Finding the Mainstream

Michael F. Goodchild

GIS is becoming mainstream

- More and more dependence on general IT solutions
  - RDBMS
  - Object models
  - CASE tools, UML
- Location as an increasingly important attribute of records
  - in transactions
  - in location-based services

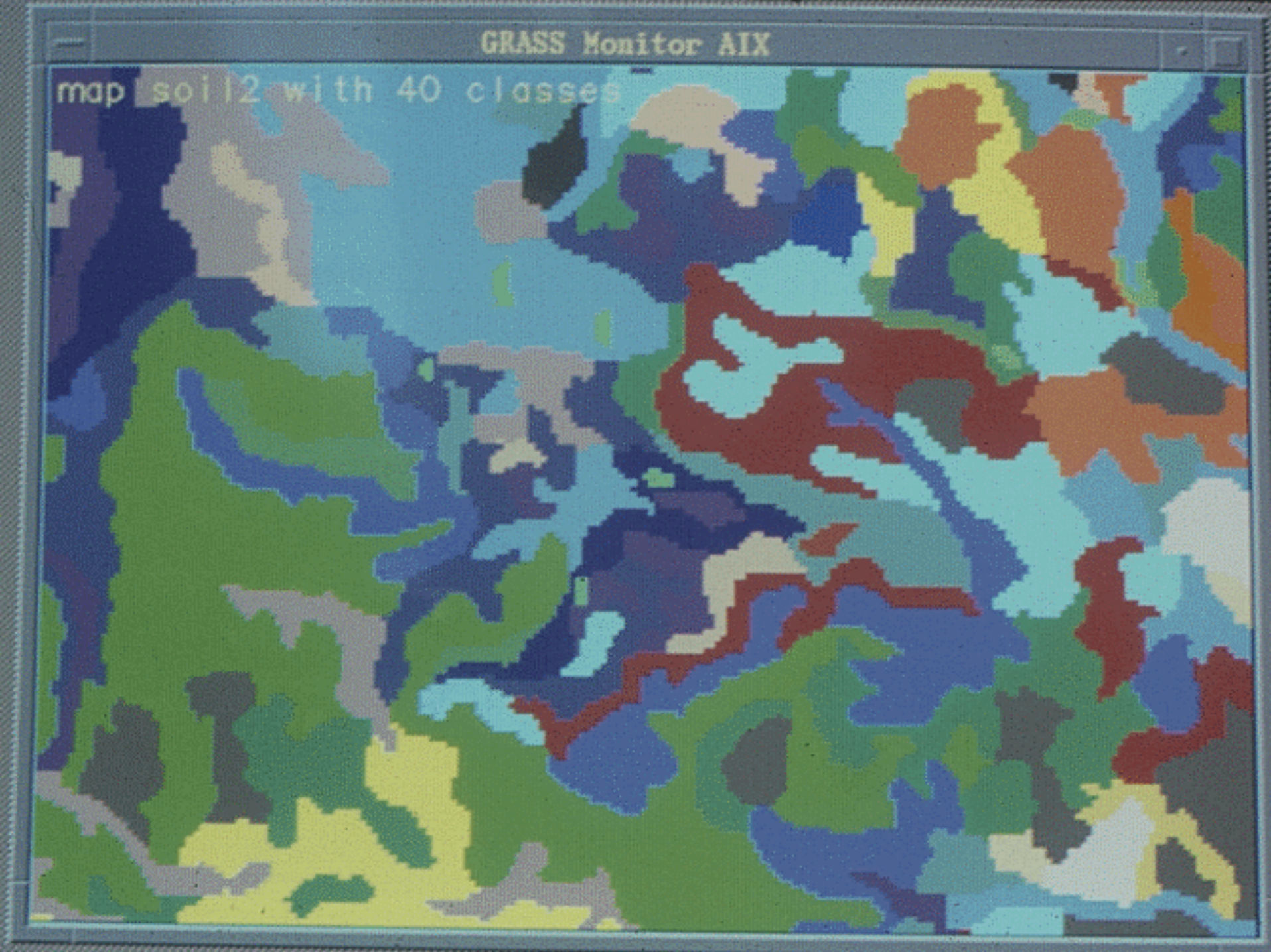
Tract	Pop	Location	Shape
1	3786	*x*,*y*	
2	2966	*x*,*y*	
3	5001	*x*,*y*	
4	4983	*x*,*y*	
5	4130	*x*,*y*	
6	3229	*x*,*y*	
7	4086	*x*,*y*	
8	3979	*x*,*y*	

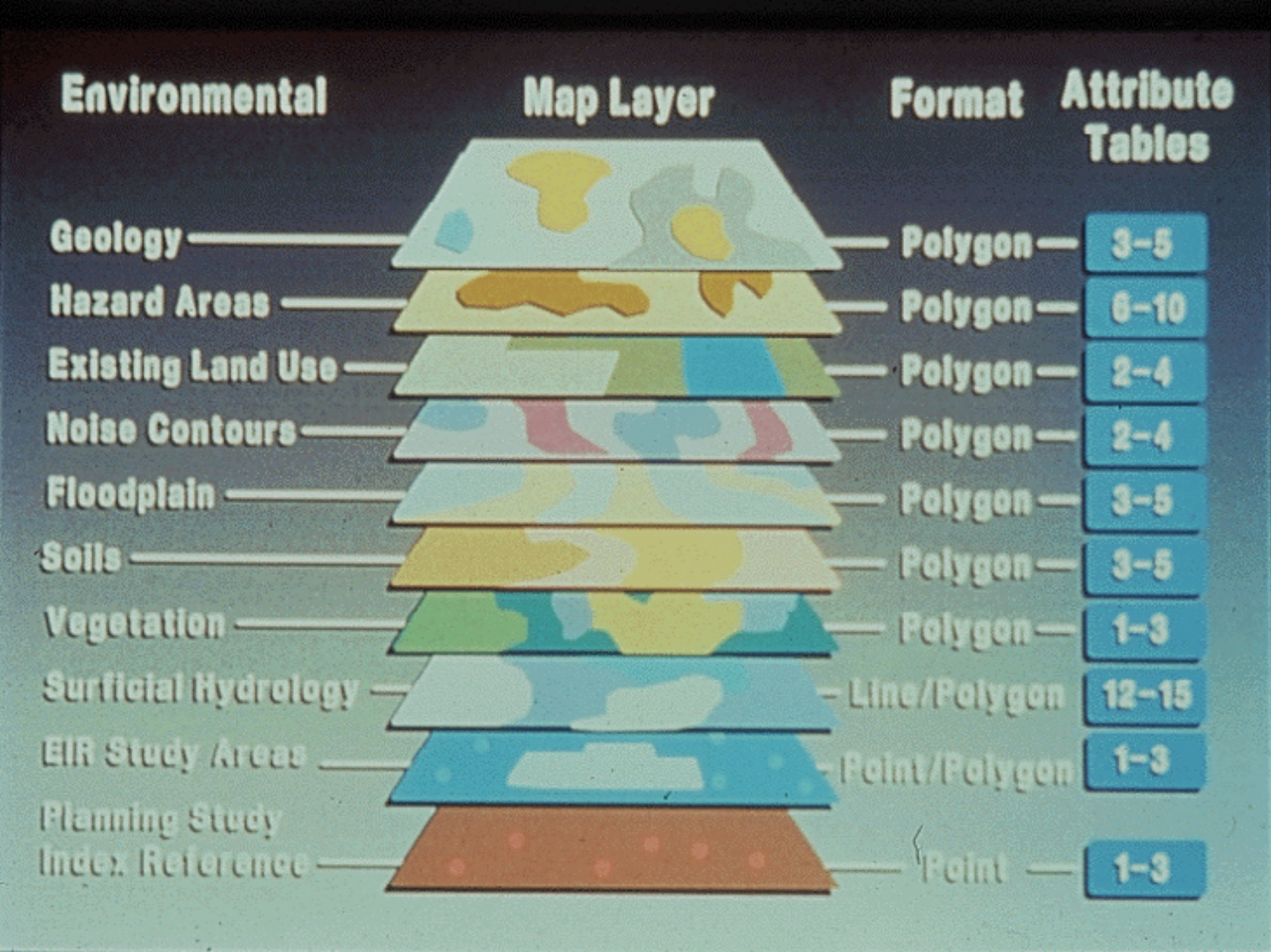
How special is GIS?

- It started as highly specialized
  - but has become less so over time
  - will GIS disappear into the IT mainstream?
- What are the special characteristics of GIS?
  - is spatial special?
  - how special will GIS be in 20 years?

