ICA Tutorial on
Generalisation & Multiple Representation
2 July 2011 Paris

Lecture 4 : Constraints: in requirement analysis and evaluation (30 mins)

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On behalf of EuroSDR generalisation team:

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Overview

Constraints in the EuroSDR project

- Introduction of the project
- Role of constraints in requirement analysis
- Constraints in evaluation
- Topics for discussions

EuroSDR generalisation project

- EuroSDR project
  - European Spatial Data Research

- "State-of-the-art of automated generalisation in commercial software"

Objectives of the project

- Possibilities/limitations of commercial software systems for automated generalisation with respect to NMA requirements
- What different generalisation solutions can be generated for one test case?

EuroSDR core project team

- Dirk Burghardt (TU Dresden)
- Blanca Baella (ICC)
- Cécile Duchêne (IGN, France)
- Maria Pla (ICC)
- Nicolas Regnauld (OS UK)
- Guillaume Touya (IGN, France)
- Jantien Stoter (TU Delft & Kadaster)

EuroSDR generalisation project

- Requirement analysis Oct 2006 till June 2007
- Testing June 2007 till Spring 2008
- Evaluation Summer 2008 till Spring 2009
- Finalising the project Autumn 2009

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Constraints in requirement analysis

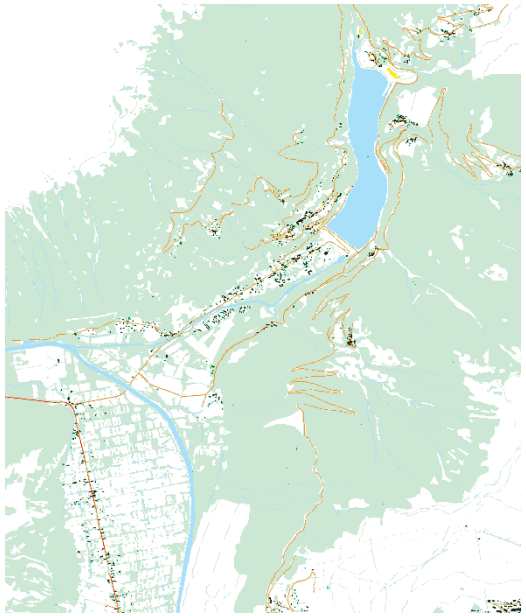
1. Selecting and sourcing test cases
2. Formalising requirements in constraints
3. Harmonising constraints
4. Comparing 4 constraint sets

1. Selecting test cases

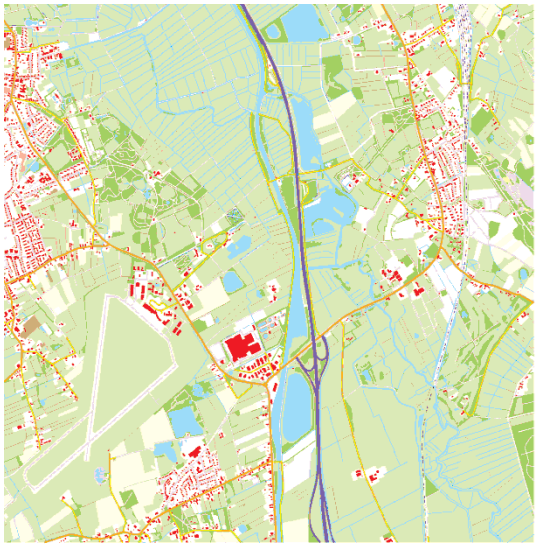
Area type	Source dataset	Target dataset	Provided by	Nr input	Main layers
Urban area	1:1250	1:25k	OS GB	37	buildings, roads, river, relief
Mountainous area	1:10k	1:50k	IGN France	23	village, river, land use
Rural area	1:10k	1:50k	Kadaster, NL	29	small town, land use, planar partition
Costal area	1:25k	1:50k	ICC Catalonia	74	village, land use (not mosaic), hydrography

Source test datatets

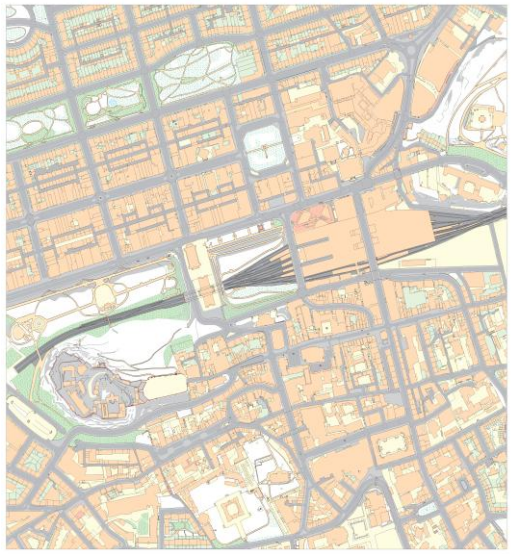
ICC, 1:25k



IGN France, 1:10K



Kadaster, 1:10k



OS GB, 1:1250

2. Formalisation of requirements

- By constraints
- Why:
  - To define how the output should look like, without addressing how this should be achieved

