ITU POLICY PAPER

TECHNICAL SPECIFICATIONS TO ESTABLISH A BROADBAND MAPPING SYSTEM IN REPUBLIC OF MOLDOVA

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The ITU Policy Paper on Technical Specifications to Establish a Broadband Mapping System in Republic of Moldova was developed by the ITU Office for Europe, in close collaboration with the Ministry of Infrastructure and Regional Development of the Republic of Moldova, National Regulatory Agency for Electronic Communications and Information Technology (ANRCETI), Information Technology & Cyber Security Service (STISC), E-Governance Agency, as well as Public Services Agency.

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This report is for information purposes only and has no binding force. The analyses and recommendations in this report are based on desk research and information and opinions collected from interviews undertaken and materials provided by the Ministry of Infrastructure and Regional Development of the Republic of Moldova, and other local stakeholders during preparation of this report.

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ACRONYMS TABLE

Term	Explanation
ANRCETI	Agenţia Naţională pentru Reglementare în Comunicaţii Electronice şi Tehnologia Informaţiei a Republicii Moldova
ALRC	Agency for Land Relations and Cadastre, Agenția Relații Funciare și Cadastru (ARFC)
ARFC	Agenția Relații Funciare și Cadastru, Agency for Land Relations and Cadastre (ALRC)
ASP	Agenția Servicii Publice, Public Services Agency (PSA)
IaaS	Infrastructure as a Service, model of providing computational resources in an infrastructural form, most often expressed and billed according to the number of provided CPU or GPU cores, RAM size as well as capacity and type of mass storage.
MCloud	IaaS platform established and run by Government of Republic of Moldova, a.k.a. M-Cloud
MIDR	Ministry of Infrastructure and Regional Development
PSA	Public Services Agency, Agenția Servicii Publice (ASP)
REIF	Registry of Engineering Infrastructure Facilities, a.k.a. ROITE
ROITE	Registry of Engineering Infrastructure Facilities, a.k.a. REIF
SIP	Single Information Point

1. Background

A. ITU Guidelines on Establishing or Strengthening National Broadband Mapping Systems

According to ITU research produced in the ITU Guidelines on Establishing or Strengthening National Broadband Mapping Systems[1], significant gaps remain within Europe and beyond when it comes to the implementation of broadband mapping systems, with currently a very heterogenous scenario. Though some administrations still rely on surveys to gather market and technical information, very few can fully utilize cutting-edge systems that support a variety of use cases. More specifically, based on ITU research, it appears that roughly 30% of national regulatory authorities (NRAs) worldwide have created mapping systems that are meant to facilitate the achievement of national goals[2].

Over the past years, a series of global events, such as the global pandemic of COVID-19, has caused an unexpected acceleration in the digitalization of all processes in every region of the globe. It is not surprising that citizens are now pressuring governments to give them adequate broadband access so they can meet their citizens' digital needs.

In this context, the ITU Guidelines offer an overview on the main barriers to setting up broadband mapping systems: these challenges can be grouped in regulatory, technical and project-related. Indeed, the overall objective of the ITU Guidelines is to respond to the gaps identified and the needs of the international community by empowering decision-makers with a broad understanding of broadband mapping systems from a regulatory, technical, financial and human resource perspectives, and providing them with the necessary reference knowledge to take action at the national level or at the very least investigate this matter further. ITU Research shows that the lack of harmonized knowledge and reference practices in these domains makes it difficult for every country, but with particular attention to least-developed countries, to adopt the right policy measures to implement broadband capabilities at the national level, especially in specific technically-difficult-to-implement geographical areas as well as in parts of the countries associated with socio-economic disadvantages.

Following the extensive experience developed at the European Union level, the ITU Guidelines consider the EU practice as the main reference point when it comes to develop harmonized processes in the field of broadband mapping systems, while also adding the as practical components and set of actions that can be undertaken by the regulatory authorities to generalize minimum requirements and milestones for the implementation of broadband mapping systems at the national level. It is for this reason, that the ITU Guidelines are also referred to the ITU toolkit for broadband mapping. In line with the scope of this paper on the technical specifications to establish a broadband mapping systems in Republic of Moldova, the ITU Guidelines will be utilized as basis thoroughout the different chapters.

[1] ITU Guidelines: Establishing or Strenghtening National Broadband Mapping Sytems
[2] Global Gap analysis on National Broadband Mapping Systems Initiatives

B. Context

ITU data shows that 76.12% of individuals in the Republic of Moldova made use of the Internet in 2017[3] while the number of fixed-broadband subscriptions per 100 inhabitants was 16.58[4] in 2019 with 94 active Internet service providers in the country[5]. Recent data from ITU[6] in 2021, shows that 67% households in Moldova had Internet access at home and 127 mobile-cellular subscriptions per 100 inhabitants and 33 fixed subscriptions per 100 inhabitants.

In 2019, half the subscribers to fixed Internet access services benefited from data access and transfer speeds between 30 and 100 Mbps, while 15,5% enjoy speeds over 100 Mbps and around 29,5% under 30 Mbps[7]. In the second quarter of 2022, ANRCETI reported the number of fixed broadband Internet connections for speeds of over 100 Mbps increased by 15.2% compared to the end of 2021, and reached more than 291,200, while the number of connections with data transfer speeds lower than 100 Mbps decreasing[8]. According to ANRCETI, between 2019 and 2020, FTTx connections increased by 14.7%, reaching 451,300, while coaxial cable connections increased by 22.1% to reach 54,128. FTTx technology now represents 67.4% of the total number of subscribers[9], with a significantly high rate in Chișinău and other major cities, while xDSL technology is most common in smaller towns and rural areas[10]. As reported in 2022, the total number of subscribers distributed as follows: subscribers connected to the global network based on FTTx technologies - 83.8%, via xDSL - 12%, subscribers connected via coaxial cable - 3.9 % and via other technologies – 0.3%[11].

In addition, for what concern the market for fixed broadband internet access services, it must be noted that in 2019 Moldova registered a significant increase, with the volume of sales rising by 5.7% year-on-year to reach 1.4 billion lei (34 million EUR)[12]. Concerning the mobile broadband market, according to ANRCETI data, the number of active mobile broadband subscriptions per 100 inhabitants in 2019 was of 88.8, an increase from the same figure in 2018 standing at 79.4[13]. In terms of network coverage, 3G covers 99.7% of Moldova's territory in 2019[14] and 4G networks provide the coverage of 95% of the territory[15], serving 98% of the population according to ITU data[16].

Finally, according to the latest ITU Digital Development Dashboard, 100% Moldova population covered by a mobile-cellular network, 100% population covered by at least a 3G mobile network, and 99% population covered by at least 4G mobile network in 2021[17]. Referring to the statistical data on the

[3] https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2019/Individuals_Internet_2000-2018_Dec2019.xls
[4] ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i992b")
[5] https://www.brodynt.com/business-internet-connectivity-in-moldova/
[6] https://www.itu.int/en/ITU-D/Statistics/Documents/DDD/ddd_MDA.pdf
[7] https://eufordigital.eu/broadband-access-up-in-moldova-as-users-opt-for-higher-speeds/
[8] https://en.anrceti.md/news_260922
[9] https://eufordigital.eu/market-value-of-fixed-broadband-internet-access-services-in-moldova-exceeded-1-billion-lei-in-first-nine-monthsof-2019/ and https://anrceti.md/news10122019
[10] https://digital.report/moldova-state-of-affairs-report/#_ftn10
[11] https://en.anrceti.md/news_260922
[12] https://anrceti.md/files/filefield/Anuar%20statistic%202019_22aprilie_2020.pdf
[13] https://anrceti.md/files/filefield/Anuar%20statistic%202019_22aprilie_2020.pdf
[14] https://anrceti.md/files/filefield/Anuar%20statistic%202019_22aprilie_2020.pdf
[15] https://anrceti.md/files/filefield/Anuar%20statistic%202019_22aprilie_2020.pdf
[16] ITU World Telecommunication/ICT Indicators Database online (2020): http://handle.itu.int/11.1002/pub/81550f97-en (indicator "i271GA")
17 https://www.itu.int/en/ITU-D/Statistics/Documents/DDD/ddd_MDA.pdf

evolution of the mobile broadband market in the second quarter of 2022, compared to the end of 2021, the total number of 4G broadband users increased by about 5.7% and was estimated at over 2.1 million, constituting a share of 76% of the total connections to mobile broadband services[18].

