Implementation of quality model for evaluating and documenting quality in map composition process

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Hellenic Cadastre – About as

The legal entity under public law with the name "Hellenic Cadastre", was established by Law 4512/2018, and is supervised by the Ministry of Digital Governance (Presidential Decree 3 / 6.1.2021).

The purpose of the Hellenic Cadastre is to ensure the reliability, publicity and availability of spatial and legal data related to real estate and to ensure public trust and security of transactions.

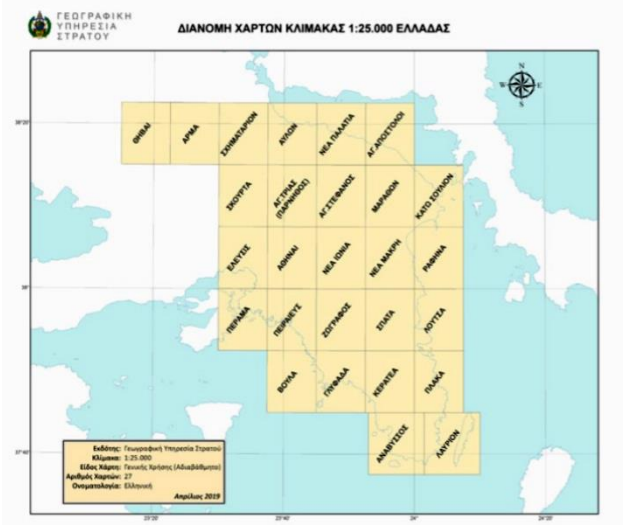
This purpose is achieved through the development, maintenance and operation of the National Cadastre, ensuring the publicity of the legal (registrable rights and encumbrances) and technical (location and boundaries) information from all the real property transactions registered in it.

Its purpose also includes the geodetic and **cartographic coverage** of the country, as well as the creation and maintenance of digital geospatial data.

Production of Topographic Map at scale 1:25.000

The "Hellenic Cadastre" as National mapping Agency, is responsible for the production, maintenance and revision of basic and value-added topographic maps and topographic diagrams.

Project	Background



Hellenic Geographical Military Service
It has published 27 map sheets at a scale of 1:25,000
They have not been revised since the 1980s

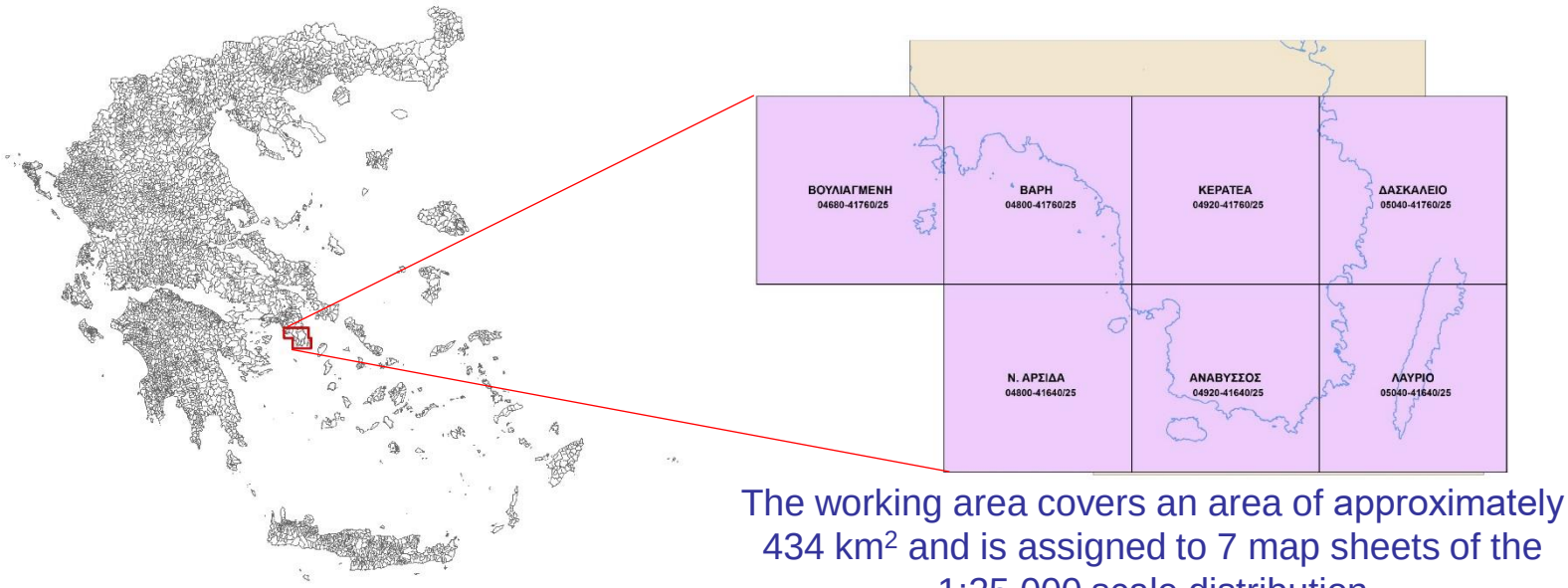
Pilot project area

Goal

Running of a pilot project for the production of 1:25.000 scale maps, using as basic data the geospatial data available from the Hellenic Cadastre.

Quality management in the map synthesis process

The pilot project involves the development and implementation of an integrated environment for monitoring and documenting quality in the mapping process. The methodology described involves the design and implementation of Quality Model based on the ISO 19157:2013 standard.



The working area covers an area of approximately 434 km^2 and is assigned to 7 map sheets of the 1:25.000 scale distribution

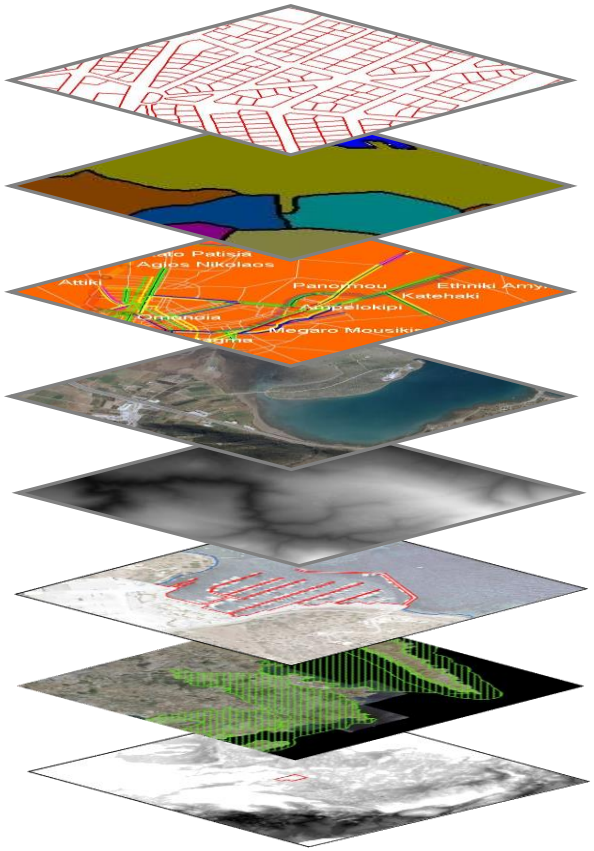
Basic data

Hellenic Cadastre

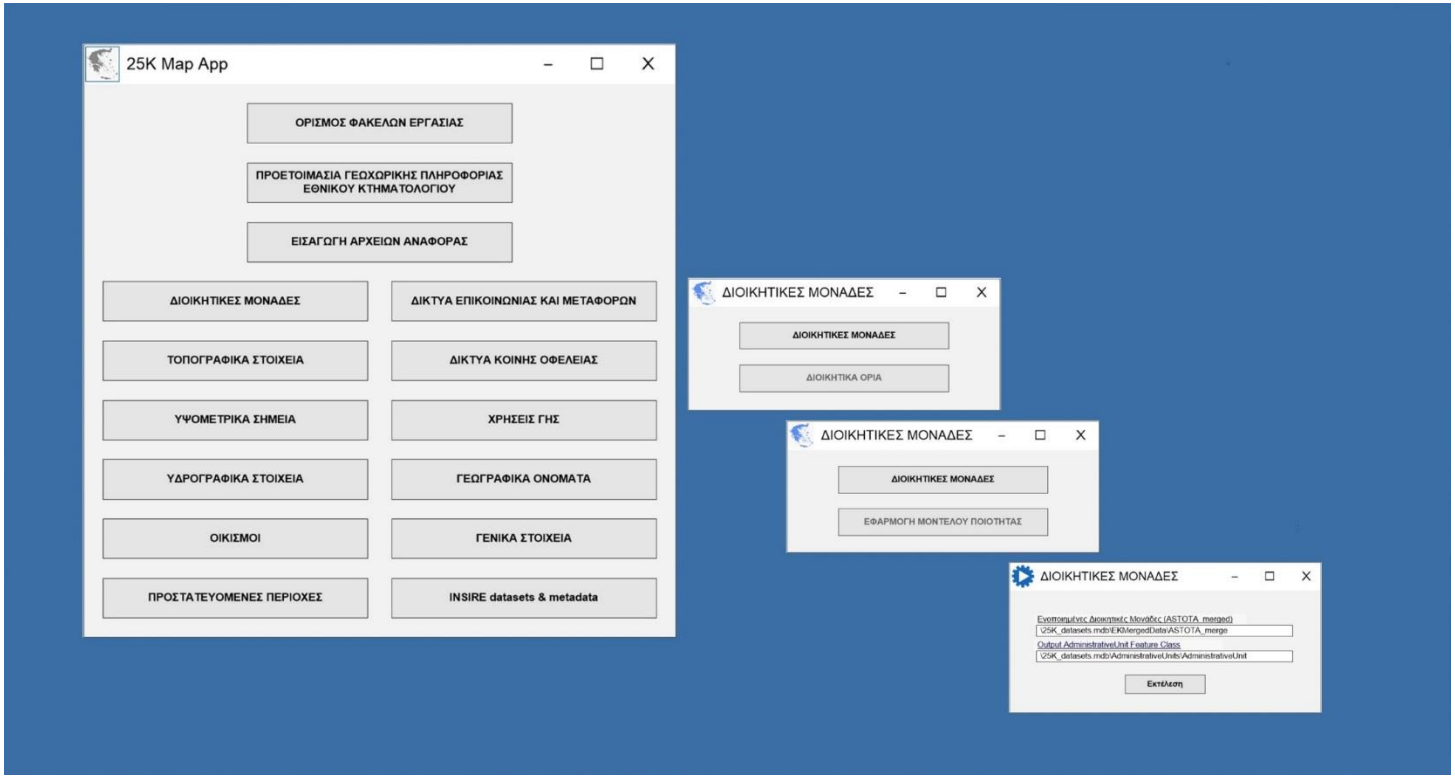
- Cadastral parcels (includes the road, railway and hydrographic network)
- Land uses
- Geographical names
- Orthophotos
- Digital Elevation Model
- Coastline
- Protected sites (e.g. NATURA areas)

