About CoGIS

Platform description

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1. About CoGIS

CoGIS is a powerful infrastructure digital platform for collection, analysis, publishing, and cooperative work with spatial geodata.

CoGIS allows publishing spatial data as map services, creating interactive maps and map applications based on these services, extending maps functionality with geoprocessing and data analysis tools, and publishing these maps and apps in Internet as Catalog with specific access permissions. CoGIS users can work with published maps and apps both in web and on mobile devices, including work in the offline mode.

1.1. Platform key features

- No programming skills are required to create fully functional web map applications;
- All the mobile apps tools and features work without Internet access;
- A system of reports generation and statistics calculation is included to platform components by default;
- A flexible setting of access permissions at the data, tools, and applications levels allows organizing cooperative work of users with different access permissions;
- Availability of ready-to-use tools for spatial data processing and analysis;
- Authorization via social networks in addition to standard authorization options;
- Sever, web and mobile CoGIS components allow solving any tasks related to work with geodata, and separate CoGIS components can be integrated to the existent IT architecture if needed;
- Support for Linux and Windows Server operating systems.

1.2. Use areas

CoGIS platform can be utilized for solving various tasks in the following areas:

- Urban and housing utilities management
- Cadaster and land resources management
- Operation and production control
- Geology and mining of natural resources
- Sustainable use of natural resources
- Emergency situations monitoring and analysis
- Research and academic activities
- Oil and gas production, and more.

Advanced platform features in regards to functionality, used data, services and flexible settings based on solved tasks allow to:

- use CoGIS as a corporate GIS platform of the enterprise;
- create a regional GIS platform or GIS for local government bodies;
- to use it as a platform for collection, exchange and publishing data of educational, scientific, and volunteer institutions;
- create a geoinformation system of an application-level federal system based on CoGIS to solve geoanalysis tasks and visualization of thematic data.

Below you can find variants of applying CoGIS for solving specific tasks. However the listed CoGIS use cases are not fixed and can be extended in accordance with the project's or organization's needs.

1.2.1. CoGIS as corporate GIS platform

CoGIS as corporate GIS platform can solve the following tasks:

- **Data collection and systematization.** Carrying out inventory of spatial data and floating of the enterprise, their systematization and structuring, maintaining spatial data bank created in accordance with the existing corporate standards.
- **Publishing geodata and managing access to geodata.** Publishing prepared spatial data as map services and creating web map apps based on this published data to organize access to data and tools for users with different privileges. At that, the users of the published services can be not only employees of the enterprise, but also information systems – either as data sources, or as consumers of services provided by the platform. Allocation of CoGIS platform in the IT architecture of the enterprise ensures reliable data protection. At the same time, the limited customized access to data from different devices allows working with the system both at the office and on-site during the field works using thin clients such as web browsers and mobile applications. At that, CoGIS platform can be integrated with the corporate providers of authorization data of users or use its own users' catalog.
- **Using application tools.** Collection, processing and providing not only spatial data, but also application services related with geoanalysis and generation of specific reports expected to use spatial analysis results, map tiles, objects location characteristics (coordinates, address), or objects geometry characteristics (area, perimeter, etc.).

See Appendix A to learn how CoGIS is used as corporate GIS by geologists and surveyors of oil production companies during field survey works.

1.2.2. CoGIS as regional or municipal GIS

CoGIS used as a platform for development of regional GIS or GIS for local government bodies can solve the following tasks:

- **Unified verified geodata source**. Creating a unified statutory environment to maintain, record and providing geodata on region or municipal unit.
- **Regional portal of spatial data.** Creating a regional portal to provide access of individuals and legal entities to the information maintained by the state authorities and local government bodies, that should be presented using coordinates, spatial data and other materials stored in regional spatial data funds.
- **Government services provision.** Integration with regional and federal portals of government services as geodata and geoservices source for work of these portals, and as executing body providing specific government services.
- **Interdepartmental interaction.** Integration with system of interdepartmental electronic interaction, including its regional segments, for interaction with federal providers of public services. Authorized access of users (individuals submitting applications and administrative officials of executive authorities) to information contained in CoGIS as in a

municipal or state information system can be organized via unified state authentication system.

- **Public CoGIS Portal**. Creation of a data mart to provide unlimited access to socially important information and public data of administrative and local government bodies, including maps and map applications.
- **Social and information services.** Implementing services on citizens appeals regarding issues with municipal territories and urban facilities, services on keeping the public informed about important cultural, social, communal and other events, services on collecting city territory data both by administrative officials and by citizens.

See Appendices B, C, D to learn how CoGIS is used as regional and municipal GIS in the urban and land recourses management areas.

1.2.3. CoGIS as platform for educational, scientific, and volunteer institutions

CoGIS used as a platform for collection, exchange and publishing data of educational, scientific, and volunteer institutions can solve the following tasks:

- **Collection of data on research objects.** Collection of field data on geographically distributed objects of research using mobile applications. The ability to specify templates for input collected data allows minimizing errors and reducing qualification requirements to the field data collectors.
- **Carrying out practical works.** Offline maps with thematic data created using the platform can be the tool for arranging practical trainings in the field conditions without Internet for students, research officers or volunteers of noncommercial organizations.
- **Simplifying interaction between community members.** Creation of platform for exchanging information materials between experts and other community members. CoGIS applications can be set in such a way to allow different user categories to enter data, to download reports or to use web services in their applications.
- **Promotion of research results, educational and scientific materials, results of public organizations activities.** Delivery of different information interactively via map applications using maps, tables, charts and graphs. Arranging dynamic presentation of intermediate results (via time slider, for example) before the research or other event completion.

See Appendix E to learn how CoGIS is used on research and education purposes at V.S. Sobolev Institute of Geology and Mineralogy of Siberian Branch Russian Academy of Sciences.

CoGIS can be integrated to the IT architecture of the federal authority as a GIS subsystem allowing to solve the following tasks:

- **Data visualization**. CoGIS maps embedded to the existent information systems and portals or set up as independent web applications can be a simple but efficient data analysis tool that requires no programming. The data source for these maps can be the existent databases of the organization, the applied external or internal services and subsystems. At that, using CoGIS the data conversion processes can be arranged without preliminary data processing.
- **Spatial analysis**. CoGIS can provide software tools allowing to analyze specific aspects of applied activities in terms of geographic characteristics, such as address, location of

objects of selected categories, transport availability, population density, location within specific territory, etc. These tools can be implemented either as software interfaces for use by the related subsystems, or as part of applications for users.

- **Reports generation**. By direct requests from users or from related subsystems CoGIS can generate specific reports expected to use spatial analysis results, map tiles, objects location characteristics (coordinates, address), or objects geometry characteristics (area, perimeter, etc.).

2. Platform components and functionality

2.1. Platform components

CoGIS platform consists of the following software components:

- **CoGIS Designer** – a constructor for creation of interactive maps and fully functional web map applications based on map services, geoprocessing and analysis tools;
- **CoGIS SOE** (SOE, an abbreviation for Server Object Extension) – a module providing support for advanced methods to work with the map services layers and objects;
- **CoGIS Portal** – a geoportal consisting of catalog of published interactive maps and map apps, tools for searching and navigation, and web pages with reference information which structure and content are set in accordance with the users' needs;
- **CoGIS Mobile** – mobile applications for work with interactive maps and map apps on iOS and Android devices and mobile service for operation of these applications;
- **eLiteGIS** – a GIS server for publishing data and tools as web services.

2.2. CoGIS Designer

CoGIS Designer is the main tool for setting up CoGIS platform. *CoGIS Designer* allows creating and setting interactive maps and map applications for online and offline work, adding supporting data to them, arranging them to catalog, and setting structure and content of *CoGIS Portal*.

2.2.1. Creating online maps

Online maps provide access to spatial data and tools in web and mobile applications when Internet connection is available.

CoGIS Designer allows:

- Adding map services on maps and make the following settings:
    - Specify definition queries for layers;
    - Redefine layers names, description and symbology;
    - Set restrictions to relevance of displayed data;
    - Specify references of values for separate fields;
    - Set reports for data upload;
    - Allow users to change color of layer objects;
    - Set default scale for zooming to objects;
    - Set layers visibility and transparency on opening the map;
    - Set layers legend view: layers grouping, whether layers should be expanded or collapsed by default, whether visible objects should be calculated, etc.;
    - Set search rules: whether to search by all or by selected field only, whether to mark found objects on map with pushpins, whether to search objects in related layers or to search objects by address with geocoding on-the-fly;
    - Set object identification cards: displayed information content, background color and dialog size;
    - Set fields list and order in the table with layer objects, set rules for calculating statistical values by objects (min, max, average, sum, number by selected fields);

- Adding image services on map and making the following settings:
    - Specify restrictions to relevance of displayed data;
    - Set layers visibility and transparency on opening the map;
    - Set legend display for layers including option of adding the layer visibility button to the map;
- Adding geoprocessing and analysis services on map as additional tools extending the online maps functionality:
    - Specify content and display method for input and output parameters that can be data from map, data entered by user (simple values, list of values or ranges) or files;
    - Set tools buttons view: select tool button icon, specify tool name;
- Adding printing service on map by specified template;
- Adding tools for creation, editing and deleting of objects to map:
    - Select layers for which this option will be available;
    - Enable geocoding by coordinates if by creation of object the address needs to be recorded to its attributes;
    - Specify whether editing templates should be used;
    - Restrict editing permissions at the level of separate operations, user groups, layers, territories and objects;
- Adding geotriggers on maps, which are automatic operations run by the system during creation, editing or deletion of objects by specific rules, for example:
    - Creation, editing or deletion of spatial relations between layer objects depending on their location;
    - Automatic recording simple values, constants, composite or calculation values to objects fields (including recording to fields of related objects);
    - Creation of objects by address, including creation by downloading XLS or CSV files containing addresses;
    - Batch recording of addresses of objects created by coordinates to the appropriate attribute fields by downloading of XLS, CSV and SHP files;
    - Automatic creation, correction and deletion of objects buffer zones, including the option of buffer zone creation by road network (service area), by attribute of the main object or by calculated value;
    - Sending messages using templates created using macros such as user name, object ID, values of object attributes before and after editing, etc.;
    - Checking and correcting topology of polygon objects by boundaries of adjacent polygons with recording breaches of topology rules to specified attribute field;
    - Calculation of current number of related objects with recording the calculated value to specific attribute field;
    - Calculation of geometry attributes for point, polyline, polygon, multipoint and multipolygon objects: XYZ coordinates of point or centroid, extent, length, perimeter, area, number of rings (inner and external), number of vertices, number of points in object, number of composite parts;
- Restrict viewing and sending requests to map service data by specific user group, layers, objects;

- Set calculation of objects in layer, records in table, objects considering layers symbology and filters specified in CoGIS Designer and set by users on online map;
- Adding the following advanced searching tools on map:
  - Searching by map service layers;
  - Searching considering filters selected by user;
  - Sorting search results by distance;
  - Searching considering restrictions by SQL condition, by territory;
- Setting saving editing history in CoGIS system tables with the following options:
  - tracking object's editing history in the Identification card;
  - restoring object's state after editing by specific date, as well as restoring object's geometry and attribute fields values;
- Adding import and export tools allowing to:
  - download data from files of SHP, XLS, XLSX, CSV, GPX formats to map service layer added to online map;
  - upload data from map service layer as files of SHP, XLSX, CSV formats;
  - convert data while download using custom coordinate systems and transformation parameters;
- Setting conditions to number of files that can be attached to object, total amount of files for layer, map scale, and file size;
- Enabling or disabling upload of data with or without geometry from map;
- Setting object identification card templates: set of tools, blocks of information, related objects, files, coordinates, editing history and custom HTML code;
- Setting map appearance:
  - Specify map name;
  - Set autosaving;
  - Add callouts for objects;
  - Enable calculation of objects for all map or in the current extent only;
  - Set legend height;
  - Hide layers menu;
  - Set object identification card size;
  - Set default zooming scale;
  - Limit maximum number of search results;
  - Enable display of image gallery on opening map;
  - Set initial and full map extent;
  - Set tool buttons location on map;
- Adding the following additional tools on map, setting their appearance and location:
  - Widget with results of calculated statistics on map service objects as graphs, charts or calculated values, reference info as HTML code, table with source data, page with link;
  - Going to random web page as button on map;
  - JavaScript plugin with additional functionality that will be run by pressing the button;

- Adding basemaps from different providers (Google, Yandex, 2GIS, OpenStreetMap etc.) on map with option to specify the access key and copyright, as well as selecting basemap that will be shown by default.

