "Underground Sewer Pipelines."

These district and city geofunds serve as repositories of modern and historical geo-information data related to the topographic-geodetic, cartographic, engineering-geological, hydrogeological, ecological, sanitary-hygienic, sociological, planning and design, historical and cultural aspects, as well as data on natural and man-made disasters, technical inventory and passport registration, microseismic zoning, and seismic stability of the "Underground Sewer Pipelines."

They are consolidated and published annually at the district, city, regional, and national levels as of December 31 [9; 10; 13].

This information is intended to provide timely support to the Unified State Cadastre Geographic Information System (USC-GIS) for the operational integration of state cadastres into the National Geographic Information System. It serves government authorities and administrative bodies, legal entities, and individuals in addressing matters related to the management and forecasting of all types of resource usage, making project-based decisions on the allocation of production capacities, regional development, and similar objectives [9;10;11].

In addition, the existing classifications must be registered in the cadastre. The classification of existing linear engineering structures in Samarkand city that have spatial locations—whether aboveground, underground, or in open space—is presented in Figure 3.

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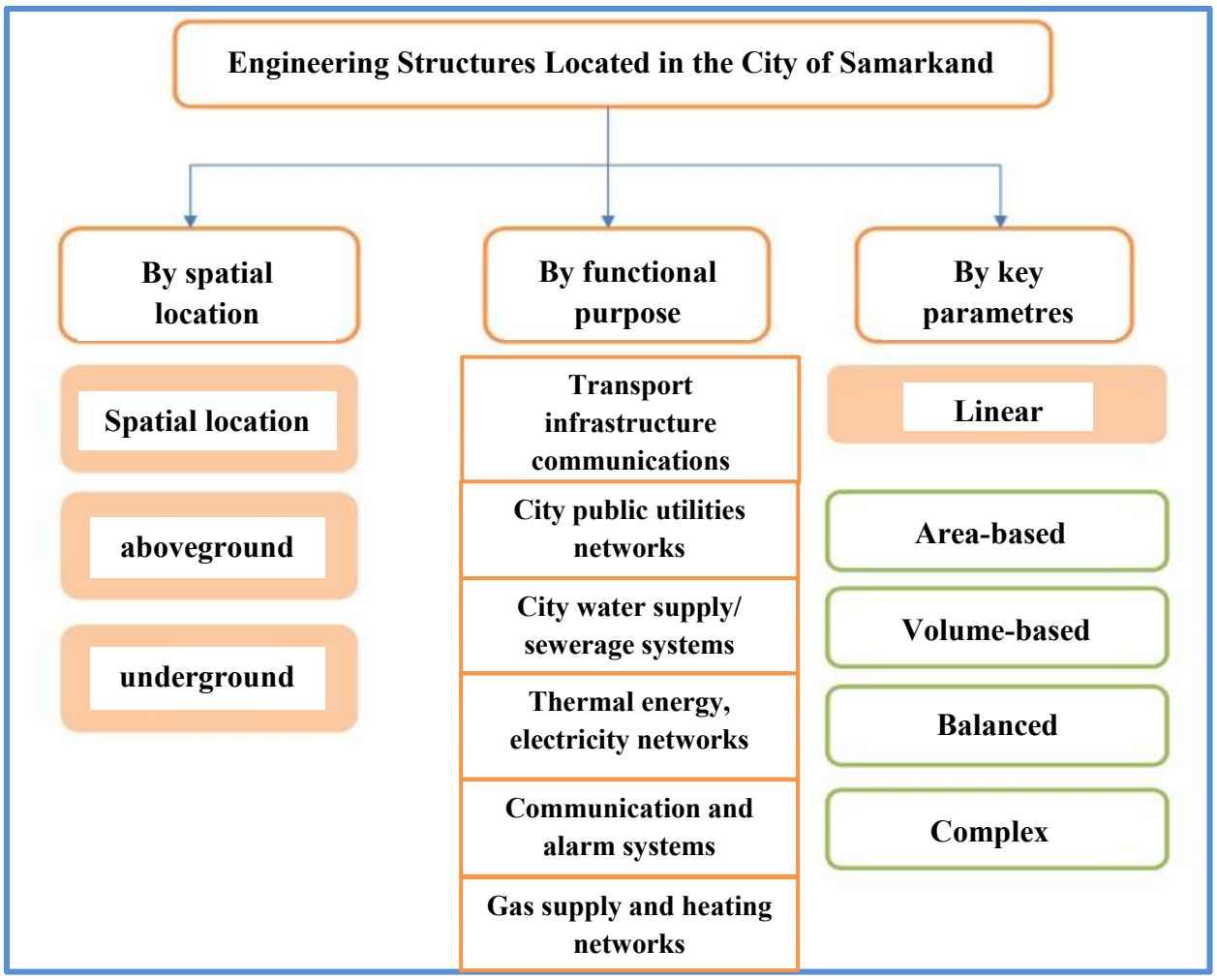

