Quality Assessment in the framework of Map Generalization

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Introduction

- Map quality refers to the overall characteristics of the map/chart considered as a communication and reference medium for measurement and decision making
- Why we need to assess map quality??
- What it takes to assess map quality??
  - Identification of the quality characteristics of the map, which can lead to an overall estimation of quality
  - Analysis and quantitative assessment of the quality components
  - Utilization of spatial data of known quality, based on internationally adopted standards (Spatial data of known and acceptable quality is not by itself adequate to confer map/chart quality)
  - Development of a cohesive methodology for quality assessment

Advantages in Adopting Map Quality Assessment

- **For map/chart producers ensures:**
  - Early error detection
  - Faster product turnaround
  - Reduced maintenance costs
  - Consistent evaluation procedures
  - Improved product and increased customer satisfaction
  - Protection from liability issues
- **For map/chart users results to:**
  - Map/chart that is trusted and usable
  - Improved spatial analysis results
  - Confident decision making
  - Improved customer experience

Components of Map/Chart Quality

- **Geometric quality:** refers to the degree of compliance of absolute or relevant positions of the features portrayed on maps/charts and their geometry with the limits set in the specifications
- **Thematic quality:** refers to the correctness of the categorization of the entities with respect to their attributes and the degree of compliance of the attribute values with those provided in the specifications
- **Aesthetic/graphical quality:** refers to the quality assessment of the map portrayal considered as the communication medium and the graphical model of the area portrayed*

* Geometric & Thematic quality are addressed in the framework of this work

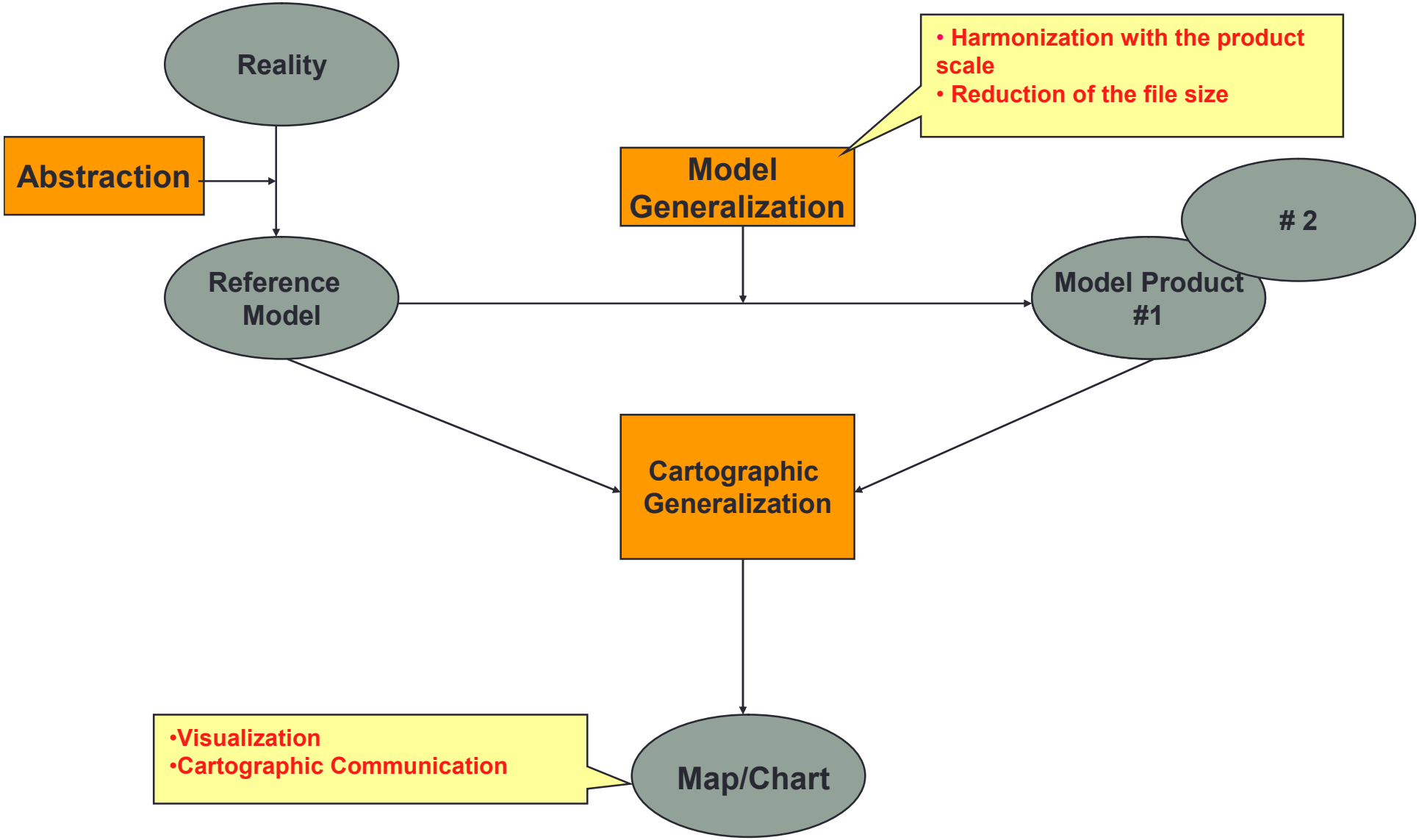
Methodology

- Design and implementation of a Quality Model that will provide quality indicators in each phase of the map composition process
- Qualitative assessment of the map/chart data resulting from each phase to ensure the integrity of the process (otherwise there is no sense to proceed with the next composition phase)
- The Quality Model will include:
  - the tools necessary for quality assessment (*quality elements and* the corresponding *quality measures)*
  - the *quality conformance levels* and the process of determining map quality against the set specifications
  - the recording of the results and
  - their synthesis for the overall assessment of map quality.

Building blocks of the Quality Model

1. Map/Chart Specifications
2. Quality criteria and Conformance levels (result from the specs)
3. Map Composition Process
    - Model Generalization
    - Cartographic Generalization
    - Symbolization
    - Toponyms
4. Quality control and Quality assessment

Model & Cartographic Generalization



Building block #1
Map/Chart Specifications

- Conceptual Model:
  - Identification of the thematic categories of the cartographic database with their respective attributes
  - Description of relationships between categories
  - Criteria for the inclusion of an entity in a thematic category (class intension rules)
- Logical Model
  - Implementation of provisions of the conceptual model
- Physical Model
  - Application environment

Building block #2 - Model Generalization

Issues*:

a. Transformation of the reference/source database schema to the cartographic data base schema (model)

b. Object and attribute aggregation

*These issues should be resolved before data transfer from the reference to the cartographic database otherwise information loss, object misclassification will occur

Building block #2 - Model Generalization

Model generalization involves:

1. Identification of the source data (classes, objects, attributes) required according to the cartographic database schema specifications
2. Actions:
   - Generalization of the source data schema
   - Change in data categorization
   - Modification of the relevant attributes
3. Migration of data from the source database into a temporary database where transformations are executed
4. Quality control on the data of the temporary database.