The figures below (see Figure 1 and Figure 2) demonstrate examples of maps created with *CoGIS Designer*.

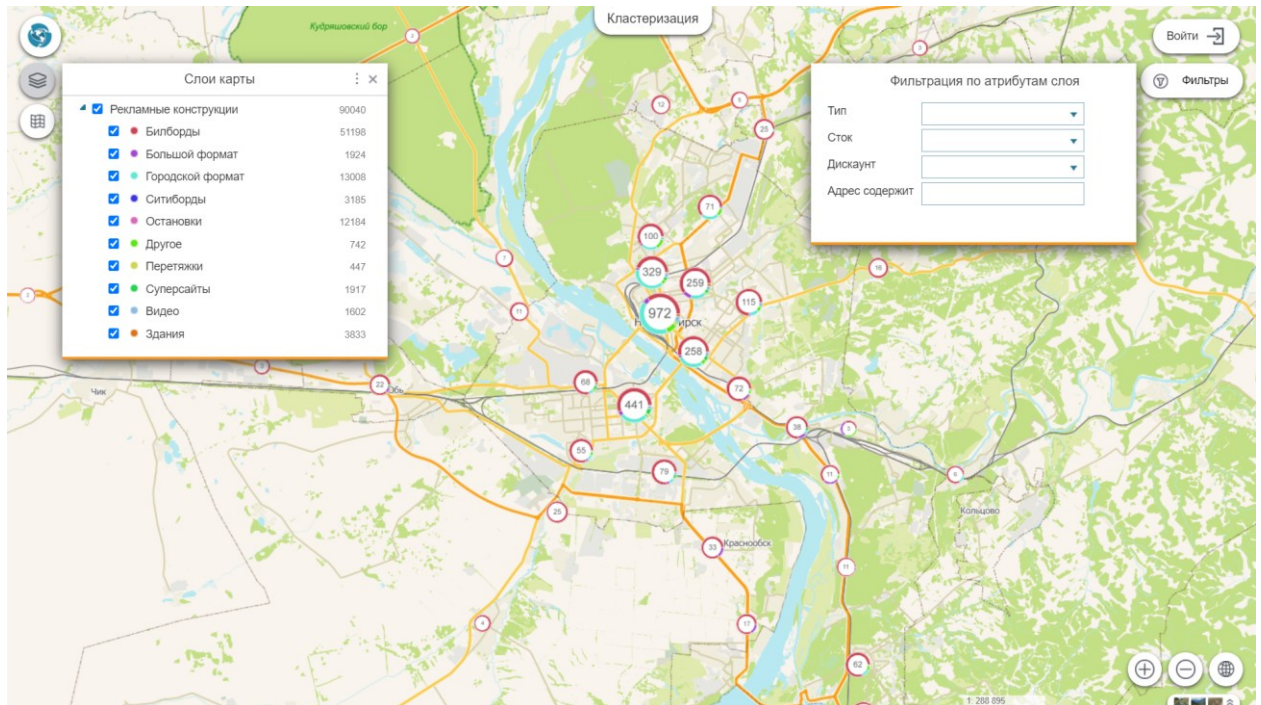Figure 1 – Map of city advertising constructions. The data are displayed using clusters. Each cluster is a chart diagram showing ratio of advertising constructions of different types. The tool for dynamic data filtration is added on map.
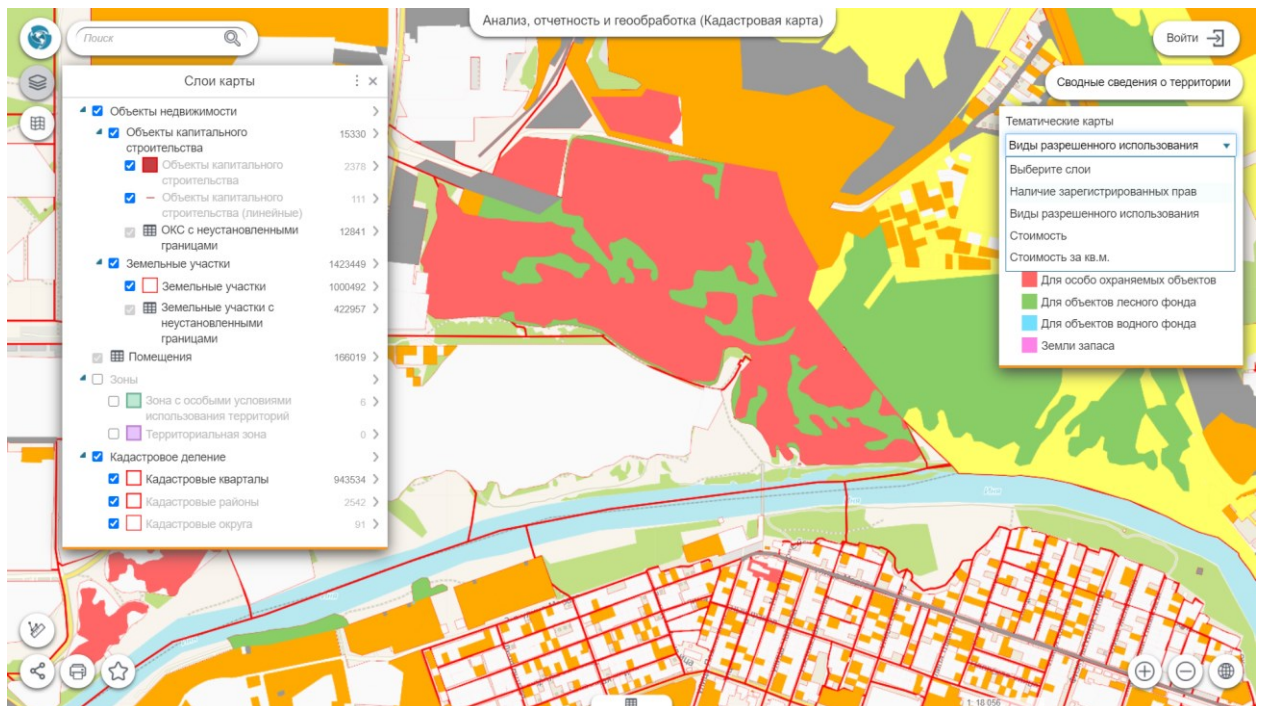

Figure 2 – Cadastral map. The land plots are colored in accordance with types of permitted use. The widget for switching between different thematic maps is added on map.

2.2.2. Creating offline maps

Besides interactive online maps with which you can work both in *CoGIS Portal* and in mobile applications, CoGIS allows creating offline maps for work in mobile applications without Internet connection.

Offline maps are created from one or multiple files of specific CMF2 format. CMF2 is the exchange format provided for storing raster and vector cartographic data and its display settings in the compressed form. CMF2 files can be created by means of CoGIS based on online maps or by means of specific desktop extension called CarryMap Builder. By creation of CMF2 file you can specify the map extraction boundaries, the list of layers and information about objects, as well as add watermark and describe your future map, if needed.

CoGIS allows delimiting access to the created offline maps, publishing them in *Catalog* and using on mobile devices.

2.2.3. Setting CoGIS Portal structure and content

CoGIS Designer allows not only creating and setting maps, but also arranging them to structure by adding service elements. Namely, with *CoGIS Designer* you will be able to:

- Group maps without limitations by nesting levels;
- Set title for group of maps and add its description;
- Set how your map will be displayed in Catalog: select image, add access counter, date, text or link;
- Describe your map using tags to enable its quick search;
- Create separate web pages with text and graphic information;
- Add links for going to CoGIS elements and to external web pages;
- Temporarily disable specific elements if you do not need them for work;
- Specify representations for any elements if you need to set their properties for specific users or user groups (for example, limit display of objects, enable or disable objects editing);
- Copy elements and save them locally as XML files;
- Set the elements access conditions: allow access for specific user groups or users, allow access by request from specific devices or specific IP addresses, ask for parameter in the access request.

2.2.4. System setting of CoGIS Portal

The following system settings of *CoGIS Portal* can be specified using the platform administration tools:

- Connection to GIS server to:
  - Get from GIS server the list of authorized users and user groups based on which the elements access permissions are set;
  - Register CoGIS users on GIS server;
  - Get list of GIS server services, run and stop these services;
- Permissions for access to administration sections and files on web server;
- Logging rules: content of actions that need to be recorded, place for storing files and frequency of information transfer;

- CoGIS interface: language, welcome page (it can be any maps catalog page or any web page), menu content and appearance (menu items can be any CoGIS elements), logos, page title in the web browser, footer content;
- Parameters for user registration and authorization by login/password, via social networks or other credentials;
- Content of the personal data processing agreement;
- Information to be displayed in case of technical works when access to web portal is limited and period of duration of these works.

2.3. CoGIS SOE

SOE is an abbreviation for Server Object Extension that CoGIS uses to extent functionality of map services. SOE is provided to:

1) Create and then update and delete on online map:

   – Objects in map service layer and their values; edit objects geometry; combine objects;
   – Records in attribute tables of map service;
   – Files attached in Identification dialogs or attached to records in attribute tables.

2) Add and delete relationships:

   – One to one. When creating or updating object in layer, it is related with object of another layer by key field.
   – One to many. When creating or updating object in layer, it is related with objects of another layer by key field.
   – Many to many. When creating or updating objects in layer, they are related with objects of another layer by key field.

3) Limit editing by:

   – operations;
   – groups of users;
   – layers;
   – objects values;
   – territory;
   – objects.

4) Run geotriggers:

   – creating relations;
   – editing related objects;
   – updating field;
   – geocoding;
   – building buffer zone;
   – sending messages;
   – updating topology;
   – calculating relations numbers;
   – calculating geometry attributes.

GEOTRIGGERS OPERATE AUTOMATICALLY WHEN PERFORMING OPERATION OF 'EDIT' PLUGIN.

5) Limit views and requests by:

– groups of users;
– layers;
– objects.

6) Track editing history by operations. Restore object after changes.

7) Download data from file of SHP, XLS, XLSX, CSV, GPX formats to map service layer added to online map.

8) Upload data from map service layer as files of SHP, XLSX, CSV formats.

9) Convert data while download using custom coordinate systems and transformation parameters.

