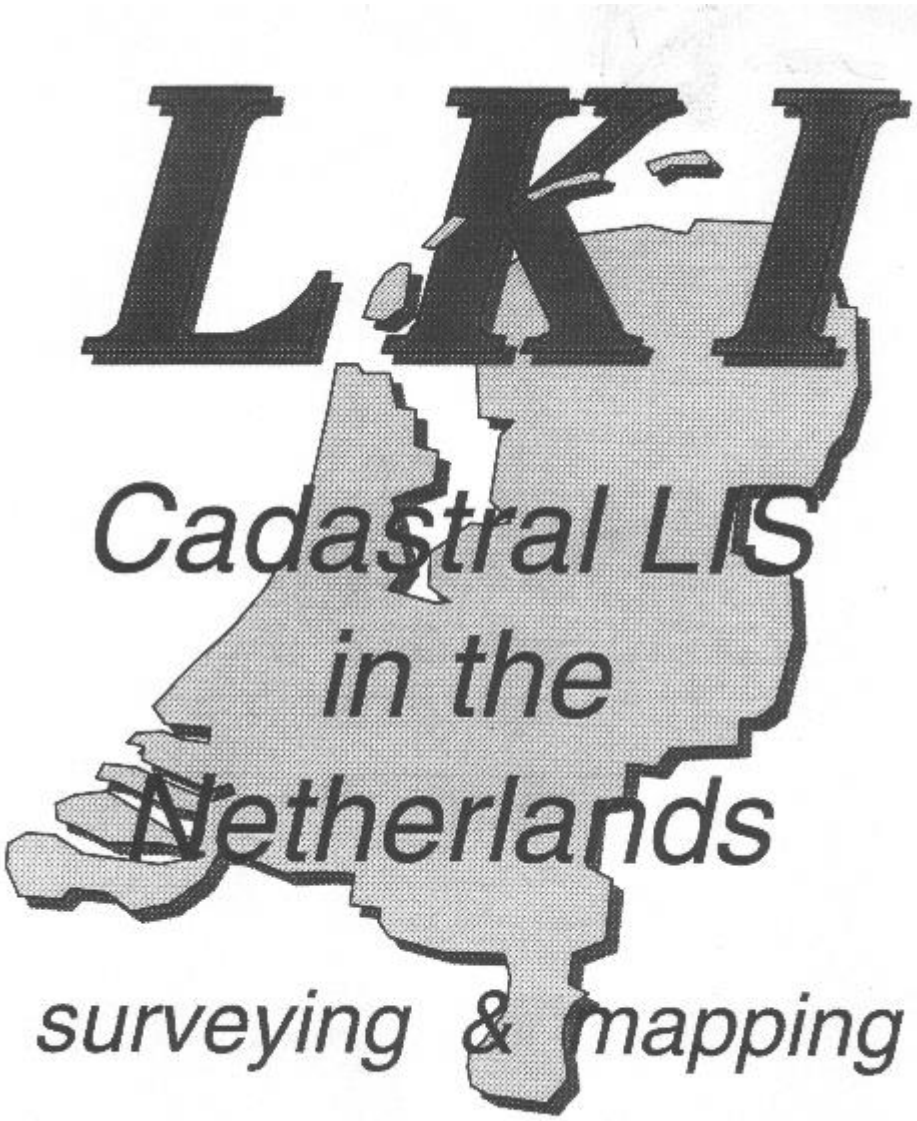

L.K.I
Cadastral LIS
in the
Netherlands
surveying & mapping

CONTENTS:

1. General Information Netherlands Cadastre

2. Basics of LKI

3. LKI-datastructure

4. LKI-applications (surveying & mapping)

5. Dutch Cadastre in the Future

1. GENERAL INFO NETHERLANDS CADASTRE

1.1. Facts & figures

- 1832 - 1994 national government institute
- Cadastre is privatised since May 1994
- 21 00 employees
- Yearly budget: 300 million US$
- statistics:
  - 3.5 million hectare
  - 15 million inhabitants
  - 7,5 million cadastral land parcels
  - 350.000 parcel updates / year

1.2. Cadastral Tasks

MAIN GOAL (COMPANY-MISSION):
To contribute on a national level to the legal security on real estate and landinformation in the Netherlands.

how?:
to deliver and present on request all object-information (landparcels) and subjectinformation (ownership, and other legal rights and limitations) of cadastral parcels which are registrated.

cadastral tasks are:
- keep public records on land transactions (deed-registration)
- maintain an update registration on land parcels, rights and subjects
  - registrative (cadastral administration)
  - cartographic (cadastral map)
- provide cadastral information (on different levels of aggregation) to the public
- maintain the national co-ordinate system (geo-reference)
- assist in land consolidation
- participate in production and updating of the Netherlands Large Scale Topographic Base Map

1.3. Cadastral Basic Structure

Next figure shows a simplified model of the basic cadastral elements with their relations.
CADASTRAL PARCEL = "Spider in the Web"

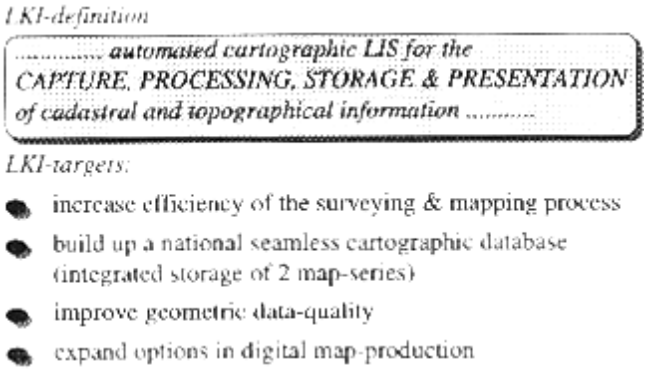
- 1832: registration and map
  CAD.REGISTRATION: up-to-date object- and subject-information on cadastral land parcels
  CAD. MAP nation-wide large scale map with the geometric location of all land parcels
- since 1900: formal storage of field-documents, which contain all survey-measurements
- 1839: Cadastre stores copies of all registrated deeds

2. BASICS OF LKI

2.1. Cadastral Map Products

	Cadastral Map	*Topographic Map*
started in	1832	1975
coverage	100% 85% digital, 15% local analogue	80% digital ready
map-form	island	rectangular
content	cadastral boundaries, parcel-numbers, main buildings	main buildings, infrastructural topography, semantic into
scale	1: 500 to 1: 5000	1: 500, 1: 1000,1: 2000
users	cadastre, local & state authorities, public waterboards, notaries	cadastre, utility companies, local authorities
update frequency	continuous	depend on agreement between participants/users

2.2. LKI-definition and objectives



SCAN-DETAIL:

- geodetic calculation software (developed with TUD)
- where used: convert field-survey measurements into co-ordinates
- advantage: high skill adjustment-techniques / error detection

FINGIS:

- GIS-software provides basic tools for all our cartographic and database applications
- From 1997: X-Fingis GIS and Openingres 2.0 OME (object management extension) as a relational database + SOL (Spatial Object Librairy)

OBJECTIVES LKI

- Integration is an important objective in LKI:
  The actual capture of cadastral and topographic changes in the field is integrated. Also the processing of land survey-data and the following cartographic activities on the digital map is done simultaneously.
  Within the LKI-database, integration is the key-word: all cadastral and topographic information will be stored in an integrated fashion. Identical objects on both map-series will be stored only once. Furthermore, the geometric location of cadastral boundaries is tuned with relevant topographic elements.
- Greater efficiency in the production and use of digital map information is expected: e.g. automated calculation of parcel-areas, automatic process-control (less manual control-activities) and very strict user-procedures (limitation on mistakes).
- Geometric quality of the LKI-database information is based upon the requirements of the former analogue maps. This means a relative precision between two well-identified points on the original map-scale. Through terrestrial updating (1:1 accuracy) the LKI-data may be gradually geometrically improved.
- LKI can have a standardising effect in the field of Dutch GIS-users. Especially the digital TopoMap can serve as a geo-reference for GIS-applications. As a result, GiS-data of different organisations can be compared and related to each other.

2.3. Overview LKI-system functions

LKI contains several 'independent' system-parts, depending on the application (workprocess).

FIELD-SURVEY:
- maintaining network of control-points (tachometers, GPS)
- terrestrial measuring of topo + cadastral changes
- data-transfer (tacheometer to computer)

FIELD-DATA PROCESSING: (==> SCAN-DETAIL)
- calculation of co-ordinates (adjustment / error detection)
- creating cartographic objects

PHOTOGRAMMETRY (application is now outplaced):
- digitise aerial photographs for building up the TopoMap
- ZEISS-instruments + PHOCUS-software

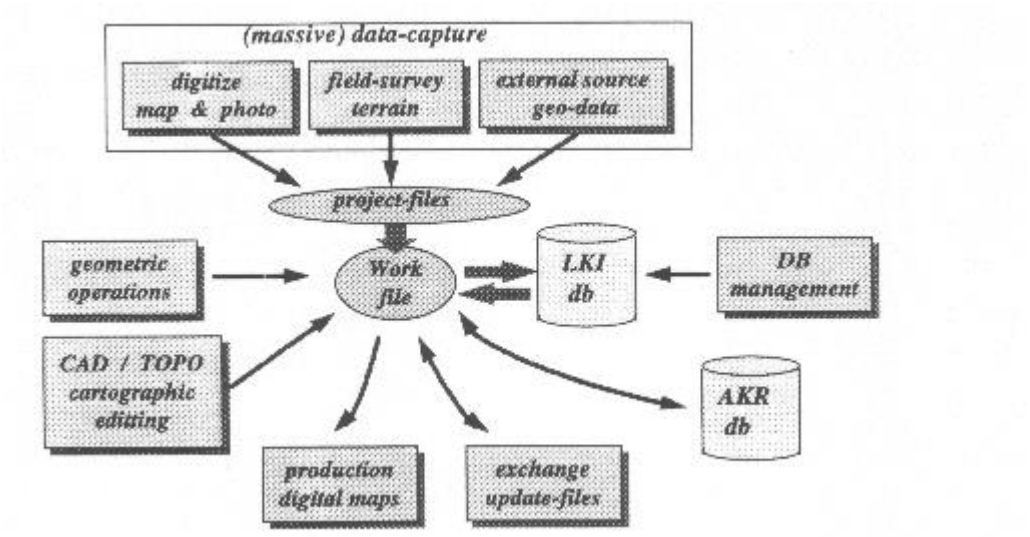
CARTOGRAPHY: (==> FINGIS, extended with X-FINGIS)
- digitising maps and map-renovation
- update LKI-database (topography + cadastral)
- production of analogue and digital maps (for in- and external use)

MAP-VERIFICATION:
- programme for quality control on digitised, photogrammetric or externally received data

MANAGEMENT:
- support of data / databases / software
- f.i. user-authorisation

SUPPORT SYSTEMS:
- auxiliary systems for plotting, file-transport
- support network facilities

2.4. LKI processes/data-flow



MAIN LKI-DATABASE:

- internally designed and developed datamodel and physical structure (1 982)
- it is a network-db, because the main goal was fast 'build-up' and not the ability to make creative DB-selections based upon very detailed queries. Every provincial branch-office has its own database. National queries and selections are possible through combined access. From 1997 the database is renewed to a relational db-structure (Ingres).
- all (massive) build-up and updating activities take place through workfiles
- No direct data-input in the DB is possible for security-reasons.

WORKFILE:

- is a copy of a small cartographic area of the LKI-database
- data-structure is the FINGIS-structure (Finnish GIS-application)
- all cartographic manipulations are done with FINGIS-software
- geodetic operations (adjustment, transformation) are also performed on the workfile; This software is developed mostly in co-operation with the Technical University of Delft.
- after an interactive session the contents of a revised workfile is updated in the LKI-database.

PROJECTFILE:

all (massive) captured data (digitising, land-survey and external sources) are placed in project-files for further processing in a workfile.

APPLICATIONS:

- data in projectfiles is transferred to workfile
- cartographic editing (object-manipulation) and the creation of new cadastral parcels is done directly in a workfile
- option: adjustment/transformation of local co-ordinates to national grid or D/D-conversions
- map-production:
  - standard analogue maps
  - topographic data for Land-consolidation projects
  - digital maps (variable in form or contents) for in- and external users
  - info-lists: statistical information can be extracted form the database and presented through various kinds of listings.

- delivery of map-updates:
  external users increasingly want to receive the cartographic changes over a pre-specified period of time

- DB-management:
  some special operations can be done directly on the database:
  - removing corrupt and redundant data (secure consistency between LKI and AKR)
  - large change of attribute-information in a specific DB-area
  - special queries (specific data selection via object-types and/or attribute values)

3. LKI-DATASTRUCTURE

3.1. Characteristics LKI-database

- LKI-db is designed to store the geometric data of the 2 Cadastral Map-series: CadMap and TopoMap. Similar objects on both maps, like buildings, are stored only once. No redundant information is allowed.

- Physical DB-structure = network-database (from 1984 - 1997)
  reason: building up the database is fast; large amounts of data can be quickly extracted and replaced.
  In 1997 the Cadastral Database will be converted to a relational dbms: Openingres 2.0.

- The access to the LKI-database (network type) was very simple and based upon the fact that the main target was to build up the LKI-database as fast as possible. No complex questions had to be answered in the past. This objective needs to be reconsidered at this moment. Therefore, conversion to a relational database is taking place in 1997. Nowadays, there is need for more complex queries, also in combination with the administrative landparcels information from AKR.

- The geometric quality of the location of cartographic objects does not need to be better then on the original analogue maps.

