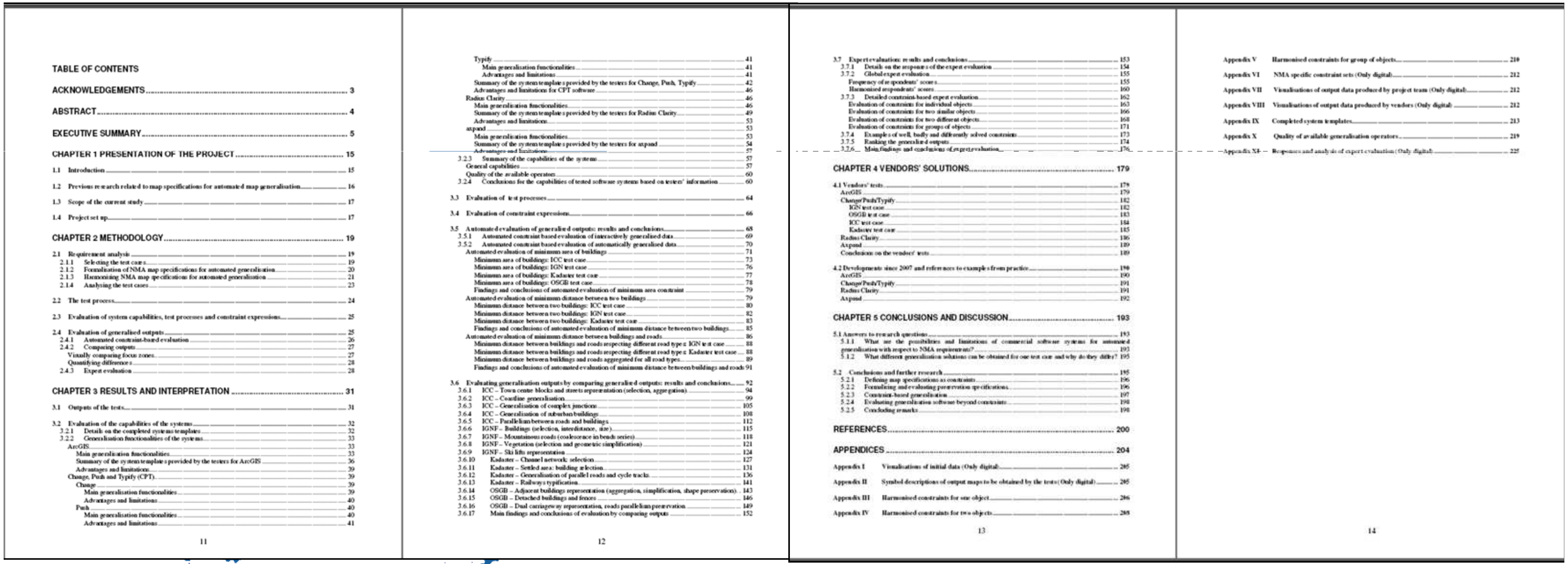
# STATE-OF-THE-ART OF AUTOMATED GENERALISATION IN COMMERCIAL SOFTWARE



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***Final report available from EuroSDR website***

www.eurosdr.net

# Objectives

- To study:
  - capabilities/limitations of commercial software systems for automated generalisation with respect to NMA requirements
  - what different generalisation solutions can be generated for one test case and why do they differ?

