

Methods of Spatial Information Analysis in the Framework of Building the Integrated Administration and Control System in Romania

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Abstract: Romanian Paying and Intervention Agency for Agriculture have started this project and also have the full responsibility for the creation and maintenance of LPIS. The orthophotoimages needed for the creation of LPIS were provided by National Agency for Cadastre and Land Registration (ANCPI). In LPIS Quality Control it was involved SIVECO, Romanian Space Agency (ROSA), Romanian Centre for Remote Sensing Apply in Agriculture (CRUTA) and Geosystems Romania. Quality control was made with VISA-ROM (Geosys France), ArcGIS 9.1 and GIS DataReviewer, a custom product developed for the ESRI ArcMap application by ESRI's Production Line Tool Sets (PLTS) Grup to support visual review and batch validation of data. Spatial data quality control (QC) tasks include a series of automated and visual checks of the orthophotos, database, topology and accuracy of the physical blocks vectorization.

Keywords: orthophotoimages, quality control, database, topology, vectorization.

The application presented in this paper was realized as part of the project in charge with the setup of the database LPIS for Romanian territory, in order to implement the procedures of agricultural subventions, according to the policy and the procedures of European Union(UE). The project was started by Romanian Paying and Intervention Agency for Agriculture(APIA). The abbreviation LPIS is used by European Union in order to define the Land Parcel Information System as part of The Integrated Administration and Control System (IACS), developed by all the European countries (member or on road to become members) according to the fundamental juridical regulations of UE.

The complex operational applications were designed and implemented by a consortium formed by SIVECO, Romanian Space Agency (ROSA), Romanian Centre for Remote Sensing Apply in Agriculture (CRUTA), Geosystems Romania, GAF (Germany) and Geosys (France).

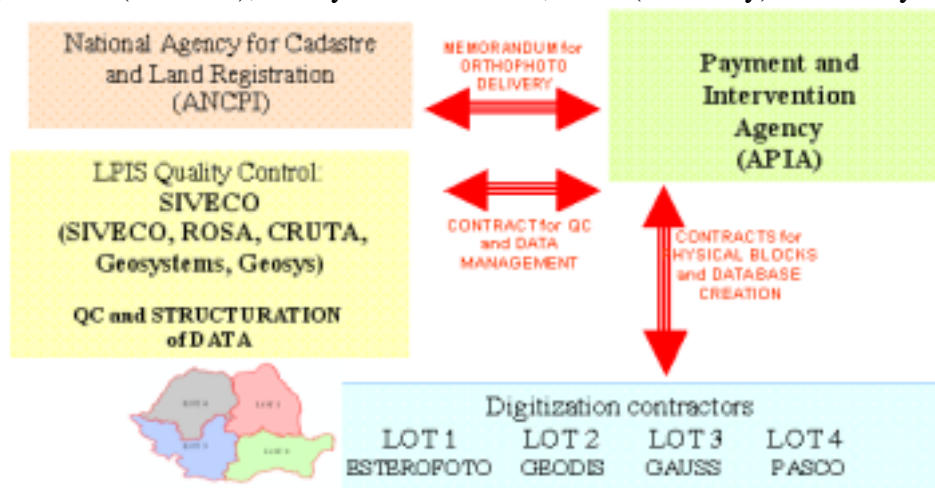


Fig. 1 LPIS Contractual Connections

In order to distribute the agricultural subventions, the farmers identify and will identify the land parcel used for agricultural purposes, in the area of a "physical block", also known as "reference parcel". So, in a first step, was realized the digitization of physical blocks corresponding to administrative units on the Romania's territory, based on the orthophotoimages supplied by ANCPI. Then it was done a "spatial database" necessary for an easy identification of the farmer's parcel, the eligible parcels are formed by physical blocks, according to the definitions presented below:

Physical block

A physical block (BA) is a parcel, with natural or artificial permanent boundaries, used for agricultural purposes by one or many farmers, which may include one or more agricultural parcels.

Land parcel

Is a continuous parcel, part of a "physical block", used for just one type of crop, used only by one farmer. The eligible land parcel has to have an area of minimum 0.3ha, and the category should be of agricultural type and to be maintained in good agricultural conditions and environment.

According to the requests and recommendations of UE, the creation of LIPS has to take into account the following aspects:

- *the utilization of orthophoto 1:5000;*

The orthophotoimages delivered by ANCPI were used as base for spatial data.

