It’s not CAD to GIS;
It’s Design to As-Built

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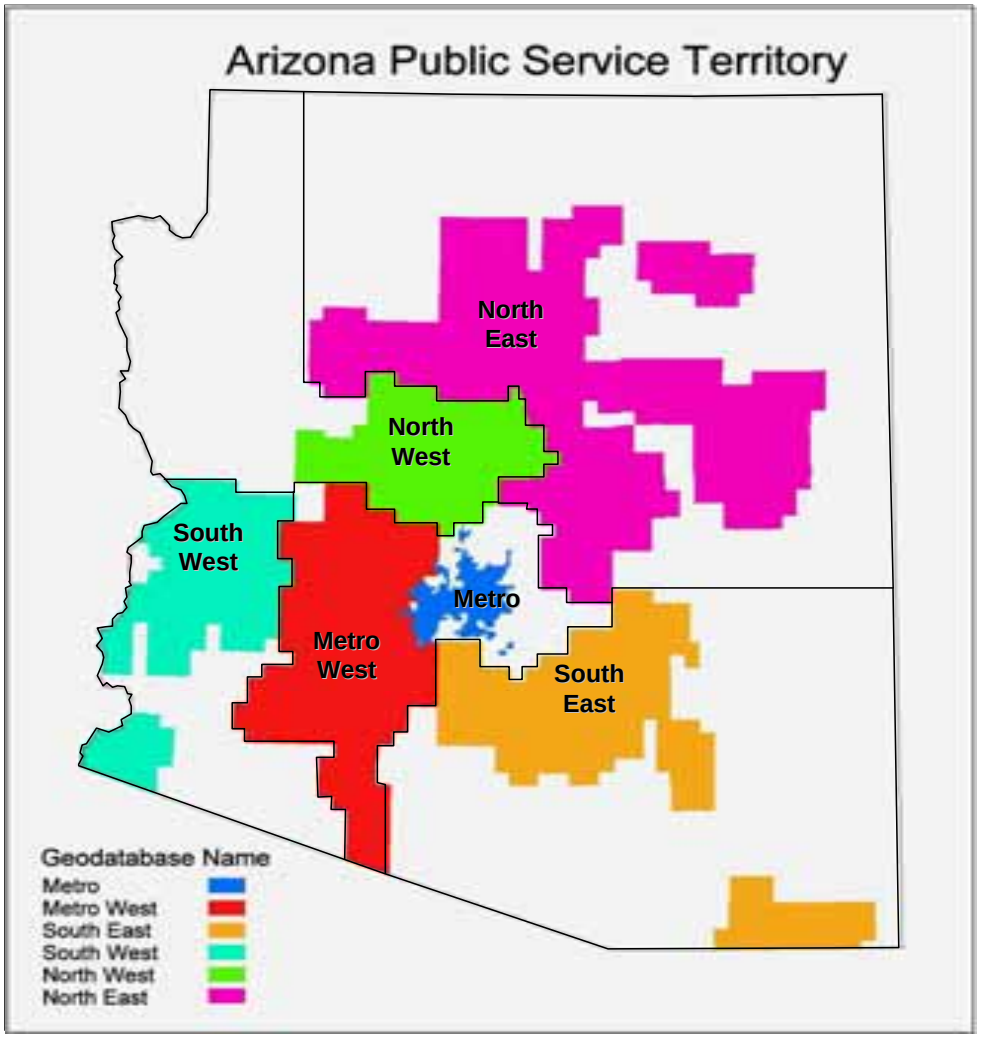
APS Background



1.3 Million Customers

5 Operating Divisions

1140 Feeders/Circuits

Metro Region =

- 75 % of Customers,
- 15% of Service Territory

One of the Fastest Growing Customer bases in United States

APS
THE POWER TO MAKE IT HAPPEN™

Contents

- Discuss issues related to managing data across the facility management organization
- Dispel myths
- Identify technical issues
- Identify non-technical issues
- Discuss options

Intended Audience

- Designed for a mixed audience
- Generally not technical
- Some understanding of AutoCAD and GIS would be helpful

Ground Rules

- No religious discussions
  - No discussion of whether GIS or CAD is better.
  - Many of us, for various reasons, need to work in an environment shared between CAD and GIS software

“It just doesn’t matter”

Photo credit: Bill Murray from the movie *Meatballs*

http://www.flixster.com/movie/meatballs/photos?p=10871326

Some Myths to Dispel

- CAD is dumb data
- GIS data is not accurate
- CAD doesn’t use coordinate systems
- Technology now allows us to capture 80% of CAD data for GIS
- CAD uses x and y coordinates, and GIS uses Latitude and Longitude
- CAD is a graphics program and GIS is a database program

CAD and GIS Basics

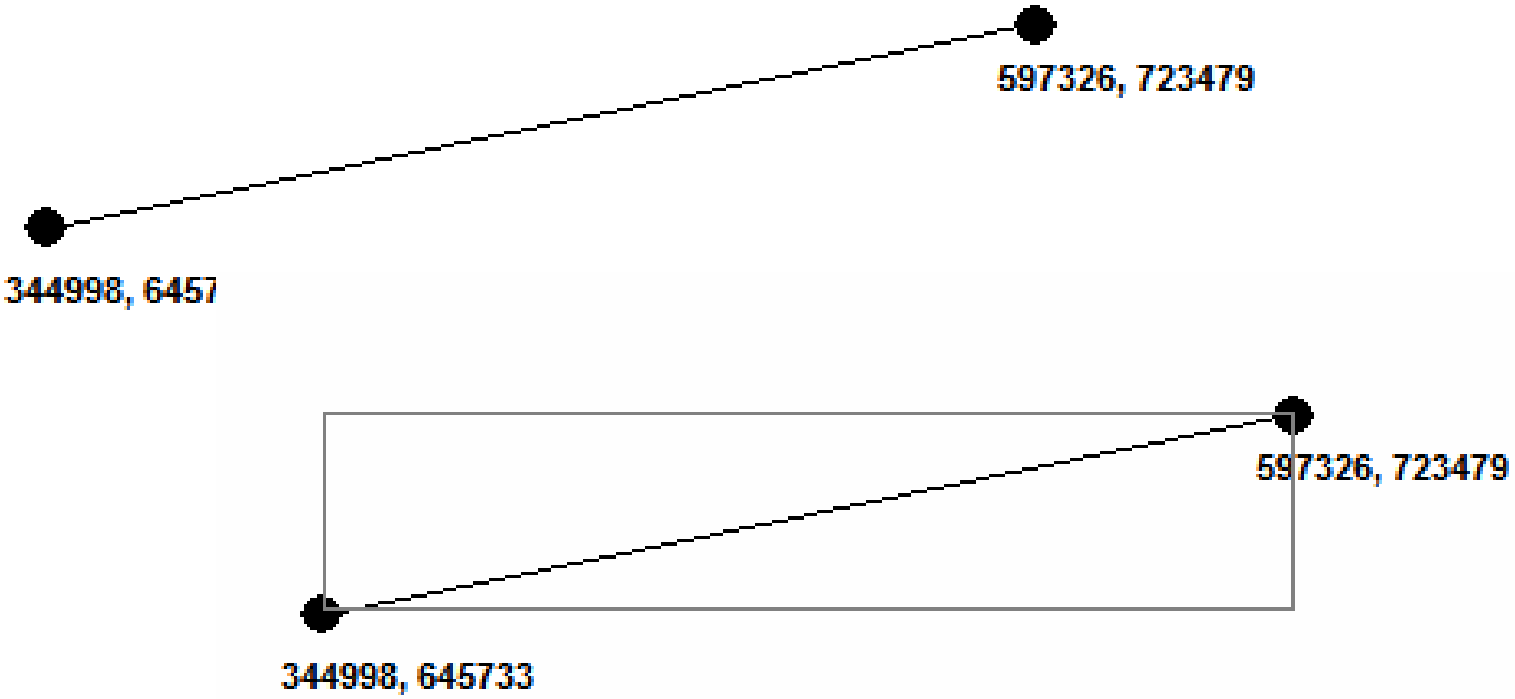
- Both consist of basic primitive elements
  - Points
  - Lines
  - Polygons
  - Attributes
- Both store this information within databases

