Chapter 4 Quality Control & Multisource Updating of Urban DataBases

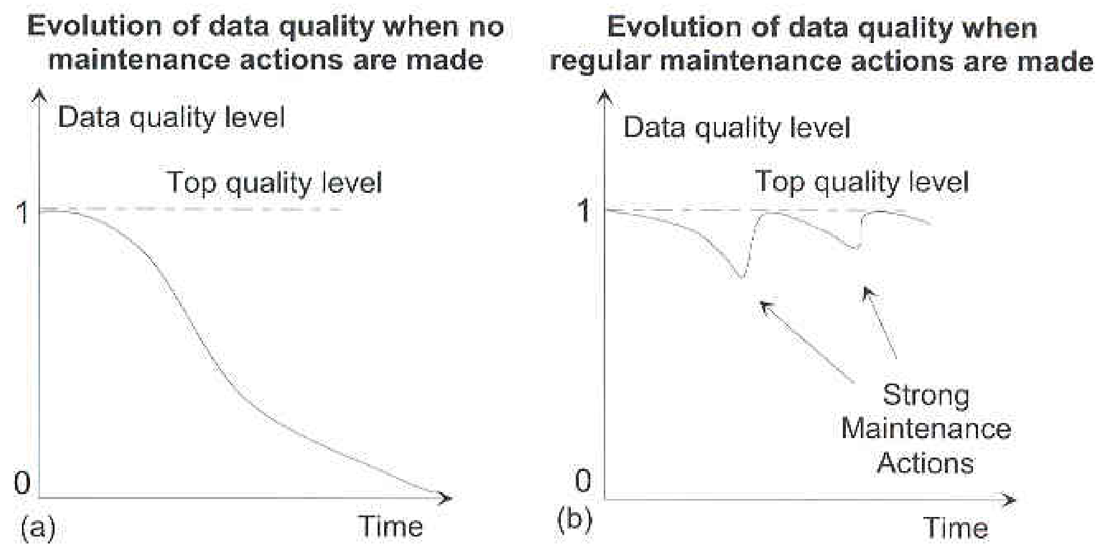

Figure 4.1 Quality and time. (a) Evolution when no maintenance is undertaken. (b) Evolution when regular maintenance actions are performed.

4.1 Quality control & assessment of spatial info

- Conventional data quality components
  : lineage, accuracy, resolution, feature completeness, timeliness, consistency, quality of meta data

- Data quality vs. maintenance
  w/ regular maintenance, quality be near the top level

<u>Lineage</u>

Define origin & history of the dataset

-> info describing the source observation, data acquisition & compilation method, analyses & derivations that data set subject to

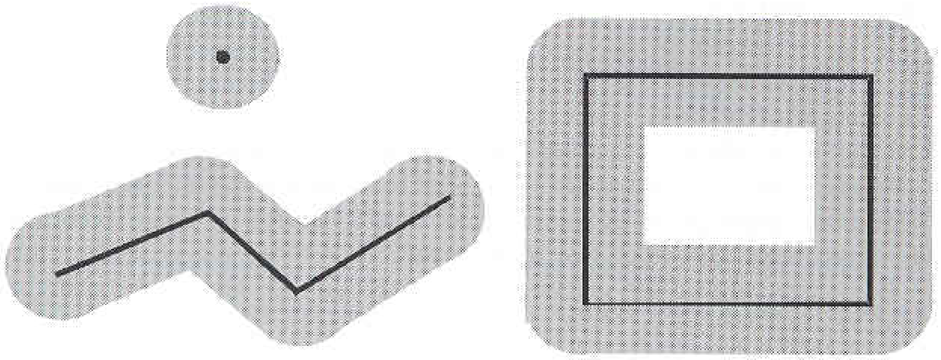

Figure 4.2 Examples of error band for a point, a line and a polygon.

Accuracy

- Accuracy is always a relative measure

   a. Spatial accuracy

      deal w/ spatial component, distance between encoded & actual

      for point – often presented by a tolerance eg. ± 1 foot

      for line – complex (point error + generalization error),

         usually presented by ε-band

   b. Temporal accuracy

      agreement between encoded & actual temporal coordinates

   c. Thematic accuracy

      accuracy of the attribute values encode in a database

      two types of theme : qualitative & quantitative

Resolution

- Refers to the amount of details can be discerned in space, time, theme
- Truth of resolution

  high resolution is not always better

  -> eg. low resolution may be desirable to formulate general models

- Resolution is linked w/ accuracy

  lower resolution has less demanding accuracy requirements

- Can be defined in spatial, temporal, thematic domain

  cf. spectral, radiometric resolution (in RS)

Feature completeness

- Refers to a lack of errors of omission

  a. data completeness

  related to error of omission observed between data & specification

  b. model completeness

  agreement between data specification & abstract universe

Timeliness

- Currency of features & their attributes

Consistency

- Refers to the absence of apparent contradictions within a database

  a. spatial consistency

     include conformance to topological rules

  b. temporal consistency

     related to temporal topology eg. one event at a location at a time

  c. thematic consistency

     lack of contradictions in thematic attributes

Quality of meta data

- Quality, consistency, completeness of meta data

  <- component of data quality

Veregin matrix

- Veregin & Hartigai proposed a matrix to measure quality as a whole

Table 4.1 Veregin and Hartigai (1995) data quality matrix

	Space	Time	Themes
Accuracy			
Precision			
Consistency			
Completeness			

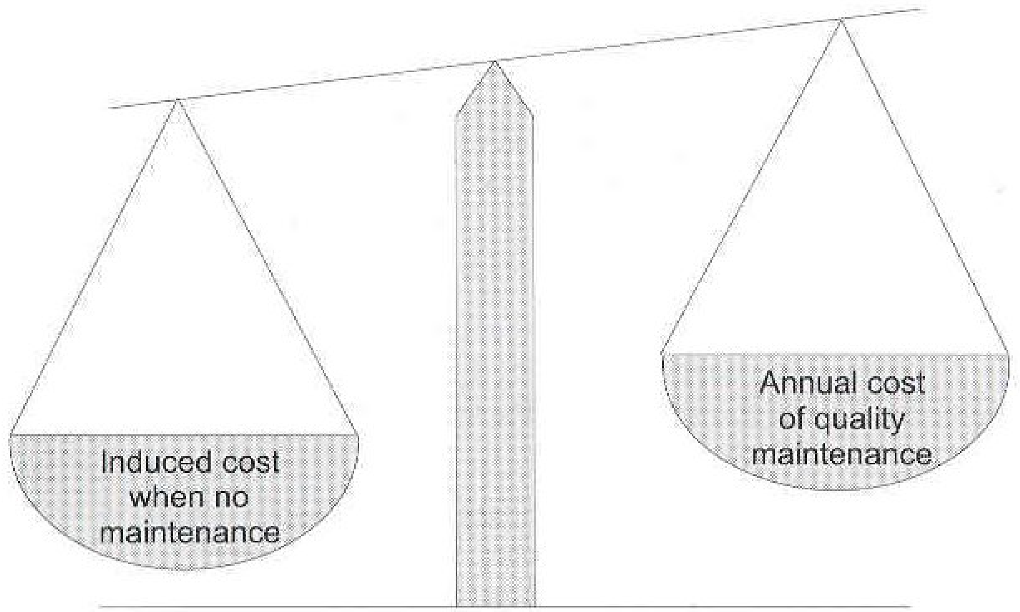

Figure 4.3 Balance between the annual cost of quality maintenance, and the induced cost when no maintenance is done.

Cost of quality maintenance

- usually 10% per year of the acquisition cost to maintain the quality
- without maintenance : cost will be great