Items in constraint template

- Constraint type
- Geometry type
- Class(es)
- Condition of object being concerned with this contraint
- Condition to be respected
- Condition depends on initial value?
- Preferred action
- Importance

2. Defining constraints

	Example on one object	Example on two objects	Example on group of objects
Condition to be respected	Area of buildings > 0.4 map mm^2	building must be parallel to road	target building density should be equal to initial density ± 20 %

- Result: 250 constraints often covering similar situations

3. Harmonising constraints

- Many constraints cover more or less similar situations

NMA	Class	Condition to be respected
IGN	Building	Building should not appear in DCM
OSUK	Building	Not displayed
ICC	Building	Maintain and area > 400 m2
TDK	Building	Instance should not appear in DCM if length (edge or diameter) < 20m

NMA	Class 1	Class 2	Condition to be respected
IGN	Building	Road	Building must be adjacent to road symbol
OSUK	Building	Road	The building is shown adjacent to the road
ICC	Building	Road	Adjacent or > 10 m. If minimal distance between their symbols < 7.5 m, building must be rotated and displaced to be adjacent to road symbol. If > 7.5, building must be displaced
TDK	Building	Part of road	Building must be adjacent to road symbol

3. Harmonising constraints

- Why,
  - Simplify test
  - Improve evaluation

Result of harmonisation process

- 45 generic constraints:
  - 21 generic constraints on one object
  - 11 constraints on two objects
  - 13 constraints on group of objects

Main constraints

Constraint type	Property	Condition to be respected
Constraints on one object		
Minimal dimension	Area	target area > x map mm^2; target area = initial area ± x %
	Width of any part	target width > x map mm
	Area of protrusion/recess	target area > x map mm2
	Length of an edge/line	target length > x map mm
Shape	General shape	target shape should be similar to initial shape
	Squareness	[initial value of angle = 90° (tolerance = ± x°)] target angles = 90°
	Elongation	target elongation = initial elongation ± x %
Topology	Self-intersection	[initially, no self-intersection] no self-intersection must be created
	Coalescence	coalescence must be avoided
Position/Orientation	General orientation	target orientation = initial orientation ± x %
	Positional accuracy	target absolute position = initial absolute position ± x map mm
Constraints on two objects		
Minimal dimensions	Minimal distance	target distance > x map mm
Topology	Connectivity	[initially connected] target connectivity = initial connectivity
Position	Relative position	target relative position = initial relative position
Constraints on a group of objects		
Shape	Alignment	initial alignment should be kept
Distribution & Statistics	Distribution of characteristics	target distribution should be similar to initial distribution
	Density of buildings (black/white)	target density should be equal to initial density ± x %

Result of harmonisation process

- About 300 constraints are defined as specialisations of generic constraints

4. Analysing constraints in test cases

Test case	Total number of constraints	Number of objects			Number of constraints for different constraint types							Number of constraints on different feature classes						
		on one object	on two objects	on group of objects	Model generalisation	Min. dimension and granularity	Position	Orientation	Shape	Topology	Distribution / Stat	Other	Building	Land use	Road	Water	Relief	Coastal features	Any
ICC	137	86	23	28	12	80	0	4	19	12	5	5	39	20	16	25	8	19	10
Kad	52	27	21	4	11	18	1	0	1	6	0	15	10	13	23	3	0	0	3
IGN	61	32	15	14	2	15	2	4	15	12	2	9	33	2	12	9	2	0	3
OS	49	24	13	12	2	16	1	0	0	8	0	22	24	1	8	1	8	0	7
Total	299	169	72	58	16	129	4	8	35	38	7	51	106	36	59	38	18	19	23

Why are the constraints unbalanced?