Origins of GIS

- The Canada Geographic Information System
  - circa 1965
  - support for the Canada Land Inventory
  - $20 million investment by the Government of Canada
  - justified by accurate cost-benefit analysis


GRASS Monitor AIX
map soil2 with 40 classes


Environmental
Map Layer
Format
Attribute Tables
Geology
Hazard Areas
Existing Land Use
Noise Contours
Floodplain
Soils
Vegetation
Surficial Hydrology
EIR Study Areas
Planning Study Index Reference
Polygon
Polygon
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Line/Polygon
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Point
3-5
6-10
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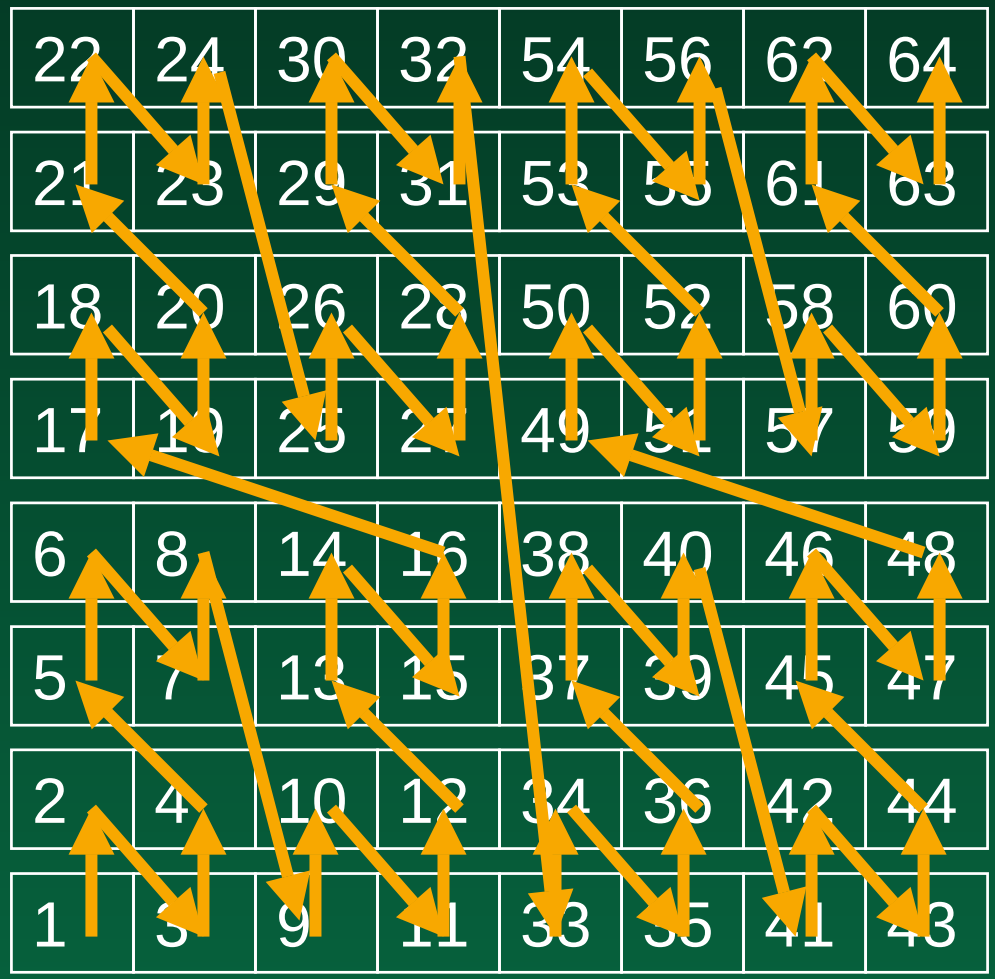
3-5
3-5
1-3
12-15
1-3
1-3

Inventions attributable to CGIS

- Measurement of area from digital maps
- The optical scanner
- The Morton order
  - to minimize seek times for adjacent tiles
- Topological data structures
  - to avoid double digitizing
  - a form of database normalization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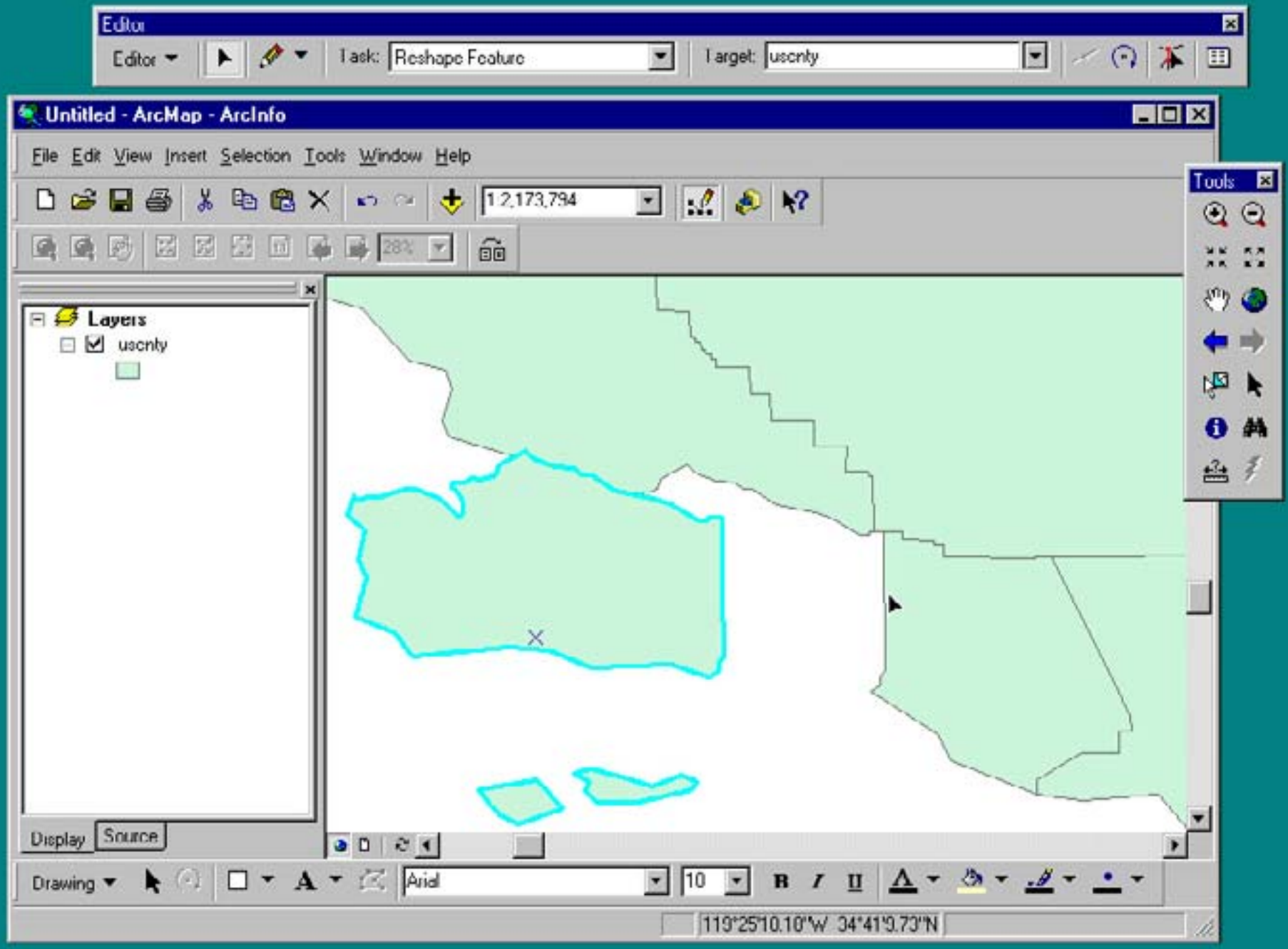
21 23 29 31 53 55 61 63
18 20 26 28 50 52 58 60
17 19 25 27 49 51 57 59
6 8 14 16 38 40 46 48
5 7 13 15 37 39 45 47
2 4 10 12 34 36 42 44
1 3 9 11 33 35 41 43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Target:
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Untitled - ArcMap - ArcInfo
File Edit View Insert Selection Tools Window Help
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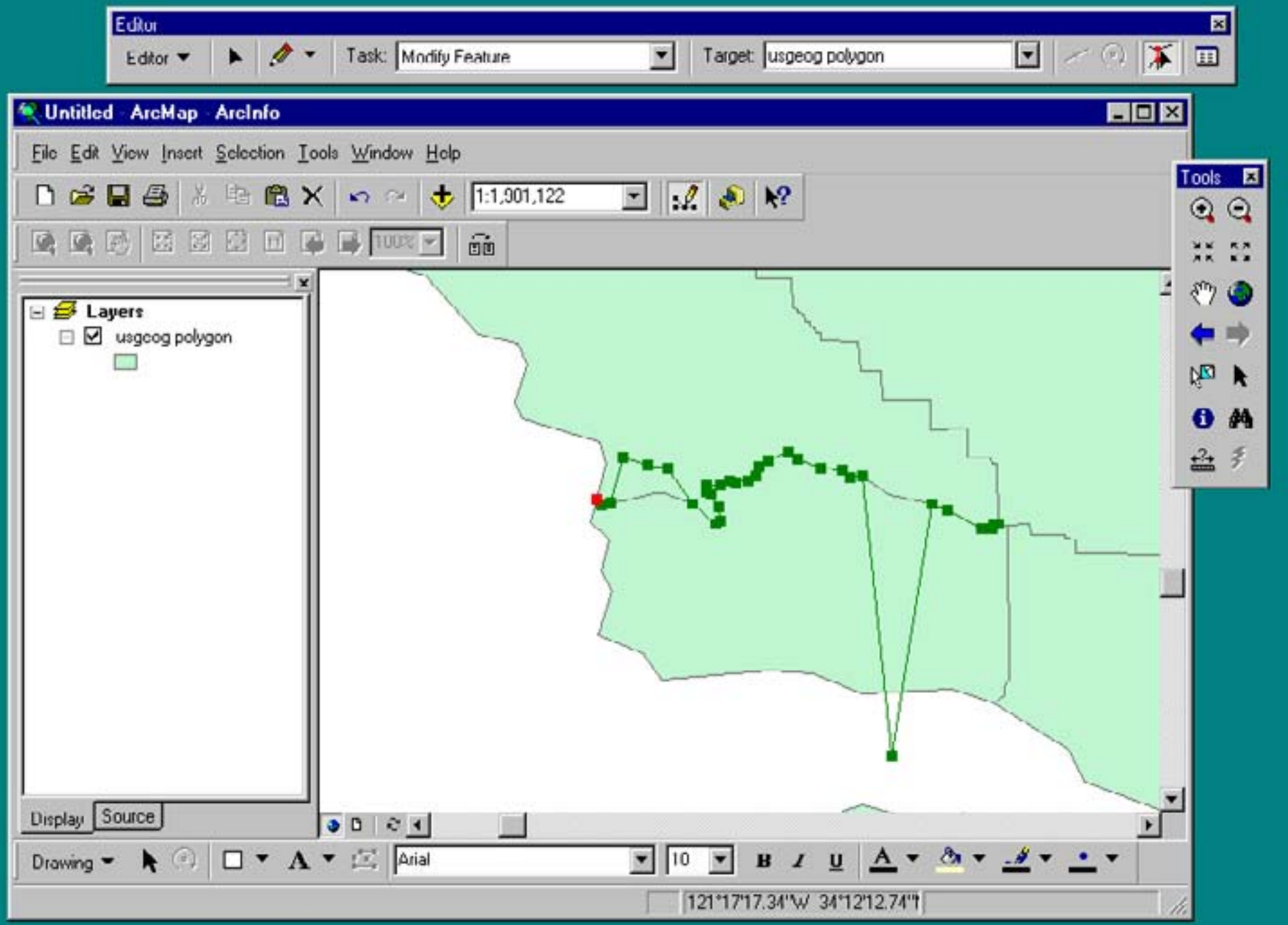
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Editor
Task: Modify Feature
Target: usgeog polygon
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File Edit View Insert Selection Tools Window Help
1:1,901,122
Tools
Layers
usgeog polygon
Display
Source
Drawing
Arial
10
121°17'17.34"W 34°12'12.74"N

