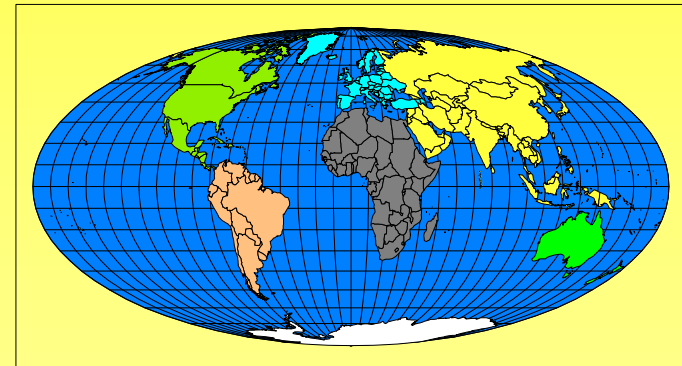




# Introduction to GIS

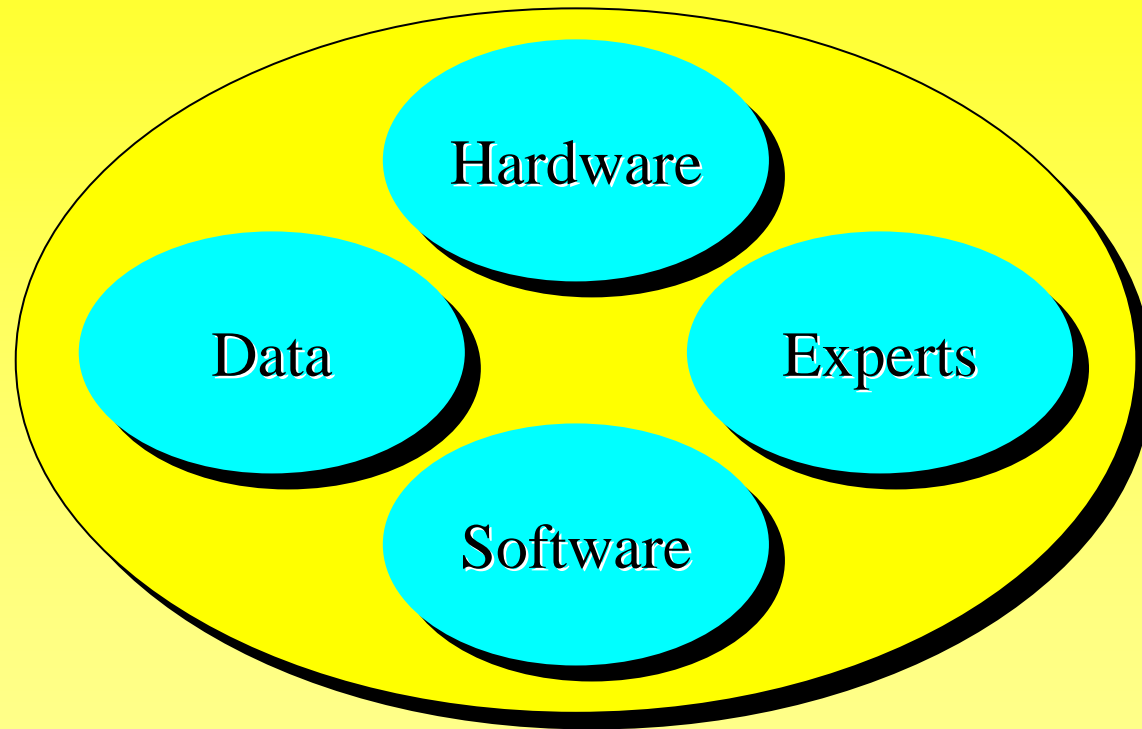
dr Siki Zoltán  
[siki@agt.bme.hu](mailto:siki@agt.bme.hu)

- **What is GIS**
- **Digital maps**
- **Relational databases**
- **GIS systems**
- **Application areas**



<http://www.agt.bme.hu>

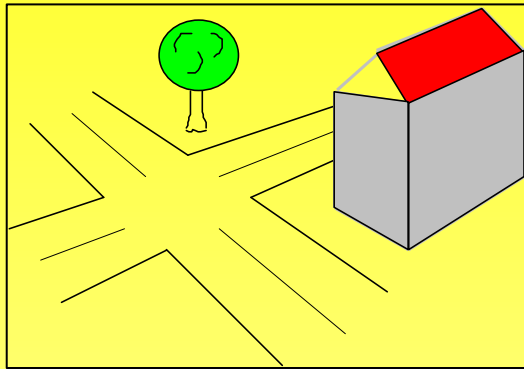
# Components of GIS



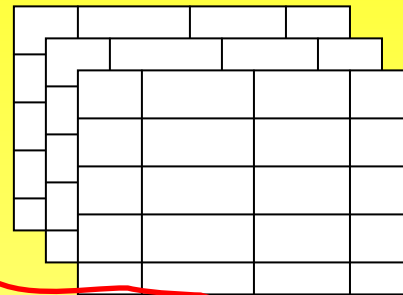
Unity of hardware, software, data and experts to collect, store, maintain and analyse spatial data

# Data model

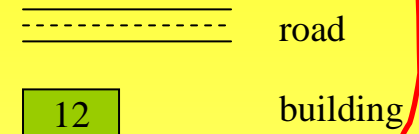
Real world



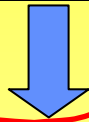
Attributes



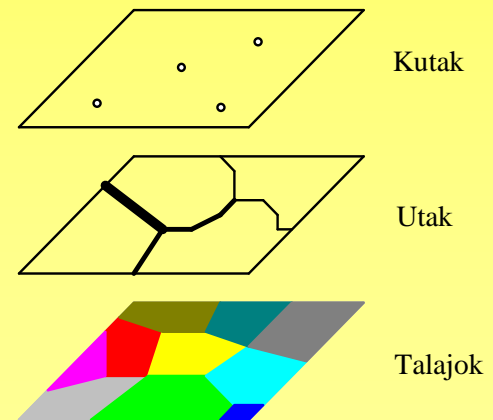
Objects



Abstraction



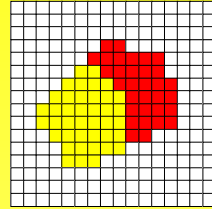
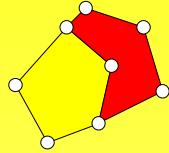
Layers