## What did we do?

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

# 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 |

| | |
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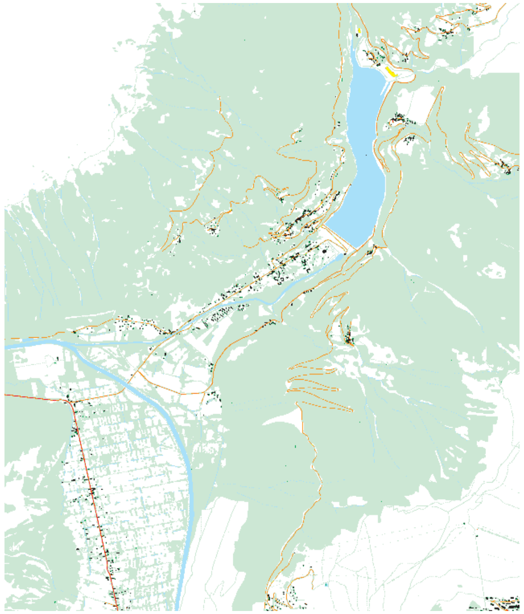
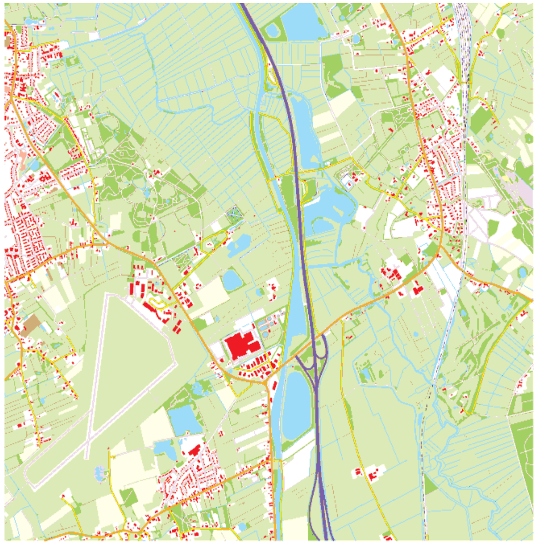
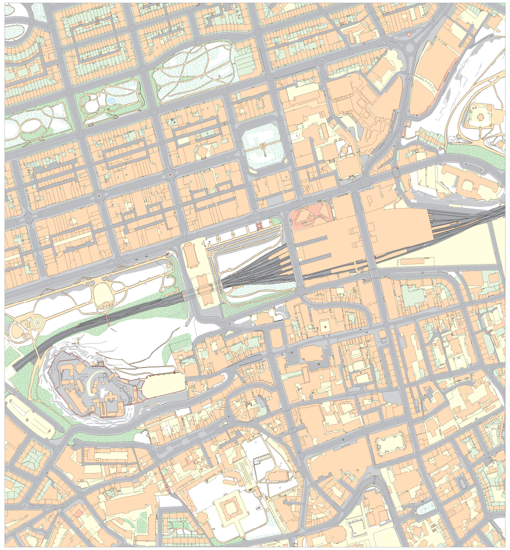
|  |  |
| ICC, 1:25k | IGN France, 1:10K |
|  |  |
| Kadaster, 1:10k | OS GB, 1:1250 |

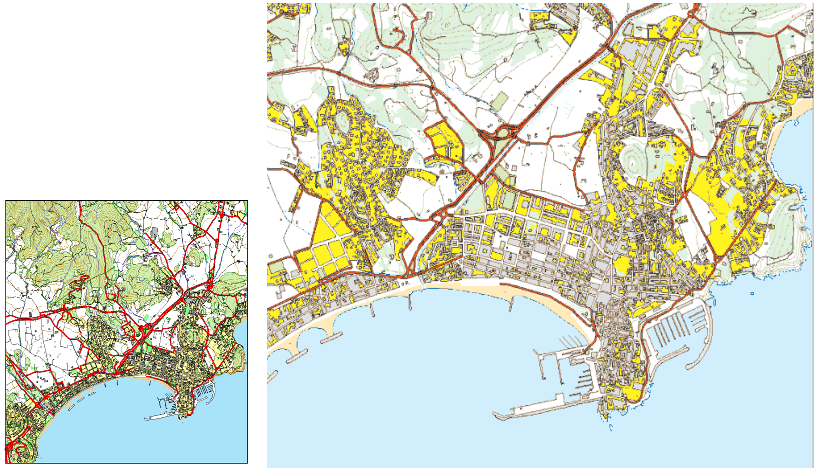
# One of the results: harmonised requirements

- 45 generic constraints:
  - 21 generic constraints on one object
  - 11 constraints on two objects
  - 13 constraints on group of objects
- About 300 constraints are defined as specialisations of generic constraints