- Extend of scientific research (e.g. generalisation of buildings)
- Incomplete handling, because focus was set only on specific data sets
- Number of constraints defined is proportional to number and complexity of map objects (effort needed on manual generalisation)

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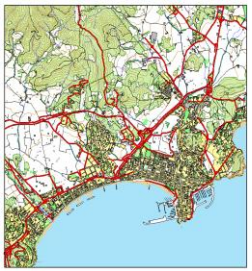
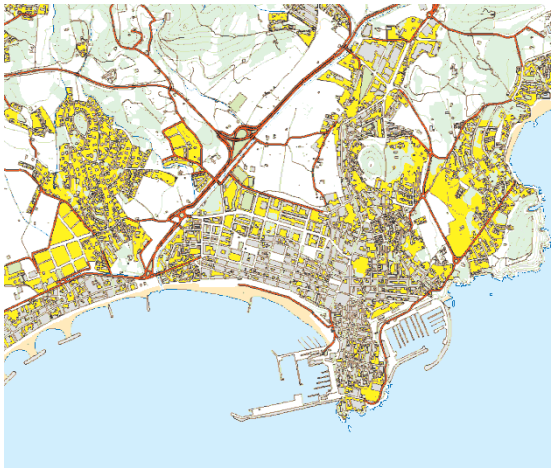
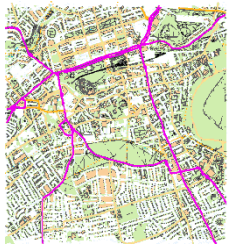
Outputs to be evaluated

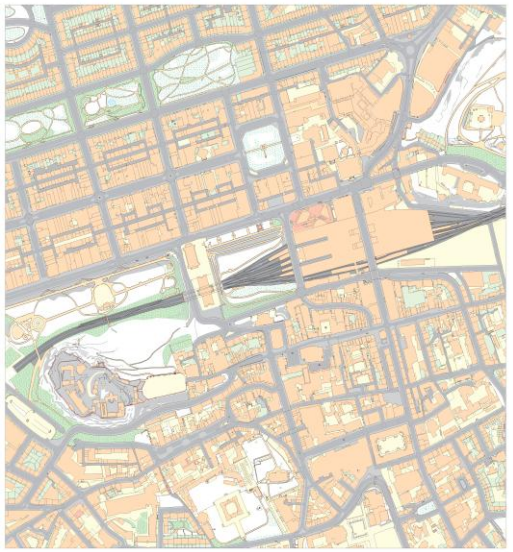
- 35 test outputs were obtained (appr 700 thematic layers). NB: 1 test cost appr 1 week



