TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

The automatic generalization of buildings whilst maintaining the settlement structure

A case study based on the 1:50`000 Swiss National Map Series

Anna Vetter – 05.12.2014

The Structure

1. Introduction
2. Theoretical foundation & state of the art
3. Methodology
4. Practical implementation
5. The evaluation: assessing the cartographic quality
6. Conclusion and outlook

1. Introduction

- Context and relevance of the topic

Generalisation →  in 

↓

Save ressources, to ensure efficiency, to maintain an update circle

Automated generalisation is from high interest for NMA`s

1. Introduction

- What is this research about?

automated generalisation of buildings

TLM (1:10`000) ⟶ DCM (1:50`000I)

whilst maintaining the settlement structure

- Why is automated building generalisation from that high importance to swisstopo?

1. Introduction

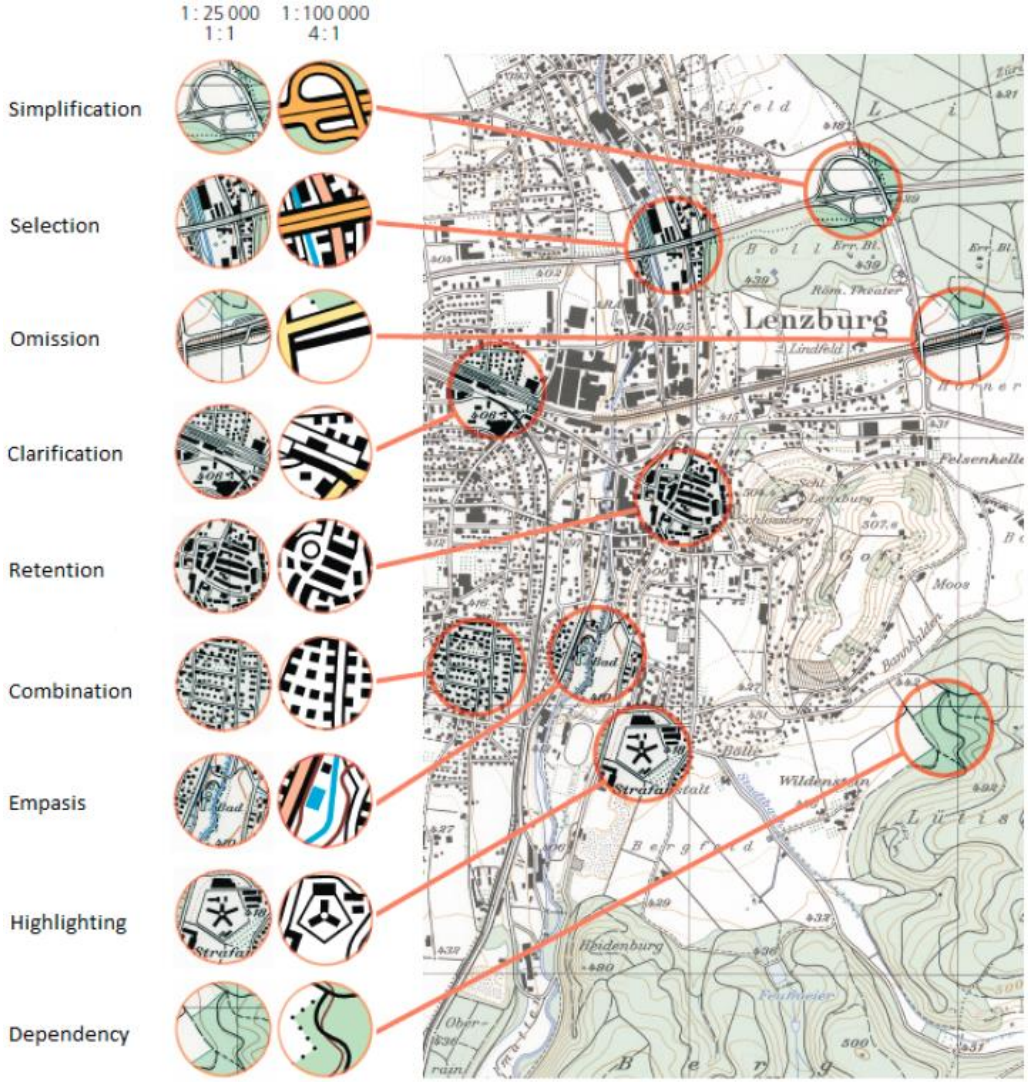
- Task and objectives

The research will indicate whether it is possible to automatically generalise the buildings for the scale of 1:50`000 under the requirement of keeping the settlement structure with ArcGIS out-of-the-box generalisation tools.

- Description of the current state of the art
- Development of an appropriate workflow
- Verification of the results quality

2. Theory & state of the art

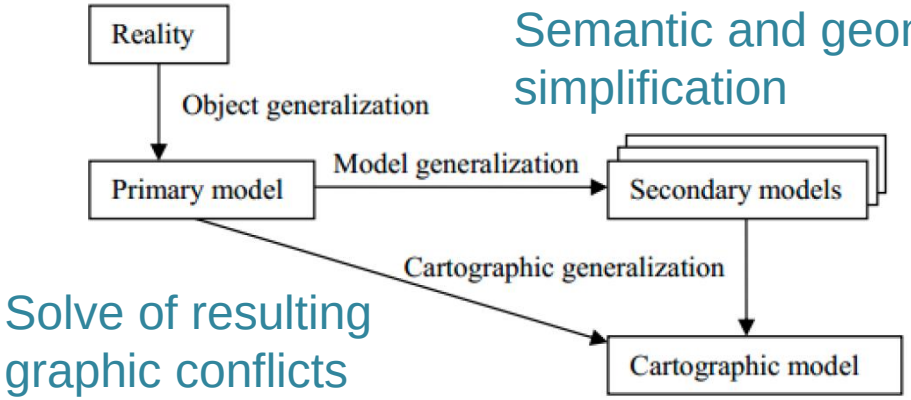
- Crucial aspects when generalising



Crucial aspects of generalisation (Spiess et al., 2002)

2. Theory & state of the art

- The concept of generalisation



Generalisation model of Gruenreich (1992)

- Operators according to Gruenreich and classified by Forster et al. (2007)

Model generalisation	Cartographic generalisation:
Class Selection	Enhancement
Reclassification	Displacement
Collapse	Elimination