Points

- Represent a position or location
- Consist of coordinates – X, Y and Z

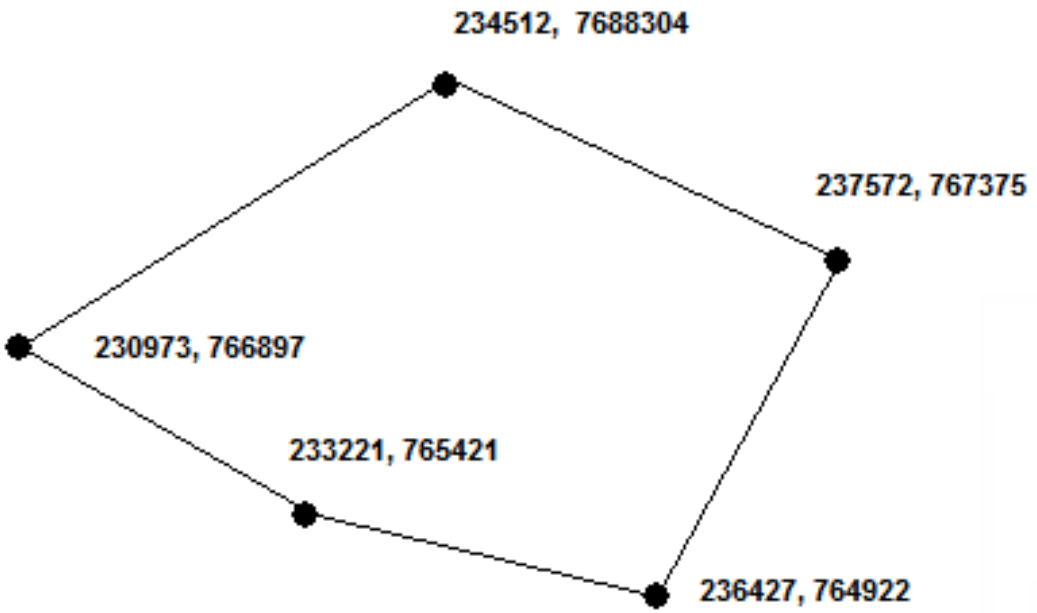
Lines

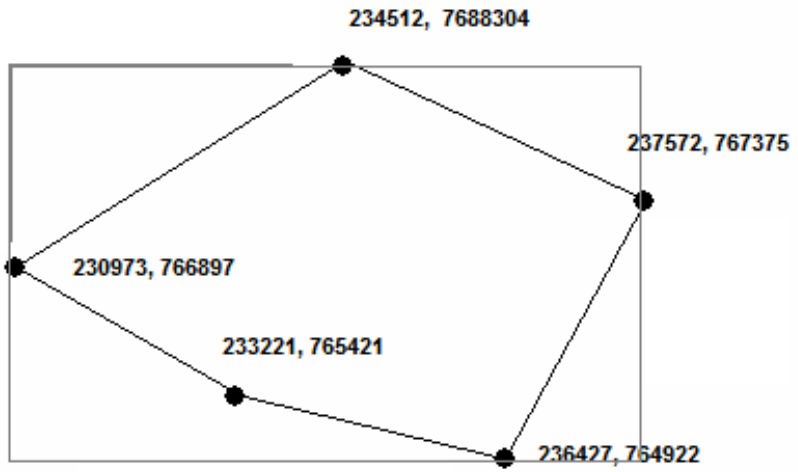
- Consist of coordinate pairs – a start point and end point



Polygons

- Consist of group of coordinate pairs – a boundary of lines

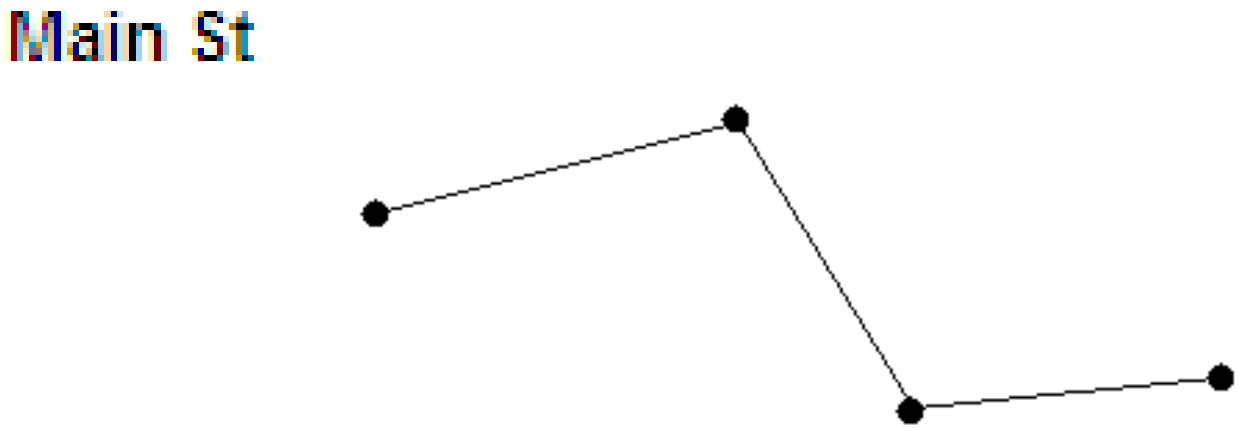




Complex Features

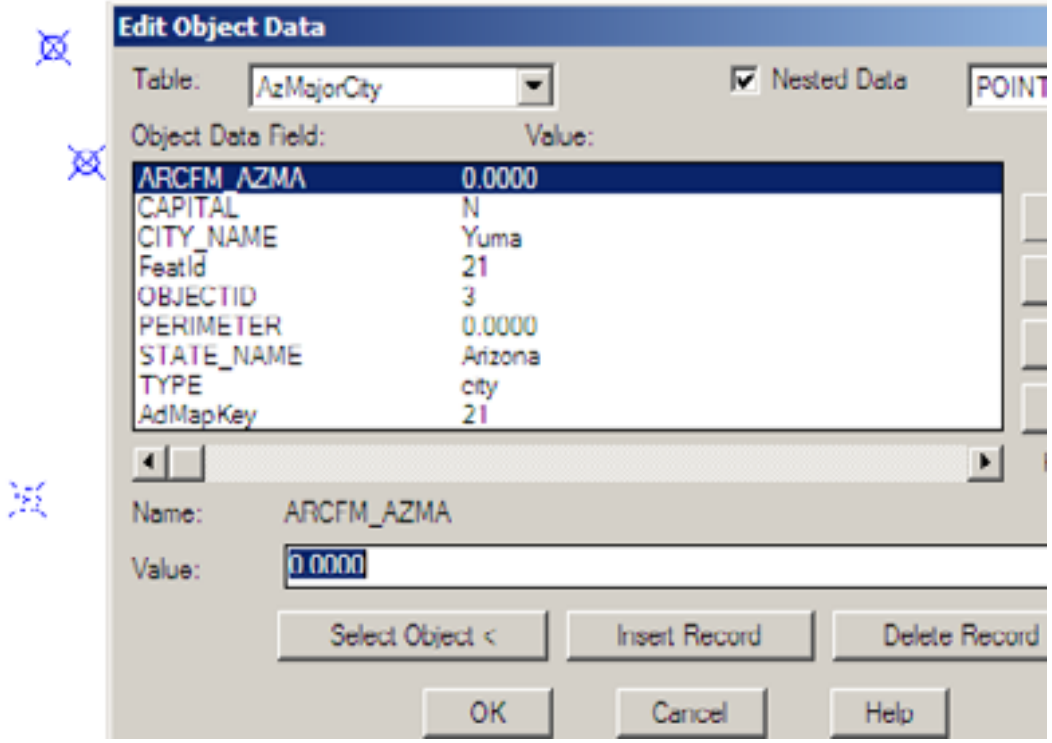
Complex features are generally some construct of these primitives

- Annotation is a form of point
- Polylines are groups of lines



Attributes

- Primitives will have data elements attached
  - Some elements describe the object itself
  - Some are data describing what the object represents



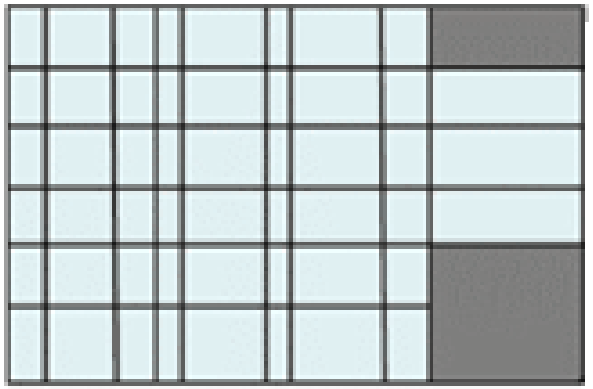
So what is the difference?