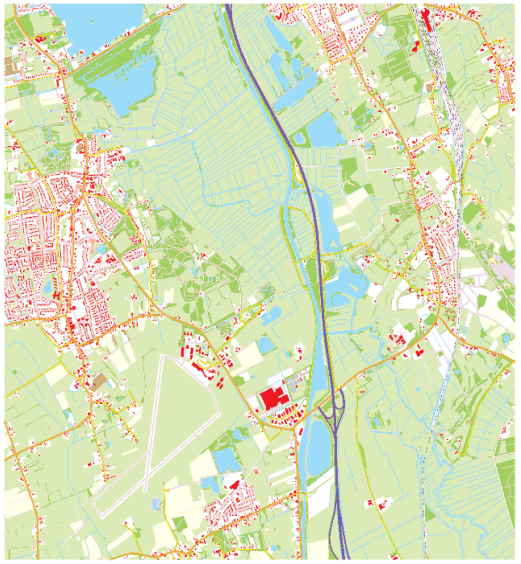


1:50K, derived from 1:25K, ICC

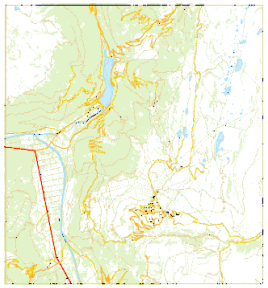


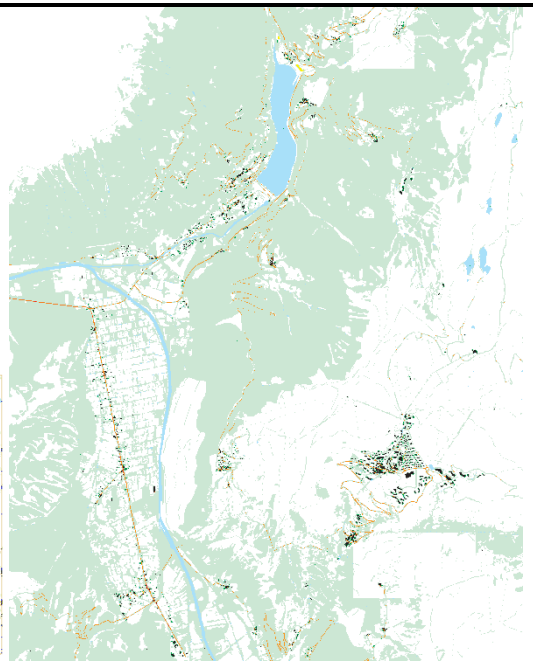


1:25K, derived from 1:1250, OSGB



1:50K, derived from 1:10K, TDK





1:50K, derived from 1:10K, IGN, France

Evaluation of generalised outputs

- Automated constraint-based evaluation

  Dirk Burghardt, Stefan Schmidt, University of Zurich

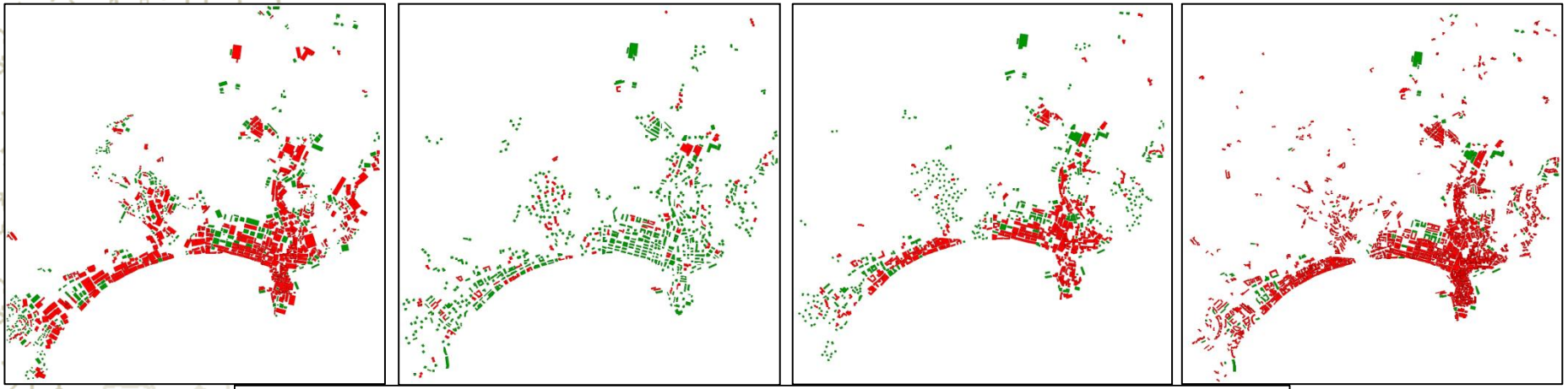
- Evaluation which visually compared different outputs for one test case