10) Display files attached in Identification dialogs or to records in attribute tables, in Picture gallery, and establish condition to:

– number of files allowed to be attached to object;
– total number of files for layer;
– scale;
– attachment file size.

11) Store files on disk outside database. Work with user attachment attributes.

12) Specify calculation of:

– objects in layer;
– records in table;
– objects considering layer symbology by unique values, by ranges.

CALCULATION IS MADE BASED ON FILTERS SPECIFIED IN COGIS DESIGNER AND SET BY USERS ON ONLINE MAP.

13) Perform advanced search for objects, namely:

– quick and flexible search by map service layers;
– search based on filters selected by the user;
– sorting search results by distance;
– search based on restrictions by SQL condition, by territory.

SOE allows to use:

– geotriggers run while performing one of the editing plugin operations;

– requests catcher provided to limit access to data using different criteria.

2.4. CoGIS Portal

CoGIS Portal is the unified access point for users to resources published by means of the platform: interactive maps, web map applications, web pages, documents, links to external sources.

The structure, content and appearance of *CoGIS Portal* sections, access permissions to them, and list of available tools for searching and navigation are set in *CoGIS Designer* and can vary depending on the user needs.

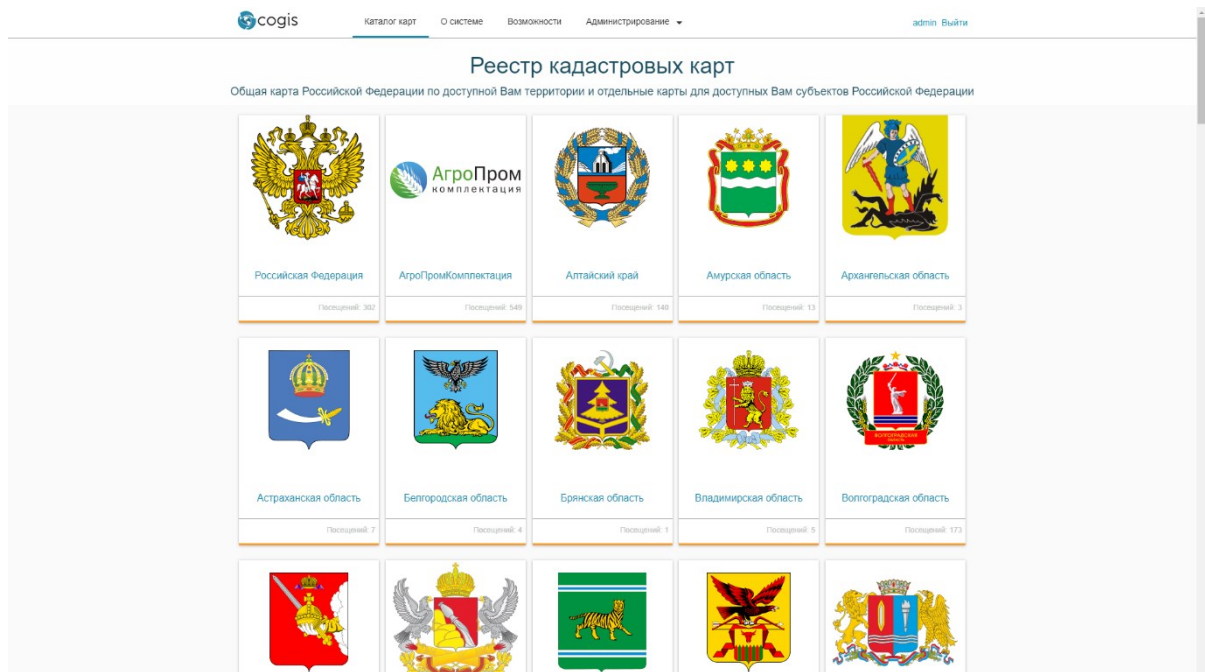Figure 3 – Example of CoGIS Portal containing only Catalog of maps and applications

Figure 4 – Example of CoGIS Portal with additional web pages

CoGIS Portal allows to:

- Switch between *Catalog* and other web pages;
- View and work with published interactive maps and map applications;
- Filter list of maps and applications available for user;
- Search for maps and applications by names or key words (tags).

2.5. Mobile apps CoGIS Mobile

Mobile apps CoGIS Mobile are provided for work with published offline and online maps on Android and iOS devices.

Mobile apps allow to:

- Authorize and get access to Catalog of maps in accordance with set permissions;
- Work in Catalog of mobile application:
    - Update list of available maps;
    - View maps description;
    - Search maps by names;
- Work with selected map:
    - View list of map layers: editable layers, recorded tracks, layers with data and used basemap;
    - Switch between basemaps variants;
    - View legend of map layers;
    - Manage layers visibility;
    - View information about selected layer;
    - Search for objects by key words, attributes, location;
    - View found objects as list and on map;
    - Get information about objects on map including attached photos, links to external sources and other data;
    - Enter collected data about objects on-site using predefined templates even in the offline mode;
    - Record movement tracks;
    - Transfer data to server for further processing and publishing automatically or forced when going online;
- Set the following mobile app parameters:
    - Hide or show zoom in/out buttons on map;
    - Enable or disable map rotation using gestures;
    - Permissible minimum map display quality for saving Internet traffic;
    - Disable screen sleep mode;
    - Mobile service to which the application should connect;
    - Synchronization with server during data collection using the application.

One of the main benefits of CoGIS mobile applications is the ability to perform field data collection and verification quickly and effectively. To do this, the following actions are required:

- The operator specifies in *CoGIS Designer* the list of data that field crew needs to collect about the objects;
- The field workers install mobile application to their devices, authorize using login and password and download maps to devices if offline work is planned.

Regardless of the selected data collection mode (online mode in case of Internet connection, postponed sending in case of not stable connection or offline mode in case when no Internet is available), CoGIS ensures delivery of data to server and synchronization of data from all involved devices.

2.6. GIS server eLiteGIS

GIS server eLiteGIS, being a part of CoGIS platform, allows creating, setting and publishing the following types of services:

- Map services (dynamic and tile services; available for view and/or edit only; with vector and raster layers);
- Geoprocessing services, including map printing services;
- Geocoding services;
- Network analysis services;
- Geometry services.

The above services can be included to interactive maps and map applications as data sources or as geoprocessing and analysis tools.

2.6.1. Map services

eLiteGIS supports publishing of map services in accordance with the following standards and protocols:

- ArcGIS Server REST API MapServer10.x and FeatureServer10.x (ArcGIS REST API);
- OGC WMS 1.3.0 (WMS);
- OGC WMTS 1.0.0 (WMTS);
- OGC WFS 2.0.0 (WFS);
- OGC TMS (TMS).

The data in the following formats can be the data sources for the above services:

- Data sources of vector layers:
  - QGS/QGZ (map project QGIS/QuantumGIS);
  - KML/KMZ.
- Data sources of raster layers:
  - CMF2 (map project CarryMap);
  - GeoTIFF.

The scope of functionality available by publishing of map services depends on the data source format.

2.6.2. Geoprocessing services

eLiteGIS allows creating geoprocessing models using visual editor (see Figure 5) and publishing geoprocessing services with access via REST API based on these models.
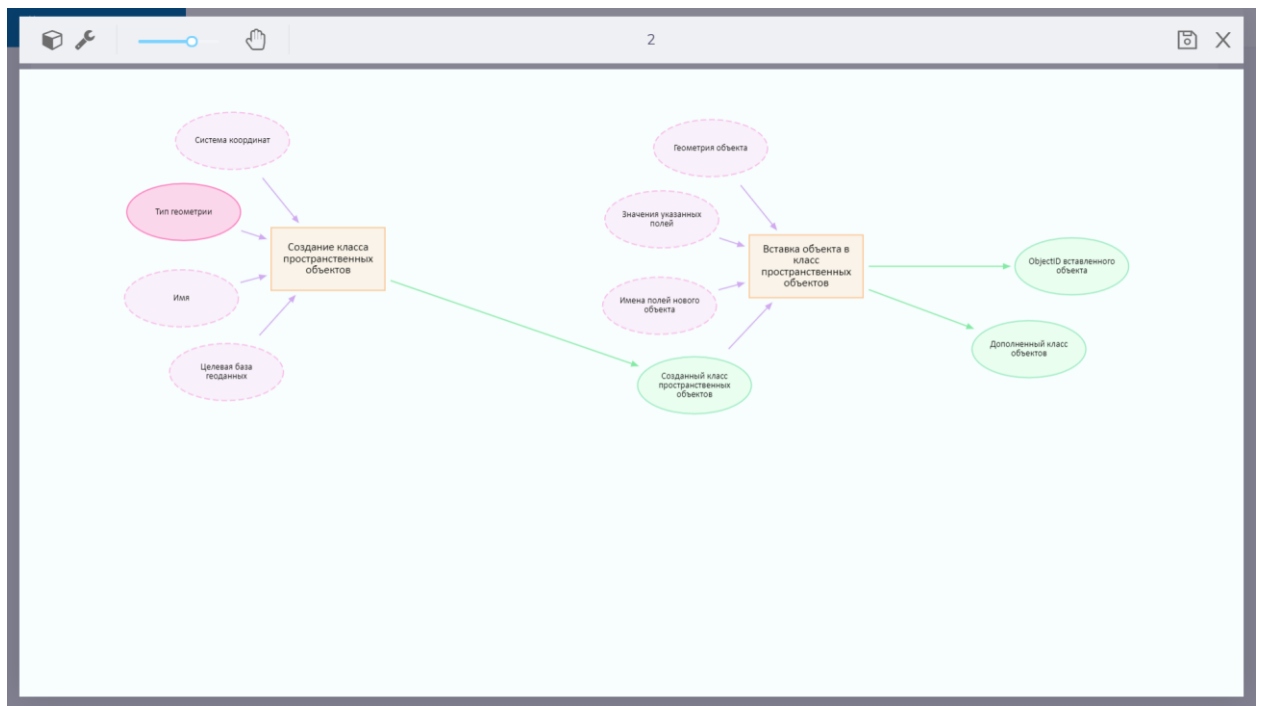
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Figure 5 – Visual editor of geoprocessing models

As a rule, the geoprocessing model consists of one or multiple tools sequentially connected with each other and option to transfer any parameters between these tools.

Parameters

The types of parameters (variables) used in models are as following:

- Integer number (Int);
- Real number (Double);
- Yes/No (Bool);
- String (String);
- Date and time (Date-Time);
- File (File);
- Geometry (Geometry);
- Coordinate system (Coordinate system);
- SQL expression (SQL expression);
- Workspace (Workspace);
- Data set (Table);
- Layer (Standalone table);
- Feature class (Feature class);
- Feature layer (Feature layer);
- Map (Map);
- Image service (Image service);
- Tile service (Tile service);
- Map service (Dynamic service);

The model can also use map or layer of the map services as parameters.