There are 2 key differences between CAD and GIS that are critical

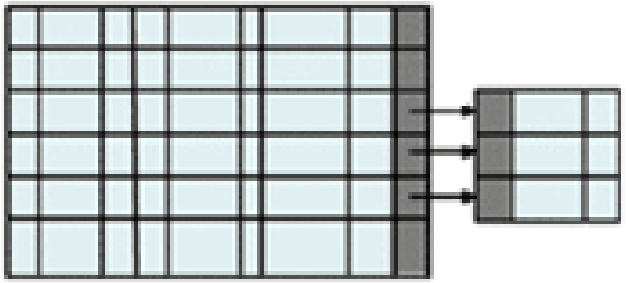
- Data Structure Paradigm
- Graphic Representation

Data Structure Paradigm

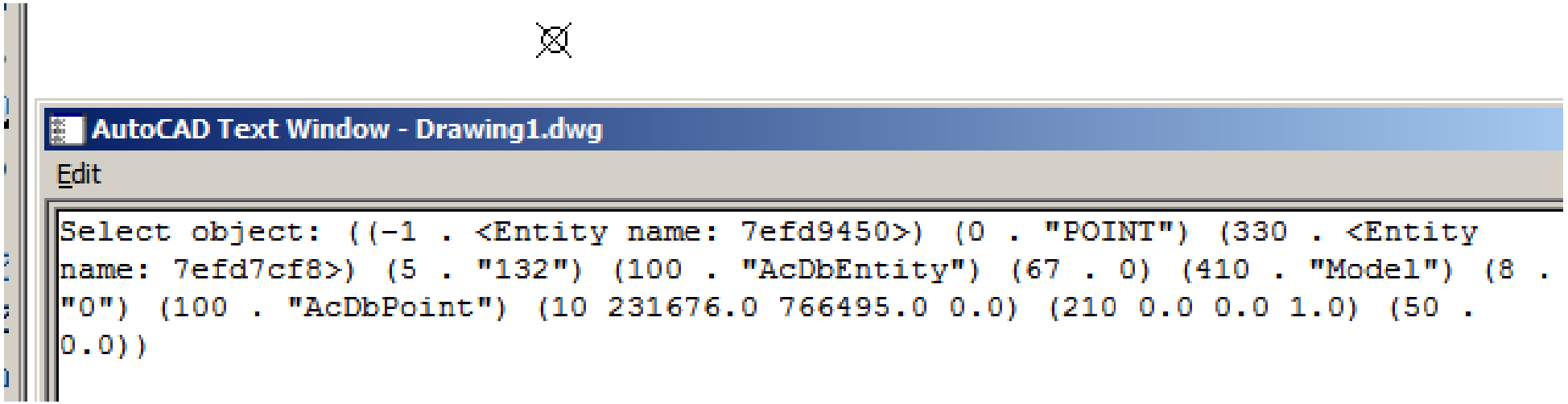
- AutoCAD stores data in a free form object oriented database where the fields in each row are defined by the entity type



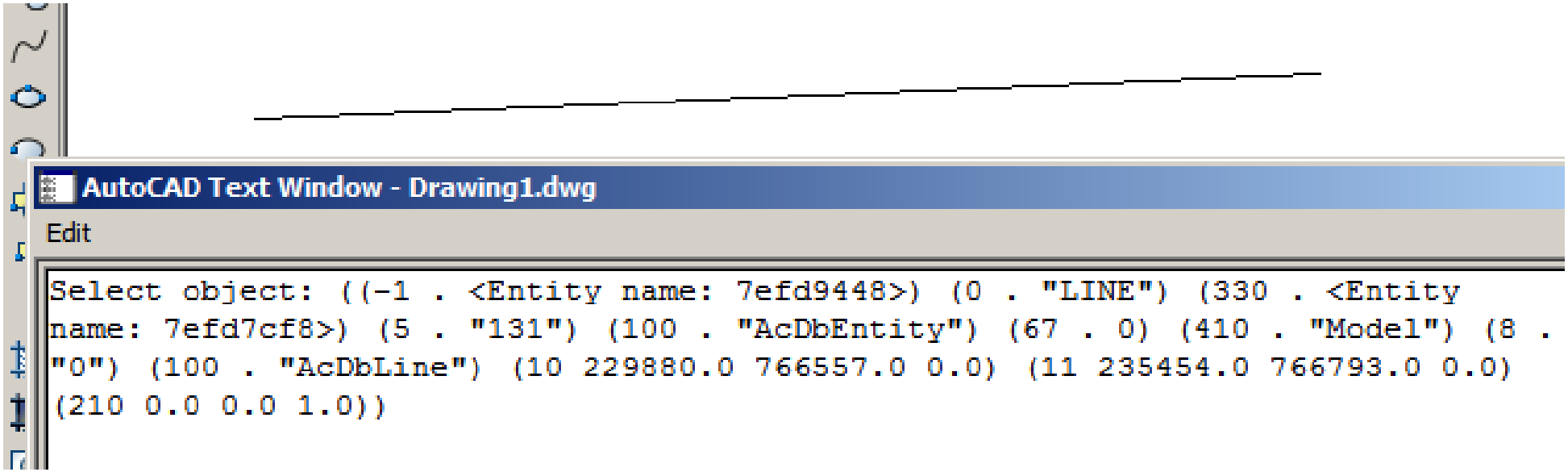
- ArcGIS stores data in predefined data structures where the fields are defined in each data type