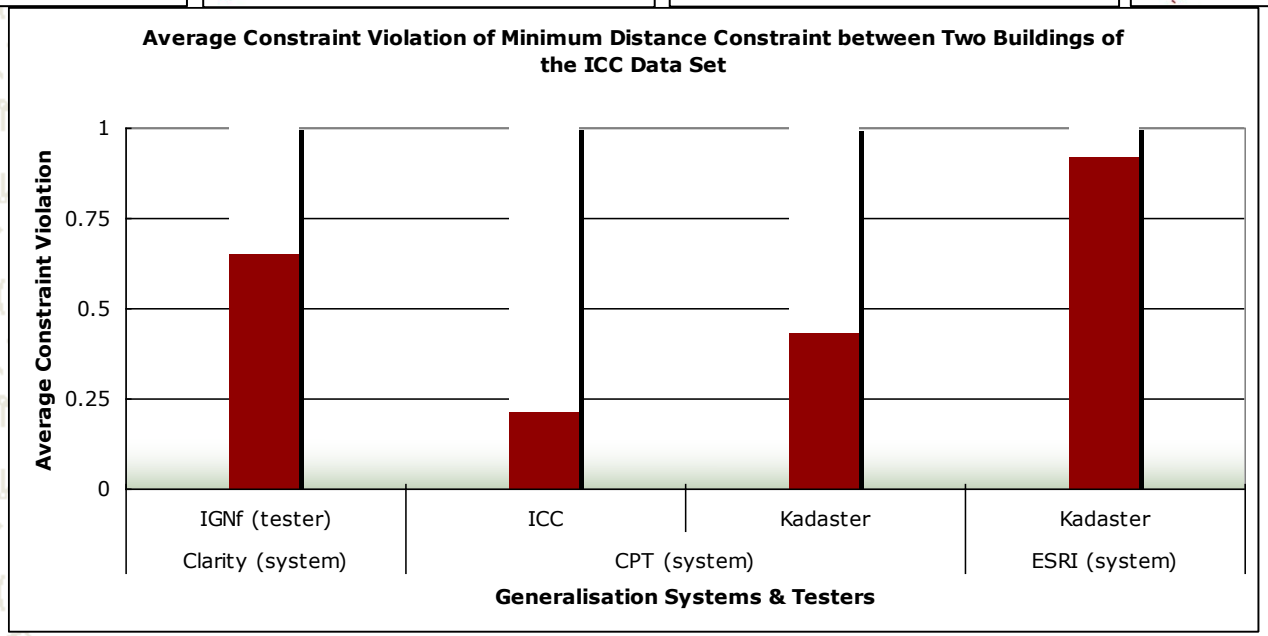
  Cecile Duchene, IGN France

- Qualitative evaluation by cartographic experts

  Connie Blok, Jantien Stoter, ITC

1. Automated constraint based evaluation





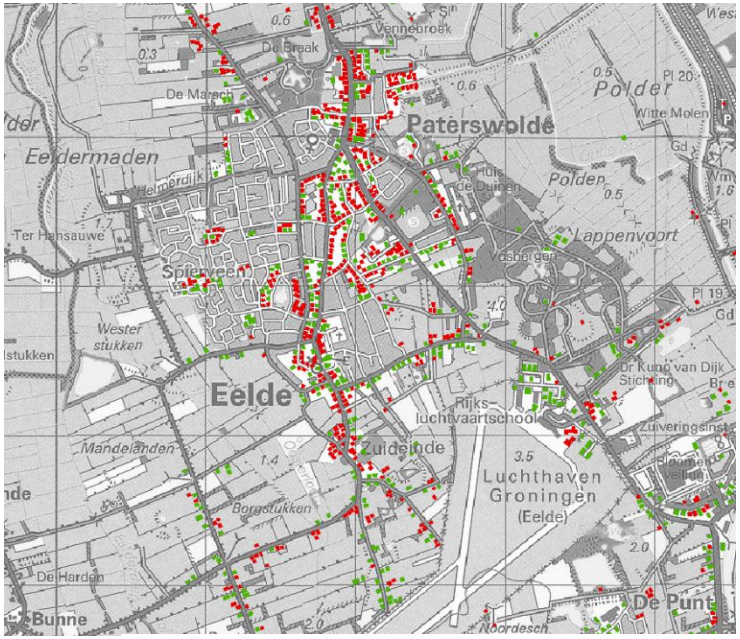
Steiniger, 2008

1. Automated constraint based evaluation

- Applied to interactively generalised data

1. Target area ≥ 0.16 map mm2

2. Target distance ≥ 0.2 map mm



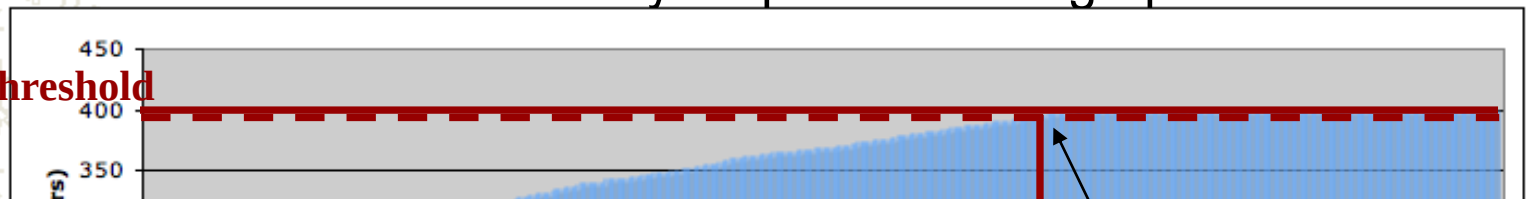
Source: TD Kataster 1:50k

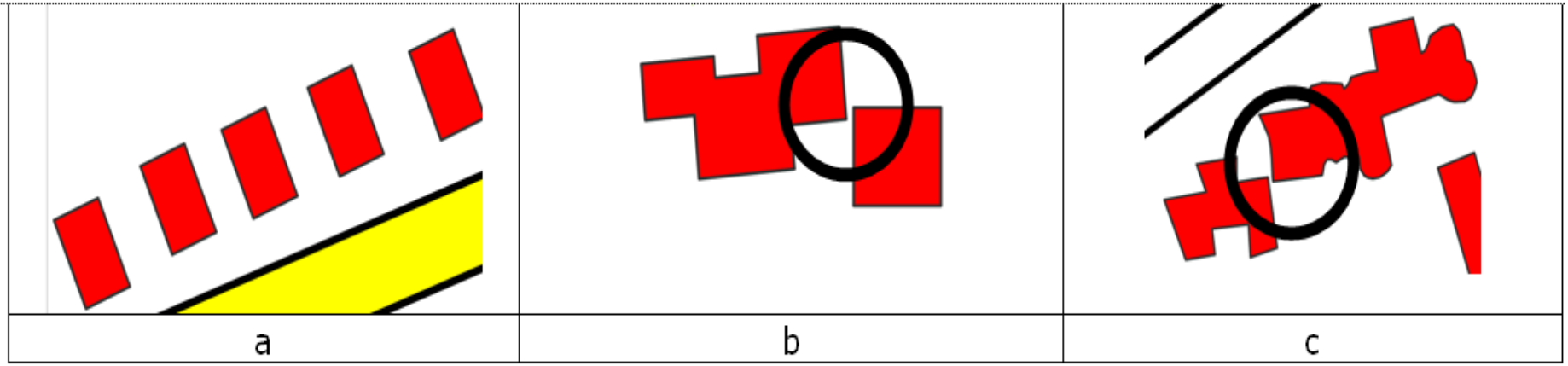
- 26% of buildings are too small
- 46% of buildings are too close