Figure 3. Classification of Engineering Structures Located in Samarkand City by Purpose, Key Parameters, and Location Status

In addition to the attribute data table of the thematic layer "State Cadastre of Buildings and Structures," tables are being developed to create a spatial database of linear engineering structures (Table 1).

Through the implementation of cadastral work, the Unified State Cadastre Geographic Information System (USC-GIS) is supplemented with information about real estate objects, including linear engineering structures.

In the "Real Estate Cadastre" section, basic and additional information about such structures is available through the preparation of technical design documents; however, this information is not systematized.

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Table 1.

Attribute Data Table of the Thematic Layer "Underground Sewer Pipelines"

№	Name of the Sewer Pipeline	Legal Documents of the Sewer Pipeline (land, structure, document name, date, and number)	Address of the Sewer Pipeline (city, district, neighborhood, street name)	Cadastral Number of the Sewer Pipeline	Length of the Sewer Pipeline (m)	Installation Depth of the Sewer Pipeline (m)	Area Occupied by the Sewer Pipeline (ha)
1	2	3	4	5	6	7	8
"Main Underground Sewer Pipeline"							
1	Sewer pipeline located at the intersection of Amir Temur and Great Silk Road streets in the city of Samarkand	Decision No. 663-Q of the Samarkand City Mayor dated October 12, 1982	Located at the intersection of Amir Temur and Great Silk Road streets in the city of Samarkand	14:16:02:04:57:1260:0340	2269.1	4	3403.65
Additional Connected Underground Sewer Pipelines							
1	Connected to the "Main Underground Sewer Pipeline" on Amir Temur Street	Based on Decision No. 437-Q of the Samarkand City Mayor dated July 24, 1984.	Located in the street Amir Temur in the city of Samarkand	14:16:02:04:57:1260:124	175.7	4	2.16

Continuation of Table 1

Document for Commissioning the Sewer Pipeline (name, date, and number)	Usage Category of the Sewer Pipeline (enterprise, multi-storey or single residential building)	Connection Distance and Type of the Sewer Pipeline (from the right or from the left)	Material and Diameter of the Sewer Pipeline (mm)	Protection Zone of the Sewer Pipeline (m)	Distance from the Axis of the Sewer Pipeline to Buildings (m)	Balance Value as of __. __.____ (thousand UZS)
9	10	11	12	13	14	15
"Main Underground Sewer Pipeline"						
Protocol No. 18 dated October 16, 1982, of the Samarkand Regional Inspectorate for Supervision in the Field of Construction and Housing and	Main Underground Sewer Pipeline	Right and left	Reinforced concrete, diameter – 1000	Under the protection of the local government	5-10	Not Evaluated

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Communal Services						
Additional Connected Underground Sewer Pipelines						
Protocol No. 38 dated July 26, 1984, of the Samarkand Regional Inspectorate for Supervision in the Field of Construction and Housing and Communal Services	Additional Connected Underground Sewer Pipelines	left	Reinforced concrete, diameter - 200	Under the protection of the local government	8	Not Evaluated

Through the execution of cadastral work, the National Geographic Information System (NGIS) is supplemented with data on immovable property objects, including linear engineering structures.

In the "Real Estate Cadastre" section, both primary and additional information on such structures is available through the preparation of technical project documentation; however, this information remains unsystematized.