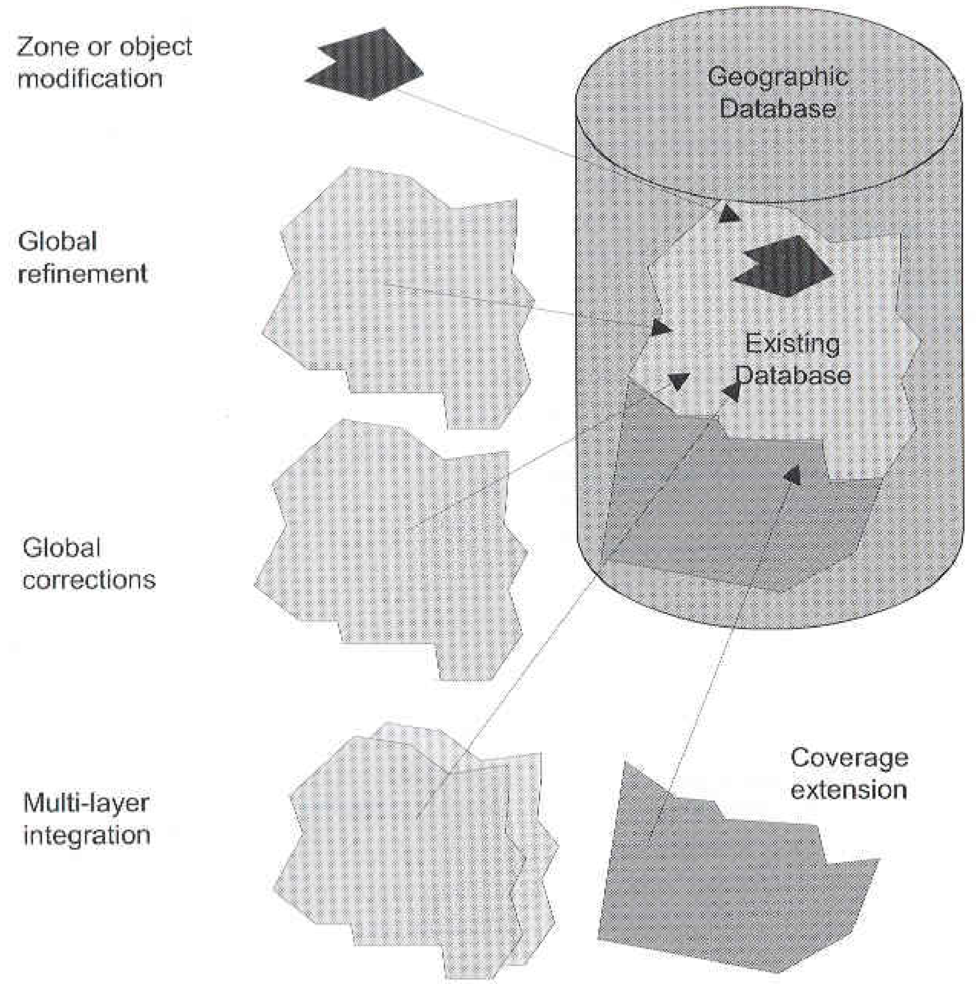

Figure 4.4 Different cases of geographical database updating.
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4.2 Generalities about updating

- Different cases of geographical data updating

  a. zonal / object modification

  b. global refinement / global updating

  c. global correction

  d. multi –layer integration

  e. coverage extension

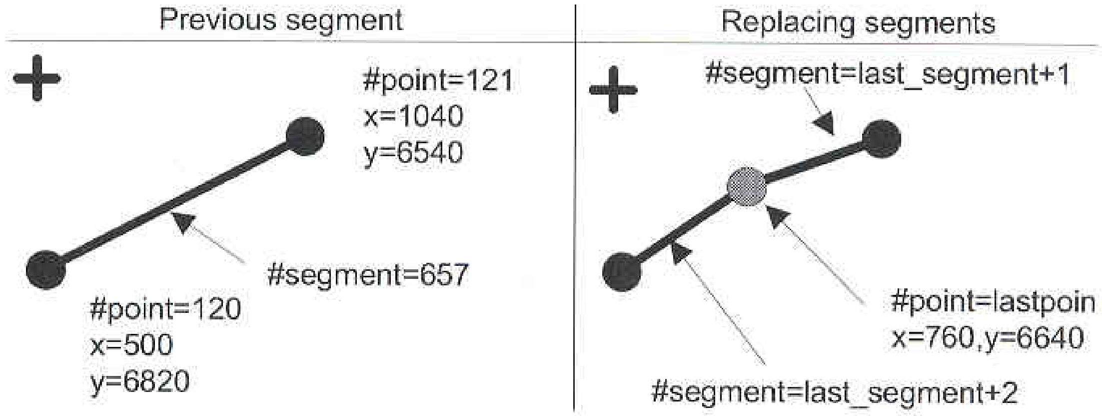

Figure 4.5 Replacing one segment by two segments.
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4.3 Alpha numeric updating

suppose a database of following relations

R1 (#parcel, (#segment)*)
R2 (#segment, (#point1, #point2)*)
R3 (#point, x, y)

- updating by means of a language eg. SQL (structured query language)

eg. change coord of a point #point=2537, x=4567, y=7890

```
UPDATE R3
SET x=4567, y=7890
WHERE #point=2537;
```

eg. replace a segment by two new segments

```
BEGIN
 DELETE FROM R2   WHERE #segment=657;
 INSERT INTO R3 (#point,x,y)   VALUES (NEW.#point, 760,6640);
 INSERT INTO R2 (#segment, #point1, #point2)
     VALUES (NEW.#segment, 120, CURR.#point);
 INSERT INTO R2 (#segment, #point1, #point2)
     VALUES (NEW.#segment, CURR.#point, 121);
COMMIT;
END;
```

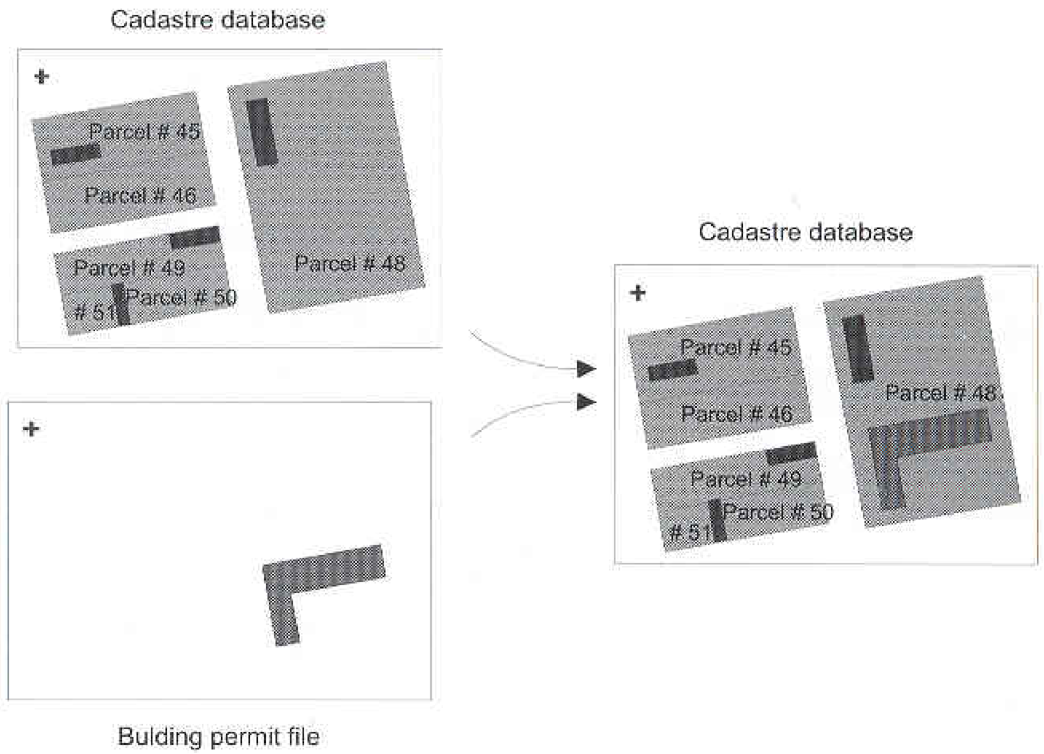

Figure 4.6 Integrating new building file into cadastre.
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4.4 Zonal updating & refinement

- Updating must be performed in two cases

  case a) when there is an evolution of geographic objects

  case b) when there is an evolution of the knowledge about them

- Refinement is to replace the old measures w/ new of more details

<u>Object integration w/o side-effects</u>

- when receiving a new file to integrate

  eg. building permit file is arrived -> update existing cadaster

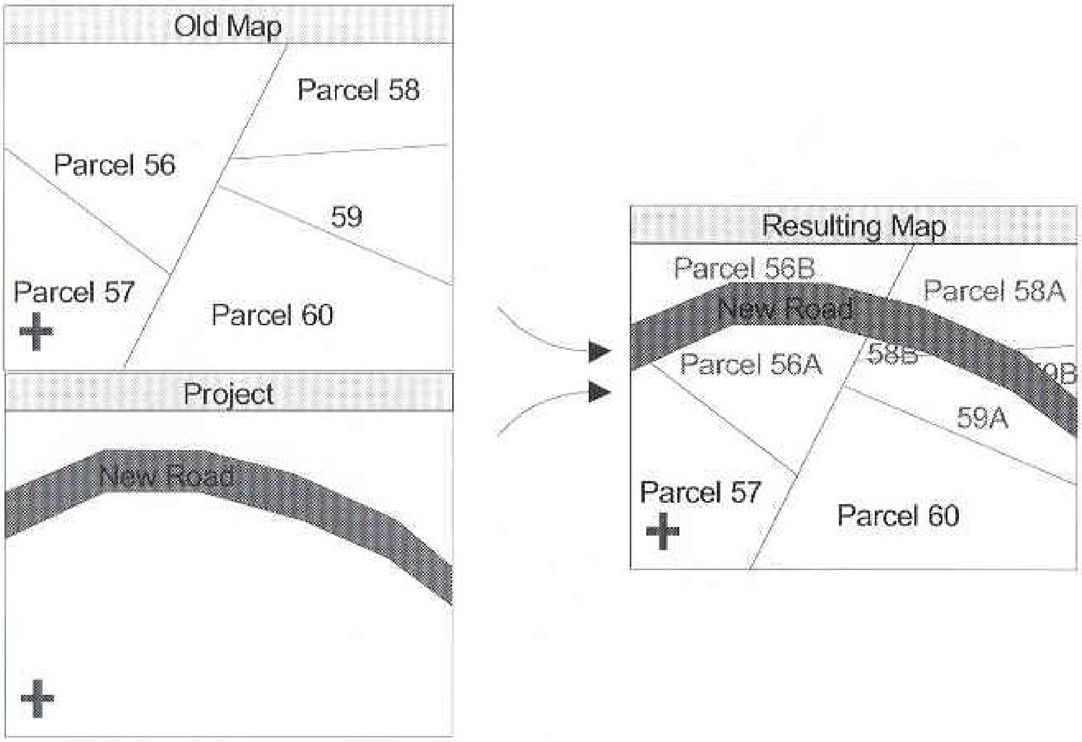

Figure 4.7 Principle of local updating with topologic reorganisation and without elastic correction.