Conceptual models

Physical model

# Vector vs raster data



## Vector

- Smaller data sets
- „Unlimited” resolution
- Complex data structure

## Raster

- Huge data sets
- Limited resolution
- Simple data structure

## Hybrid model



# Digital map

Map – scaled down, generalized representation of objects on the surface of the Earth

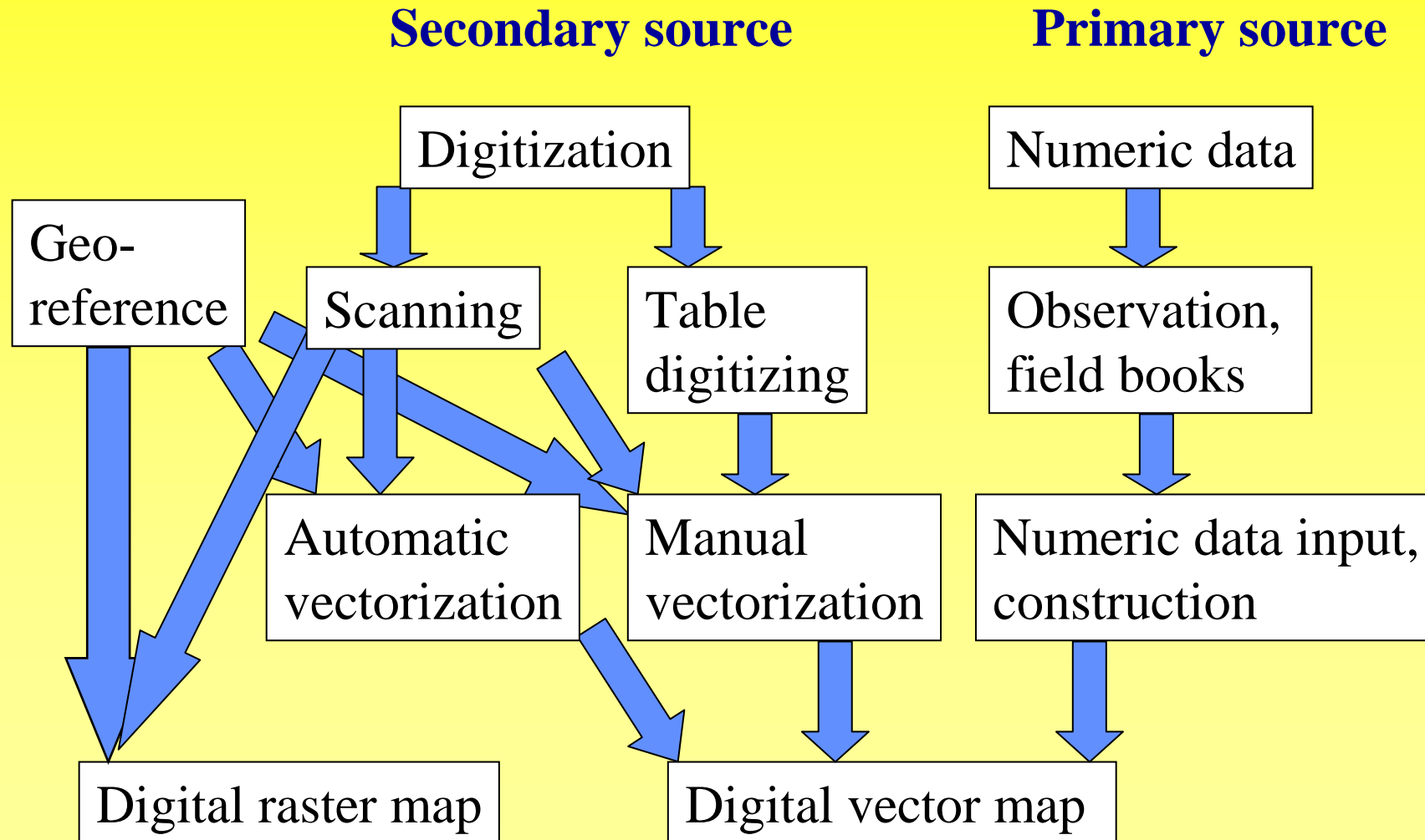
Digital map - numeric description of a map (co-ordinates, lines, etc.)

Graphical elements of digital maps

- Point (symbol)
- Line, polyline
- Text
- Polygon



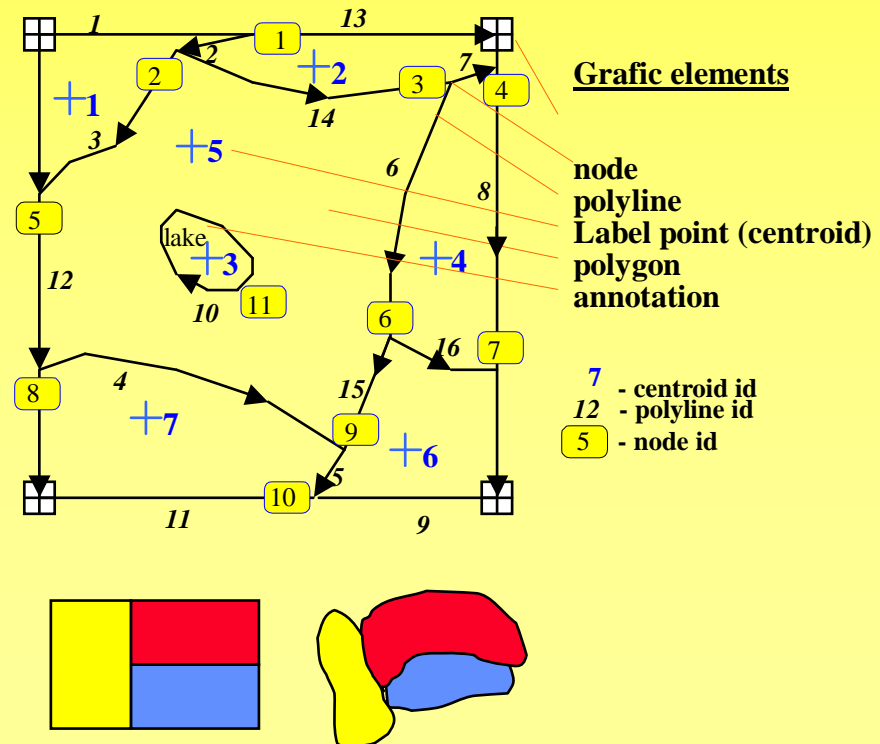
# Creation of digital maps



# Topology

- Neighbourhood and continuity of map elements
- Topology invariant from the co-ordinate system
- Used in analyses e.g. find shortest route