Broadband mapping

At the moment, Moldova does not have particular provisions enshrined in law which mandate the national regulator, the National Regulatory Agency for Electronic Communications and Information Technology (ANRCETI), to request operators for georeferenced data on infrastructure and services. The prevalent rationale adopted in the past was based on the request for information but for statistical purposes only. As such, the country's regulatory framework is not fully aligned with the BCRD, the EU Guidelines on state aid for broadband and the EECC[19].

Although the country publishes statistical information via an interactive map[20], the country has not yet introduced broadband mapping systems as defined in the context of this paper. A more detailed analysis of broadband mapping in Moldova was carried out in the project "Eastern Partnership Countries (EaP) Broadband Infrastructure Development Strategy" financed by the EU4Digital project, which provided a comprehensive overview of the regulatory and technical developments in the field of broadband mapping as well as country recommendations [21] https://ituint.sharepoint.com/:w:/r/sites/ITU-D/eur/_layouts/15/Doc.aspx?sourcedoc={725FC291-5357-4FAB-9454-C380648468E3}&file=final_Report 3_Broadband Mapping EU4Digital_MD[1].docx&action=default&mobileredirect=trueThis activity's report on "ITU Guidelines - Establishing or Strengthening National Broadband Mapping Systems[22]" was released in May 2022.

The country has already foreseen the importance of developing new access technologies and network in the National Development Strategy "Moldova 2030". In line with this strategy, alongside the Radio Spectrum Management Program, emphasis has been put on the creation of the enabling environment for the advancement of broadband networks including 5G deployment. Considering the indisputable benefit of purposeful broadband mapping implementation in other European countries, Moldova's national strategy would benefit from a review of the broadband mapping enabling environment as well as from receiving recommendations to establish a roadmap for implementation.

Furthermore, despite the high internet coverage in Moldova, the Digital Transformation Compact – report for Moldova[23] also pointed out that adequate high-speed home access to broadband remained

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18 https://en.anrceti.md/news_130922

19 https://www.berec.europa.eu/sites/default/files/files/document_register_store/2021/3/BoR_(21)_30_BEREC_opinion_on_the_revision_of_the_BCRD.pdf

20 https://www.anrceti.md/bandalarga2019

21 Internal Report Document. EU4Digital "Broadband Strategies in the Eastern Partnership Region" Technical Assistance Project Report 3 - Broadband Mapping Recommendations.

22 https://ituint.sharepoint.com/:w:/r/sites/ITU-D/eur/_layouts/15/Doc.aspx?sourcedoc={725FC291-5357-4FAB-9454-C380648468E3}&file=final_Report 3_Broadband Mapping EU4Digital_MD[1].docx&action=default&mobileredirect=truehttps://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Projects/2022/Executive%20Meeting%20on%20Broadband%20Mapping%20Systems/MAY%202022%20ITU%20Guidelines%20for%20establishing%20or%20strengthening%20national%20broadband%20mapping%20systems_v1.2%20-%20RTR1_AG%5b1%5d.pdf

23https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2021/Regional%20Innovation%20Forum/Digital_Moldova.pdf challenging. And a united infrastructure development plan across ministries, with an assessment of the enabling environment to establish the national broadband mapping system and aim at facilitating investment in the non-served areas, could help remove the cost barriers to connectivity. Based on all information above, it appears advantageous and meaningful that Moldova is equipped with the broadband mapping systems.

2. Methodology

To deliver on the scope of this work, a methodology, which is based on the ITU Guidelines, was followed to produce the technical specifications to establish a broadband mapping system in Republic of Moldova. The following steps were considered:

First, a meeting between all parties involved in this work granted the opportunity to explain in detail what were the needs and how the technical specifications would respond to those needs. The Ministry of Infrastructure and Regional Development presented their views and ITU took note of those. After the preliminary consultation phase was concluded, a draft table of content was produced by ITU and was then submitted for validation.

Secondly, upon reaching consensus on the table of content, the ITU started reviewing materials received and use the in-house body of knowledge developed internally by ITU in the field of broadband mapping systems. It is worth mentioning that Indeed, ITU with the ITU Office for Europe has carried out extensive research on this topic over the past 3 years, including through the development of the policy paper on "*Broadband mapping initiatives and regional harmonization initiatives*[24]" (December 2020) as well as developing the "*ITU Guidelines- establishing or strengthening broadband mapping systems" (presented above);* this body of knowledge has been utilized as basis for the work. In addition to that, this expertise must, however, be complemented by in-field experience from NRAs who have already overcome the obstacles currently present in Moldova. Under the ITU coordination, different stakeholders have been involved at different stages to ensure a concerted and inclusive elaboration, that is fit for the objective of this assistance[25].

Third and finally, after the table of content was developed, the ITU experts kicked-off a series of comprehensive analysis focusing on the legislation and policy documents, in parallel with exchanging with ANRCETI and related local institutions introduced by ANRCETI, to have first-hand and updated information in order to compile the required technical specifications for the sake of building and structuring an appropriate SIP for further implementation. This allowed ITU to gather and include relevant data that would then be utilized to produce the set of recommendations. Ahead of producing the final version, an advance draft benefited from feedback among all parties involved in order to ensure that all aspects were covered to the extent needed.

[24] https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Events/2020/RRF/21-01-15%20Background%20Paper_Broadband%20Mapping%20Systems%20in%20Europe%20and%20Regional%20Harmonization%20Initiatives_final_clean.pdf

[25] This effort of the ITU is direct result of the request of ITU to deliver on the EUR1 Regional Initiative on Digital infrastructure development https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Pages/Regional%20Initiatives/2022/ITU-Europe-Region-Initiatives-2023-2025.aspx

3. Description of the organization of the project

A. Stakeholder analysis

When initiating a project, it is essential to start with a stakeholder analysis. Stakeholders are the parties that will be affected by the project at any point in its lifecycle and their input can directly influence the outcome. Good stakeholder management and continuous communication are important for project collaboration. Therefore, it is necessary to identify who the various stakeholders are, as well as their level of interest in the project, the potential impact it will have on them, and the authority they have to shape the process and its outcome. In the case of the construction of the SIP in Moldova, the stakeholder onion diagram may look like this:

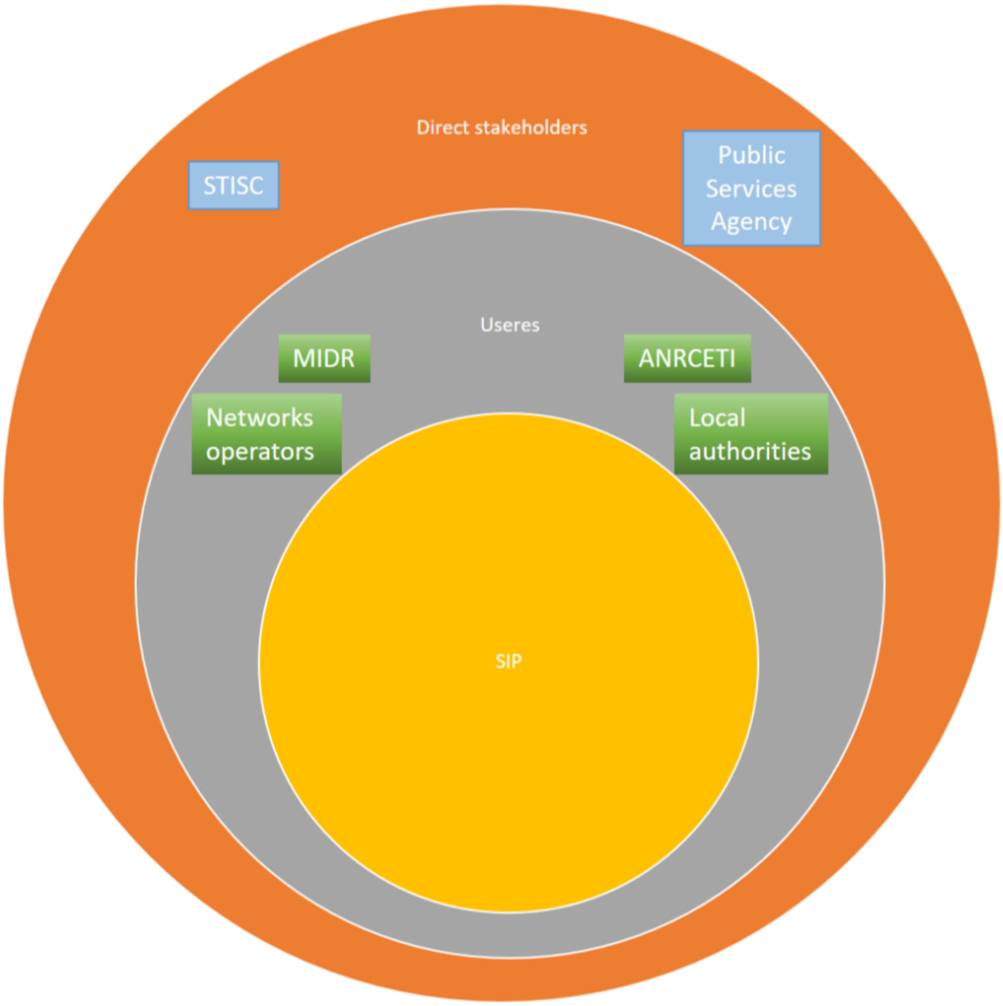


Figure 1. Stakeholder Onion Diagram

The presented onion diagram has two layers. The first indicates system users and the second other related entities.