According to the last date of the previous quarter, the attributive data of the thematic layer "Underground Sewer Pipelines" (Table 1), based on the State Cadastre of Buildings and Structures, is submitted to the Unified State Cadastre System. This data is incorporated into the base cartographic map of the National Geographic Information System (NGIS-GIS) at a scale of 1:200,000.

Discussion: At present, the state immovable property cadastre system is being continuously updated and developed: methods for presenting and displaying spatial data are being improved, service delivery is becoming increasingly automated, and innovative technologies are being introduced. At the same time, due to the increasing complexity of the configuration of immovable property objects—which can no longer be adequately represented using modern two-dimensional projections—there is a growing need to use Geographic Information Systems (GIS) in the development of a spatial data base for linear engineering structures (Figure 4) [2; 3; 4].

This approach is aimed at addressing existing challenges in registering immovable property located at various levels (both aboveground and underground), including linear engineering structures and other facilities, within the State Cadastre. It significantly simplifies the information management process and allows for timely access to current data about immovable property, as well as effective monitoring of changes [8; 11; 12].

Thus, linear engineering structures are considered immovable property objects, and information about them must be included in the Unified State Cadastre System (USCS).

By performing cadastral work, the USCS is supplemented with up-to-date and reliable information about immovable property, including linear engineering structures [6; 7; 8; 9].

To implement the proposed methodology, part of the sewer pipelines was examined to verify the object length. For this purpose, geodetic measurements were carried out at characteristic points that establish the axis of the underground linear engineering structure. To measure the angles and lengths of the lines accordingly, the Topcon GRT-3505N electronic total station was selected (instrumental accuracy: $m\beta = 5''$ and $mL = 0.5\ cm + 0.2\ cm \times L(km)$).

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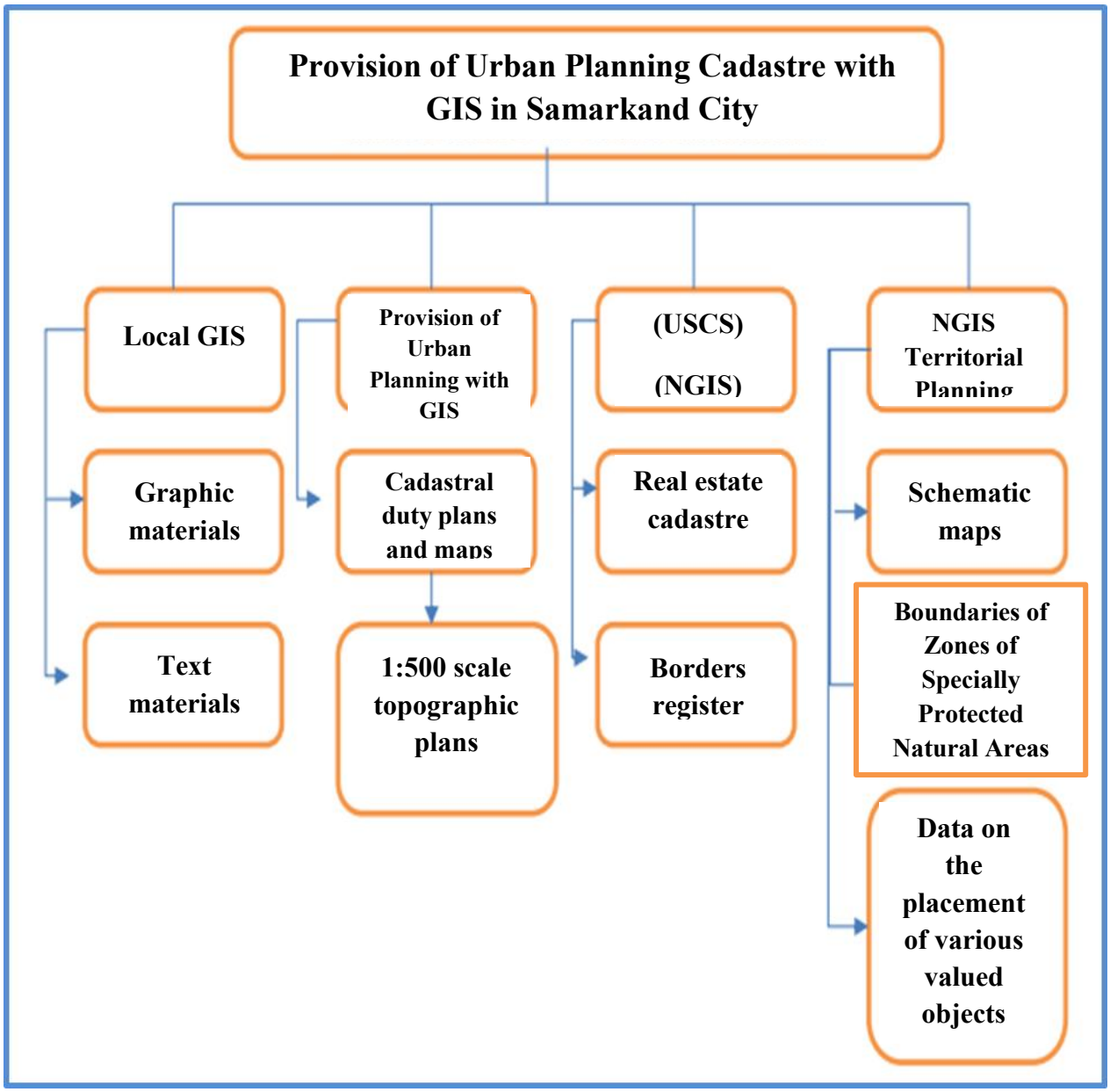