Building block #2 - Model Generalization Quality criteria

Criteria based on Conceptual Model

- Correct categorization of the entities and their attributes
- Conceptual consistency of entities' relationships
- Correct recording of attributes

Criteria based on Logical Model

- Geometry of entities
- Topological relationships

Criteria based on Physical Model

- Format of attributes

Building block #2 - Model Generalization Results

- Quality results are acceptable or not acceptable
- If the results are not acceptable, data migration from the temporary database to the cartographic one is not carried out and new transformations are executed until results comply with the adopted conformance levels
- The resultant cartographic database is considered as **"error free"** and its content is readily available for input to the subsequent phases of map composition (cartographic generalization, symbolization).

Application on Model Generalization [I]

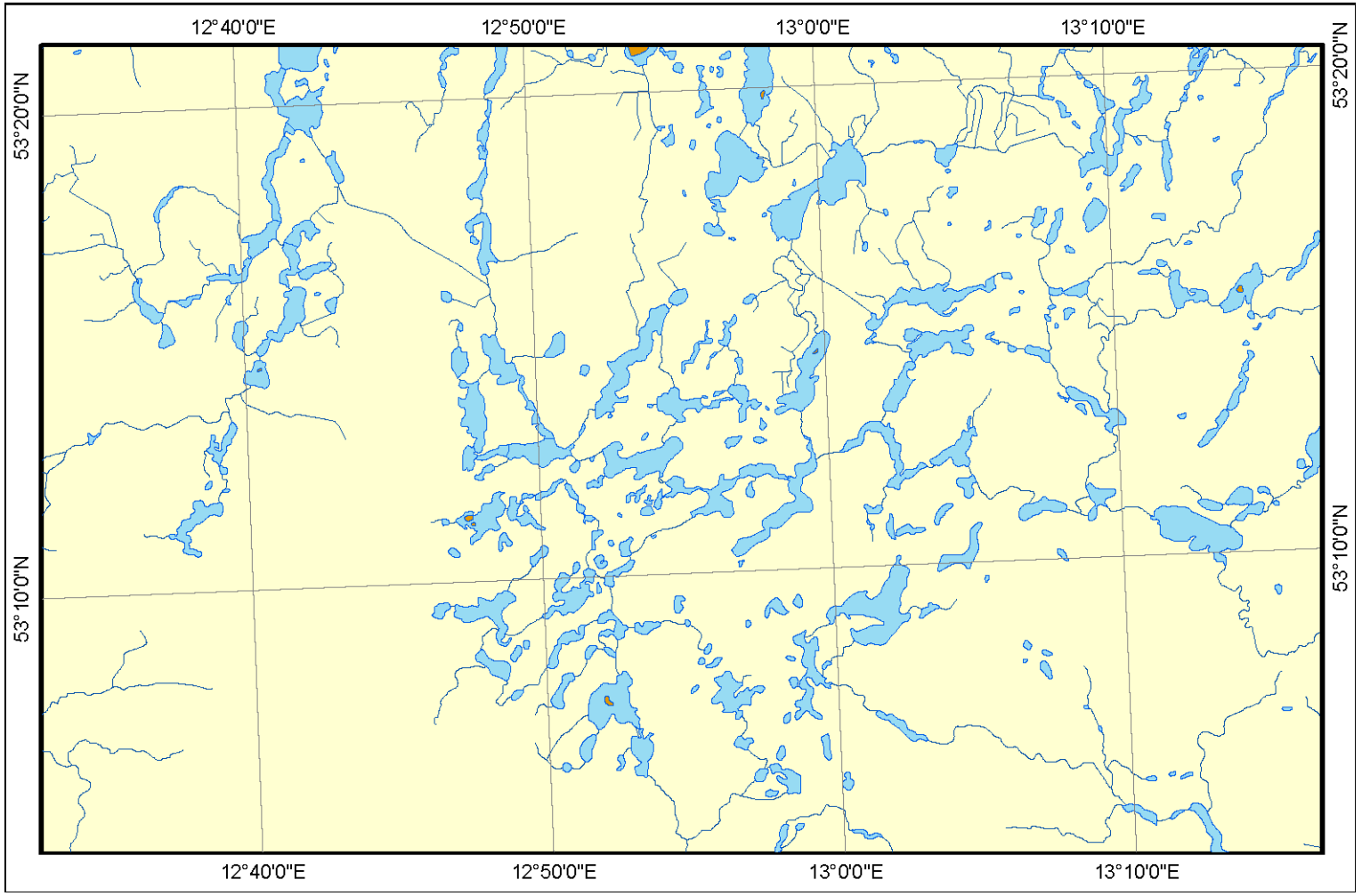
- Input data set: scale 1:250.000
- Map to be produced: scale 1:1.000.000
- Features: lakes & rivers

Application on Model Generalization [II]

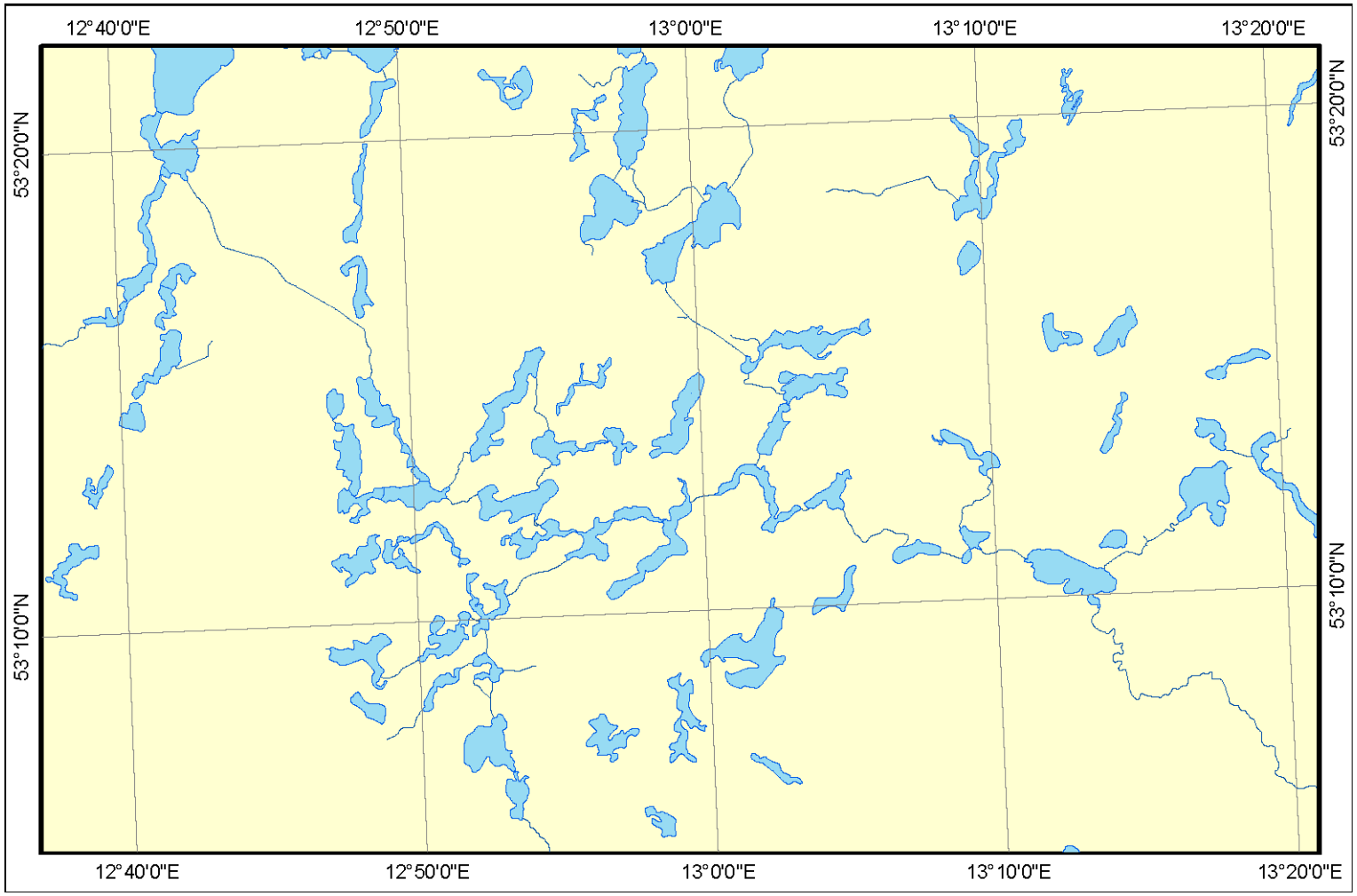
Quality element, measure and conformance levels for feature LAKES