CGIS engineering

- Low-level source code (PL1)
- IBM operating system (JCL)
- Custom input device (map scanner)

A contemporary GIS

- RDBMS
- CASE tools for database design
  - Visio, UML
- Graphics libraries
- Reusable software components
- Dynamic linking with other component libraries

Mainstream database solutions

- The georelational model
  - adaptation of RDBMS
  - related tables
  - a hybrid of mainstream and specialized
- Object-oriented modeling
  - objects as instances of general classes
  - classes as specializations of more general classes (inheritance)
  - methods associated with classes (encapsulation)
  - associations between objects

Specialized GIS data models

- The basic elements built into the GIS
  - points, lines, areas
  - the GIS mainstream
- How these elements are specialized in application domains (vertical markets)
  - railroad track as a class of transportation link
  - transportation link as a class of line

Unified Modeling Language

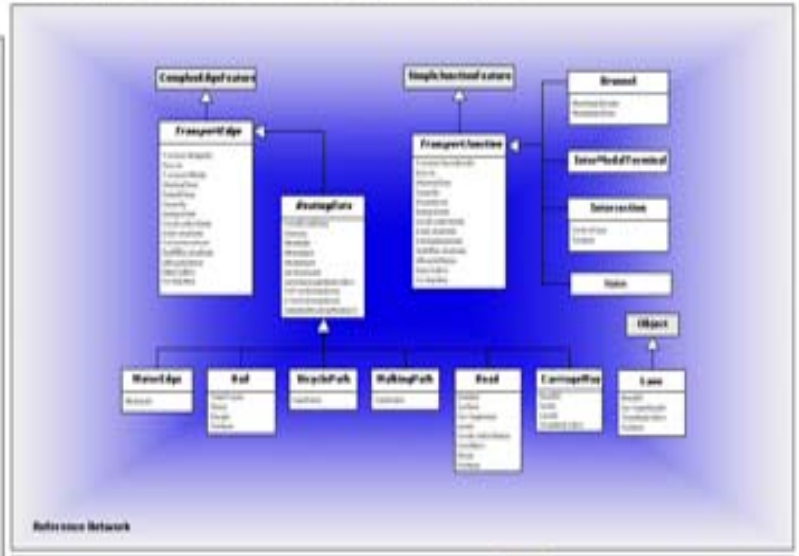
- Visual representation of a data model
  - conventional symbols
  - implemented in Visio
- Creation of database layout
  - use CASE tools
  - build tables
  - populate tables with data

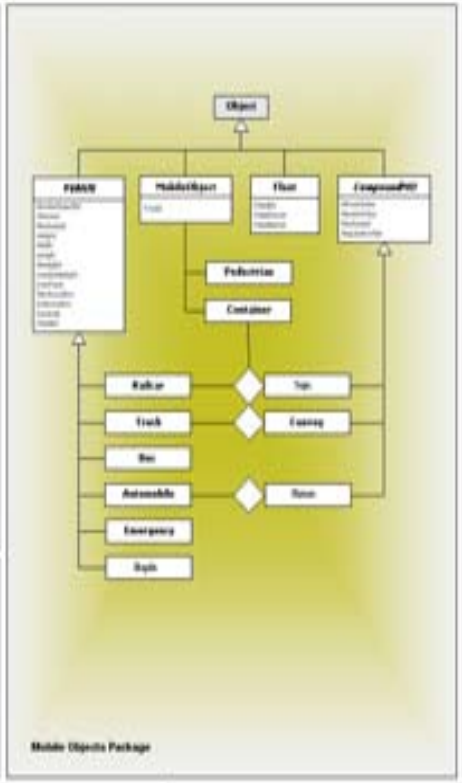
UNETRANS

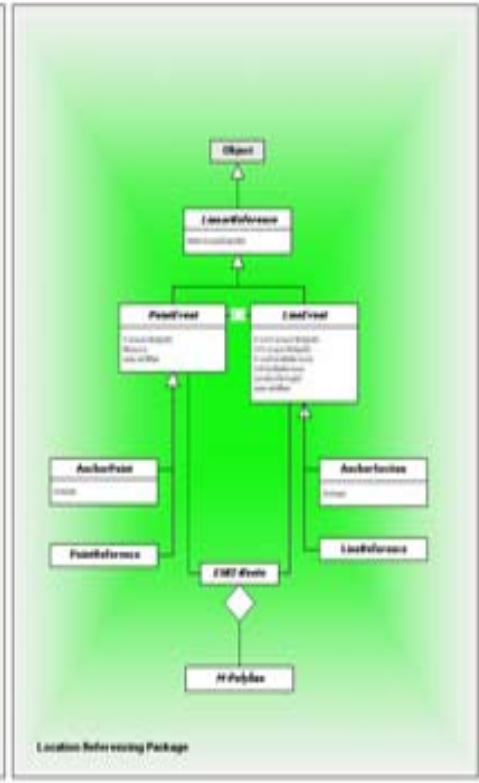
- Helping transportation users of ArcGIS by providing a database framework that includes familiar elements
  - contains the core items
  - is easy to extend and specialize
  - add new attributes
  - add specialized classes

