



LPIS

Land Parcel
Identification System



1 EXECUTIVE SUMMARY

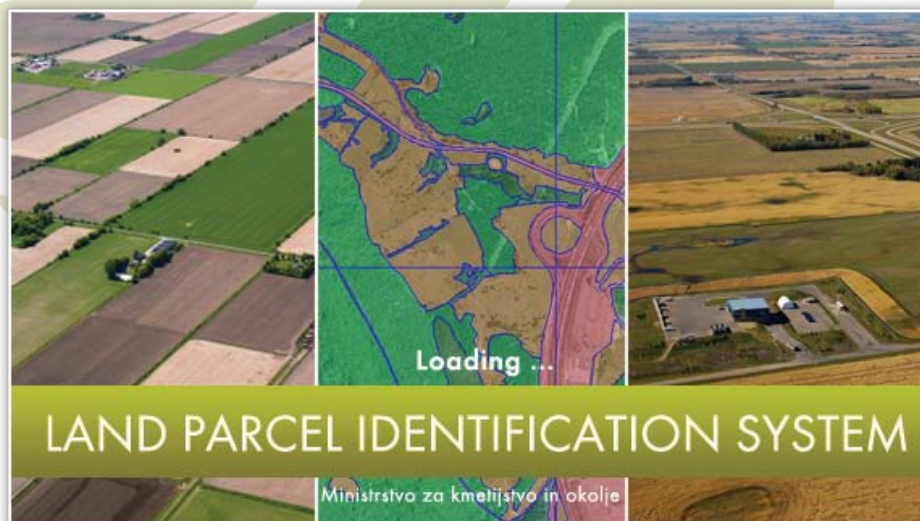
Sinergise is very experienced in developing and operating Land Parcel Identification Systems in several member states. LPIS is not just one single application but rather a highly controlled set of processes, supported by IT tools, which range from managing input data, handling farmer's input, performing several stages of cross-checks, updating the data annually and finally providing QA reports to EC. These processes have to be run in parallel in order to meet the criteria of the DG Agri.

Sinergise has developed an innovative and powerful set of Java-based tools that cover all aspects of LPIS. They can be deployed in client-server architecture, in an Internet-based system or even on a CD. We have combined these tools into an Internet-based system for editing the graphical and descriptive information on usage of agricultural land.

The application is being used on a daily basis by hundreds of users in Slovenia, Croatia and Macedonia for EU farming subsidy applications monitored under IACS regulation. Sinergise has also developed Land management systems in Mauritius, Nigeria and Tanzania.

Main features of the good LPIS:

- Facilitates operation by farmer, inspector, PA.
- Allows systematic monitoring.
- Better performances (reduction of inspections).
- Lower IACS operating costs.
- Reduced risk for the EU funds.



2 GENERAL CONSIDERATIONS

The Giselle LPIS system and especially the LPIS database is one of the most important parts of an IACS software solution, allowing accurate calculation of area-based payments as well as provide a means to control farmers' application and resolve disputes. It is also possibly one of the most complex IACS sub-systems, mostly due to the graphical nature of the data and the variety of different data formats involved, as well as the distributed nature of the whole operation, with a large number of concurrent users (more than 200) from local offices simultaneously accessing and updating the data.

In order to properly address the importance and complexity of the LPIS system, the following considerations were taken into account when designing the software solution:

- data integrity,
- low maintenance and installation effort,
- high performance of the central system,
- low bandwidth requirements,
- ease of use.

2.1 Data Integrity

The following features of the proposed software design, based on Oracle RDBMS, help ensure integrity of the data:

- Graphical and attribute data are stored in a single database table.
- All users access the central database – no duplication and synchronization is necessary to keep the data up-to-date. Duplication can be used as a backup mechanism.
- Data is accessible via OGC-compliant open API.
- Querying using standard SQL is possible.
- Area calculations and other classifications are performed automatically upon update of the database.
- Role-based security prevents unauthorized access and manipulation of spatial data. The viewer and the GIS client application can be configured to be either freely accessible to all users without any authentication, or limited to registered users. Several standard authentication and security mechanisms are possible – from simple username / password authentication to authentication with digitally signed credentials.
- Locking mechanism prevents errors when multiple users access the database simultaneously.
- History is kept indefinitely for graphical and non-graphical data. Each update is tagged with a user id and timestamp, providing full audit tracking capability.

The system validates the data on several levels:

- The user interface of the client application is engineered to prevent erroneous input. Topology verification is performed during editing, which means that the user cannot enter invalid data.
- Simple validation of graphical and attribute data is performed in the client application before submittal.
- Advanced topological validations are executed on the server prior to updating the database.
- Validations of database constraints are triggered upon update.

2.2 Installation and Maintenance

To ensure easiest possible installation and maintenance, we have put a lot of effort into making as much available directly from the browser as possible. Those parts, which require highest precision, are implemented in so called "desktop client", however, they are still run directly from the browser.

The desktop client software is installed automatically, which simplifies its distribution to the local offices and to the large number of internal users. Java™ Web Start technology allows effortless installation and execution of the client applications from within a web browser.

Upgrades of the software require no effort at the local offices – the browser based execution ensures that users always run the latest version of the client application.

The web application for external users is based on AJAX¹ technology, which allows it to run in a standard web browser without the need for installing special software and plug-ins.

Installation of servers in the central cluster as well as in local offices is also automated: when new updates are available, they are automatically distributed to all the servers in the middle tier, reducing the need for system administration and preventing stability problems during upgrade periods. Orthophotography and other supporting data can be downloaded automatically during periods of low network traffic, i.e. at night or during weekends.

2.3 Performance of the Central System

In order to process the large number of requests coming from more than 1000 different users, the server application is distributed on several machines and the load on these servers is balanced to achieve maximum efficiency. The server application also reduces load on the database by caching data needed for graphical renderings.

The distributed and load-balanced cluster of servers is useful also for distributing the processing power between different modules, so that the internal client application, for example, is not affected by increased load on the external web GIS or other less important processes such as printing of the application forms.

The implemented distributed approach is not only highly performant, but also very cost-efficient; a cluster of servers can be used instead of special or high-performance mainframe hardware. This also improves scalability of the system: servers can be added into the cluster when higher loads are expected (e.g. during months of peak usage of the Giselle LPIS system, when new applications cause a lot of changes of parcel boundaries) and removed at times of low activity.

Another benefit of the proposed approach is transparency of the system. The system enables the administrator to monitor many aspects of the running processes in real time, including the following:

- database performance,
- CPU usage,
- network utilization,
- end client throughput.

¹ AJAX – Asynchronous Javascript and XML (<http://en.wikipedia.org/wiki/AJAX>)

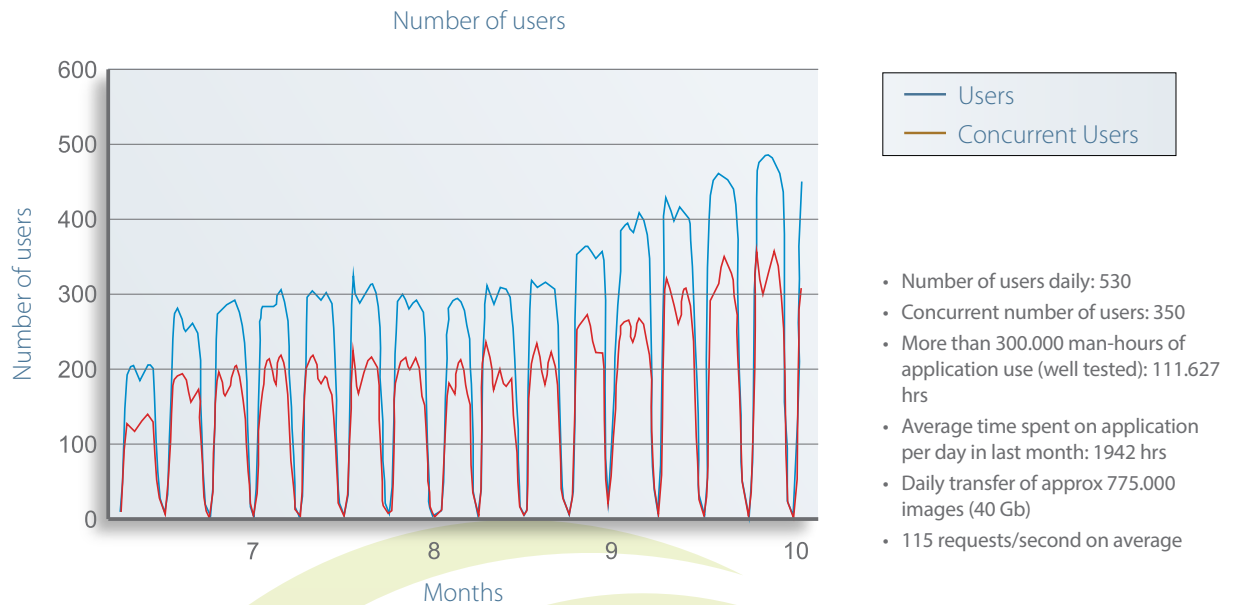


Figure 1: Number of active users versus time and other statistics from the system running at Slovenian MAFF

2.4 Client Bandwidth and System Requirements

Users of the Giselle LPIS system can be located in regional offices, therefore high-bandwidth internet connection to the central office may not always be available. Considering the fact that large amounts of spatial data, including orthophotos, have to be displayed and manipulated by the users, internet bandwidth has to be utilized efficiently.

The software design addresses bandwidth issues with the following mechanisms:

- The communication between the client application and the server is reduced to the minimum – vector data is transferred from the database only when the user starts editing and is transferred back at the end of the editing process. Advanced topological checking and validation is performed locally. A very small request (two coordinates) is needed for snapping, instead of downloading large amounts of vector data for the background layers.
- The client application does not access the database and other remote spatial data sources directly; the server, which has direct access to the spatial data, creates a map image, which is sent to the client. This reduces the need for transfer of large amounts of raw data and enables image

compression, which further reduces the required bandwidth.

- Data from locally stored data sources is seamlessly integrated with the data accessed remotely, which improves overall performance of the system without reducing its user-friendliness.
- Compression and format of the transferred images is adjusted automatically, reducing image quality and increasing responsiveness of the user interface. For example, JPEG compression is most efficient for raster imagery and images composed of both rasters and vector drawings, while GIF and PNG are the most effective for transferring entirely vector images with large areas of the same color.
- Orthophotographic imagery and other infrequently updated data can be stored at local offices and updated periodically at times when there is little other network traffic.

The above mechanisms allow efficient use of the client software at network bandwidths as low as 256 kB/s, which can be achieved with an ISDN line or even via mobile networks.

2.5 Ease of Use

The system can be used by various groups of users with different levels of technical knowledge, most of which have little or no experience with GIS software. It is therefore very important that user interface is as simple and intuitive as possible. The following approaches help with achieving friendly user experience:

- The client application is started from a web browser and updated automatically when new versions, updates and patches are available.
- The solution is based on web technologies and Java™ platform, which allows the software to run on a variety of different platforms and operating systems.
- The user interface, including error messages, can be entirely localized.
- Attribute forms use advanced constraints to check the data entered by the users and guide them in case of omitted or erroneous entries.
- Graphical editing can be fully topological, preventing errors during editing and guiding the user during advanced editing tasks (holes, splitting, snapping), and errors (intersections, misplaced centroids, duplicate points ...).

- Links to context-related HTML help pages are available in various portions of the user interface.
- Task-oriented user interface can ensure a steep learning curve even for novice users. More powerful features, although not explicitly visible in the user interface (they would distract the novice users), are accessible to advanced users and experts.
- Server application enables support center personnel to see the graphical view of the users or even join the users' session in "conference editing" mode, so they can provide assistance remotely in case of topological difficulties or ambiguities.

Editing of attribute data is highly customizable (sample screen is shown in Figure 2) and supports various data formats and different constraints, such as pre-defined lists of values and regular expressions. Validity verification of the attribute and spatial data is performed in the client application and detailed comprehensive reports of the verification are displayed to the user (Figure 3 and Figure 4).

Figure 2: Editing of characteristics with pre-defined constraints (configuration defined in XML)

SESTANEK - Seznam GERK (3/5)

V tabeli so prikazani GERK-i za izbrani KMG. Odključajte GERK-e, ki jih želite urejati. Po uskladitvi GERK ponovno obključajte. Ko končate z urejanjem, kliknite gumb "Končaj".

Preverjanje GERK-ov KMG MID: 100200300

ID	Domače ime	Raba	TNS	Površina					P
3015584	HRIB	1211		0 01.42.97					
3015591	A	1300		00.19.03					
3015600	MMMM	1211		0 00.41.12					
3015606	CESTA	1211		0 00.06.28					
3015609	HHK	1211		0 00.51.66					
3015611									
3015612									
3015613									
3015614									
3015615									
3015632	JANC 5	1300		00.82.91					
3015633	EMILLIAN 2	1222		0 00.18.47					
3015634	POD DOMO...	1100		0 00.01.00					
3015635	NA VASI	1230		0 00.01.00					
3015636		1230		00.01.00					
3015637		1230		00.01.00					
3015638	APPLE ORC...	1221		0 00.38.45					

Pomoč

Napaka pri preverjanju GERK

Polje 'TNS MID' ne sme biti prazno (RABA-1230).
 Polje 'Domače ime' ne sme biti prazno.
 Polje 'Št. enote rabe' ne sme biti prazno.