Feature type/ Attribute	**Quality Element/ Sub element**	**Quality Measure**	**Description**
LAKE	Completeness/ Commission	Error count /id 2	*Scope*: All items classified as "LAKEs" in the dataset.
Feature Definition: A body of water surrounded by land		Number of ex-cess items (Full inspection)	*Measure*: All lake areas larger than 0.5 km2.
			Measure definition: Number of excess items in the data-set in relation to the number of items that should have been present.
			Evaluation method descrip-tion: Count the number of items with Area < 0.5 Km2.
			Evaluation method type: Internal
			Result value type: Integer
			Result unit: Number
			Conformance level: Zero commissions in dataset

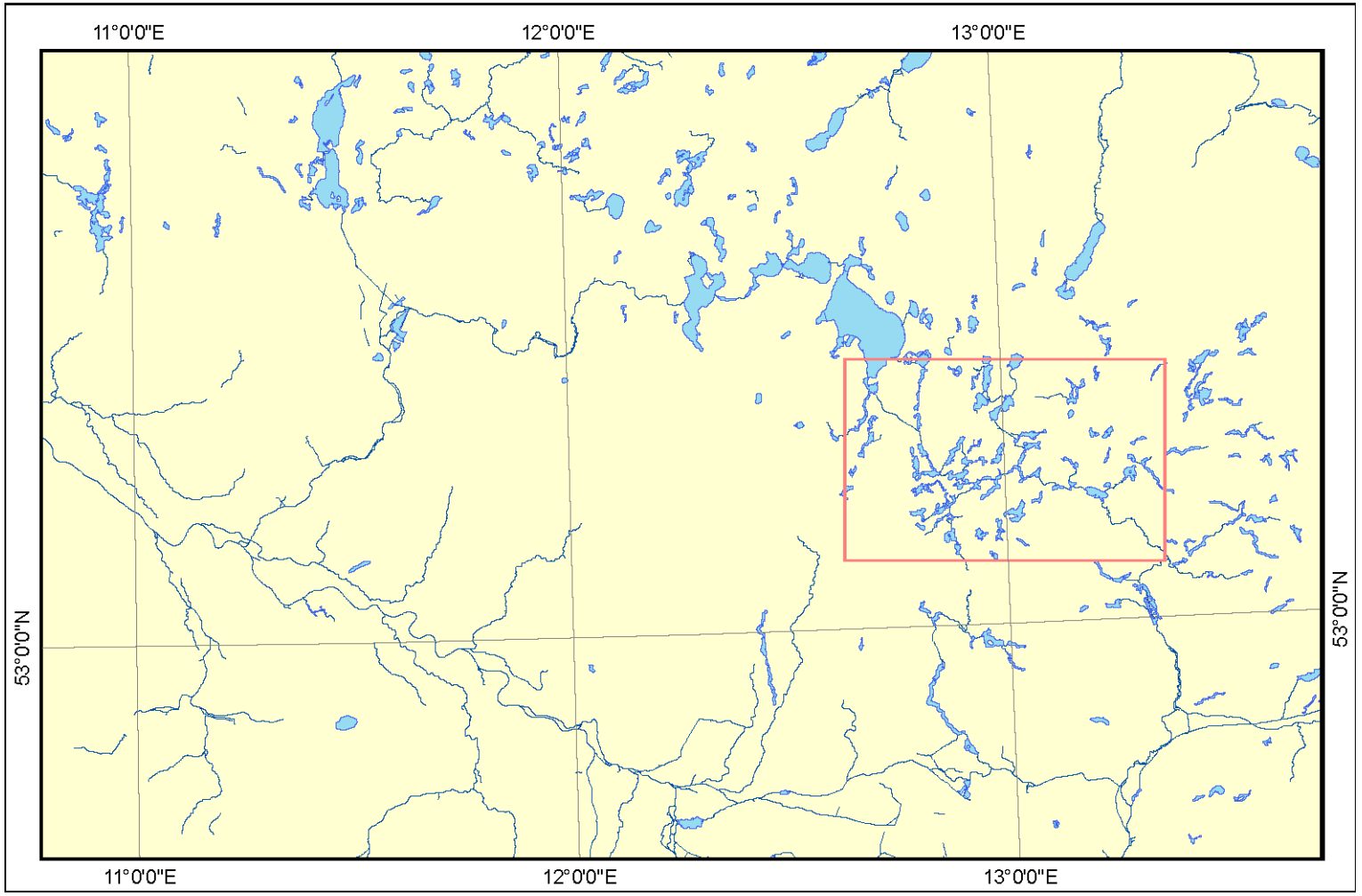
Hydrographic network - original data (scale 1: 250 000)



Hydrographic network - after model generalization (scale 1: 250 000)



Hydrographic network - after model generalization (scale 1: 1 000 000)



Building block #3 - Cartographic Generalization

Quality assessment in cartographic generalization involves:

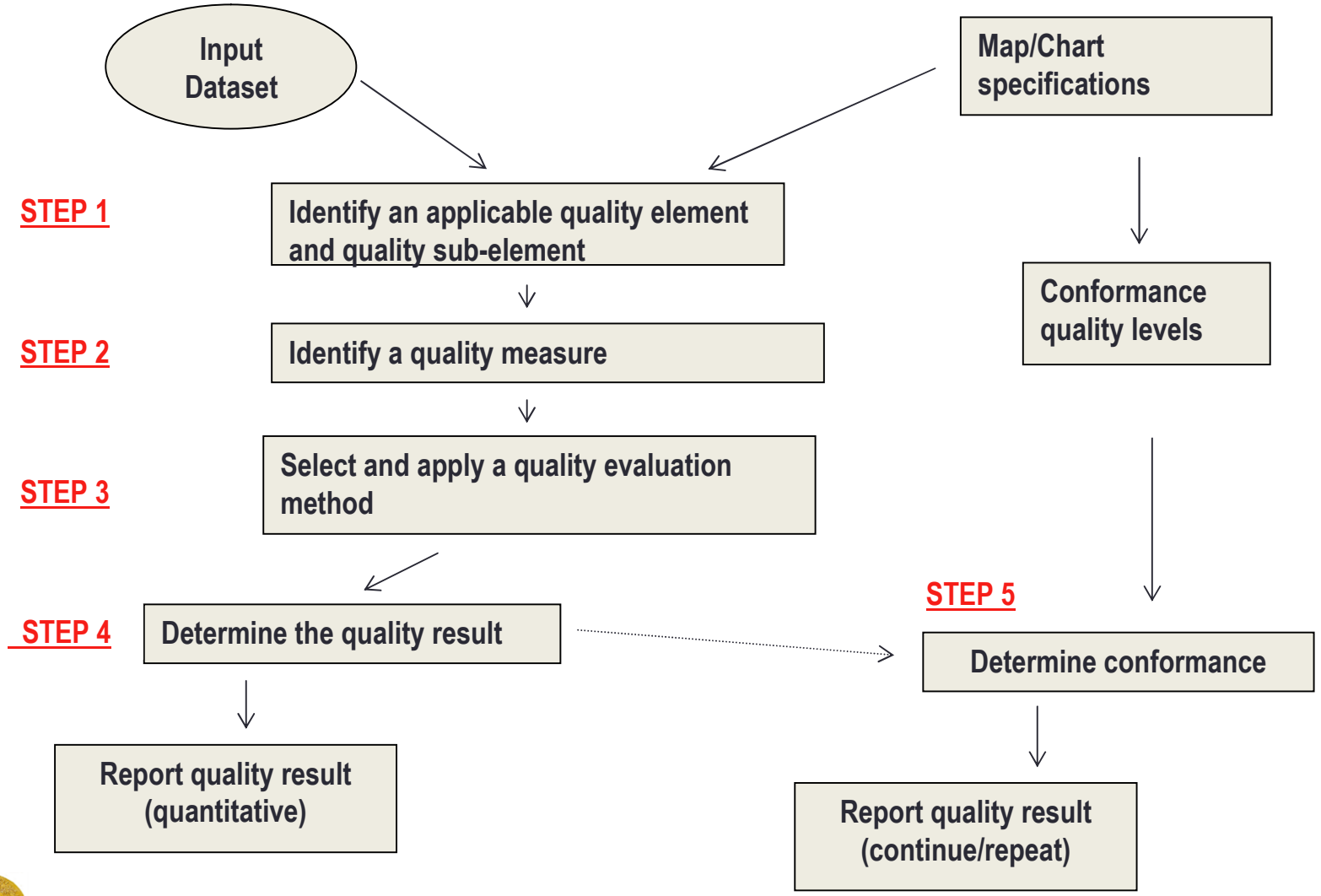
- Identification of map quality requirements based on map specifications and setting of the respective conformance levels
- Selection of generalization algorithm/parameter value and execution
- Quality checks of the result based on the ISO quality elements (completeness, logical consistency, topological consistency and positional accuracy) complemented with the extra element of “shape similarity” for lines and polygons
- Cartographic data correction and quality checks until the results meet the acceptable conformance levels
- Report results

Building block #3 Cartographic Generalization Quality criteria - Quality control

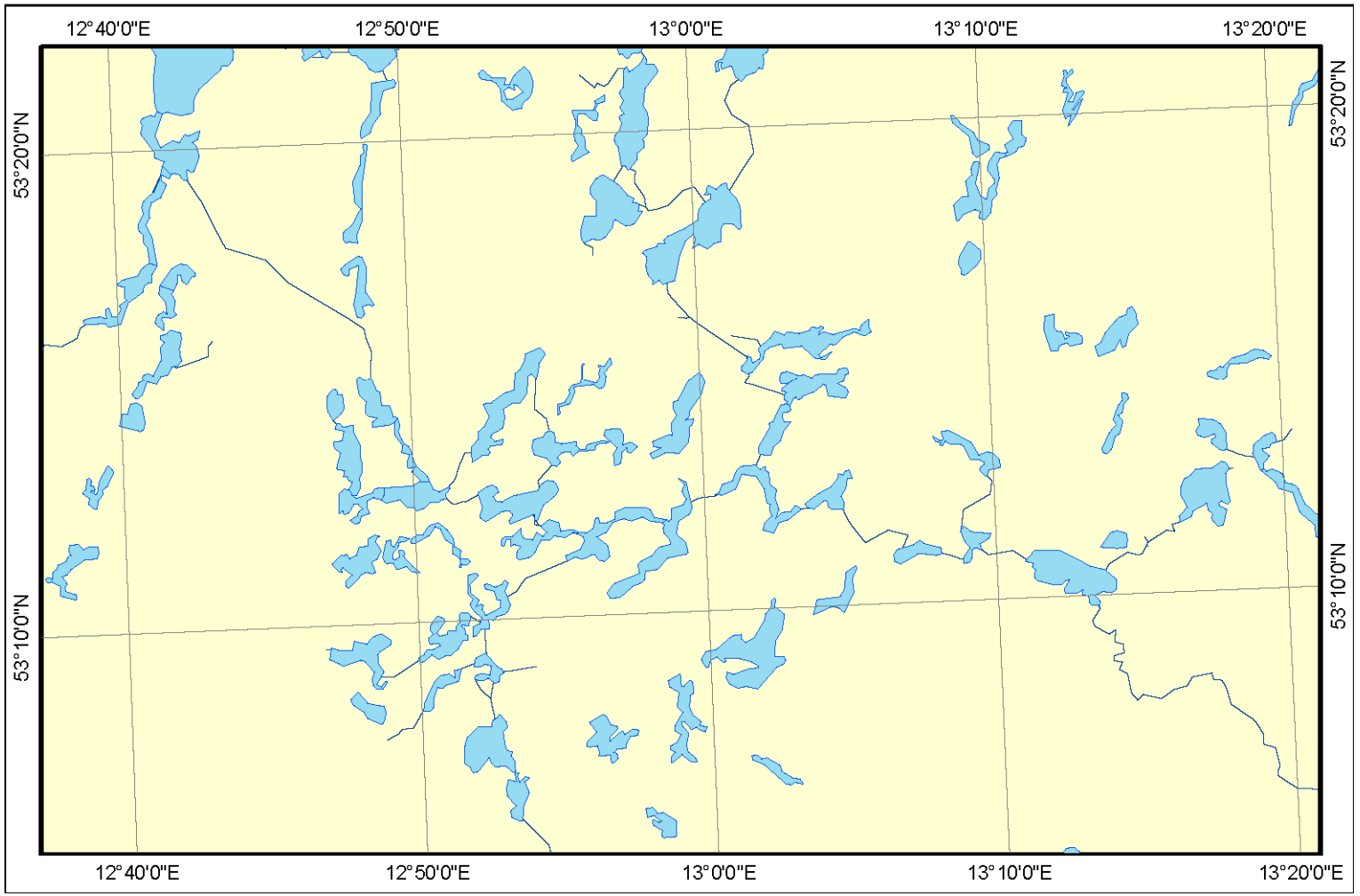
Availability of a quality indicator for every transformation carried out during the map composition process, prohibits the cartographer to proceed unless the assessed phase gives acceptable results