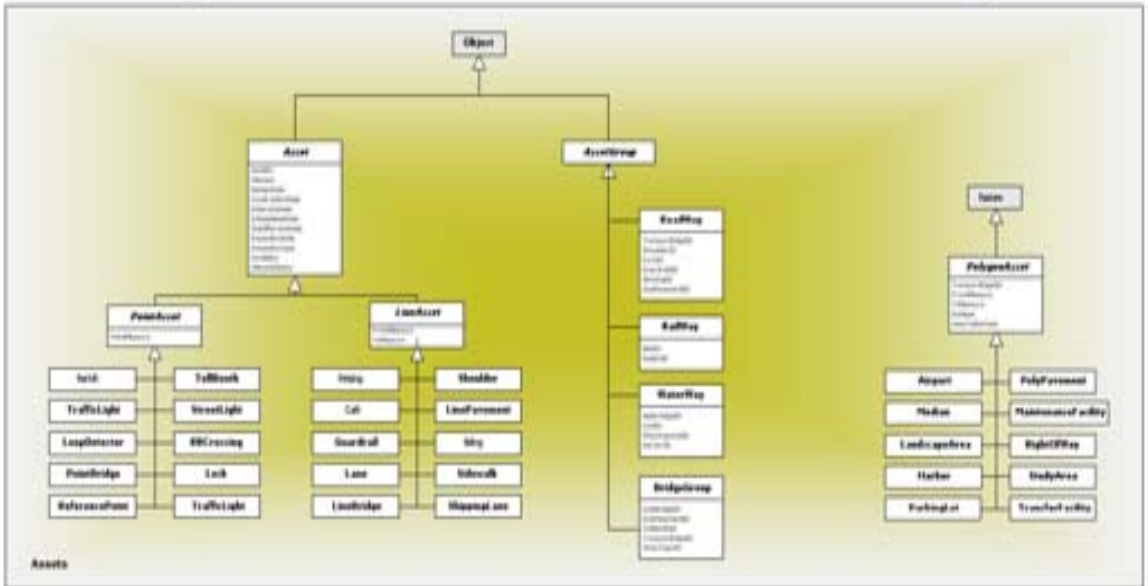
ArcGIS Transportation Data Model

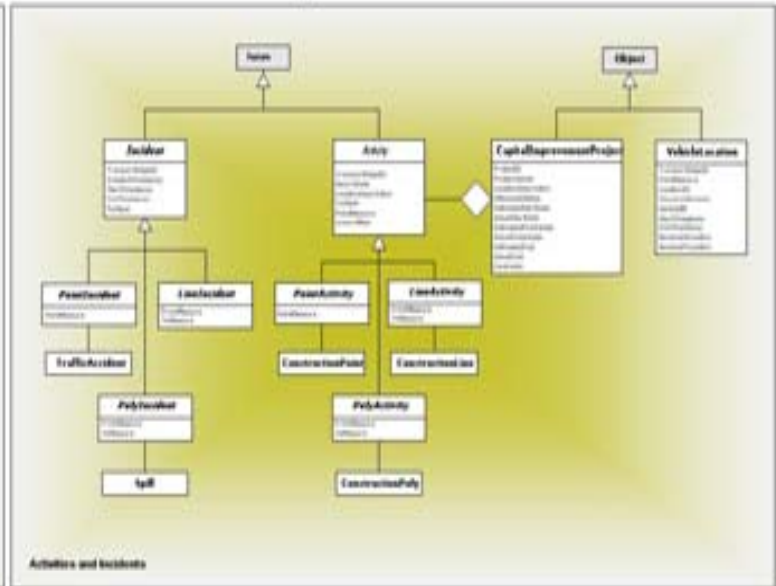
Feb. 21, 2001

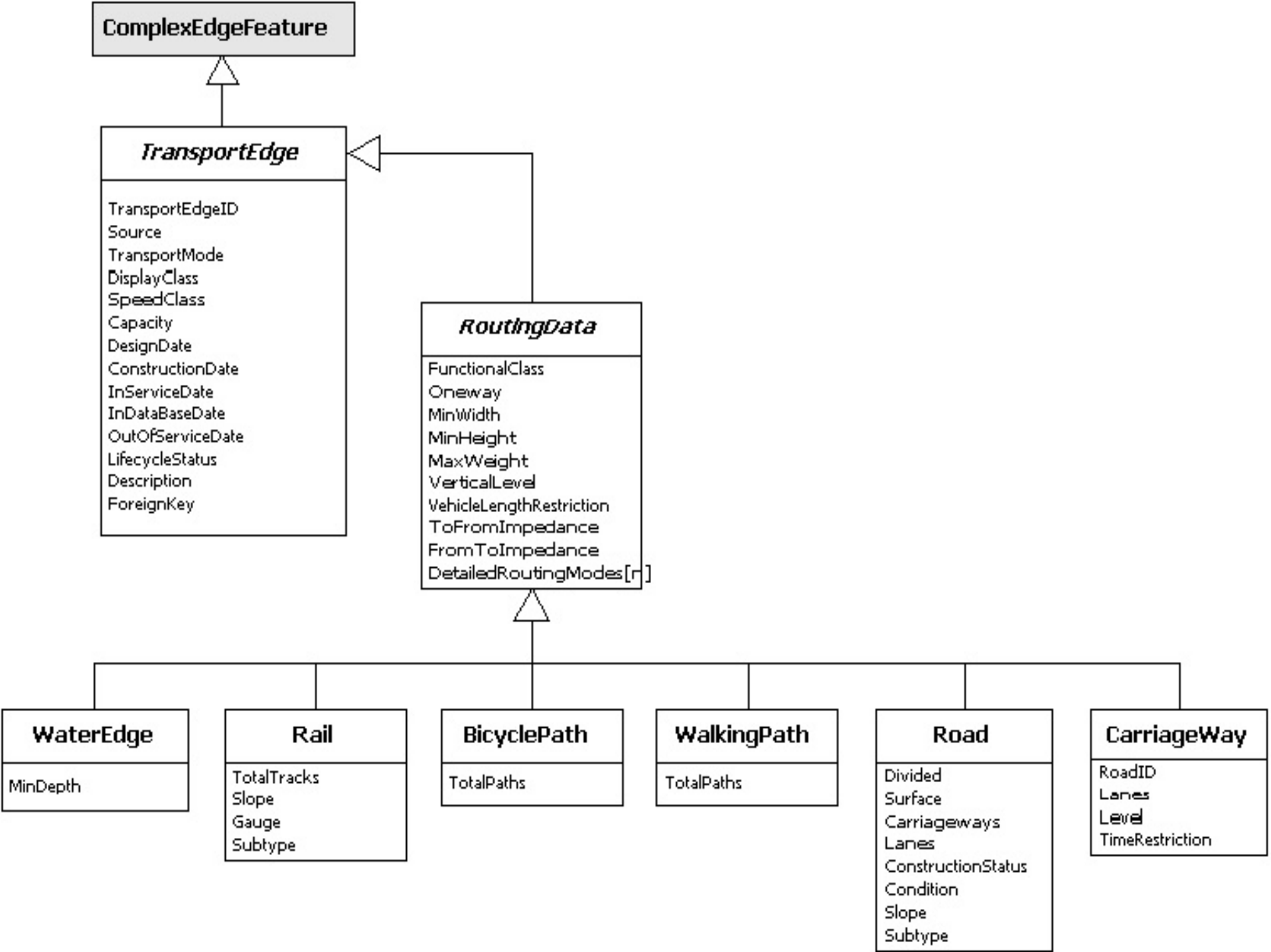








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TransportEdge
TransportEdgeID
Source
TransportMode
DisplayClass
SpeedClass
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DesignDate
ConstructionDate
InServiceDate
InDataBaseDate
OutOfServiceDate
LifecycleStatus
Description
ForeignKey
RoutingData
FunctionalClass
Oneway
MinWidth
MinHeight
MaxWeight
VerticalLevel
VehicleLengthRestriction
ToFromImpedance
FromToImpedance
DetailedRoutingModes[n]
WaterEdge
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Rail
TotalTracks
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Gauge
Subtype
BicyclePath
TotalPaths
WalkingPath
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Subtype
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RoadID