Other sources

- Hellenic Statistical Authority (Population data)
- Hellenic Navy Hydrographic Service (Bathymetry)
- Hellenic Train S.A. (Categorization of railway network)
- Hellenic Commission for Large Dams (spatial location of dams).



Software application



Visual Studio

python™

ArcGIS Python

Thematic content of map

Feature Attributes Coding System - FACS

AdministrativeUnits
- AdministrativeUnit ●
- AdministrativeBoundary ● ■

Topography
- ContourLine ● ■
- VoidArea ●
- MineArea ●
- Mine ● ■

SpotElevation
- SpotElevation ● ■

PopulatedPlaces
- PopulatedPlace ● ■
- Building ● ■

NamedPlaces
- NamedPlace ● ■

Hydrography
- LandWaterBoundary ● ■
- Islets ■
- WatercourseArea ● ■
- WatercourseLine ● ■
- StandingWater ● ■
- Crossing ● ■
- DamOrWeir ●
- DamOrWireLine ● ■
- Falls ● ■
- Spring ● ■
- Wetland ● ■

LandUse
- HCLandUseDataset ●
- HCLandUseObject ● ■
- HCSpecificLandUse ●
- HILUCSLandUseDataSet ●
- HILUCSLandUseObject ●
- HILUCSSpecificLandUse ●

UtilityNetworks
- ElectricityCableLink ● ■
- ElectricityCableNode ■
- ElectricityCable Area ●

Transport Networks
- Eroad ● ■
- Road ● ■
- RoadTunnels ● ■
- RoadBridges ● ■
- RoadArea ●
- RoadNode ●
- RailwayLine ● ■
- RailwayTunnels ● ■
- RailwayBridges ● ■
- RailwayArea ●
- RailwayNode ●
- RailwayStationArea ●
- RailwayStationNode ●
- VerticalPosistionLine ●
- VerticalPosition ● ■
- AerodromeArea ●
- PortArea ●

ProtectedSites
- ProtectedSite ● ■

Relief
- Hillshade ■
- Bathymetry ■

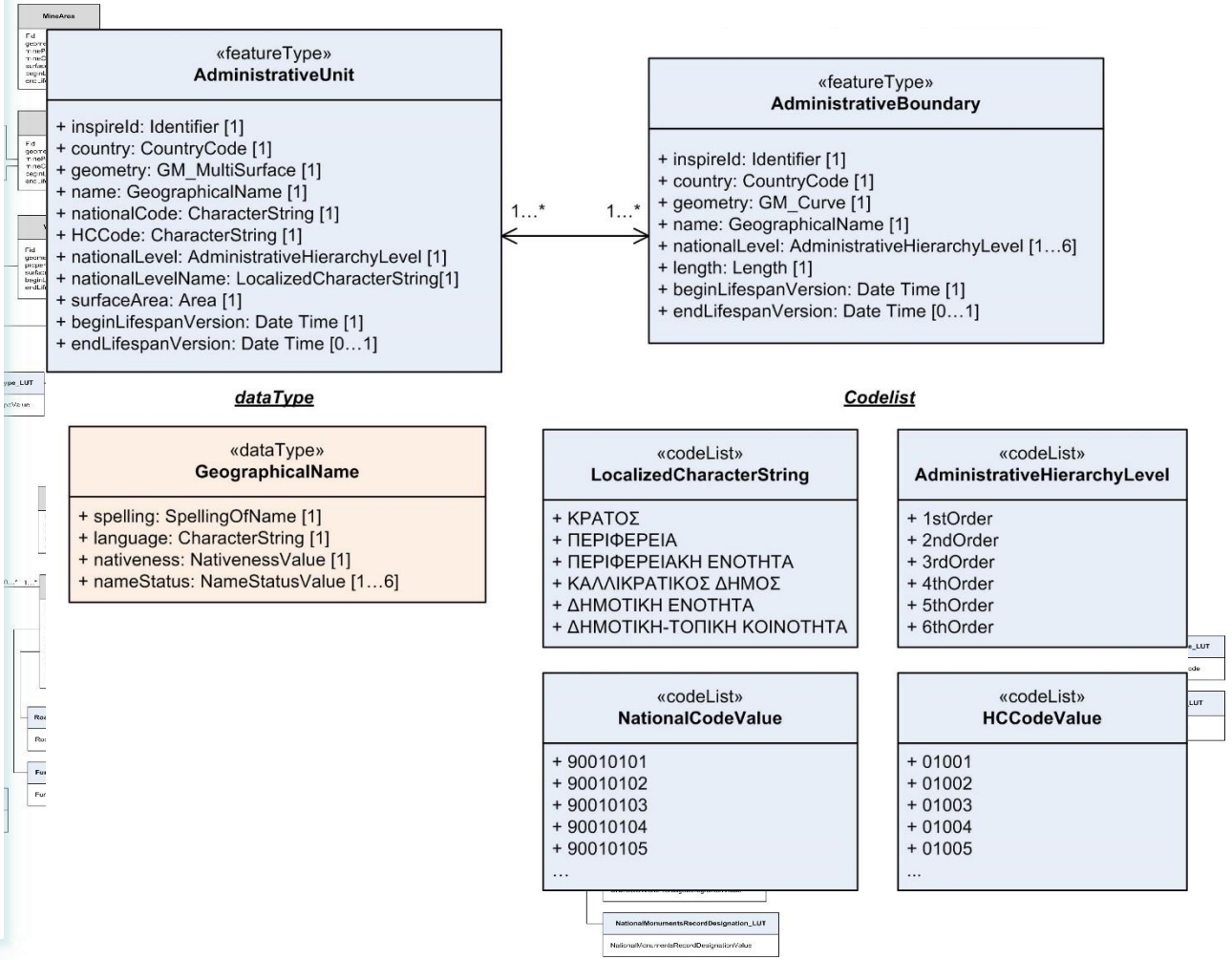
● Geospatial database

■ Cartographic database / Map

Data model

INSPIRE Specifications

- Administrative Units
- Cadastral Parcels
- Coordinate reference systems
- Geographical Names
- Hydrography
- Protected sites
- Transport networks
- Elevation
- Land use