Tools

One of the eLiteGIS tools or other service model can be used as the model tool.

eLiteGIS includes more than 60 ready geoprocessing tools that can be used for creation of models, see Figure 6.
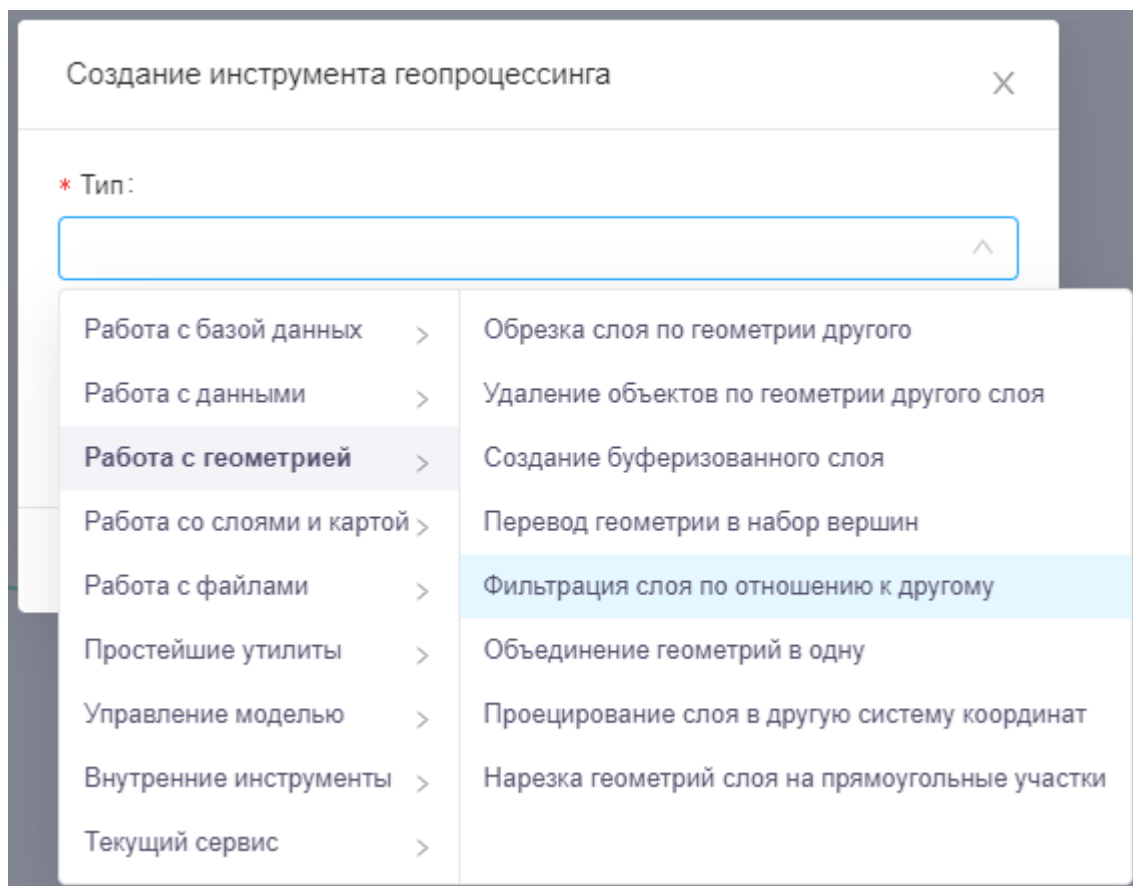

Figure 6 – Selection of geoprocessing tool type

Description of ready tools that can be added to the geoprocessing models is provided in the manual 'Publishing of GIS services in eLiteGIS'.

2.6.3. Geocoding services

GIS server eLiteGIS allows building geocoding service by map service.

Normally geocoding service in eLiteGIS can be used not only with address data for comparison of addresses and coordinates, but also with any other data as a general service for searching by random text string.

The geocoding service functions are as following:

- Direct geocoding, i.e. searching for coordinates and parameters of the address object by the single string address value;
- Direct geocoding in a batch mode;
- Reverse geocoding, i.e. searching for address object parameters by coordinates.

When specifying the search string by address, it is also possible to specify additional filtering fields, such as district, city, etc., depending on map service layers based on which geocoding service is built.

2.6.4. Network analysis services

eLiteGIS allows building network analysis service based on index rotix file built by the TrueDrive library.

Index rotix file can be built based on data from OpenStreetMap, Here or on any other data.

The network analysis service functions are as following:

- Searching for optimal route by two or multiple points;
- Building/calculation of service areas;

The algorithm abilities:

- Use of roads hierarchy;
- Use of restrictions (for example, no left turn, etc.);
- Specifying of point/line/polygon barriers;
- Calculation by multiple rules (cost/impedance), for example, the shortest route by distance and time.

2.6.5. Geometry services

Geometry service is part of eLiteGIS functionality providing support for the following platform operations:

- Projecting of geometries from one coordinate system to another;
- Applying additional transformations and transformations chains between coordinate systems during projecting or spatial calculations;
- Calculation of distances and areas;
- Reduction to geometry without self-intersections (operation of simplifying geometry);
- Topology operations:
  - o Intersection of two geometries;
  - o Subtraction of one geometry from another;
  - o Combining multiple geometries.

2.6.6. Authorization and access rights differentiation

GIS server provides the following functionality for users authorization and access privileges:

- Authorization of users by login/password;
- Registration of users;
- Maintaining registry of users and user groups;
- Limitation of access to services at the level of available functionality, service layers, service fields;
- Limitation of access to services at the level of users and user groups:
  - o All, even not authorized users;
  - o All authorized users;
  - o Users from selected groups;
  - o Selected users only;
- Privileged access for adjacent elements included in GIS server (for example, only for requests from geoprocessing and geocoding services).

Storing data about users, user groups and other related information is done in the selected editable database, in specific tables. At that user passwords are not stored neither open nor encrypted, as GIS server stores only password hash.

2.6.7. Managing services

GIS server functionality can be used via API and via specified web application eLiteGIS Server Manager.

eLiteGIS Server Manager allows preparing services for publishing, managing their state and GIS server parameters. The following options are available in the web application:

- Viewing of hierarchical catalog of services, searching for services;
- Adding or updating of services based on the downloaded map project files, including projects prepared in QGIS;
- Renaming, copying and transferring, deleting of the existent services;
- Managing services states via changing of the web access parameters, list of service functionality, tile caching parameters;
- Viewing and changing of service content;
- Viewing list of users and user groups, searching, creation/editing of users and user groups, adding/excluding users and user groups;
- Viewing/changing of general settings of GIS server.

3. Integration options

3.1. General method for working with data in CoGIS

CoGIS allows working with geodata at the following independent levels:

- Data;
- Map projects;
- Services;
- Map applications.

The work with open source formats and data transmission protocols is supported at each level, which allows using only part of the platform components and deploying GIS to the existing IT architecture if needed.

3.1.1. Data level

CoGIS can use MS SQL Server or PostgreSQL databases with PostGIS extender and also files with vector (Shapefile, GeoPackage) and raster (GeoTIFF, CMF2) data as data sources. For work with database CoGIS does not require use of any middleware (such as ArcSDE) and creation of additional data structures. This means that changes in data (new tables, records, fields etc.) can be made in database using the regular client software, for example, pgAdmin for PostgreSQL/PostGIS. Besides, CoGIS supports indices and geotriggers created at the database level.

So, CoGIS can use the existent database with the well worked inner logic as the geodata source and does not require conversion of accumulated data to any specific format.

3.1.2. Map projects level

Normally, the map project defines how the map will look by publishing as map service: data content, display method and data sources for layers. The layers in map projects can be raster and vector, single and grouped. Besides, the tables with data containing no objects geometry and layers created based on external web map services can be also added to the project.

CoGIS allows publishing map services based on map project files in QGS format that are created in the Open Source Geographic Information System QGIS. The publishing is seamless, the user just needs to drag the project file to the web console eLiteGIS Server Manager and the map service will be published automatically.

CoGIS supports various settings that are specified at the QGS project's level, including additional variables at the layer's or project's level for fine-tuning of the data representation. For example, to set definition SQL query for layer, visibility settings, relationships between objects via attribute field, scale dependency and different symbology settings for objects rendering, etc. Or, to create heat map via interpolation of values by selected mathematic function or to enable pseudo 3D option depending on objects height or number of stories, to enable support of subtypes (classification of data where subgroups of objects of feature class with similar attributes are used), to set 'many-to-many' relationship between objects, etc.

Additionally, in CoGIS you can publish map services based on KML/KMZ, CMF2 and GeoTIFF files.

That is, CoGIS allows using Open Source software (QGIS) to perform severe editing and data preparation operations, and as map projects it uses files of open formats (including files already

used or/and created within the existent business processes) without strict limitations on their maintenance.

3.1.3. Services level

CoGIS includes its own GIS server eLiteGIS provided for publishing services and organizing web access to them via REST API. Management of services is done via web console eLiteGIS Server Manager providing graphic interface for publishing GIS services and setting GIS server. CoGIS allows publishing tile and dynamic map services, geocoding, geoprocessing, printing, network analysis, and geometry services.

eLiteGIS supports publishing of the following types of services:

- **Map services** by specifications: ArcGIS Server REST API MapServer10.x and FeatureServer10.x, OGC WMS 1.3.0, WMTS 1.0.0, WFS 2.0.0 or TMS. Published map services can be dynamic and tile, with vector and raster layers. Map services allow searching for objects by string, providing information about selected object (attributes, geometry, file attachments, related objects), showing selected map area according to SQL filters applied to layers, selected coordinate system with reprojecting on the fly, user access privileges and custom symbology set on the client, as well as allow creating, editing, deleting of objects, attachments and relations between them. For tile map services it is possible to set parameters of tile cache creation (maximum size, scale range, tiles life time and parameters, areas of preliminary caching), and also to enable monitoring of changes in geodata for automatic recreation of cache upon these changes.
- **Geoprocessing services**, including map printing services. Geoprocessing services allow performing geodata analysis and processing via tools used by predefined algorithm and that transfer parameters between each other. eLiteGIS includes more than 60 ready geoprocessing tools and visual editor for building models.
- **Geocoding services**. Geocoding service gets address as input data and returns coordinates of requested location, and vice versa, returns address which is the nearest to input coordinates. Geocoding services can be used, for example, for searching for objects, creating new objects by address, including creation in a batch mode, or for automatic recording of addresses for objects with known coordinates. Normally geocoding service in eLiteGIS can be used not only with address data for comparison of addresses and coordinates, but also with any other data as a general service for searching by random text string.
- **Network analysis services.** These services are provided for making network analysis operations, such as search for optimal route and calculation and building of service areas. Network analysis service is published based on index rotix file built by the network tasks server **TrueDrive**. TrueDrive is a separate software product developed and owned by Data East which functionality is used only partially in the basic version of CoGIS platform, namely for searching for optimal route. If needed, TrueDrive can be included to CoGIS in whole.
- **Geometry services.** Geometry service is included in the eLiteGIS functionality and provides support for the following platform operations: reprojecting coordinate systems from one to another (the list of coordinate systems is not limited, it is enough to set system description as a WKT string or a WKID identifier), calculation of distances and

areas, geometry simplification, topology operations (intersection, subtraction, combining of geometries).

All services published using eLiteGIS are accessed via REST API and can be used both in map applications created in CoGIS and in other external applications.

3.1.4. Map applications level

CoGIS Designer allows creating web map applications and publishing them as catalog on geoportal CoGIS Portal.