When describing the stakeholders, one should undoubtedly start with the national regulatory authority. In most countries that are advanced in mapping telecommunications infrastructure, national regulators are responsible for these systems. Another important participant is the Policy

Maker, i.e., Ministry of Infrastructure and Regional Development. The Ministry may also be a system user through dedicated accounts in the system or defined reports.

The next group of stakeholders are networks operators listed in the Directive 2014/61/EU of the European Parliament and of the Council of 15 May 2014 on measures to reduce the cost of deploying high-speed electronic communications networks, which is planned to be transposed into national legislation. These network operators are undertakings providing or authorised to provide public communications networks as well as an undertakings providing a physical infrastructure intended to provide: a service of production, transport or distribution of gas, electricity, including public lighting; heating; water, including disposal or treatment of waste water and sewage, and drainage systems; transport services, including railways, roads, ports and airports.

Finally, the last group of system users are local authorities, which are responsible for issuing building permit and urban planning certificate.

Two other public institutions are also important participants in this process: Information Technology & Cyber Security Service (STISC) and PUBLIC SERVICES AGENCY. Both institutions will play an important role in building the system. STISC will provide the IT infrastructure and the Public Services Agency will share its data. At the project initiation stage, it is important to ensure agreements between the above-mentioned institutions in which responsibilities, scope of tasks or SLA will be defined.

These are the main users of the system. Data providers will be dissatisfied system users, especially in cases where data transfer is mandatory, so it is worth ensuring ongoing contact with them, e.g. in the process of defining the data structure or testing the system.

B. Implement approach

One of the first decisions to be made when implementing an IT project is the implementation formula. There are several basic options: outsourcing, hybrid solution and in-house solution. In the case of the Moldovan project, **an outsourcing solution is recommended**. This choice is based on the fact that the project of building the SIP system in Moldova appears to be an interdisciplinary project: after completing all the pillars of its functionality, i.e. the system construction (1), the knowledge of system administration (3), the use of resources from other institutions (4), or methods of communication with other public systems (5), ITU concludes that body leasing appears to be the most efficient option to achieve all elements mentioned above.

Body leasing/team leasing is a type of outsourcing. Personnel outsourcing involves the periodic hiring of IT specialists for IT tasks in a given company. In the next part, a short analysis of the differences between body leasing and IT outsourcing will be presented. Body IT leasing is used when the organization needs to recruit employees with specific IT skills only for a specific period of time or for a specific project. An external IT consultant, with a properly formulated candidate profile, will have competences and provide a fresh look at the project. Nevertheless, the company should employ a specialist at this time to assess the work of an external consultant and make sure that he or she is heading towards the goal that has been set for him. It therefore requires additional involvement of the human resources of the organization. When choosing a body leasing, an external specialist must implement all processes and rely solely on the company's solutions. Outsourcing of IT services consists in transferring full responsibility for the entire project to an external company. It is not only using the resources and knowledge of an experienced technological partner, but also transferring to the scope of his duties work related to the current administration of the institution's hardware and software IT resources. In summary, body leasing is a great solution for achieving short-term goals. However, this is not the right long-term strategy, where outsourcing works better, as it allows for savings not only on personnel costs, but also related to the operation and management of IT infrastructure.

As mentioned, body leasing will work better in an IT project than complete outsourcing, when the IT infrastructure was previously defined in the project, i.e. the selection and maintenance of IT infrastructure is not an element of outsourcing.

As part of this project, it is advisable to use cloud solutions, hence the appropriate cooperation between ANRCETI and the another public institution, i.e., the Information Technology & Cyber Security Service (STISC).

STISC is a public institution whose purpose is to ensure the administration with:

- the maintenance and development of the information technology infrastructure, the telecommunications system of the public administration authorities (as part of the special communications network and state information systems),
- the management of the single infrastructure of the Government's public key,
- the implementation of state policy on cyber security.

It is also worth emphasizing that if the idea of body leasing is used in this project, ANRCETI will have to have at least one specialist who will be able to evaluate the programming work of external specialists employed in body leasing.

C. Budget

According to "*ITU Guidelines on establishing broadband mapping systems*", the valuation of a mapping system depends mainly on the complexity of the system. These guidelines define four levels of complexity for mapping systems:

- simple;
- medium;
- advanced;
- complex.

The table presents below more details on the four different levels:

Complexity of the system	simple	medium	advanced	complex
Scope of mapping: • infrastructure mapping • service mapping • demand mapping • investment	1-2 items	2-3 items	all	all
A separate model for mobile networks	X	V	V	V
Form of data transfer: • data transmission, e.g. e-maildata • transfer interface	e-mail	transfer interface	transfer interface	transfer interface
Number of supported data formats	1	1-2 formats	2-3 formats	more than 3

Data detail: • grids • buildings • points • lines	grids	grids/points	points; buildings; lines	points; buildings
Data presentation portal	X	X	V	V
Data validation rules	X	simple	advanced	advanced
Additional tools supporting data preparation	X	V	V	V
Helpdesk system	X	V	V	V
Mobile app	X	X	V	V
The level of detail in relation to the system documentation	low level	medium level	high level	high level
Availability of analyzes, reports	X	X	V	V
Single Information Point with geospatial connections between passive and active infrastructure	X	X	X	V

As appendix to the guidelines, a simplified cost calculator has also been developed to support in the decision-making process of building a broadband mapping system. After determining the complexity of the planned broadband mapping system, three other factors were included into the equation used by the calculator, i.e a) the area of the country (in thousands of square kilometers), b) the number of system users and c) the average men-day price of a developer in country (in any currency - the model result will be calculated in this currency). The user will receive the following information:

- number of days required to develop the broadband mapping based on only one developer working on it;
- broadband mapping system costs;
- the annual cost of maintaining the system.

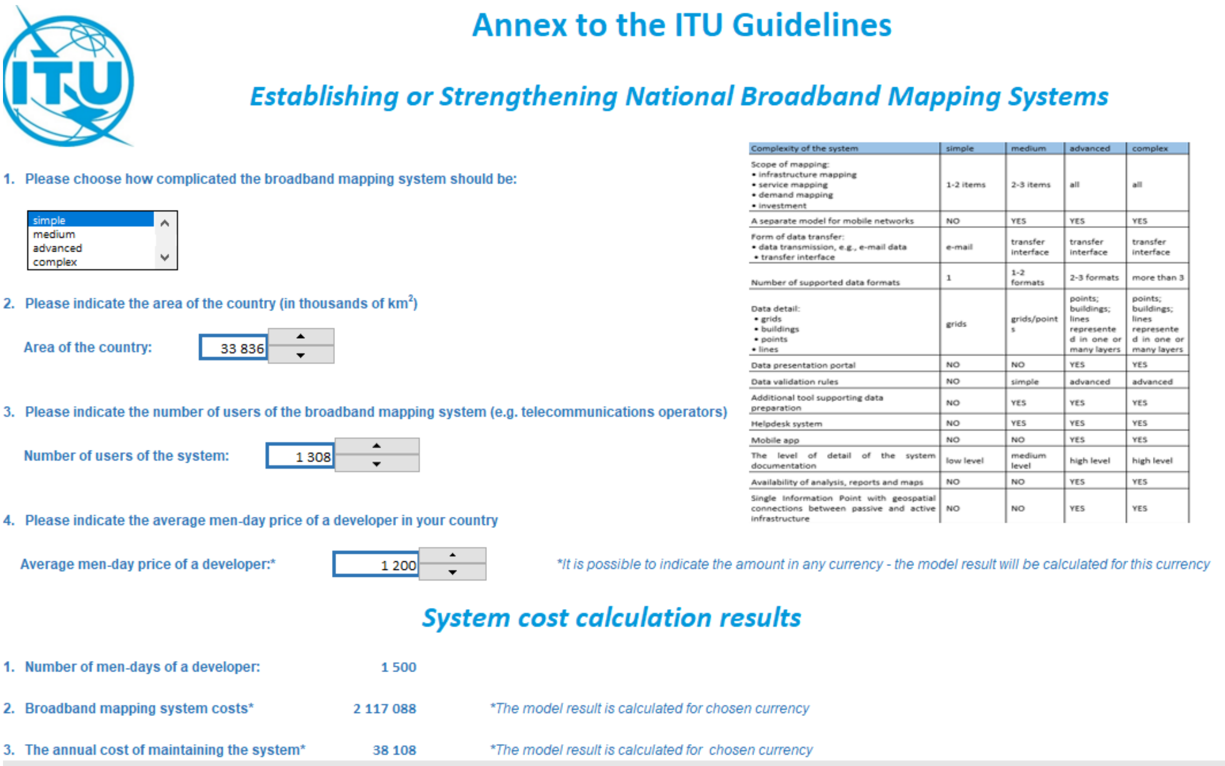
When estimating the costs of building the system for Moldova, it was assumed that the planned system would be at a simple level due to the fact that in the first stage Moldova does not plan either the component concerning the collection and presentation of information on the Internet, the access service, and the component concerning the demand for services. In addition, the PUBLIC SERVICES AGENCY plans to collect information from network operators (including the infrastructure of telecommunications operators) about passive infrastructure, so there will be no need to handle the collection of this data as part of the system under construction. However, it will be necessary to ensure complete interoperability between PUBLIC SERVICES AGENCY and ANRCETI systems. Additionally, other required fields were completed:

- area of the country: 33 836 km^2;
- number of system users: 1308;
  - 319 providers of public electronic communications networks and/or publicly available electronic communications services;
  - 2 gas transportation operators;
  - 24 gas distribution operators;
  - 1 transmission system operator;
  - 2 electricity distribution operators;

- 10 heating energy operators;
- 45 water supply and / or sewerage operators;
- 1 railroad operator;
- 1 road operator;
- 903 local authorities

* average men-days price for developer: 1200 MDL.

The broadband mapping system construction cost calculator view for Moldova is presented below:



Annex to the ITU Guidelines

Establishing or Strengthening National Broadband Mapping Systems

1. Please choose how complicated the broadband mapping system should be:

simple
medium
advanced
complex

2. Please indicate the area of the country (in thousands of km^2)

Area of the country: 33 836

3. Please indicate the number of users of the broadband mapping system (e.g. telecommunications operators)

Number of users of the system: 1 308

4. Please indicate the average men-day price of a developer in your country

Average men-day price of a developer:* 1 200

*It is possible to indicate the amount in any currency - the model result will be calculated for this currency

Complexity of the system	simple	medium	advanced	complex
Scope of mapping: • infrastructure mapping • service mapping • demand mapping • investment	1-2 items	2-3 items	all	all
A separate model for mobile networks	NO	YES	YES	YES
Form of data transfer: • data transmission, e.g., e-mail data • transfer interface	e-mail	transfer interface	transfer interface	transfer interface
Number of supported data formats	1	1-2 formats	2-3 formats	more than 3
Data detail: • grids • buildings • points • lines	grids	grids/points	points; buildings; lines represented in one or many layers	points; buildings; lines represented in one or many layers
Data presentation portal	NO	NO	YES	YES
Data validation rules	NO	simple	advanced	advanced
Additional tool supporting data preparation	NO	YES	YES	YES
Helpdesk system	NO	YES	YES	YES
Mobile app	NO	NO	YES	YES
The level of detail of the system documentation	low level	medium level	high level	high level
Availability of analysis, reports and maps	NO	NO	YES	YES
Single Information Point with geospatial connections between passive and active infrastructure	NO	NO	YES	YES

System cost calculation results

1. Number of men-days of a developer: 1 500
2. Broadband mapping system costs* 2 117 088 — *The model result is calculated for chosen currency
3. The annual cost of maintaining the system* 38 108 — *The model result is calculated for chosen currency

D. *Requirement for human capacity*

Broadband mapping system in Moldova will be provisioned by the contractor emerged from tendering process, thus the requirements for human capacity within elaborating system's executive project, its development, verification by testing, deployment and commissioning lays within that entity, i.e. contractor competences. Nevertheless, significant effort and labour are required to elaborate the tender, conduct the contractor selection process, consult and communicate with stakeholders, pilot, guide and verify contractors' work.

The first step, which is the elaboration of Tender Specification (TS), Terms of Reference (ToR) and Draft Contract can be realized by its own means depending on qualifications and competences of Public Services Agency staff. In authors' opinion, the task should be feasibly done by a team consisting of:

1. **Programme Leader**, who has and keeps the vision of the system to be implemented in regards of core features (functionalities) and processes that will be supported or serviced by the system. They (she or he) will be in charge of formulating and communicating the implementation programme to its stakeholders and participants, ensuring the completeness and consistency of requirements formulated within TS, ToR and Contract by the team members.

2. **Business Analyst**, who is in charge of describing the processes with use of consistent, preferably standardized or at least well-documented notation, running workshops and interviews with stakeholders when needed. The Business Analyst should be focused on simplification of the processes, synergising the needs and expectations of particular stakeholders and avoiding falling into a pitfall of overdetailing and uncritically accepting all the expectations reported to him/her by particular stakeholders regarding the scope of system implementation programme.

3. **IT Systems Architect**, who is responsible for architecture requirements formulation with regards to the planned use of MCloud Platform services and cooperating closely with Business Analyst and GIS Specialist.

4. **GIS (Geographic Information System) Specialist** is in charge of formulating technical requirements for the system regarding its interoperability with SIP/ROITE and ensuring that industry standards are reflected in the requirements.

5. **Security Consultant**, who is responsible for addressing public IT systems and services requirements arising from both legal requirements, industry standards, best practices as well as formulating plan and requirements for security testing.

6. **Testing Specialist**, responsible for formulating requirements regarding acceptance tests, performance tests and partially security tests with cooperation with Security Consultant.

7. **UX and Accessibility Consultant**, the role concerns two closely related fields regarding user experience, i.e. usability and ergonomics of systems design and accessibility which is a matter of specific requirements defined by well-known and widely adapted WCAG[1][26].

8. **Legal Consultant** plays a crucial role of ensuring legal requirements are identified, formulated and named within TS and ToR as well as Draft Contract preparation.

The general remark is that each particular role can be fulfilled by individuals, including multidisciplinary individuals as well as groups of specialists. On the other hand, the roles can be handled by external services provided by professional, specialized entities or providing consulting services in those fields.

It is advisable to keep the above listed roles, especially when fulfilled by own human resources which will contribute to Human Capacity Building for the project. Nevertheless, after the successful selection of the contractor, the team will face the transition to the operational execution of the contract. In that case the main workforce and its coordination will be provided and handled by the contractor. The focus should be set on supporting the contractor with information and explanations, managing change

[26] WCAG stands for W3C Accessibility Guidelines provided by the World Wide Web Consortium. More info about WCAG and other standards, guidelines and initiatives are available at https://www.w3.org/WAI/standards-guidelines/

requests, monitoring the execution of works and executing acceptance and performance tests as agreed in test scenarios.

In that stage of the venture, the minimal recommended team composition would be:

1. **Project Manager**, the standard role which can be fulfilled by the Programme Leader or appointed to other (new) team member.

2. **Business Analyst**, supervises the provisions of business processes analysis and participates in resolving the change requests considering business processes, including additional workshops and interviews with stakeholders. Considering that the business processes documentation was elaborated in accordance with the provisions proposed above, it is not crucial to have the author's supervision to fulfil that role.

3. **IT Systems Architect**, supervising the agreed architecture implementation, coordinates and conducts operational activities with MCloud Platform personnel, participates in the resolution of the change requests regarding system architecture, monitors testing process and acknowledges test results as well as consults on the development of amendments resulting from tests.

4. **GIS Specialist** supervises the implementation of agreed and defined technical requirements and participates in the resolution of the change requests within GIS domain.

5. **Security Consultant**, assessing compliance with established and defined security requirements, participates in the resolution of the change requests, when necessary, monitors security tests execution and results, consults on the development of amendments.

6. **Testing Specialist** coordinates tests execution according to the testing scenarios, elaborates proposed test teams' composition, hence with support and in cooperation with the Project Manager or depending on required level of authority or representation with Programme Leader, appoints testing teams members:
    a. Testing Team(s) composed of internal users,
    b. Testing Team(s) composed of external users

    The number of Testing Teams and their composition (size) should match the expected timeframe for manual tests' execution according to tests' plan and scenarios, which define number of operations for each users' groups (actors) in particular testing stage.