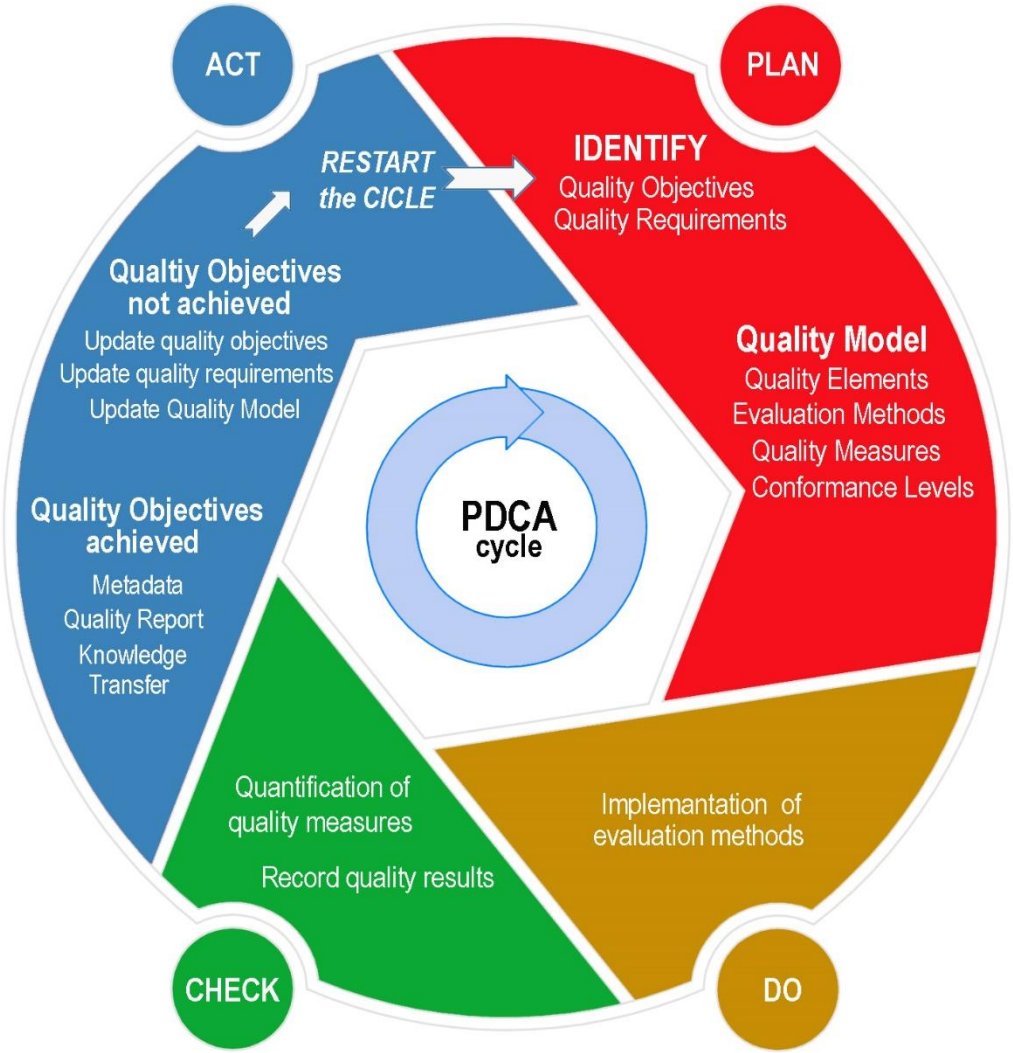


Quality Model based on ISO 19157/13

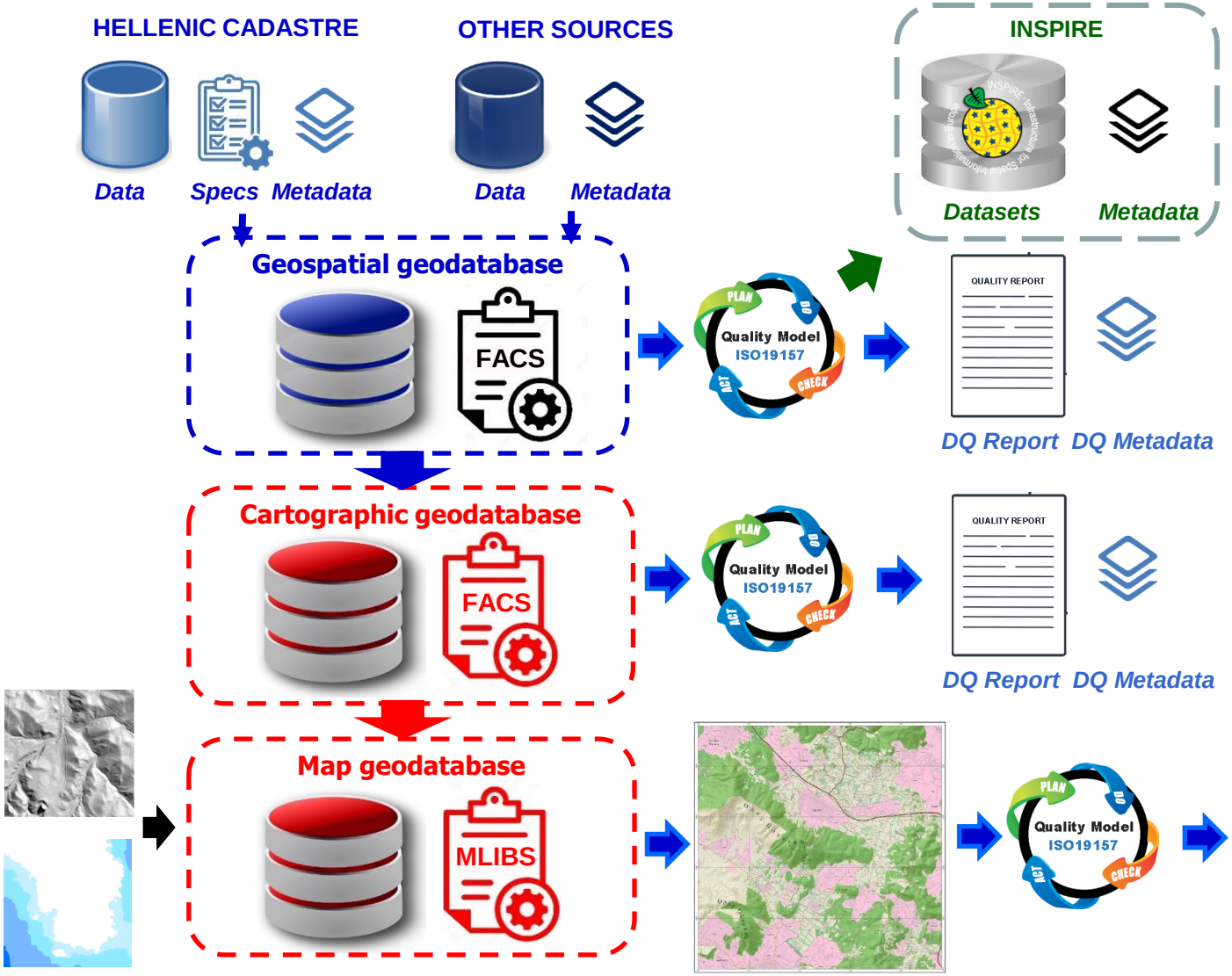
Geospatial database Quality Model (part)											
Entity type & Attribute	QUALITY ELEMENTS										
	COMPLETENESS		LOGICAL CONSISTENCY				POSITIONAL ACCURACY	TEMPORAL ACCURACY	THEMATIC ACCURACY		
	COMMISSION	OMISSION	CONCEPTUAL CONSISTENCY	DOMAIN CONSISTENCY	FORMAT CONSISTENCY	TOPOLOGICAL CONSISTENCY	ABSOLUTE ACCURACY	TEMPORAL VALIDITY	CLASSIFICATION CORRECTENESS	NON-QUNTATITATIVE ATTRIBUTE ACCURACY	QUNTATITATIVE ATTRIBUTE ACCURACY
AdministrativeUnit	Error count Id 2 Error count Id 2	Error count Id 6 Error count Id 6	Correctness Indicator Id 9		Error indicator Id 119				Error count Id 60		
inspireId				Error indicator Id 14							
counrty				Error indicator Id 14							
geometry	Error count Id 4		Error count Id 11			Error count Id 23, id 24, id 25, id 26, id 27	Id 28				
name									Error count Id 60	Error count Id 65	
nationalCode				Error indicator Id 14						Error count Id 65	
HCCode				Error indicator Id 14						Error count Id 65	
nationalLevel				Error indicator Id 14						Error count Id 65	
nationalLevelName				Error indicator Id 14						Error count Id 65	
surfaceArea											LE99.8 Id 73
beginLifespanVersion								Error indicator Id 14			
endLifespanVersion											

Full inspection Sampling inspection (ISO 2859-1) Sampling inspection (ISO 3951)

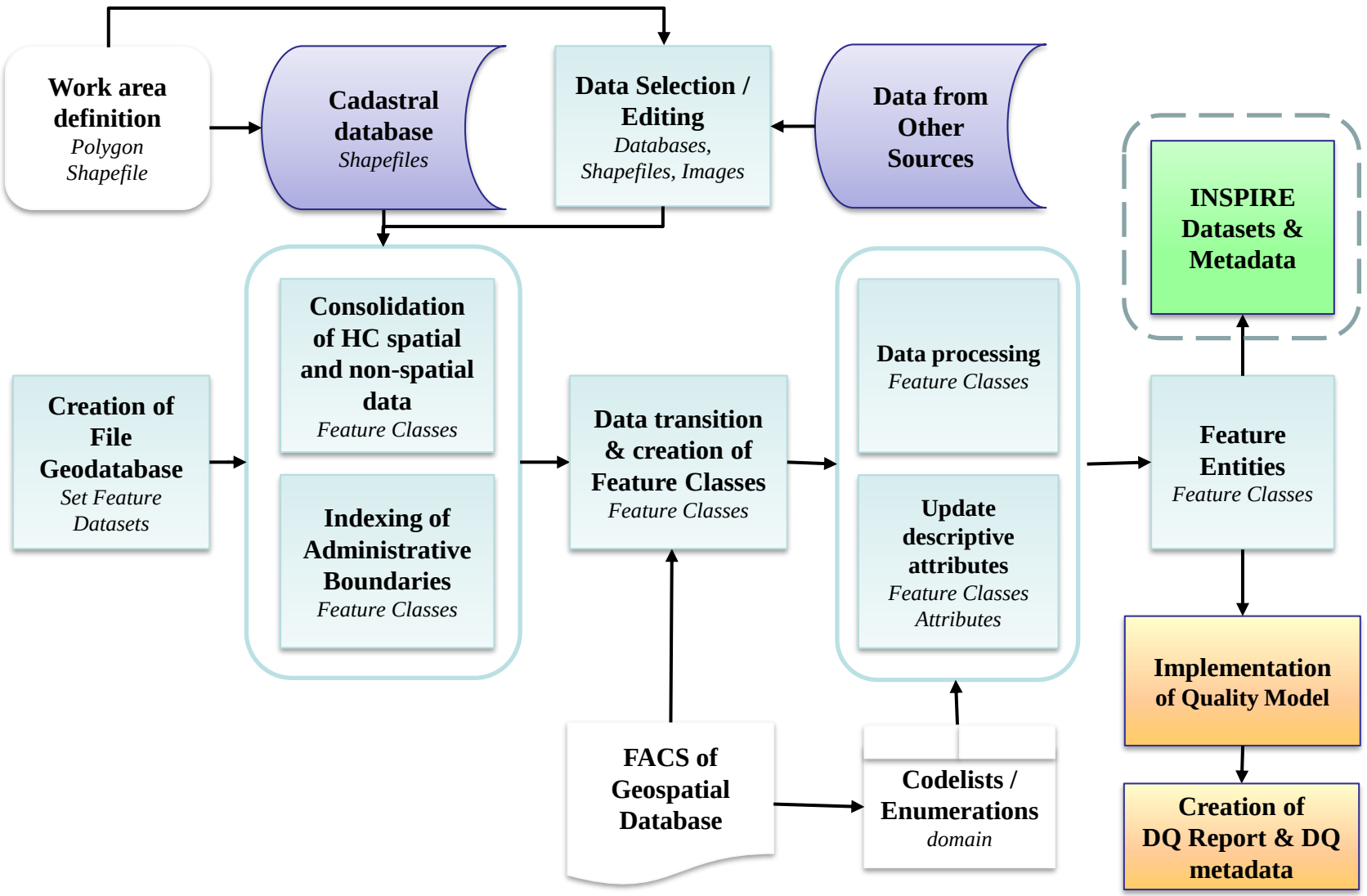
Implementation of Quality Model in production process