- *the creation of the database in a GIS environment;*
- *the homogeneity of the database.*

The polygons which are defining the physical blocks should not have overlapping or artificial limits (the limits of the maps or administrative units). In order to have a cartographic representation continuous and unique for the whole Romanian territory was chosen the national projection Stereographic '70. For fill in the GIS database concerning the communes' boundaries was used the Romanian database at a 1:100.000 scale offered by Geosystems Romania, in ArcView Shapefile format. Later on, it was received from ANCPI a dataset in AutoCAD format, then in ArcView Shapefile format, dataset which contained the administrative boundaries of the communes, based on maps at scales 1:2000 and 1:5000.

- *minimum accuracy*

The minimum accuracy of the database has to be conform with cartographic standards for a scale of 1:10.000. The use of the orthophotoimages at a 1:5000 scale and the digitization at a bigger scale (1:1000 – 1:2000) had guaranteed automatically this condition.

It was done the AUDIT of the contractors in charge with the digitization of the physical blocks. This action had targeted mainly the analyze of the following aspects:

- the solution used;
- the digitization technology;
- the traceability of data and actions;
- the instruments used for work management (the stock of orthophotos, the level of digitization for each administrative unit, the priority management);
- the verification of continuity and adjacency between neighboring communes;
- program of training for photointerpreters;
- the risk management (quality, schedule);
- the internal quality control: organization, traceability of the results, actions taken in case of errors, the following of the technical specifications.

It was agreed with the beneficiary (APIA) to do specific recommendations and was proposed solutions for each of the named activities thus to be able to homogenize and to make compatible the activity of contractors.

The external quality controls based on two complementary actions which determine if the work of contractors is according with the technical specifications concerning the:

- respect of data format
- quality of photointerpretation – the unit for quality control was the commune(UAT)

Phase I

The application Visa-Rom developed by Geosys France, used for the quality control of data delivered by the contractors in charge with the digitization of the physical blocks, was created to work in a ArcGis 9.x software. The functions implemented allow precise analyzes for the identification of the possible topological errors (overlaps, multipart polygons, gaps), the accuracy of the database fields and to find out the tolerances according to the European standards.