- Cadastral maps and Topographic maps are stored in a map-independent way. A separate storage-structure is designed, which makes it possible to store every object completely. Physical clipping of objects is not allowed or necessary.

- Besides the geometric attributes of the objects (object-form, location, co-ordinates) also attributes containing technical and administrative object-data is stored.

- Only for cadastral parcels (boundaries) a topological structure is demanded. The relation between parcel-boundaries of adjacent cadastral parcels is needed for the automated process of area-computation. Topological relations between neighbouring topographic objects are not stored explicitly because the use of the digital TopoMap did not require that. At this moment some users do have such demands, so the datamodel will have to be changed accordingly (see chapter Future Developments).

3.2. Cartographic object-types & classification

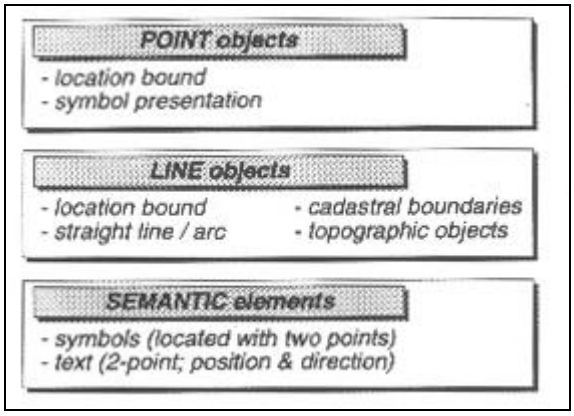
Within the database all objects are classified according to a basic form of hierarchy, based upon shape and representation in the terrain (real world). Some objecttypes are part of the content of both map-series. Classification is the most important object-attribute.

All terrain-object (line-oriented structure) are classified from 2 view-points:
- the nature of the element itself (f.i. wall, fence)
- as separation between 2 areas (road-boundary or parcel-boundary)

There are 7 main classification-groups (appr. 110 group-elements), which each a different physical record-structure.
- cadastral parcel (boundaries, parcel number)
- topographic artefact (buildings, constructions)
- topographic line (road & waterboundaries, wall, fence, ditch, topographic point (pylon, bus-shelter, telephone, inspection lid,
- symbol (road & water types)
- text (streetnames, housenumbers, local area-descriptions,
- control point (national & local reference points)

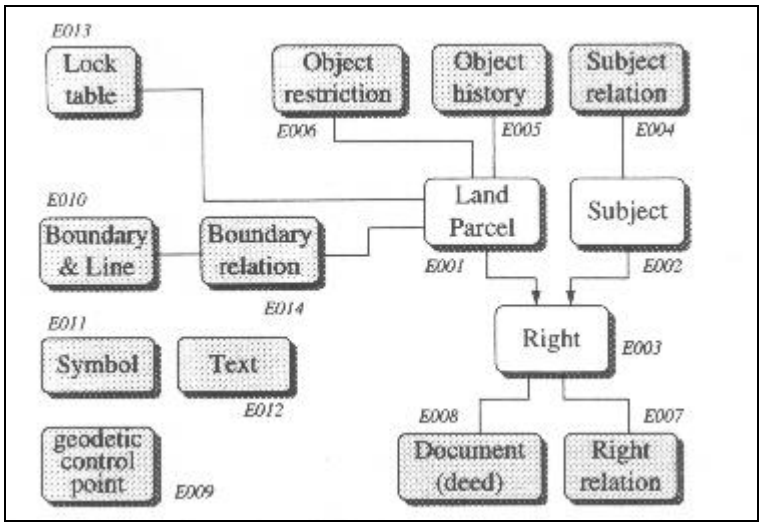
In order to set up a object-classification table it was necessary to make an analysis:
- analyse the existing analogue map-information
- transform the real world model to a suitable computer-model
If you just want to automate map-production, a very simple model containing these 3 object-types is sufficient.

3.3. Physical LKI model (previous version)



remark:
The object-type "area" (or face) is not physically recognised. The object ‘parcel' is implicitly represented by its boundaries (edges). In order to obtain the area object 'parcel' the system needs to calculate and create the area at the moment the user needs it. The text object 'parcelnumber' (centre-point) is used to find the corresponding line objects "cadastral boundaries" which together form the complete shape of the area of the land parcel.

3.4. Current data model Cadastral Registration



In the next part all entities are described shortly, together with their attributes and relations.
(fk foreign key)

El: Land Parcel

definition: part of the surface of the earth which is regarded as one consistent area
synonym: cadastral lot, real-estate

attributes:
- identification: municipality, section, number
- apartment-index
- date of insertion / deletion (system time-stamps)
- parcel description (specification of topographic elements)
- formal parcel-area
- location-identifier (XY centre-point)
- relations: E3; E14; E6; E5

E2: Subject

definition: a subject is a person (natural/non-natural) which is registrated in the Cadastral LIS.
synonym: rightfull claimant

attributes:
- identification
- name, initials and titles
- gender
- date of birth
- profession
- address (residence: street name, house number, postal code, municipality, country)
- date of insertion / deletion

relations: E4; E3

E3: Right

definition: describes the type and measure of disposibily of a SUBJECT on a LAND PARCEL

attributes:
- identification
- type of right = classification: ownership, mortgage, usufruct, emphyteusis (long lease), right of superficies (right to build on a parcel)
- portion (e.g. 1/1, 1/2)

- ranking order (mortgage)
- fk-E2: subject identifier
- fk-El: land parcel identifier
- date of insertion / deletion
- fk-E8: identification Public Register

relations: El; E2; E7; E8

E4: Subject relation

definition: describes how SUBJECTS (natural and non-natural persons) are related in a group, like marriage, partnership in a firm or foundation etc..

attributes:
- identification
- fk-E2: subject-identifier
- type of relation
- date of insertion 1 deletion

relations: E2

E5: Object history

definition: relation in time of new LAND PARCELS with overlapping old LAND PARCELS (1:n)

attributes:
- fk-El: new parcel identification: municipality - section - number
- fk-El: old parcel identification: municipality - section - number

relations: E1

E6: Object restriction

definition: public or private restriction/limitation in the use of a LAND PARCEL as an owner, e.g. servitude (right of way on one parcel on behalf of another parcel)

attributes:
- identification
- fk-El: land parcel identifier
- date of insertion 1 deletion
- type of restriction
- identification restriction in Public Register
- date of registration in PR
- date of end restriction (duration of right)

relations: E1

E7: Right relation

definition: describes the relation between two or more RIGHTS, e.g. mortgage on ownership, mortgage on usufruct, right of superficies on ownership

attributes:
- identification
- fk-E3: right identifier
- date of insertion / deletion

relations: E3

E8: Document (deed)

definition: a deed is a legal document which reflects an agreement between two or more persons or SUBJECTS (alienator, obtainor) in order to transfer one or more RIGHTS on one or more LAND PARCELS. A deed must be inscribed in the Cadastral Public Register (PR) and is the trigger for updating the Cadastral Registration.