Combine	Typification
Simplification	Amalgamation
Amalgamation	

2. Theory & state of the art

- Considerations when generalising buildings
  - Selection
  - Graphic generalisation
  - Generalisation of the shape
  - Retaining the settlement structure
    - Retaining density
    - Preserving size differences
    - Retaining orientation
    - Retaining distribution
    - Retaining characteristic ground plan shapes
  - Shifting and Displacement

2. Theory & state of the art

- The EuroSDR-Project
  - Identification of NMAs requirements when generalising
  - Pointing out possibilities and limitations of commercial out-of-the-box generalisation systems [ArcGIS (Esri), Change/Push/Typfiy (University Hanover), Radius Clarity (1Spatial), axpand (Axes Systems)]

- Dutch Cadastre
  - Most current project of fully automated generalisation (2013)
  - Configuration of ArcGIS tools, FME, Python, ModelBuilder
  - Workflow: Model generalisation, Symbolisation, Cartographic generalisation

3. Methodology

- Defining the test case
  - Representative of typical generalisation problems
  - Cover of a large variety of different settlement patterns

3. Methodology

- Requirement analyses
  - Map specifications are defined as a set of cartographic constraints (Stoter et al., 2010)
  - Constrained-based generalisation

- Constraints defined by swisstopo
  - Cartographic constraints need to be satisfied within the results
  - Constraints sorted regarding the considerations when generalising buildings

Buildings smaller than 5 sqm are not to be considered and can be omitted

The minimal dimension for a single house is 400 sqm

Buildings are only merged if they are not separated by a road axis

The ratio between built-up and vacant areas (black-white ratio) should be preserved when possible