OK

Glavno okno

Preverjanje GERK

Opis napake	
GERK 3015600 prekriva 3015622 s površino 1.32453453564...	
GERK 3015600 prekriva 3015621 istega KMG-ja	
GERK 3015600 prekriva 3015664 KMG-ja - 3	

Figure 3: Validity verification of characteristics

Figure 4: Validity verification for spatial data

3 LPIS MODULES

3.1 GIS Desktop Client Application

The client GIS application is used for maintenance of the LPIS database. Although it does not need to be installed on the client machine (it is executed using Java™ Web Start), it functions as a full-featured desktop application.

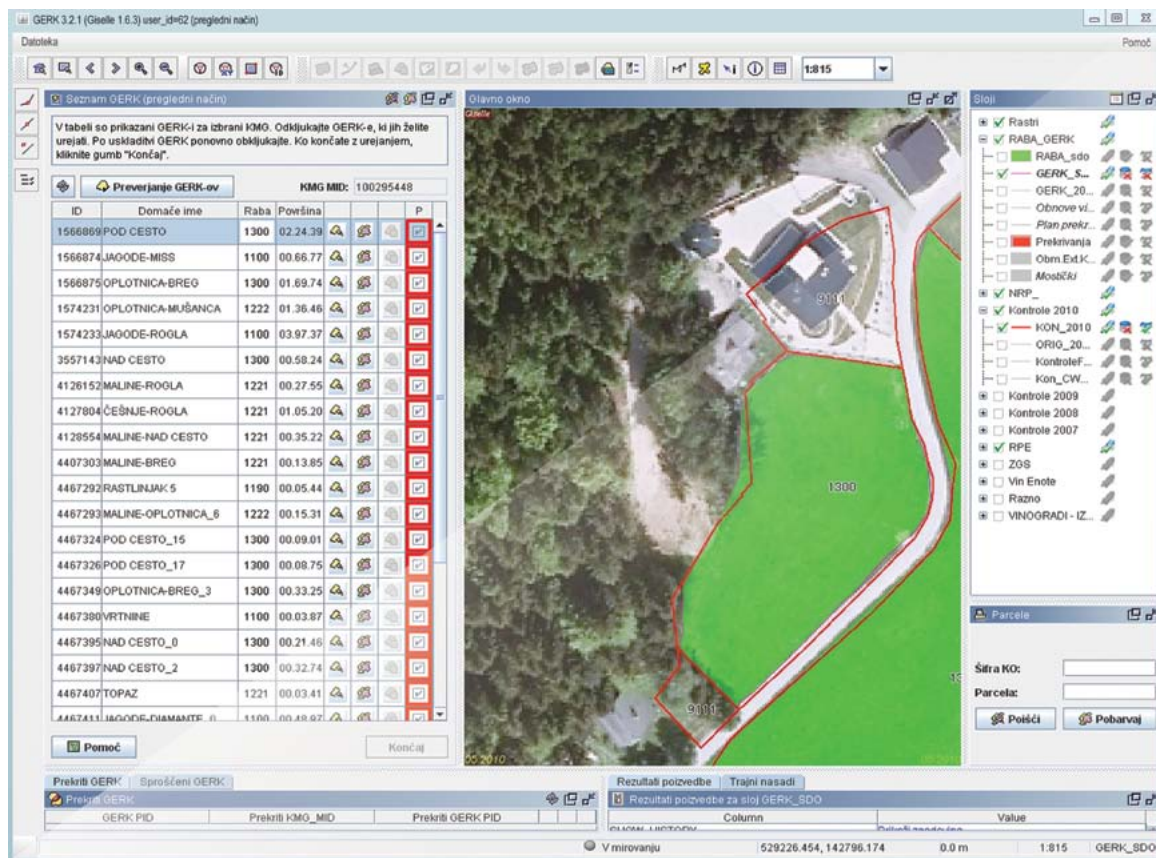


Figure 5: LPIS client application, displaying several selected land parcels, overlaid on orthophoto imagery. The panel on the left displays all parcels for a selected farmer. The application features navigation tools, advanced topological editing tools, such as creating holes, splitting polygons, advanced attribute data editing, layers' display properties manipulation

▶ 3.1.1 Range of industry standard GIS functionality

The client GIS application provides all the basic functionality like zoom, pan, scale, layers list, layer properties, grid and scale display, measurement, data browsing and locating.

The possibility to define new editable layers and to have full access to its definition is also considered a basic functionality of the system. Adding a new layer

requires little more than the definition of a new table in the database or connecting to an existing one.

Additional useful features of the client application are filters and selection sets. The former can be used to render individual features differently according to their attribute characteristics. The latter allow selection and manipulation of multiple parcels based on several criteria (SQL query, graphical definition of extent, selection by ID ...).

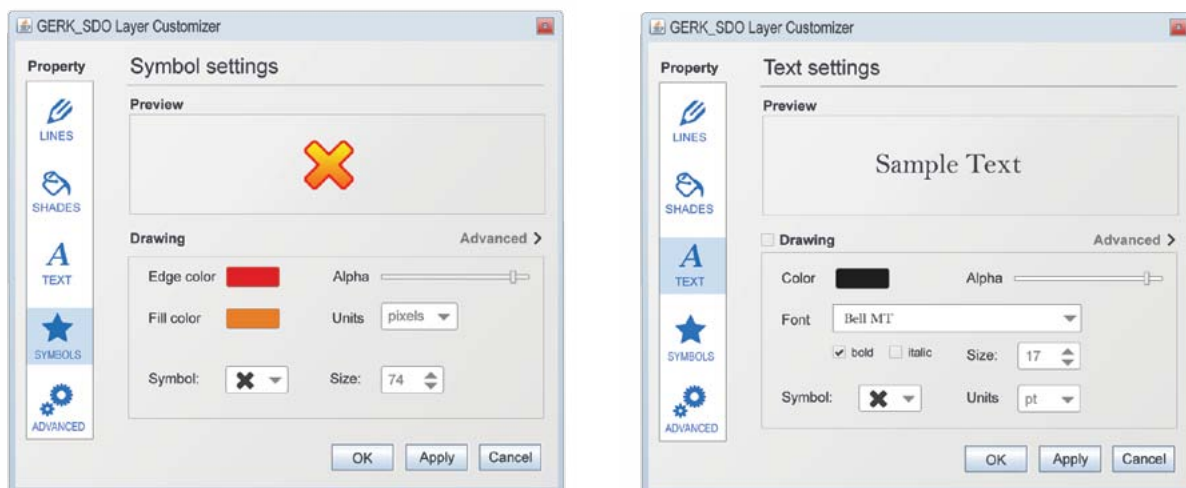


Figure 6: Display settings for layer: (left) settings for symbols; (right) settings for textual labels

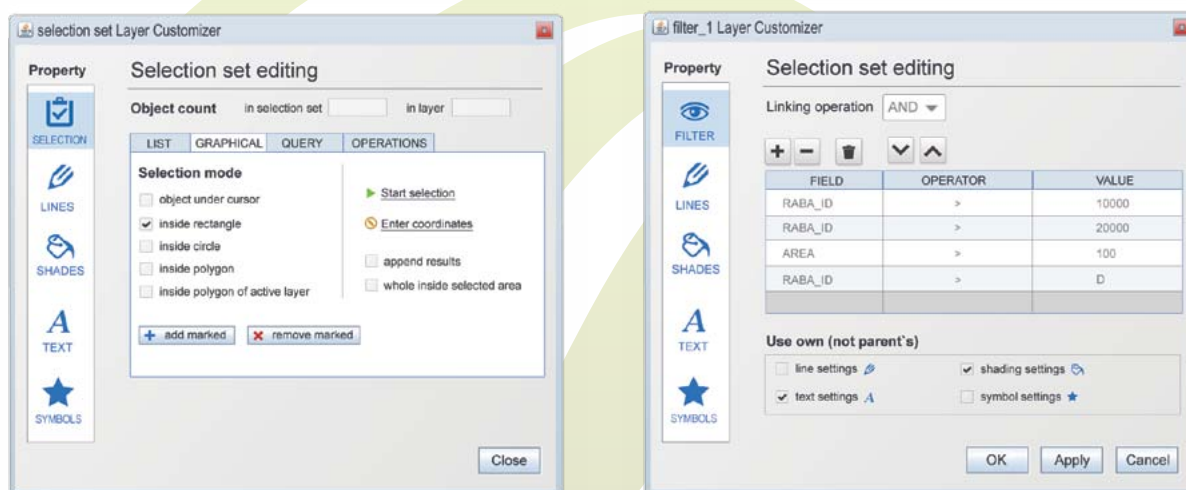


Figure 7: Selection set editing (left) and filter definition (right) GUI dialogs.

▶ 3.1.2 Boundary changes and data capture

Graphical editing of land parcels is fully topological. It provides a rich set of functions for changing existing parcel boundaries and data capture of newly declared parcels. It includes the following functions:

- add polygon,
- change border,
- join polygons,
- split a polygon,
- make a hole in a polygon,
- fill a hole in a polygon,
- change polygon attributes,
- unlimited undo and redo.

Below is described some of the non-standard functions that were implemented during several years of system improvements:

- Declare overlap with another parcel - the farmer should have an option to say that part of his neighbor's parcels is his. Such an area should be specially marked in the system and nobody of the conflicting farmers should be able to use that area in the claim until the issue is resolved. Note that non-intended overlaps are prevented at the digitization level (full topology editor is preventing the point to be drawn over the border of another field).
- Ineligible areas are maintained in the same layer as field data, marked with specific set of attributes. That function makes it easier for the user as both

datasets can be edited at the same time. It also significantly contributes to the consistency of the data.

- Declaration of landscape features with specific set of business rules (e.g. the wall at the border between two fields being shared by both of them, the area distributed proportionally to the border length).
- Declaration of "common use" on some types of fields (e.g. permanent pastures).
- Uploading the attachments (photos, notes) with defined location and (in cases where needed) also the bearing. In that way we can establish a good picture of the environment and assist the editors to assess the situation properly.
- Validation of data before commit - both standard topology validation including identification of spikes, kick-backs, gaps, slivers, duplicated points etc. and content-wise validation with other spatial layers (e.g. warning user if the parcel is overlapping the non-agriculture area in land-cover layer).
- Quality assurance business rules - e.g. not allowing digitization of fields on small-scale levels, requiring user to draw vertices to specific level of details.
- 3D view of specific area, which might be useful in cases when interpretation based on AP is difficult.

Additional functions can be defined and easily implemented when the need arises. In cases of boundary disputes or explicit doubly-declared areas, topology checking can be disabled while editing; however, polygons resulting from such editing are marked and can later be retrieved

when resolving the dispute or excluded when calculating the area eligible for payments.

Attribute characteristics of the land parcels are edited via a fully configurable user-friendly attribute form. The flexible configuration of the user interface is very important, because it allows detailed control over the display and behavior of the attribute forms and enables procedural changes and updates of the attribute data constraints to be implemented efficiently, while ensuring validity of the entered data. The properties of the individual fields, which can be adjusted painlessly via XML configuration (Listing 1), include the following:

- label text,
- visibility,
- enabled/disabled state,
- data type (string, integer, double, date,...),
- length of data type (string) and range (integer, double),
- read-only,
- not-null,
- default value,
- regular expression constraints (allow only certain characters, define custom rules for special strings e.g. postal code),
- list-of-values constraints (values, as well as their colors and description can be read from the database),
- dependencies – constraints for individual fields can change according to values of other fields (e.g. comment should not be empty when selected parcel type is 'OTHER'; crop type can only be selected when the parcel type is arable land).

```
<Layers>
+ <Layer0 active="false" addr="192.168.2.123" color="ff00ff" dataset="DOF5-LAST" fromScale="1" group="Raster" hidden="false"
  name="DOF" noRedirect="false" on="true" port="12340" remote="true" snapon="false" toScale="500000000" type="WMS"
  whiteTransparent="false" tablename="RASTER_FILES" textExpression="<math>to\_char(datetime, 'MM YYYY')</math>">
+ <Layer1 name="DKN" on="true" color="ffffff" group="Shapes" type="SDO" table="DKN_SDO" keyColumn="featureid"
  geomColumn="geometry" maxScale="10000" active="false" remote="true" fromScale="1" toScale="500000000" hidden="false"
  snapon="false">
+ <Layer2 name="RABA" on="false" active="true" color="ffffff" group="Shapes" maxScale="50000" table="RABA_SDO"
  keyColumn="robo_pid" sequenceName="robo_seq" geomColumn="geometry" historyProcedure="robo_sdo2hist" editable="FALSE"
  type="LU" remote="true" fromScale="1" toScale="500000000" hidden="false" snapon="false">
+ <Layer3 dbPort="1521" table="GERK_SDO" keyColumn="GERK_PID" geomColumn="GEOMETRY" sequenceName="GERK_SDO_seq"
  historyProcedure="M" maxScale="15000" editable="true" name="GERK_SDO" on="true" color="ffcccc" type="GERK" remote="true"
  fromScale="1" toScale="500000000" hidden="false" snapon="false" active="true" group="RABA/GERK" table="GERK-INT"
+ <Layer4 name="GERK-INT" on="false" active="true" color="ff0000" group="Shapes" maxScale="50000" table="GERK-INT"
  keyColumn="GERK_PID" geomColumn="geometry" editable="FALSE" type="SDO" remote="true" fromScale="1" toScale="500000000"
  hidden="false" snapon="false">
+ <Layer5 name="TTN5" on="false" color="ffcccc" group="Shapes" path=".\\Karto\\TTN5\\tn5.shp" type="SHP" active="false"
  remote="true" fromScale="1" toScale="500000000" hidden="false" snapon="false">
+ <Layer6 name="KO" on="false" color="ffcc00" group="Shapes" path=".\\RPE\\KO.shp" type="SHP" active="false" remote="true"
  fromScale="1" toScale="500000000" hidden="false" snapon="false">
+ <Layer7 name="OB" on="false" color="ffaa00" group="Shapes" path=".\\RPE\\OB.shp" type="SHP" active="false" remote="true"
  fromScale="1" toScale="500000000" hidden="false" snapon="false">
+ <Layer8 name="UE" on="false" color="ffaa00" group="Shapes" path=".\\RPE\\UE.shp" type="SHP" active="false" remote="true"
  fromScale="1" toScale="500000000" hidden="false" snapon="false">
+ <Layer9 name="DR" on="false" color="ff0000" group="Shapes" path=".\\RPE\\DR.shp" type="SHP" active="false" remote="true"
  fromScale="1" toScale="500000000" hidden="false" snapon="false">
+ <Layer10 name="HMO" on="false" color="ff66ff" group="Shapes" path=".\\KatMesina\\slo_katmesina.shp" type="SHP" active="false"
  remote="true" fromScale="1" toScale="500000000" hidden="false" snapon="false">
+ <Layer11 name="XHMO" on="false" color="ff0000" group="Shapes" path=".\\KatMesina\\slo_evimes.shp" type="SHP" active="false"
  remote="true" fromScale="1" toScale="50000" hidden="false" snapon="false">
+ <Layer12 name="KMG" on="false" color="ff00ff" group="Shapes" type="KMG" table="KMG" keyColumn="KMG_MID"
  geomColumn="geometry" active="false" remote="true" fromScale="1" toScale="500000000" hidden="false" snapon="false">
</Layers>
```

Listing 1: Sample configuration of characteristics of a spatial feature

3.1.3 Querying Attribute and Graphical Data

Basic queries can be performed either by entering the ID of a parcel or by clicking inside the parcel on the map. In the first case the map display is repositioned and rescaled on MBR of the requested parcel, the parcel is highlighted and its attribute data are shown in a table view. In second case only highlighting is made and attribute data are shown. Beside that, a tool named QueryBrowser, which is integrated into the thick client application, can be used for definition and execution of queries. Results are displayed in a table and highlighted on the map (Figure 8)



Figure 9: Storage and execution of pre-defined queries

User can save or restore a query or can use queries managed by the system administrator. Automatic queries can also be defined (e.g. when a farmer is chosen then all parcels owned by him are highlighted (Figure 9).

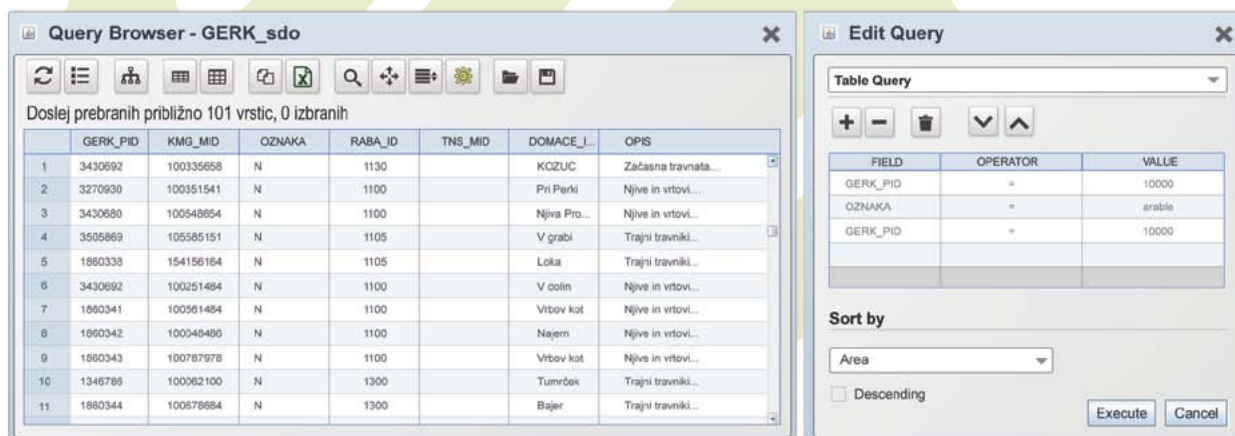


Figure 8: Query results (left) and query definition dialog (right):

3.1.4 Additional spatial data

LPIS layer and orthophoto are not the only spatial datasets supported by the application; additional datasets are used for reference, snapping and classifications, and they can be retrieved from different data sources. The following are examples of such datasets:

- Digital land registry (Cadastral);
- Land use layer;
- LFA areas;
- National/regional parks, Nature 2000 sites;
- National boundaries;
- Administrative boundaries;
- Registry of irrigation.

Visibility of individual layers can be controlled by the administrator and it is stored in each user's configuration. Layers can be stored in an Oracle SDO table or in a Shapefile, which can be located either on the central server or the local file storage. In both cases the user can manipulate the layer's rendering properties or query its attribute data.

3.1.5 Recording of Historical Data

Journaling and auditing is treated to highest possible level of importance. For each change in the dataset additional data are recorder (user id, timestamp, reference to the process through which the change was made - e.g. was it on farmer's request or based on inspections results). Full featured history management support:

- Getting a list of changes for specific field both as a list or as a graphical representation of each change.
- Setting a past date on specific layer and previewing that layer as it was valid on that date on-the-fly. This is available both for vector and raster layers (even in case of mosaic-built layers such as aerial imagery with many updates at different locations).

The system can:

- Allow for historical parcel boundary data to be maintained indefinitely.
- Allow for the production of a complete audit trail for changes to attribute data and land parcel boundaries.

Depending on the user's needs we have a few options here. The default option is to audit every transaction and to keep history on every update on geometries. For this we use two separate Oracle tables. Audit table has a fixed structure like who, what, when while history table has to have the same structure as original table plus a column for storing date when the geometry went to history. All those dates are managed by transactions i.e. when user change a border between two (or more) polygons they are all moved into history with the same date. From such history table every step can be traced back, but in environments where many updates are expected, that table can grow very fast. In that case a different backup option could be used or the table could be cleaned after some time period.

In cases when intermediate steps are not important the scenario with history updates at the end could be used. In that scenario the application just ignores history records and fills in the history info when the user finishes.

Rezultati pretraživanja za sloj ARKOD	
Column	Value
SHOW_HISTORY	Pokaži povijest
ID	189185
FARM_ID	127283
LAND_USE_ID	200
TITLE	
SHORT_DESCRIPTION	Oranica
LAND_USE_ID_2	0
HOME_NAME	RAMEŽ
NOTE_INSERT	111 z
NOTE_FARMER	na čestici je vidljiva sjena od šume
NOTE_ORGANISATION	
COUNTRY	
AREA	9263.06323242188
REFERENCE_ID	9263.06323242188

Figure 10 - option to show history within a feature info

Povijest za 189185 (ARKOD)							
ID	FARM_ID	LAND_USE	HOME_NAME	NOTE_INSE	NOTE_FAR	NOTE_ORG	COUNTY
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
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189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		
189185	127283	200	RAMEŽ	111 z	na čestici je...		

Figure 11 - list of all changes on specific parcel



Figure 12 - comparison of history data

▶ 3.1.6 Automatic Attribution of Classifications

The client application can allow for various land parcel classifications to be attributed automatically at the point of digitizing or boundary amendment, i.e. Less Favoured areas. These can be calculated against existing geographical layers for such areas.

To solve this in the configuration of a layer we have so called "*AutomaticFields*". Their purpose is to define a field value based on some rules. The rules can include the following:

- simple, like a constant;
- well known, like user_id, sysdate;
- based on geometry like area or
- complex, like ID of another layer.

If rule is very complex then we can add a specific java code snippet to resolve it.

In the above example of Less Favored Areas we can use an automatic field for determination, but this probably isn't enough, since we must use the parcel centroid to do the check. However, that check gives correct results only in cases when the whole parcel is completely inside or outside an LFA polygon. Although most cases can probably satisfy this condition, it would be more suitable to calculate an exact intersection and to tell how much area (or relative area / percentage) of a parcel is in which LFA polygon. This procedure is being used at Slovenian MAFF on the fly with LFA and 4 other layers.

There is also another possibility, for example to put a parcel in one or other class if more than 80% of the parcel area meets a condition. We do that to define the country for a newly entered parcel (Near the border citizens have parcels in e.g. Austria).

▶ 3.1.7 Unique Identification of Land Parcels

The system can allow unique identification of individual land parcels by means of an Oracle sequence for that. The sequence name is written in the LPIS layer's configuration and it is used whenever a new parcel is going to be inserted.

In case there are special requirements for identification of Land Parcels (e.g. if a parcel's ID is determined from the location of its centroid), the identification numbers can be calculated using the procedure for automatic classifications.

▶ 3.1.8 Statistical Analysis and Thematic Mapping

Since parcels are stored in an Oracle table, executing statistical queries on geometries is possible by using simple SQL queries. Our application can use styling properties (i.e. shading colour) directly from database so thematic mapping is very simple to achieve. At Slovenian MAFF for example, LPIS parcels are always coloured according to their class (i.e. vineyards are yellow, meadows are green...).

This is achieved by configuring the layer to use a view, which is a join of parcels table and a classification table. The colour of individual classes is written in the database and retrieved together with the graphical parcel data for rendering. The settings can be controlled using standard layer properties dialog (Figure 13) or Config Manager application.

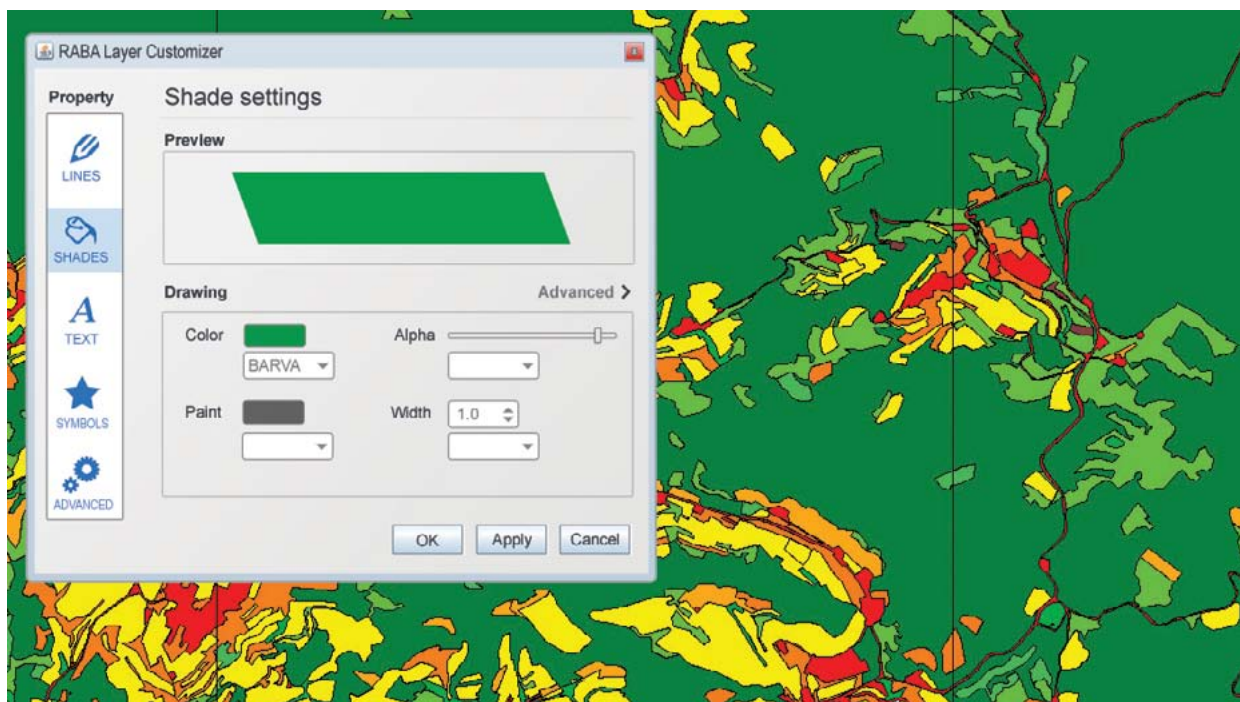


Figure 13: Example of thematic mapping: The shading color of the polygon is determined by using the "BARVA" field in the database, selected from a drop-down list in the dialog box.