Schmidt 2008

Results on interactively generalised data

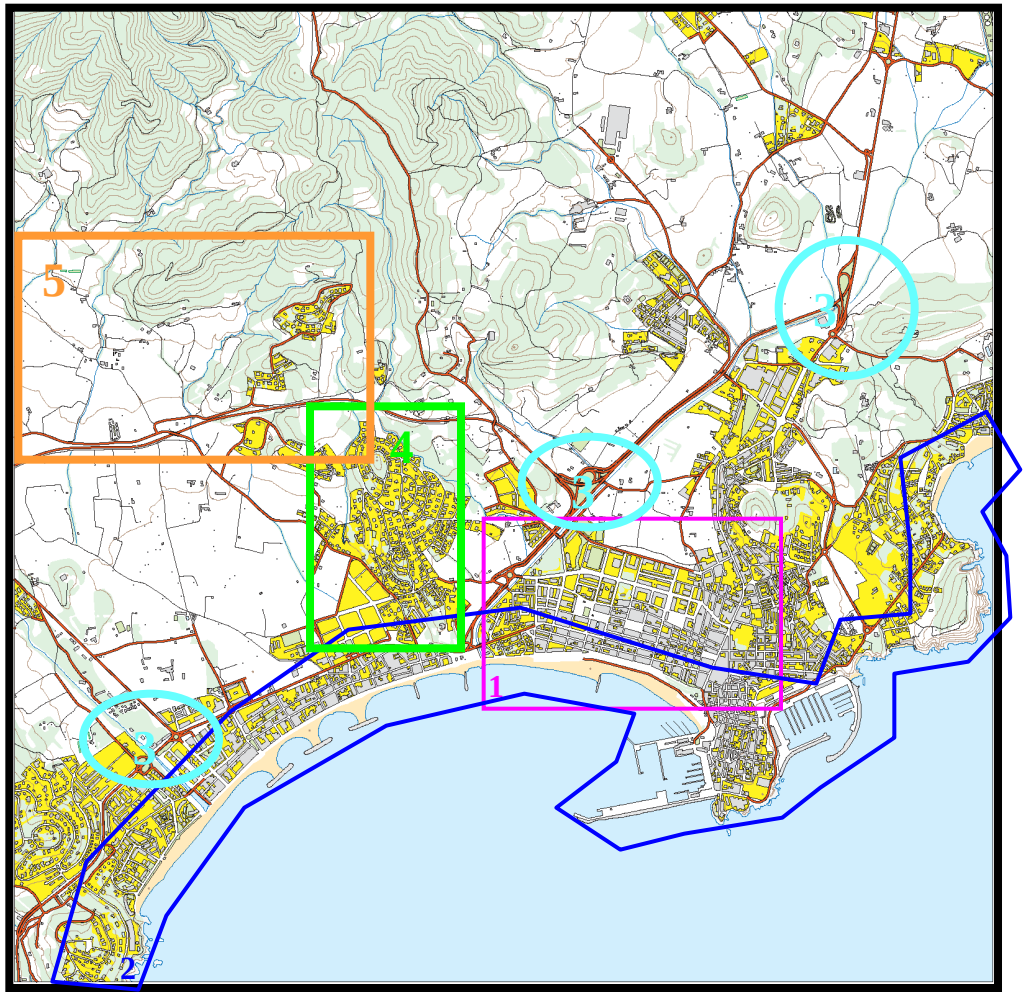
- Explanation of ‘errors’:
  - Flexibility range; partly ignore values to meet more important conditions
  - Constraints do not always represent cartographic conflicts