1. Automatic check Visa-Rom for 100% of UATs

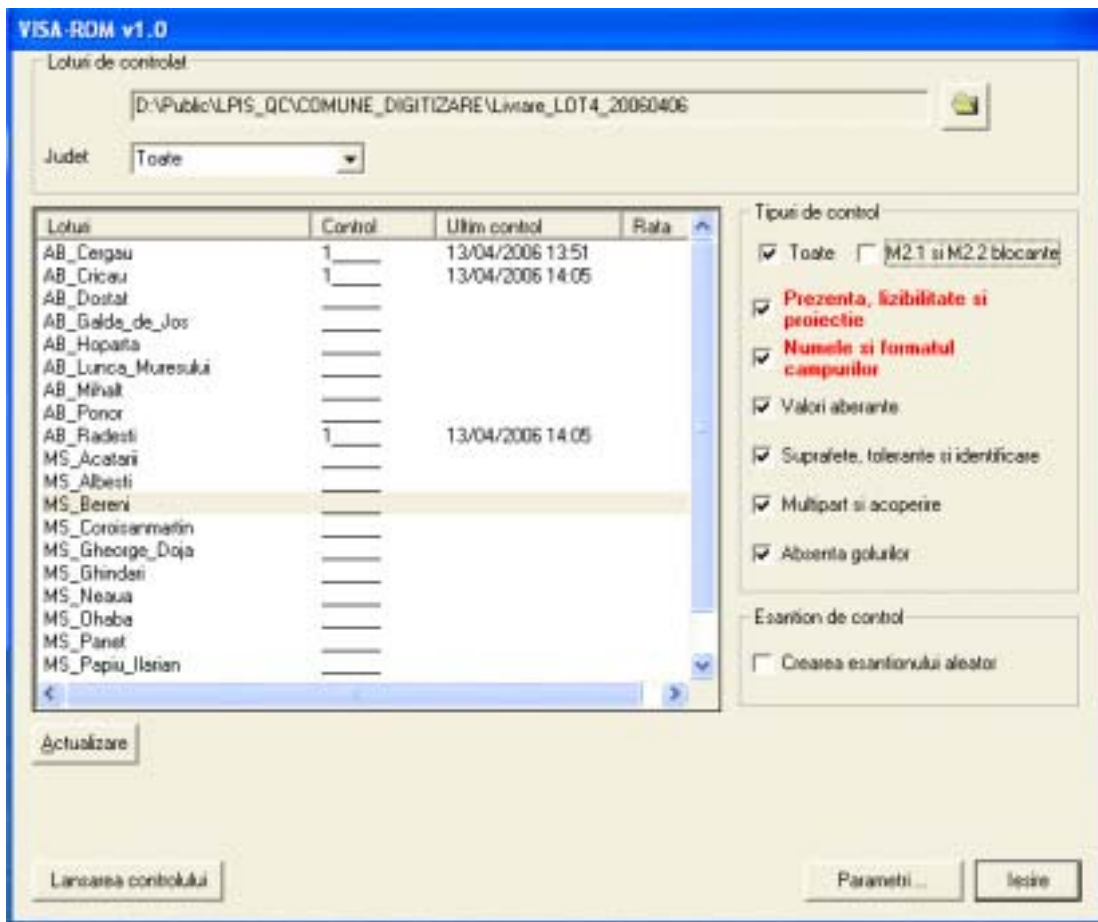


Fig. 2 The first control is realized (topology and structure of data) using Visa-Rom (Map Objects based software application)

The control application generates reports in Romanian which are transmitted to the contractors, in the situations of acceptance or the rejection of an administrative unit

Those reports present:

- The list of physical blocks and errors, the number of errors, the number of errors per block;
- Total number (and the percentage) of errors;
- The integrity of data according to reference layer (ANCPI shapefiles).

RAPORT DE CONTROL AL DATELOR		M2.2 NUMELE SI FORMATUL CAMPURELOR	
UAT CONTROLAT : AB_PONOR Data QC : 17.04.2006 Ora QC : 11:00 Durata QC : 00:00:47s Sinteza rezultatului QC : 111110		NR_POLIG : Present, Format OK SUPRAF_BLOC : Present, Format OK (N0.2) PERIMETRU : Present, Format OK TOLERANTA : Present, Format OK (N0.2) STARE : Present, Format OK DATA_CEAR : Present, Format OK OP_CREATE : Present, Format OK DATA_ACTUA : Present, Format OK OP_ACTLIZ : Present, Format OK VERSIUNEA : Present, Format OK TIP_OBJECT : Present, Format OK JUDET : Present, Format OK NUME_COM : Present, Format OK COMUNA : Present, Format OK IDENT_BLOC : Present, Format OK POL_PAI_TAN : Present, Format OK POL_SEC_TR : Present, Format OK OBSERVATII : Present, Format OK PAR_ADR_MB : Present, Format OK DATA_ZBOR : Present, Format OK OBS_ORTO : Present, Format OK Campuri in plus : 0	
PARAMETRI Praguri de toleranta : Georeferentiere : 50% Suprafata BLOC : 100 m² Perimetru BLOC : 1 m Toleranta BLOC : 100 m² Eroarea adusa a vectorizarii : 2,000 m Praguri de intrerupere a QC : Prezenta, lizibilitate si proiectie : 100 Numele si formatul campurilor : 100 Valori aberante : Oprit Suprafete, toleranta si identificare : 100 Cazuri multipart si suprapunere : 100 Soluri : 100		M2.3 VALORI ABERANTE Cautarea valorilor aberante : Oprit Numarul poligonului nu este unic : -- Identificatorul blocului nu este unic : -- Polosinta principala/secundara nu este unica : --	
SINTEZA RESULTATELOR Prezenta, lizibilitate si proiectie : 1 Eroare Numele si formatul campurilor : 2 Erori Valori aberante : Oprit Suprafete, toleranta si identificare : 85 Erori Cazuri multipart si suprapunere : 1 Eroare Soluri : OK Numarul total de erori detectate : 89		M3.1 SUPRAFETE SI TOLERANTE Encderente ale suprafetelor (alfanumeric/geographic) : 0 Encderente ale Perimetrului (alfanumeric/geographic) : 81 Encderente ale tolerantei (alfanumeric/geographic) : 0	
M2.1 PREZENTA, LIZIBILITATE SI PROIECTIE AB_Ponor_digt.dbf : Present, Lizibil, Format OK, (562 Inregistrari) AB_Ponor_digt.shp : Present, Lizibil, Acoperit 98% AB_Ponor_digt.shx : Present, Lizibil, Format OK AB_Ponor_adm.dbf : Present, Lizibil, Format OK, (1 Inregistrare) AB_Ponor_adm.shp : Present, Lizibil, Acoperit 100% AB_Ponor_adm.shx : Present, Lizibil, Format OK AB_Ponor_imag.sld : Present, Lizibil AB_Ponor_stats.xls : Lipsa		M3.2 CAZURI MULTI-PART SI SUPRAPUNERE Poligoane multipart detectate (numar de Inregistrari) : 1 Poligoane cu suprapuneri detectate (numar de Inregistrari) : 0	