▶ 3.1.9 Import and Export

The system can allow for the Import and Export data of spatial and associated attribute data from other systems. We have a robust and quick tool for import/export of ESRI shapefiles. For export, user can define a set of SQL query/file name pairs. For import, the user defines a path of the shape file and Oracle table name to which the data can be inserted.

▶ 3.1.10 Secure Internet Access to Claimants

The web GIS application can be fully integrated into the IACS web application, when necessary, allowing secure Internet access to all the claimant-related data using a single point of entry. Links to LPIS spatial data can thus be available from all the appropriate claimant modules, such as Farmer Registration, Animal Registration, etc.

▶ 3.1.11 Identification of Doubly-declared Areas

If we configure the parcel layer to be a clear topological layer, then it is impossible to draw a parcel over existing one. (Topological checks on the client application cannot allow that and also checks upon commit can reject transaction in that case).

But there are some situations where you have to enter overlaps. In MAFF that was also the case. To achieve this we added a button, which enables user to temporary disable topological checks and to draw an overlap. In parallel we added a layer, which explicitly shows those overlaps.

This layer fetches its data from a separate table which is a result of intersecting parcel table with itself. This intersection is done by our set of functions for administrators, scheduled for execution once a week.

► 3.1.12 Additional Features

If elevation data (Digital Elevation Model or Digital Terrain Model) is available, it can be used to display 3D view of the inspected area with overlaid land parcels. This view helps identify areas and boundaries that are not clearly visible in the 2D orthophoto images (Figure 14).

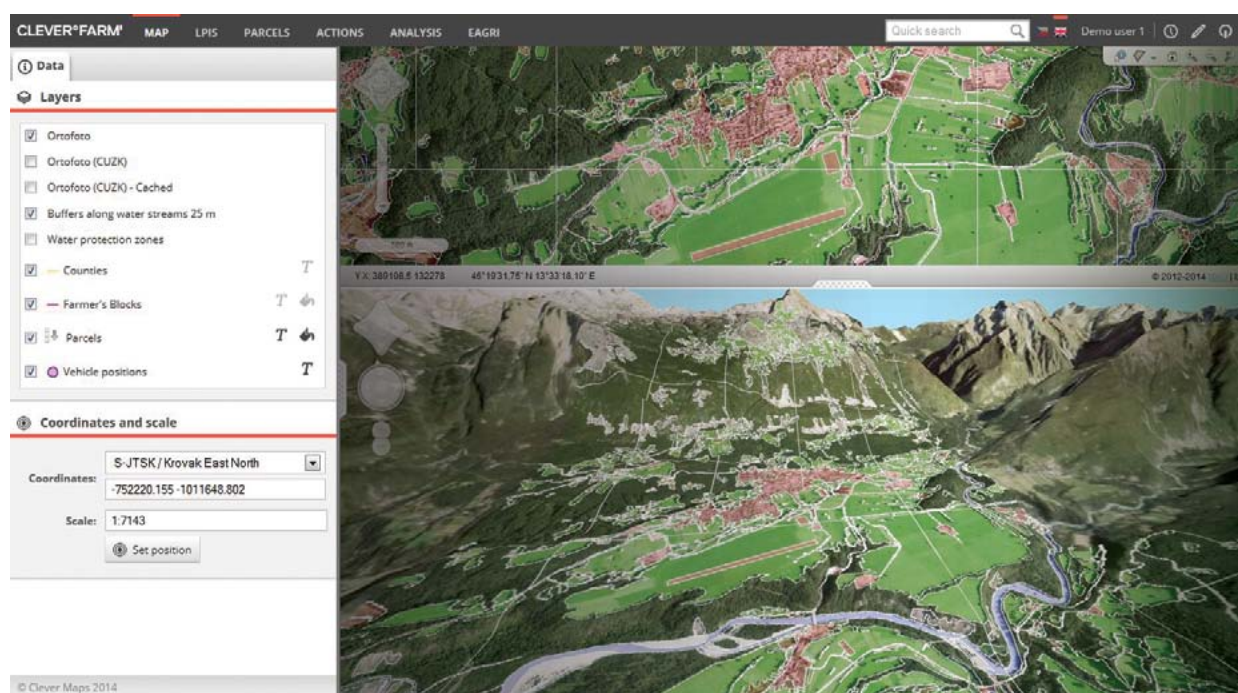


Figure 14: 3D view synchronized with the map display

3.2 Large-scale Batch Output of Maps

Paper maps are one of the essential elements of LPIS for communication with farmers, field inspections etc.

Within our system we are using three ways of communicating the spatial data:

- Printing single map (by generating PDF) using different templates (from any of the above mentioned applications).
- Mass generation of maps in PDF format for further printing.
- "Publishing" of the results in the form of GIS viewer. This form is becoming more and more

used. For each of the end-users we generate one-time username and password and send these via e-mail along with the address of the application. User then logs into the application, where the data are displayed to full details, but limited to only those fields which are related to this specific user.

Preparing thematic maps

Entering KMG_MID s

In the box below, enter code KMG_MID s.
Each KMG_MID enter into a new line without punctuation.

Create PDF

Selection of quality

Maximum

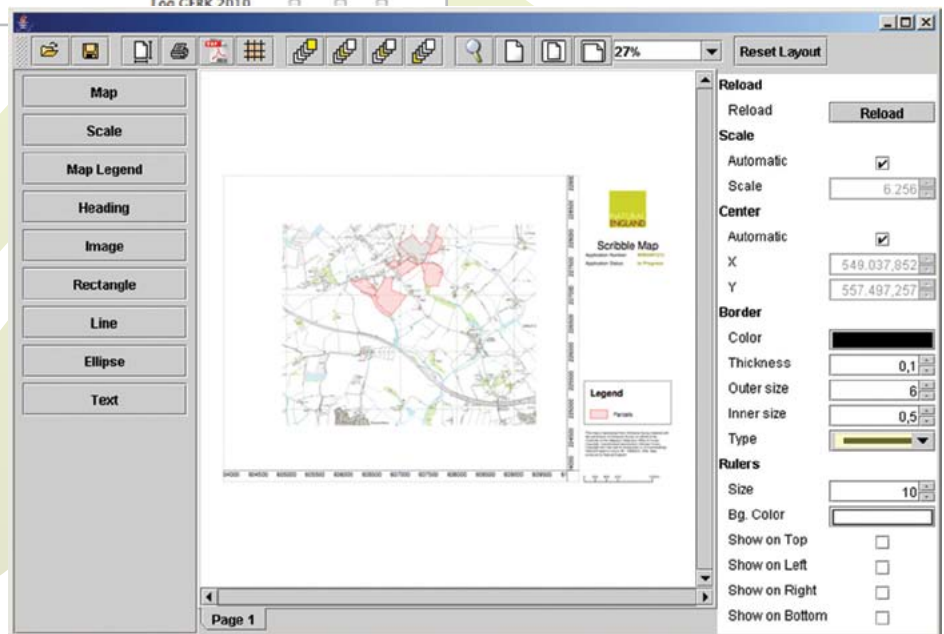
The selection of layers

Select the layer that will be displayed on a thematic map

Layer	Include Text Shade	
Orthophoto 2006	<input type="checkbox"/>	<input type="checkbox"/>
Orthophoto 2009	<input type="checkbox"/>	<input type="checkbox"/>
Orthophoto 2010	<input type="checkbox"/>	<input type="checkbox"/>
Ortho-united	<input type="checkbox"/>	<input type="checkbox"/>
CERK_MKGP	<input type="checkbox"/>	<input type="checkbox"/>
Cadastre (DKN)	<input type="checkbox"/>	<input type="checkbox"/>
Nature	<input type="checkbox"/>	<input type="checkbox"/>
VVO_1_10	<input type="checkbox"/>	<input type="checkbox"/>
VVO_10	<input type="checkbox"/>	<input type="checkbox"/>
USE	<input type="checkbox"/>	<input type="checkbox"/>
For CERK 2010	<input type="checkbox"/>	<input type="checkbox"/>

Figure 15 - the application for mass creation of maps

Figure 16: Print Template Editor enables the possibility to design the print-out, setting the position of the maps, their scales, legend, title, add corporate branding etc.



The printed documents can contain both attribute forms and land parcel maps. The page sizes within a single document can be changed, so that attribute forms are printed on A4 paper and land parcel maps on A3 paper. The parcels, contained within a selected farm are automatically laid out in a way that minimizes paper use and ensures optimal scale of the maps.

An index map can be printed first, which shows the extents of individual map pages. Layout of a single page can be customized using a powerful page layout editor.

Apart from the batch printing process, which can be executed using the generic application for running advanced scripts, it can be possible to print an application form on-line from a plain HTML viewer upon request. After entering a farmer ID (or logging into the web application with appropriate credentials), the user can generate a PDF containing a set of maps using a predefined template. First map is an overview map and others are optimized based on scale and parcel boundaries. The map generation after the pre-print is important in cases when changes were made after receiving pre-prints.

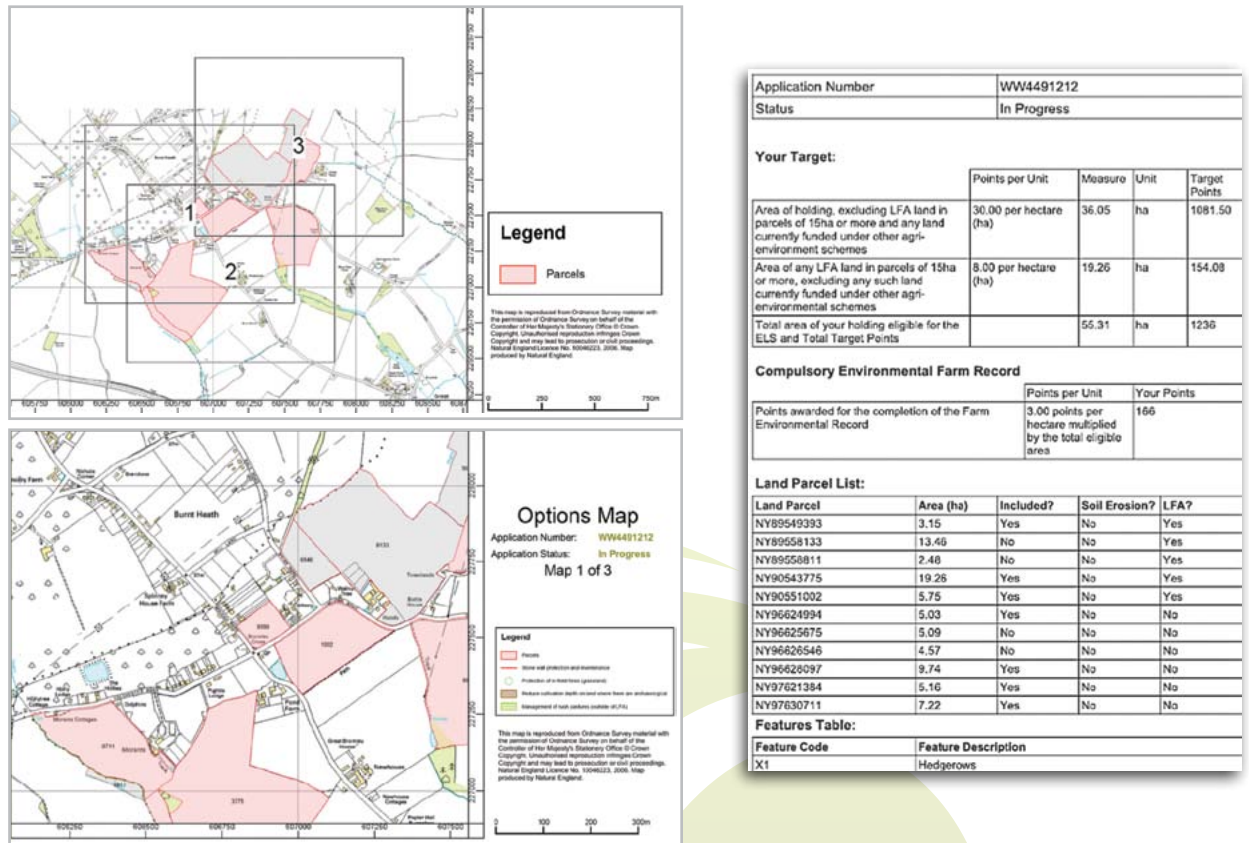


Figure 17: Printout or PDF file contains both attribute and spatial data (first there is an index print displaying the location of the maps drawn on further documents). The spatial data are printed on A3 size papers and attribute data on A4.