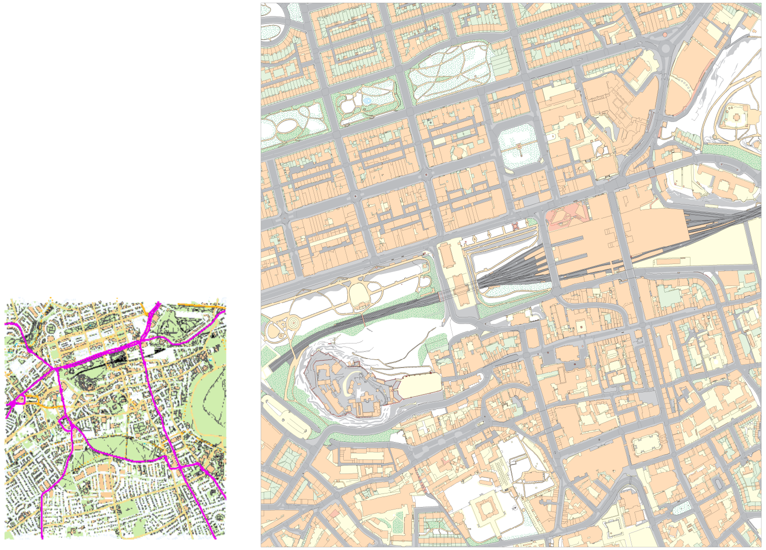
# Tests

- Were performed:
  - by project team members on out-of-the-box versions
  - by vendors (1Spatial, ESRI, University of Hanover, Axes systems), possibly on improved and/or customized versions

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

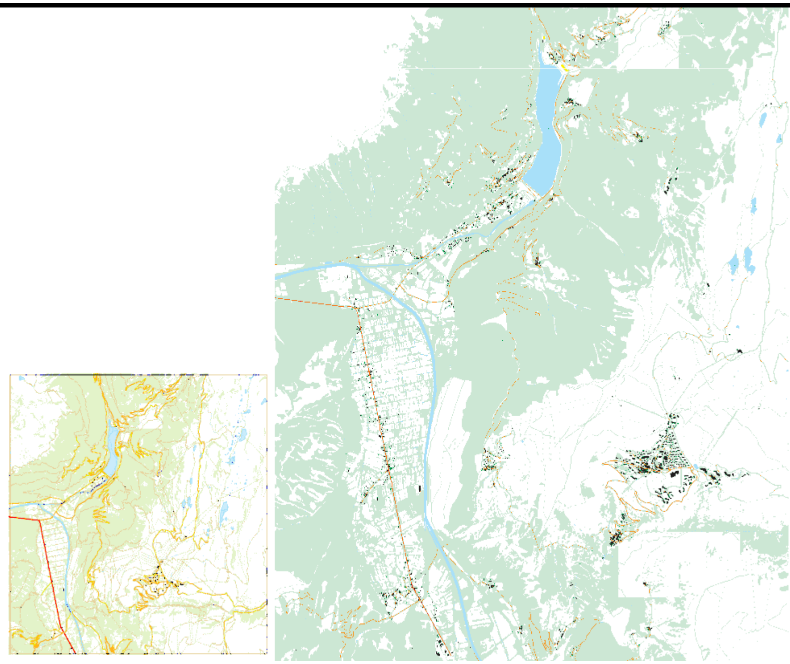


1:50K, derived from 1:25K, ICC



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

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



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

# Evaluation

- Evaluation of:
  - System capabilities (based on completed system templates)
  - Processing (based on actions templates)
  - Constraint expression (based on constraint expression templates)
- Evaluation of generalised data:

# Evaluation of generalised outputs, three methods

- Automated constraint-based evaluation

  **Dirk Burghardt, Stefan Schmidt, University of Zurich**

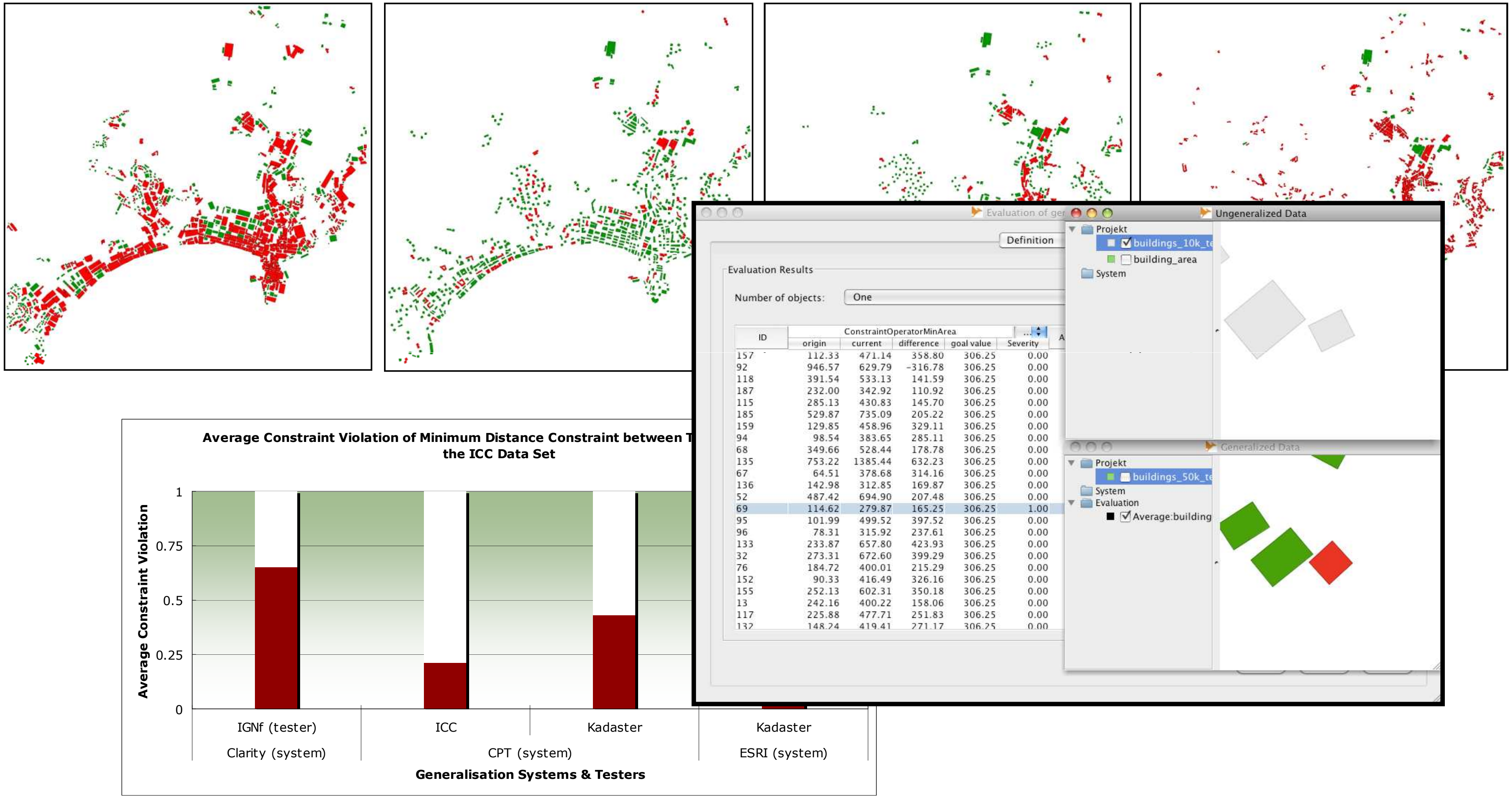
- Evaluation which visually compared different outputs for one test case