<u>Updating w/ local modification w/o elastic transformation</u>

- When there is a case of topological + geometric modification

  eg. integration of a new road into a cadastre

  -> not necessary to move some points / some segments

  -> elastic transformation is not necessary !!

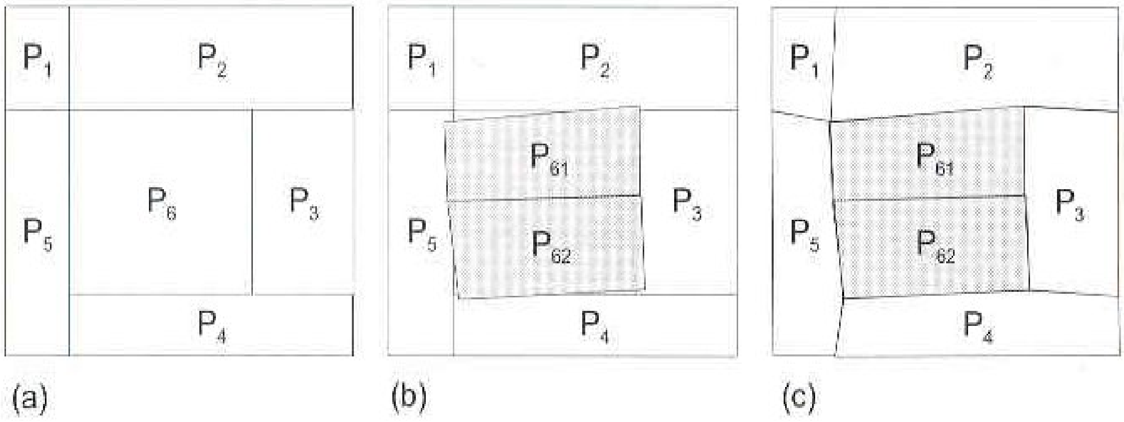

Figure 4.8 Consequences of introducing updating into cadastral maps (after Spéry 1999). (a) Initial situation. (b) Integrating without corrections, French-style approach. (c) Integrating with correction, Danish-style approach.

cf. Two cases of cadastre updating

case a) French style approach

integrating w/o corrections – 'patchy & dirty' databases

topological inconsistencies exist

case b) Danish style

integration w/ corrections – topologically clean

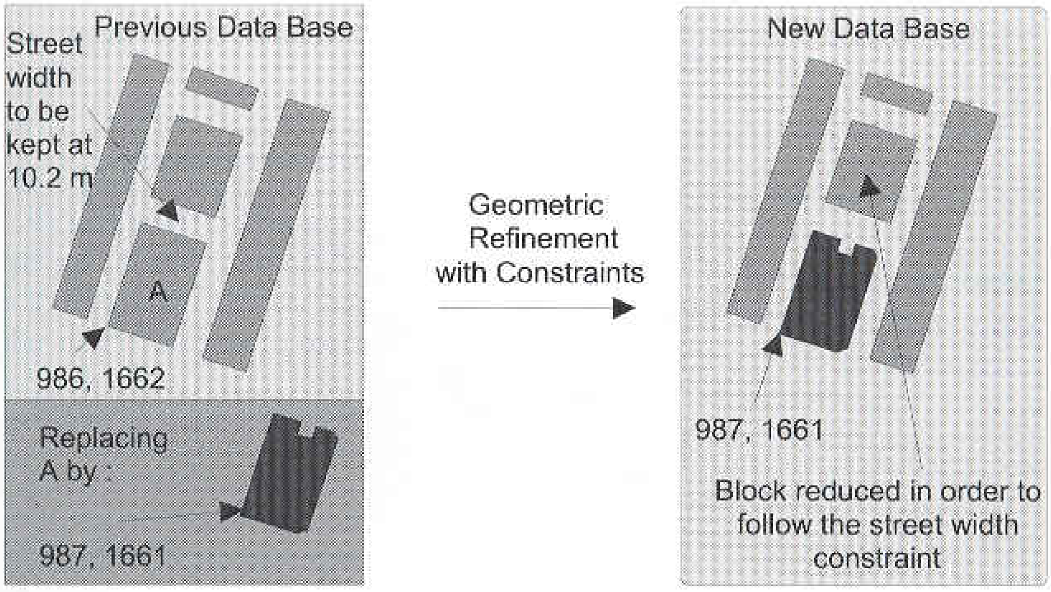

Figure 4.9 Zone refinement with constraints.
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<u>Updating w/ elastic transformation</u>

- Need when a patch to integrate does not meet the existing geometry
- Elementary actions

    a. force-fit a point (coordinates)

    b. force-fit the length of a segment

    c. force-fit an angle (especially right angle)

    d. force-replace a segment by a new polyline

    ➔ transformation follows some constraints & need to detect segment, characters as well as cartographic objects

- Map conflation / rubber-sheeting to perform feature alignment & feature matching

  eg. linear transformation technique

$$X = axy + bx + cy + d$$
$$Y = a'xy + b'x + c'y + d$$

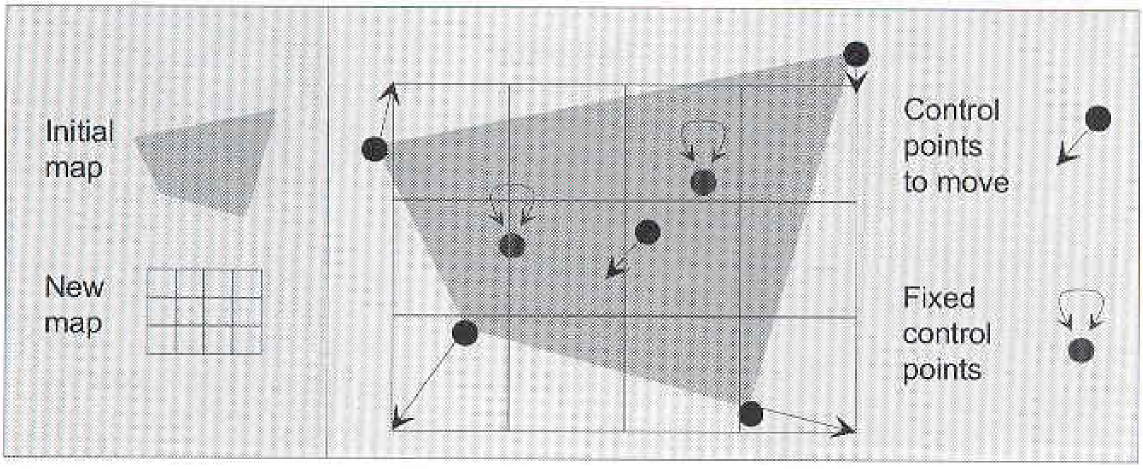

Figure 4.10 Multi-point rubber-sheeting with constraints.
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4.5 Global updating

- When a reference system has to be changed

  When new measures of local geodetic points are provided

- Several methods

  a. conventional rubber-sheeting (when a few control pts are provided)

  b. sophisticated rubber-sheeting (based on several pts w/ constraints)

  c. global updating (based on aerial photos)