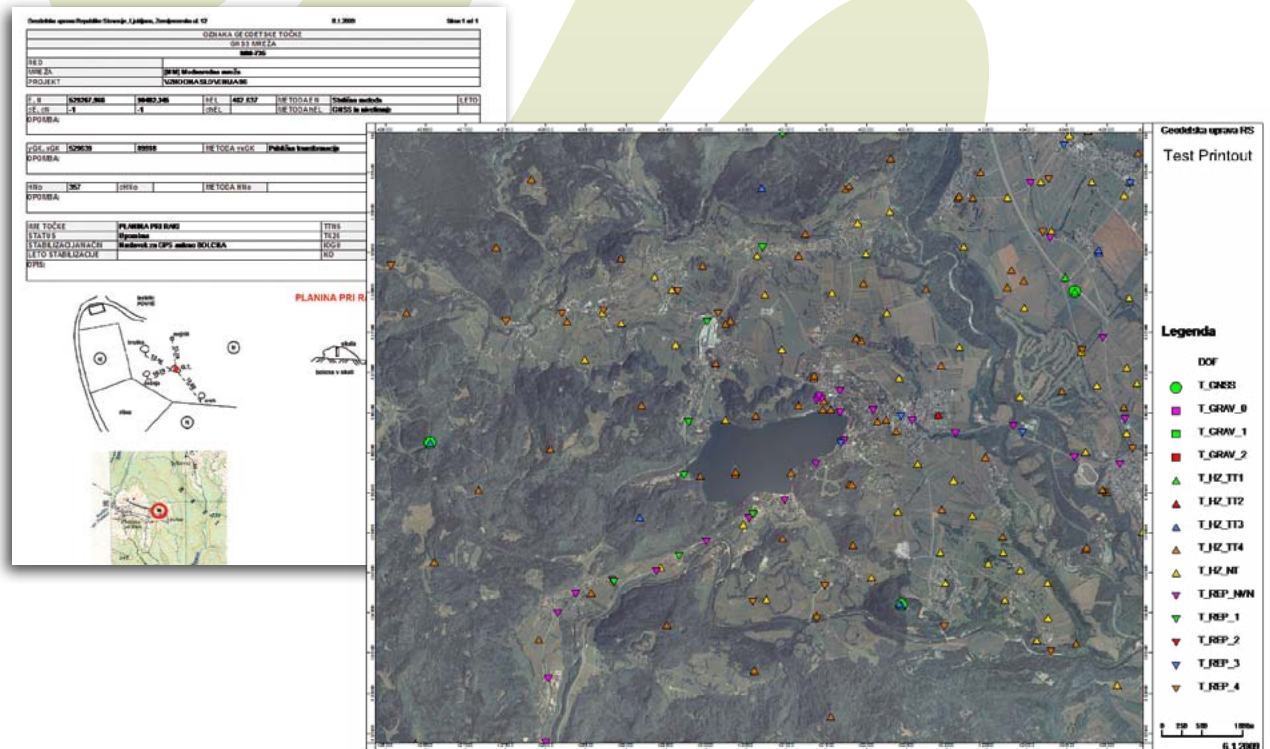


Figure 18: Showcase of printout or PDF file contains attribute data with detailed position of an object observed, and overview map of specific area with geodetic points (The Surveying and Mapping Authority)

3.3 HTML web GIS

The HTML web GIS application can provide secure internet access to the claimants to view restricted data related to their claim. The web portal can display the graphical layout of the claimed parcels along with a tabular display of the associated attribute data. There can also be a possibility to print an overview sheet for a selected parcel or to download a PDF document with a complete application form for the claimant.

The web application connects to the core LPIS application server and displays live data directly from the database. It allows navigation, simple querying, layer manipulation, distance and area measurements and simple editing (all configurable).

The technology behind the GIS viewer is AJAX, which enables advanced functionality within a web browser and requires no additional software or plug-in installation.

Functions include:

- Basic GIS functions
 - ✓ Zoom in/out, pan left/right/up/down, previous view.
 - ✓ Zoom to window, pan with mouse.
 - ✓ Dynamic zoom (adjust the scale by moving the mouse).
 - ✓ Set scale / location by textual entry (or copy-paste).
 - ✓ Turn layer display on/off.
 - ✓ Toggle text display on layers.
 - ✓ Change layer colors.
 - ✓ Area and distance measurement.
- Search and query
 - ✓ Gazetteer.
 - ✓ Find reference parcels by farm id.
 - ✓ Query layer by clicking on the map.
 - ✓ Query features by their attributes, display results on the map.
 - ✓ Query user-entered area (point, line or polygon) with one or many spatial layers.
 - ✓ Display pre-defined reports from the database, linked to the map view.
- Print
 - ✓ Print of the current map view.
 - ✓ Generation of PDF file of selected areas for download.
- Other
 - ✓ Corporate branding.
 - ✓ Help.

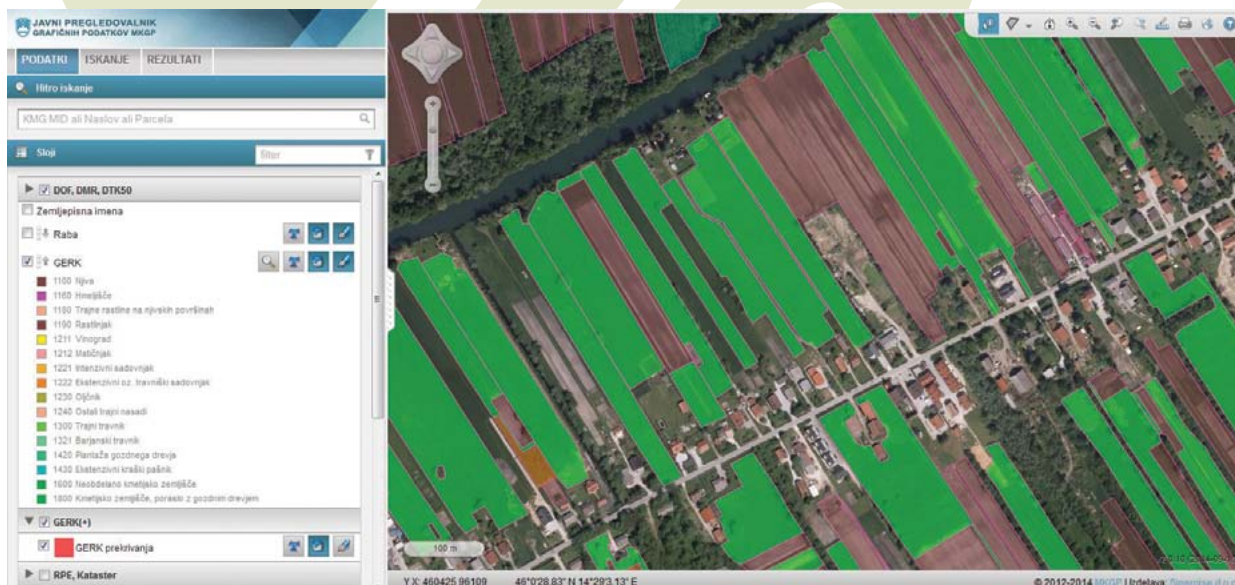


Figure 19: Example web GIS browser, showing land parcels coloured according to their land use

3.4 Validation of data on many points

▶ 3.4.1 On-the-fly topology validation

Topology errors usually originate either from cloning of the original input data or in the digitization process - the software not being optimized for full topology checking and editing. They may not indicate problems related to distribution of funds but they can cause significant problems in any kind of spatial processing of these data (e.g. double counting or overlaps, intersections etc). Additionally, they might indicate some digitization related problems, e.g. lack of accuracy. There is often strong correlation between careless editing and technical (e.g. topology) errors. That is why it is essential to identify and correct them.

Once the data are clean of topological anomalies, it is important to maintain that integrity:

- Before inserting any kind of external spatial data, which is directly or indirectly related to the business processes, we have to perform topology validation and reject/fix the dataset if problems are found.
- LPIS digitization tools perform on-the-fly validation before committing the entry in the database. If problems are found, the user is warned to update it. This is an additional alert/prompt to the user, that his editing must pass a minimum acceptable standard, and that careless editing will not be permitted

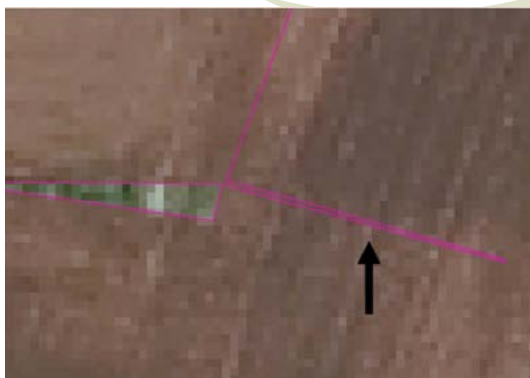


Figure 19 - an example of a spike, lying in a neighborhood LPIS

There are two types of topological errors, which are critical in terms of downstream quality and processing - duplicated features and overlaps - which can directly influence on the wrongly-calculated subsidies. Therefore we have to be especially careful about those.

Additional to topology, the validation should also focus on the consistency of the alpha-numerical attribute data associated to LPIS parcels (e.g. land-use, area, etc.).

▶ 3.4.2 Cross-checking with other spatial layers

Independently acquired and updated land cover layer is being used in several countries to perform regular updates. Being based on aerial imagery, it helps us to perform a "content-related" analysis of the LPIS data. Instead of cross-checking with ortho-photo (manual process as the automatic image recognition does not bring satisfactory results yet), we use vector-based representation of it - land cover. There are two common problems, which can be easily identified by intersection of LPIS and land-cover layers:

- Illegible areas within the parcels - e.g. build-up areas, roads.
- Change of borders due to reforestation or similar processes.



Figure 20 - process for resolving LPIS/land cover inconsistencies. The user can decide whether to update the LPIS or declare wrong land cover

We also we implemented cross-checking before any insertion or update of LPIS data. The user cannot by any means change the LPIS not to fit the land cover.

▶ 3.4.3 Visual Control

EC legislation requires 100 % administrative controls to be done. Since aerial imagery is used as one of the basic controls of IACS it should be regularly updated (at least every 5 years, recommended every 3 years). And after every update we have to check if reference parcels do fit aerial imagery. If we do not have intermediate layer (such as land cover, as described in the previous section), we have check every parcel visually. This is not so easy as it sounds due to vast number of parcels, usually in several 100.000.

▶ 3.4.4 Visual control on aerial imagery update

By observing this task (we wanted to optimize the process as every second counts with such numbers) we identified two important things:

- Most of the parcels are OK and no change is required.
- Wherever a change is noticed, it is best to update it straight away.

The system was designed in a way to present the editor (support centre staff) with a number of tasks, each task being one parcel, all residing on a nearby area (so that the imagery features are common). Editor is presented with a parcel and has to decide whether any change is needed and whether the change is minor or major. If minor, the editor can open the LPIS application and update it. In case of major problems the parcel is marked and the farm is scheduled for a meeting with farmer to resolve the inconsistency.

Application for visual control has been developed for quick and efficient change control of LPIS parcels. Changes are related either to remarks from a farm holder (LPIS Update) or to change of reference spatial layers - orthophoto or similar.

System was designed to support most efficient work of the operators. One can use two synchronized map screens, each displaying different spatial layers. In that way the changes are as clear as possible. Process is based on task lists - the operator moves from one task to another, focusing on one parcel at a time and deciding whether to approve the parcel or not.