  **Cecile Duchene, IGN France**

- Qualitative evaluation by cartographic experts

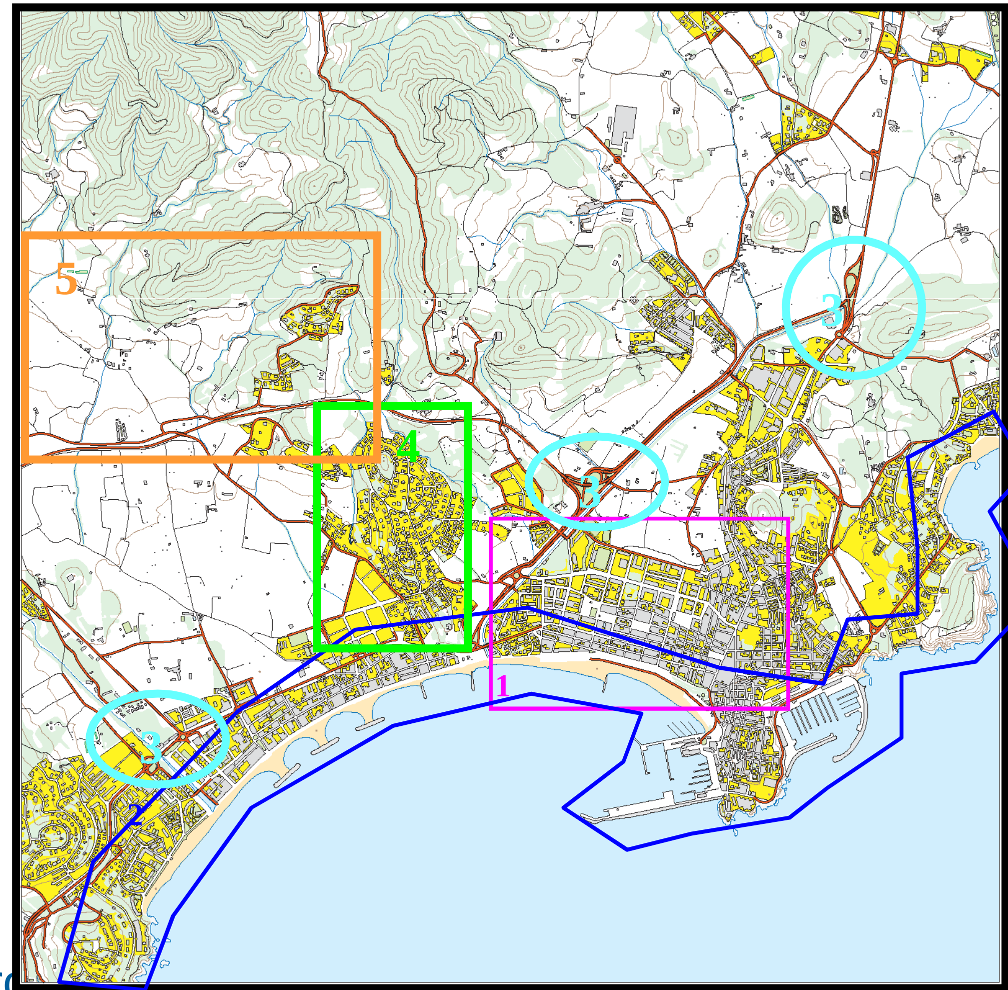
  **Connie Blok, Jantien Stoter, ITC**

# Automated constraint based evaluation of generalised data

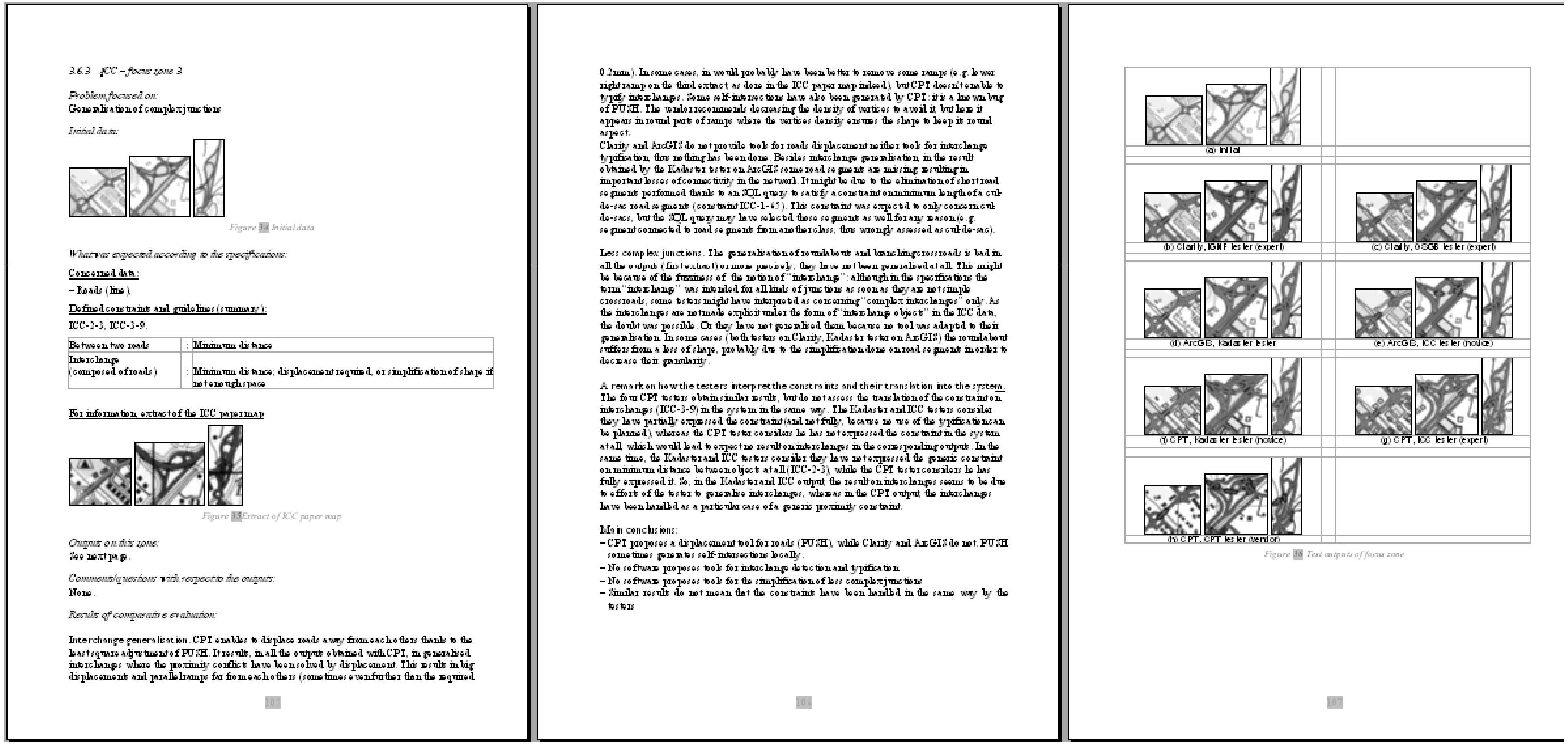


# Comparison evaluation of 16 focus zones

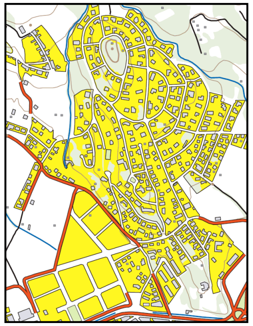
1. Town centre blocks and streets representation (selection, aggregation)
2. Coastline simplification
3. Conflicts in road interchanges
4. Generalization of suburban buildings (namely: preservation of buildings spatial distribution, buildings alignments)
5. Parallelism between roads and buildings