FNODE_	TNODE_	LPOLY	RPOLY	LENGTH	ID
1	5	1	-1	287	1
1	2	2	1	82	2
2	5	5	1	143	3
8	9	5	7	223	4
9	10	6	7	43	5
3	6	4	5	195	6
3	4	2	4	51	7
4	7	-1	4	204	8
7	10	-1	6	185	9
11	11	3	5	101	10
8	10	7	-1	264	11
5	8	5	-1	102	12
1	4	-1	2	248	13
2	3	2	5	213	14
6	9	6	5	59	15
6	7	4	6	89	16



# Difference between CAD and GIS data structures

## CAD (DXF, DWG, DGN)

- Construction of plans
- Several different element type
- One file several layers
- Spagetti data model
- Geometry and display attributes
- Attributes are optional
- 3D

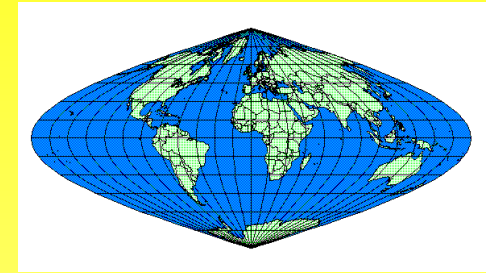
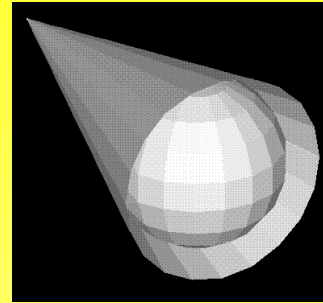
## GIS (Shape, TAB, GeoBase)

- Query and analyze
- Point, polyline, polygon, (text)
- One layer several files
- Topological data model
- Geometry only
- Attributes are integral part
- 2D, 2.5D

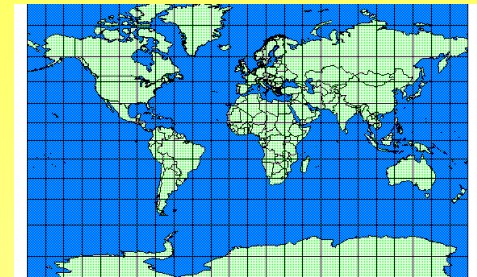
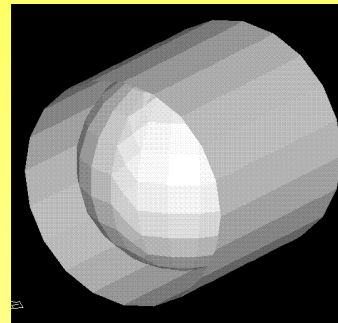


# Projection systems

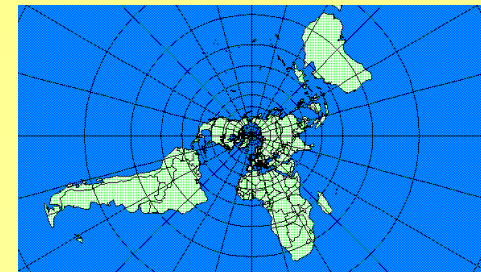
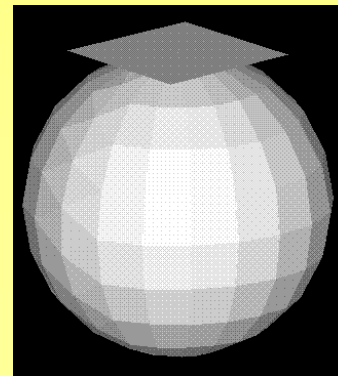
- Reference system
  - Sphere, ellipsoid
  - Datum



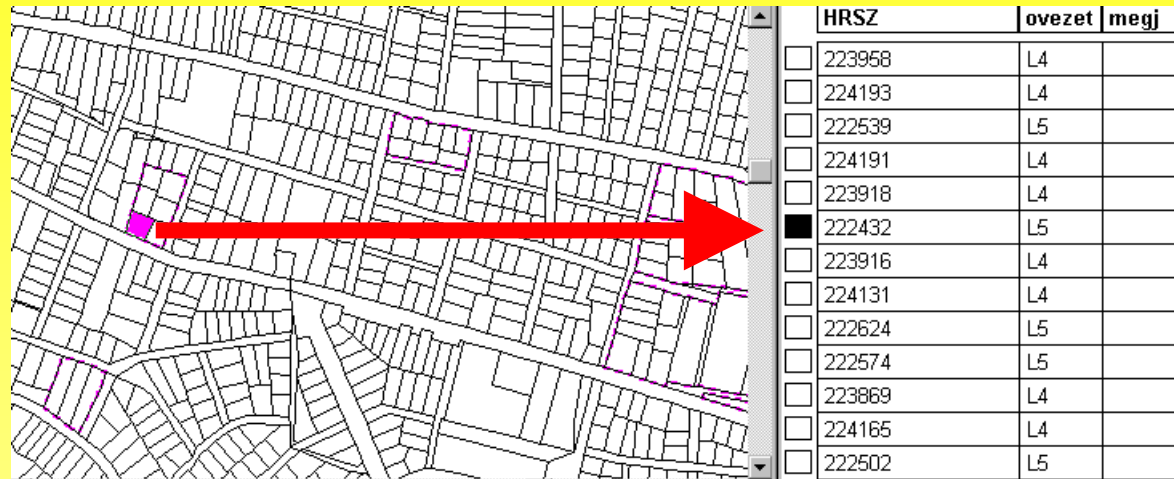
- Target surface
  - Cone
  - Cylinder
  - Plane



- Type of projection
  - angles preserved (comform)
  - areas preserved



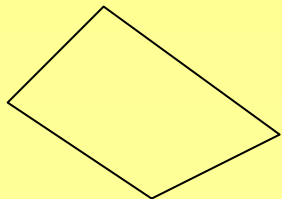
# Connection between graphical and attribute data