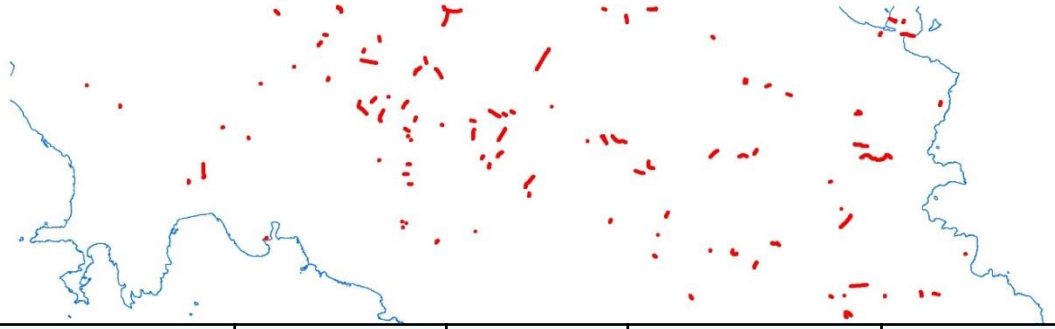
Project workflow



Project workflow - Phase 1



Project workflow - Phase 1
Implementation of sampling inspection



Feature Type / Attribute	DQ ELEMENT		NameOfMeasure	Measure Identification	DQ_QuantitativeResult	ResultValueType	DQ_ ConformanceResult
surfaceCategory	Thematic accuracy	Classification correcteness	error count	60	2	Integer	10

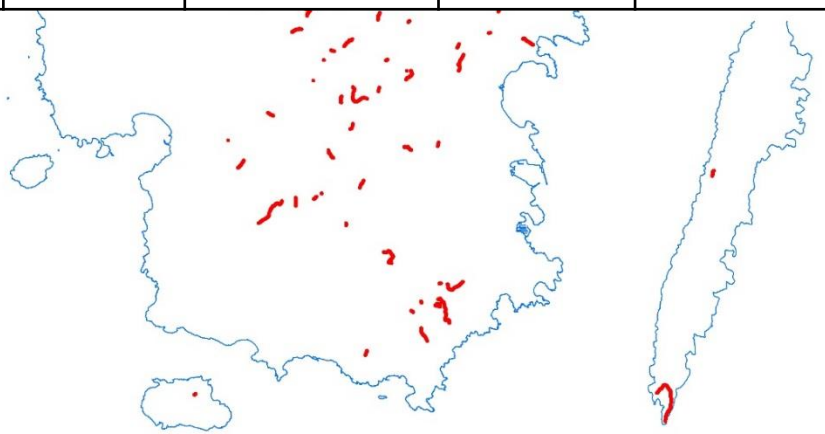
Table

Roads_surfaceCategory60

FID	Shape *	inspireId	surfaceCategory	Length
0	Polyline	GR.RNT.LNR.L000022	unpaved	45,45
1	Polyline	GR.RNT.LNR.L000027	paved	1489,06
2	Polyline	GR.RNT.LNR.L000068	paved	139,46
3	Polyline	GR.RNT.LNR.L000081	unpaved	429,49
4	Polyline	GR.RNT.LNR.L000126	paved	66,42
5	Polyline	GR.RNT.LNR.L000140	paved	148,48
6	Polyline	GR.RNT.LNR.L000149	unpaved	92,93
7	Polyline	GR.RNT.LNR.L000153	unpaved	49,62
8	Polyline	GR.RNT.LNR.L000157	unpaved	961,7
9	Polyline	GR.RNT.LNR.L000189	paved	651,72
10	Polyline	GR.RNT.LNR.L000192	paved	47,01
11	Polyline	GR.RNT.LNR.L000307	unpaved	684,87

0 (0 out of 200 Selected)

Roads_surfaceCategory60

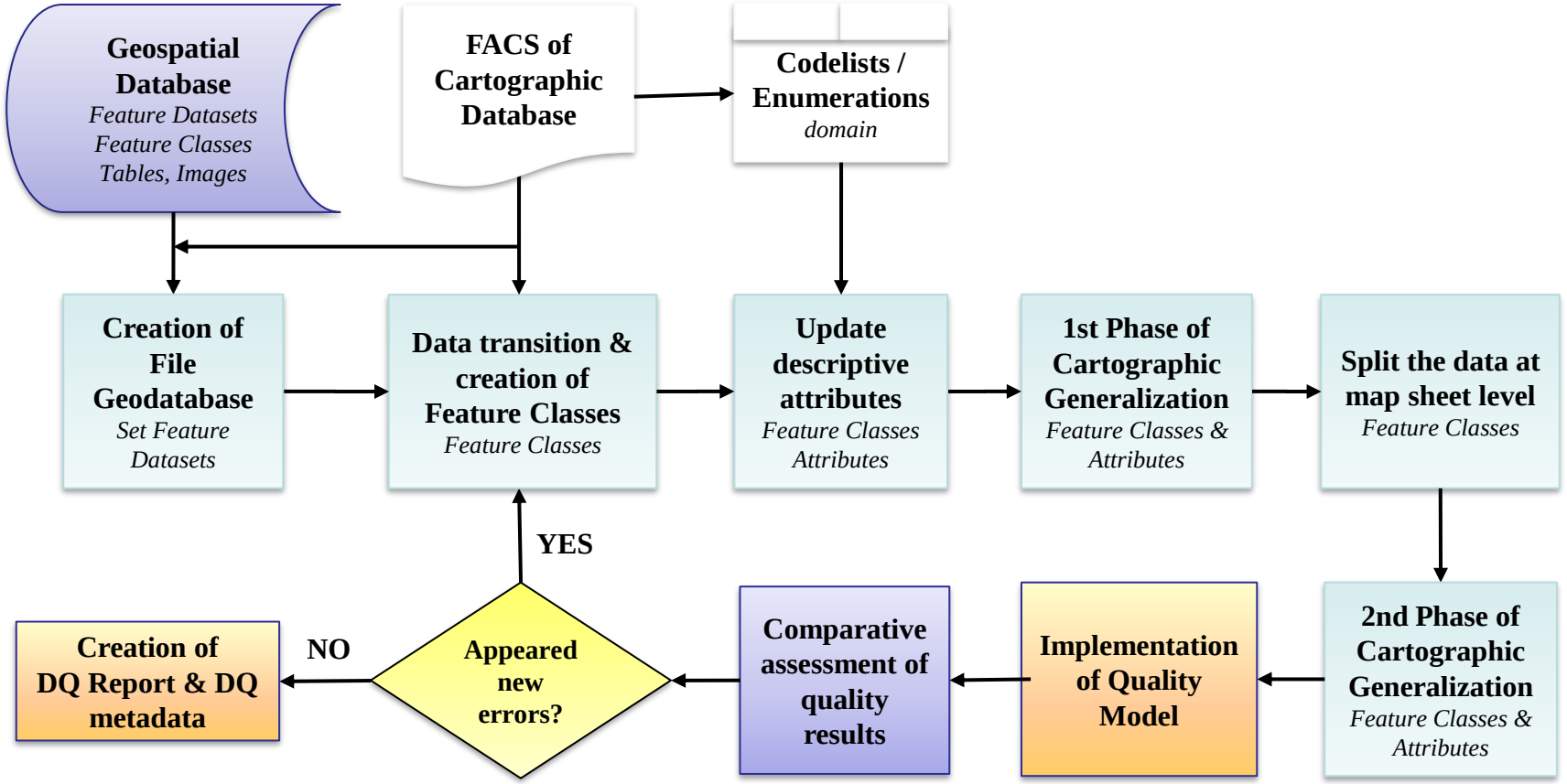


ID	Feature Type / Attribute	DQ ELEMENT		NameOfMeasure	Measure Identification	DQ_QuantitativeResult	ResultValueType
1	HCSpecificLandUse	Completeness	Commission	error count	2	0	Integer
2	HCSpecificLandUse	Completeness	Omission	error count	6	0	Integer
3	HCSpecificLandUse	Logical Consistency	Conceptual Consistency	Correcteness indicator	9	True	Boolean
4	HCSpecificLandUse	Logical Consistency	Format Consistency	error indicator	119	True	boolean
5	HCSpecificLandUse	Thematic Accuracy	Classification Correctness	error count	60	0	Integer
6	geometry	Completeness	Commission	error count	4	0	Integer
7	geometry	Logical Consistency	Conceptual Consistency	error count	11	0	Integer
8	geometry	Logical Consistency	Topological Consistency	error count	23	0	Integer
9	geometry	Logical Consistency	Topological Consistency	error count	24	0	Integer
10	geometry	Logical Consistency	Topological Consistency		25	3	Integer
11	geometry	Logical Consistency	Topological Consistency		26	0	Integer
12	geometry	Logical Consistency	Topological Consistency	error count	27	0	Integer
13	geometry	Positional Accuracy	Absolute Accuracy	Mean value of positional uncertainties	28	1.37	Meters
14	HCLandUseCode	Logical Consistency	Domain Consistency	error indicator	14	True	boolean
15	HCLandUseCode	Thematic Accuracy	Non-Quantitative Attribute Correctness	error count	65	1	Integer
16	HCLandUseCat	Logical Consistency	Domain Consistency	error indicator	14	True	boolean
17	HCLandUseCat	Thematic Accuracy	Non-Quantitative Attribute Correctness	error count	65	1	Integer
18	HCLandUseCatId	Logical Consistency	Domain Consistency	error indicator	14	True	boolean
19	HCLandUseCatId	Thematic Accuracy	Non-Quantitative Attribute Correctness	error count	65	1	Integer
20	HCLandUseSubCat	Logical Consistency	Domain Consistency		14	True	boolean
21	HCLandUseSubCat	Thematic Accuracy	Non-Quantitative Attribute Correctness	error count	65	1	Integer
22	hilucsLandUse	Logical Consistency	Domain Consistency	error indicator	14	True	boolean
23	hilucsLandUse	Thematic Accuracy	Non-Quantitative Attribute Correctness	error count	65	1	Integer
24	surface	Thematic Accuracy	Quantitative Attribute Correctness	LE99.8	73	True	boolean
25	beginLifespanVersion	Temporal Accuracy	Temporal Validity	error indicator	14	True	boolean