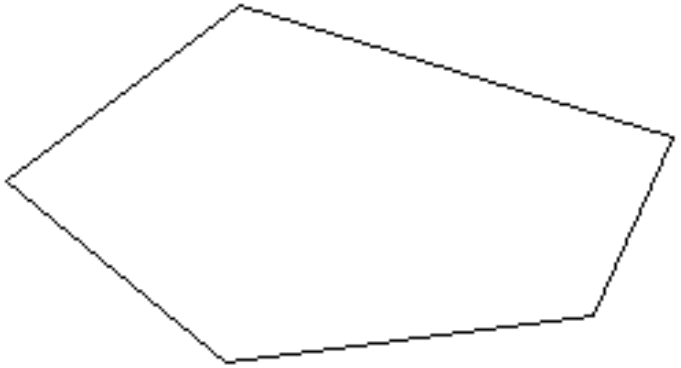
AutoCAD Points



AutoCAD Lines



AutoCAD Polygons

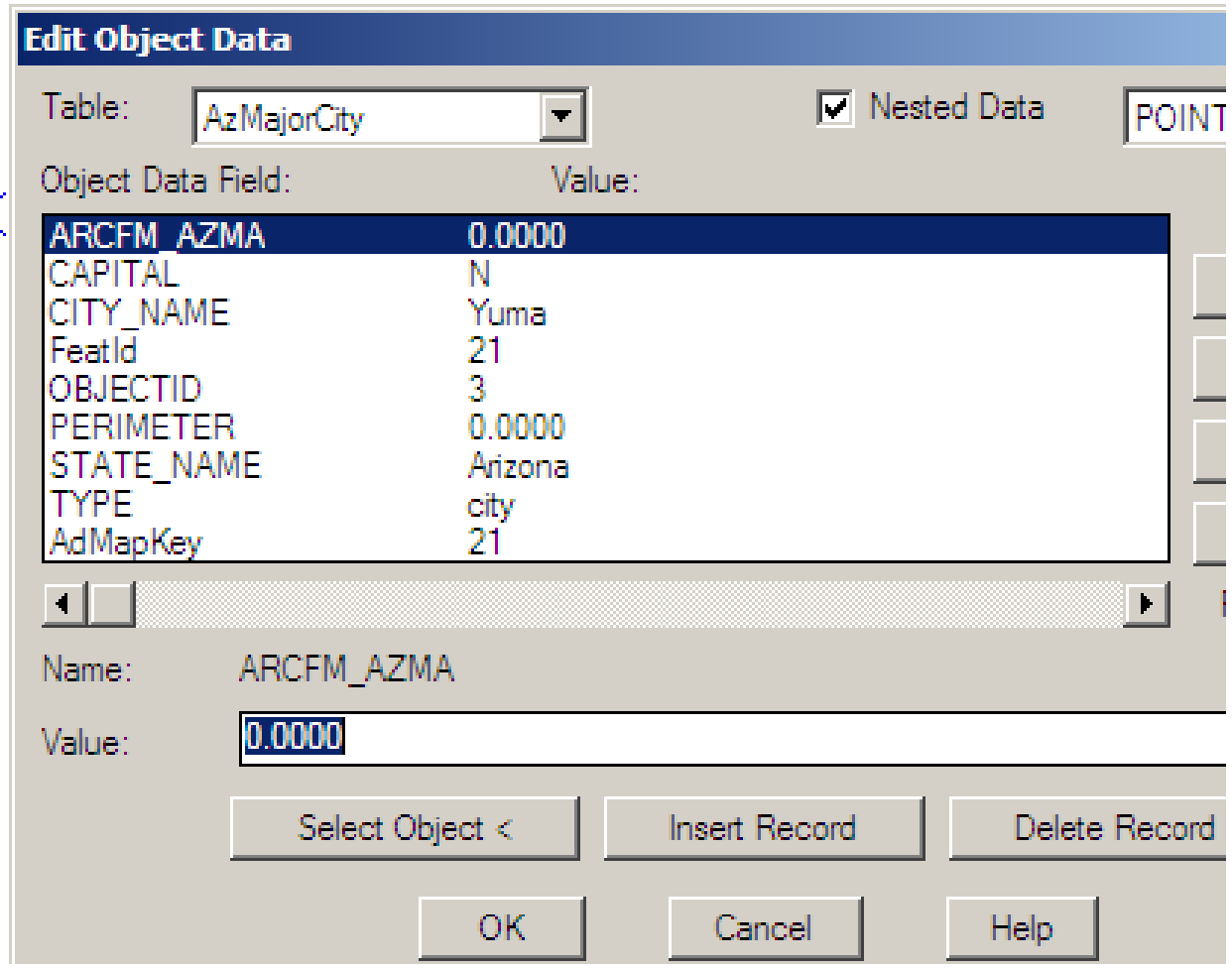


AutoCAD Text Window - Drawing1.dwg

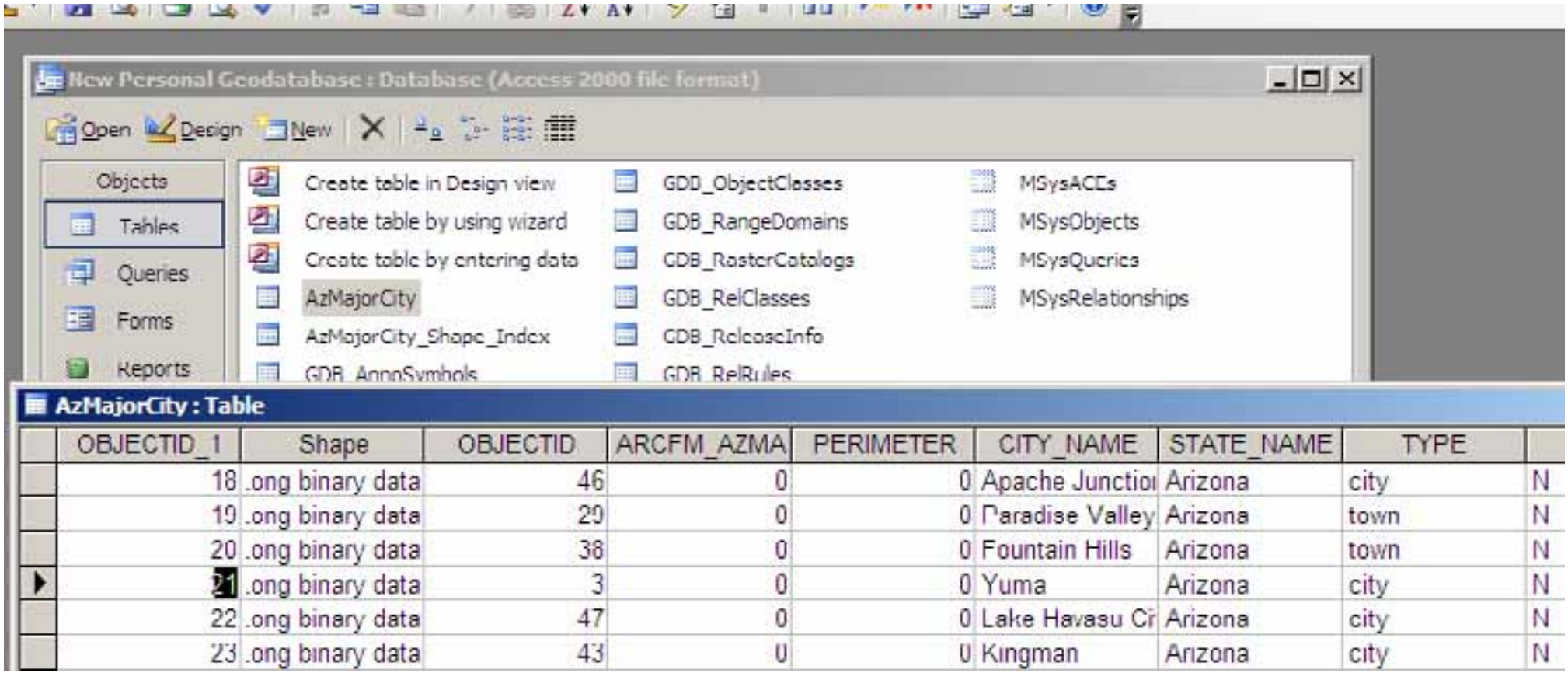
Edit

```
Select object: ((-1 . <Entity name: 7efd9458>) (0 . "LWPOLYLINE") (330 .
<Entity name: 7efd7cf8>) (5 . "133") (100 . "AcDbEntity") (67 . 0) (410 .
"Model") (8 . "0") (100 . "AcDbPolyline") (90 . 5) (70 . 1) (43 . 0.0) (38 .
0.0) (39 . 0.0) (10 231314.0 767603.0) (40 . 0.0) (41 . 0.0) (42 . 0.0) (10
230254.0 766806.0) (40 . 0.0) (41 . 0.0) (42 . 0.0) (10 231252.0 765984.0) (40
. 0.0) (41 . 0.0) (42 . 0.0) (10 232923.0 766196.0) (40 . 0.0) (41 . 0.0) (42 .
0.0) (10 233284.0 767005.0) (40 . 0.0) (41 . 0.0) (42 . 0.0) (210 0.0 0.0 1.0))
```

AutoCAD Point Data Set with Attributes



ArcGIS dataset



AzMajorCity : Table

OBJECTID_1	Shape	OBJECTID	ARCFM_AZMA	PERIMETER	CITY_NAME	STATE_NAME	TYPE	
18	.ong binary data	46	0	0	Apache Junctior	Arizona	city	N
19	.ong binary data	29	0	0	Paradise Valley	Arizona	town	N
20	.ong binary data	38	0	0	Fountain Hills	Arizona	town	N
21	.ong binary data	3	0	0	Yuma	Arizona	city	N
22	.ong binary data	47	0	0	Lake Havasu Ci	Arizona	city	N
23	.ong binary data	43	0	0	Kingman	Arizona	city	N

What this Means

- The means that AutoCAD will store multiple data types in a single DWG, while ArcGIS will store multiple data types in separate structures (tables or files)
  - Tables in Geodatabase
  - Sets of files for Shapes and other formats

Graphic Representation

- In AutoCAD, the graphic representation is stored on the object as part of the individual object definition
  - Redefining appearance can be time consuming
- In ArcGIS, the graphic representation is kept separate from the data and generated on the fly
  - Redefining appearance comes from changing the legend

What this means

- Sharing a DWG file provides an exact representation of the original graphic representation