- Identification of features that changed their type or were deleted due to generalization
- Identification of conceptual/logical inconsistencies resulting due to deletion of features or other factors
- Identification of topological inconsistencies due to shape change
- Positional displacement of features
- Linear – Polygon features' shape change

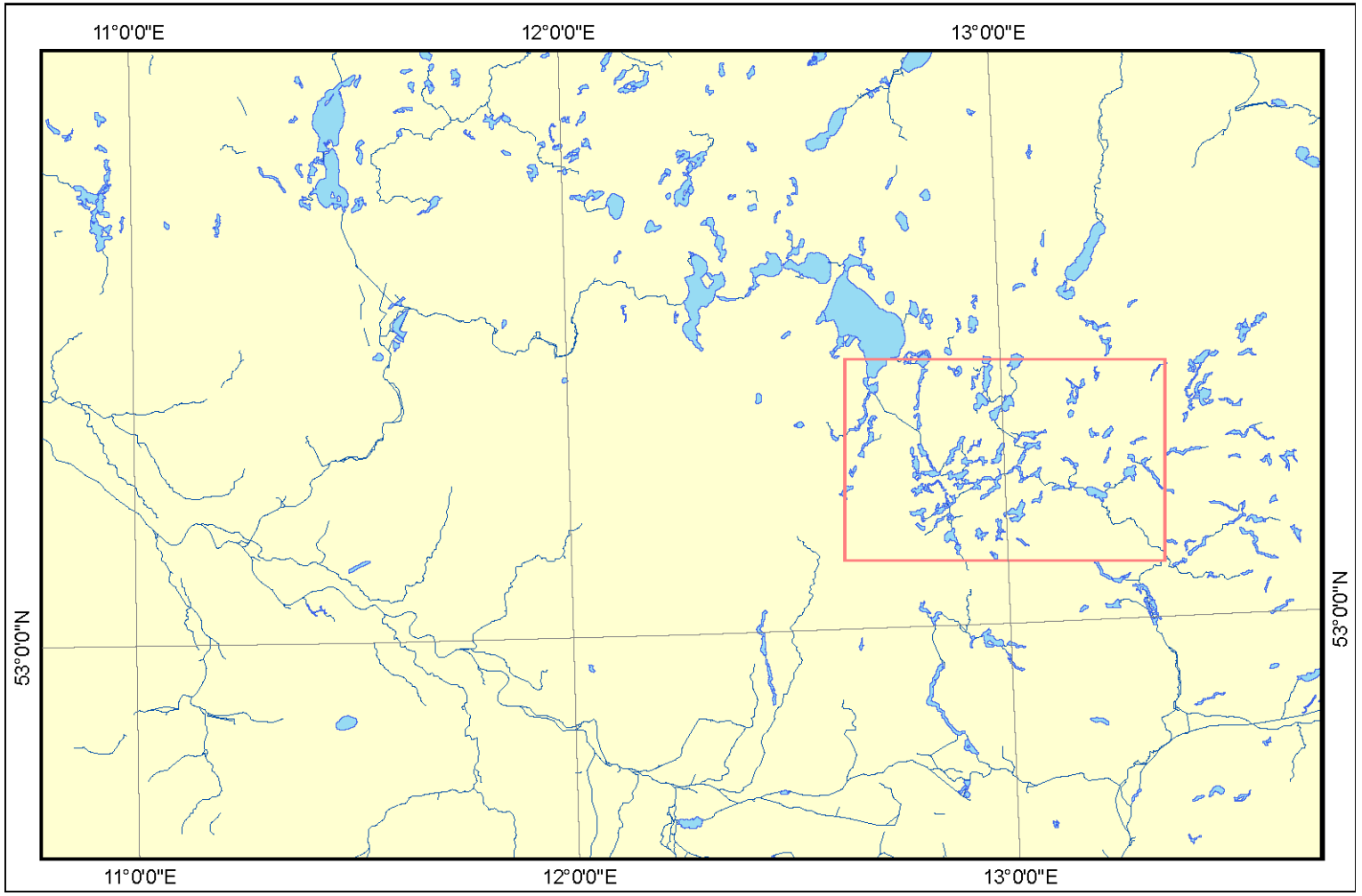
Map/Chart Quality Assessment Process



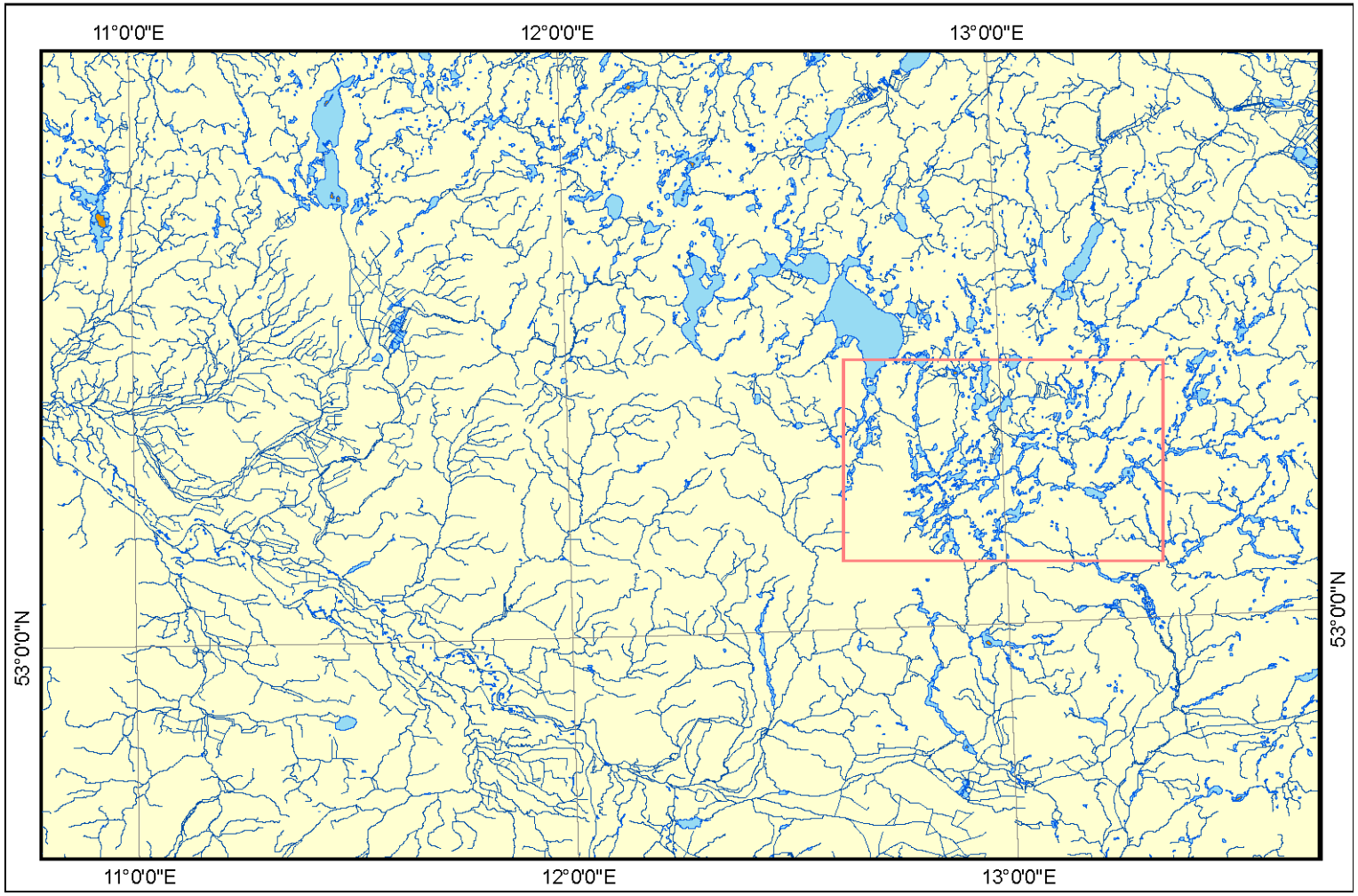
Hydrographic network - after cartographic generalization (scale 1: 250 000)