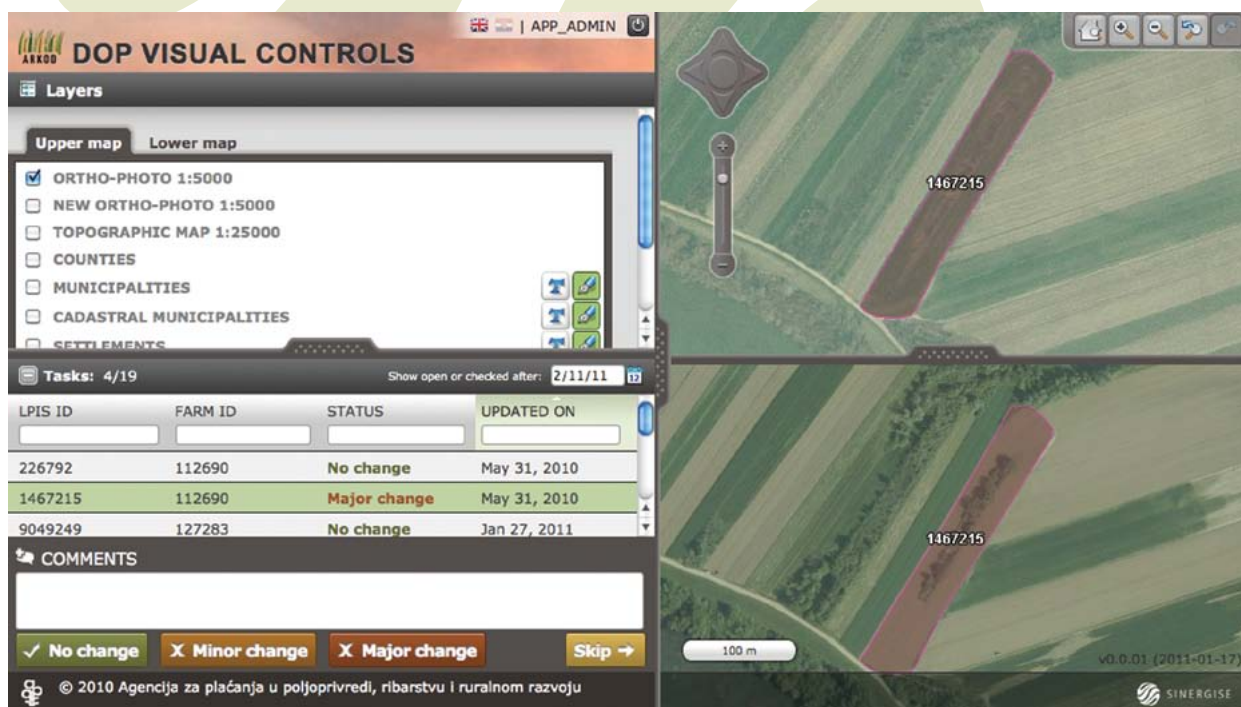


Figure 21 - Visual control application shows the parcel in two synchronized windows. By being able to see both old aerial imagery (above) and the new one (below) the editor can easily differentiate changed features from acquisition changes effects

3.4.5 4-eyes check

A large number of users demands some level of control over their work. Even though they go through the same trainings and they have the same work assignments, some simply work better than others. Since it is agency's responsibility to ensure the proper quality of work, they have to double-check some part of the work. Most common problems noticed are:

- Inaccurate digitization of the borders (for this we do recommend to mark border points every few meters, not only on the corners of the parcel).
- Improper use of supportive layers - e.g. as the farmers are more used to cadastral parcels than LPIS polygons they insist on using that layer for digitization even though it is not in line with aerial imagery (shift problems or similar). In Slovenia this problem was solved through time by modifying software to turn-off cadastre layer while editing. It was only visible before the editing.
- Improper interpretation of land cover.



Figure 22 - inaccurate digitization, probably due to too small scale. After noticing these problems the software was modified to not allow editing under specific scale levels.

The system designed to perform 4-eyes control was build on before mentioned Visual control as the functionality is very similar.



3.5 LPIS Update

There are several processes related to LPIS update, which can be generalized to the following workflow:

- Importing the data from external source.
- Topology and content validation of imported data (we should not allow erroneous data to be imported, if these data are used further on in the business process).
- Processing of data and comparison with LPIS data, creation of tasks where inconsistencies are found.
- Distributing tasks to editors (based on location of changes or similar).
- Manual processing of task by editors.
- Finishing the tasks.

3.5.1 Update based on field inspection's results (OTS/CWRS)

We have designed two processes, which separate itself on the pre-processing of input data:

- If the results of the inspection do relate only to one specific parcel (and not to the neighboring parcels), the update can be completely automatic in almost all cases (based on our experience about 95%) - the ineligible areas are excluded, parcels might be split in several parts or similar.
- In case the findings may affect also the neighboring parcels, the process is semi-automatic:
 - ✓ Spatial intersection between the declared parcel and the inspector's findings. The resulting polygons represent areas, which are OK (both declared and determined), illegible areas and newly found areas.
 - ✓ Small and elongated polygons are processed automatically. These are usually the result of GPS error and are neither removed nor added.
 - ✓ The user then goes through all areas and decides whether to update it or not. This is done by simply ticking a box as shown in the picture.
 - ✓ If needed, the user does some manual spatial editing.

Figure 23- the brown area represents the OK area. Green - newly found area and will be added. Red - illegible area will be excluded. The orange one is newly found area, which overlaps with the neighboring parcel.

3.6 Quality Assurance - Executive Test Suite

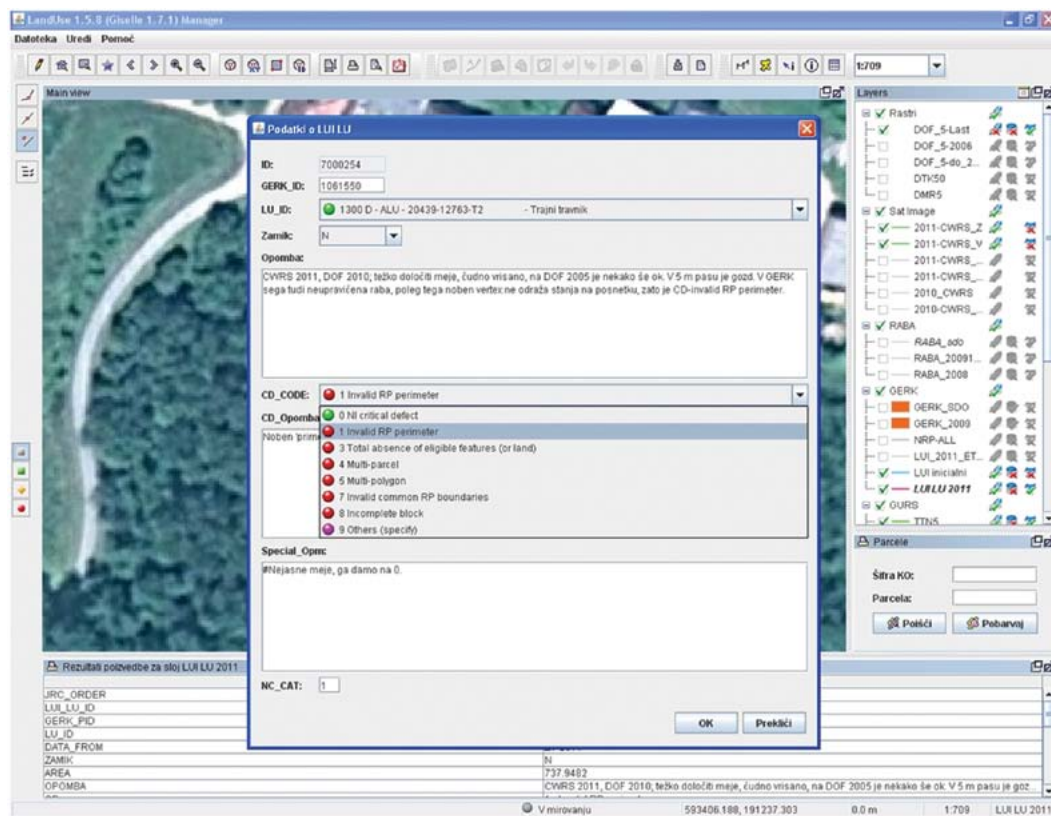


Figure 24 - digitization module, conformity results are entered after digitization

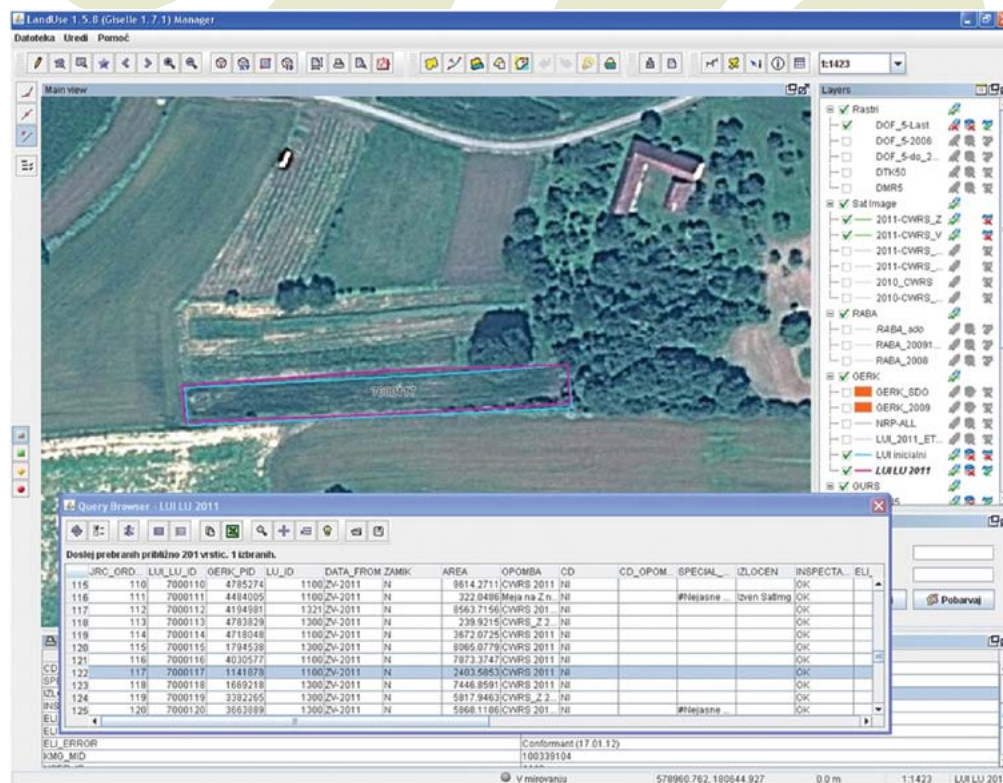


Figure 25 - immediate calculation of the determined area supports users to create non-conformant results due to minor differences (e.g. one pixel difference)

3.7 External spatial dataset management

We see external spatial datasets not as generic spatial layers but as a part of the business process of the LPIS refresh. That is why the tool was designed for import, integrated with TopoCheck, metadata entry and export facility.

3.8 Training facilities

Due to the complexity of the process and importance of the quality of work the training options do have to be well established. It is not sufficient to simply create a copy of the system and let the users to play.

Some non-standard features we found useful:

- Option to multiply data schema of most relevant tables (e.g. LPIS parcels, landscape features). This is important for organized trainings where a group of 10-20 end-users do have to work on exactly the same fields - we should prevent that the work of one user affects the work of the other.
- Automatic nightly cleanups of the training tables, so that we can repeat the trainings over and over.

EXTERNAL SPATIAL DATA MANAGEMENT

Layers

Create

DETAILS	NAME	DESCRIPTION	DATE OF INSERT	START DATE OF VALIDITY	END DATE OF VALIDITY	LAYER TYPE	GEOMETRY	DATE OF UPLOAD	IMPORT	EXPORT	DELETE
	bla	asdf	11.06.2012	12.06.2012	27.06.2012	Vector	Line				
	GERK	Test GERK	11.06.2012	11.06.2012	11.06.2013	Vector	Polygon				
	test_big	BIG test	24.07.2012	01.07.2012	31.07.2013	Vector	Polygon	25.07.2012			
	test_big2	BIG test 2	25.07.2012	01.07.2012	31.07.2013	Vector	Polygon				
	test1	test1	15.06.2012	12.06.2012	21.06.2013	Vector	Polygon	15.06.2012			

Items 1-5

LAYER DETAILS

NAME: GERK

DESCRIPTION: Test GERK

DATE OF INSERT: 11.06.2012

START DATE OF VALIDITY: 11.06.2012

END DATE OF VALIDITY: 11.06.2013

X_MIN: 0

Y_MIN: 0

X_MAX: 0

Y_MAX: 0

LAYER TYPE: Vector

GEOMETRY: Polygon

D_UPLOAD:

DBSCHEMA: SKZG.dbo

TABLE: GERK

DIRECTORY:

BATCH_COLUMN_NAME:

Editing layer Close

Figure 26 - tool for managing imports and exports of data

3.9 Monitoring tools

As the process of managing LPIS data is highly complex and work intensive, it is essential to reduce any software and hardware issues to the minimum. The system should be operational 24/7.

That is why we developed advance monitoring tools - they support the discovery of errors in the infrastructure when they occur.