# Descriptive sheet of each focus zone (16) included in final report

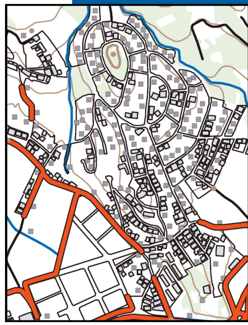


# ICC dataset – buildings in suburban areas

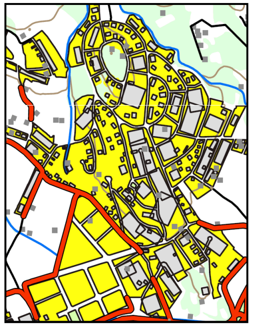


(a) Initial

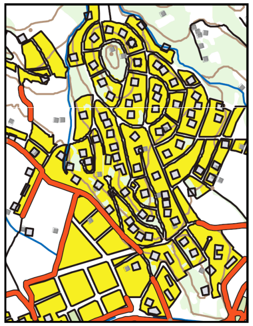
(f) CPT, TDK tester (novice)



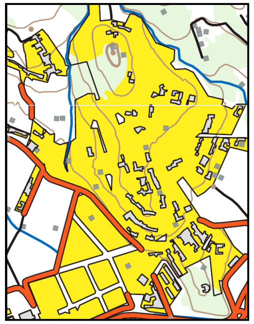
(d) ArcGIS, TDK tester (novice)



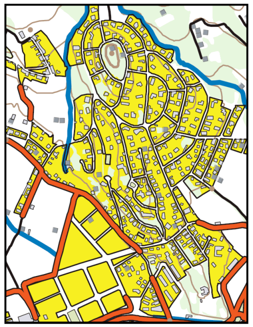
(b) Clarity, IGNF tester (expert)



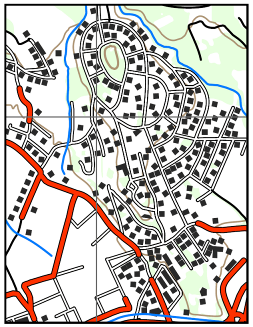
(g) CPT, ICC tester (expert)



(e) ArcGIS, ICC tester (novice)



(c) Clarity, OSGB tester (expert)



(h) CPT, CPT tester (vendor)