## Graphic database

Graphic data + identifier

$x_1, y_1; x_2, y_2; x_3, y_3; x_4, y_4$

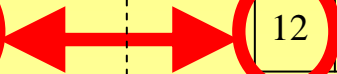


12

## Relational database

Attribute data + identifier

12	4563/2	L4
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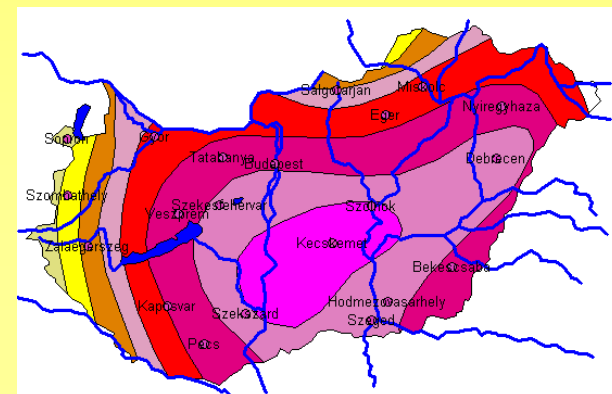
# GIS systems

Topologic data model, network and polygon topology

Graphic data and display attributes (e.g. color, line type, etc.) are separated

Map and attribute editing tools

Analyses tools



# Questions answered by GIS

- Position – What is here?
- Condition – Where are ...?
- Trends – What has changed?
- Pattern – What spatial patterns are?
- Modelling – What would be if ...?



# Tools to answer questions I.

- Selection

- Based on database table (Where are ...?)

SQL queries

- Geometric conditions (What is here?)

By point

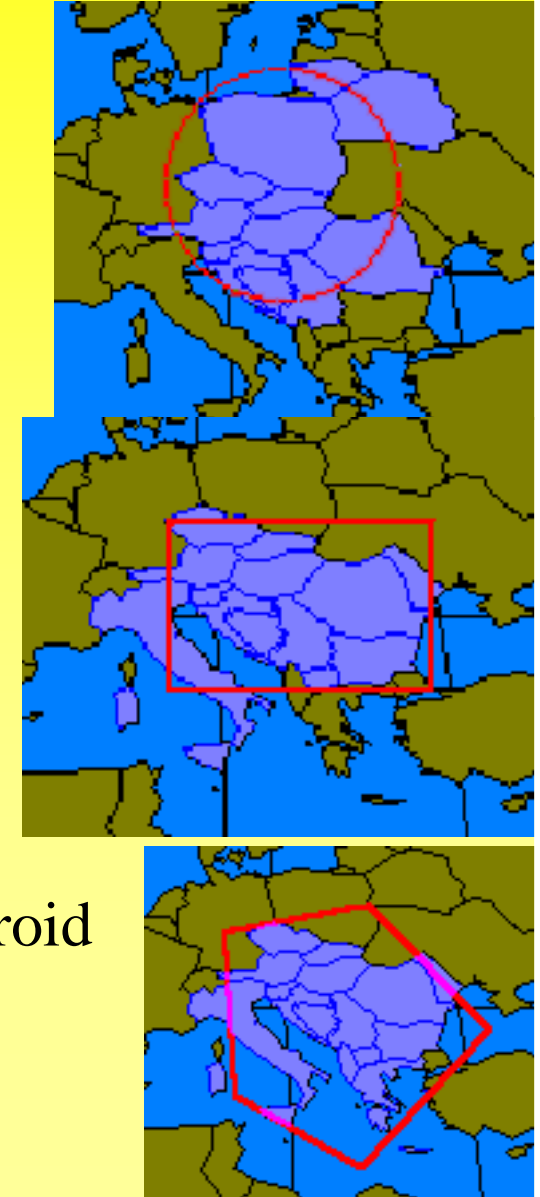
Within a circle

Within a rectangle

Within a polygon

Contains entire, partly within, contains centroid

- Spatial join, between two layers



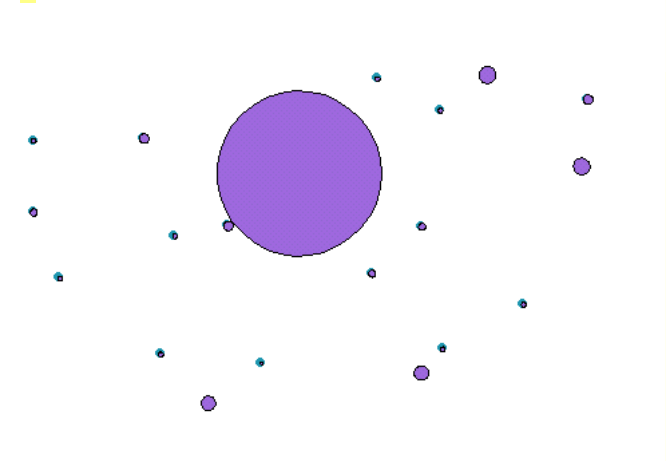
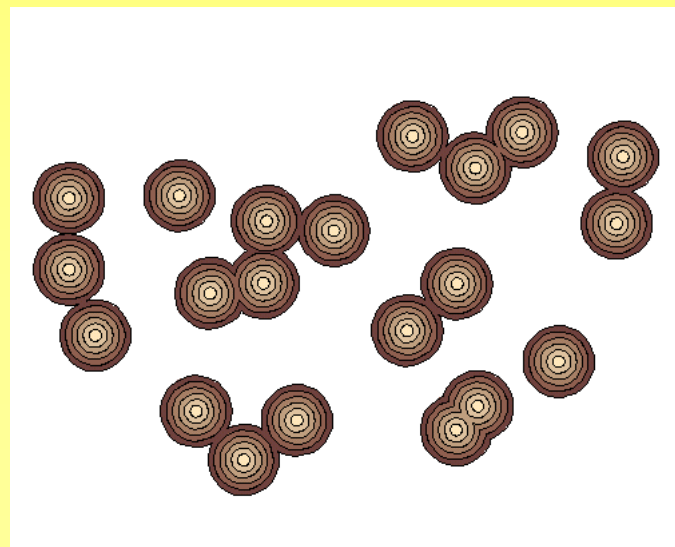
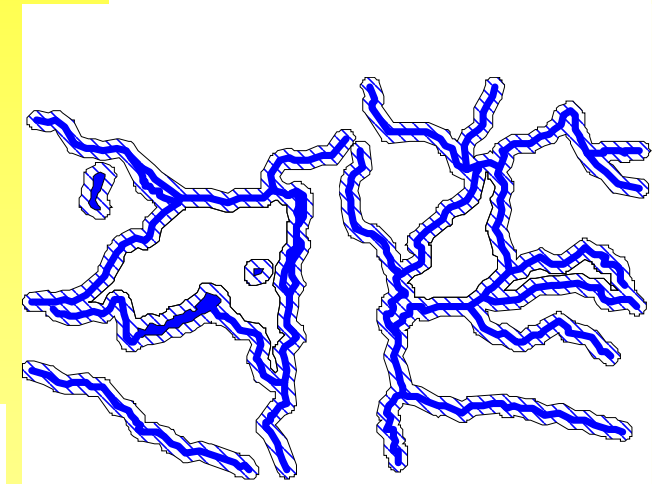
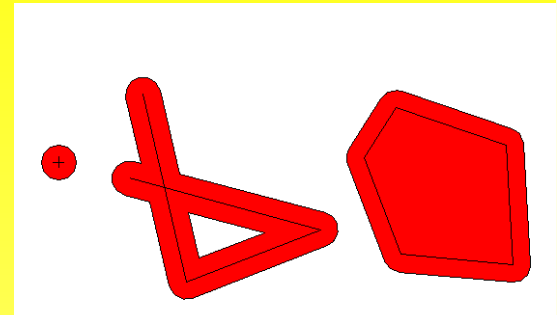
# Tools to answer questions II.