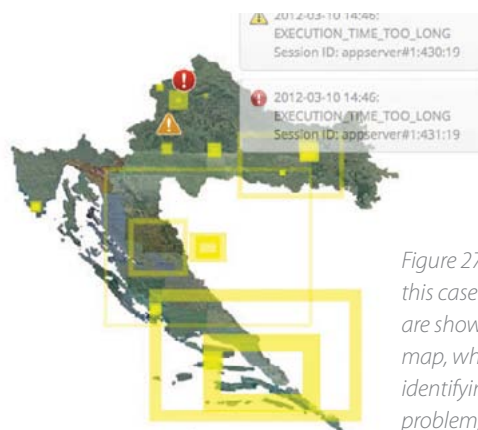


Figure 27 - Errors (in this case timeout) are shown on the map, which helps identifying the problem, usually resulting from network problems

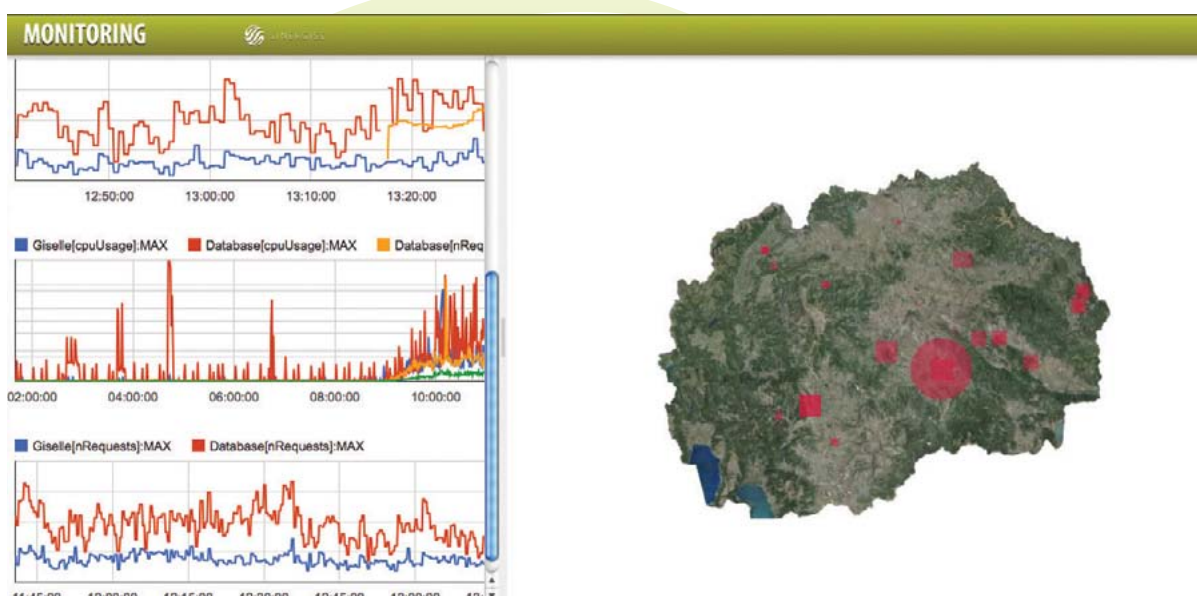


Figure 28 - map is displaying the locations where LPIS updates are happening at this moment (in last 5 seconds). The charts do display the state of the system

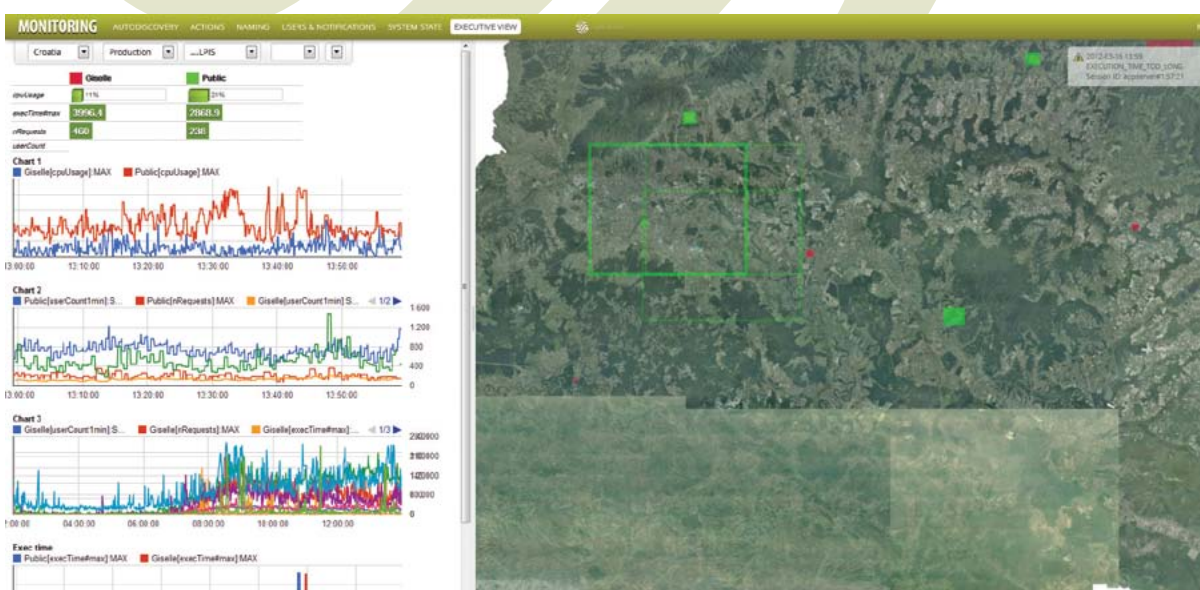


Figure 29 - displaying details of one event in Croatia

3.10 Server Administration tool

For more efficient work of Support center, we have developed a Server administration tool, which supports administrators to track user activity in real-time - observing actual movements and edits. This is especially useful when monitoring newly trained users in production and when trying to resolve some specific end-user's problem. One mode of operation of this module is in a "conference editing" mode, where both users (end-user and support staff) do share the application and both of them can do actions (and see other's actions). In that way Support center staff can efficiently identify the problem or solve some complex spatial task.

Some of the parameters of the system and individual servers, that can be monitored using this tool, are:

- database performance,
- CPU consumption,
- memory consumption,
- network utilization,
- end client throughput.

The administrators or support center staff can also monitor activity of individual users, enabling them to:

- resolve ambiguities in the process using information about the user's current activity,
- help users with cases of complex or difficult topologies of the parcels; According to a survey conducted by Slovenian MAFF, this was the most popular feature of the Giselle LPIS solution (according to both – users and the support center staff) as it enabled very efficient problem resolution.

It enables the following actions on the distributed image servers:

- load/manipulate images,
- monitor distributed servers,
- manage cached data on distributed servers,
- schedule updates for data in local offices.

Figure 30: Administrator client enables the possibility to monitor users and servers, change settings and configurations of specific users, take-over user's sessions and assist them with problems



3.11 Migration Tools

Migration tools can be developed to enable transfer of the data stored in ESRI Shapefile format or other file-based formats into the central relational database. Features of these tools include:

- batch import of ESRI Shapefiles into the database,
- advanced topological checking,
- resolution of topological errors (in agreement with the administration and in accordance with regulations),
- advanced attribute data checking.

The validation and clean-up can be performed using custom scripts and can be monitored using a special application.

3.12 Advanced tools for various GIS tasks

Data preparation, data cleaning and analysis of very large data sets can be a time consuming process. Our grid processing capabilities make such operations faster by distributing the tasks to many computers. The programmer writing such scripts does not need to be aware of such run-time environment.

A special application is available for running these automatic scripts, scheduling their execution and monitoring their progress (Figure 31).

Scripts that are used for IACS, include:

- Import of the initially captured data;
- Data integration and clean-up procedures;
- Large-scale creation of pre-printed application forms;
- Automatic creation of intersections of different datasets;
- Large-scale advanced validation and error correction of the spatial features and topology.

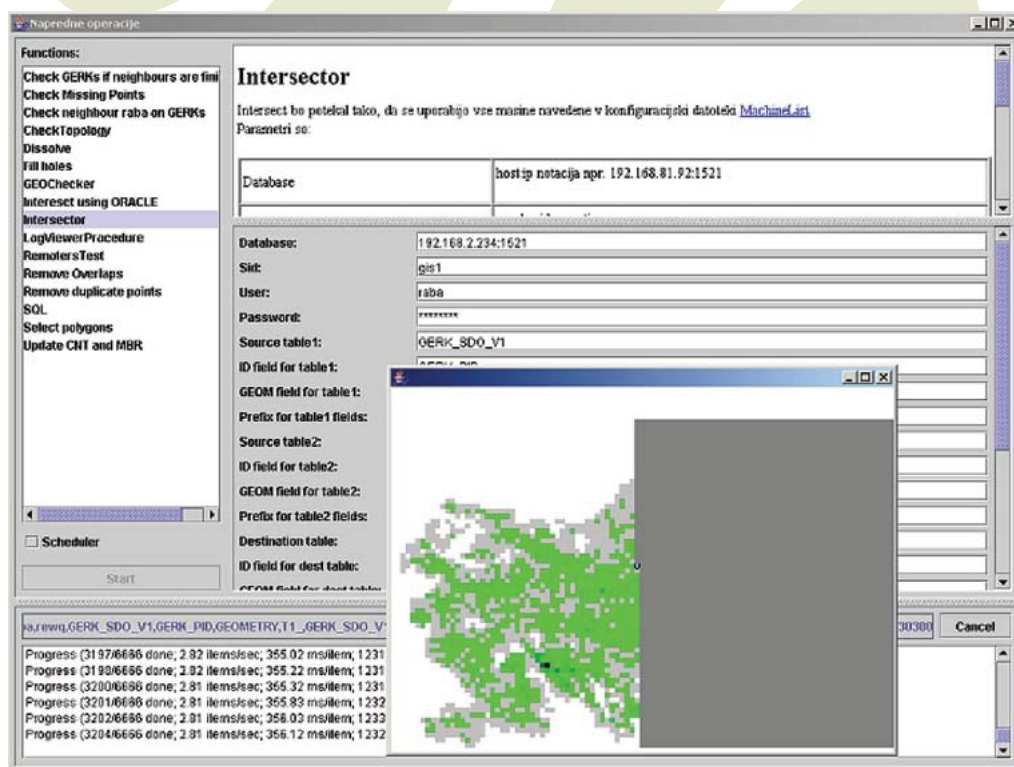


Figure 31: Application for running lengthy procedures, showing progress and status of the procedure

3.13 Geo Toolkit – Data Quality Tools

In order to assess topological and content-wise quality of current LPIS data we should perform spatial analysis. We developed TopoCheck (www.topocheck.com) for this purpose. If some errors were found, they would have to be resolved using above mentioned tools (“Visual Control”, “Field editor”).



Figure 32 - TopoCheck - setting spatial analysis thresholds

The following can be done:

- Quality analysis of the currently available data in the LPIS system (to the moment of start of contract).
- Report about found data inconsistencies and a list of proposed actions (e.g. additional warnings to users, prevention of some combination of actions etc.).
- Implementation of agreed actions.
- Automatic update of found past inconsistencies according to the agreed rules (where automatic update is possible).

We can use the tool also to do cross-checks with other related spatial layers, if available.

Another possible use of TopoCheck is to calculate “uncertainty” of the polygon area due to non-quality-based reasons (e.g. long narrow parcels etc.). These calculations may show useful when trying to find arguments for ETS results (which are in most member states worse than expected based on thresholds).

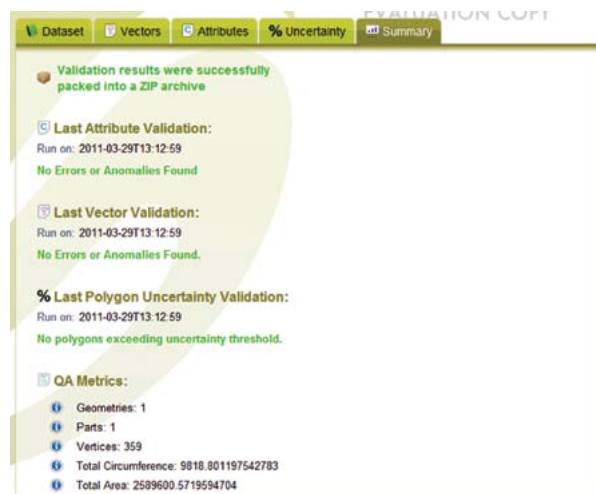


Figure 33- TopoCheck - executive summary of the results

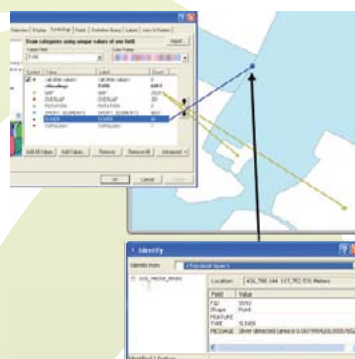


Figure 34 - spatial representation of errors in SHP file

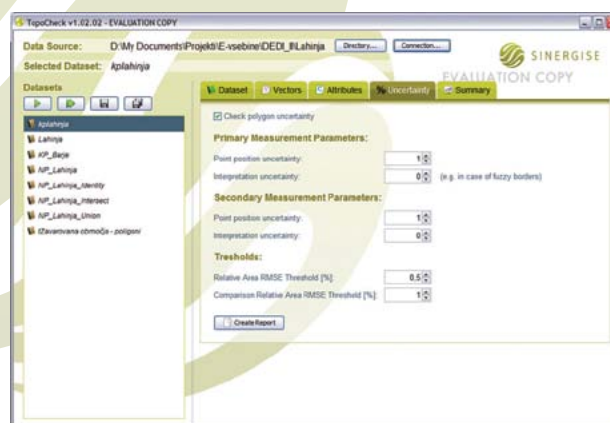


Figure 35 - uncertainty calculation

4 ARCHITECTURE

Giselle LPIS is a three tiered system. The RDBMS tier is Oracle Spatial. It consists of a set of tables, views, sequences, functions, triggers, etc., for managing spatial data, history of changes, auditing, statistics, advanced GIS operations (poly A - poly B), etc.

The middle tier is a clustered set of PCs running business logic. This tier also hosts an Image server and a set of server applications, like Intersector (finds double declared areas), import-export procedures (import captured physical blocks), pre-printed map generator etc.