7. **UX and Accessibility Consultant**, supervises agreed UX research execution, accessibility guidelines and requirements implementation, including compliance assessment, participates in the resolution of the change requests with regards of user experience and accessibility, audits or plans for audit of accessibility compliance.

8. **Legal Consultant**: issues legal opinions on doubtful or contentious issues, participates in the resolution of the change requests, when necessary, prepares annexes if necessary.

4. Analysis and description of data collected and functionality of the Registry of engineering infrastructure facilities (REIF) in the context of ensuring interoperability with the Moldovan SIP system, including participation in meetings with stakeholders.

In parallel to the broadband mapping system, the ROITE system (Moldovan Public Utility/Tech. Infra Registration System) will be built.

According to law no. 150/2017on the Register of Objects of Technical-Constructions Infrastructure Article 5 Subjects of legal relations regarding the Register:

(1) The owner of the Register is the State.

(2) The owner of the Register is the Land Relations and Cadaster Agency. Register holder:
a) ensures the organizational and financial conditions for creating and maintaining the Register;
b) organizes the creation of the automated information system for maintaining the Register;
c) performs the external control regarding the maintenance of the Register.

(3) The holder of the Register is the Public Services Agency. Register Holder:
a) manages the automated information system "Register of technical-constructions infrastructure objects";
b) appoints persons responsible for the registration of technical-constructions infrastructure objects and the rights over them;
c) accumulates, systematizes and preserves the information regarding the technical constructions infrastructure objects and the rights over them;
d) organizes the provision of information from the database, establishes the structure and way of their provision;
e) ensures the security of data storage and data transfer through the network.

There will be three main stakeholders involved in this system: utilities/infrastructure owners/operators (primarily utility companies but may also include citizens or other legal entities), the Public Service Agency (PSA) and local public authorities. According to the plan, ROITE will provide:

- **Infrastructure Utility/Facility Owners/Operators:** by providing easy access to data and information on any other infrastructure of the Operator, e.g. operating in the same area (necessary for the design, implementation of any new infrastructure projects and maintenance of the existing one), leading to the minimization of unintended damage in their networks during the operation of excavators, proper registration in the State Utility Register of their Facilities and Laws increasing their legal security of ownership of their property;

- **Public authorities:** improving urban planning and management, reducing development costs and development duration;

- **Public Services Agency:** as a state organization, it maintains standard 24/7 data availability for interested parties and registration of facility infrastructure in accordance with applicable legal requirements.

- **Media/infrastructure operators:** These operators are companies (public or private) that administer or manage a public service using the city's technical infrastructure facilities. and the management of network infrastructure, the provision of services and products (e.g. gas, electricity, etc.) to end users (citizens or companies). These companies' business processes are highly dependent on their own infrastructure registry, which is typically used to optimize the operational costs associated with maintaining their network. In Moldova we can distinguish the following types of Operators:

    - Water supply and sewage networks
    - Electric networks
    - Gas networks
    - Heating networks
    - Road networks
    - Railway networks
    - Transport facilities (port/marina, airport)
    - Electronic communication networks
    - Waste management

Data in the ROITE system will show where this infrastructure is located, what elements it contains, some description of the physical parameters of the infrastructure, information about its owner, protection zone, etc. All this information will be used and visualized by the SIP/broadband mapping system, but in addition the system should provide the following functionalities not provided by ROITE:

1. Collect and provide registered users with information about planned construction works for all types of physical infrastructure. This information should include the name and contact details of the entity that planned the execution of construction works, GIS information or addresses (if construction works will be carried out in a given locality), along with a visualization.

2. Collecting and providing registered users with information on the possibility of using the existing infrastructure to install the public electronic communications network (PECN). The system should visualize the possibility of using the infrastructure facility (green marking - no PECN installed; yellow - some PECNs are installed, there is limited space for others; red - no space for PECN installation or installation is not possible for technical reasons or security restrictions).

3. Collecting and making available to registered users information about all publicly owned buildings that offer access to PECN installations. In this respect, cooperation with the Real Estate Register kept by the Public Services Agency should be ensured https://www.cadastru.md/ecadastru/f?p=100:1:3850251427501747.

4. Provide information on the type of ownership of the plots through which the route of the planned PECN will run. For publicly owned land, provide details of the public entity to be contacted for access to the land.

In order to enable the aforementioned functionality of the SIP/broadband mapping system, the following stakeholders should enter the relevant data into the system:

A. All physical infrastructure operators and public entities should provide data on all types of planned construction works;

B. All physical infrastructure operators with infrastructure that can be used to install PECN should provide data on the ability to install PECN on their infrastructure.

C. All entities with publicly owned buildings should publish the conditions of access to these buildings.

ANRCETI should have access to all information in the SIP/broadband mapping system. The level of access to information for other stakeholders depends on their role as mentioned above. PECN providers should also have access to all information in the SIP/broadband mapping system. Operators of networks other than PECN (gas, electricity, etc.) and public entities that planned construction works can see only their own information entered into the system and information on construction works planned by other operators or entities, including PECN.

5. Defining the project framework and objectives

A. Data sources

As already mentioned, the broadband mapping system is being considered in conjunction with REIF. The system will operate on the basis of the law no. 150/2017 on the Register of Objects of Technical-Constructions Infrastructure Media/infrastructure operators. Pursuant to the aforementioned Act, the entities that will transfer data to REIF are:

- Water supply and sewage networks
- Electrical networks
- Gas networks
- Heating networks
- Road networks
- Railway networks
- Transport facilities (port/marina, airport)
- Electronic communication networks

All this information will be used and visualized by the broadband mapping system, but additionally the system should collect from the same entities information on planned construction works for all types of physical infrastructure. The system will also collect data on the possibility of using the existing infrastructure to install a public electronic communication network from telecommunications network operators.

To sum up, the appropriate sources of data for mapping broadband networks should be infrastructure owners, telecommunications operators, utility companies and local government authorities. For data provided by a major group of data sources, and Public Service Agency which will be the most important data source.

It is important that, in the case of REIF regulations, there are appropriate provisions obliging the listed entities to submit data to the broadband mapping system.

B. Information to be collected

The information that can be collected from operators within broadband mapping can be divided into three levels. The first level (i) is the type of information:

- nodes of public telecommunications networks,
- flexibility points,
- fiber optic and other fixed cable lines,
- cells of base stations of mobile public telecommunications networks,
- wireless lines,
- coverage of fixed and mobile public telecommunications networks,
- telephone services, data transmission services providing broadband Internet access and radio and television broadcasting services provided on the basis of telecommunications infrastructure and public telecommunications networks providing fixed broadband Internet access,
- buildings enabling collocation.

The second level (ii) of information might relate to the master description which is added to the basic information about the very existence of the infrastructure or the availability of broadband service. This type of information is called attributes:

- details regarding service provider,
- type of the access technology in fixed and mobile telecommunications infrastructure,

ADSL
ADSL2
ADSL2+
VDSL
VDSL2
VDSL2(vectoring)
G.Fast
(EURO)DOCSIS 1.x
(EURO)DOCSIS 2.x
(EURO)DOCSIS 3.x
10 Mb/s Ethernet
100 Mb/s Fast Ethernet
1 Gigabit Ethernet
2,5 Gigabit Ethernet
5 Gigabit Ethernet
10 Gigabit Ethernet
25 Gigabit Ethernet
100 Gigabit Ethernet
WiFi – 802.11a in the 5GHz band
WiFi – 802.11b in the 2.4GHz band
WiFi – 802.11g in the 2.4GHz band
WiFi – 802.11n in the 2.4GHz band
WiFi – 802.11n in the 5GHz band
WiFi – 802.11ac in the 5GHz band
WiFi – 802.11ax in the 2.4GHz band
WiFi – 802.11ax in the 5GHz band
WiFi – 802.11ax in the 6GHz band
WiFi – 802.11ad in the 60GHz band
WiMAX
LMDS
radiolinia
CWDM
DWDM
SDH/PDH
EPON
10G-EPON
GPON
NGPON1 (XGPON)
NGPON2 (XGPON)

XGSPON
25G PON
MoCA
CoaxData
EoC
GSM (including GPRS and EDGE)
CDMA2000
UMTS
HSPA
HSPA+
DC-HSPA
DC-HSPA+
MC-HSPA
MC-HSPA+
LTE
LTE-A
LTE-Pro
NR SA
NR NSA