3. Methodology

- The test process for the practical implementation
  - Conduction with existing tools in ArcGIS 10.2
  - «this may not seem innovative» (Stoter et al. 2014)
  - Stoter et al. (2010) highlighted that there are main problems of applying existing generalisation tools in commercial software

- Devolopment of the workflow
  - Identification of all appropritate tools within ArcGIS 10.2
  - Performing model generalisation
  - Performing graphic generalisation
  - Improving the generalisation process by reviewing each step
  - Verifying the workflow and improving where needed
  - Concatenation of the steps within ModelBuilder of ArcGIS

3. Methodology

- Importance of results verification during the process

> *"we start with some hazy thumbnail sketch of what we want, we then source the data, apply some set of generalisation operators, view the result and repeat and refine subsequence application of generalisation operators in a cycle until a satisfactory solution is found" (Mackaness, 1995)*

- Evaluation of the results accomplished by the developed workflow

4. Practical implementation

- Determination of the generalisation tools
  - Grünreichs model ⟶ most suitable within NMAs
  - Classification of ArcGIS tools ⟶ according to Foerster et al. (2007)

- Operators for model generalisation

Operators by Foerster et al.	Corresponding operators within ArcGIS:
Amalgamation	Aggregate Polygons
Simplification	Simplify Building
Class Selection	Select Layer by Attribute Select Layer by Location Select (SQL expression)
Reclassification	Field calculator
Collapse	Delineate-Built-Up Areas

Operators by Foerster et al. (2007) and their corresponding operators within ArcGIS

4. Practical implementation

- Operators for cartographic generalisation

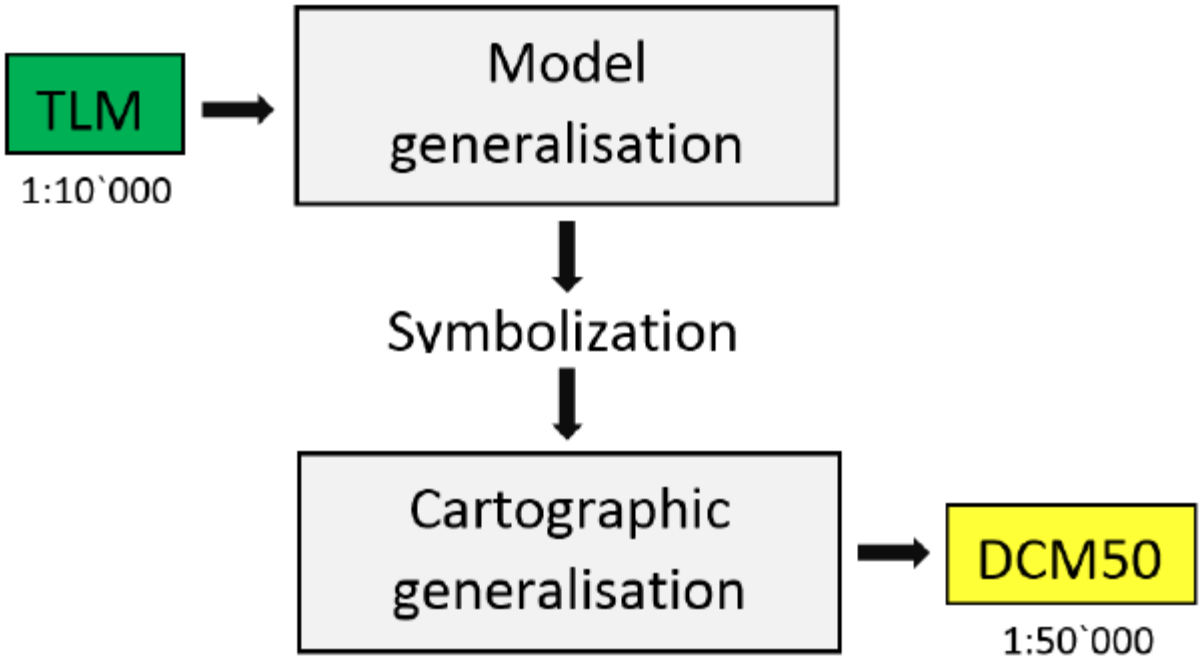
Operators by Foerster et al. (2007)	Corresponding operators within ArcGIS:
Displacement	
Typification	
Enhancement	Resolve Building Conflict
Amalgamation	
Elimination	