Number of invalid slivers

Incorrect land use type

Project workflow – Phase 2



Implementation of Quality Model at Cartographic database

Geospatial database Quality Model

Entity type & Attribute	QUALITY ELEMENTS											
	COMPLETENESS		LOGICAL CONSISTENCY				POSITIONAL ACCURACY	TEMPORAL ACCURACY	THEMATIC ACCURACY			
	COMMISSION	OMISSION	CONCEPTUAL CONSISTENCY	DOMAIN CONSISTENCY	FORMAT CONSISTENCY	TOPOLOGICAL CONSISTENCY	ABSOLUTE ACCURACY	TEMPORAL VALIDITY	CLASSIFICATION CORRECTENESS	NON-QUNTATITATIVE ATTRIBUTE ACCURACY	QUNTATITATIVE ATTRIBUTE ACCURACY
LandWaterBoundary	EC - id 2	EC - id 6	CI - id 9		EI - id 119				EC - id 60		
inspireId				EI - id 14							
geometry	EC - id 4					EC - id 21, id 23, id 24, id 26, id 27	id 28	*mean value of positional uncertainties*			
origin				EI – id 14					EC - id 60		
shoreCategory				EI - id 14							
length											LE99.8 - id 73
beginLifespanVersion								EI - id 14			
endLifespanVersion											

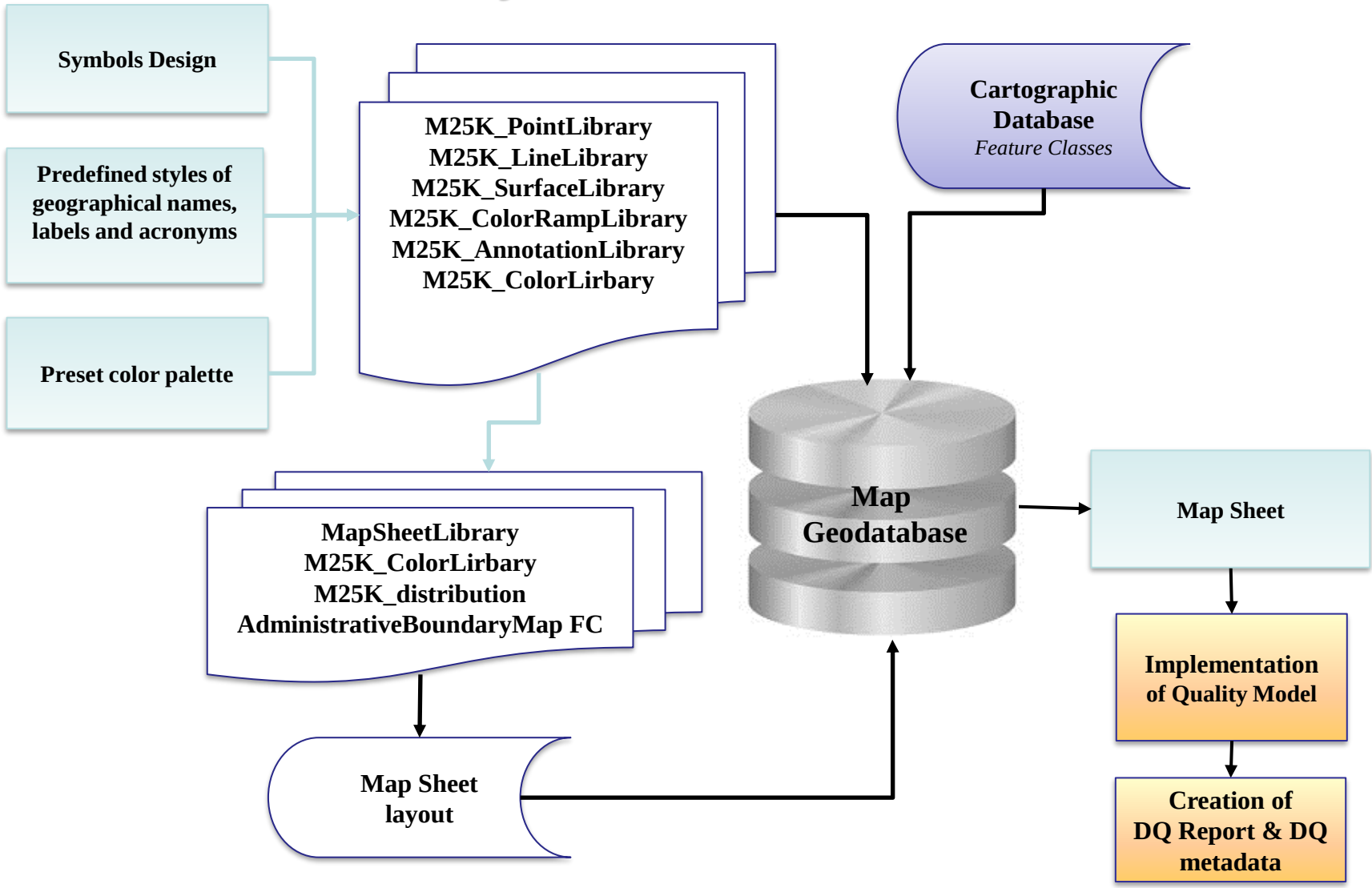
Cartographic database Quality Model

Entity type & Attribute	QUALITY ELEMENTS										
	COMPLETENESS		LOGICAL CONSISTENCY				POSITIONAL ACCURACY	TEMPORAL ACCURACY	THEMATIC ACCURACY		
	COMMISSION	OMISSION	CONCEPTUAL CONSISTENCY	DOMAIN CONSISTENCY	FORMAT CONSISTENCY	TOPOLOGICAL CONSISTENCY	ABSOLUTE ACCURACY	TEMPORAL VALIDITY	CLASSIFICATION CORRECTENESS	NON-QUNTATITATIVE ATTRIBUTE ACCURACY	QUNTATITATIVE ATTRIBUTE ACCURACY
LandWaterBoundaryMap	EC - id 2	EC - id 6	CI - id 9		EI - id 119						
inspireId				EI - id 14							
Geometry	EC - id 4					EC - id 21, id 23, id 24, id 26, id 27	id 30	*number of positional uncertainties above a given threshold*			
Origin				EI – id 14							
shoreCategory				EI - id 14							
Length											LE99.8 – id 73
beginLifespanVersion								EI – id 14			

The conformance levels of the quality results of the cartographic database were defined as the quality results of the geospatial database

Full inspection | Sampling inspection (ISO 2859-1) | Sampling inspection (ISO 3951)