Web map applications created in CoGIS can be both simple geodata viewers and automated workstations with wide range of tools. Going to any of the published applications can be done via general Catalog or via separate URL address. The following components can be added to mobile applications:

- List of layers with legend with option to apply spatial and/or attribute filters to layers, set custom symbology for layers (including classification by unique values and ranges), customize transparency, visibility and order of attributes, as well as export selected layer objects to CSV, XSLX and Shape files;
- Quick search panel with options to set layers and fields by which the objects should be searched, and also to specify that geocoding service should be used for searching;
- Attribute table for displaying the objects list, their sorting, filtration, printing and exporting to file;
- Gallery of images for viewing files related to objects with option to go to object from file;
- Tools for creating new objects by predefined templates;
- Objects identification cards of predefined structure (tabs, blocks), including display of related objects and available tools (add to Favorites, zoom, start editing, report about error, print identification card);
- Favorites to save list of selected objects, extents or map states;
- Widgets with statistics (charts, graphs, tables) dynamically recalculated in case of making changes in data;
- Buttons for starting geoprocessing tools and displaying geoprocessing results that can use objects or current map layers as parameters;
- Buttons for quick generation of reports by specified DOCX or XLSX templates with dynamic fields filled in with information about objects in the current map;
- Widgets based on JavaScript plugins that can call any external tool or service, or widgets using HTML code for displaying the reference information, and many other tools.

With CoGIS Designer you will be able to not only set content of data and tools in the application, but also set application's appearance: color and location of tool buttons on map, default view, logo.

The access to applications can be set using different authentication methods: via social networks or by login/password set for the user on the GIS server.

Both services published via eLiteGIS and services of the external GIS (Here, Yandex, OSM, Google, Esri etc.) can be used as data sources for basemaps, geodata, network analysis tools, geoprocessing and geocoding tools.

Access to published applications is also available via mobile applications CoGIS Mobile for iOS and Android.

3.2. Integration with GIS software

The use of all the CoGIS components at a time is not obligatory. The development technologies used to create the platform, as well as standards and protocols based on which the integration is done, allow integrating only separate CoGIS components to the existent IT architecture, if needed.

Variants of integrating separate CoGIS components:

- **Integration with DBMS**. CoGIS can use already implemented database of the organization (for example, database under DBMS PostgreSQL or Microsoft SQL Server) as the data source.
- **Integration with server software**. The map services source to create map applications in CoGIS can be the GIS server used in the organization (for example, GeoServer or ArcGIS for Server).
- **Integration with portal solutions**. If your organization has own geographic information systems and portals, CoGIS GIS server can be used for publishing data and tools as web services that would be connected to the existent applications directly without use of *CoGIS Designer*.

3.3. Integration with related software

CoGIS platform can be integrated with any accounting, monitoring and other related systems used in the information environment of the company, such as SharePoint etc.

CoGIS can be the source or the provider of information for business processes related with geodata.

Interaction can be implemented by direct network connection via HTTP/HTTPS protocols, via RESTful services or by connection to databases and file systems by means of operating systems based on which the CoGIS components are run.

Examples of implemented integration services in addition to basic functionality of the platform:

- *CoGIS and SharePoint for Municipal portal 'My Novosibirsk'. SharePoint is used as the data source on utility systems cut-offs, social objects, electors' mandates to deputy and other objects both for the public part of the GIS portal (providing citizens with information related with the city life) and for the service part in tasks related with geodata maintenance and analysis (for example, modeling of utility systems cut-offs).*
- *CoGIS and Rosreestr web services for Terrascope portal. The tool for requesting and processing of XML documents and cadastral plans from Unified immobility access registry of Russia by request to the appropriate web services is implemented as part of the Terrascope portal.*
- *CoGIS and FTP server for oil production company. CoGIS provides service for processing of files from FTP server containing data from meteorological observing stations on temperature, content of chemical elements in the air and other parameters. The service is provided for processing and downloading of data to CoGIS for their further visualization,*

calculation of derived indices and generation of user notifications in case of exceedance of statutory criteria.

- ***CoGIS and satellite communication means for Yamalo-Nenets Autonomous Okrug in Russia***. *As part of the regional GIS the synchronization service is implemented to monitor work of mail server receiving messages from Iridium satellite phones of the Eskimo people (about 3000 families). These messages contain information about current location of the sender and the SOS signal. The service allows processing these messages and attached files, saving them to database and visualizing on map in CoGIS.*

3.4. Incorporating tools and data to CoGIS

Besides integration at the level of databases and business logic of server applications, CoGIS provides a number of simple but effective methods of incorporating the external systems elements to own applications as widgets:

- Incorporation based on JavaScript plugins that can call any external tool or service;
- Incorporation using HTML code to display reference information.

4. Development technologies

4.1. General info

Development technologies of CoGIS maintain high reliability and performance of the output solutions, apply no usage restrictions and are cross-platform.

CoGIS supports software environments of OS Linux and Windows (IIS+Kestrel). At that CoGIS can be installed both on physical and on virtual servers, including cloud infrastructure. CoGIS supports both proprietary virtualization environments (for example, VMWare) and open source virtualization environments (for example, KVM).

The following shared libraries are used to extend CoGIS platform components functionality:

- JsonCpp (https://github.com/open-source-parsers/jsoncpp);
- Clipper (https://sourceforge.net/projects/polyclipping);
- OGR (http://gdal.org/1.11/ogr);
- Expat (https://libexpat.github.io);
- Freetype (https://www.freetype.org);
- GeoTIFF (https://trac.osgeo.org/geotiff);
- ICU (http://site.icu-project.org);
- Jpeg (https://github.com/LuaDist/libjpeg);
- LibPQ (https://github.com/LuaDist/libpq);
- OpenSSL (https://github.com/openssl/openssl);
- Png (http://www.libpng.org/pub/png/libpng.html);
- Proj4 (https://proj4.org);
- Protozero (https://github.com/mapbox/protozero);
- Sqlite (https://www.sqlite.org);
- Tiff (http://www.libtiff.org);
- Webp (https://developers.google.com/speed/webp);
- Zlib (https://zlib.net).

4.2. Development technologies of CoGIS GIS server

The core of CoGIS GIS server is written in C++ 14 which ensures high performance of the code, in particular owing to direct work with memory and running of code by processor directly.

GIS server supports horizontal scaling that can be implemented via one of the following methods:

- Multithread processing of user requests at the web server level by threading them within single process;
- Multiprocess processing of requests using web server infrastructure (on one server multiple web services of GIS server are deployed, for requests distribution either web adapter is used or the logical distribution by different GIS server web services is arranged);
- Balancing of requests between GIS servers with the same configuration and access to needed databases for all servers.

4.3. Development technologies of CoGIS web applications

The upper level CoGIS logic is written in .NET Core (C#), ASP.NET Core Web Application and HTML/JavaScript. .NET Core is the solution with the open source code supporting cross platform deployment and deployment in Docker containers, if needed. The use of C# ensures high reliability of server infrastructure.

4.4. Development technologies of CoGIS Mobile applications

CoGIS mobile applications are developed using native development stacks, such as Kotlin and Java for Android, Swift and Objective-C for iOS platform. This ensures high performance of the applications (the native code has direct access to all functions of the operating system) and positive user experience owing to direct integration of the applications with mobile operation system and adaptation to different screen sizes.

5. Useful resources

To learn more about CoGIS platform functionality, visit the following links:

- https://cogis.dataeast.com/ - CoGIS website
- https://cogis.dataeast.com/portal - CoGIS demo portal
- https://cogis.dataeast.com/CoGIS/Support - CoGIS FAQ and support request form
- https://builder.carrymap.com/ru/overview/ - description of CarryMap Builder, the ArcGIS extension to create compact interactive maps and their further use on mobile devices
- http://dte.dataeast.com/ - description of TrueDrive
- https://dataeast.com/ru/about-us/ - information about Data East, the product developer

The following manuals can be also helpful:

- Publishing GIS services in eLiteGIS;
- Installing and setting eLiteGIS;
- Installing and setting CoGIS;
- Creating map projects in QGIS;
- Creating map applications in CoGIS;
- Working in mobile applications CoGIS Mobile.

Appendix A – CoGIS as corporate GIS – System used by geologists and surveyors of oil production companies

Based on CoGIS platform the corporate system to maintain design, survey and exploration works has been implemented.

CoGIS allows storing data on drilled and projected wells, and is also used for organizing the process of projecting of the new wells. The platform allows getting the complete picture on works performed in the oil fields, analyzing geodata in 3D format and promptly generating various reports and other documentation. Besides, the platform allows managing all stages of the drilling process from desktop computers or mobile devices.

Figure 7 – Processes supported by CoGIS platform

Extensive access permissions system allows participation in management process of specialists from the following organization's divisions:

- **Organization's management staff** performs general management and control of the projecting process.
- **GIS experts** carry out download and processing of geodata, manage map projects, GIS services and thematic map applications.
- **Surveyors** carry out projecting of target-points, well rows, well pads and project wellbores, make corrections in the coordinates of well heads and well rows based on the field observations results, build wellbore geometries based on inclination and gyroscope correction data, perform 3D analysis of well drilling data, maintain documentation and generate reports at each stage of processing works.

All the operations with data are verified automatically and all the changes are saved.

Appendix B – CoGIS as regional GIS – Unified cartographic system of Yamalo-Nenets Autonomous Okrug in Russia

Unified cartographic system of Yamalo-Nenets Autonomous Okrug in Russia is a fully functional GIS created based on CoGIS and provided for aggregation, storage, and update of large cartographic and thematic data volumes (electronic maps, satellite images, etc.) and managing access to published data for users.
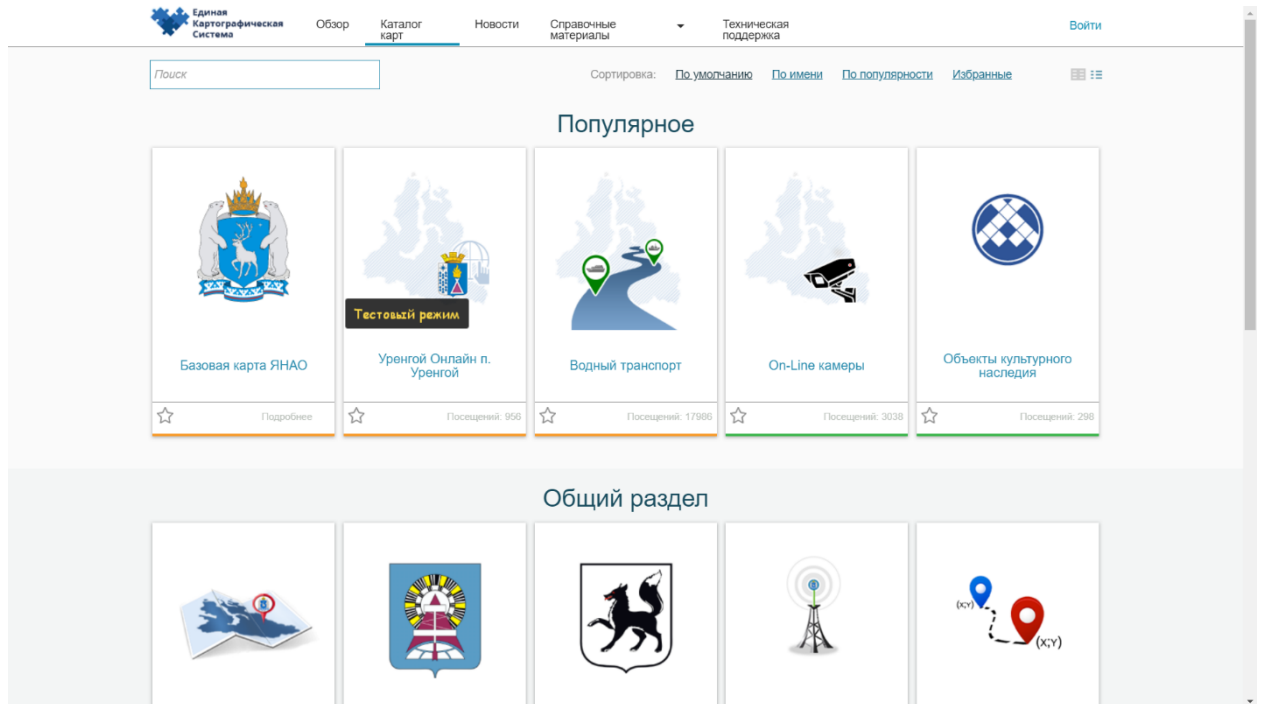

Figure 8 – Catalog of maps of Yamalo-Nenets Autonomous Okrug

This regional GIS put into operation in 2015 is provided for building a unified geoinformation environment of the autonomous okrug and arranging interaction between administration bodies, municipal units, and citizens.