- transmission medium of the telecommunications infrastructure,

fiber optic cable
coaxial copper cable
twisted-pair cable
radio

- Internet access bandwidth,

2 Mb/s
10 Mb/s
20 Mb/s
30 Mb/s
40 Mb/s
50 Mb/s
60 Mb/s
70 Mb/s
80 Mb/s
90 Mb/s
100 Mb/s
200 Mb/s
300 Mb/s
400 Mb/s
500 Mb/s
600 Mb/s
700 Mb/s
800 Mb/s

900 Mb/s
1000 Mb/s
2000 Mb/s
3000 Mb/s
4000 Mb/s
5000 Mb/s
6000 Mb/s
7000 Mb/s
8000 Mb/s
9000 Mb/s
10000 Mb/s

- Internet connection speed,

2 Mb/s
10 Mb/s
20 Mb/s
30 Mb/s
40 Mb/s
50 Mb/s
60 Mb/s
70 Mb/s
80 Mb/s
90 Mb/s
100 Mb/s
200 Mb/s
300 Mb/s
400 Mb/s
500 Mb/s
600 Mb/s
700 Mb/s
800 Mb/s
900 Mb/s
1000 Mb/s
2000 Mb/s
3000 Mb/s
4000 Mb/s
5000 Mb/s
6000 Mb/s
7000 Mb/s
8000 Mb/s
9000 Mb/s
10000 Mb/s

- data transmission services,

IP Peering

IP Transport
VPN MPLS
VPN FR
VPN-MetroETH
VPN SD-WAN
Ethernet VLAN
Lease lines

- radio bands in mobile public telecommunications networks,

420 MHz	410 – 430 MHz
700 MHz	694 – 790 MHz
800 MHz	791 – 821 MHz oraz 832 – 862 MHz
900 MHz	800 – 915 MHz oraz 925 – 960 MHz
1800 MHz	1710 – 1785 MHz oraz 1805 – 1880 MHz
2100 MHz	1920 – 1980 oraz 2110 – 2170 MHz
2600 MHz	2500 – 2690 MHz
3600 MHz	3400 – 3800 MHz
26000 MHz	24250 – 27500 MHz

- type of the fixed cable line,

Underground cable line
Cable line placed in cable ducts (including cable pipeline, microducts)
Cable line placed in technological ducts
Above-ground cable line on a telecommunications poles
An above ground cable line on electric power infrastructure

- type of public telecommunications network node interface,

Ethernet 100Mb/s
Ethernet 1 Gb/s
Ethernet 10 Gb/s
Ethernet 25 Gb/s
Ethernet 40 Gb/s
Ethernet 100 Gb/s
Ethernet 200 Gb/s
Ethernet 400 Gb/s
Ethernet 800 Gb/s

- transmission system for the radio medium,

WiFi
WiMAX
LMDS

- type of service – retail or wholesale,
- provided wholesale services,

Access to cable ducts

Access to dark fibre
Local Loop Unbundling
Virtual Unbundling Local Loop
Access to telecommunications poles, towers and masts
Colocation service
Colocation network connection service
Line mode network connection service
Service provided to end users

- provided retail services – fixed broadband access, fixed wireless access, IPTV or DTV, VoIP telephony,
- type (individual or business) and number of clients broken down by the speed of data transmission services provided,
- latitude and longitude of individual elements of telecommunications infrastructure.

The third layer (iii) should contain defined values or terms for the second-level attributes.

In order to achieve broadband objectives, it is fundamentally important that there is reliable and valid data on existing broadband infrastructures and services offered. Data on broadband infrastructure and services are crucial to identify gaps in broadband coverage, quality of service level, and identifying suitable investment areas. Gathering infrastructure data will be particularly useful to avoid duplication of financing as subsidies can be allocated to areas truly affected by market failure. Mapping infrastructure and services data are usually not comparable across countries. The public authorities need more detailed data to set policies, to ensure that public funding is compliant with relevant regulations, to program funds and successfully monitor the execution of these actions at the regional and national levels. This lack of accurate data risks resulting in policy paralysis, regulatory uncertainty, and poor planning of broadband projects. In order to avoid the negative consequences of broadband data shortage, the mapping platform has to collect data sets concerning broadband infrastructure and services. Data collection on the investment and demand can be performed voluntarily.

The exemplary scope of data can include the following:

C. Data formats

GIS data can be divided into the following types:

- vector spatial data,
- spatial raster data (e.g., orthophoto map),
- attribute tables, which are represented in tabular format.

At this point, it is worth revisiting the BEREC Guidelines on Geographical Surveys of Network Deployment. The recommended data format is vector data, due to its advantages, e.g. location accuracy, less required disk space, faster handling (saving, loading, displaying, editing, copying, deleting) and the ability to perform complex calculations and analyzes (e.g. areas, perimeters, etc.). A vector data model is a direct numerical representation of real-world objects using corresponding geometric objects in a spatial data model.
The objects of a simple vector model are:

- point,
- line,
- surface.

The most common vector data formats are:

- **Shapefile** - Esri's vector data storage format for storing the location, shape, and attributes of geographic features. It is stored as a set of related files and contains one feature class. Shapefiles often contain large objects with lots of related data and have historically been used in GIS desktop applications.

- **GeoJSON** – a format for encoding various geographic data structures. GeoJSON supports the following geometry types: Point, LineString, Polygon, MultiPoint, MultiLineString, and MultiPolygon. Geometric objects with additional properties are feature objects. Feature sets are contained in FeatureCollection objects.

- **Keyhole Markup Language (KML)** - An XML-based markup language designed to describe and overlay visualizations on various web-based 2D web maps or 3D Earth viewers (such as Google Earth).

- **Extensible Markup Language (XML)** - A file format used to create common information formats and make both format and data available on the World Wide Web, intranets, and elsewhere using standard ASCII text.

- **Comma Separated Values (CSV)** - contains various values separated by a separator that functions as a database table or intermediate form of a database table. In other words, a CSV file is a set of database rows and columns stored in a text file such that a new line and columns separate rows by a semicolon or comma.

Considering that many entities will transfer data, the system should support as many indicated formats as possible. Experiences from other countries show that CSV files are the most popular. At the same time, if possible, it is not recommended that the system handle raster files.

D. Data supply process

It should be done through a data transfer platform to ensure the most efficient delivery of data in the broadband mapping process. The platform must meet strict security and data transfer protection criteria.

Undoubtedly, such a platform is the subject of these guidelines. Generally speaking, the platform must provide validation of entities. Notably, only logged-in users should be able to report data. The platform should enable access to view data as well as edit and update data for reporting entities.

The platform should enable data transfer in two basic ways - manual and automatic. The first method should enable manual data reporting via a browser - i.e. "drawing," e.g. network routes (this will apply to entities that do not have the required data in electronic form). This form of data transfer will mainly concern entities with a small amount of data to report and those whose data changes only slightly between reporting periods.

The second, automated method should enable entities to transfer data via previously prepared files. These files should have an appropriate structure, which should be determined in advance. These data files can be, for example, SHP, KML, GPKG, GML, GeoJSON, GeoTIFF lub CSV files.

E. Quality checks

One of the biggest challenges in the data collection process is undoubtedly ensuring their high quality. At the project's implementation stage of building a broadband mapping system, it is worth taking care of an appropriate data quality control process.

Certainly, automatic rules related to interconnections in data, their completeness and correctness of geometry should be provided in the system:

General verification:
- Is the file's coordinate system specified?
- Has the chip been recognized?
- What is file encoding?
- Is it the same as database coding?

Geometry:
- Do all the features in the data file have the same geometry type (point/line/polygon)?
- Does the data have the correct geometry (rules of correct geometry below)?
- Does the prepared data contain data with exactly the same geometry and identical attributes?
- Are the points more than 1 meter apart (finding potential bugs)?
- Are all added objects within the area to which the entity is entitled (in the case of road managers; in other cases, the territory of Moldova)?

Geometry correctness rules:
- The point is always valid.
- Multipoint is correct when points do not repeat.
- A line is valid when it does not pass through the same point more than once.
- A multiline is valid when all components are valid and the only points where the components meet are at their beginnings or ends.
- A polygon is valid when:
- His rings do not intersect,
- has no bayonets,
- Inner rings are completely inside the outer.
- A multipolygon is valid when all components are valid and do not intersect (they may touch).

Attributes :
- Are all required attributes filled in?
- Does the data entered into the fields correspond to the data types in the target model?
- Do the values in the cells match the dictionary values?

The second possibility of data quality control is feedback from system users. In the case of the broadband mapping system, it is not planned to record data on telecommunications services for the time being, so feedback from individual customers will not be provided.