Hydrographic network - after cartographic generalization (scale 1: 1 000 000)



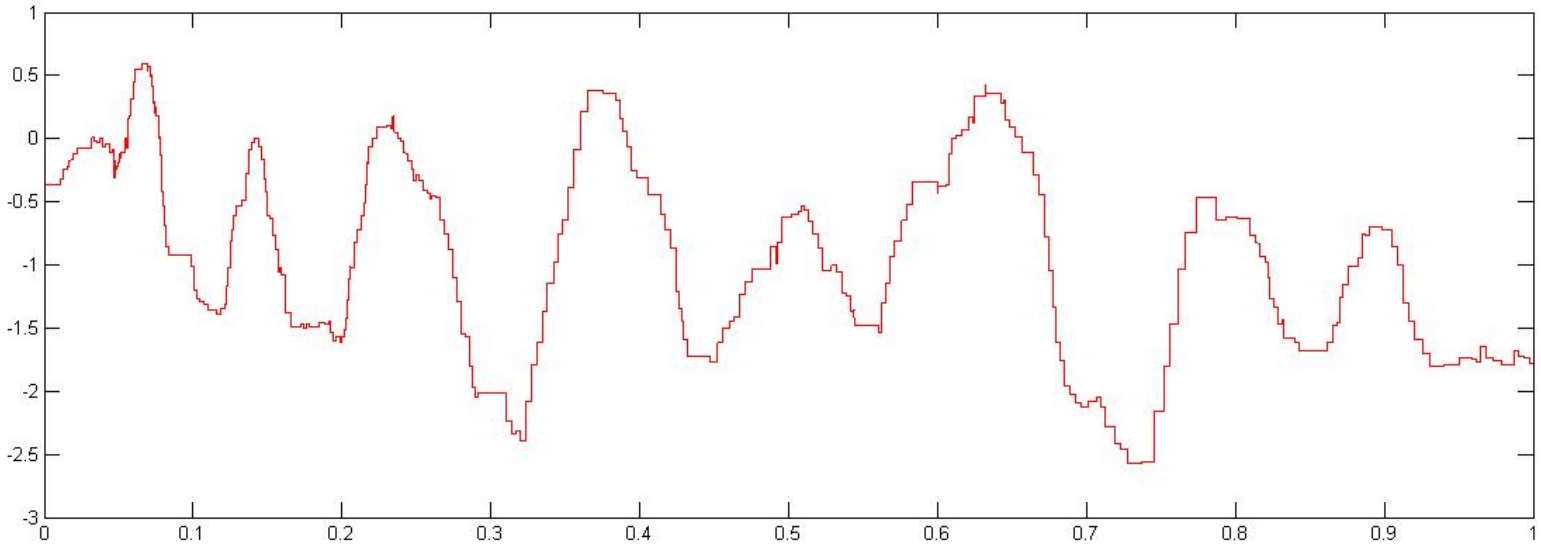
Hydrographic network - before model & cartographic generalization (scale 1: 1 000 000)



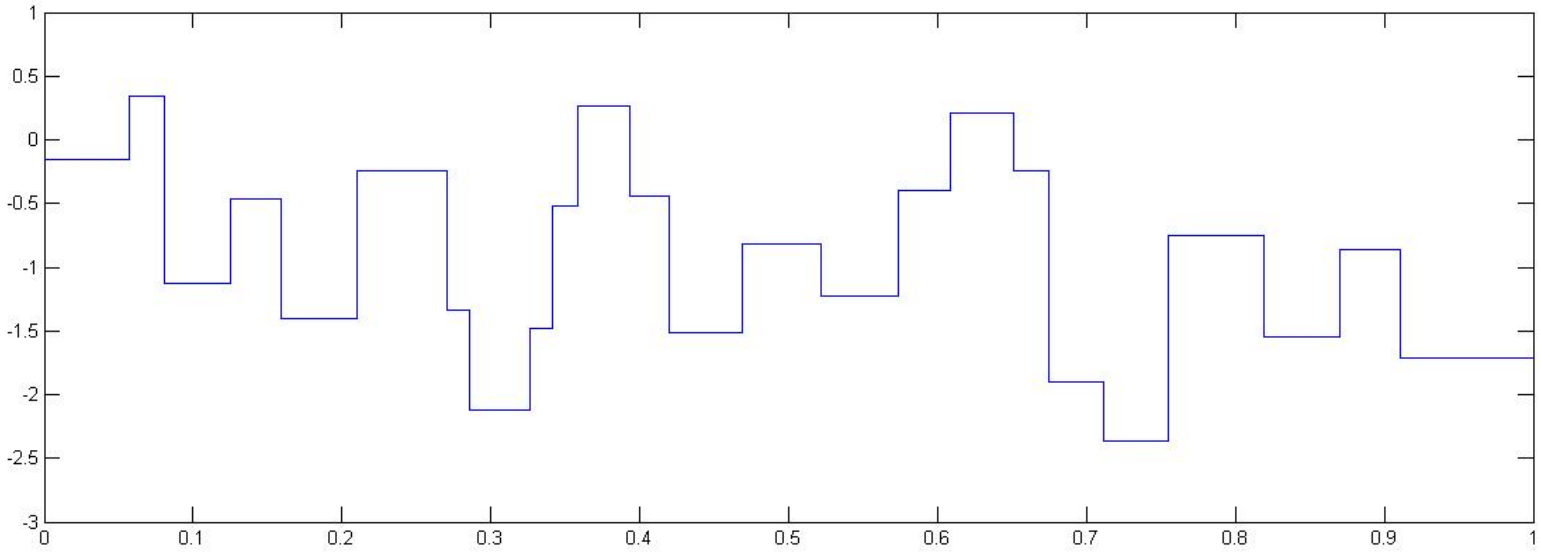
Cartographic Generalization
New Quality elements & Measures

- "Shape similarity" complementary to the ISO quality elements has been adopted in the proposed model to control shape change
- Assessment of shape change of lines and polygons utilizes the 'turning function' (Arkin *et al*., 1991)
- Turning function does not depend: a. on change of scale b. on rotation and c. on translation (change of position)
- Results are reported as a shape similarity measure between the initial object and the object after generalization
- Positional displacement of features is assessed using the percentage of a feature length outside of buffer zone whose width is equal to the level of acceptable positional accuracy (Goodchild and Hunter, 1997).