The main tasks solved by the system are monitoring of forest fires, monitoring of ice conditions, maintaining work of the unified operations control service of Salekhard, monitoring of forestry activity, and planning and ordering of satellite imagery.
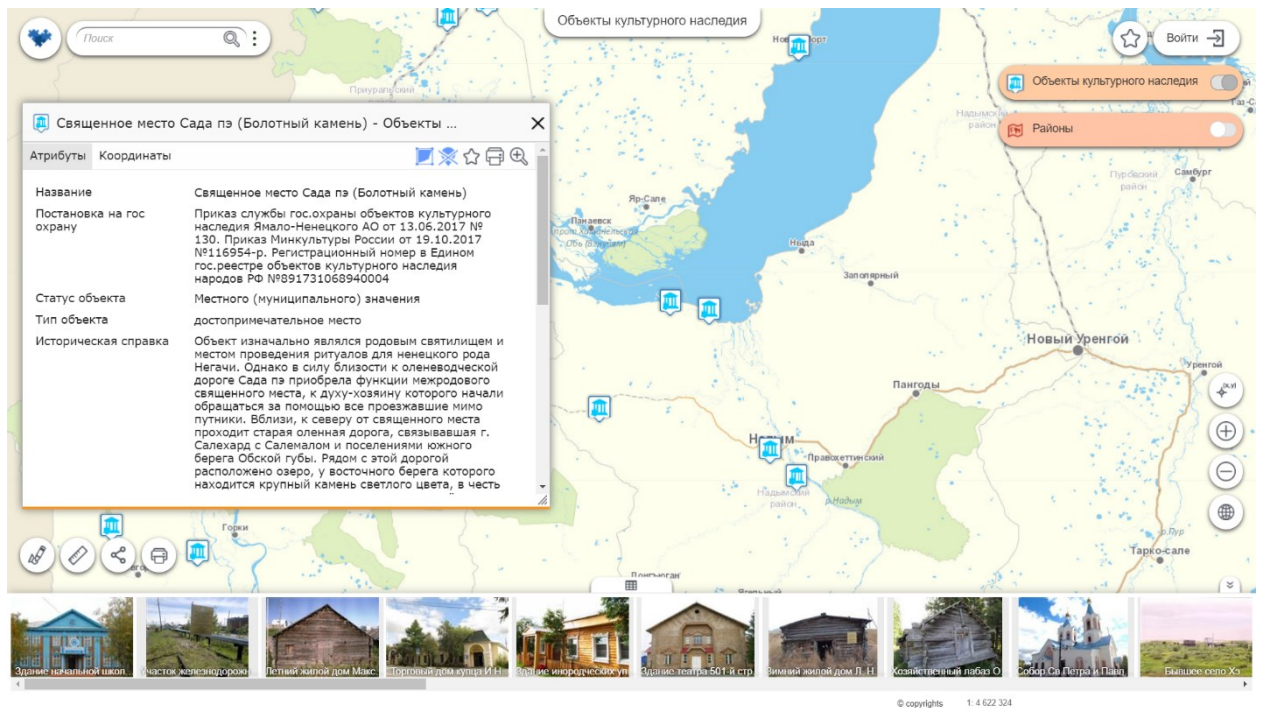
Figure 9 – Map of cultural heritage sites of Yamalo-Nenets Autonomous Okrug

Statistics of system's work:

- 700 registered users;
- 200 portal visits daily;
- 4500 requests for portal map Winter trails of Yamal.

Link to portal of Yamalo-Nenets Autonomous Okrug: https://karta.yanao.ru/eks/catalog

Appendix C – CoGIS as municipal GIS – Geoinformation portal 'My Novosibirsk' for Novosibirsk City Hall

'My Novosibirsk' is the comprehensive software platform based on CoGIS and combining system for creation, storing, and classification of geodata on city area, service portal for geoinformation support of city administration departments activities, and public portal for information support of citizens and obtaining feedback from citizens.
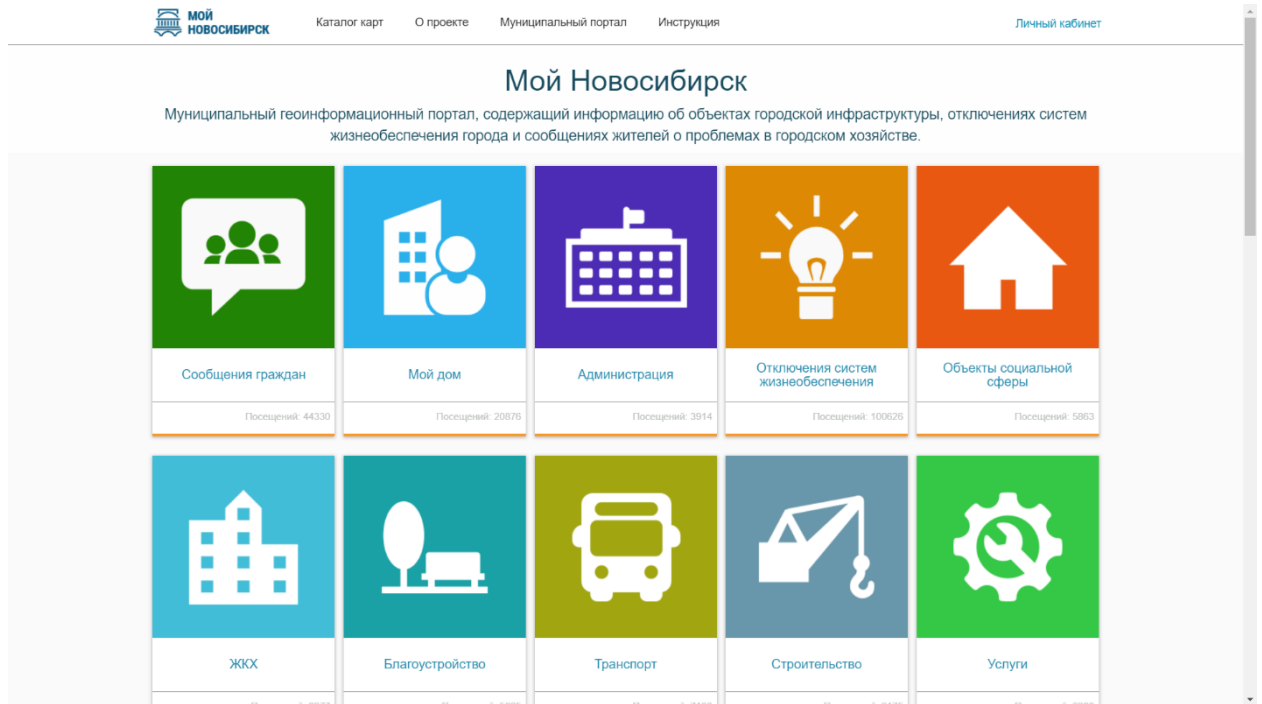
Figure 10 – Catalog of maps of 'My Novosibirsk' portal

The portal is the interaction site for city administration and citizens regarding the comfort city environment, namely:

- Managing municipal infrastructure;
- Recording planned and emergency excavation works;
- Maintaining and repairing city roads;
- Modeling municipal facilities cut-offs;
- Managing outdoor advertising;
- Recording municipal facilities;
- Recording burial sites;
- Recording waste disposal sites.

Working with the portal, citizens get the actual information about municipal facilities and their state, can address to city administration with questions and get feedback, and city administration, in turn, get the effective tools for maintaining municipal facilities and simplifying interaction between municipal services.
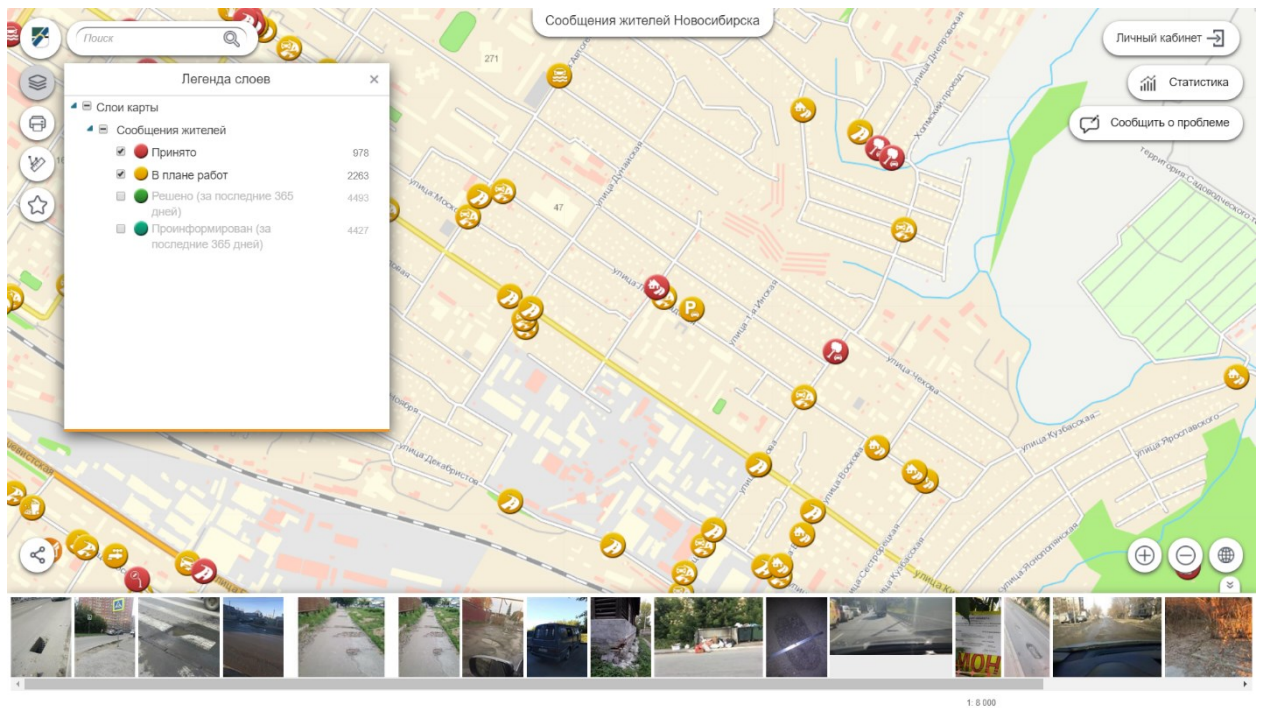
Figure 11 – Interactive map 'Messages of Novosibirsk citizens'

Statistics of portal's work:

- More than 250000 viewings of published maps;
- More than 1000000 visits of portal.