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Level
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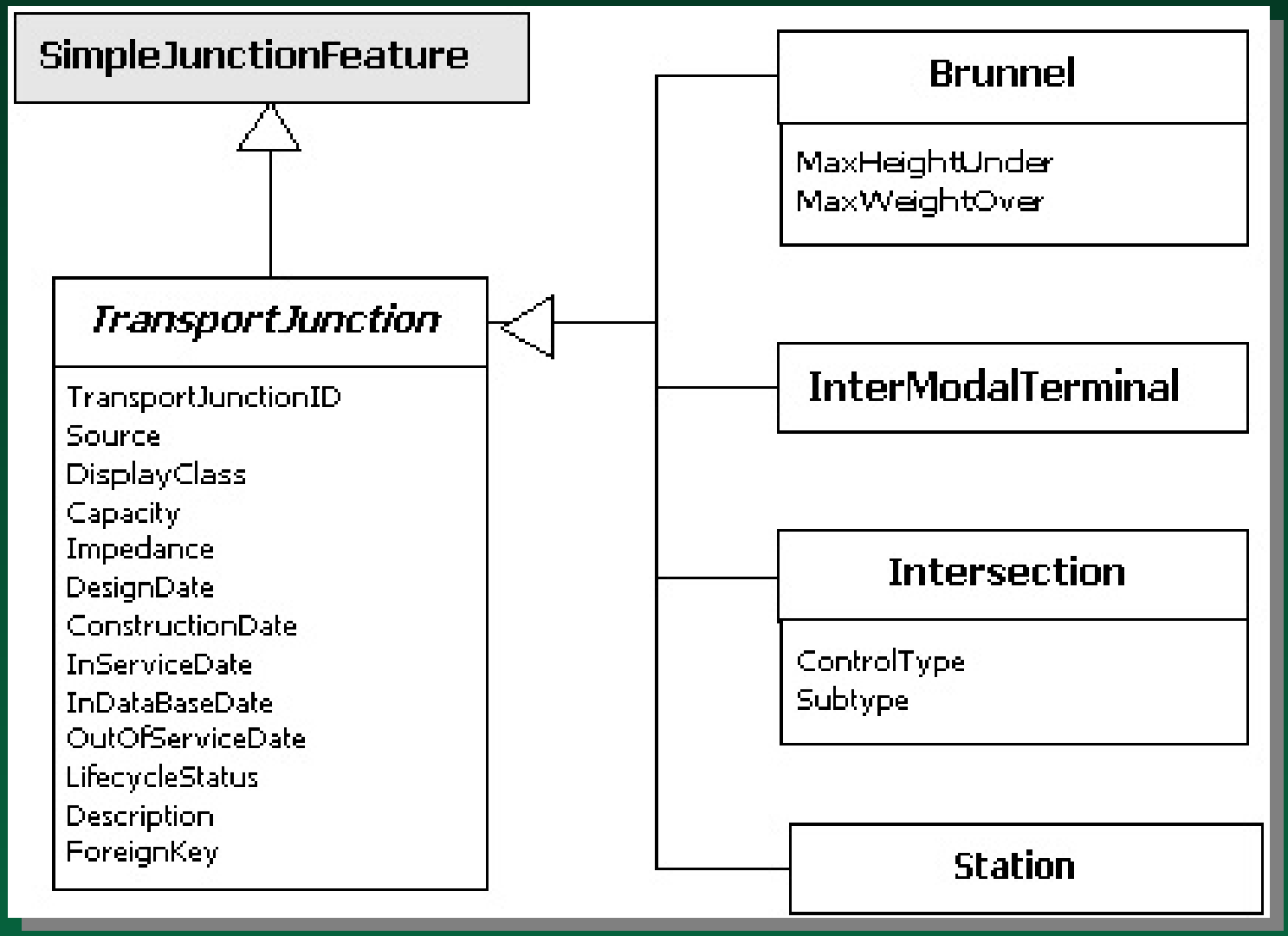
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TransportJunction
TransportJunctionID
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DesignDate
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MaxWeightOver
InterModalTerminal
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ControlType
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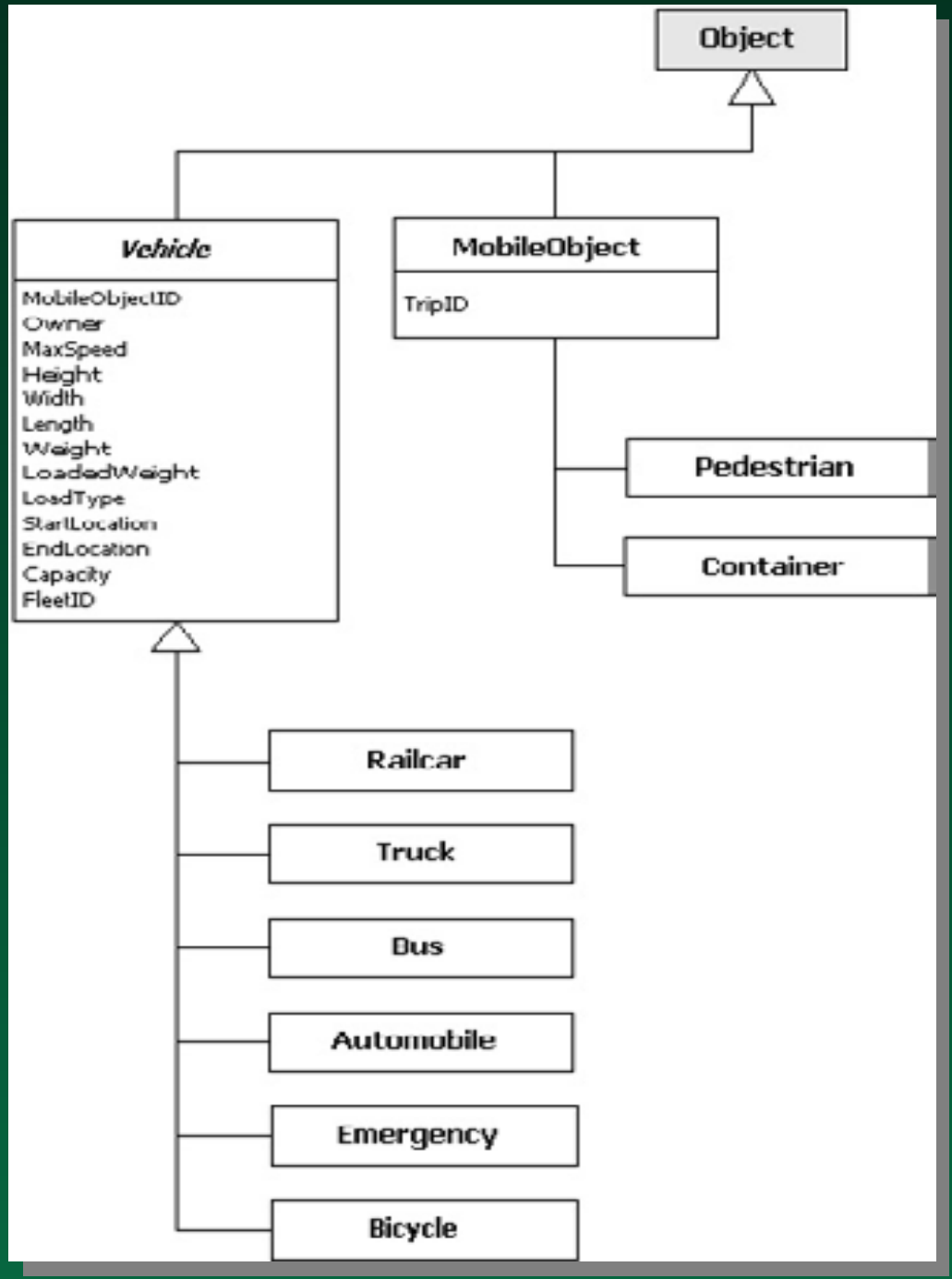
Station


Object
Vehicle
MobileObjectID
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LoadType
StartLocation
EndLocation
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FleetID
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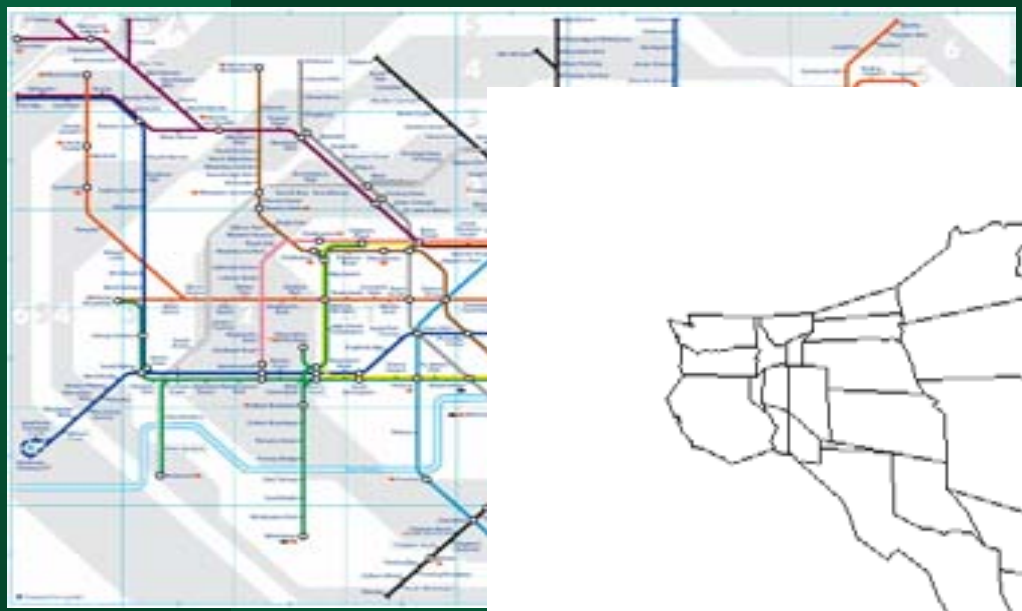
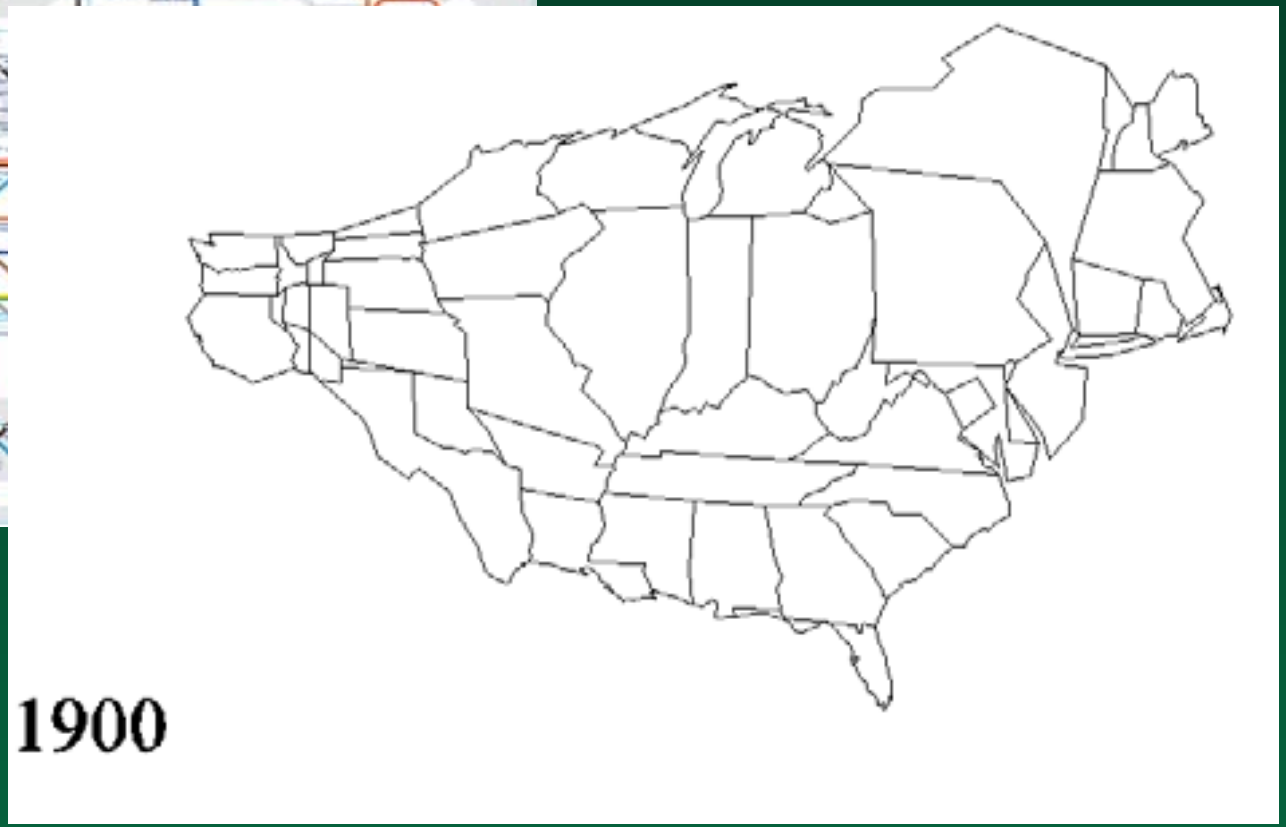
TripID
Pedestrian
Container
Railcar
Truck
Bus
Automobile
Emergency
Bicycle