attributes:
- identification (PR index-number)
- fk-E3: right identifier
- type of transaction
- identification of notary (provider of deed)
- purchase price
- mortgage + interest-rate
- date of transport, date of inscription in Public Register
- date of insertion 1 deletion

relations: E3

E9: Geodetic Control Point

definition: reference-point in the national coordinate-system for the transformation of local terrestrial and photogrammetric surveys

attributes:
- identification: municipality-code + point-number
- type of GCP (classification)
- XYZ-coordinates
- (original) method of capture
- terrain identification (stone, iron tube)
- last date of survey
- date of insertion / deletion

E10: Boundary/Line

definition: a boundary is the line between two adjacent areas; a line can also be a representation features (e.g. buildings)

attributes:
identification
- type of boundary/line (classification)
- XY-coordinates bounding box
- last date of survey

- source document code
- interpolation code (straight line, arc)
- method of capture
- date of insertion / deletion
- for each point: XY-coordinates

relations: E14

E11: Symbol

definition: representation of a point-object or feature (e.g. the nature of a terrain-element)

attributes:
- identification
- type of symbol (classification)
- XY-coordinates
- rotation
- date of insertion / deletion

E12: Text

definition: representation of semantic information on a map (e.g. street name)

attributes:
- identification
- type of text (classification)
- XY-co-ordinates
- rotation / displacement
- text-string
- date of insertion / deletion

E13: Lock Table

definition: table that contains area-identifiers in the database which are locked for write access during an updating process

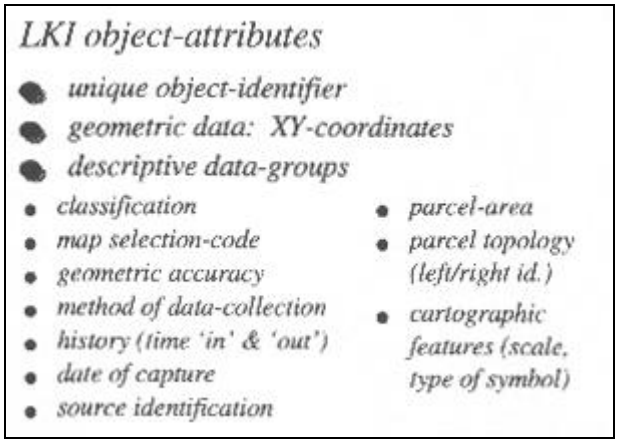
attributes:
- workfile identification
- XY-co-ordinates bounding box (work area rectangle)
- username / user-identification
- date of insertion / deletion

E14: Boundary Relation

definition: set of references concerning all boundaries related to one land parcel

attributes:
- identification
- fk-E1: land parcel identifier
- fk-E10: boudary identifier
- connectivity code (sign of boundary)

3.5. LKI object-attributes



Besides information of their geometric location (co-ordinates and line-interpolation) every object-type has a separate set of attributes containing technical and administrative information.

use:
- DB-selections can be based on specific attribute information (special products, quality control activities)
- extract management information (planning and statistical purposes)

CLASSIFICATION:
The LKI-classification-system is as much as possible tuned to the national classification agreements.

MAP SELECTION-CODE:
This code connect a specific object to a specific map-product.

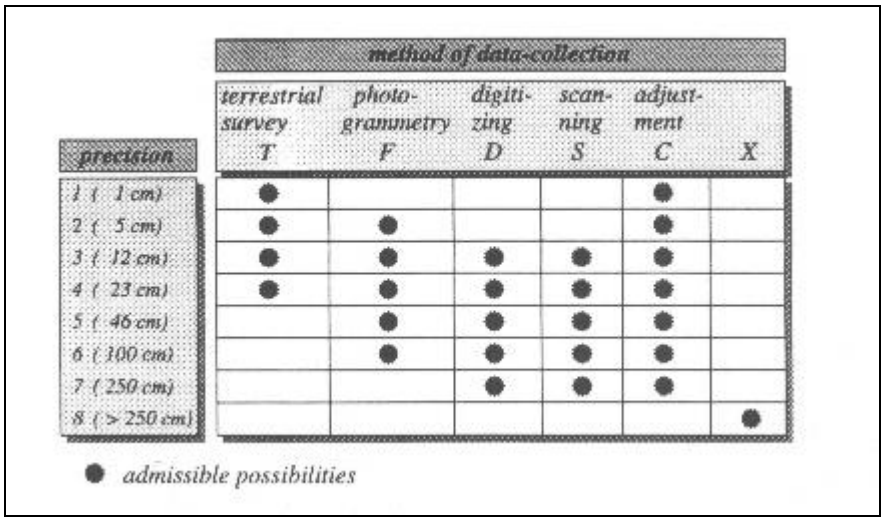
use:
- makes fast selection of our standard map-products possible
- e.g. selection of all objects with selection-code "B" result in the complete content of a Cadastral Map

- geometric accuracy:
  Describes the accuracy (precision) of the method with which an object was captured. Field-survey is more precise then digitising information from a map in the scale 1:5000. Also the method of data-collection is regarded as an indication for geometric quality.
- history (system-time 'in' & 'out')
- date of capture: Represents the moment an object was captured. It can also serve as an indication how actual an object is.
- source identification: measuring document (field-sketch) or photo/map-scale
- control point identification: nature of control point (stone, iron tube)
- visibility
  - visibility of an object from the air
  - object above/under the surface of the earth
- parcel-area (calculated & formally fixed)
- parcel topology
  The cadastral parcel numbers, which are left and right of a cadastral boundary, are physically connected to the boundary.

- cartographic features
  - map-sheet number
  - scale/type/dimension of symbols and text-objects
  - additional variable text-information

3.6. Geometric quality description

During the process of converting analogue maps to a digital cartographic database it is extremely important to keep track of the geometric quality of all converted objects. Both the original object accuracy and the subsequent quality effect of the conversion method must be determined and stored as an object-attribute.



For this reason the Cadastre developed a quality model for the geometric attributes of a spatial object, in which the relation between the method of data-capture and the relative precision (a in cm) is recorded. The relative precision between two points or lines is based upon two factors: the measuring process and the following data-process by which measurements are converted to map-coordinates.

Every object receives a quality-code, represented by 2 positions:
- character: method of data-capture (X means 'unknown');
- cipher: precision code-number representing a cm-interval (standard-deviation);
- e.g. "D4" means an object is digitised from a map in the scale 1:1000;
- "C" means an object was earlier captured and transformation or adjustment geometrically improves the co-ordinates.

Earlier on, the Cadastre also recognised 'idealisation' as an independent object-attribute, but this feature is regarded as redundant because it can be derived from the object-classification. Originally we also registrated an attribute 'reliability' (ability to detect errors), referring to the number of times an object was involved and controlled in a geodetic process. In practice we have problems to apply the concept of 'reliability' for single points. It is probably better to record information about the whole production process.