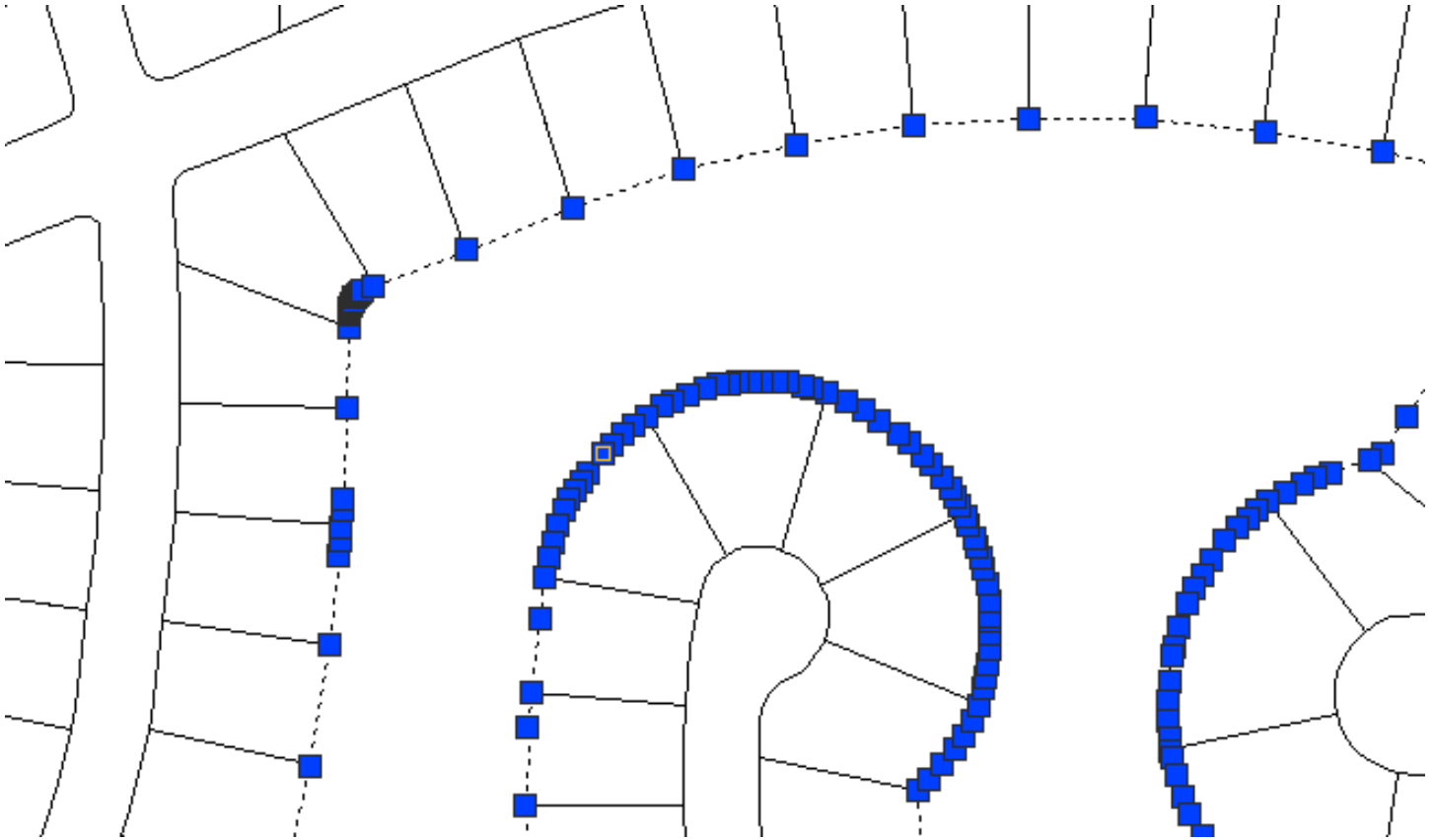
- Sharing a GIS data set will not provide an exact representation of the original graphic representation, without the ancillary support files

Not Good or Bad – Just Different

Other Differences

- Coordinate number data types
  - Floating point vs Long Integers
    - 32-bit
  - Single vs Double Precision
- Some differences in primitives
  - Annotation – feature linked as well as annotation objects
  - Curves – curve data isn't carried through some GIS data sets

Curves from a Shapefile



What's The Point

The physical transfer of data is a minor technical issue

- Most software vendors now provide excellent tools to transfer data back and forth
- Most will allow direct editing of other data formats

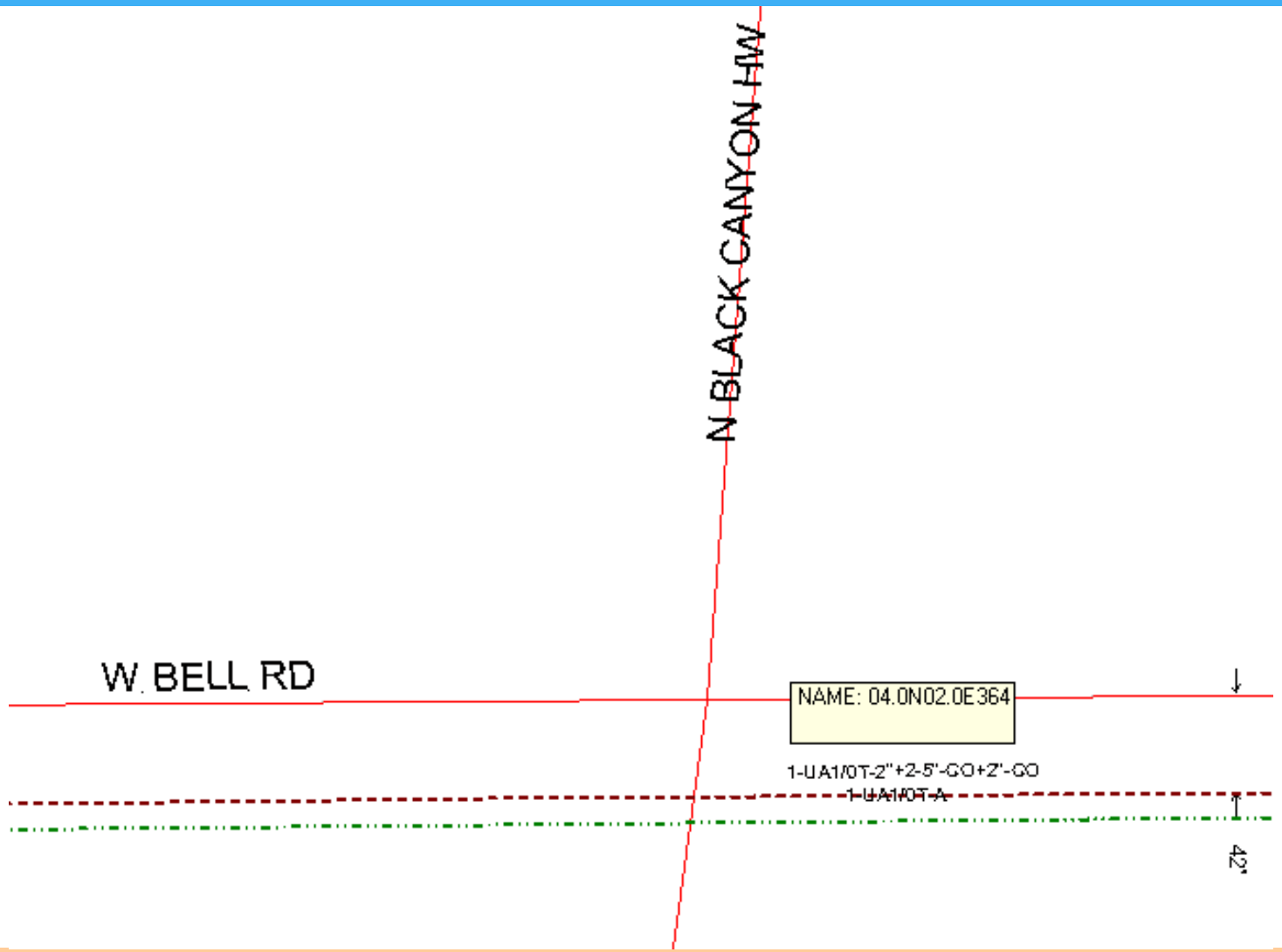
Third-Party Options

- Additionally, there are a number of third-party applications to further enable this interaction between systems
  - FME by Safe Software
  - GISConnect by Haestad Methods (Bentley)
  - Crossfire by EMS

So What's the Problem?

Design Representation

How it is seen in GIS



Integration Barriers

- The primary barriers to integration are data organization and business issues rather than technical issues
- The purposes of the data have a much larger impact than how the data is stored
- Understanding those issues can remove the barriers

Purpose of the Data

- The purpose of the data can have a profound impact on the data

- Across the facility management environment, there are a number of areas of the lifecycle, each with its own requirements

Commonality Across the Workflow

- Design and Facility Management are different activities that have unique requirements
- Identify the common requirements and you identify the targets of integration
- Then we can move to a real design to as-built data management process