How important are coordinates anyway?





Kocmoud and House, Texas A&M University

Space as a matrix

- ***W*** where w_{ij} is some measure of interaction
  - adjacency
  - decreasing function of distance
  - invariant under rotation, displacement
  - readily obtained from a GIS

Lumpers and splitters

- Lump GIS with other IT applications
  - and benefit from economies of scale
  - one RDBMS fits all
- Split GIS from other IT applications
  - it addresses a unique type of information
  - it must adapt to the unique properties of that type

What's special about spatial? A statistician's view

- Spatial dependence
  - Tobler's First Law of Geography
  - "All things are related, but nearby things are more related than distant things"
  - properties vary slowly across the Earth's surface
  - try to imagine a world in which that's not true
    - try to describe, navigate in, live in such a world
    - hell is a place with no spatial dependence
- Spatial heterogeneity
  - results of analysis vary from one place to another

What's special about spatial? An SAP's view

- Large volume
  - petabytes online
- Uncertainty
  - impossible to measure location exactly
  - impossible to be certain about some attributes, e.g. vegetation cover, soil
- Applications
  - in virtually all areas of human activity
- Production arrangements
  - produced by central mapping agencies
- Impacts on society
  - privacy


display.june.stp - Display
File View Map GPS Comm Window Help
A B C D E F G H I
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Time: 1.00
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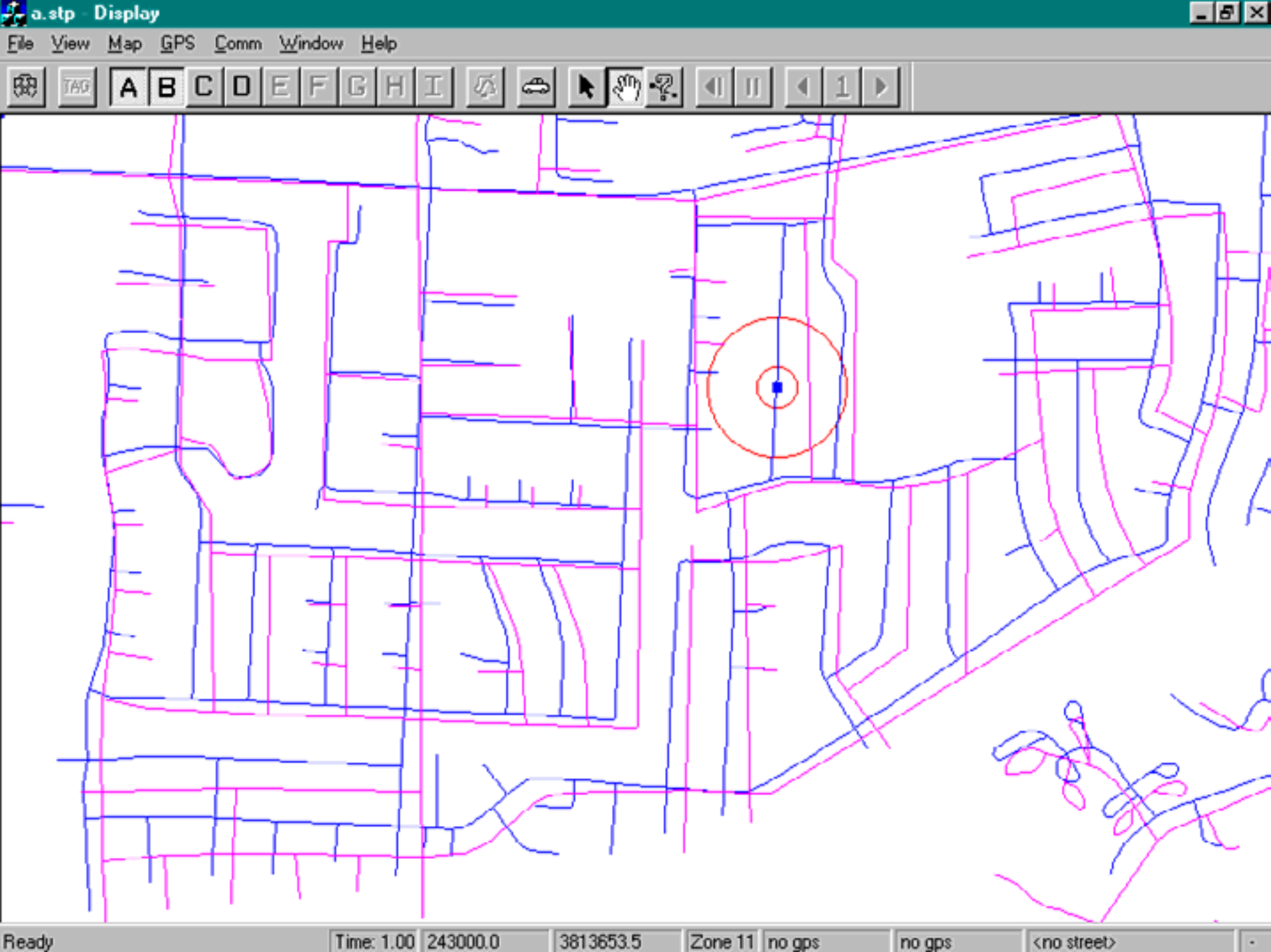
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File View Map GPS Comm Window Help
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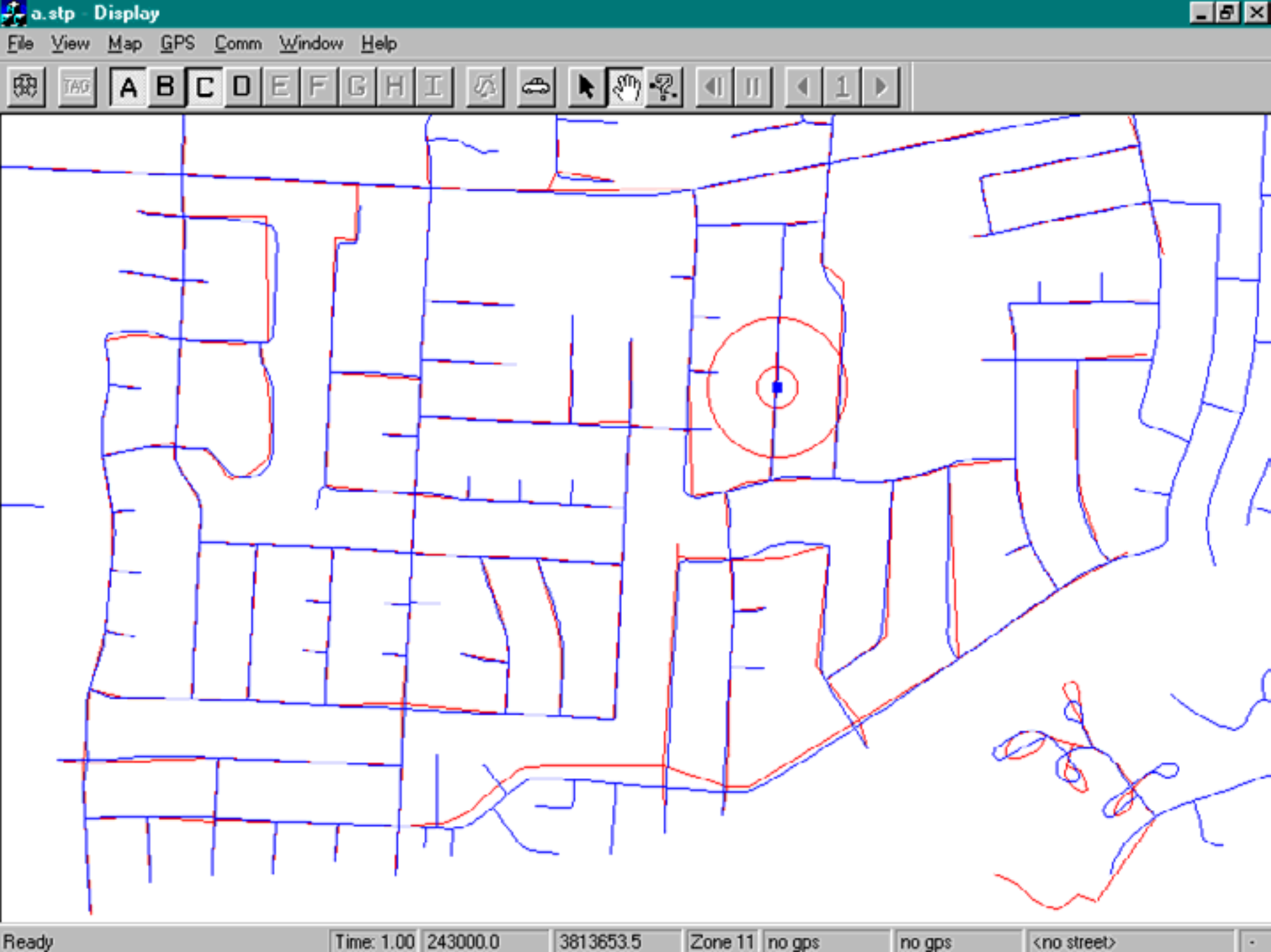
a.stp - Display
File View Map GPS Comm Window Help
A B C D E F G H I
1
Ready
Time: 1.00
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Zone 11
no gps
no gps
<no street>