Project workflow - Phase 3

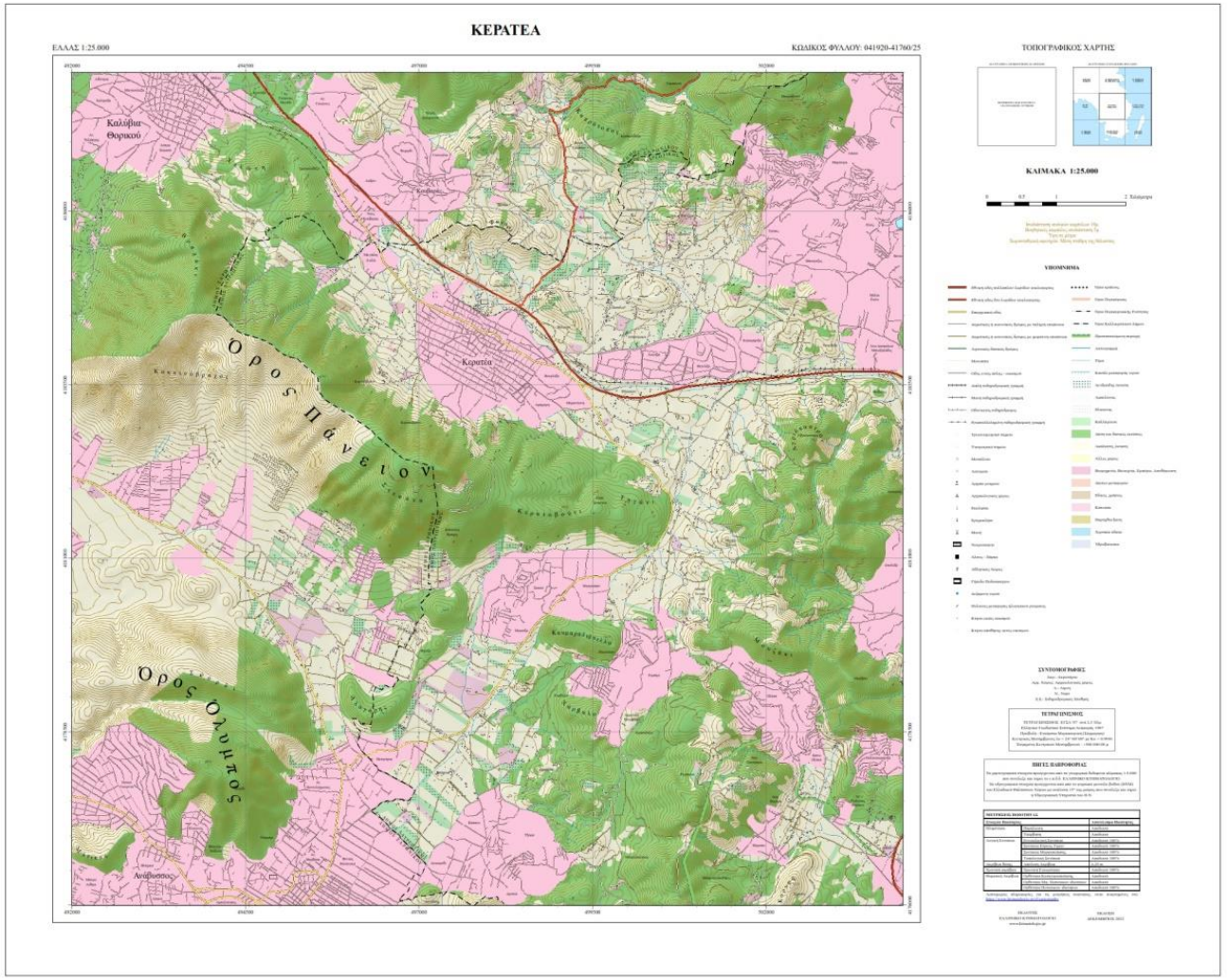


Map - Quality Model based on ISO 19157/13

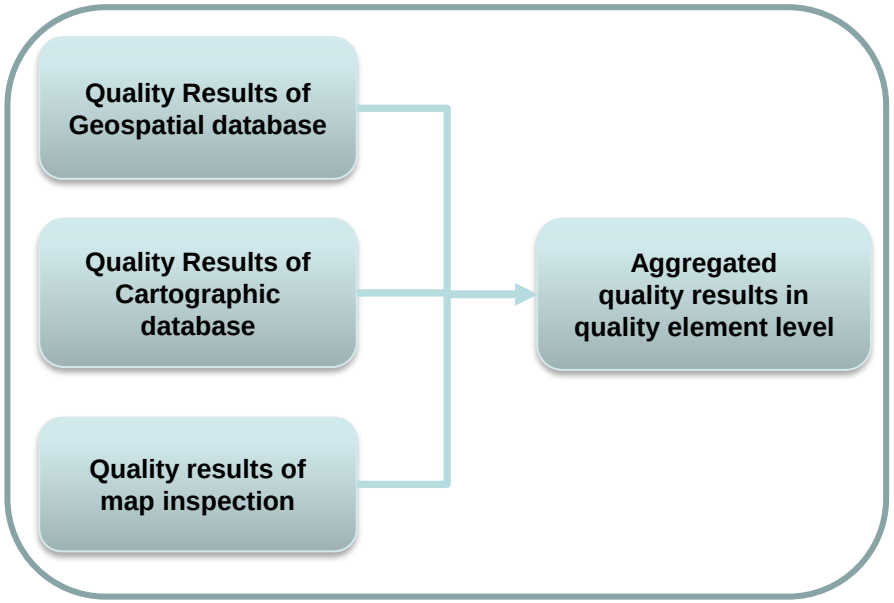
Map Quality Model						
Entity type & Attribute	QUALITY ELEMENTS					
	COMPLETENESS		LOGICAL CONSISTENCY	POSITIONAL ACCURACY	THEMATIC ACCURACY	
	COMMISSION	OMISSION	CONCEPTUAL CONSISTENCY	ABSOLUTE ACCURACY	CLASSIFICATION CORRECTENESS	NON - QUNTATITATIVE ATTRIBUTE ACCURACY
Map Sheet	Error count Id 2	Error count Id 6				
pointFeatureSymbol				Id 30	Error count Id 60	
pointSymbolAnnotation					Error count Id 60	
lineFeatureSymbol				Id 30	Error count Id 60	
lineFeatureAnnotation					Error count Id 60	
sufaceFeatureSymbol				Id 30	Error count Id 60	
annotaionSymbol					Error count Id 60	
sufaceTrasparency						Error count Id 65
featureRelationships			Correctness Indicator Id 9			
hierarchy						Error count Id 65
opticalBalance			Correctness Indicator Id 9			

Manual inspection

Map sheet


ΚΕΡΑΤΕΑ
ΕΛΛΑΣ 1:25.000
ΚΩΔΙΚΟΣ ΦΥΛΛΟΥ: 041920-41760/25
ΤΟΠΟΓΡΑΦΙΚΟΣ ΧΑΡΤΗΣ
ΚΑΙΜΑΚΑ 1:25.000
ΥΠΟΜΝΗΜΑ
Καλύβια Θορικού
Κερατέα
Όρος Πάνειον
Όρος Ολυμπός
Ανάβυσσος

Results – Quality results



Quality Measures		
Quality Elements		Quality results
Completeness	Commission	Accepted
	Omission	Accepted
Logical Consistency	Conceptual Consistency	Accepted 100%
	Domain Consistency	Accepted 100%
	Format Consistency	Accepted 100%
	Topological Consistency	Accepted 100%
Positional Accuracy	Absolute Accuracy	6.25 μ
Temporal Accuracy	Temporal Validity	Accepted 100%
Thematic Accuracy	Classification Correctness	Accepted
	Non-Quantitative Attribute Correctness	Accepted
	Quantitative Attribute Correctness	Accepted 100%

Reporting - Quality Documentation

QC Report template

ΕΡΓΟ: *Ονομασία έργου (π.χ. Σύνθεση χάρτη κλίμακας 1:25.000 για τη χώρα»*		**ΚΩΔΙΚΟΣ:**	*Κωδικός έργου*
ΦΑΣΗ ΥΛΟΠΟΙΗΣΗΣ: *Ονομασία φάσης υλοποίησης (π.χ. Βάση Γεωχωρικών Δεδομένων).*			
ΘΕΜΑΤΙΚΗ ΚΑΤΗΓΟΡΙΑ: *Ονομασία θεματικής κατηγορίας (π.χ. Διοικητικές Μονάδες)* **ΘΕΜΑΤΙΚΟ ΕΠΙΠΕΔΟ:** *Ονομασία θεματικού επιπέδου (π.χ. AdministrativeUnit)*		**ΗΜ/ΝΙΑ:**	*Ημερομηνία συμπλήρωσης της έκθεσης*

ΕΦΑΡΜΟΓΗ ΜΟΝΤΕΛΟΥ ΠΟΙΟΤΗΤΑΣ					
ΣΤΟΙΧΕΙΟ ΠΟΙΟΤΗΤΑΣ ΜΕΤΡΟ ΠΟΙΟΤΗΤΑΣ ΟΡΙΣΜΟΣ ΜΕΤΡΟΥ ΠΟΙΟΤΗΤΑΣ	**ΟΝΤΟΤΗΤΑ / ΙΔΙΟΤΗΤΑ ΑΠΑΙΤΗΣΗ ΠΟΙΟΤΗΤΑΣ**	**ΕΠΙΠΕΔΟ ΣΥΜΜΟΡΦΩΣΗΣ**	**ΑΠΟΤΕΛΕΣΜΑ ΠΟΙΟΤΗΤΑΣ**		**ΟΝΟΜΑΣΙΑ ΑΡΧΕΙΟΥ ΚΑΤΑΓΡΑΦΗΣ ΣΦΑΛΜΑΤΩΝ**
			Αποδεκτό	**Μη Αποδεκτό**	
ΠΛΗΡΟΤΗΤΑ (COMPLETENESS)					
Commission id 2 - Error count Number of excess items	*(1)* *(2)* *Παράδειγμα* *AdministrativeBoundary* *Δεν υφίστανται υπερβάσεις στο θεματικό επίπεδο που αποδίδει την ακτογραμμή*	*(3)*	☐	☐	*(4)*
Commission id 4 - Error count Number of duplicate feature instances	*(1)* *(2)*	*(3)*	☐	☐	*(4)*
Omission id 6 - Error count Number of missing items	*(1)* *(2)*	*(3)*	☐	☐	*(4)*
ΛΟΓΙΚΗ ΣΥΝΕΠΕΙΑ (LOGICAL CONSISTENCY)					
Conceptual consistency id 9 - Correcteness indicator Conceptual schema non-compliance	*(1)* *(2)*	*(3)*	☐	☐	*(4)*

QC Metadata template

DQ_DataQuality	
scope: MD_Scope	
level: MD_ScopeCode	AdministrativeUnits
report: DQ_Commission	
measure: DQ_MeasureReference	
nameOfMeasure: CharacterString	Number of excess items
measureIdentification: MD_Identifier	
code: CharacterString	2
measureDescription: CharacterString	Indication that an item is incorrectly present in the data
evaluation: DQ_SampleBasedInspection	
evaluationMethodType: DQ_EvaluationMethodTypeCode	directExternal
evaluationMethodDescription: CharacterString	Compare AdministrativeUnits in the data set against AdministrativeUnits in the universe of discourse. Selection of enough sampling units so that sample ratio is fulfilled. Visual inspection using reference data. Reference data is Municipality boundaries that presented to municipalities web sites.
evaluationProcedure: CI_Citation	
title: CharacterString	Quality Model of geospatial database
date: CI_Date	
date: Date	2019-10-11
dateType: CI_DateTypeCode	Publication

Conclusions

Provides, through the developed software application, the possibility of approximately 90% automation of the production process of the 1:25,000 scale map for the country, utilizing cadastral data, significantly reducing production costs and required resources.