Present and future use of the geometric quality attribute:
It plays an important role in error-detection when using geodetic adjustment programmes for:
- future digital map improvement

- connection problems during the cartographic update process (adjustment of new measurements)

Adjusted cartographic data automatically receives a correct quality description based on the quality code of the control-points (or other 'known' points or lines).

3.7. Object-History

Since 1997 the Cadastre implements history in the LKI-database.
This means that deleted or changed objects will no longer be physically erased. Every object is extended with two additional attributes (time-stamps):
- **Tmin** system-time 'in'
- **Tmax** system-time 'out'

If *both* time-stamps have a value the object is no longer valid.
The object is only valid within that time period. Current objects have a special Tmax-value: Max-time, indicating that they are valid.
Apart from these system- or transaction-timestamps, every object has a user-time attribute **"object_dt",** indicating the moment when an object was 'formally" created or for the first time observed.

Purpose of these time-stamps:
- time-stamps make iteasier to compose anupdate-file within a given time-frame.
- Every object with a *Tmin of Tmax* value within this time-period has been changed in that period. the use of time-stamps make is possible to select a map-situation that was actual on a certain moment in time (in the past) for historical research etceteras..

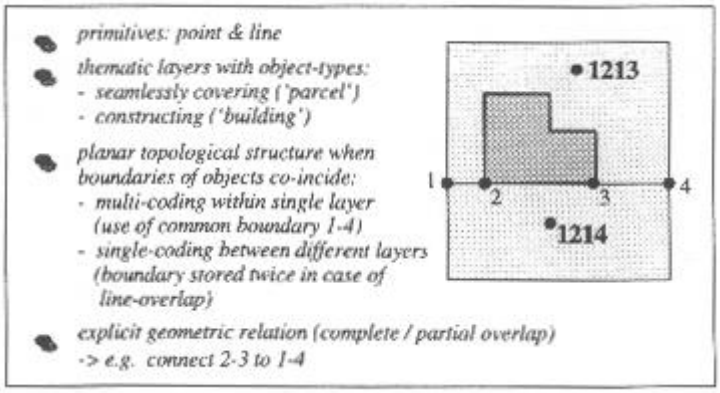
Updating of the database result in the following values in of the time-attributes:
- object is created: "Tmin" is current time; "Tmax" is Max-time
- object is deleted: "Tmax" = Max-time is replaced with current time
- one of the object-attributes is changed:
  - old object is deleted: 'Tmax" = Max-time is replaced with current time
  - new object with changed attribute-value is created: "Tmin" = current time

  The old and new object-versions have the same object-id, so the changes in time can be viewed.

For further detailed information see:
Oosterom, Peter van, *Maintaining consistent Topology including Historical data in a large Spatial Database,* Paper presented at Auto-Carto 13, Seattle WA 8-10 april 1997

3.8. Topology

Geographic data-elements can be distinguished in the cartographic primitives "point" (cadastral landparcel, topographic element, control point, symbol and text) and "line (cadastral boundary & topographic element). With these primitives, objects can be described that are point-, line- and area-shaped.
Boundary and Land parcel are recognised as primary objects.



The data-elements are thematically organised in layers, e.g. 'cadastral parcels & boundaries', 'buildings', 'topographic objects' etc.
In LKI we recognise area-shaped objects only for cadastral parcels and buildings. All objects in the same thematic layer can either be characterised as:

- seamlessly covering (the surface of the earth is seamlessly covered with objects, like cadastral land parcels)
- constructing (objects that further specify objects from the previous kind, like buildings)

In principle we choose for a planar topological structure:

- multi-coding (or perhaps better called "bi-coding")
  Boundaries of objects within one thematic layer are used commonly (one line represents part of the boundary of two adjacent area-objects).
- single-coding
  Boundaries of adjacent objects within the same and between different thematic layers are physically stored twice.
  Or, in some cases in the past, a boundary was stored only once and is attached to the most important object-class. This method could have created unjustified 'holes' when viewing all elements of the other theme.
  If a boundary is stored twice and there is complete or partial overlap, this can be stored in the database explicitly by expressing a geometric relation ("line 'a' co-incide with line 'b...

3.9. Selection Workfile from LKI-database

Updating of viewing cartographic data from the database can only be done through the so-called
workfiles. How does the selection of a workfile takes place?:

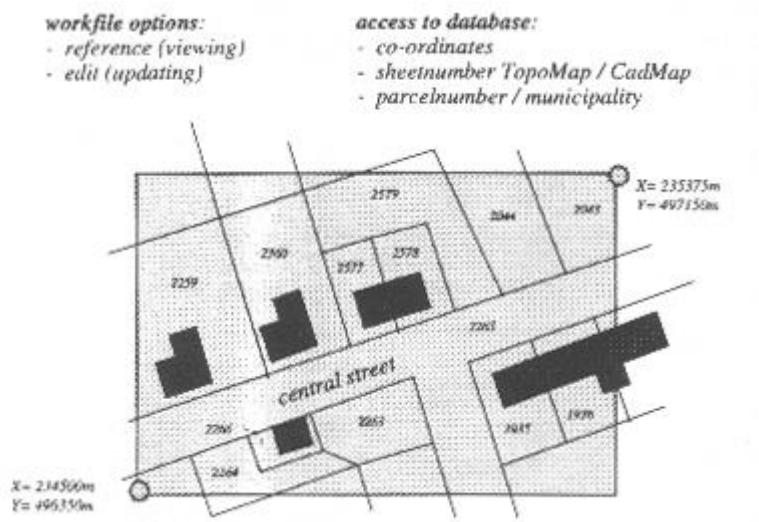
- Access through:
  - parcel numbers or map sheet-number
  - co-ordinates (a rectangular area based on left under and right upper points of the area).

- selection is very fast for the data in all zones, which lie completely within the workfile-area. Objects in zones, which are partly within the workfile-area, will have

to be selected individually. This process is much slower. In this way 95% of all objects are selected in fast mode.

options:

- reference: in case of viewing or plotting maps
- edit : for updating LKI-db
  In this case the selected zones (field indexes) and objects are **'locked'** in the database for further'edit'-selection by other users.



3.10. Transfer geo-information from database <-> workfile

In order to perform cartographic activities on a LKI-workfile, the selected workfile is converted to a specific FINGIS-structure.