Fig. 3 The Quality Control Report

2. The check of photointerpretation for a 5% sample of physical blocks (sample generated by Visa-Rom)

The administrative unit is considered **REJECTED** if more than 20% of the 5% physical block sample is presenting errors. The commune rejected is retransmitted to the contractor to correct the digitization.

If the number of rejected blocks is less or equal with 20% of the 5% sample, the administrative unit is considered **admitted**.

Accepted if errors ≤ 20%

Rejected if errors > 20%

SIVECO I/O		UAT CONTROLAT		SIVECO I/O		UAT CONTROLAT			
BHL BARAGLANI		SRL_SAP 30648		BHL CAMPANA		SRL_SAP 28709			
DATA PRIMIRE 15.06.2006		DATA VALIDARE 23.06.2006		DATA PRIMIRE 15.06.2006		DATA VALIDARE 23.06.2006			
LOT 4		LOT 4		LOT 4		LOT 4			
NR. CRT	IDENT. BLOC	TIP OBJECT	TIP ERORARE	STARE	NR. CRT	IDENT. BLOC	TIP OBJECT	TIP ERORARE	STARE
1	3000110000	SA		ADMIS	1	3000110000	SA		ADMIS
2	3000110001	SA		ADMIS	2	3000110001	SA	DOCS CADR	RESPINS
3	3000110002	SA		ADMIS	3	3000110002	SA	DOCS CADR	RESPINS
4	3000110003	SA		ADMIS	4	3000110003	SA		ADMIS
5	3000110004	SA		ADMIS	5	3000110004	SA	DOCS CADR	RESPINS
6	3000110005	SA		ADMIS	6	3000110005	SA		ADMIS
7	3000110006	SA		ADMIS	7	3000110006	SA		ADMIS
8	3000110007	SA		ADMIS	8	3000110007	SA	DOCS CADR	RESPINS
9	3000110008	SA		ADMIS	9	3000110008	SA	DOCS CADR	RESPINS
10	3000110009	SA		ADMIS	10	3000110009	SA	DOCS CADR	RESPINS
11	3000110010	SA		ADMIS	11	3000110010	SA		ADMIS
12	3000110011	SA		ADMIS	12	3000110011	SA		ADMIS
13	3000110012	SA		ADMIS	13	3000110012	SA		ADMIS
14	3000110013	SA		ADMIS	14	3000110013	SA		ADMIS
15	3000110014	SA		ADMIS	15	3000110014	SA		ADMIS
16	3000110015	SA		ADMIS	16	3000110015	SA		ADMIS
TIP OBJECT NUMAR ADMIS RESPINS SA 0 0 0 TOTAL 16 4 0		A fost controlat un eșantion de 5% din totalul blocurilor eligibile. Procent de respingere este de 20%. In urma efectuării controlului de calitate 14% din blocuri prezintă erori, dreptul de prag de respingere.		RESPINS					
A fost controlat un eșantion de 5% din totalul blocurilor eligibile. Procent de respingere este de 20%. In urma efectuării controlului de calitate 10% din blocuri prezintă erori, dreptul de prag de respingere.		ADMIS							

Figure 4. The result of the photo-interpretation control is summarized by a control report

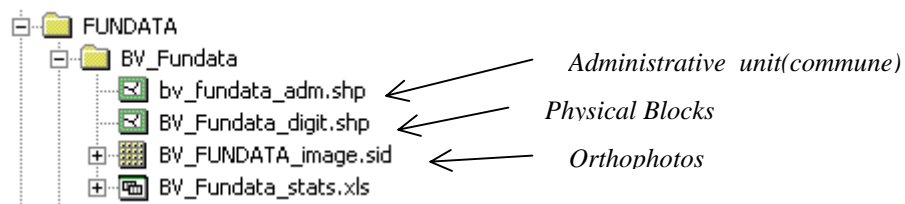
Phase II

We have chosen a sample of 30 communes in order to test, set up the final checks (quality control), and to identify/correct the database errors.