Some of the Issues

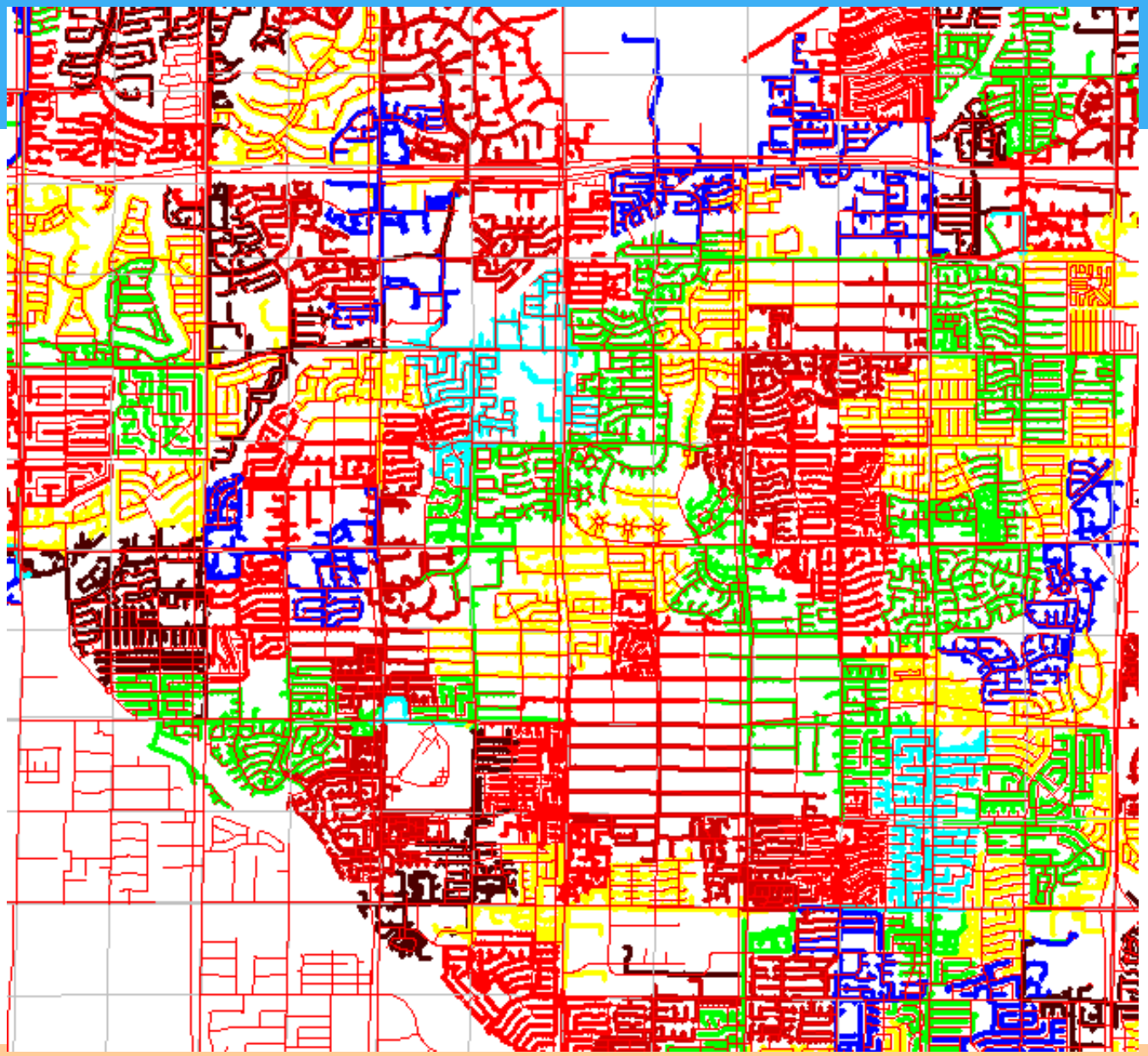
- Scale
- Precision
- Granularity
- Generalization
- Data Capture
- Cartographic Issues

Scale

- Different scales have different requirements
- Generally, design scales will be much larger than GIS map scales – Design scales get in the 1”=20’-50’ range, where system maps get much smaller, as in 1”=100’-400’