However, it is worth providing in the system functionality related to reporting discrepancies. In what cases would such functionality apply? Well, if the telecommunications undertaking, as part of contacting the infrastructure owner of, for example, a power pole, obtains the information that the pole has been damaged and the information about the possibility of using it for telecommunications purposes is no longer valid.

In such cases, the system should allow users to report discrepancies between data and the actual state, identified as part of services other than quality management (e.g., data browsing, network availability analysis, etc.). As part of recording information about data discrepancies, the system should allow for selecting an object/objects or drawing an area or inserting a point on the map. In the case of drawing an area or inserting a point, the user must be able to specify which layer/layers the discrepancy concerns - by e.g., selecting a layer/layers from the list with a comment after recording discrepancies in the system, the system should also allow for automatic sending of information to the person/institution responsible for the indicated data.

F. Access to data

Publication of broadband data is an important tool by which end-users can obtain information about the availability and selection of services and the location of the telecommunications infrastructure. At the same time, in accordance with national laws on commercial confidentiality and personal data protection, some information collected as part of the broadband mapping may be considered confidential and should be protected by the national regulatory/national competition authorities.

The choice any mapping initiative has to make with regard to data publication is about who should have access to the data. There are three options for data access:

- **internal use** - data is collected only for analysis purposes
- **limited access to data** - data made available in justified cases upon request
- **public access** - all data collected within broadband mapping is publicly available

The goals of the broadband mapping initiative, as well as the level of detail that is theoretically available from the data collected, determine the choice of these options. If the goal is to inform the public or even generate interactions with the public, e.g., through a feedback function, then detailed data access that does not reveal any company secrets seems to be the most obvious choice.

Conversely, if the information could harm a particular stakeholder's revenue or business development by providing classified information to competitors or be used for criminal purposes, it would be more prudent to restrict access. A good solution is for all (potential) data providers to be offered the opportunity to negotiate an approach with authorities prior to starting a mapping project and whenever changes to the publication format are planned.

A good incentive from the regulatory authorities would be to publish reference infrastructure sharing offers, thus providing an incentive for public sector institutions (e.g., local governments) and other public or private institutions to publish the data. This would incentivize traditional telecom operators to come forward, finding that benefits outweigh the costs of sharing information about one's network.

In addition to the issue of commercial confidentiality and protection of personal data, the particularity of critical infrastructure should also be taken into account in data publication.

A minor problem is found with data publication on mapping services and demand. The information can, in principle, be available to everyone, including users who are not logged in.

When considering publishing data on telecommunications infrastructure in the context of critical infrastructure, three options can be mentioned:

1. define in the act what the critical infrastructure is and:

- collect information about it and do not publish it,
- do not collect this information,

2. collect information about critical infrastructure with the attribute, whether the infrastructure is critical (yes/no) and provide such information only in justified cases.
3. do not collect information about critical infrastructure and decide what critical infrastructure is left to network operators.

It is recommended to consider a scenario that mixes three possible options of confidentiality, i.e., defining the critical infrastructure in the legal act, introducing an attribute (yes/no) where the operator can indicate based on the elements of the critical infrastructure described in the act and determining which collected information on the critical infrastructure cannot be publicly available.

Also, in the BEREC guidelines to Art. 22 EECC there are recommendations for publishing data that are worth quoting here:

"It should be noted that the requirements of the GS information system should reflect the guidelines of the INSPIRE Directive, given that all public institutions of a Member State that have spatial information are obliged to manage and make available the data and the GIS in accordance with common principles and rules.

The interests liable to be harmed by disclosure must, objectively, be worthy of protection. It is highly recommended that operators establish their claims for confidentiality, and that the NRAs/OCAs settle those claims according to clear and non-discriminatory criteria. The assessment of whether a piece of information constitutes confidential information should be made on a case-by-case basis by the relevant authority (depending on the kind of information, and the circumstances).

Some examples of information that could qualify as business secrets and may be deemed to be confidential in the context of GS are:

1. *Operators' deployment forecasts; Operators' detailed information regarding the position and type of different network elements, with the exception of network elements that are subject to a wholesale access obligation that requires the publicising of this information; and*
2. *Operators' production secrets and processes, as well as information relating to an undertaking's know-how, such as the tools and methods it uses to calculate coverage information.*

   Some examples of information that may not be considered confidential in the context of GS are:
3. *Information which is publicly available. The coverage area of an operator will usually be available to customers and should therefore not be considered to be confidential;*
4. *Information that has lost its commercial importance, for instance due to the ageing of information because of the passage of time;*
5. *Information which is common knowledge among specialists in the field (for example, in relation to mobile propagation models); and*

Statistical or aggregate information, in so far as it does not allow for the identification of business secrets.

Policy makers should make room for actions for the national regulatory authority to find the optimal balance with the network operators.

G. Publication format

BEREC Guidelines on Geographical surveys of network deployments suggests several options for publishing GIS data:

• Interactive maps published in a dynamic web application;
• Interactive address search published in a dynamic web application;
• Application Programming Interfaces ("APIs") for accessing data;
• Datasets in open and generalized formats such as CSV;
• Statistical reports, including tables and analyses.

Considering these guidelines for the broadband mapping system in Moldova, it is recommended to provide Interactive maps published in a dynamic web application. This solution will allow browsing and searching for information.

Additionally, for users who would like to use the data in their systems, Application Programming Interfaces ("APIs") for accessing data is recommended. Web services have the advantage of being always up-to-date as the data is stored on a web server and is made available on demand over the network for display in the user's GIS. Therefore, if the data is updated, it is guaranteed that external users will also receive the updated information.

On the other hand, users who will not be able to use the API should be able to download files (CSV is recommended), so the system should enable data export to CSV files.

It should be emphasized that each of the described data access options should be taken care of to ensure that this access is authorized. It is proposed that the data download option should be available only to network operators.

H. Update frequency of data supply

The frequency of reporting data by entrepreneurs and public entities should correspond to the needs of the government administration. Data reporting should be done at least once a year (reported by the end of February or March and updated at the end of the previous year). It is viable to set up a large reporting window, i.e., a quarter, however, with presumed reporting of data status as of a set date. This enables smooth monitoring of the telecommunications market, as well as meeting most reporting needs.

Depending on the collecting body’s needs, semi-annual (reported by the end of February or March, updated at the end of the previous year and reported by the end of September, updated at the end of June) or quarterly reporting might be considered. However, it should be noted that more reporting obligations mean more significant workloads and costs for reporting entities. The possibility of reporting and updating data should be continuous, and the reported data should be up to date for the time reported. The collecting body should elaborate on a designated platform for data transfer to ensure the most efficient data provision within the broadband mapping process. This is a core component of a mapping project and a key determinant of its success within a given country.

The platform has to fulfill rigid safety and security criteria for data transfer but also balance the user experience to facilitate compliance by operators, particularly in contexts where the voluntary approach is adopted.

On the entity validation aspect, one basic method is using a logging-in system, which may be significantly strengthened by a separate procedure of obtaining usernames and passwords by the reporting entities. Importantly, only logged-in users should be able to report data. Simultaneously, the reporting system should give the possibility to log in only to entities that report data. The platform should allow access to view data, as well as to edit and update them for reporting entities.

The platform should enable to transfer of data in two basic ways – manual and automated.
The first way should allow reporting data manually by a browser. It would be dedicated to entities with a small amount of data to report and those whose data changes only a little between reporting periods. The second, automated method should allow transferring data by entities via pre-prepared files. These files should have an appropriate structure, which has to be determined in advance. These data files could be for example CSV or XML files, or both. The precise reporting setup regarding the way of reporting in an automated way via files would be determined by the specific design of the reporting platform. This method should be dedicated to entities with large amounts of data to report.

I. Data confidentiality

Data confidentiality protects data from unintentional, unlawful, or unauthorized access, disclosure, or theft. Confidentiality concerns the privacy of information, including permissions to view, share and use it. Low-confidential information may be considered "public" or otherwise non-threatening if disclosed outside its intended audience. Highly confidential information is deemed secret and must be kept confidential to prevent identity theft, breaches of accounts and systems, legal or reputational damage, and other serious consequences.