Figure 4. Classification of the Use of Geographic Information Systems in Creating a Spatial Data Base for Linear Engineering Structures

To determine the coordinates of characteristic points of linear engineering structures and to register them in the state cadastre, the following methods, established by the current normative and legal framework, are recommended to be applied at the stages shown in Figure 5 [11; 12; 13]:

– Geodetic method: using traditional terrestrial geodetic measurement techniques and technologies.

– Satellite-based geodetic measurement method: currently a widely used method, particularly in RTK (Real-Time Kinematic) mode, where continuously operating differential base stations with state-supported satellite systems (CORS – Continuously Operating Reference Stations) are installed at the site.

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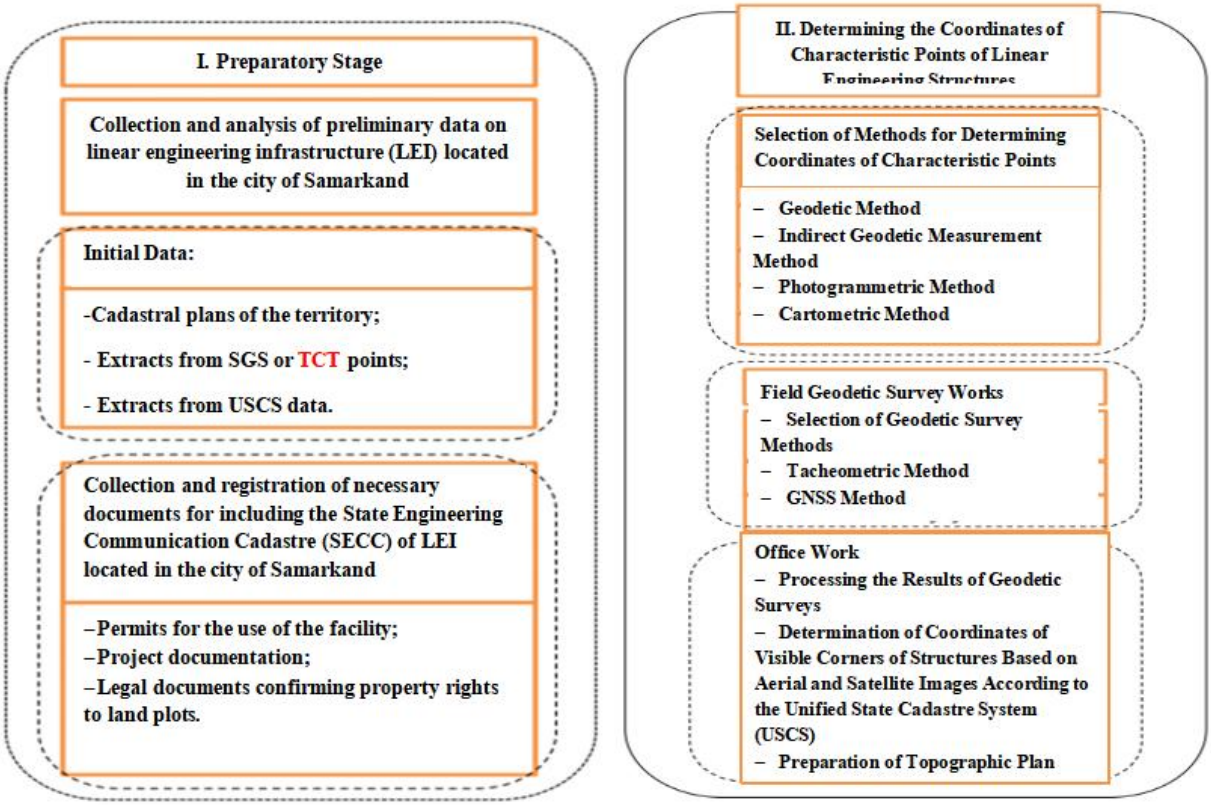
– Combined method: a combination of modern terrestrial measurement technologies and GNSS (Global Navigation Satellite System) technologies, which is currently the most advanced and widely used method. This method is also recommended in situations where poor visibility from characteristic points to GNSS satellites and CORS stations makes satellite-based measurement difficult.
– Photogrammetric method: widely used with unmanned aerial vehicles (UAVs).
– Cartometric method: involves measuring the coordinates of characteristic points from topographic maps or plans. The disadvantage of this method lies in the accuracy of coordinate determination, which depends on the map's scale.
– Analytical method: in this method, the initial coordinates of a characteristic point of the linear structure are determined using satellite technology.