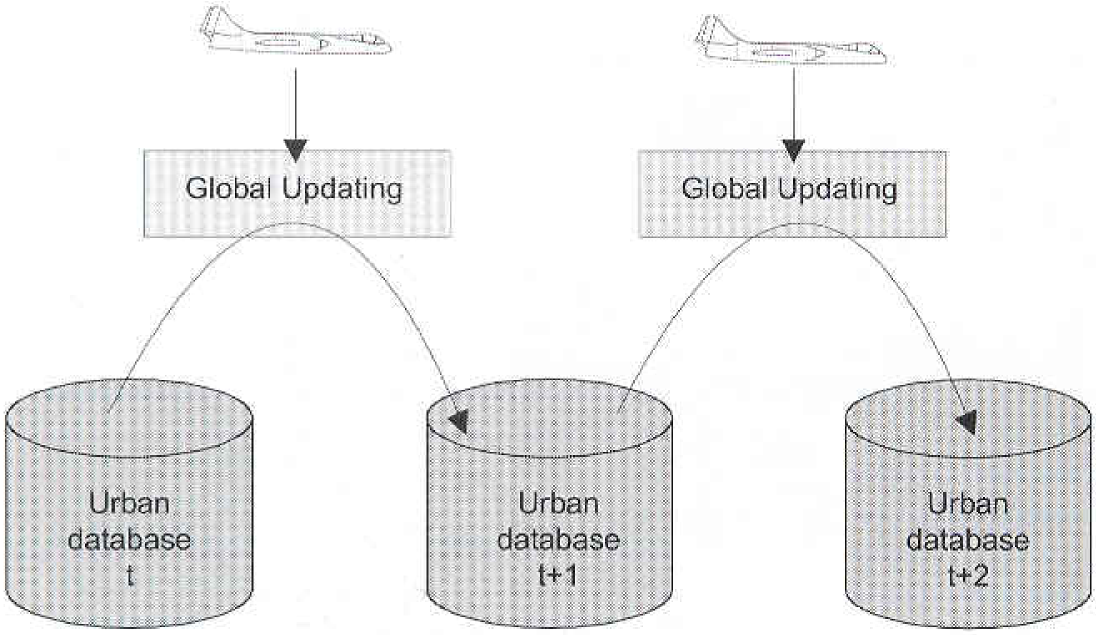

Figure 4.11 Main steps for regularly updating an urban database from aerial photos. Reprinted from *Computers, Environment and Urban Systems* 18 4, R. Laurini 'Multi-Source Updating and Fusion of Geographical Databases' 243–56 © 1994, with permission from Elsevier Science.

Global updates using aerial photos

- Organize flights regularly (eg. every year) & process following tasks

  a. image dewarping : correct distortions due to relief & tilt

  b. construction of a texture & a knowledge base

  c. extraction of zones w/ homogeneous textures & comparison w/ the database contents

  d. if discrepancy is detected, then, update

  e. (sometimes) some extra info can be used (eg. building permit)

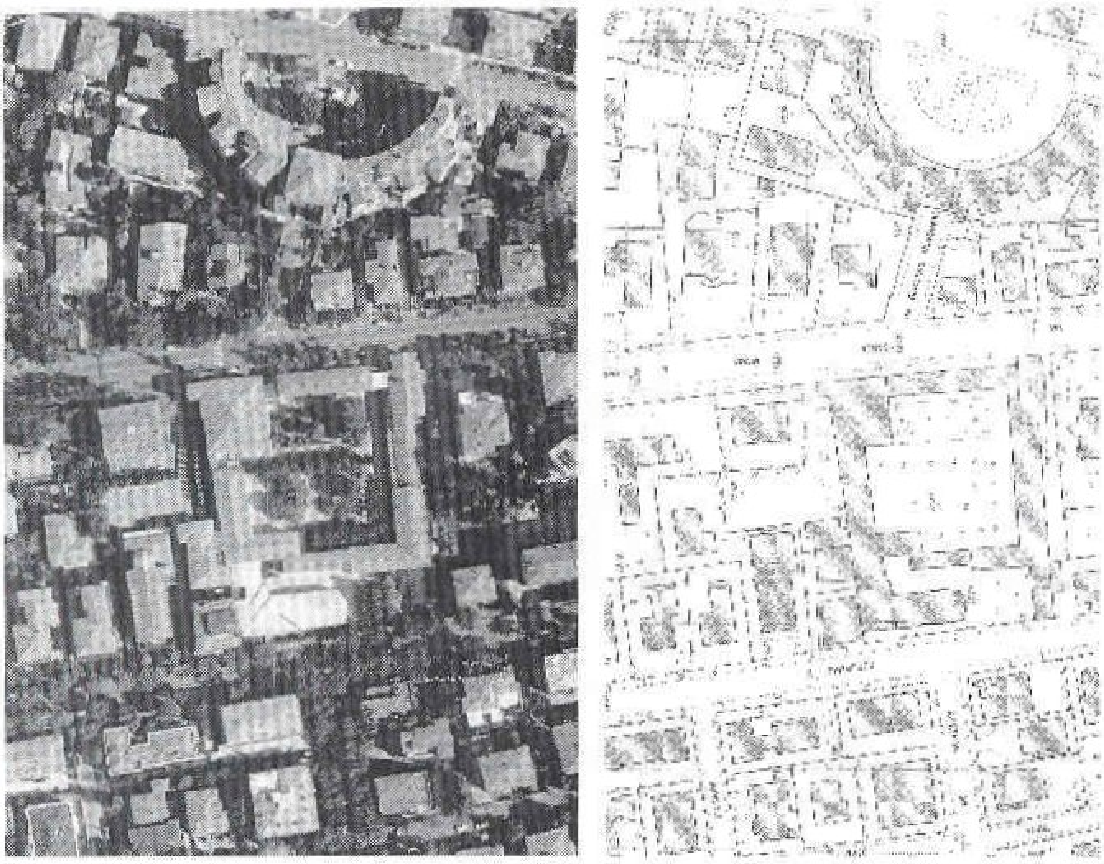

Figure 4.12 Example of aerial photos and the corresponding data in the database. The goal is to compare the map and the photos in order to find the differences and to update automatically the database (Tellez and Servigne 1998).

- Example of aerial photos & corresponding data in the DB
  -> goal is to update the DB

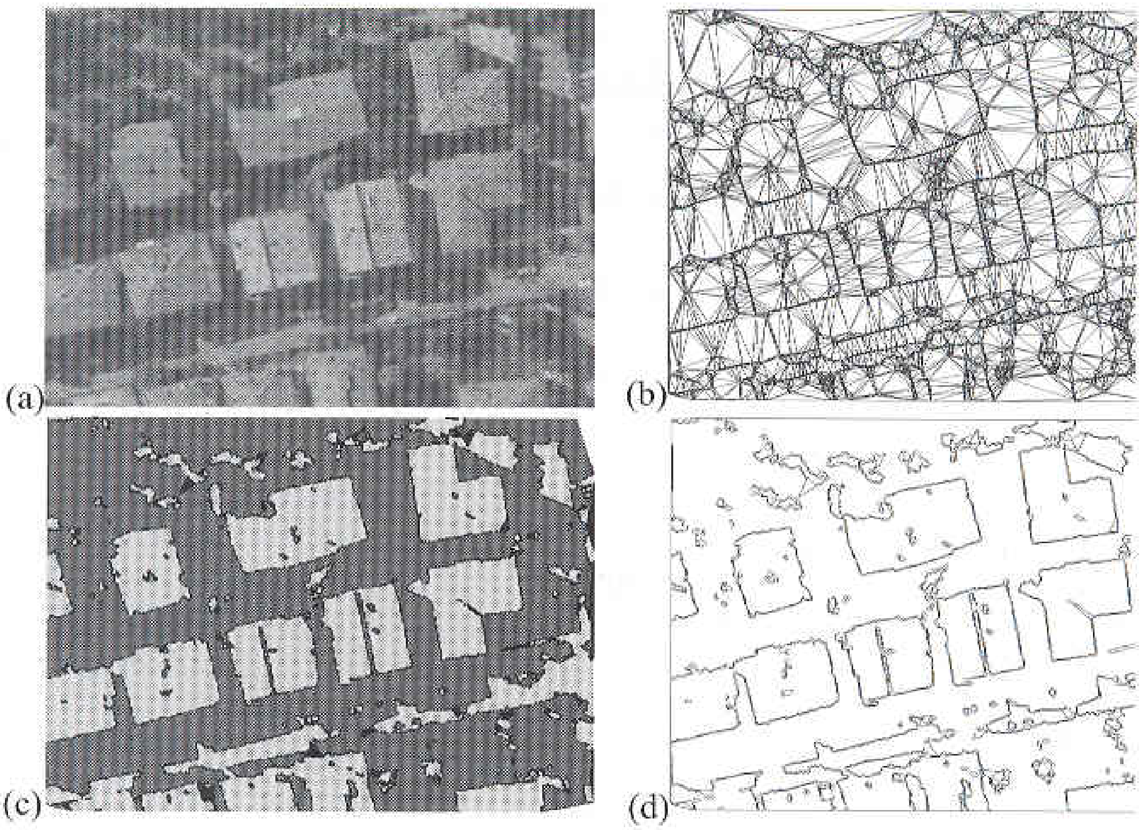

Figure 4.13 Object extraction in aerial photos. (a) Initial Photos. (b) Triangulation before colour classification and contour points extraction. (c) Triangles classification bright/zone, dark/background, black/boundary. (d) Objects extraction with double contours (Tellez and Servigne 1998).