When publishing or granting access to data, the legitimate interest of operators in protecting trade secrets and other information, such as critical infrastructure, should be considered. A trade secret is defined as confidential information relating to a company's business activities, the disclosure of which could cause serious harm to the same company. Information that can be classified as trade secrets and that can be considered confidential detailed information of operators regarding the location and type of individual network elements, excluding network elements covered by the wholesale access obligation, which requires this information to be made public, or secrets and production processes of operators, as well as information on company know-how, such as the tools and methods used to calculate range information. On the other hand, information that cannot be considered confidential is the operator's coverage area, information that has lost its commercial significance, for example, due to the obsolescence of information due to the passage of time and information necessary for the sharing of passive infrastructure. As far as the issue of critical infrastructure is concerned, it should be mentioned that critical infrastructure means systems and their functionally interconnected objects, including construction objects, devices, installations, key services for the security of the state and its citizens, and for ensuring the efficient functioning of public administration, as well as institutions and entrepreneurs.

In Moldova, the subject of critical infrastructure in the context of mapping infrastructure and sharing information about it is particularly important. This is due, among other things, to the geographic location of Moldova. Therefore, it should be considered how to minimize the risk of inappropriate use of public information about networks.

In order to minimize the risk of access to data on critical infrastructure, it is first necessary to specify in the act what constitutes critical infrastructure, introduce an attribute (yes/no) for each element of infrastructure that is subject to reporting, where the operator will indicate based on the act what constitutes infrastructure and non-publication of information on critical infrastructure.

6. System concept – main characteristics and functionalities of the system

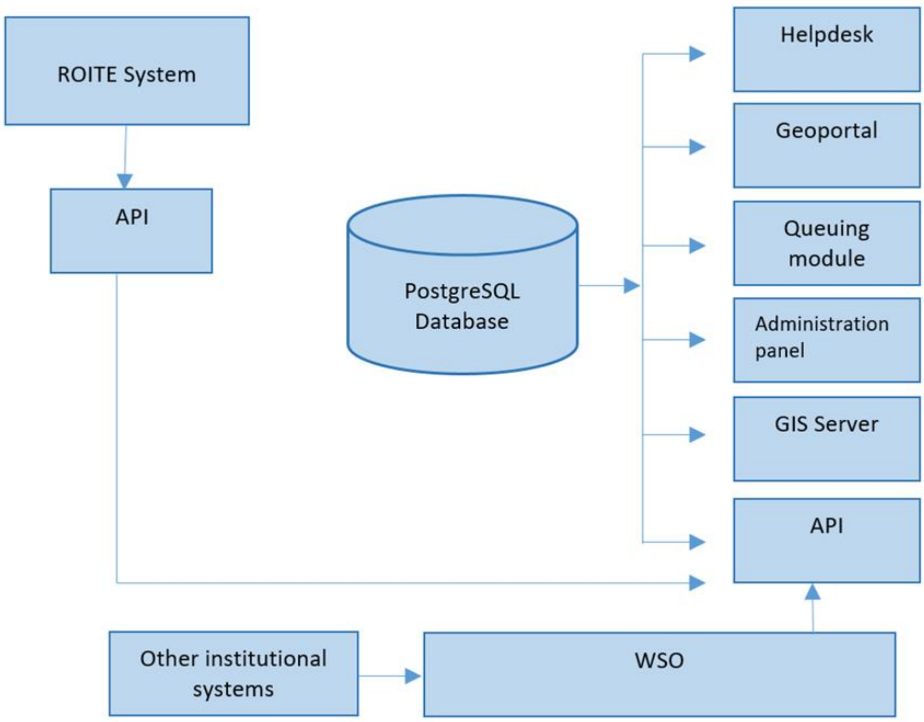
Considering the general rule stated in the Minimum technical requirements of the ITU Guidelines for establishing or strengthening national broadband mapping systems, and on the basis of information gained during the meetings and workshops, the authors present the the following software components as a possible solution to be adopted and to be used to build the system. All software components are Open-Source software:

- **PostgreSQL** – object-relational database system
- **PostGIS** – spatial database extender for PostgreSQL object-relational database
- **Geoserver** – server for sharing geospatial data
- **QGIS** – Geographic Information System which enables the creation, editing, visualization, and publishing of geospatial information

The following environments should be used to implement the system:

- **Development** – implemented for the internal needs of technical specialists
- **Tests** – implemented for tests by business and operators
- **Production** – implemented for business

The system must be built based on microservices. An extensive System must consist of interrelated functional components. The diagram shows the method of connecting the essential elements of the System and its environment.



An element of the system must be an API. The API must support all relationships between the system's front-end layer and the system's back-end layers. The API must also serve the System Users who decide to supply the System with their own tools.

An auxiliary component for the API must be the queuing module, which is designed to control the execution of tasks such as: supplying the System by Users, supplying the System with data from external systems, generating reports and printouts, data export.

The front-end layer of the System is to operate in a web browser environment and consist of two main components:

- **user** - to support Users of the System, used, among others, to transfer data, view them, export and use technical support through the Helpdesk system.
- **administrator** - modules used to administer the System and view reports intended for Administrators, manage permissions and roles, and analyze the System status.

The back-end part of the System is to be based on a relational database cluster in which all databases are to be stored. This division is logical. The physical architecture of the database subsystem must enable querying, visualization, and analysis using data from all of these sets simultaneously.
The GIS server uses the data collected in the database cluster to serve spatial data in the form of web services for the needs of the front-end part and for the purpose of publishing data using OGC services outside the System, taking into account roles and permissions.

Users can be authenticated and authorized via the Single Sign-On system based on the WSO2 Identity Server software.

Model of security provisions – IaaS
Interoperability is provided by the M-Connect platform based on an agreement. The SIP should be interoperable with other systems such as addresses. The interested party submits an application to M-Connect governing entity (e-gov agency), and connection parameters are provided upon approval. Should “SI INGEOCAD” spatial data sets be concerned individually/separately or within ROITE?

7. Defining technical requirements for the SIP

J. Detailed technical specifications regarding hardware and software

At a minimum, the system should consist of 5 servers:
Portal server: 1 server, 6x vCPU, 64GM RAM, 500GB HDD
Map servers: 4 pcs each, 12x vCPU, 96GB RAM, 1TB HDD. In addition, one shared space of 1TB is allocated to the servers.

In addition:
The system will use the SSO system, which for reference can consist of 3 servers: 2 servers have 4x vCPU, 12GB RAM, 50GB HDD, one server has 4x vCPU, 8GB RAM, 100GB HDD. A shared space of 100GB is connected to the first two servers.

The database of the system is based on a database cluster. The database cluster consisted of up to 5 servers. Three are database servers, each 32x vCPU, 112GB RAM, 2.1TB HDD. These servers are additionally connected to a shared space of 3.5 TB for the backup of all databases. The next two are management servers, each with 4x vCPU, 2GB RAM, 50GB HDD.

All spaces used by the system, whether exposed to servers as local drives or as network resources, are located on a matrix, preferably with NVMe SSDs.

The resources shown above are for the production environment only. Test environment with fewer resources than those allocated for production should be provided.

8. Conclusions

The technical specifications developed in this paper are intended to aid in the development of broadband mapping systems in the Republic of Moldova while also ensuring interoperability with the ROITE System. The first and second chapters focused on background information (1), i.e. the set of information and body of knowledge developed by the ITU to offer technical assistance, and the methodology (2) used to produce this report. Chapter three focused on the project's organizational aspects, including stakeholder analysis (a), implementation strategy (b), budget considerations (c), and human capacity requirements (d). Chapters four and five address the specific components required to establish the broadband mapping system and the project framework in accordance with the Republic of Moldova's specifications. Finally, Chapters six and seven defined the system concept, including its functionalities and technical requirements.

Broadband mapping systems play a crucial role in determining the availability and accessibility of high-speed internet in a given area. These systems use various data sources to create detailed maps displaying infrastructure-related information and information on access to the internet, such as fixed and broadband coverage. These sets of information are essential for decision-makers as these can be used to identify areas with poor or no connectivity. Thanks to broadband mapping systems, governments, service providers, and other stakeholders make informed decisions about how to improve and expand broadband access.

In the Republic of Moldova, developing and implementing broadband mapping systems capabilities would be particularly important as this would help address the digital divide and promote economic development in the country by making evidence-based decisions that would help achieve the digital transformation, in line with its national digital strategy.

The choice of implementing a broadband mapping system that is interoperable with the Register of Physical Infrastructure may play an important part, among other things, to the digital development and economic growth of the country. A simple, but yet, fully functional broadband mapping system would provide accurate and up-to-date information on the availability and quality of broadband services, enabling the ANRECETI to produce reliable source of information that would allow the Ministry of Infrastructure and Regional Development make informed decisions on investment and infrastructure development. Interoperability with the Register of Physical Infrastructure would also increase efficiency and reduce duplicated efforts, thereby saving resources and maximizing the impact of government initiatives.

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