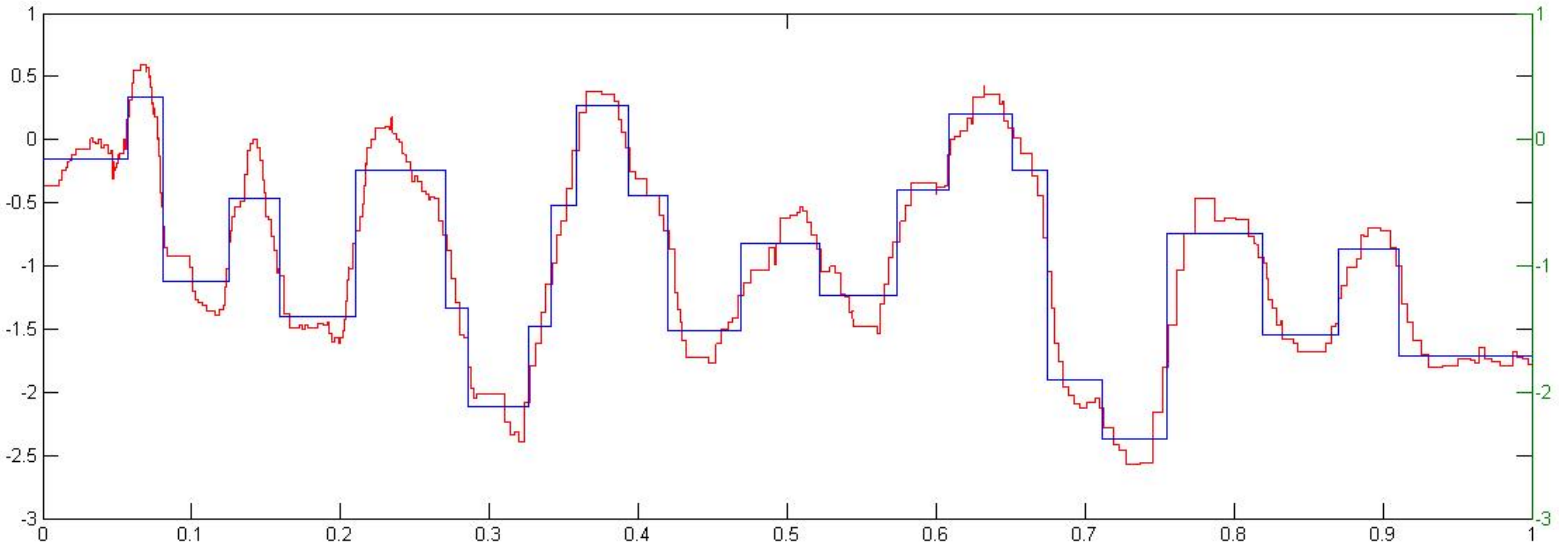
Cartographic Generalization - Shape similarity
Turning function – Original line



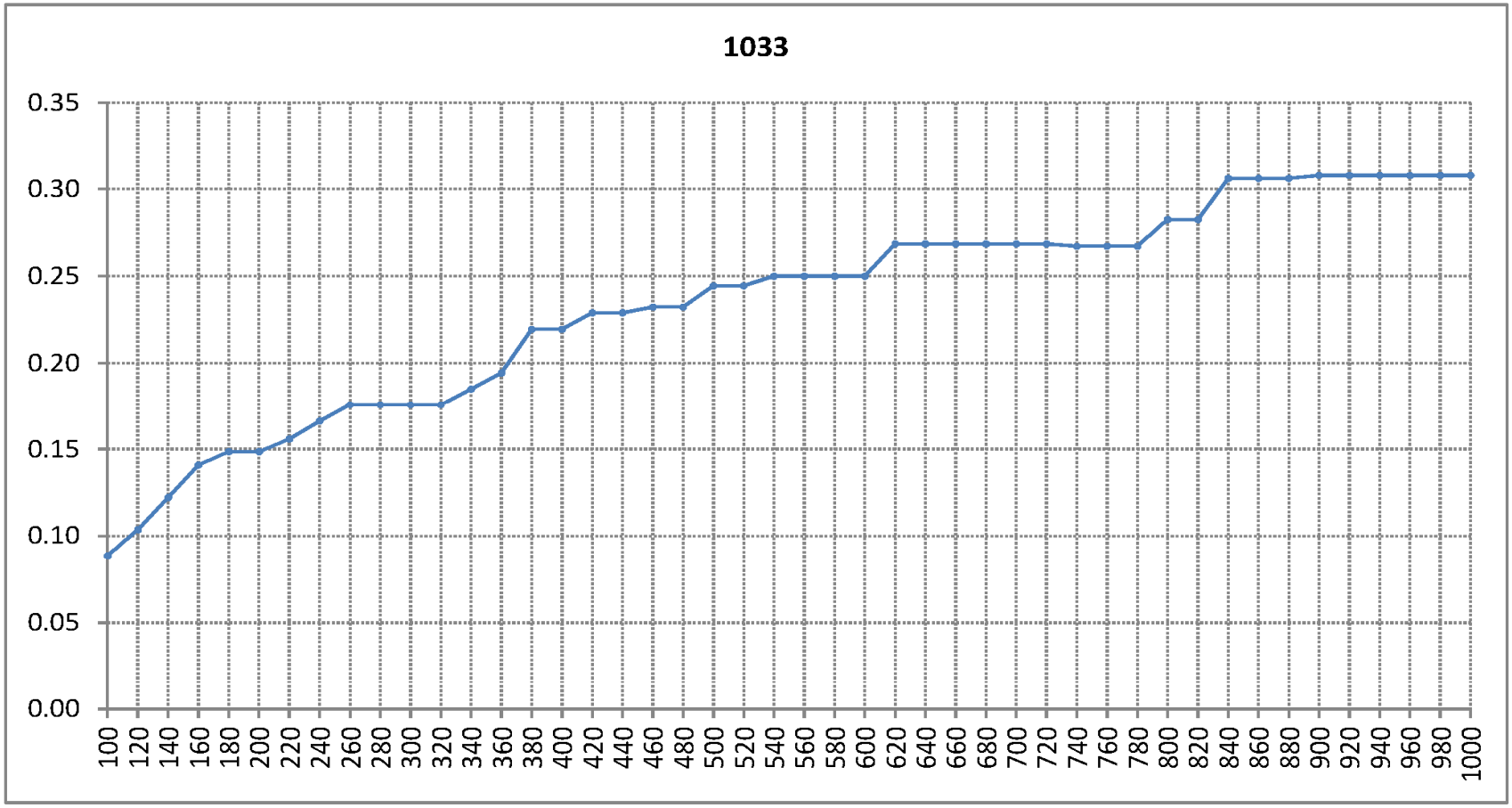
Cartographic Generalization – Shape similarity
Turning function – Generalized line (tol = 300 m)