- Object extraction in aerial photos

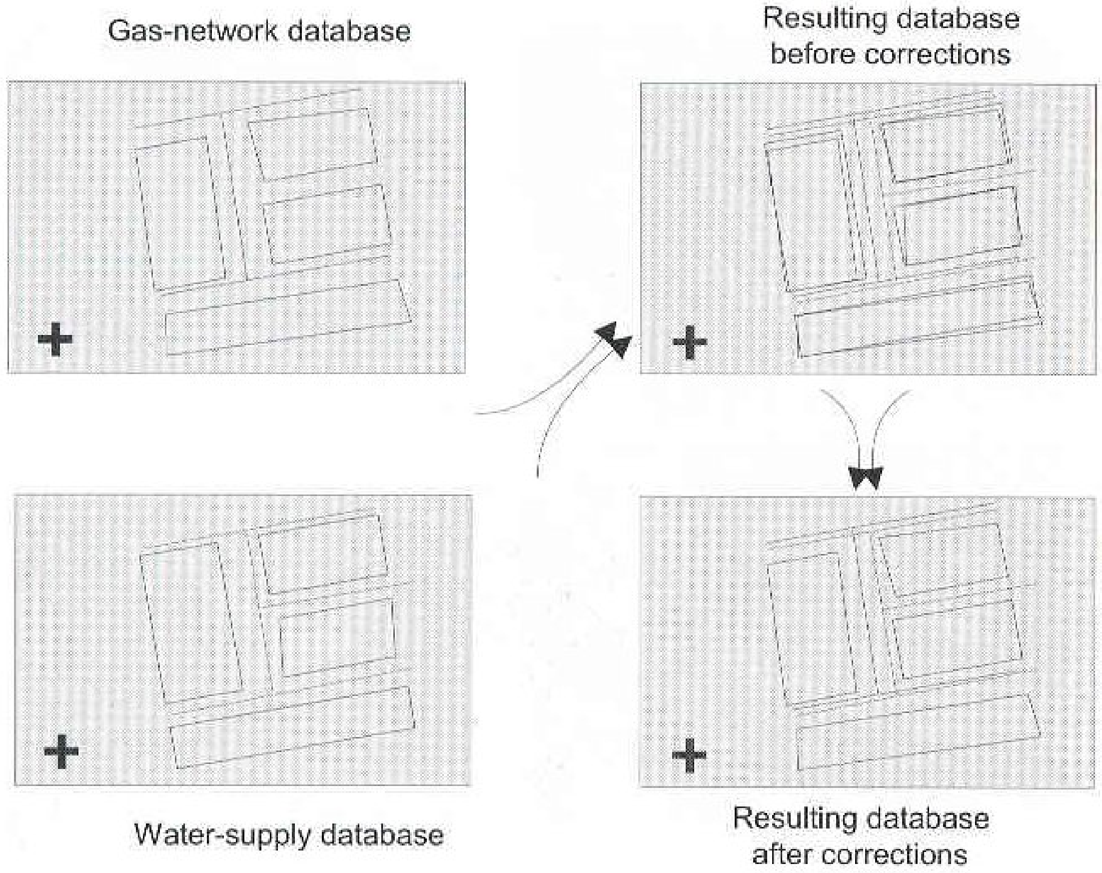

Figure 4.14 Example of layer mixing.
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4.14 Mixing two layers

- Mixing two layers of different sources causes discrepancy problem

- Modification w/ or w/o constraints is necessary before updating

  eg. gas network & water supply DB

    need to do elastic transformation w/ constraints

    -> force-fit to some points, segments, angles

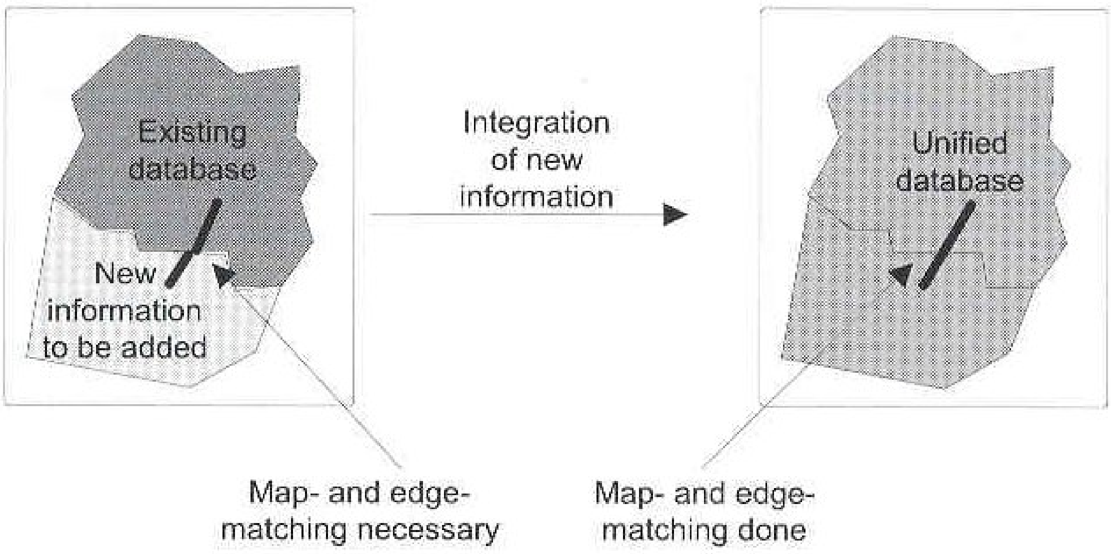

Figure 4.15 Geographic database coverage extension.

4.7 Coverage extension

- Coverage extension causes discrepancy at the boundary
  usually due to the differences in measurements

- Elastic transformation w/ constraints can be used
  coefficients must be determined by the LS method
  should based on some control points w/ constraints

- Some useful constraints
  alignment of streets
  parallelism of curbs or parcel limits
  rectangularity of some buildings

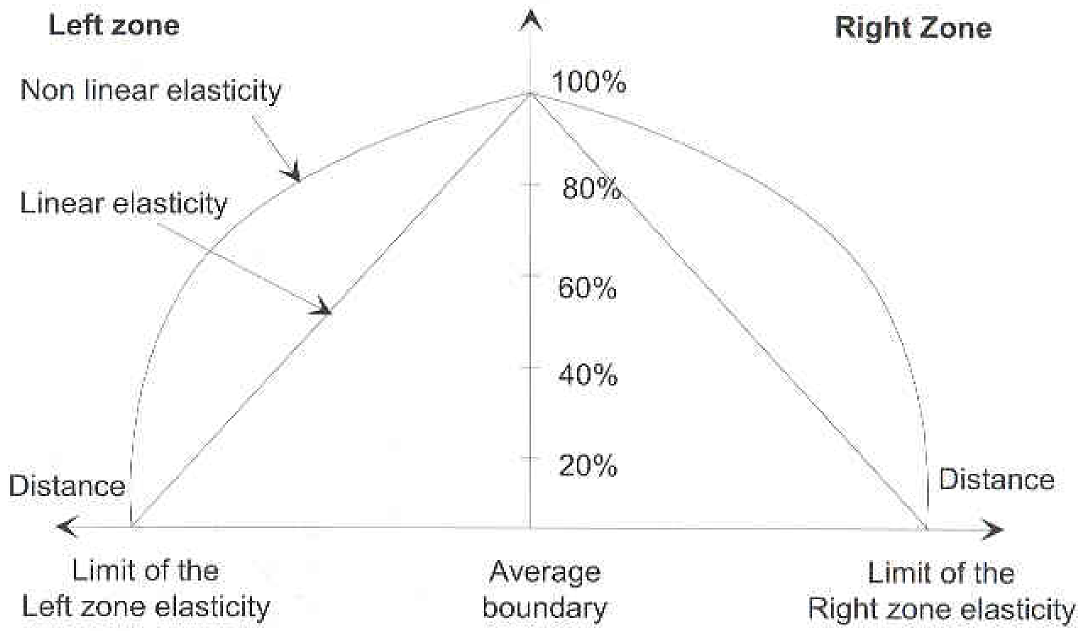

Figure 4.16 Elastic functions.