- Buffers

Near to or far from something

Buffer distance

- Constant
- Attribute value
- Multiple rings



# Tools to answer questions III.

- Overlay (between a polygon and an other layer)

Union

Intersection

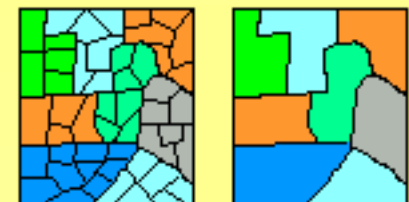
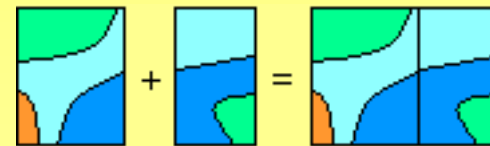
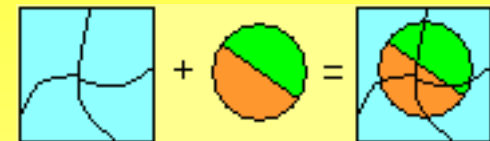
- Other operations

Clip

Merge

Dissolve

- Thematic maps



# Analysis example

**Task:** find the area suitable for ...

**Conditions:**

Near to a lake or river (10 km)

Soil type (8)

Sunny hours > 1800 hours / year

Area > 15 km<sup>2</sup>

**Necessary data/layers:**

Rivers and lakes map

Soil map

Sunny hours map



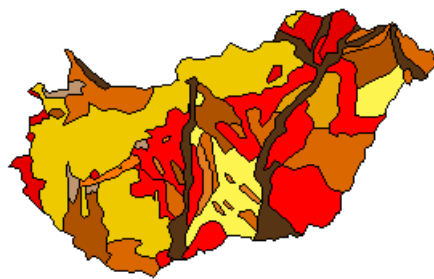


# Solving the task

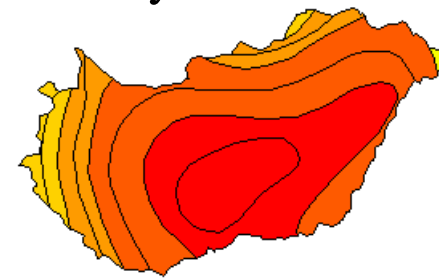
Rives and lakes



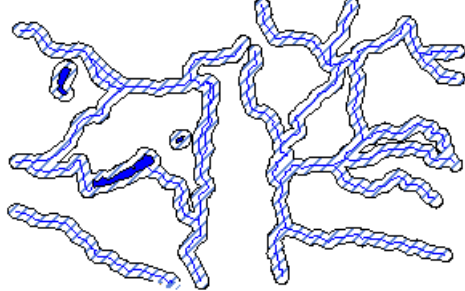