Quality model provides an integrated structured quality assurance environment at every stage of the map composition process. It enables the producer to have a high level of control over the production process, to identify and manage errors, and to improve the production process and the quality of a product.

As a result of the implementation of the proposed quality models, the produced map has a known and documented quality.

Use of international standards in the development and implementation of the quality model and the harmonization of quality information with them

- ✓ ensures the interoperability of quality information, and
- ✓ provides an environment for applying consistent and objective quality inspection methods.

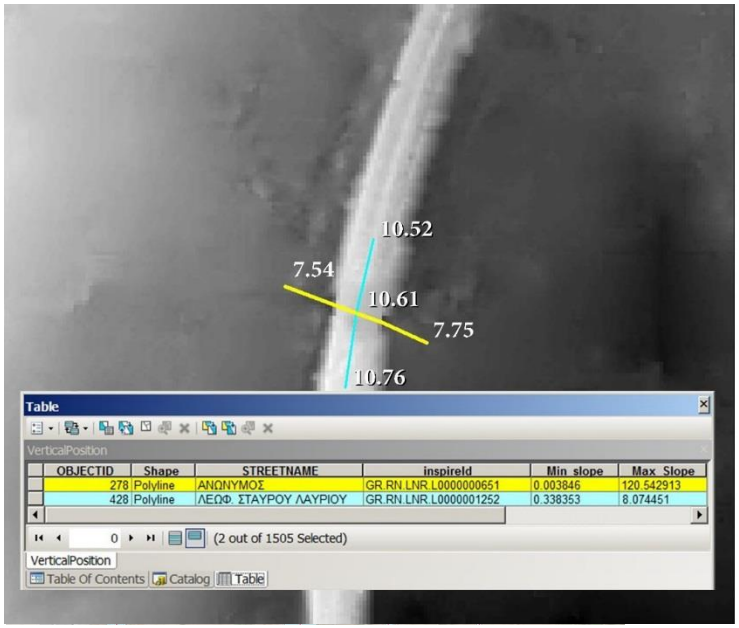
Feature work

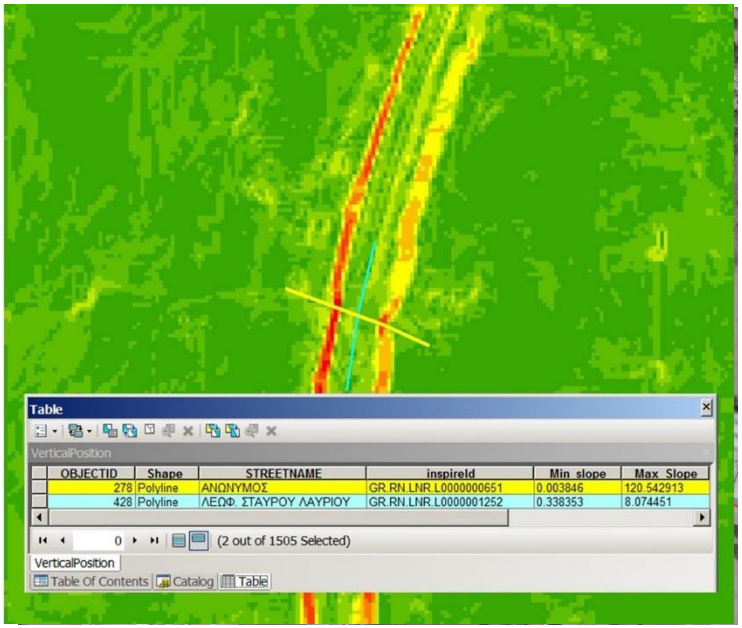
Future research may focus on the following:

- **Quality issues**
  - ✓ To analyze the needs, in terms of quality, of the different users of spatial data, by identifying and effectively recording how many and which of the quality parameters users want to be recorded and how.
  - ✓ To improve the way in which the results of the quality inspection are recorded and presented so that they are more comprehensible to the average user. ISO 19157:2013, although estimated to be complete and detailed in the documentation of the quality results and their recording, is mainly intended for specialized users.
- **Map improvement issues**
  - ✓ Revision of specifications to improve the 1:25,000 scale map.
  - ✓ Production of maps of various scales with documented quality, adopting the methodological approach proposed for the process of map synthesis.

Thank you for your attention

Geospatial database
Example of detection and indexing of overpass road nodes

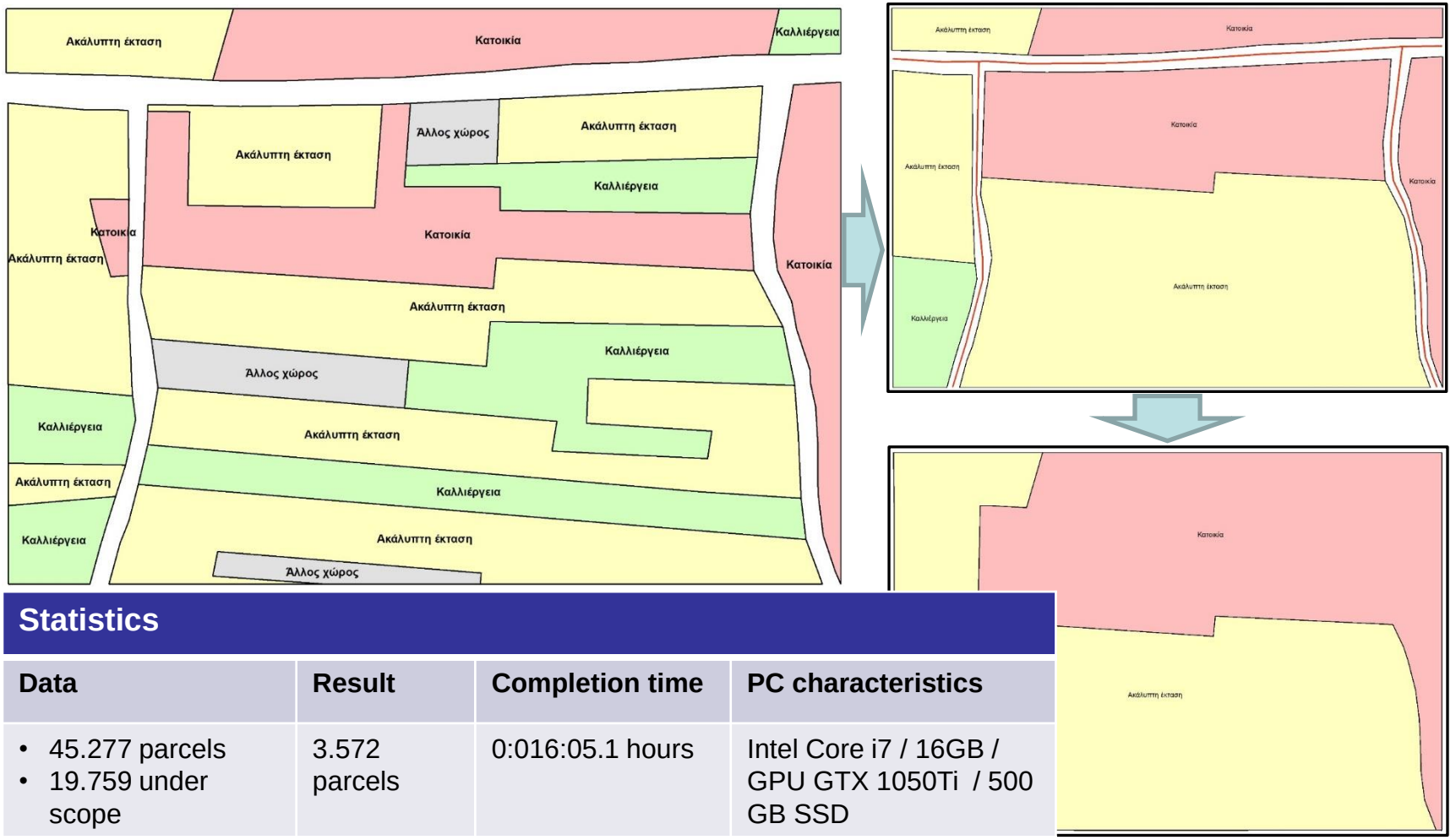




Statistics

Data	Result	Completion time	PC characteristics
• 28.655 roads • 13.974 road nodes • 2.291 road nodes under scope	7 overpasses	0:01:54.0 hours	Intel Core i7 / 16GB / GPU GTX 1050Ti / 500 GB SSD

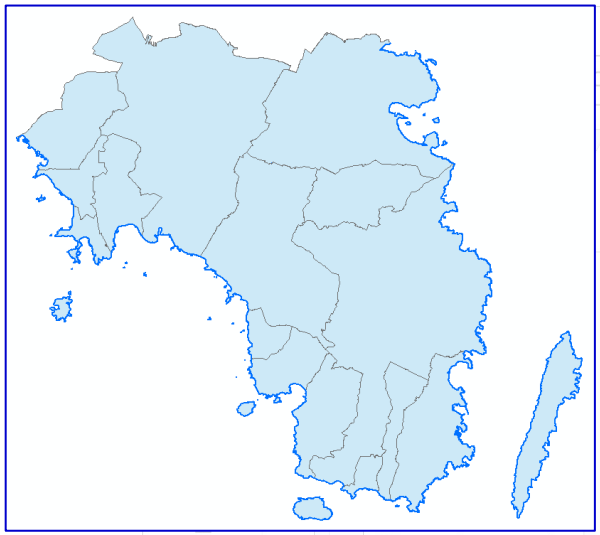
Cartographic database
Example of land use cartographic generalization