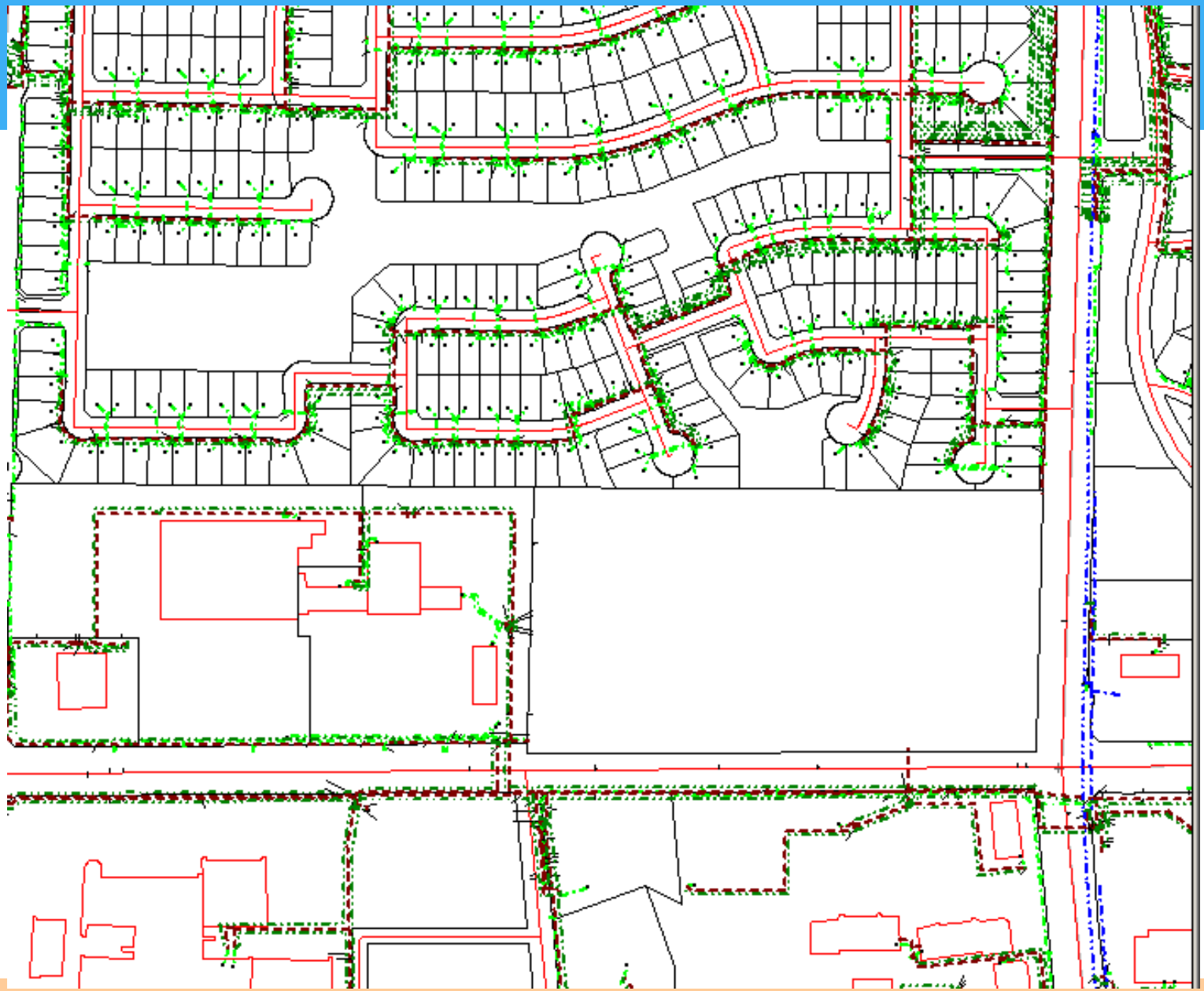
1”=5000’ Map Electrical System Map

It shows the road centerlines and the feeders



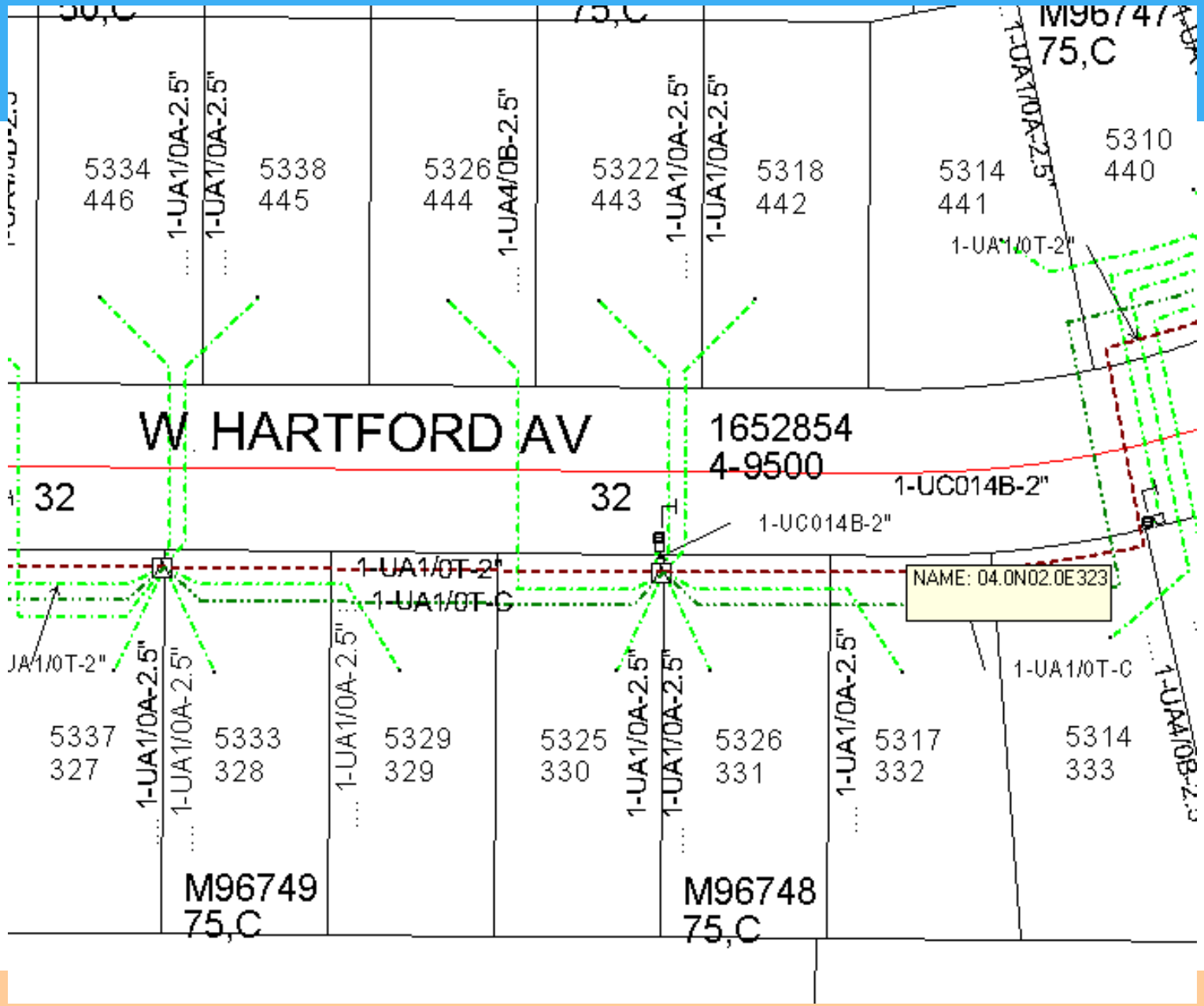
1”=500’ Distribution System Map

Shows parcels, buildings, primary, secondary and service lines



1”=50’ Distribution System Map

Shows addresses, individual services, line labels, individual runs



Precision - Critical Terminology

- Error
- Accuracy
- Precision

"You keep saying that word. I do not think it means what you think it means."

Photo Credit: http://www.mandypatinkin.net/PB/pb.html

Error

Measurement is an inexact science. There is error inherent in all measurement.

- Errors can exist due to mistakes
- Errors can exist due to methods and tools

Accuracy and Precision

"*Accuracy* - closeness of an estimated (e.g., measured or computed) value to a standard or accepted [true] value of a particular quantity."

FGDC-STD-007.1-1998

Precision - in statistics, a measure of the

tendency of a set of random numbers to cluster about a number determined by

the set.

FGDC-STD-007.1-1998

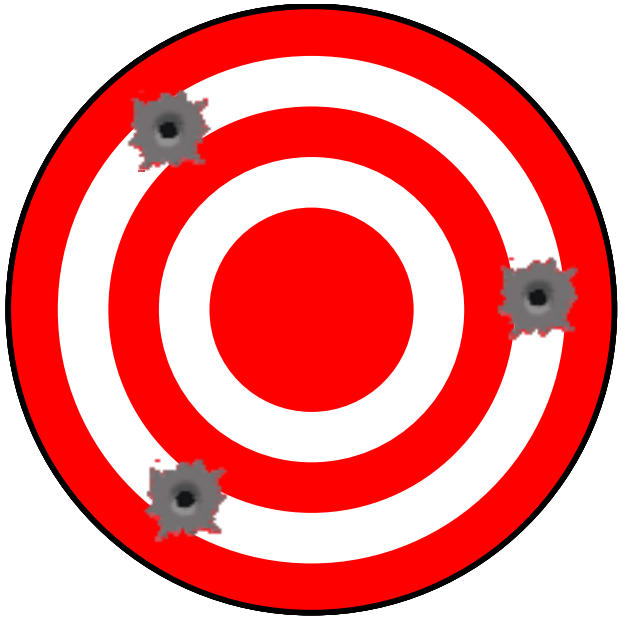
Photo credit: NOAA Collections

http://celebrating200years.noaa.gov/distance_tools/theb1670.html

Photo Credit: How to:

http://www.westone.wa.gov.au/toolbox6/hort6/html/resources/visitor_centre/how_to/measure.htm

Target Model of Data Quality

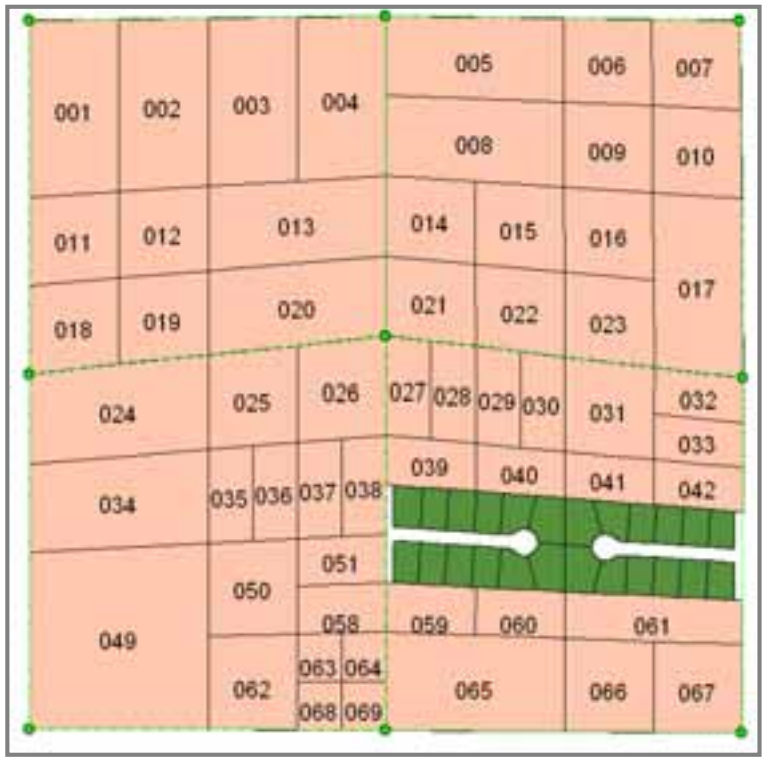


ACCURATE

PRECISE

ACCURATE & PRECISE

Data Sets at Different Levels of Precision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018 019 020 021 022 023
024 025 026 027 028 029 030 031 032 033
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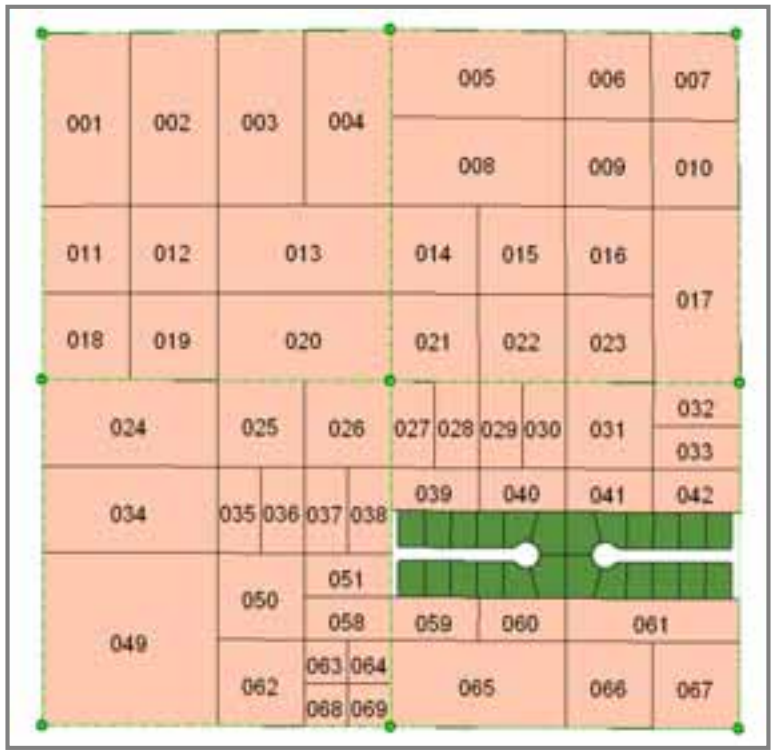
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062 063 064 065 066 067
068 069