CHARACTERISTICS OF FINGIS FILE-STRUCTURE:

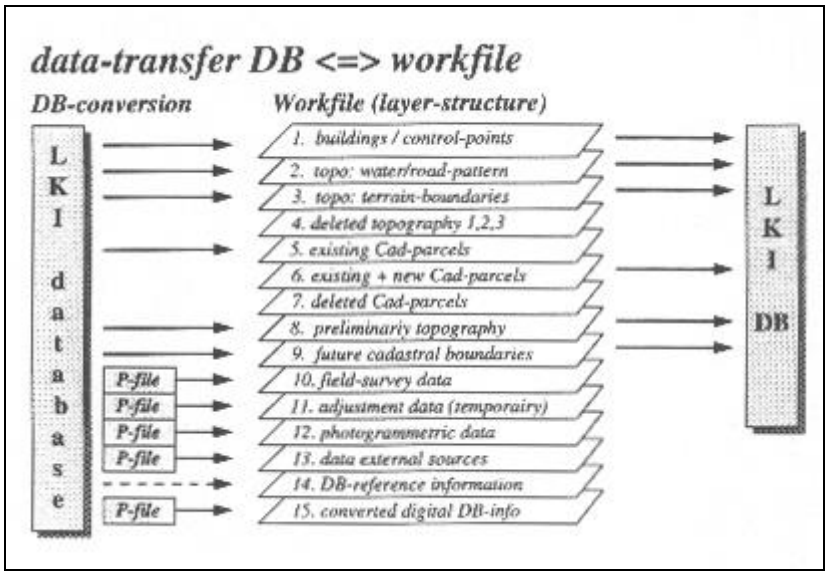
In order to perform cartographic activities on a LKI-workfile, the selected workfile is converted to a specific FINGIS-structure (max. of 40 layers to subdivide the data: object-classification).

FINGIS has a special feature, called polygon-management. With this facility the system automatically checks if polygons are closed. If so, area-calculation (or polygon-filling) is possible or other cross references can be made.

- obiect-groups: line, point, text and symbol
  These groups represent the physical record structure of the objects. An object (occurrence) will be classified by its group number (1 to 160) and a separate classification-number (001 to 999).
- layer-structure (40 layers)
  One layer contains a set of objects, which belong to the same theme. A theme means:
  - a set of related objects like all existing cadastral parcels (boundaries + parcel numbers)
  - set of pre-processed data from a certain type of project-file, which has to be graphically edited

In every layer all 4 object-groups are present. The group-numbers in one layer are unique:
- line : group 1 to 40, text: group 41 to 80
- symbol: group 81 to 120, point: group 121 to 160
- e.g.class"6,31" means a line on layer 6 with the class "municipal boundary"

polygon management
FINGIS has a special feature, called polygon-management. It can be set per layer. In our applications for the layers 5,6 and 7.



DATAFLOW DURING CONVERSION 'DB -> FINGIS-WORKFILE -> DB:

automatic conversion:
- LKI-DB-data will be converted to layers 1,2,3,5,8,9 and 14

- Projectfile-data is placed in layers 10,1 1,1 2,13 and 15 interactive cartographic edit-session:
- Deleted topographic objects are automatically moved from layers 1,2,3 to layer 4.
- New topographic objects will be directly constructed in the layers 1,2,3.
- All cadastral info from layer 5 is copied to layer 6.
- Relevant boundary-information from layer 9 can be transferred to layer 6.
- New cadastral parcels will be directly constructed on layer 6.
- Relevant data from projectfiles (layers 10,1 1,1 2,13 and 15) is transferred to the layers 1,2,3 and 6.
- Deleted cadastral parcels are automatically moved to layer 7.
- Measured data that can not yet be approved will be stored in the layers 8 or 9.

revision of LKI-DB:
- Only the content of the layers 1,2,3 (topography), 6 (cadastral parcels) and 8,9 (non approved data) is converted back to the LKI-DB.
- Layers with deleted information and projectfile-layers are not transferred back to the database!

4. LKI-APPLICATIONS (SURVEYING & MAPPING)

LKI-systems are used for a number of applications:

MAP CONVERSION & RENOVATION
- digitise + adjust analogue cadastral maps
- conversion maps form local to national co-ordinate system
- quality improvement procedures:
  - geometric accuracy of digital map data
  - consistency of administrative and cartographic parcel-information

  There are special facilities for:
  - integrity check on existing digital LKI-data (topology, double objects, line-filtering)
  - geometric quality adjustment in the database (when better connection points are available)

UPDATE CADASTRAL / TOPOGRAPHIC INFORMATION IN LKI
- production / maintenance national TopoMap
- a survey of new cadastral boundaries
- cartographic + administrative update of parcels (LKI+AKR)

PRODUCTION OF GEO-INFORMATION FROM LKI
- standard / tailor-made map products * automatic delivery of update-files
- Construction of cadastral boundaries

- supply integrated administrative + cartographic parcel-information
- combine cadastral information with other thematic information

4.1. Targets Cadastral Map Conversion

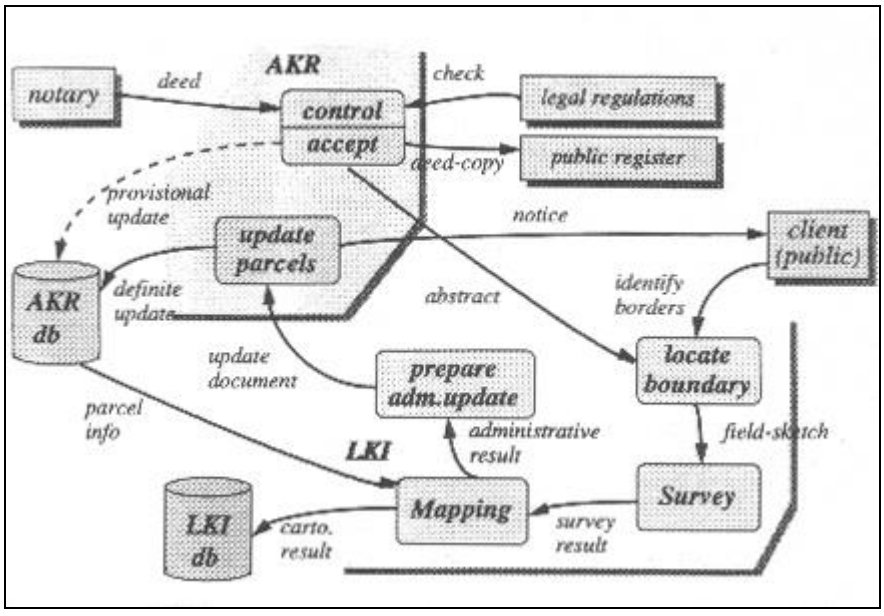
Why convert Cadastral Maps to a digital form and standard quality?

- internal:
  The most important cadastral activity is the cadastral updating process, the daily revision of the Cadastral Administration and Map. The availability of a digital map has many advantages. Also, in some areas, the geometric quality of cadastral maps needs to be improved.
  In a fully digital environment we expect cost-reduction and personnel-reduction of more than 50% compared to the analogue approach.
- external:
  A digital geographic database creates a situation in which cadastral (administrative and cartographic) and topographic data will become available in more ways then before. More map-products (in form and contents) for more different users can automatically be generated.