Link to portal 'My Novosibirsk': https://map.novo-sibirsk.ru/portal

Appendix D – CoGIS as municipal or regional GIS – Portal 'Terrascope'

Terrascope is the GIS portal based on CoGIS provided for managing territories and immovable assets.
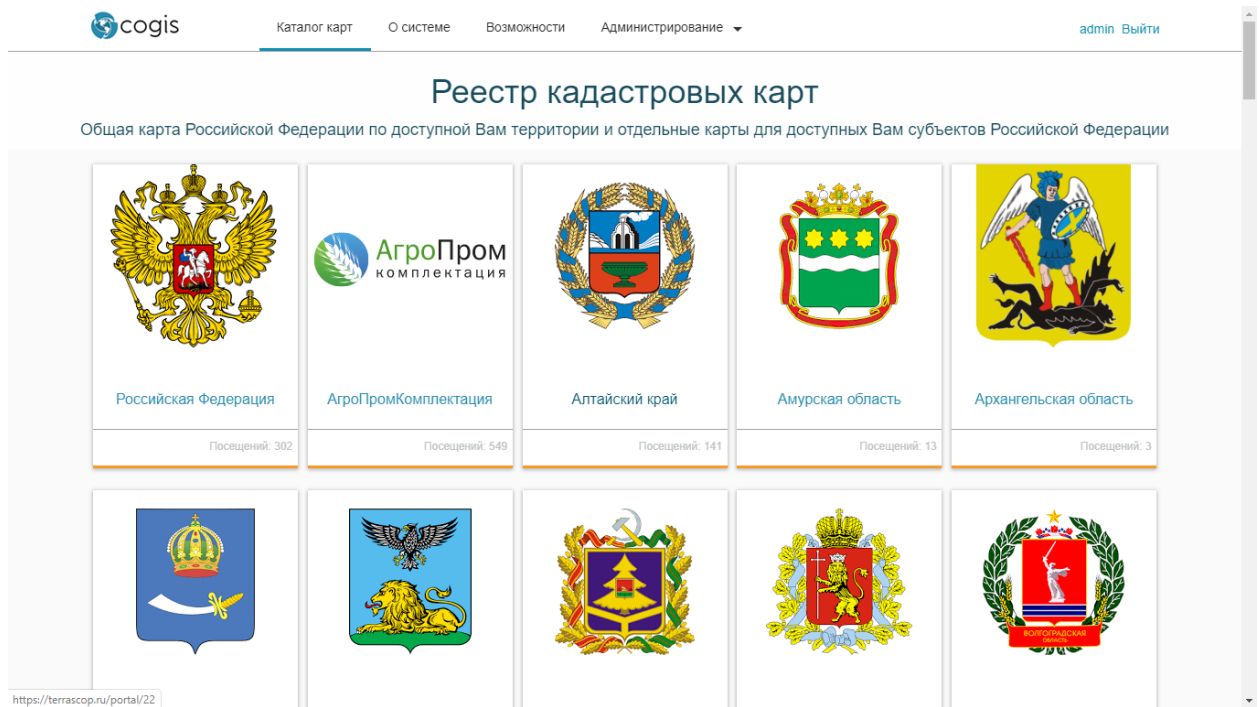

Figure 12 – Geoinformation portal Terrascope with cadastral maps of federative and municipal units of Russia

Terrascope can be used both by administration bodies and by commercial companies. Using Terrascope you can create cadastral map of the needed territory (district, region, municipal units or any random territory) depending on location of recourses that need to be managed.

Cadastral maps are cartographic web applications allowing to:

- Download data on immovable assets (land plots, buildings, constructions, unfinished constructions, special territories, cadastral districts and regions) from Federal Agency for the Cadaster of Real Properties and Federal Tax Service of Russia;
- View downloaded data on the map;
- Create analytical thematic maps and reports on immovable assets based on the following cadastral parameters:
    o   Types of permitted use;
    o   Lands categories;
    o   Cadastral value of land plots;
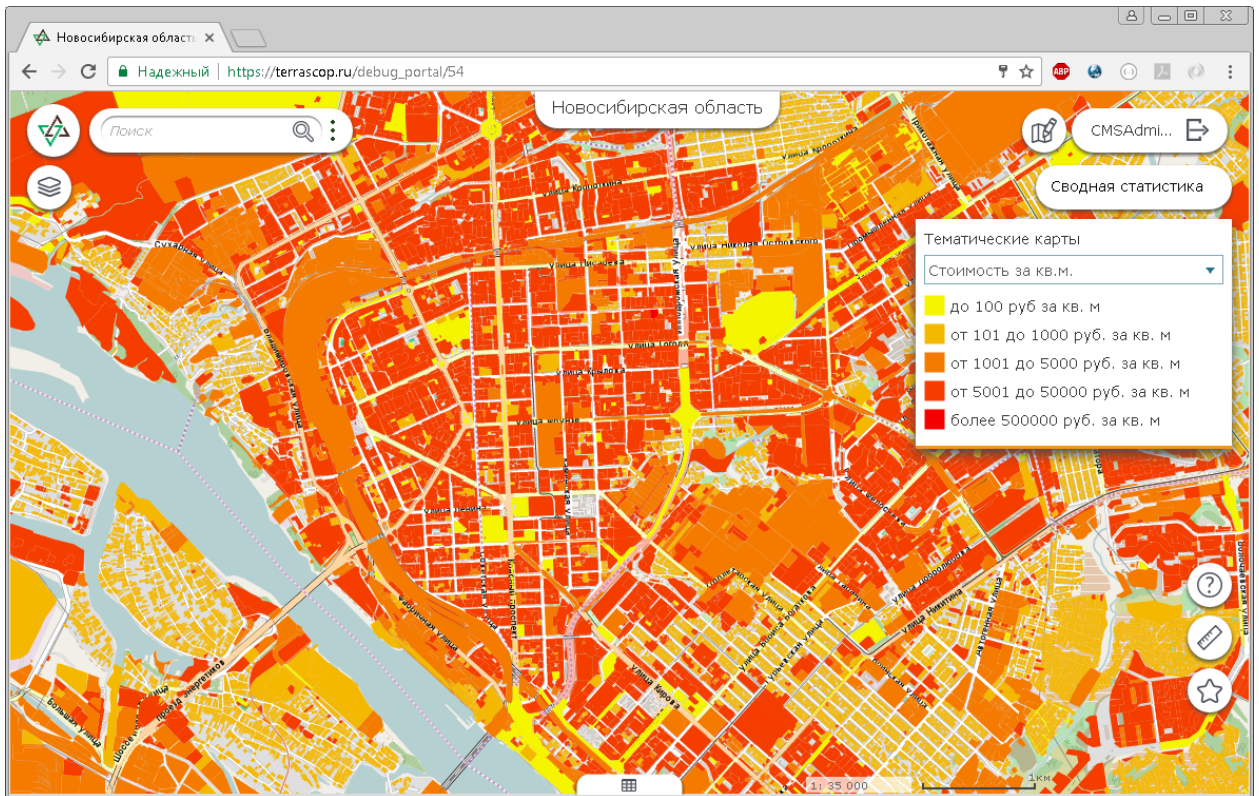
Figure 13 – Example of thematic map showing cadastral values of land properties

- Analyze data with respect to tax assessment:
  - o Find immovable assets without recorded entitlements;
  - o Find immovable assets that are not registered in the unified system of Federal Tax Service;
  - o Generate summary reports on territories with inconsistency of data from federal and cadastral registries.
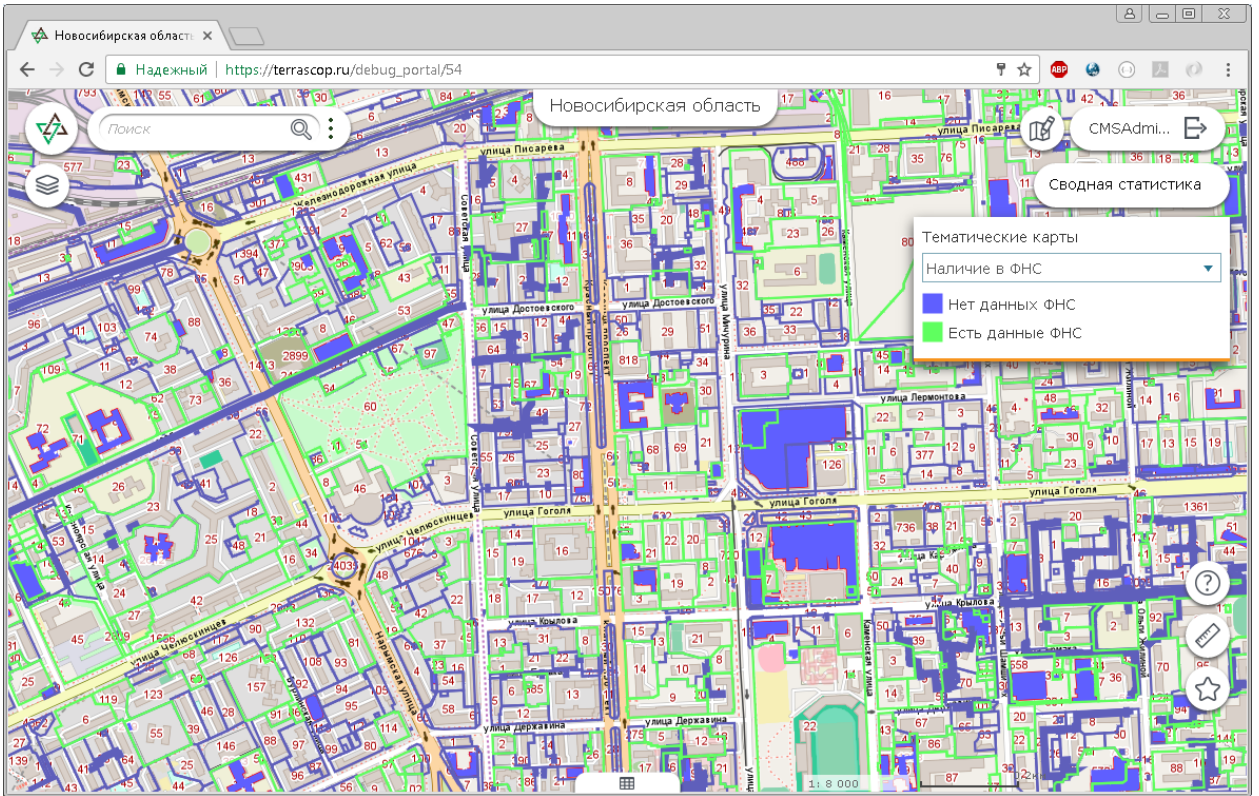
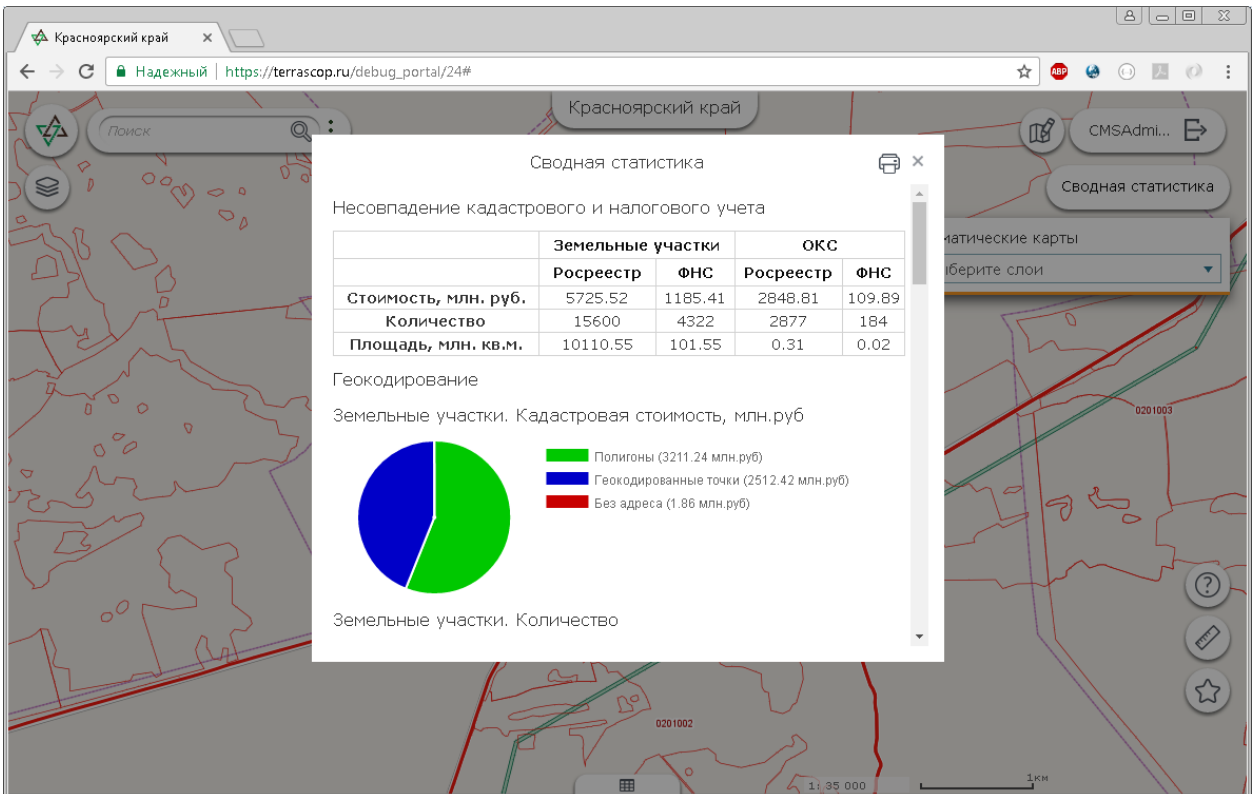Figure 14 – Example of thematic map showing immovable assets with information from Federal Tax Service