Operators by Foerster et al. (2007) and their corresponding operators within ArcGIS

- Resolve Building Conflict operator
  - Buildings are enlarged, symbol conflicts are resolved
  - Operator applies an optimization technique and an optimiser kernel improves the constraints

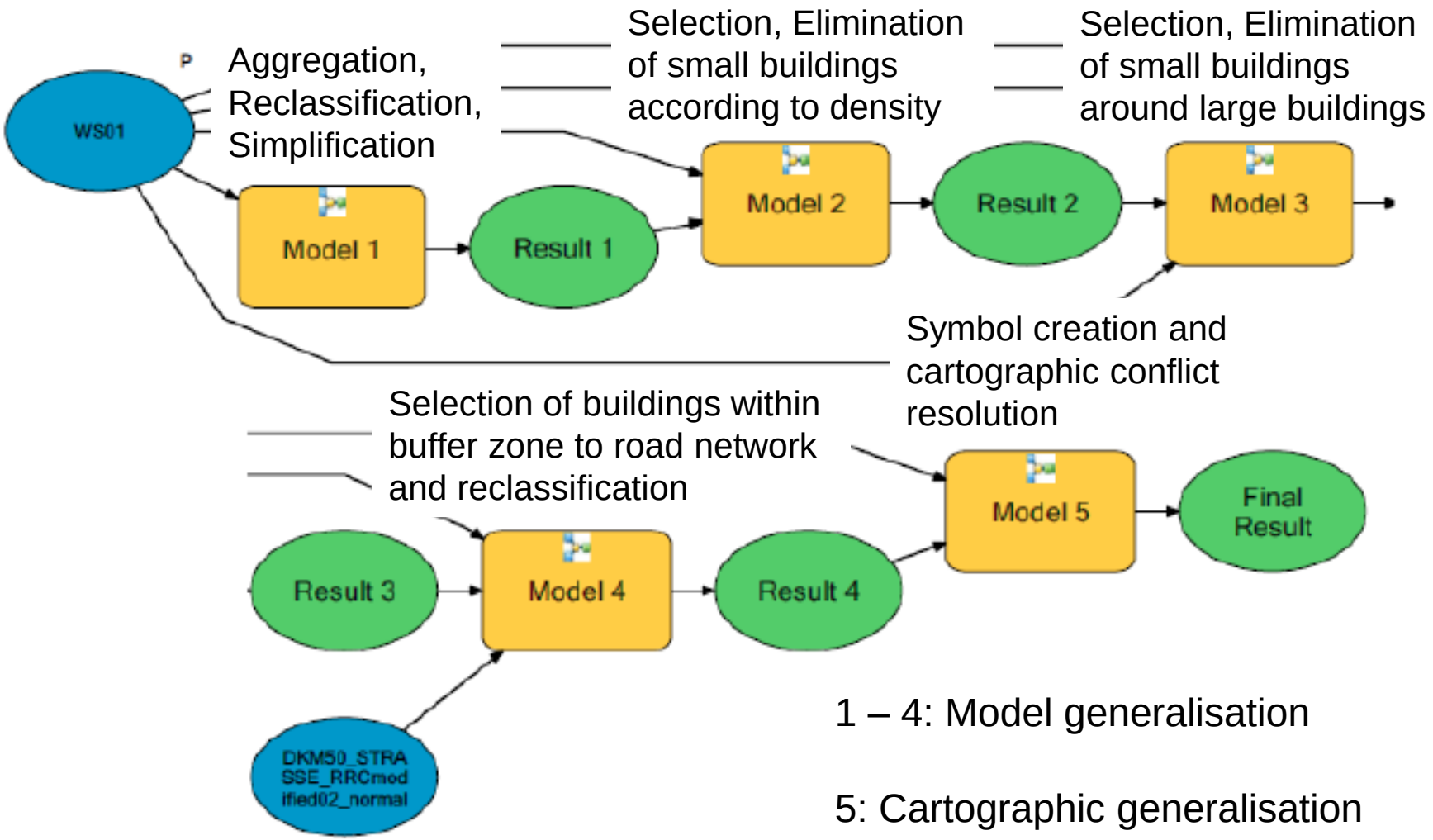
4. Practical implementation

- The development of an automated workflow



4. Practical implementation

- Concatenation of the operators to an workflow



4. Practical implementation

- Results

Left side: TLM Data
Right side: 1:50`000 map extract, buildings obtained fully automatically)

5. The expert evaluation