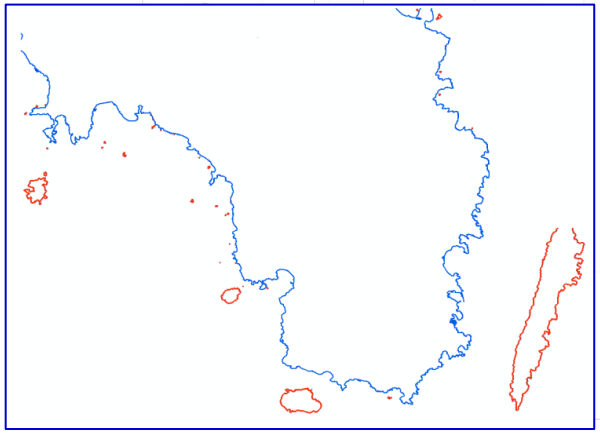


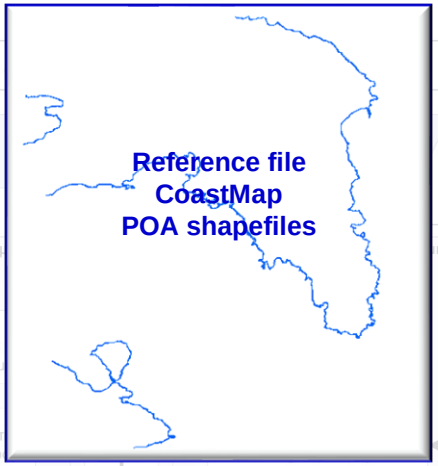
Statistics

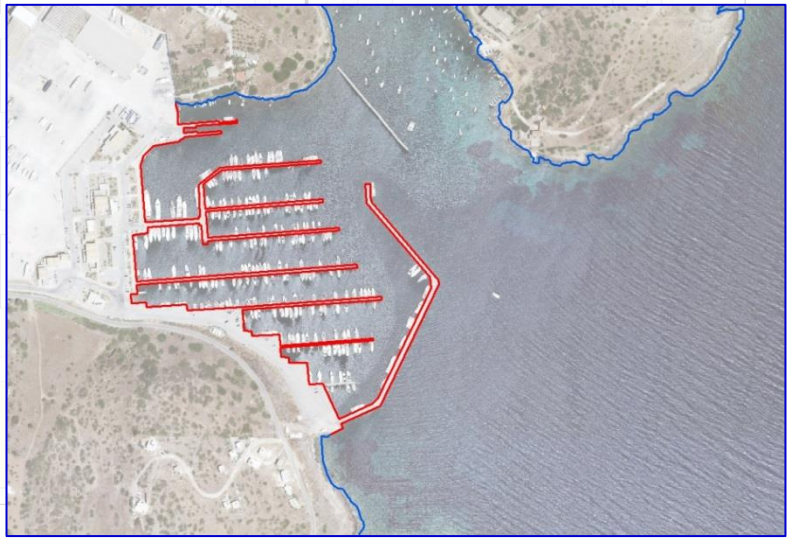
Data	Result	Completion time	PC characteristics
• 45.277 parcels • 19.759 under scope	3.572 parcels	0:016:05.1 hours	Intel Core i7 / 16GB / GPU GTX 1050Ti / 500 GB SSD

Cartographic database
Example of coastline cartographic generalization (1)

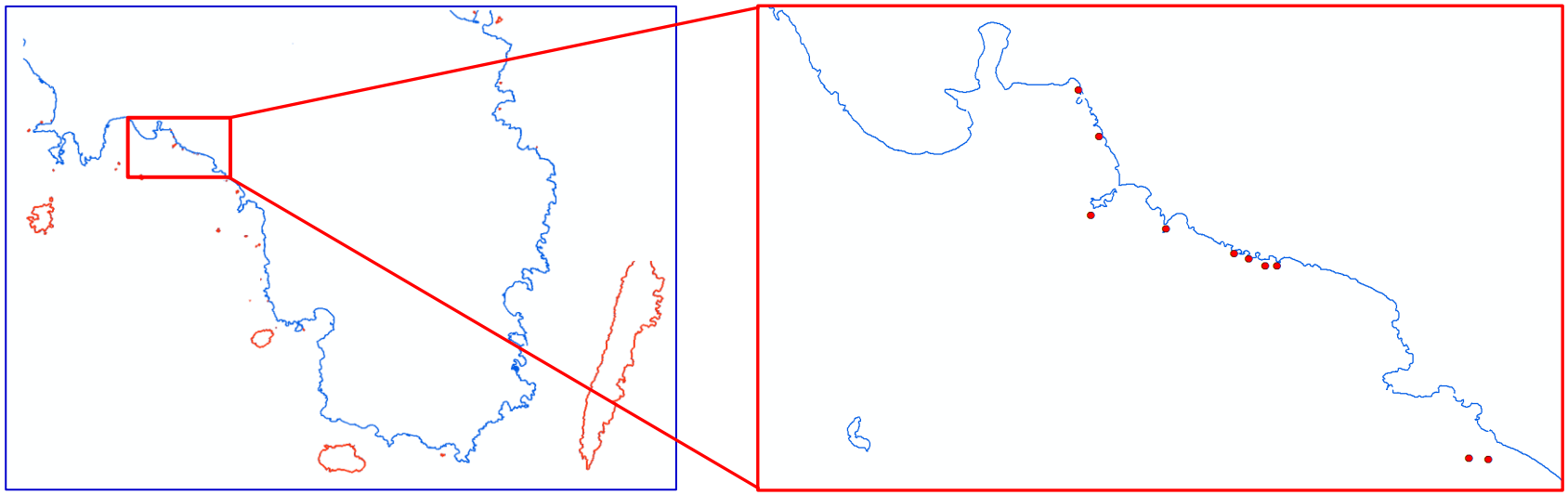
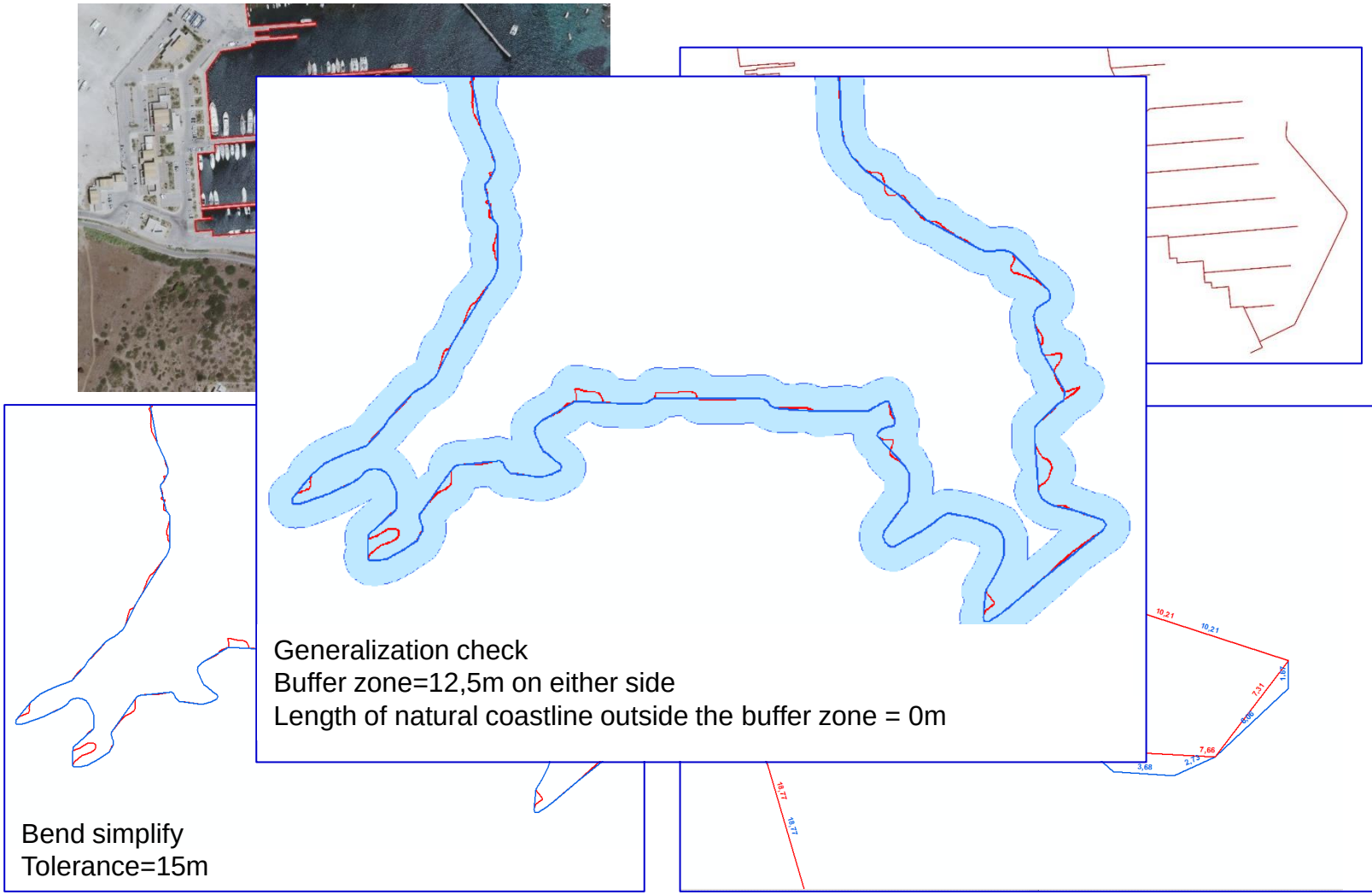








Cartographic database
Example of coastline cartographic generalization (2)



Cartographic database
Example of coastline cartographic generalization (3)