The goal was to identify geometrical and attribute errors and to correct the attribute errors. The control was realized for 100% of the physical blocks in an administrative unit.

The existing data for each commune were:

- the limits of the commune in shapefile format;
- the physical blocks digitization by contractors;
- the orthophotoimages at 1:5000 scale in MrSID format.



1. Prepare data

All 30 communes are in a shapefile format. Each of this shapefile has to be checked for errors and loaded in the GeoDatabase format.

Initially was discovered a lot of missing/null values in the attribute table. This could lead to inconsistency in the GeoDatabase.

Attributes of BV_Fundata_digit										
TIP_OBJECT	REDET	IBRME_COM	COMUNA	REBT_BLOC	FOL_PR_TRB	FOL_SEC_TR	OBSERVAT	PAR_AGE_M	DATA_ZIS	
SA	BV	Fundata	40991	S22991-438198	CC					
SA	BV	Fundata	40991	S23091-438148	CC	TA				

Fig. 5 Attribute table of the shapefile

Performing the QC requires that the data should be loaded in an intermediated workspace, a Personal GeoDatabase which allowed us to perform a series of checks. Each commune was loaded in a distinct Geodatabase.

The Geodatabase has a feature datasets named *Blocuri_Fizice*. This feature dataset stores a feature class named *BL_FIZ* and a topology named *Blocuri_Fizice_Topology*.

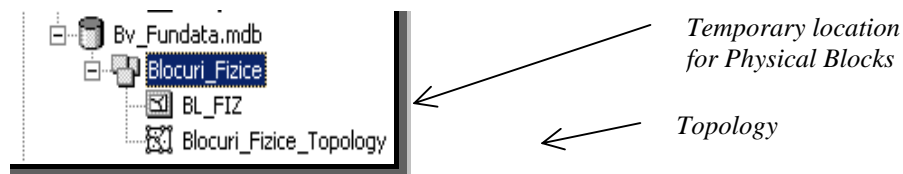


Fig. 6 Example of a geodatabase where is stored Fundata commune from Brasov.

The *BL_FIZ* feature class is just a collection of features that have the same geometry, attributes, and spatial reference. The *Blocuri_Fizice_Topology* is a collection of rules and relationships who, coupled with a set of editing tools and techniques, enables the geodatabase to model and control the geometric relationships between features (physical blocks) and to maintain them during editing.

Geodatabase topology rules are used as initial quality control checks for spatial relationships such as adjacency, coincidence and connectivity.

There are two rules for *Blocuri_Fizice_Topology* :

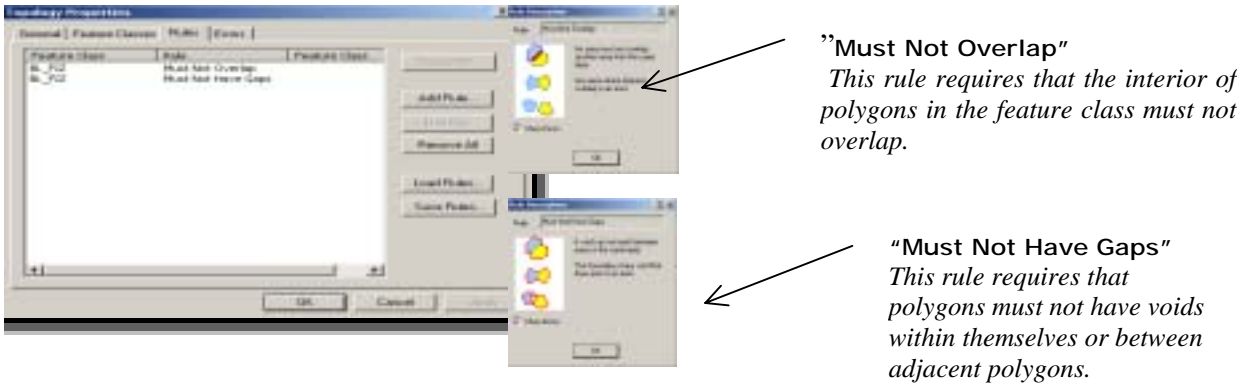


Fig. 7 Topology Properties dialog box

Topology errors discovered during validation are stored in the Geodatabase and can be reviewed using the **Error Inspector**.