- Transformation is important at the vicinity of boundary
  but, vanishing w/ the distance

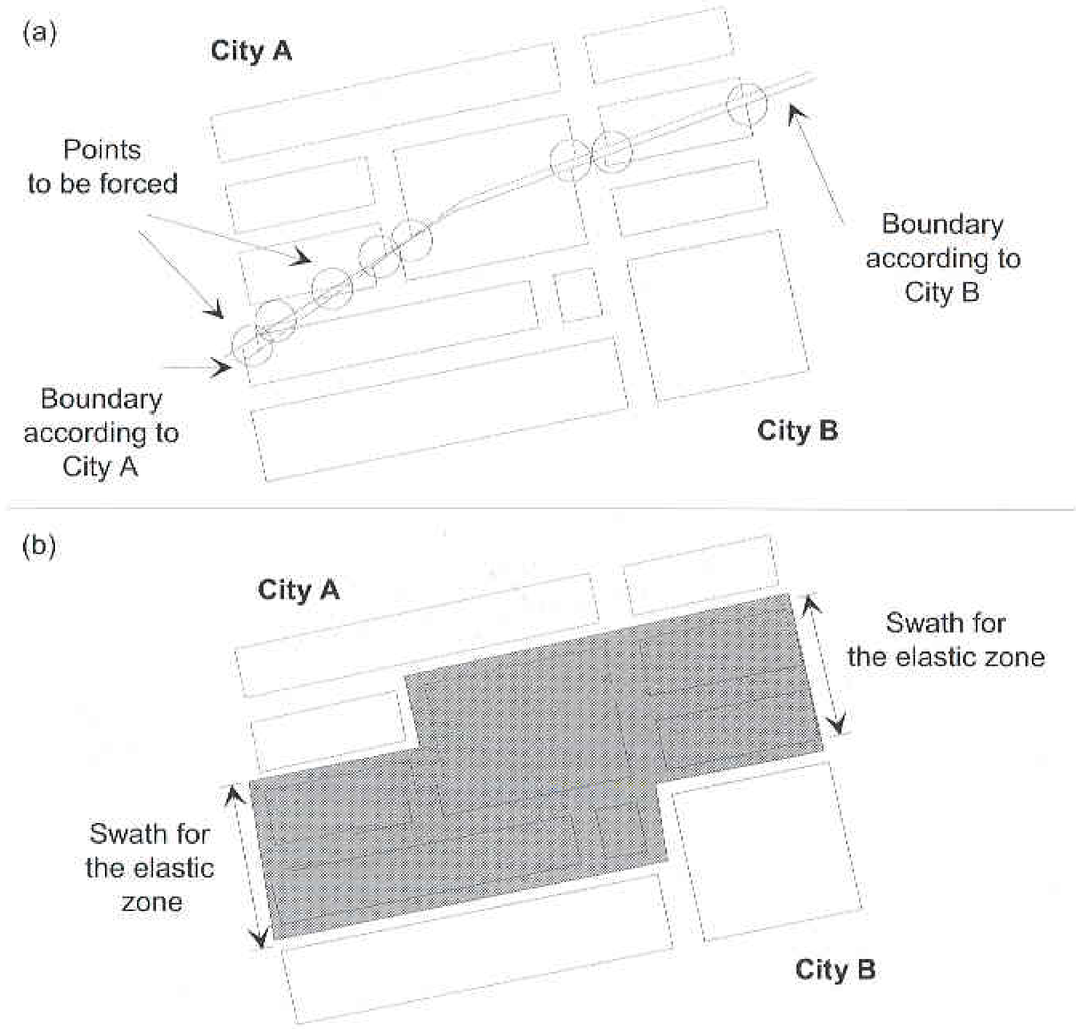

Figure 4.17 In an urban context, defining the boundary of the correcting swath along street axes. (a) before correction, (b) after correction.
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- Defining a swath as a constraint can be useful in transformation

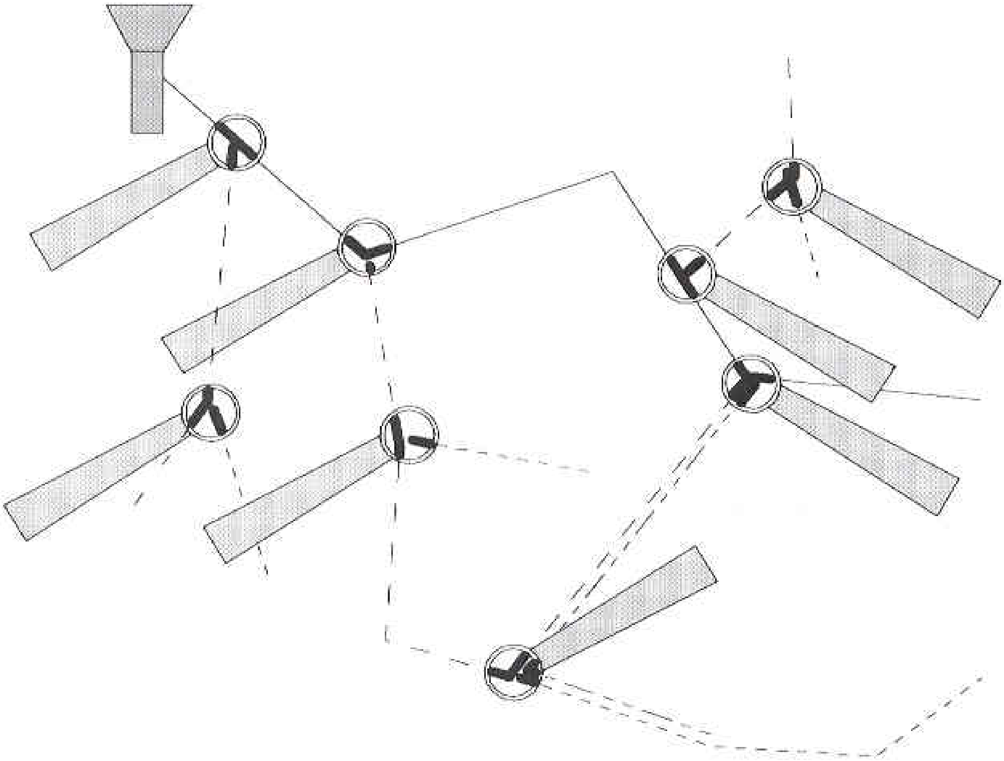

Figure 4.18 Detecting topological errors in a water network.
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4.8 Global corrections

<u>Single-layer corrections</u>

- error in a layer (eg. a water network)

- using geometric & topologic properties, consistency checking is possible
  -> implies correction of DBs

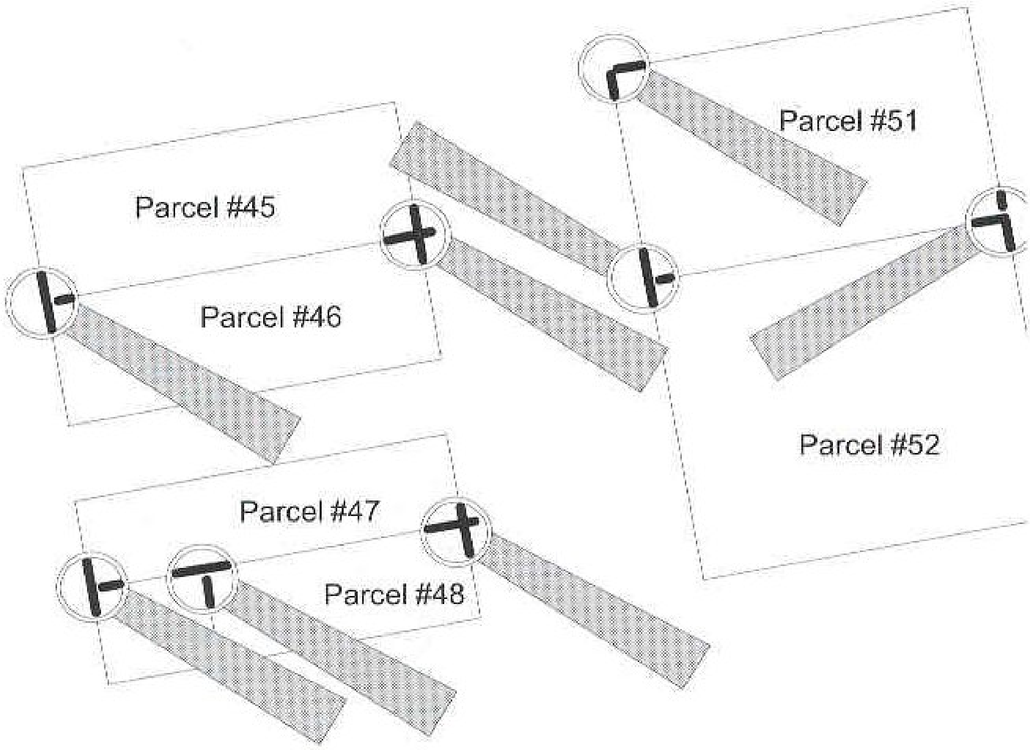

Figure 4.19 Detecting topological errors in a cadastre.
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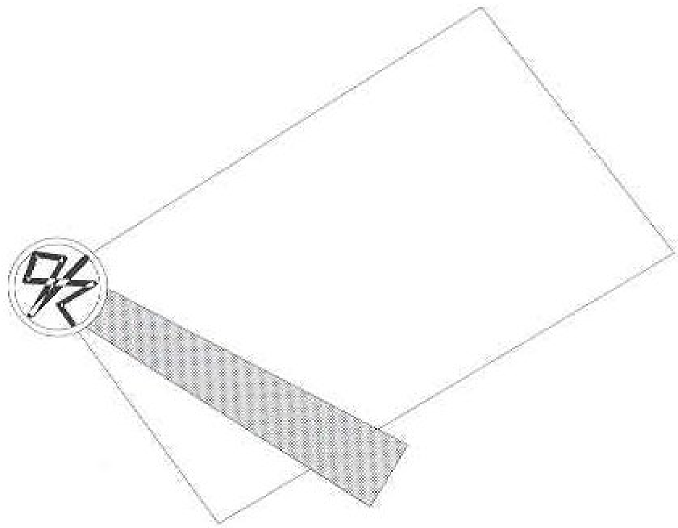

Figure 4.20 Strange errors due to awkward finishing of digitising (Ubeda *et al.* 1997).