What's special about spatial? A database view

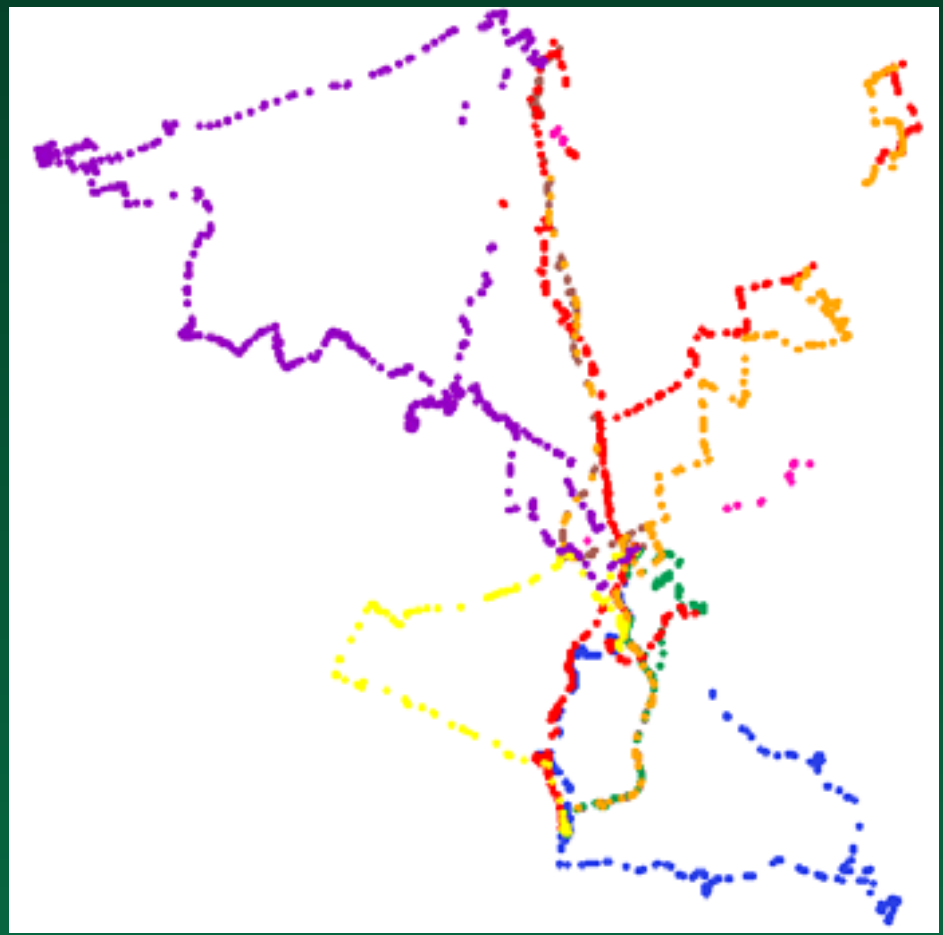
- First principle of OODB design
  - all objects are instances of more general classes
- Not all geographic phenomena are easily conceptualized as discrete objects
  - road networks, topography are continuous
  - must be broken into discrete objects to be handled in DBMS
    - but there are many possible ways of breaking them into discrete chunks
    - dynamic segmentation

Scottish Munros

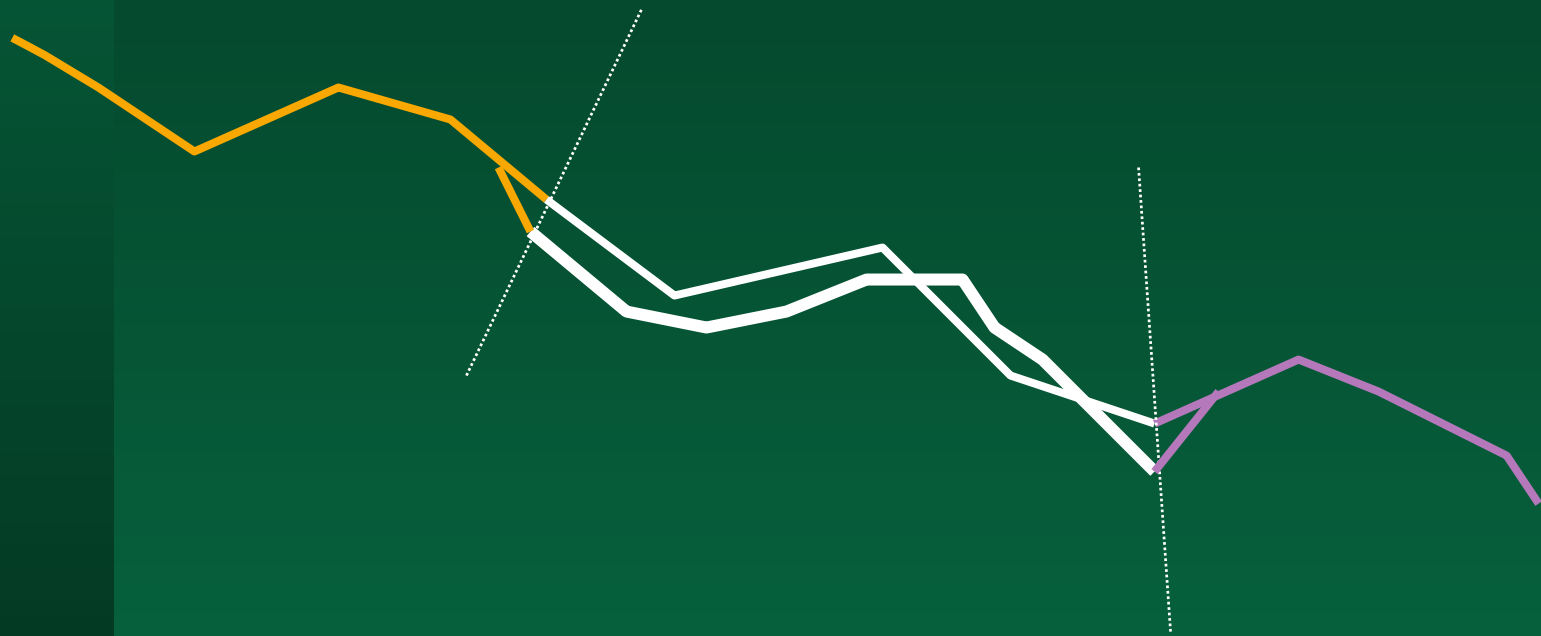
1.. Ben Hope
2.. Ben Klibreck
3..Ben More Assynt
4..An Teallach
5..Seana Bhraigh
6..Ben Wyvis
7..Slioch
8..Sgorr Ruadh
9..Moruisg
10..Sgurr na Ruaidhe
11..Bia Bheinn
12..Sgurr na Lapaich
13..Ben Attow
14..The Saddle
15..Creag a' Mhaim
16..Ladhar Bheinn

17..Coireachan
18..Ben Nevis
19..Ben More
20..Ben Starav
21..Braeriach
22..Ben Avon
23..Meall Chuaich
24..Mt Keen
25..Deinn Dearg
26..Glas Maol
27..Driesh
28..Schiehallion
29..Ben Chonzie
30..Ben Lawers
30..Ben Challum
32..Ben Lomond