2. Perform automated QC checks using GIS Data ReViewer

GIS Data ReViewer is a custom product developed for the ESRI[®] ArcMap[™] application by ESRI's Production Line Tool Sets (PLTS) Group to support visual review and batch validation of data. ArcMap is an application within the ArcGIS[™] Desktop products (ArcView[®], ArcEditor[™], and ArcInfo[™]).

GIS Data ReViewer is composed of a series of buttons, tools, and context menus used to identify where corrections and deletions must be made to the spatial data and its attributes. GIS Data ReViewer provides tools for selecting and editing, performing spatial analysis, creating QC Grids, finding overlapping features, creating error tables, capturing and digitizing missing features, and making topology checks. Errors are logged into a table that stores all the necessary information for historical tracking.

Each commune has a new ReViewer Session that generates a personal geodatabase who stores error table information.

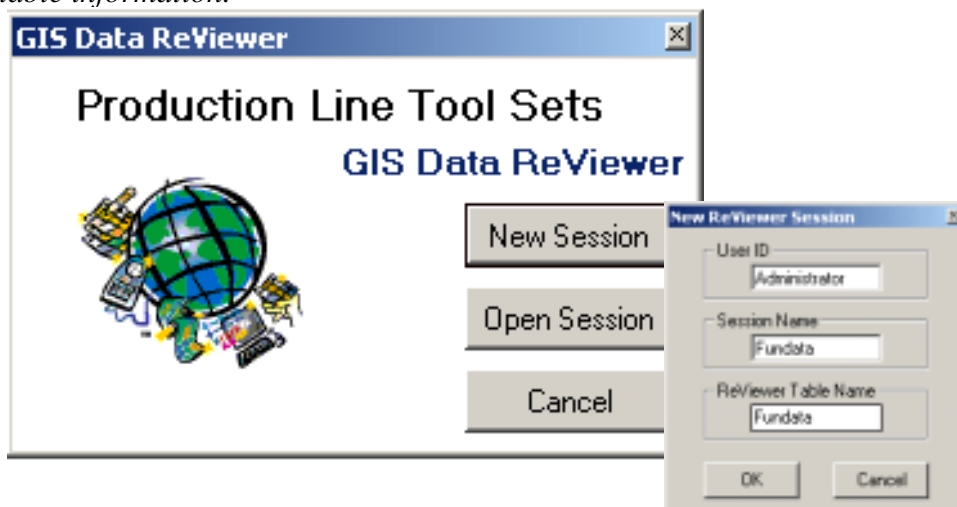


Fig. 8 GIS Data ReViewer Session

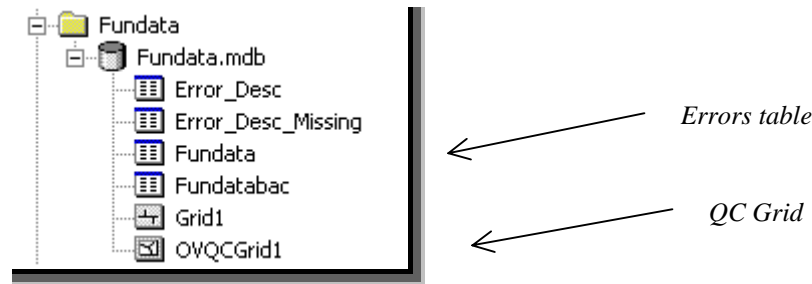


Fig. 9 Example of a geodatabase generated in a ReViewer Session.

2a. Inspect the quality of attributes

1. Check physical blocks *IDENT_BLOC* field for duplicate values- the result will indicate the occurrence of the physical block unique identifiers

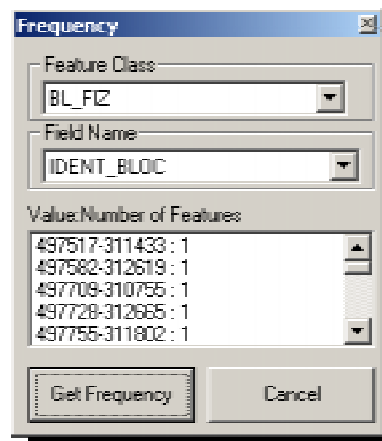


Fig. 10 The Frequency dialog box

2. Perform a feature count- in this step is checked that number of features in the source data (shapefile) is equal with the number of features in the destination data.