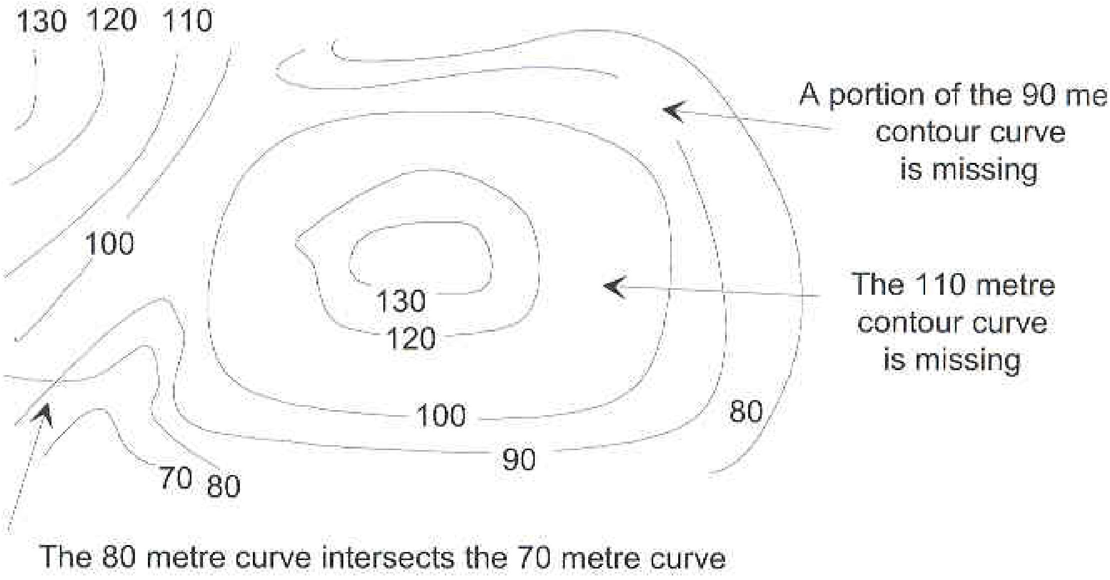

Figure 4.21 Detecting topological errors in contour level curves.
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- Example : contour curves

extended relational model CONTOUR (#curve, closing_flag, z, (x,y)*)

contour curves has a tree structure

possible integrity constraints

a. existential constraints : root & leaves apart, if z exists then z+h & z−h must exist

b. including constraints : root & leaves apart, any contour curve z must include the curve z+h & must be included in the curve z−h

c. non-overlapping constraints : any two level curves must not intersect

d. open curves except at the boundaries, level curves are never open

-> these constraints can be used for updating

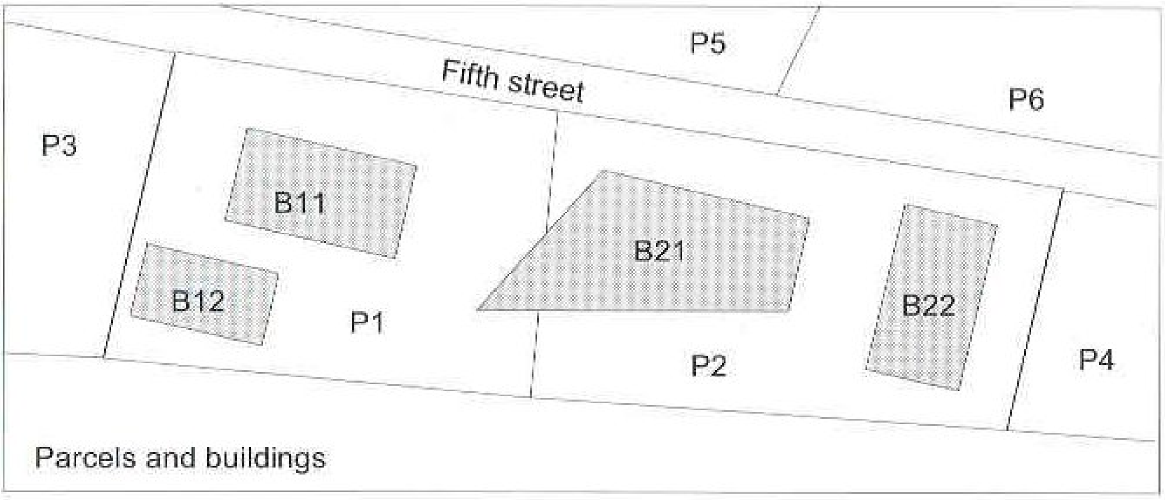

Figure 4.22 Detecting inconsistencies between parcel and building layers. Reprinted from *Computers, Environment and Urban Systems* 18 4, R. Laurini 'Multi-Source Updating and Fusion of Geographical Databases' 243–56 © 1994, with permission from Elsevier Science.

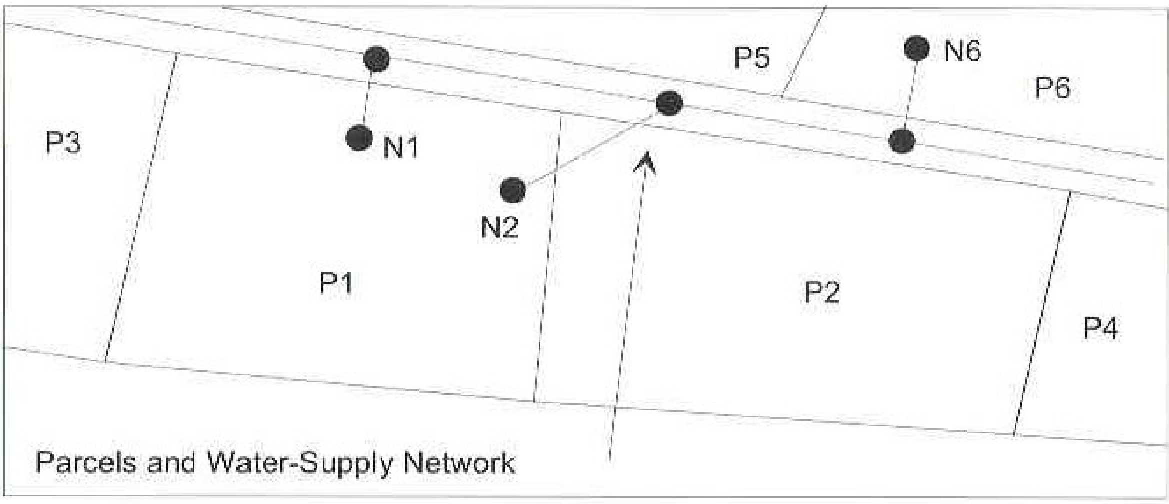

Figure 4.23 Detecting inconsistencies between parcel and water-supply layers. Reprinted from *Computers, Environment and Urban Systems* 18 4, R. Laurini 'Multi-Source Updating and Fusion of Geographical Databases' 243–56 © 1994, with permission from Elsevier Science.

Multi-layer corrections

- Another possibility for updating is by confronting several layers
  eg. parcels & building,   parcels & water-supply network

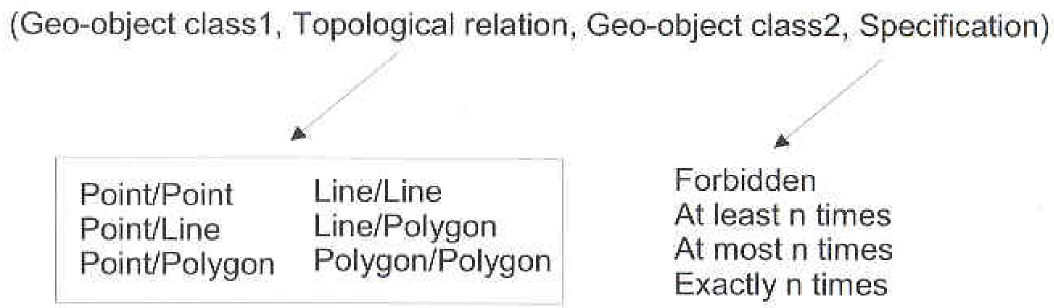

Figure 4.24 Definition of topological integrity constraints.
According to Ubeda (1997).