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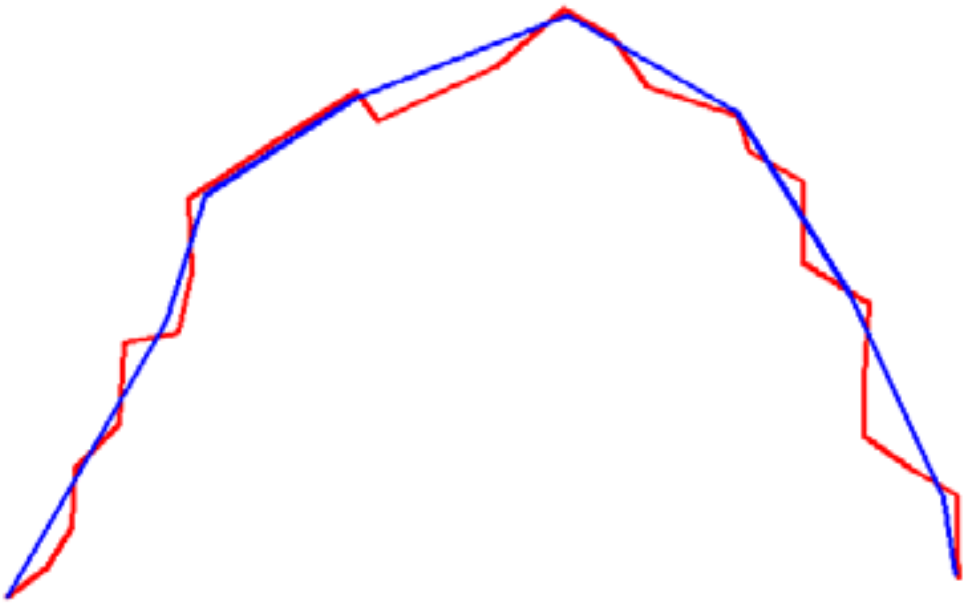
Precision and Accuracy

- Higher accuracy is more expensive
- Design requires a high degree of accuracy
  - Underground utilities
- Most new construction work will include a site survey of 3rd order (or close) to identify the existing conditions
- With a large land base, highly accurate data is likely too expensive to create and maintain

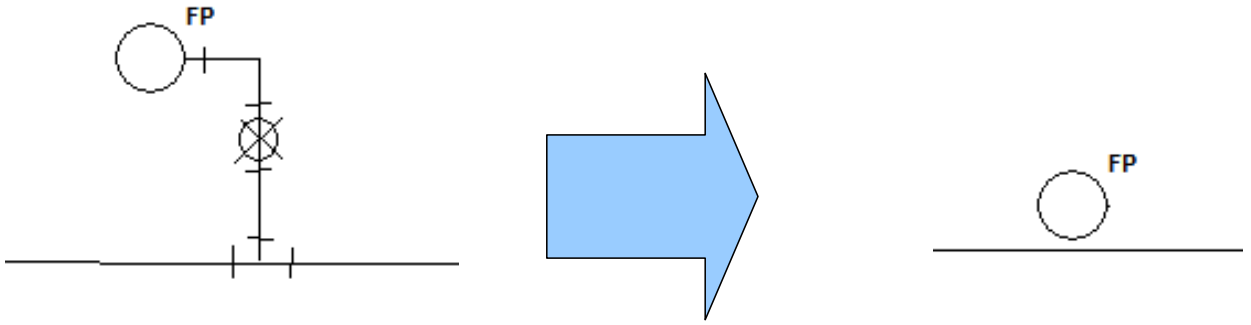
Generalization

- Reduce complexity by
  - Grouping of similar objects to simplify an image
  - Simplification of lines based on scale
  - Feature coalescence, selection and complexity reduction



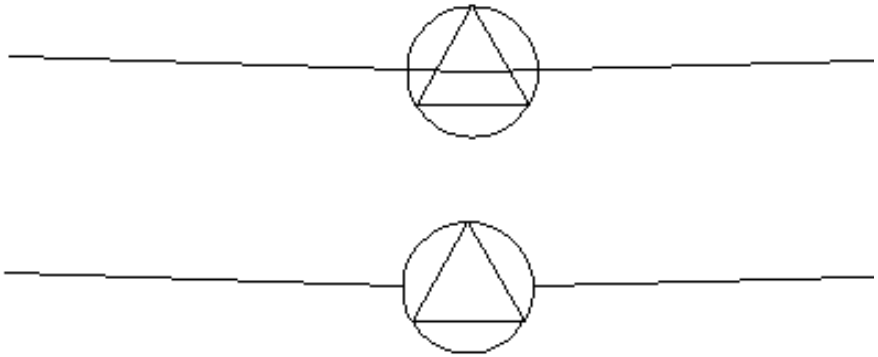
Granularity

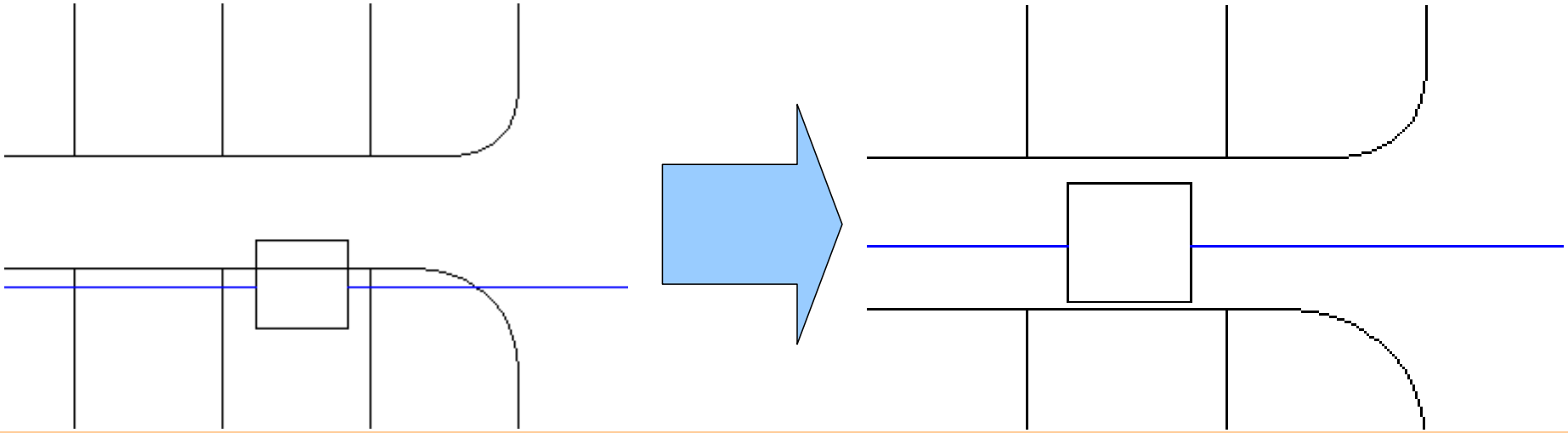
- Granularity is the grouping of dissimilar objects to represent a single feature
- Items that aren’t important to the operation of the system may be dropped from facility maps



Cartographic Issues

- Symbols
  - Blocks vs Fonts
  - Linetypes and masking
- Appearance – White Space





Putting It Together

- Determine what data can move through the work flow
- Understand how the pieces fit together
- Be willing to re-evaluate your processes
- Use the information to develop CAD standards that can make integration possible

Standards

- Freeform nature of AutoCAD allows great flexibility
  - the Sword of Damocles
- We can constrain CAD data to a similar organization as GIS through standards

Photo credit: Richard Westall, *The Sword of Damocles,* 1812 – Public Domain

http://www.ackland.org/tours/classes/westall-image.html

Areas of Standardization

- Layering
- Symbols (Block)
- Geometry
- Attributes

Layers

- In AutoCAD, layering is the most common method of segregating data
- In ArcGIS, feature classes and subtypes define the segregation of the data
- Match layers to feature classes and subtypes to segregate the data
- Use similar object types within each layer
  - ie. Lines with lines, points with points

Point Symbols

- Represent points in data set
- ArcGIS uses a font in the map document to create the symbol
- AutoCAD would use a block in the drawing
- Identify Font-Block Mappings during conversion

Geometry

- Maintain snapping through connected line features – use wipeouts to mask lines
- Insure intersections are broken within a single data set
- Use closed polygons to identify polygons

Attributes

- Use attributes to label items rather than text labels
- Use label blocks to attribute polygons and lines – after conversion, they can be spatially joined
  - By placing insert point on line, an intersection of the label points will join the attributes to the lines, and the actual text features can be placed anywhere
- One label block per element
- Consider using external database links and maintaining an ID as an attribute

Conclusion

By understanding the issues that really impact our processes, we can develop workflows that will allow us to take the most advantage of our data

Questions?

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