2b. Check for topology errors with Validate Simple Geometry

In this step, we just look for overlaps and duplicate vertices in the *BL_FIZ* layer. With *Validate Simple Geometry* tool, we run the selected topological checks (also known as validation processes) for the *BL_FIZ* feature class who stores polygons of the physical blocks. Vertices were considered duplicate if they were located within 1 meter distance each other.

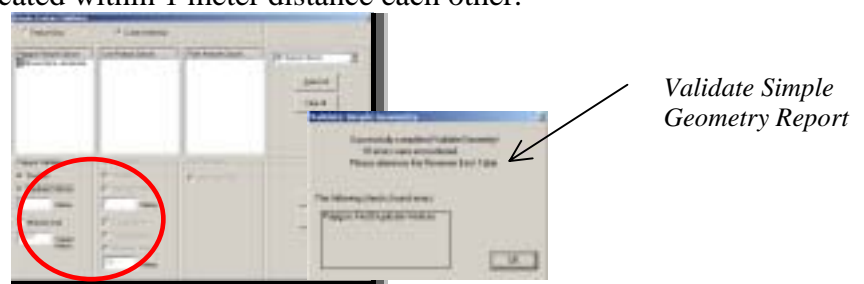


Fig. 11 Simple Feature Validator dialog box



Excessive digitization of the forest limits

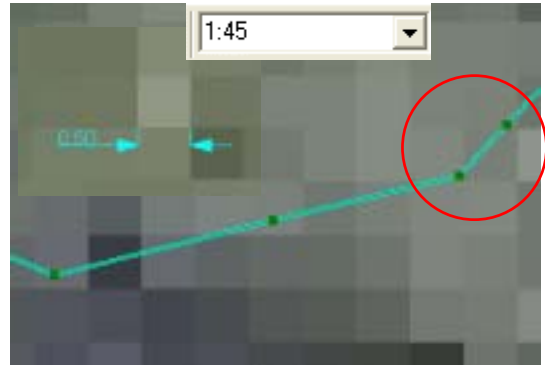


Figure 12: Example of the vertices that are located under 1 meter one of another . The scale of the digitization is 1: 1000 and the resolution of the orthophotoimage is 0.50 meter.

All of the errors encountered by the *Validate Simple Geometry* tool were automatically added to **Error Table**.

Sfarsita	Locatie	StrucuraClasa	FCade	Check	Rev. Status	Rev. Tech	Rev. Data	Car. Status	Car. Tech	Car. Date
1	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: null	3 Top Features	isoborn duplaj	Administrata	1/25/2005	creat	creat	creat
2	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 7	Administrata	1/25/2005	creat	creat	creat
3	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 8	Administrata	1/25/2005	creat	creat	creat
4	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 9	Administrata	1/25/2005	creat	creat	creat
5	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 3	Administrata	1/25/2005	creat	creat	creat
6	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 14	Administrata	1/25/2005	creat	creat	creat
7	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 15	Administrata	1/25/2005	creat	creat	creat
8	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 10	Administrata	1/25/2005	creat	creat	creat
9	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 10	Administrata	1/25/2005	creat	creat	creat
10	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 8	Administrata	1/25/2005	creat	creat	creat
11	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 1	Administrata	1/25/2005	creat	creat	creat
12	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 20	Administrata	1/25/2005	creat	creat	creat
13	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 21	Administrata	1/25/2005	creat	creat	creat
14	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 30	Administrata	1/25/2005	creat	creat	creat
15	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 30	Administrata	1/25/2005	creat	creat	creat
16	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 10	Administrata	1/25/2005	creat	creat	creat
17	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 10	Administrata	1/25/2005	creat	creat	creat
18	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 8	Administrata	1/25/2005	creat	creat	creat
19	C:\Cmune.apa\FUNDATA\BV_Fundat	Stanca foisor vesticol	1: HERTS	Batch Geometry Check	Duplicate vertices found. Pair = 0:Vertex = 1	Administrata	1/25/2005	creat	creat	creat

Fig. 13 Records in the Error Table

3. Perform visual QC checks using GIS Data ReViewer

This step assumes visual checks of each physical block to identify photointerpretation and attribute errors and to correct *only* the attribute errors.



Fig. 14 Example of the errors in photointerpretation and digitizing.