What procedure has been adopted?

- The end-result should be a seamless national cartographic database with a, for all users acceptable, standard geometric quality.
- All, still local, CadMaps must be transformed to the national co-ordinate system in such a way that a standard homogeneous 'cartographic' quality (completeness and accuracy) can be guaranteed. At the same time all CadMaps must be digitally available.
  A simultaneous target is to guarantee that the cadastral parcel-information on the map (LKI) is consistent with the administrative parcel-information in AKR.

4.2. Cadastral Update Process



- This schematic process-model describes the primary cadastral activity, the updating of the Cadastral Maps and Administration.
  In this model only the transfer of a **part** of a cadastral parcel is explained. The transfer of a whole parcel is simpler: the deed is checked and accepted and the administrative attributes are directly updated in AKR. In this case there is no surveying needed!

- The process is divided in 2 parts:
  - administrative and legal activities (AKR)
  - surveying and mapping activities (LKI)

  There are several interfaces between the separate activities.

  DEED: legal land-transfer document
  CHECK: check the content of the deed with the formal cadastral and legal rules
  ABSTRACT: information, extracted from the deed, needed by the surveyor
  IDENTIFY: buyer and seller point out the new cadastral boundaries to the surveyor in the field
  NOTICE: letter to the new owners containing the new parcelnumber and the calculated parcel-area

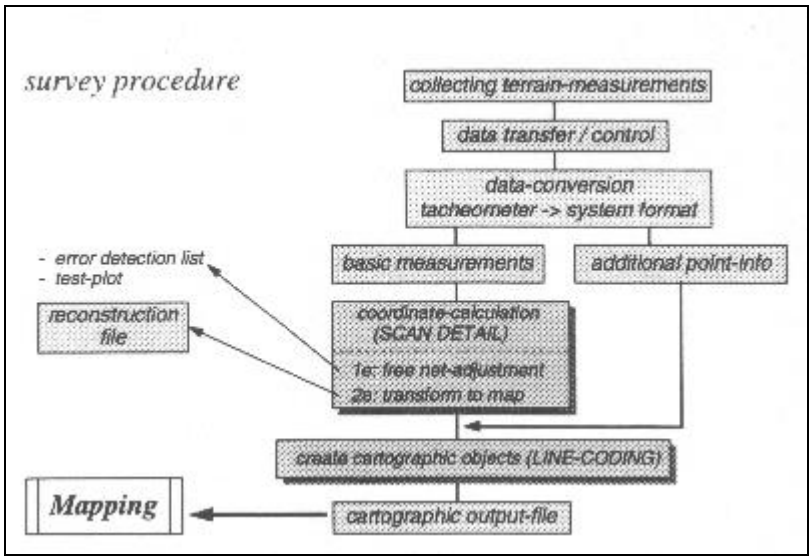
In the next paragraphs the surveying and mapping applications will be further explained.

4.3. Procedure: Terrestrial Survey

For capturing + automated processing of field-survey measurements a special LKI-subsystem is operational.
It is build around 2 software-modules:

SCAN DETAIL

- calculation of co-ordinates
- error detection in measurements and co-ordinates
- adjust the new survey-data to the graphic accuracy of the digital map, using existing points, which were also measured



LINE CODING

- create objects (line-strings, circular arcs and points) based on the line-code (interpolation between points) and classification-code
- convert the object-file in the standard data format, suitable for further cartographic processing

PROCEDURE + DATA-FLOW

- automatic collecting terrain measurements
  - The Surveyor can use 4 basic measuring types
  - every detail-point receives a unique pointnumber and a line-code and classification-code
- measurement data-transfer from electronic instrument to a computer
  - read data from tacheometer-memory and electronic field-memory
  - automatic control-program for errors in data-format and incorrect line- and classification codes
- conversion measuring data from a specific tacheometer-format to our standard system-format
- the data is pre-processed:
  Only basic measurements are needed for co-ordinate-calculation in SCAN-DETAIL.

So they are separated from the additional point-information (line- and classification-codes)

- **SCAN-DETAIL:** co-ordinate calculation in 2 phases
  1st phase: free net-adjustment
  - system tries to process all measurements and calculate co-ordinates in one local co-ordinate system (1:1 accuracy)
  - measuring errors and point-identification faults will be detected
  - result is separately stored for later reconstruction of points in the field
  - make a test-plot (using line-codes and point numbers)
    detect incomplete objects
    locate survey errors

fit new objects in existing analogue maps (when LKI-DB is not available in the area)

2nd phase: adjust the new data to the existing digital map .
same calculation-process as in the 1 e phase;
The difference is that the coordinates of remeasured existing points in the LKI-DB participate in the process as extra 'observations'.

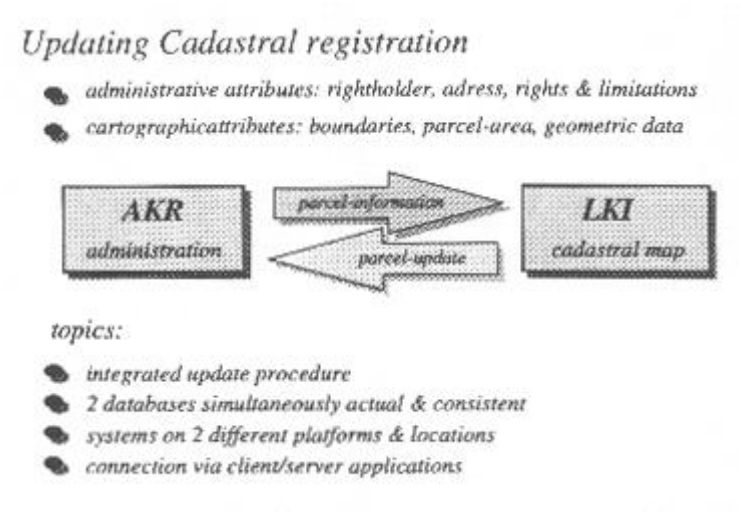
- LINE-CODING: composition of a cartographic project-file
  - point- and line-objects are created using the additional line-codes and classification-codes
  - the object-data is directly converted to the recordstructure of the standard data exchange format
- resultiscartographicoutput-file(=project-fileonFINGISlayerlO)
- the project-file is further processed in the MAPPING system
  read the data in the'update'workfile

4.4. Updating Cadastral Registration

The Cadastral Updating Process contains 2 different update-facilities. Both LKI and AKR need to be updated with respect to the cartographic and administrative attributes of cadastral parcels.