Figure 15 – Example of statistics report on inconsistency of data from federal and cadastral registries

Link to Terrascope portal: https://terrascop.ru/portal/catalog

Appendix E – CoGIS as platform used on research and education purposes at V.S. Sobolev Institute of Geology and Mineralogy of Siberian Branch of Russian Academy of Sciences

CoGIS was used to develop the application called 'Electronic log of geologist' provided for automating the field works of geologists from Institute of Geology and Mineralogy of Siberian Branch Russian of Academy of Sciences and also the CoGIS portal of maps and map applications on institute data.

Mobile application 'Electronic log of geologist'

During the field season geologists collect hundreds of samples, which coordinates should be fixed and recorded and which properties should be described. Besides samples collection, geologists perform survey works, plan their routes, and the field team leads prepare the expeditions budgets. Until recently, all these works were done manually using the paper logs and navigators, which meant a very time consuming postprocessing and digitizing of the collected data upon the season's end. Electronic log was provided to simplify this process and allowed organizing work of the field crew or laboratory.

'The app allows downloading any maps to mobile device, creating points on map and adding description to them, attaching photos to points of interest. Each geologic sample is described according to specific standard, namely, the sampling conditions, name of the rock, description of source and secondary minerals, the change ratio, etc. In order to automate this process and ensure its performance quality, we started to use thematic reference guides. When the specialist wants to describe the sample, he just selects the required record in the predefined list of parameters specified for each item, so there is no need to manually type the text on the screen. This option helps avoiding typos and speedups the data input', — says Mikhail Zadorozhniy, the project's supervisor and junior research associate of Institute of Geology and Mineralogy of Siberian Branch of Russian Academy of Sciences.
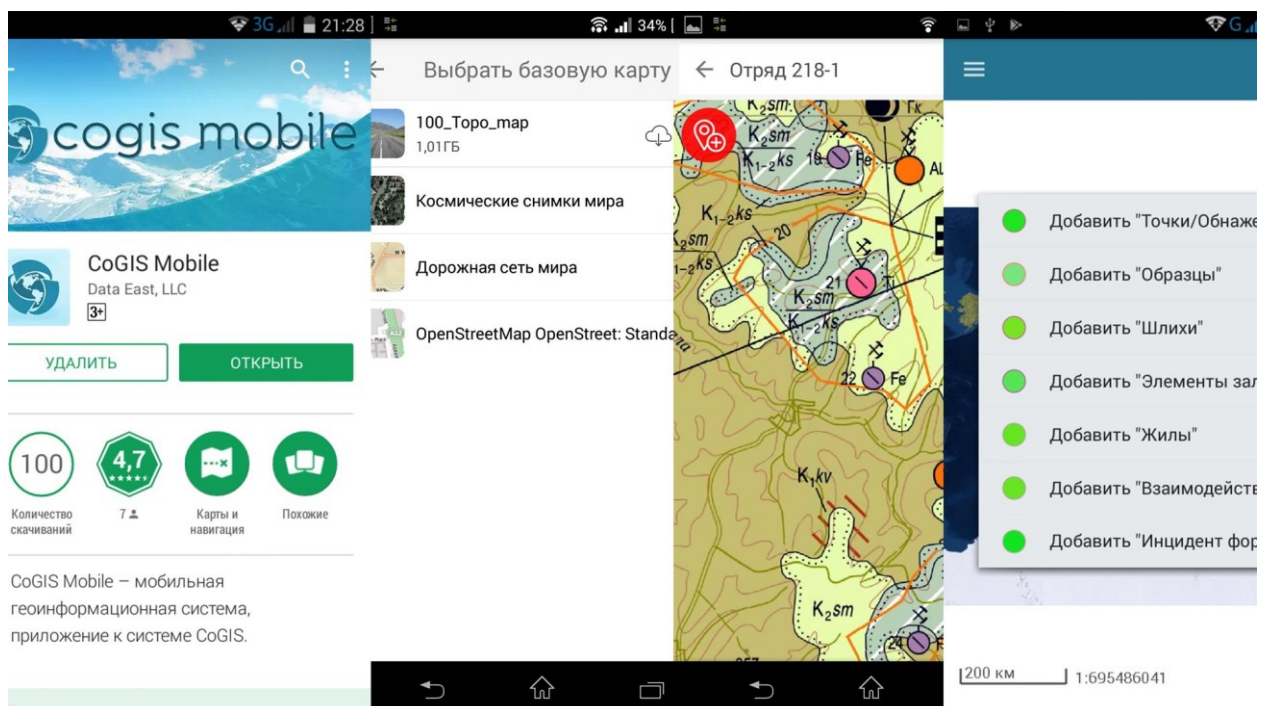

Figure 16 – Electronic log of geologist based on CoGIS Mobile application

CoGIS Portal of Institute of Geology and Mineralogy of Siberian Branch of Russian Academy of Sciences

Besides use in field studies, the platform is used in the Institute of Geology and Mineralogy of Siberian Branch of Russian Academy of Sciences to organize samples, thin sections, and other items for which spatial reference is important. That way a major part of the geology museum of the Institute has been processed.

'With CoGIS, more than 15000 display exhibits of the museum, which are samples brought from various geologic sites, finally got their geographic reference. We created the interactive display stands where we 'arranged' all the samples with pictures, description, year of entry, name of grantor, name of deposit. There is also the option to filter data by specified parameters, for example, to find all exhibits containing specific minerals or granted by specific person. The access to museum data has different levels: for museum employees, for students, for virtual visitors and etc.', — says Mikhail Zadorozhniy.

Figure 17 – Example of providing information of samples collected in the Sinyukhin golden-skarn deposit
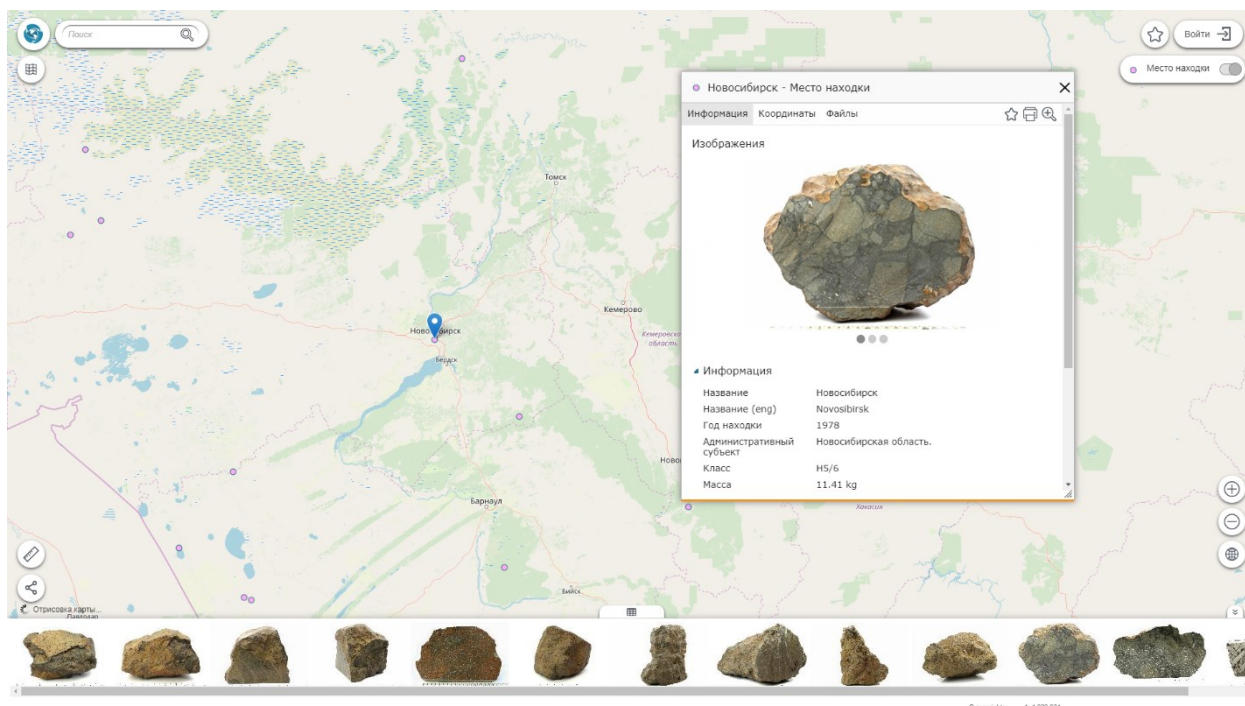
Figure 18 – Example of providing information on the meteorite in map application 'Meteorites of Russia' published on CoGIS Portal of the Institute

Link to Portal of the Institute of Geology and Mineralogy of Siberian Branch of Russian Academy of Sciences: https://mus.igm.nsc.ru/cogis/catalog