All the errors identified by visual QC process are describe and stored in the GIS Data ReViewer **Error Table**. In **Errors Table** there are some fields who offer information about visual QC like correction status, technician’s name and the date of the correction. The correction status (**Cor_Status**) is updated, indicating the corrective action taken. The correction technician's name (**Cor_Tech**) and date of the correction (**Cor_Date**) are automatically stored in the error table.

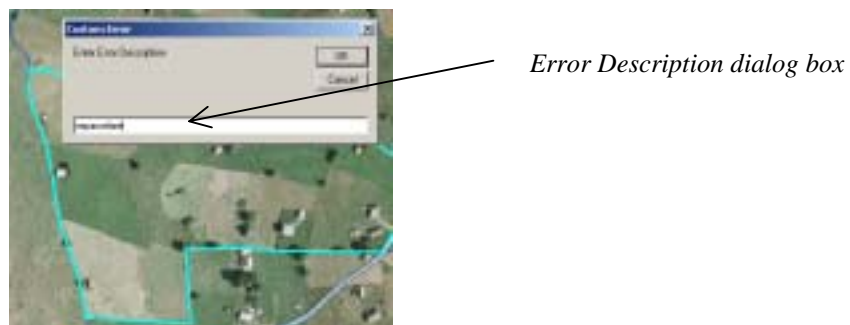


Fig. 15 Example of the error description

For a homogeneous errors description it were identified possible errors and were allocated error codes. Those codes were added during the quality control checks based on the new errors identified by the operators.

QC01	Limite gresit digitizate in NORDUL blocului fizic
QC02	Limite gresit digitizate in SUDUL blocului fizic
QC03	Limite gresit digitizate in ESTUL blocului fizic
QC04	Limite gresit digitizate in VESTUL blocului fizic
QC05	Limite gresit digitizate in interiorul blocului fizic
QC06	Geometrizare excesiva a limitelor
QC07	Impartire nejustificata a blocului fizic
QC08	Limite fixe neluate in considerare
QC09	Includere de suprafete non-agricole in blocul fizic
QC10	Atributare eronata
QC11	Lipsa atribut

Fig. 16 Example of the error codes

To systematically track the visual review process, GIS Data ReViewer allowed us to create a **QC Grid** over the data. Each grid cell it was updated (yellow color) along with visual check, to indicate that the cell has been reviewed.

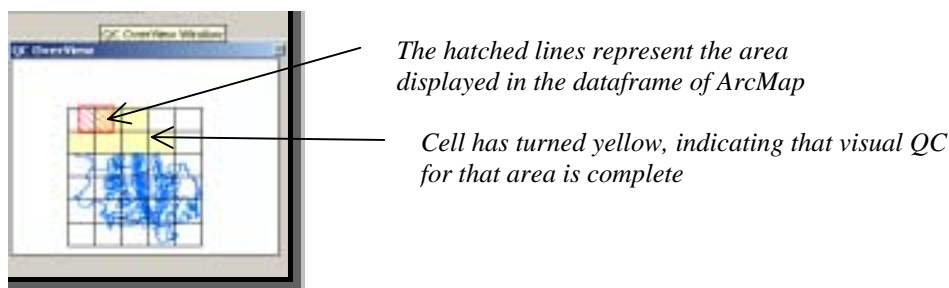


Fig. 17 QC OverView window

Conclusion

- The intelligible and detailed technical specifications lead to a homogeneous and compatible activity of the contractors.
- The training for the operators who are digitizing and photointerpreting is an important element for a final quality product.
- In forest area, due to excessive digitization of the boundaries, was generated a high number of vertices at distances lower than 1 meter. That is affecting the size of the database.
- It were identified communes with thousand of overlapping vertices. The utilization of the Trace tool generates automatically useless vertices.
- During the quality control process, the number of existing physical blocks from an administrative unit, do not have an influence the necessary time allocated for each commune checks. The quality of initial photointerpretation and digitization is decisive.

Reference

- [1] APIA (2006) - *Ghid de Fotointerpretare si digitizarea blocurilor fizice pentru crearea bazei de date LPIS Romania*
- [2] Environmental Systems Research Institute, Inc. (2006) - *QA/QC for GIS Data*
- [3] Michael Zeiler, Environmental Systems Research Institute, Inc. (1999) - *Modeling our world- The ESRI Guide to geodatabase Design*
- [4] www.esri.com , www.esriro.ro