Soils



Sunny hours

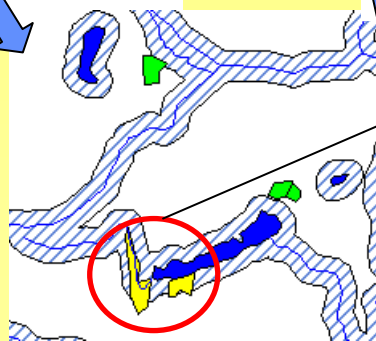


Buffer of 10 km



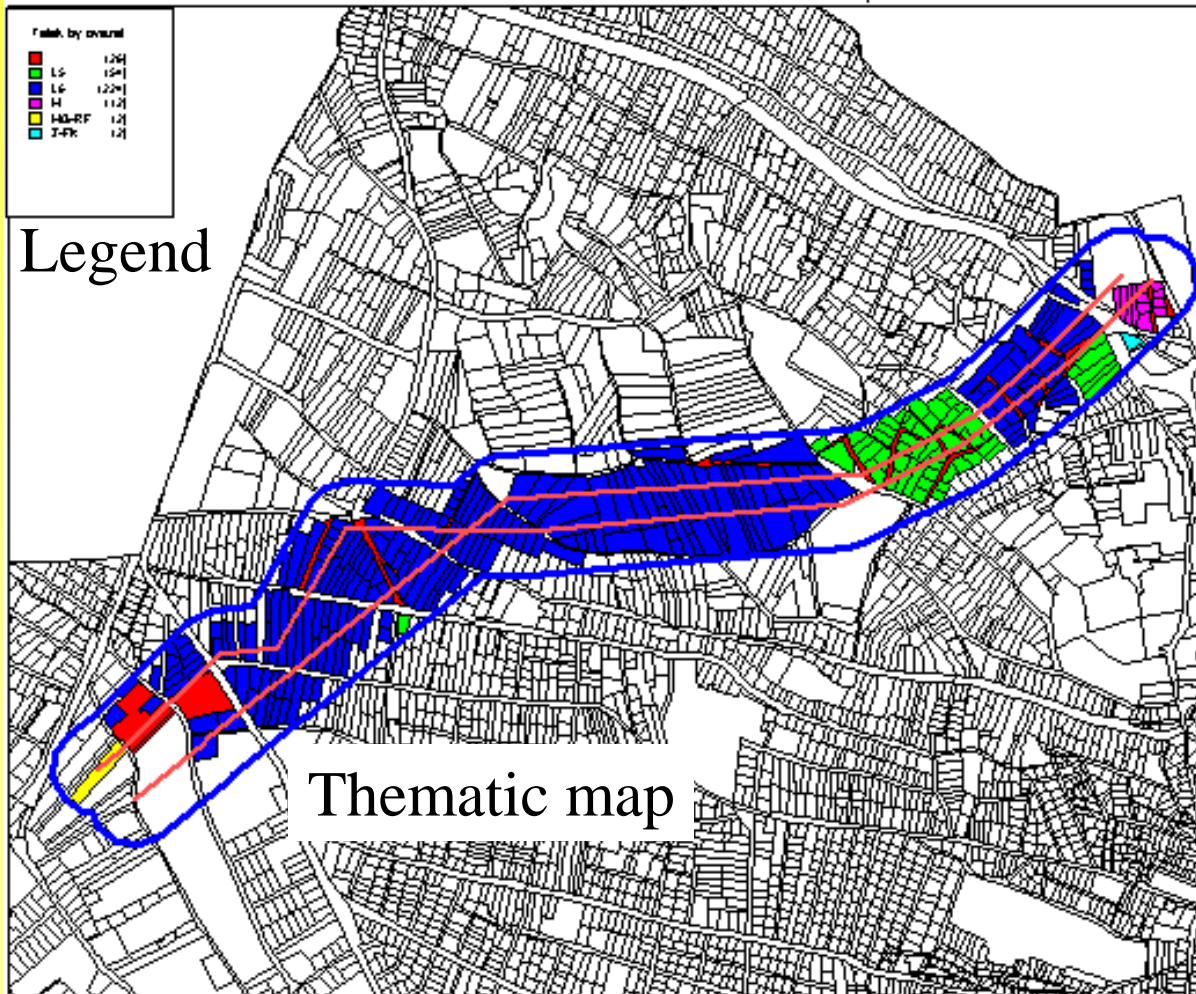
Overlay of soils and sunny hours + selection soil type = 8 and sunny hours > 1800

Suitable areas for all conditions



# Results of an analysis

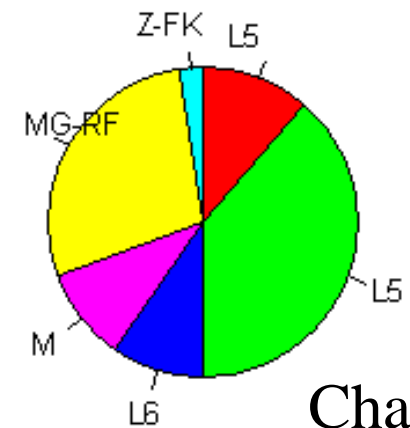
Távvezetékek által veszélyeztetett területek



Tabular data

OSZTÁLY	TERÜLET, by osztály
L5	126
L6	154
M	122
MG-RF	12
Z-FK	12

Elektronos üzemeltetők köze lévő terület



# Raster analysis

Derive a new grid from one or more existing ones

Operation between the cells at the same position

Grid algebra

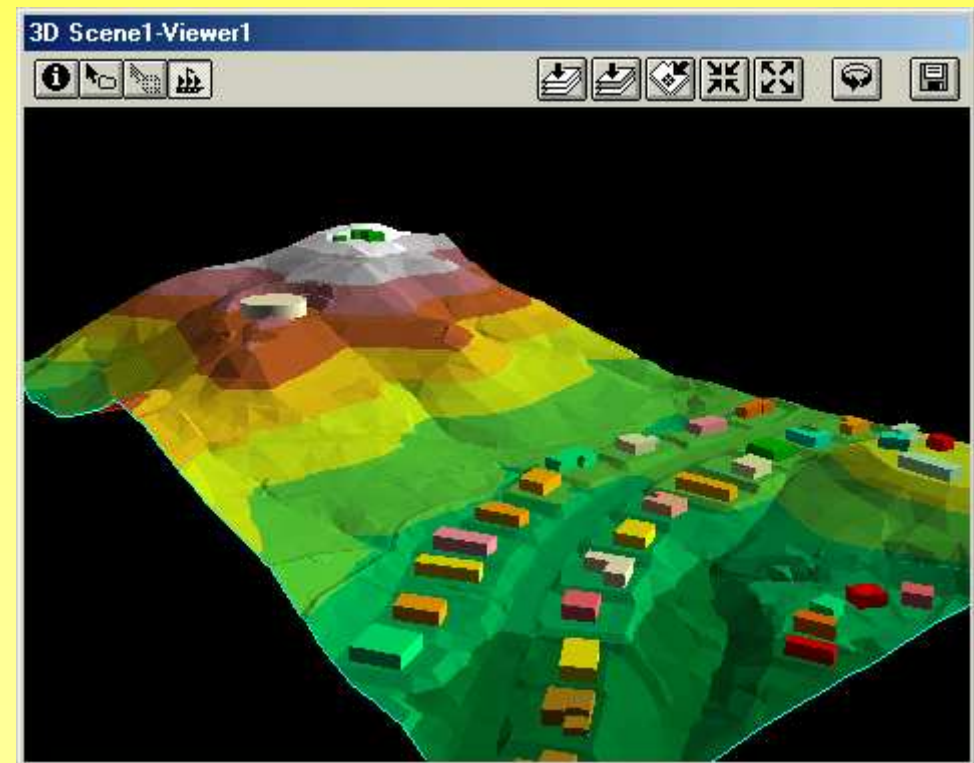
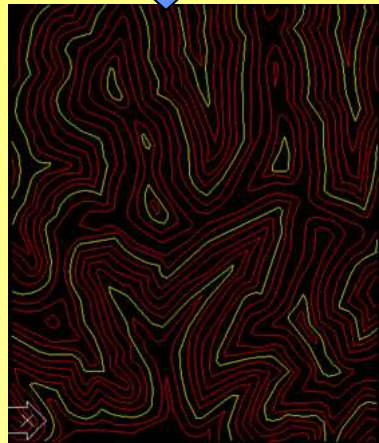
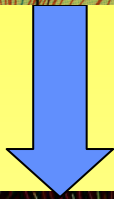
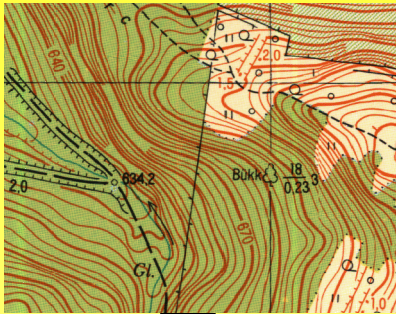
Aritmetic operators  $+$ ,  $-$ ,  $*$ ,  $/$