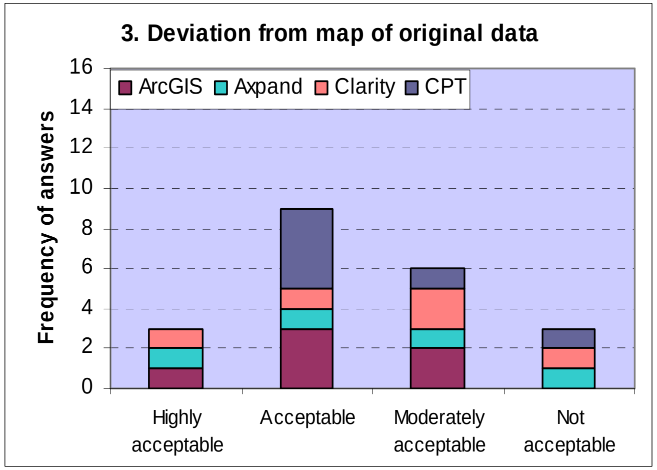
# Expert evaluation: methodology

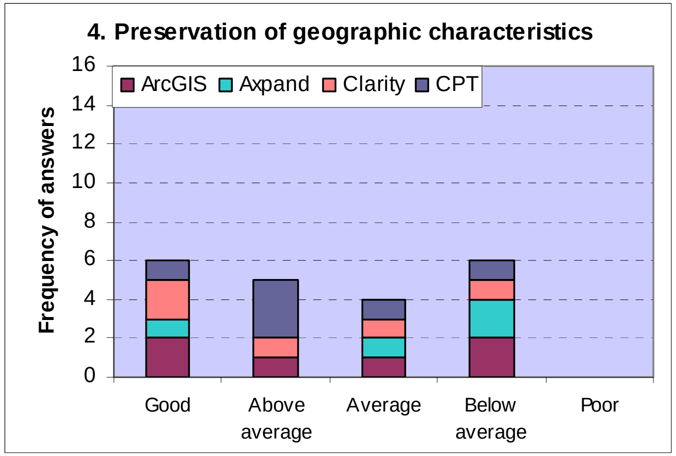
| Global indicators |
|---|
| Level of manual editions required to meet the constraints |
| Deviation from initial (ungeneralised) data |
| Preservation of the geographic characteristics of the test area |
| Legibility |
| Seriousness and frequency of main detected errors |
| Number of positive aspects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

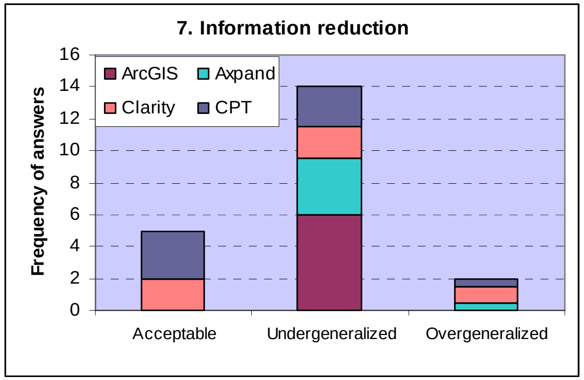
- Good scores for:

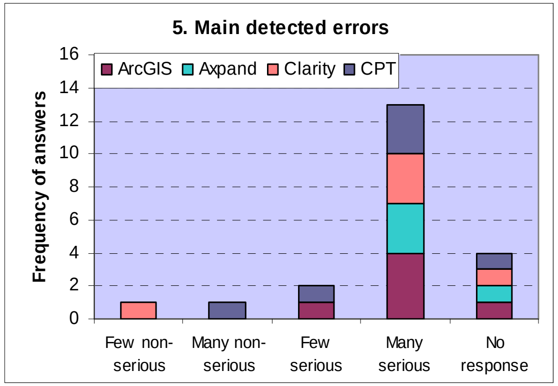


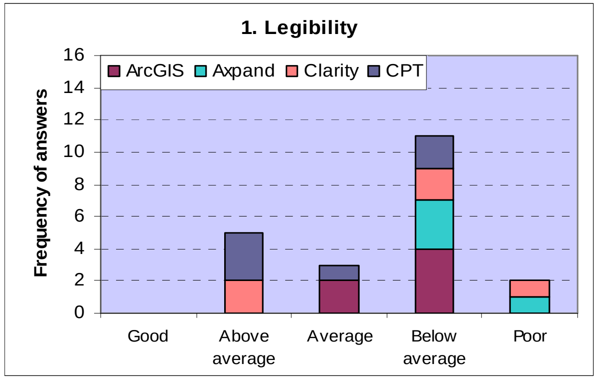



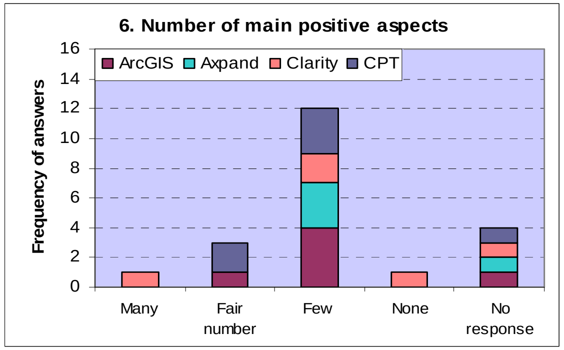
# Expert evaluation: example results

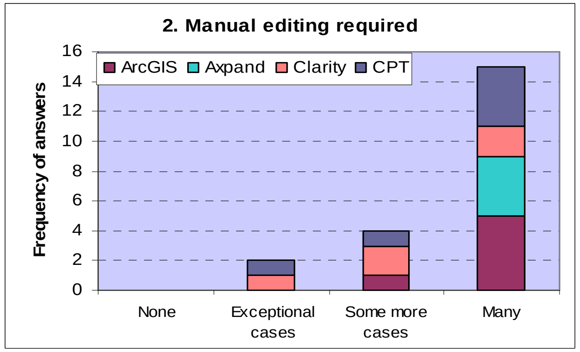
- Lower scores for:




- Interesting if interactively generalised data would have been included

# Conclusions capabilities of systems (1/4)

Discussed with vendors at IGN, Paris at 22 September 2009

- All systems offer potentials for automated generalisation, especially for single objects

# Conclusions capabilities of systems (2/4)

- No generalisation problems are fully solved by the out-of-the-box systems
  - Some are close to being solved:
    - buildings and roads
  - Some are far from being solved: e.g.
    - apply different algorithms/parameters in different contexts (either not supported and/or detection measures are missing)
    - operations that concern more than one object (e.g. network typification)
    - terrain generalisation (relief)
    - displacement only in CPT and axpand

# Conclusions capabilities of systems (3/4)

- For other problems solutions do exist (e.g. building simplification), but:
  - algorithms are difficult to parameterise; a direct match between parameters and constraints was often missing
  - detection tools are missing
  - controlling the effects of parameter values is difficult

# Conclusions capabilities of systems (4/4)

- Satisfying complete NMA requirements requires customisation, progress should focus on:
  - Good customisation tools
  - Generic solutions (includes default parameterisation and default tools)
- Shortcomings have been solved by research (e.g. detection tools), and by vendors in parallel tests (e.g. displacement in Clarity and ArcGIS)

# Conclusions on different results for one test case

- Specifications:
  - are sometimes fuzzy
  - do not fully express NMA requirements (focus on common/well known situations)

- Difficulties to parameterize the systems (once testers have understood the specifications):
  - Specification expression and parameters expected by the system often don’t match
  - Differences between novice and expert testers of the system, or of the test case (even if expert of the system)

- Differences between testers:
  - Avoiding many errors versus striving for very good results for certain constraints or areas

# Considerations on results

– Results are not that bad as they may look:
  - High expectations of the project (constraints, selection of complex/known problems, high quality paper maps)
  - Some missing functionalities have been fixed in vendors' parallel tests
  - Not a surprise that out-of-the box versions are not capable of fulfilling NMAs requirements; customization is definitely required
  - Systems are used more satisfactory in practice
  - Project is well received by vendors to push internal developments

## Topics for future research

- Completing/refining constraints set
- Formalising/evaluating preservation constraints
- Constrained based evaluation:
  - Weighting & prioritizing
  - Interaction between constraints
  - Ignoring constraints for satisfying others
  - Constraint satisfaction values in ranges

## Future project

- Testing on criteria beyond constraints
  - User-friendliness for parameterisation
  - Scalability and performance
  - Customisation!
  - Preservation of topology
  - Creation of links between initial and output data
  - Generalisation of incremental updates

Only if significant improvements are achieved on criteria tested in this project!

# Many thanks to:

**vendors:**
***Axes systems, ESRI, University of Hanover, and 1Spatial***


| Core project team | Temporal members | Testers |
|---|---|---|
| Jantien Stoter (TUD&KAD)<br>Dirk Burghardt (Zurich)<br>Blanca Baella (ICC)<br>Cécile Duchêne (IGNF)<br>Maria Pla (ICC)<br>Nicolas Regnauld (OS GB)<br>Guillaume Touya (IGNF)<br>Connie Blok (ITC) | Karl-Heinrich Anders,<br>Jan Haunert (Hanover)<br>Nico Bakker (Kadaster, NL)<br>Francisco Dávila (IGNS)<br>Peter Rosenstand (KMS, DK)<br>Stefan Schmid (Zurich)<br>Harry Uitermark (Kadaster, NL) | Magali Valdepérez (IGNS)<br>Patrick Revell (OS GB)<br>Stuart Thom (OS GB)<br>Sheng Zhou (OS GB)<br>Willy Kock (ITC, NL)<br>Annemarie Dortland (Kadaster, NL)<br>Maarten Storm (formerly Kadaster, NL)<br>Patrick Taillandier (IGNF) |