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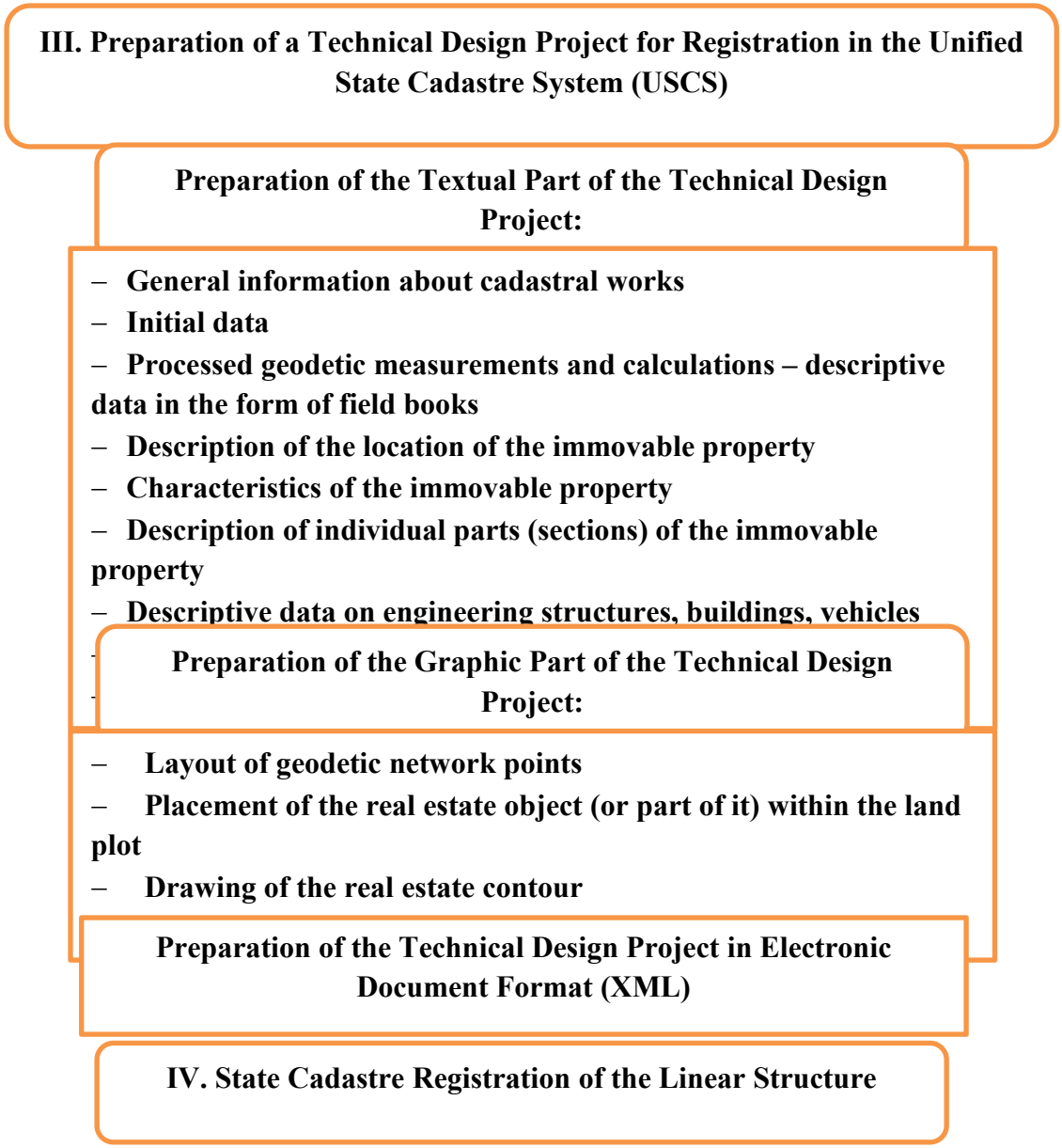