SPECIFICS:

- During this mapping activities the LKI-user has a constant on-line access to the most current and actual AKR-parcel information.
  Therefore 5 interfaces are build between AKR and LKI.
- In LKI an update-document on new cadastral parcels is digitally available.
  This digital update-document is available in both digital and analogue areas. The digital update document from LKI is automatically sent to the AKR-system.
- In AKR a completely user-unattended process starts to update the new cadastral parcel information in the administrative database. This includes also some legal error-checking facilities.
- Furthermore, several sub-processes in LKI are being improved:
  - interactive processes are further automated
  - creation of a so-called digital 'NUMBER' database in order to improve the quality and consistency of LKI- and AKR-databases;
    This is a nationally kept database, containing all the last used cadastral parceinumbers, cadastral sections and municipalities, numbers of field-sketches and update-maps. In this way a lot of mistakes can be avoided when new unique numbers are connected to parcels and documents.



4.5. Technical infrastructure

The technical infrastructure (cadastral computer-network) will be strongly expanded because of the extra data-transfer between LKI and AKR.
We applied some aspects of the client/server concept: Any user in his own application has access to data in other applications or data-sources. He experiences the information as part of his own application.
Through the implementation of automated interfaces between AKR and LKI, the AKR-database information becomes transparently available for the LKI-user during his mapping activities in LKI.

- Every AKR-user has a separate personal connection with the AKR-database: expensive and old-fashioned!
- The Digital Computer-network is expanded. Standard networking-software is acquired and a special server is connected to the AKR-databases in our computer centre at Heerlen.
- All LKI-users are regarded as clients for a single session on AKR. The server handles all data request and transport.
- In the future this concept will probably be used when more external users must be connected to cadastral databases.

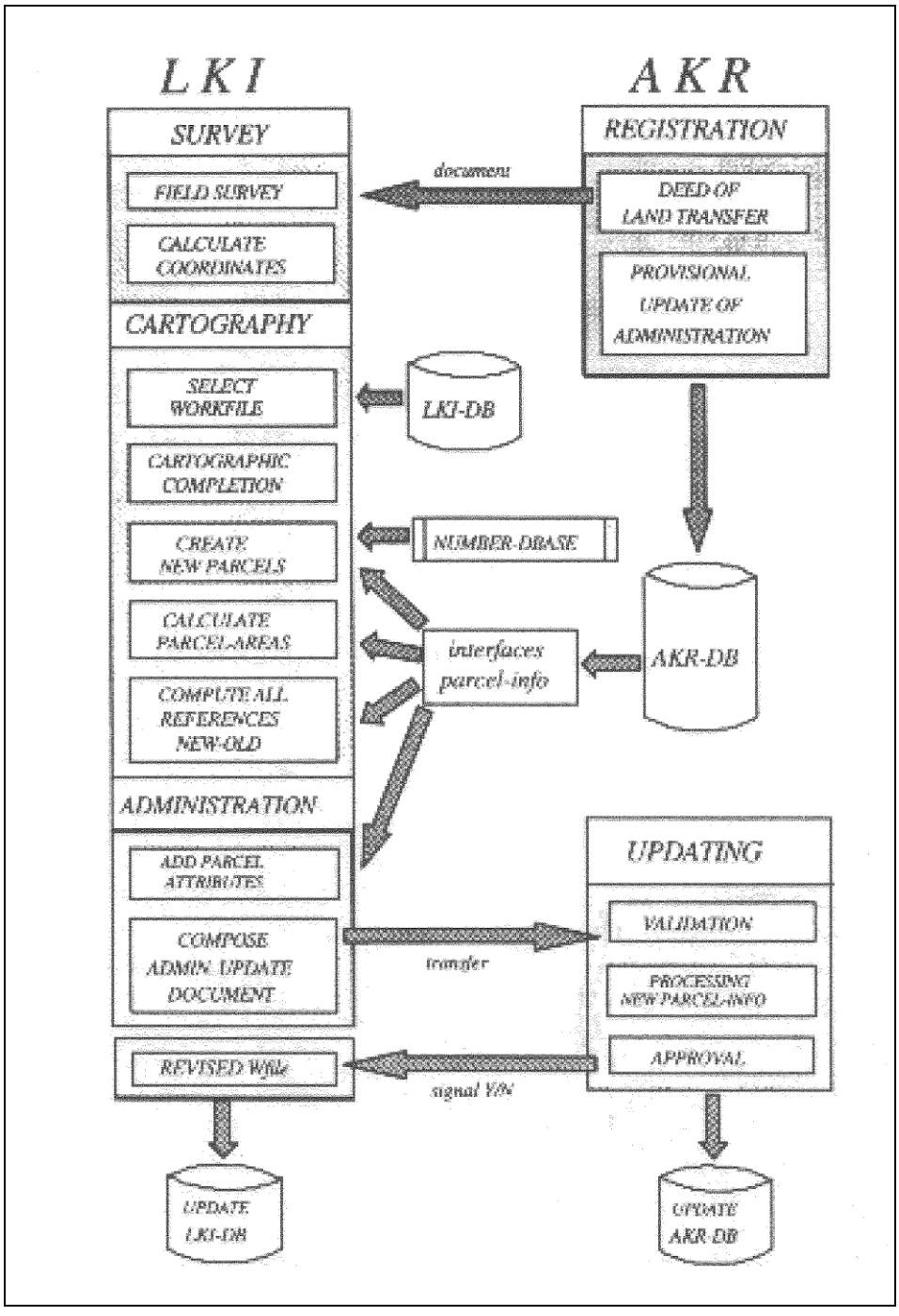
4.5. Procedure Cadastral Updating

This section describes in detail the whole process-flow of the update-procedure on cadastral parcels in AKR and LKI.
triggers:

- deed with the sale of a part of 1 or more Cadastral Parcels
- request on dividing / unification of Cadastral Parcels

REGISTRATION:

- check the deed with formal cadastral rules for legal consistency
- (preliminary) update in AKR:
  - the concerned parcels are split;
  - Every part gets a temporary parcel-part number (NUMBER+Dxxxx) reason: to present actual information to the public during the further update-process
- an abstract of the transaction-dwument is sent to the surveyor



5. DUTCH CADASTRE IN THE FUTURE

Since 1996 a large research & development programm has started. Primairy target is to modernize all cadastral systems and infrastructure. Most important motive is to improve all cadastral services to the public and our professional clients.
All cadastrall system-applications must be integrated into one new Cadastral Land Information System (KVS = Kadastraal Vastgoedinformatie Systeem).
In all business areas new ideas and concepts, software development tools, the latest db-technology, modern technical infrastucture shall be implemented.

In order to manage such a large and expensive programm special teams are formed to carry out these activities in seperate projects (business process redesign, new engineering and development tools, database research, GIS technology).
Because of the complexity of the undertaking, the whole organization has been analyzed using a new method of business information planning. The approach is more business- and data-oriented than process-oriented.

The result was a well-documented Cadastral Information Architecture. This document contains several policy-papers on different subjects:
- Software Architecture
- Technical Infrastructure
- Information Architecture
- Global description of the overall System Concept
- Organization plan (administrative organization)
- Project plan & procedures

More information on the document can be received by the end of this year. Politicians are still discussing the details and before the change of the milenium one cannot get details on the subject.