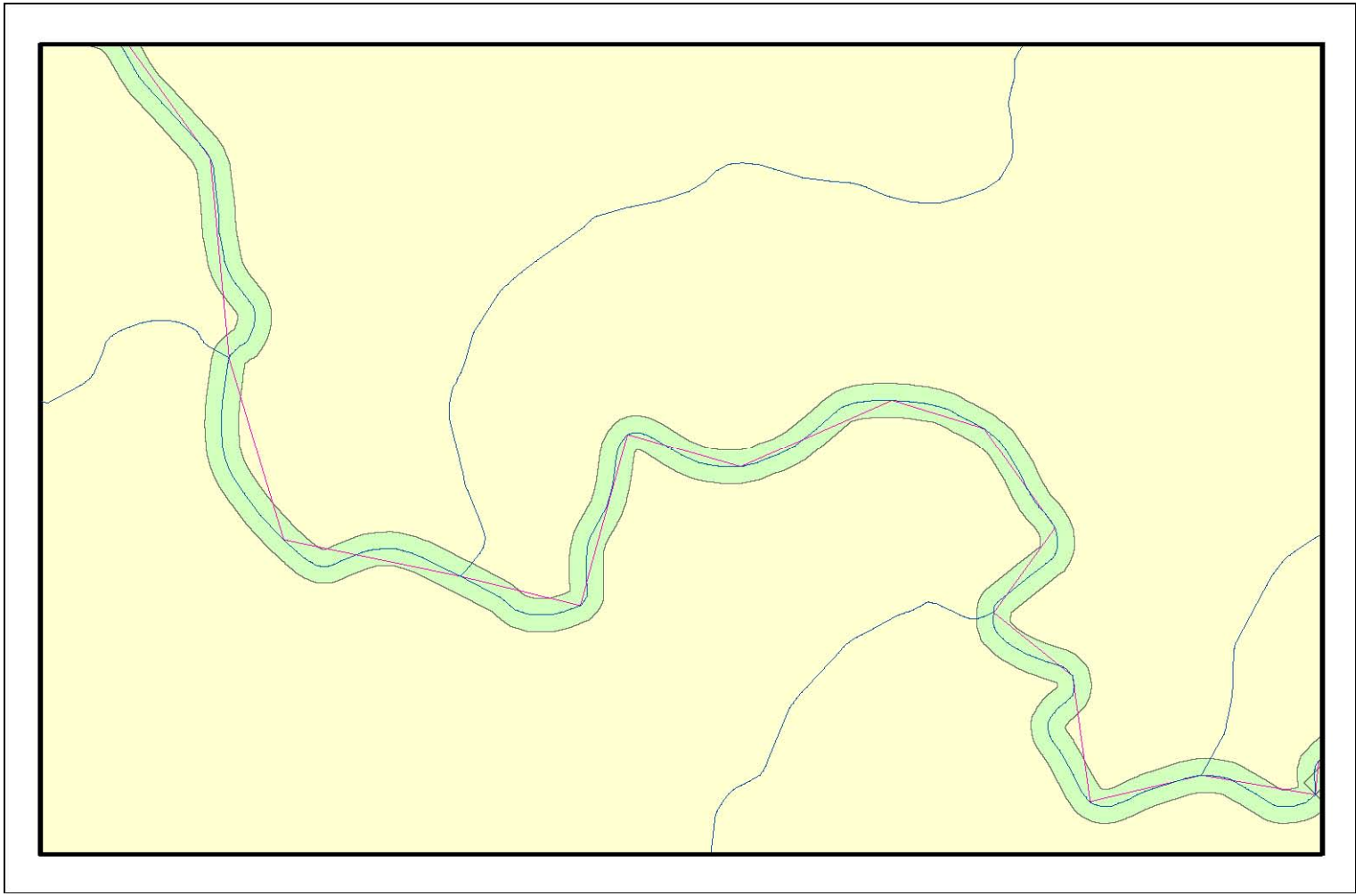
Turning function – Original & Generalized line



Turning function
Variation with respect to the Tolerance used



Positional Displacement
Percentage of a feature length outside the buffer zone



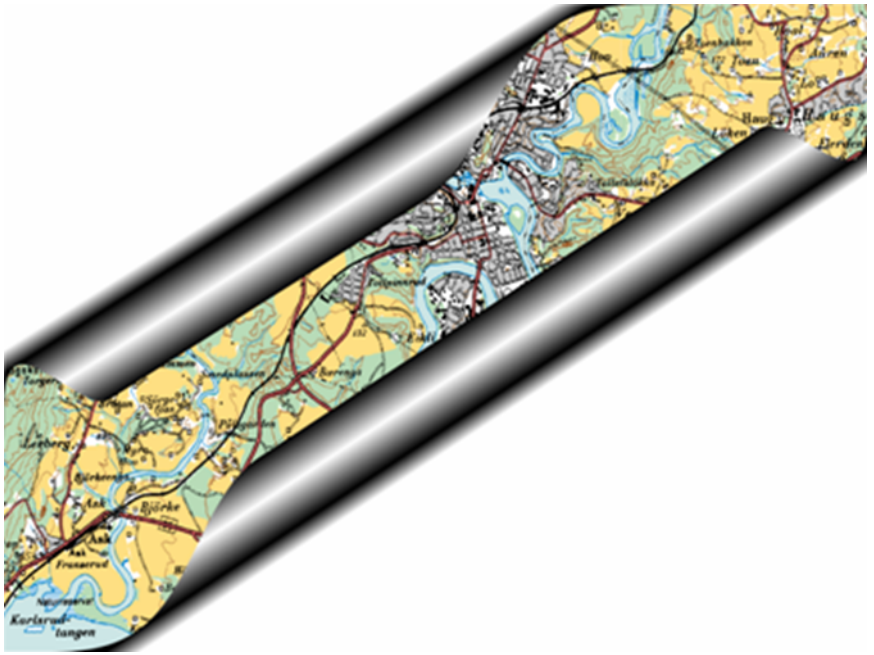
Cartographic Generalization - Quality control Results

- Quantified results for each phase in the map composition process are available
- Compliance with the adopted conformance levels enables the cartographer to proceed to the next phase
- If the results are not acceptable, the specific phase is repeated through the selection of a different generalization algorithm/parameter that gives acceptable results
- This approach monitors the consequences of cartographic generalization and verifies that the map produced is composed according to the specs.

Future work

- Further analysis of the Turning Function characteristics to identify critical values for shape similarity of lines and polygons
- Development of quality models for more themes
- Automation of the process
- Aggregation of the quality assessment results

Thank you for listening!!!



Questions??