A week in Jonathan Raper's life

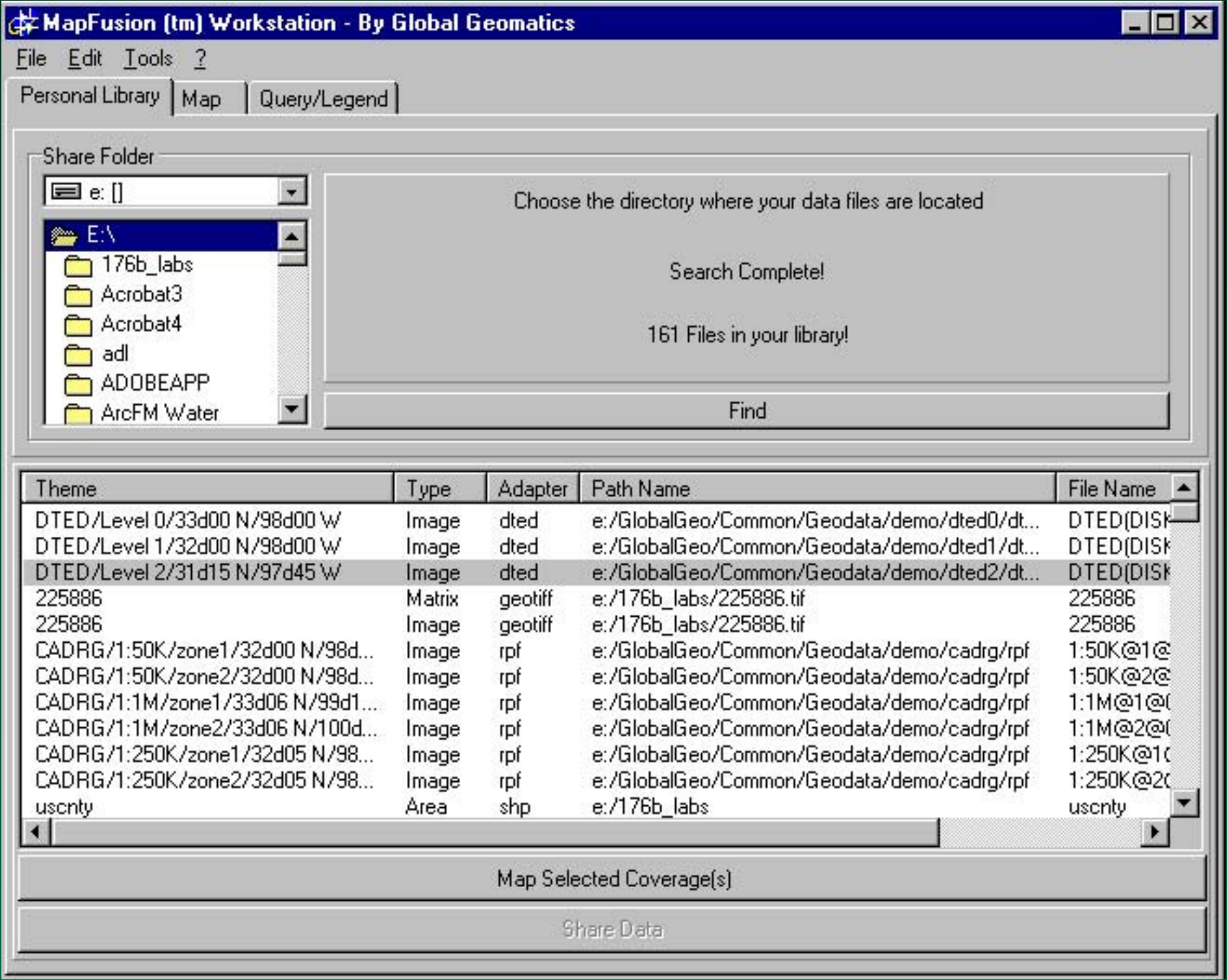


Updating a street database through transactions



If spatial is special...

- Special courses for SAPs
  - education in the principles of GIS
  - training in the practice of GIS
- A distinct metadata standard
  - FGDC, ISO 19115, ANZLIC
- Search engines
  - specialized to find geospatial data


MapFusion (tm) Workstation - By Global Geomatics
File Edit Tools ?
Personal Library
Map
Query/Legend
Share Folder
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ArcFM Water
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161 Files in your library!
Find
Theme
Type
Adapter
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DTED/Level 0/33d00 N/98d00 W
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1:250K@1
CADRG/1:250K/zone2/32d05 N/98...
Image
rpf
e:/GlobalGeo/Common/Geodata/demo/cadrg/rpf
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Area
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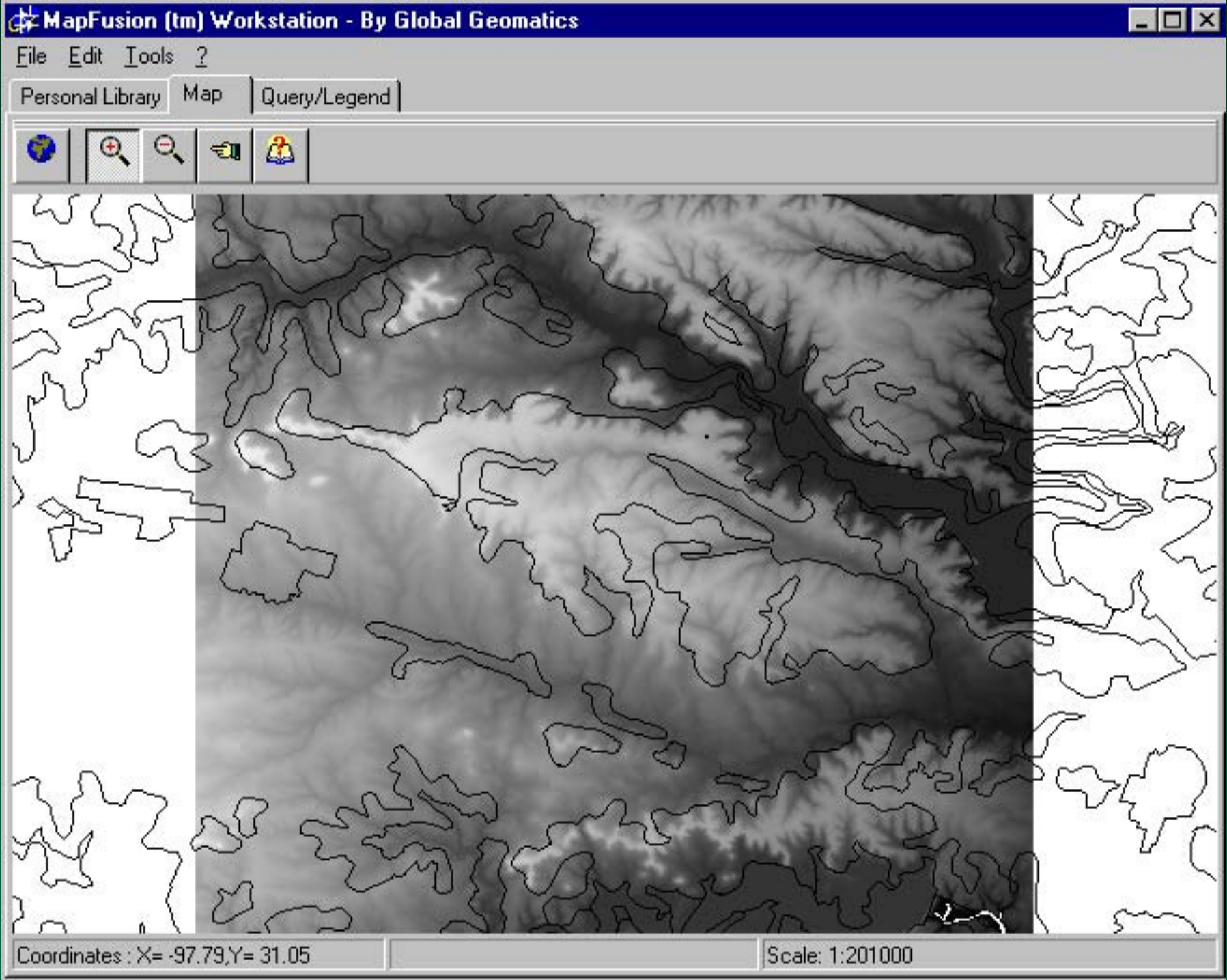
uscnty
Map Selected Coverage(s)
Share Data


MapFusion (tm) Workstation - By Global Geomatics
File Edit Tools ?
Personal Library
Map
Query/Legend
Coordinates : X= -97.79,Y= 31.05
Scale: 1:201000

Conclusions (1)

- Some GIS applications are more compatible with the IT mainstream than others
  - discrete objects
  - location as an attribute
  - transactions

Conclusions (2)

- Other applications are much less compatible
  - GIS in scientific research
    - dominance of fields of continuous variation
    - rasters vs discrete vector objects
  - network applications
    - arbitrary chunking of networks

Conclusions (3)

- Economies of scale will continue to pull GIS into the mainstream
  - applications that are more specialized will have to pull hard in the opposite direction
- GIS data sets require highly specialized tools for search and retrieval
  - a new generation of search engines is badly needed

Conclusions (4)

- Because of the diversity of GIS, it will always be difficult to bound and regulate the field
  - except in limited, well-defined areas such as the cadaster
- The special characteristics of GIS will continue to foster
  - a science of geographic information
  - education in GIS at all levels
  - a need for training at all levels