Figure 5. Stages in the Preparation of Geospatial Data of Linear Engineering Structures:
I – Preparation stage for cadastral registration;
II – Determination of the coordinates of characteristic points;
III – Third and fourth stages of the updated algorithm for performing cadastral works

Conclusion:

Based on the research conducted, the following issues are identified as having the potential for effective resolution:

1. In the process of creating the district and city geofund databases, it is advisable to compile a dataset of thematic attribute information on "Underground Sewer Pipelines", categorizing the structures into groups based on their functional significance—namely, “Main Underground Sewer Pipelines” and “Additional Connected Underground Sewer Pipelines”. It is also recommended to form data reflecting their legal, economic, and construction statuses.

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2. To ensure the effective and rational use of underground sewer pipelines, it is essential to adhere to scientifically grounded urban planning, engineering, and construction regulations. Additionally, in developing the organizational and legal framework for the integrated economic development of territories, the following factors must be taken into account:

– the value of underground sewer pipelines;
– the nature of their use;
– their intended purposes in production;
– usage in accordance with designated objectives;
– and other relevant information.

These considerations must be incorporated into:

– land use planning schemes;
– general urban master plans;
– settlement placement projects;
– as well as compliance with urban development norms and regulations.

The following parameters of the pipelines must be fully identified:

– construction material,
– diameter,
– total length,
– total occupied area,
– connection distance and type (from the right, from the left),
– usage category (industrial, multi-storey, or single-family residential),
– construction date,
– establishment of protection zones,
– distance from the pipeline axis to buildings,
– and other technical specifications.

After full identification, it is required to:

– formalize this information in the cadastral dossier,
– register it with the state,
– and submit it within the prescribed time frame to the National Geographic Information System, aimed at integrating state cadastres.

3. Within the framework of the State Cadastre of Buildings and Structures belonging to the Unified State Cadastre System (USCS) and the National Geographic Information System (NGIS), the collection and processing of attribute data of the thematic layer “Underground Sewer Pipelines” must ensure the following:

- The precise location of the underground sewer pipelines,
- Ownership rights or other property rights held by legal or physical entities,
- The legal grounds and duration of such rights,
- The expiration or termination dates of these rights,

This information must be properly formalized and submitted within the established timeframe to the Unified State Cadastre System and the National Geographic Information System, in alignment with efforts to integrate various state cadastre systems.

To prepare the geospatial data of the attribute information related to the thematic layer “Underground Sewer Pipelines,” the process is recommended to be implemented in the following three stages:

I. Preparatory stage for registration in the cadastre;
II. Determination of the coordinates of characteristic points;

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III. Preparation of the technical design (cadastral dossier) of the infrastructure and its official state registration.

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