- Qualitative evaluation of accomplished results
  - Allows a statement regarding the quality of the generalised results
  - Expert survey was developed

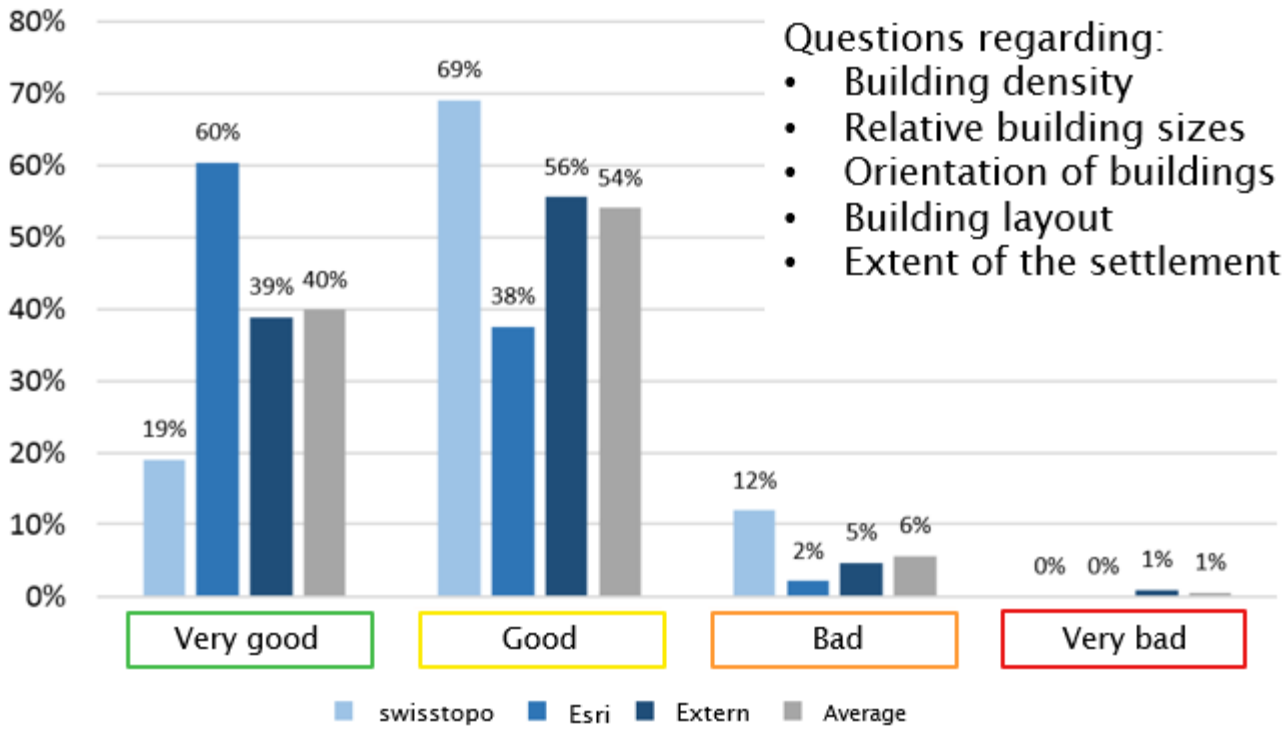
- Participants
  - Experts directly involved with the subject of generalisation
  - 3 different user groups with overall 33 participants
    - Software specialists from Esri Inc. (8)
    - Cartographers from swisstopo (7)
    - Experts in the theory and practise of generalisation (mostly higher education) (18)
  - An external panel has be chosen to receive a more «neutral» feedback due to the fact that the research was conducted in cooperation with Esri and swisstopo