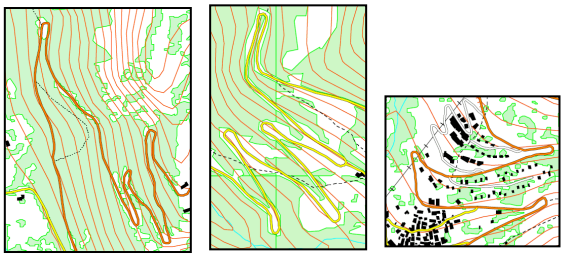


2. Comparison evaluation

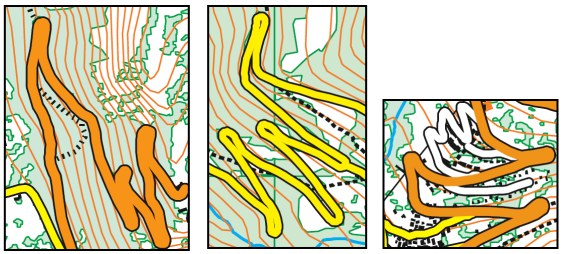
1. Town centre blocks and streets representation (selection, aggregation)
2. Coastline simplification
3. Conflicts in road interchanges
4. Generalization of suburban buildings (namely: preservation of buildings spatial distribution, buildings alignments)
5. Parallelism between roads and buildings