Two clients acting as the presentation tier are available: Thin client (HTML) and thick client (JAVA). Thin client is used for general view of data and can be accessed by any farmer (or the general public). It is also used for producing simple geographical views for other modules of the IACS, e.g. 'show the picture of the parcel with ID on top of orthophoto image' for the On-the-spot Checks module or 'show the position of the farm with ID (based on address)' for the Farm Registry System.

Thick client is used for editing like digitalization of a new parcel, boundary change etc., which is usually coupled with some kind of wizard for the procedure (like choose a farmer ID, show other data, print session report, etc.). These procedures usually require a rich set of functions and a responsive user interface; a thick client is the most suitable architecture for this purpose. Both thin and thick clients are launched as web modules in line with single sign-on principle of the main application.

4.1 Internet Technologies

The solution is completely internet based; all user functions are accessible from an internet browser.

There is no need for software installation and upgrades on client computers, which makes the system very easy to manage and available from

anywhere, anytime and on all commonly used operating systems. The GIS editor for Giselle LPIS can run either inside the browser or can be deployed as a client / server desktop application, the choice is left to the convenience of the user (or the system administrator), thanks to the system's flexible configuration.

A network launch protocol is used to automatically apply new versions or patches to all users, thus making maintenance an effortless process.

4.2 Oracle Spatial Database

Oracle spatial database is a proven, reliable and scalable RDBMS with built-in spatial support, which provides open access to the data, therefore it was chosen to be the foundation for the system. Other business functions can access spatial data without any custom software, just as any other attribute data. There is no lock-in for the users.

Additional arguments to use Oracle spatial are:

- Editing and viewing of spatial data are seamlessly integrated with the non-spatial part of the business application.
- Many off-the-shelf tools and open APIs exist to access and manipulate the data using common development languages such as Java or C++.
- Spatial data resides inside the database itself, so there is no need for awkward linking between spatial and non-spatial data. In addition, standard database tools such as report generators, various designers or CASE tools can be used with the spatial data.
- Built-in validation of spatial data.
- The spatial data can be managed with a generic SQL tool.

Giselle LPIS system can easily be adapted to use any other spatial data source, such as ESRI shapefiles, ESRI ArcSDE database extensions, MySQL spatial, Web Feature Server etc.

4.3 Distributed Deployment

The system is distributed, which allows deployment in various environments. The software's modular design allows arbitrary division of storage space and processing power between different computers located either at a central location or dispersed among regional offices.

The following benefits of the distributed approach can be identified:

- scalability: more computers can be added to the cluster to increase performance.
- failover: failed computers are automatically excluded from the operation; the remaining computers handle the extra load.
- cost-efficiency: normal computers can be used for the server environment; they can be utilized as ordinary client machines when the load on the server cluster is low.
- high throughput: the distributed environment efficiently utilizes network resources in the production environment; cached data on the server reduces load on the database, allowing for higher throughput of the system.

- ✓ Two modes of operation.
- ✓ Stateless: Used for thin clients (HTML) who don't need editing.
- ✓ Stateful: Used in full-featured GIS client application.
- configuration storage module
 - ✓ Customizable definition of data locations (databases, image servers, disk storages).
 - ✓ Configuration storage for different users / clients (administration, controller, claimant).
 - ✓ Storage of pre-defined queries (list of land parcels with topological errors, doubly declared parcels, parcels for a single administrative unit).

4.4.1 Distribution of Orthophotography

The requirements for efficient distribution of orthophotography are ideally solved with the Sinergise Image Server, which has been developed as part of the Giselle LPIS system. The architecture consists of one central image server, many clients and an optional local image server, one for each LAN of clients. The local image server aggressively caches images and the central server ensures that data are consistent and up to date (see below for the list of features). Images can be transferred either via Internet, physically via DVD/CD, or both. The clients access the local image server for images. If an image is not cached yet, it is transparently loaded from the central image server to the local image server. The applied technology is similar to bitTorrent or other new generation P2P networks, which deal with distribution large data sets among many hosts.

4.4 Modular Design

The server application for LPIS features a modular design, which enables low-effort maintenance and improves stability of the system. The modules of the server application include the following:

- image server
 - ✓ Processing large amount of image data.
 - ✓ Scalable – the load is distributed among different servers.
 - ✓ Distributed – images can be cached or stored at local offices to decrease WAN traffic.
 - ✓ Updatable – portions of imagery can be updated in run-time; changes are released to all the servers automatically.
 - ✓ High performance – optimized image processing (tiling, storing different levels of detail) and efficient network transfer (variable formats and compression levels).
- application server
 - ✓ Handles requests to the database for each user.
 - ✓ Produces images from several different layers.

The essential feature of the Sinergise Giselle Image Server, which other LPIS systems lack, is that the central server manages both the images and the clients. A conventional architecture with independent clients installed on local machines would require maintenance and configuration efforts, license managements, etc. Other solutions such as terminal-host and Citrix would suffer heavy network performance penalties during peak load (i.e. all local clients accessing images), because requests are not distributed and parallelized. This in turn would

require a larger available bandwidth, although it would be idle most of the time. Even Citrix, which is optimized for screen transfer, must reload the complete image, if a pan operation is executed.

Our architecture ensures that no local IT managing expertise and effort is needed besides setting up a normal PC, thus keeping down long-term costs, often neglected by other solutions, which try to play down long-term aspects and user satisfaction.

Furthermore, the Sinergise Giselle Image Server has been designed to provide the best experience to end-users, as proven in the case of the Slovenian LPIS application, where it has been in use with over 1000 registered users, many of them without large computer experiences.

Unlimited raster layers in different formats:

TIFF (1, 8, 16, 24, 32 bit format), TFW, JGW, DBF. Sinergise Giselle Image Server supports local offices with the following features, designed to provide the best experience to end-users.

Regional data pre-loading:

When the local system is set up, the administrator can set the area which is of interest to the local office; data for that area is then downloaded during (configurable) off-peak hours to provide instant access. Data can also be loaded directly into the local system from a physical media, such as hard drive or DVD.

Distribution topology:

Local offices can optionally distribute data between themselves, without involving the master server at all.

Configurable image transfer size and fidelity:

For each link between Image Server instances, the administrator can set the format and quality of the images being transferred through it. For example, high-speed LANs allow the images to be transferred without compression, placing the least load on CPUs involved, while slow links to remote sites require higher compression. For lossy compression modes (e.g. JPEG), the quality

is configurable and can even vary depending on the network bandwidth. Finally, when bandwidth is available (e.g. in the case all regional data was already downloaded in lower quality), the server can be configured to retrieve lossy-compressed files again with a lossless codec (PNG), to provide quality identical to the original.

Local caching of retrieved data:

After an image is requested from the master server, it is stored locally for later use, while expunging the least recently used images from the cache, if the size limit is reached. This process ensures that the commonly used images are available locally even without specific configuration. Caching of non-regional data can be disabled, to not interfere with normal operation.

Smart Level-Of-Detail (LOD) processing:

Image Server builds an image pyramid, where each level has a lower LOD than the previous, up to any number of levels (about 10 are usually required). This process ensures that view requests for large areas can be served quickly with good image quality. In case an image with the requested LOD is not locally available, it can be retrieved from the master server, with an important optimization - if the request could be satisfied using the same bandwidth by transferring a higher-LOD image, it is transferred instead, allowing the lower-LOD image to be calculated locally, effectively producing two (or even more) images for the price of a single transfer.

Support for tiled Web mapping server:

to optimize the speed of image loading and to minimize the amount of data being transferred, Image server supports tiled image distribution. Using tiled WMS, the user only downloads the parts of data he/she does not already have cached.

The presented design of the Image Server application can greatly improve performance of the system (compared to either accessing images from a central location or reading unprocessed images stored on local network file servers),

while facilitating maintenance of the software infrastructure as well as orthophotographic images. It is possible to update images in a central location, and the updates can automatically be distributed to local offices without the need for local system administration.

► 4.4.2 Advanced Configuration Editing

Most of the system's functionality can be specified through a customizable XML document, which contains settings for data sources, default display properties of layers, user interface functionality etc. Part of this configuration can be edited by the user through the 'layer properties' dialog.

System administrators can edit XML configuration

[illegible]

Listing 2: Sample configuration of layers, displaying:

- different layer types [red]
- different access (read/write) rights [blue]
- data source definition [green]
- snap properties definition [brown]

application (Figure 36). Its main purpose is to edit configurations that are used by the client application; however, it can be used to edit any configuration that is XML based. The configuration can be stored either in a file, or can reside inside a database.

ConfigManager has two modes of operation: it can either validate the XML contents against a schema (stored in a database or loaded from a file), or it can treat the XML just like any other tree structure that can be edited in a hierarchical way. In the first case, the validation mechanism restricts the user from making any mistakes when editing a configuration, and warns the user if a loaded configuration has errors. In the second case, when schema validation is not used, the user is free to shape the XML tree in any way he wants.

ConfigManager also allows for simple reuse of elements (or sub-trees): user can select an element from an existing configuration and copy it into another configuration using drag-and-drop. Another method of reuse is a special repository of XML fragments (called prototypes), which contain sub-trees of valid configuration elements. They can be named and later used in various configurations as well.

for different types of users via the ConfigManager

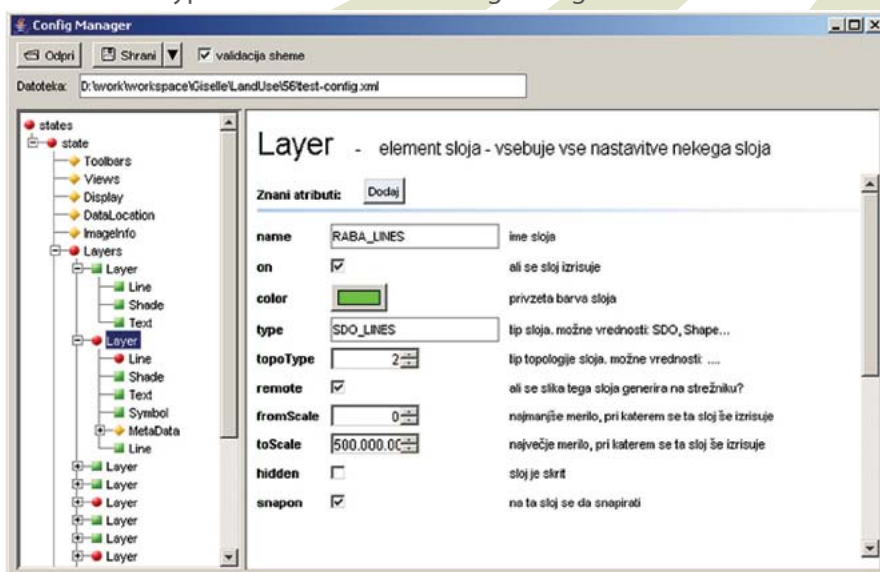


Figure 36: Config Manager application provides a user-friendly interface for advanced editing of the system configuration.

5 EXTENDING THE USE OF LPIS INFRASTRUCTURE

When organizations start building a system, the next phase, extensibility, is usually not of the highest importance. But it is important to think about it and to plan it. The costs of setting up an LPIS are humongous, and most expensive are the data. Any government should not afford to pay such expenses many times. As the legislation is changing quickly, there has to be a possibility to introduce new registers, procedures and processes in the system. It should be that easy that the question about the budget should not come in the way of implementing it. Extensibility is also important for the ease of use - the end-users are not fond of learning new systems, so adding new features to an existing system is much better.

Building an extensible infrastructure brings all sorts of positive effects. As one is not limited with one set of applications, all of them can be accessible at the same place. The user (farm-holder) can therefore get all the data at once. And as there is a possibility to show more data to him, he can give better feedback.

As described, LPIS holds different sets of information – beside basic farm-holding data and land-use data, there are also aerial photos, maps, elevation model, and other graphical and attribute data. Mentioned data are usually the basis of every GIS application upon which some specific data are presented.

In the last few years there were several implementations of Giselle-based system in Slovenia and abroad, in view to connect existing governmental databases to make them more operative for administration, and more approachable for outer users. For instance, In MAFF (Ministry of Agriculture, Forestry and Food), Slovenia, our system has been implemented around this idea, and now there are several usages possible:

- GIS viewing – system administrators can set-up a new application in a matter of minutes – they have to select which data layers are used, which will be searched-upon, etc. and they can do it while the system is running.
- Editing – browser-based or desktop application can be implemented much quicker as the development can build on top of underlying infrastructure (image distribution, access control, LPIS control procedures) and focus only on problem-specific functionality.
- Custom-made applications can also benefit from LPIS infrastructure as they can get all the information needed via web services (WMS and similar).

Since some organizations demand to store their data in-house, the system cannot be completely centralized and has to follow some basic needs:

- Different access points (public web, secured connection, internal systems, etc.);
- use of different data sources – Oracle, ESRI SDE and others in multiple instances;
- local caching of raster layers to minimize the data transfer and speed-up the process but still making sure that the most recent data are used.

We introduced different applications in the MAFF (LPIS, drainage and irrigation inventory, land consolidations) and in related organizations – Veterinary Administration, Phytosanitary Administration and Forest Service – which are all using the same infrastructure




Central SDI system – Image server + GIS server



Figure 37: of LPIS technology in governmental institutions





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