<u>Using spatial integrity constraints</u>

- Ubeda (1997) proposed spatial integrity constraints
  -> to checking the topological consistency of geo DBs

Spatial Integrity Constraints

a. each point has no null coordinates
b. each edge has two different nodes, and not other points
c. each edge has two faces
d. each face is represented by a simple circuit
e. each circuit must be closed
f. no intersecting faces
g. no node within a face
h. the corresponding graph is connected

based on these constraints, a topological integrity constraint can be:

(Geo-object class1, topological relation, Geo-object class2, specification)

eg. (Road, cross, building, forbidden)

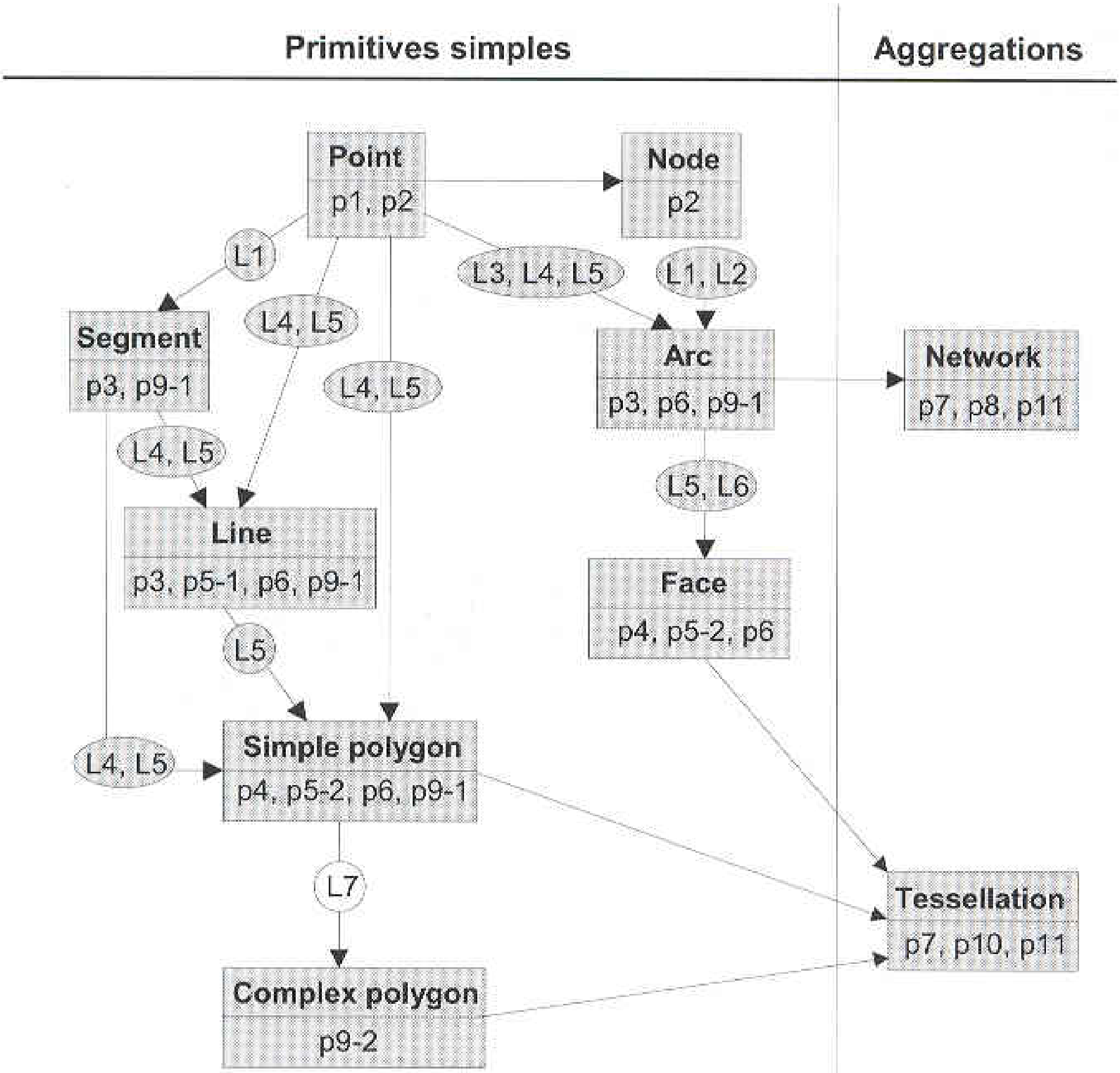

Figure 4.25 Links between constraints.
After Ubeda (1997).

- Ubeda also established properties of geometric & geographic objects
  -> used as topological integrity constraints

For geometric objects

p1 : consistency of points

p2 : unicity of punctual elements (points & nodes)

p3 : unicity of linear elements (segments, lines & arcs)

p4 : unicity of surface elements (polygons & nodes)

p5-1 : openness of lines

p5-2 : closure of polygons & faces

p6 : non-intersecting feature

p7 : connexity of the feature

p8 : good-looking networks

p9-1 : orientation p9-2 : orientation of the contour

p10 : total coverage of the space

p11 : non-overlapping of elements within a tesselation

For geographic objects

L0 : referential integrity

L1 : the two points or nodes are different

L2 : belonging at least to two objects

L3 : belonging to exactly one object

L4 : all objects within a list are different

L5 : the list objects are ordered

L6 : belonging to exactly two objects

L7 : belonging at most to two objects

⇒ DB is scanned to check whether all objects follow these constraints

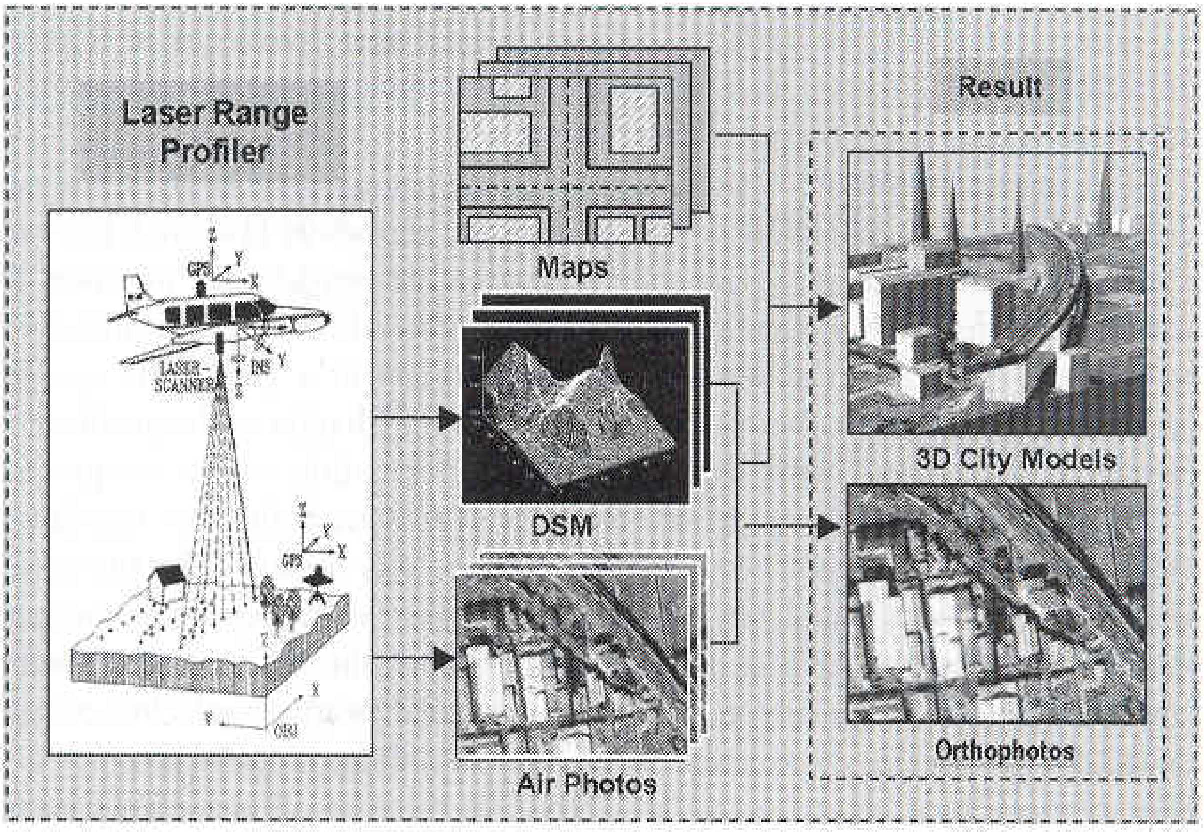

Figure 4.26 The outline of a system for generating a 3D model of a city based on a range profiler, digital terrain models (DSM) and aerial photos.
From Chen, X. 1999 used with kind permission.

- Example of multi-source updating

  : mixing aerial photos & laser data