IGNF dataset – Example: mountainous roads



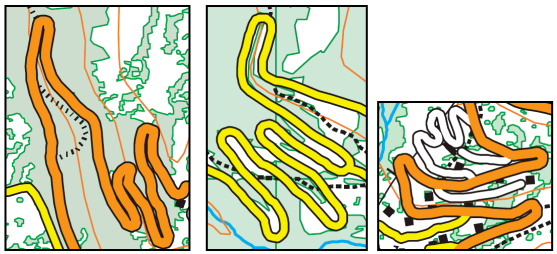
(a) Initial



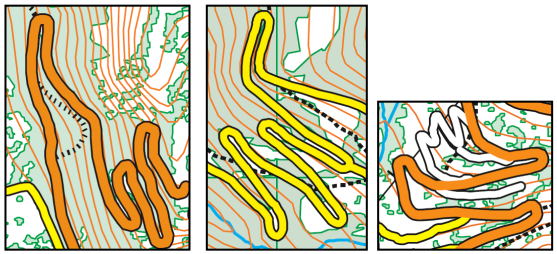
(b) Output 1

(c) Output 2

(e) Output 4

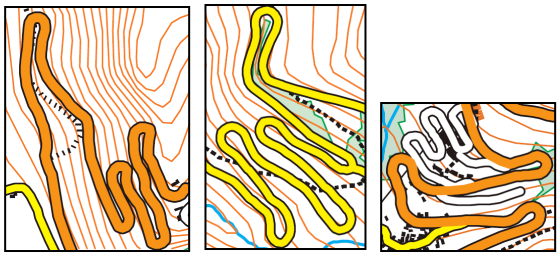


(f) Output 5

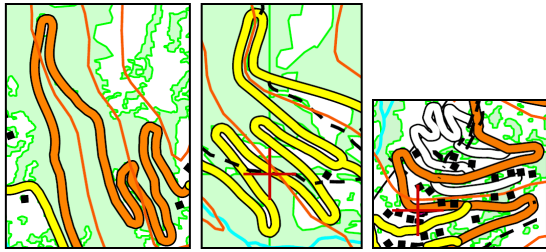


(g) Output 6

(i) Output 8



(j) Output 9



(h) Output 7

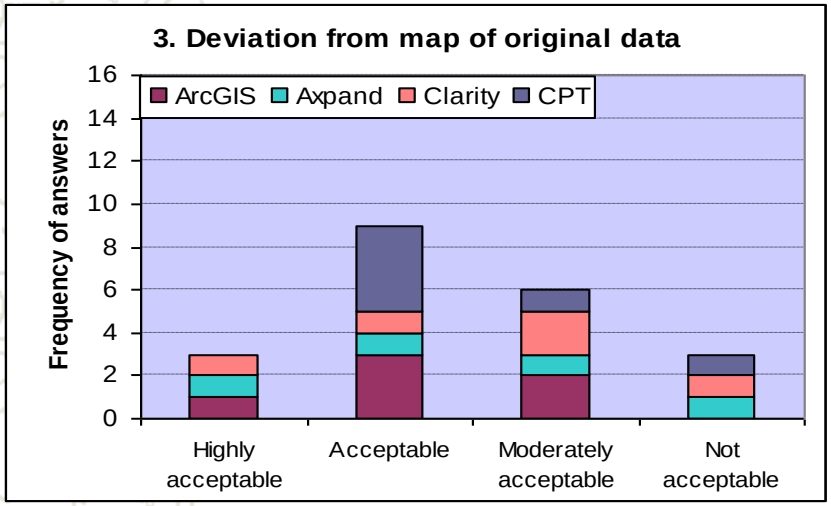
Expert evaluation: methodology

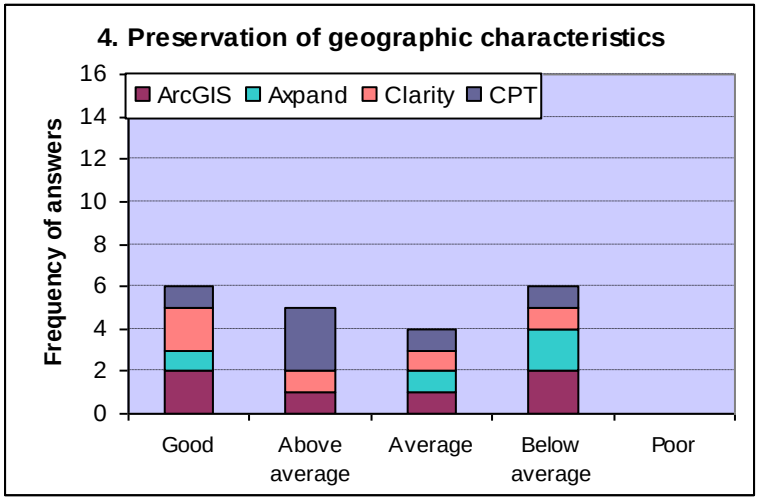
Global indicators
Level of manual editions required to meet the constraints
Deviation from initial (ungeneralised) data
Preservation of the geographic characteristics of the test area
Legibility
Seriousness and frequency of main detected errors
Number of positive aspects
Information reduction (undergeneralisation / overgeneralisation)

Individual constraints assessed in expert survey		
Constraints on one object	Constraints on two objects	Constraints on group of objects
minimal dimensions	spatial separation between features (distance)	quantity of information (e.g. black/white ration)
granularity (amount of detail)	relative position (e.g. building should remain at the same side of a road)	spatial distribution
shape preservation	consistencies between themes (e.g. contour line and river)	

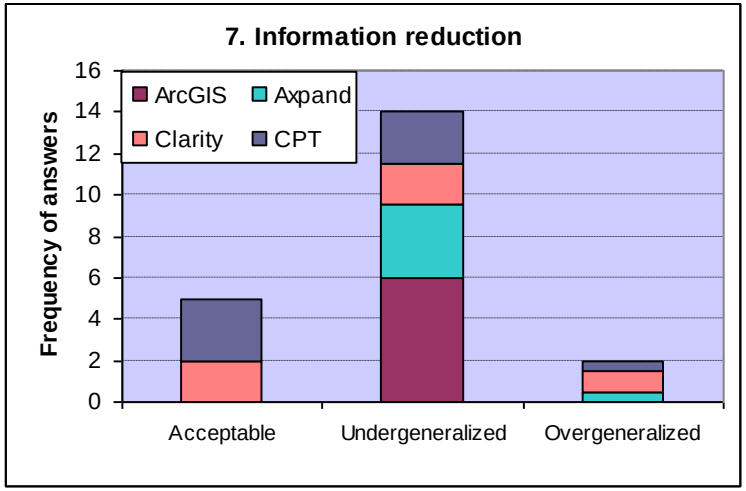
Expert evaluation: example results

- Good scores for:





- Lower scores for:



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Topics for discussions (1/3)

- Constraints are well suited to apply to generalisation processes (flexible, distinction between conflict analysis and solution)
- Constraints used to direct the process and to evaluate if output meets specifications: be careful
- Constraints not always good indicator of quality

Topics for discussions (2/3)

- Results for individual constraints not a good indicator for overall solution:
  - Violation may be intended
  - Constraint may not define the situation well
  - Good results for one constraint may coincide with bad results for another
  - Non-satisfied constraint can be due to missing functionality OR due to imprecise constraint
  - How well does the set of constraints describe the desired output: complete? balanced?

Topics for discussions (3/3)

- Further research
  - More/complete set of/improve constraints
  - Improve formalisation level:
    - How to formalise preservation concepts+accepted change
  - Enable notion of threshold values in constraints evaluation:
    - Not interesting of a constraint is violated, but if this yields unacceptable situation
  - Making constraints comparable
  - How to aggregate the evaluation to one measure

State-of-the-art of automated generalisation
in commercial software

March 2010

- http://www.eurosdr.net/projects/generalisation/eurosdr_gen_final_report_mar2010.pdf

Temporal project team members
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Questions?

Summary of the project available at ica.ign.fr, see workshop 2010 in Zurich:
"EuroSDR research on state-of-the-art of automated generalisation in commercial software: main findings and conclusions", 13th Workshop of the ICA commission on Generalisation and Multiple Representation