Functions

„No data” value, any operators with „No data” value results  
„No data”

# Digital Terrain Models (DTM)

TIN or GRID



# Delaunay triangulation

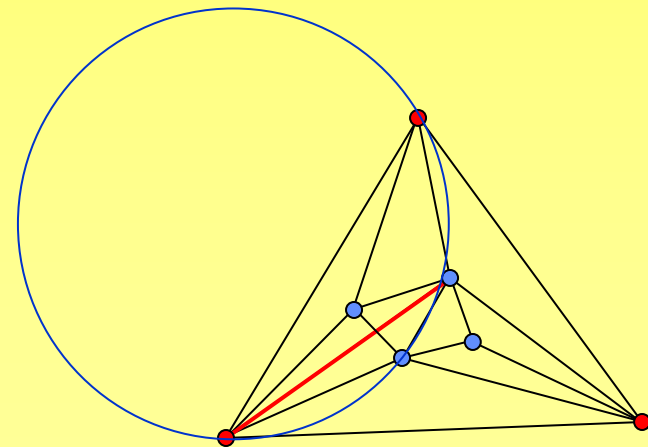
Trinagular network based on 3D points

Sum of the perimeter of triangles is minimized

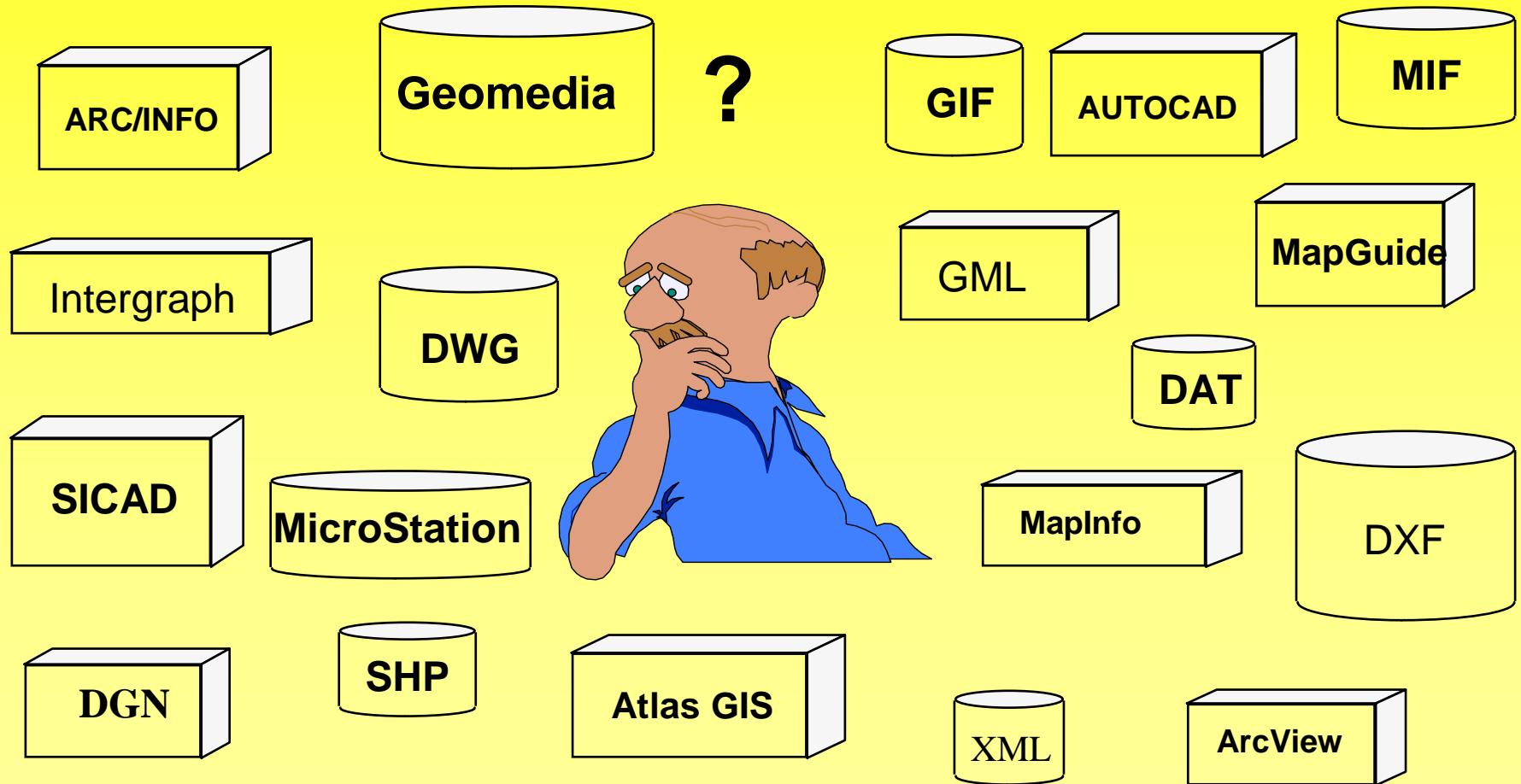
Creation algorithm:

Starting with an optimal network of three points,  
new points are inserted

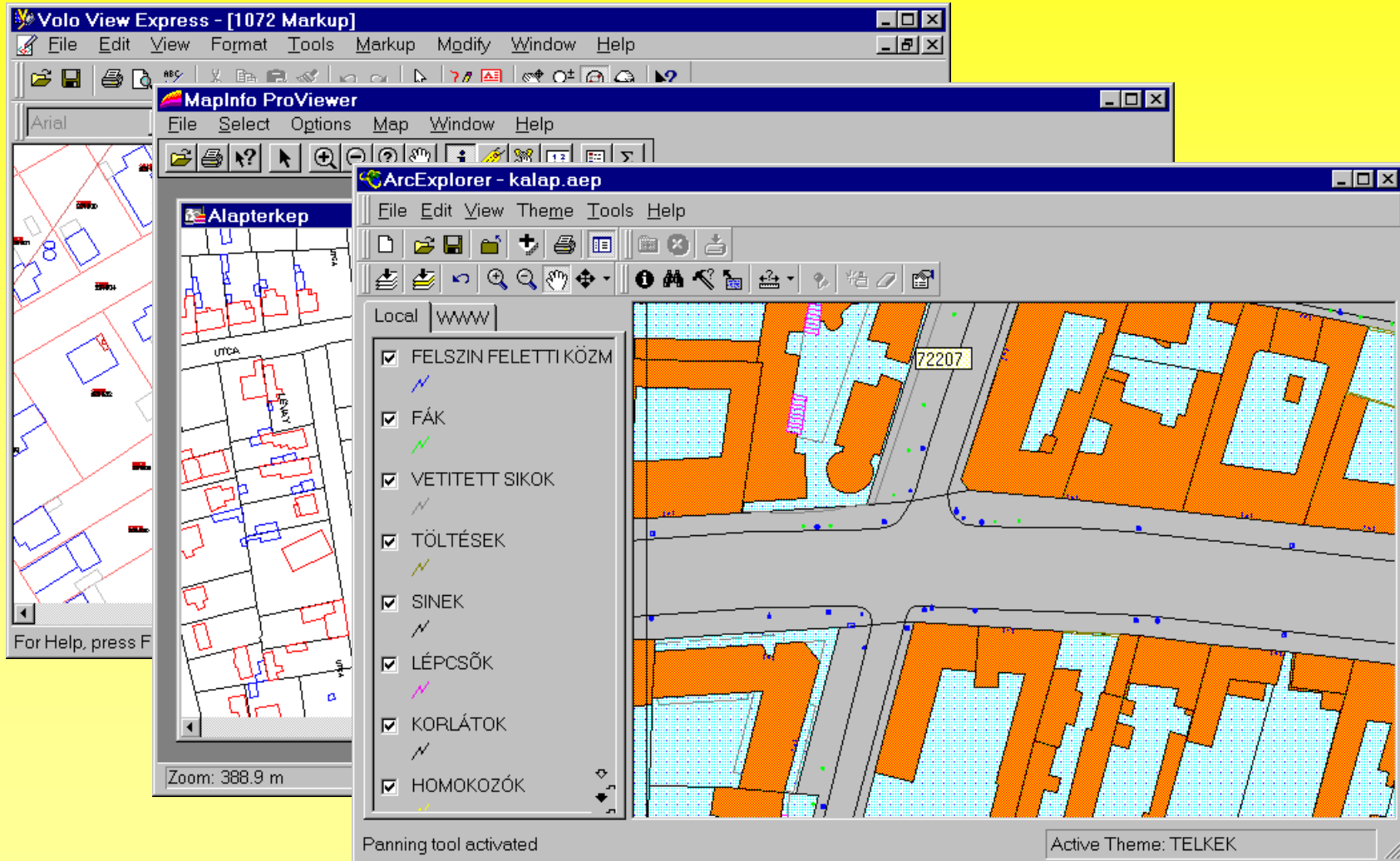
Optimum condition: no point inside  
the circle around any triangle



# GIS world today's

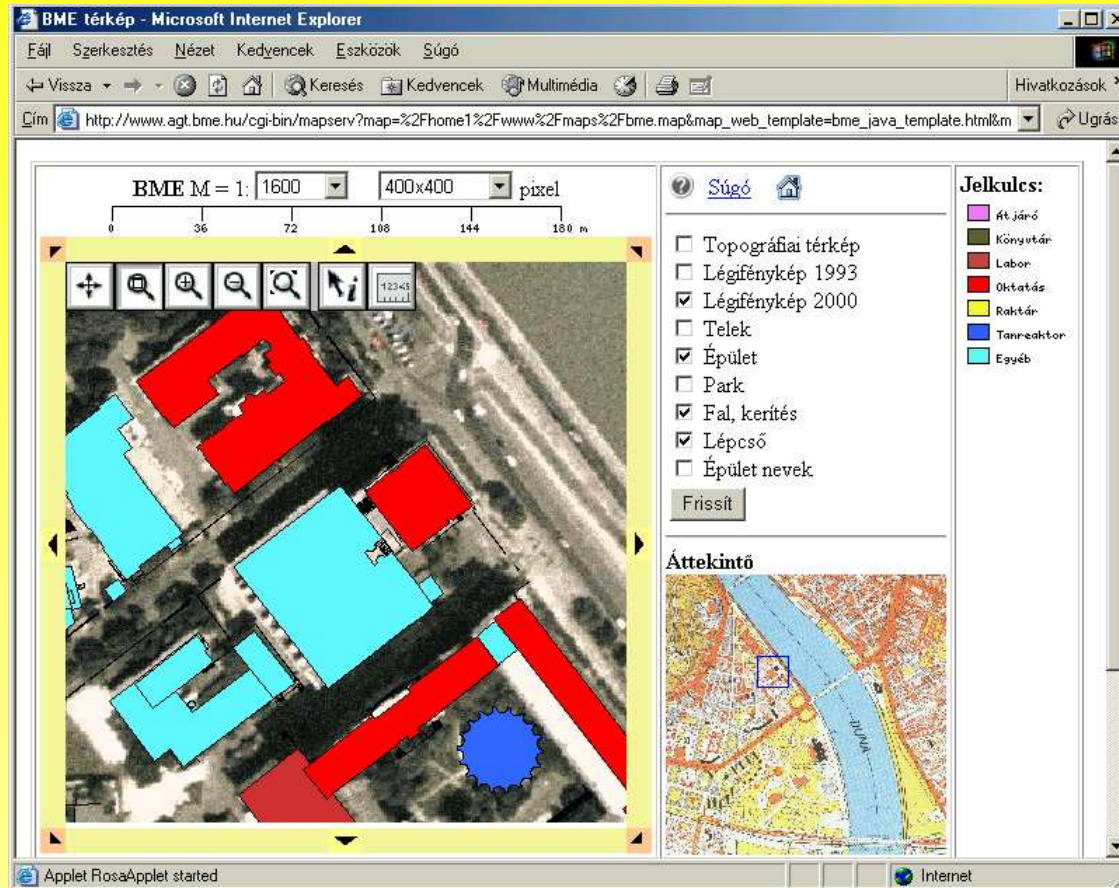


# Free GIS tools



# Internet map servers

[www.agt.bme.hu](http://www.agt.bme.hu)



[www.esri.com](http://www.esri.com) [www.autodesk.com](http://www.autodesk.com) [www.mapinfo.com](http://www.mapinfo.com) [www.bentley.com](http://www.bentley.com) ...