5. The expert evaluation

- Conduction of the survey
  - Sending out the questionnaire
  - 3 question blocks:
    - 1. short initial questions to receive knowledge about technical background and experience in the field of generalization
    - 2. specific questions concerning the quality of the building generalisation (Quality critera: Very good, good, bad, very bad)
    - 3. Open questionnaire to gain knowledge about most successful and problematic areas

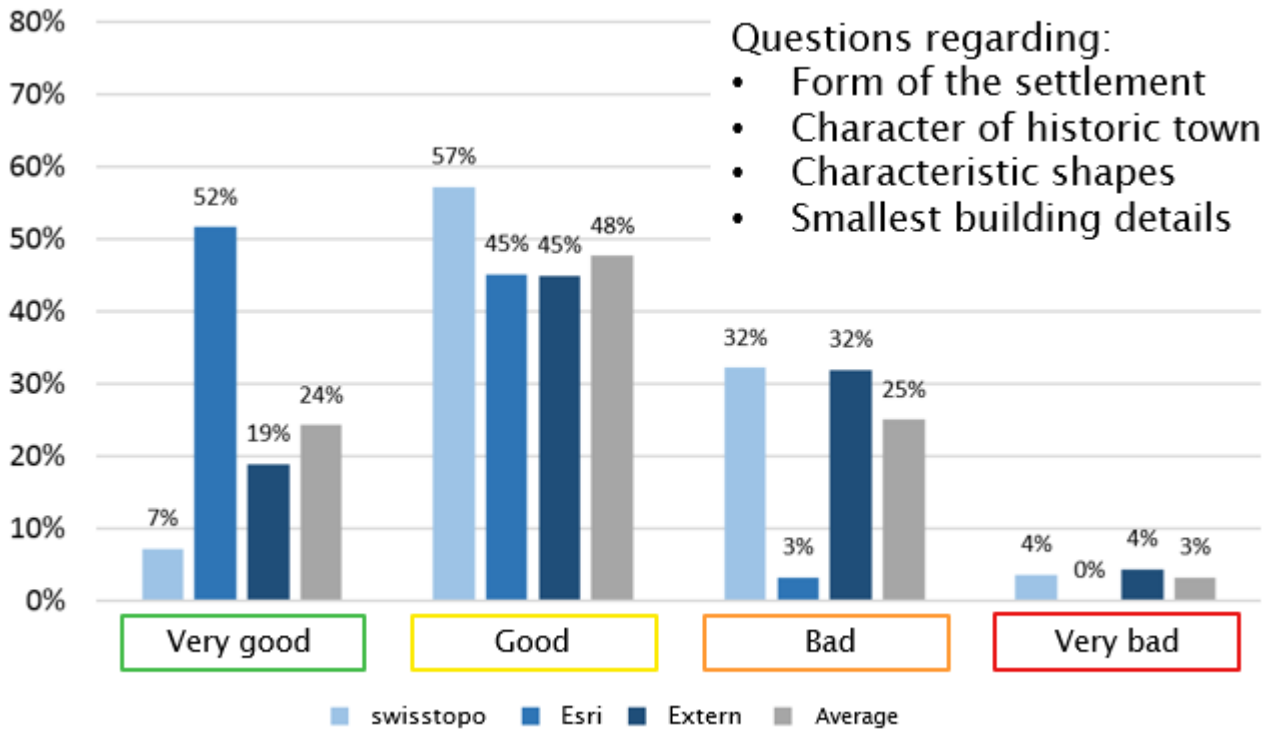
5. The expert evaluation

- Overall result retaining the settlement structure



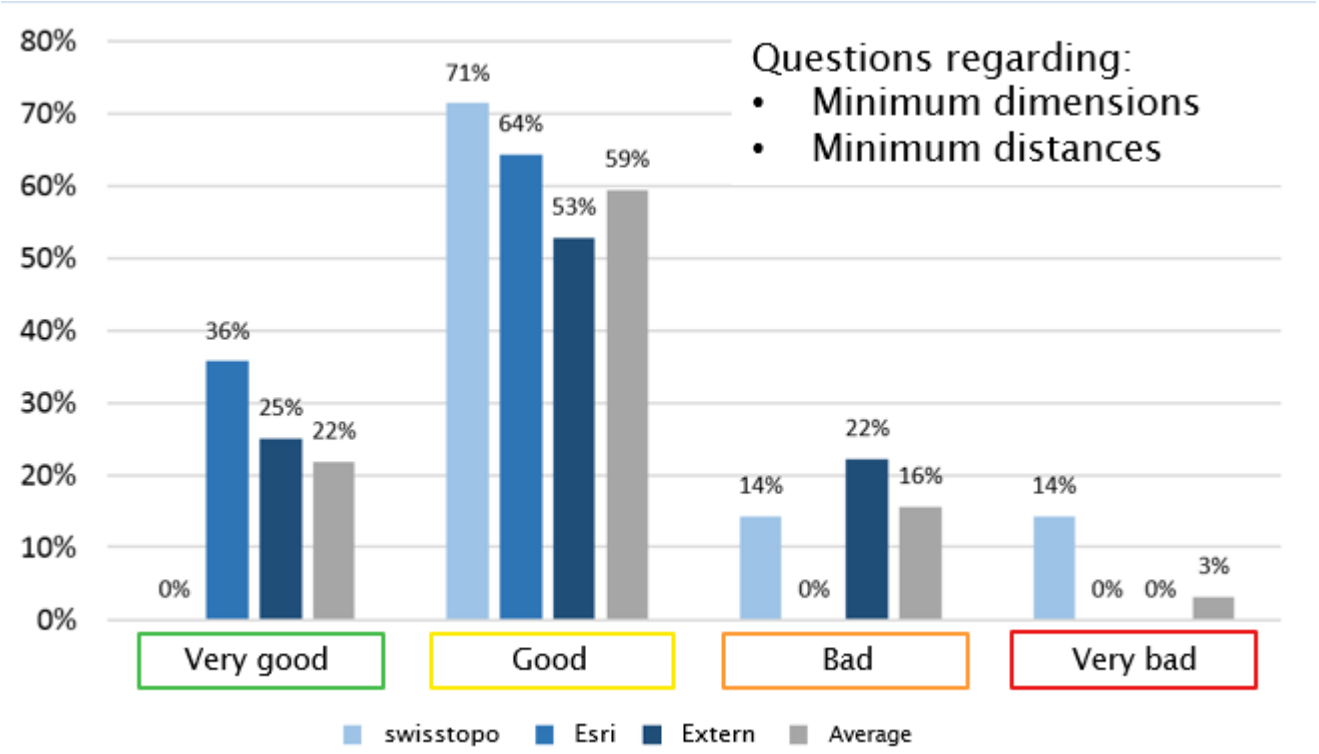
5. The expert evaluation

- Overall result generalising the shape



5. The expert evaluation

- Overall result graphic generalisation



6. Conclusion and Outlook

- Promising opportunities for automated generalisation within ArcGIS
- Operators resolved most of the constraints
- Most challenging is the adaption of parameters and to put everything in the right order
- Further research:
  - Workflow can be used to further adapt parameters
  - Adaption of requirements
  - Considerations of the «Big Picture» when generalising

Thank you very much for your attention!

a.vetter@esri.ch