



THE SCIENCE OF MAPPING

Geographic Information Systems (GIS)

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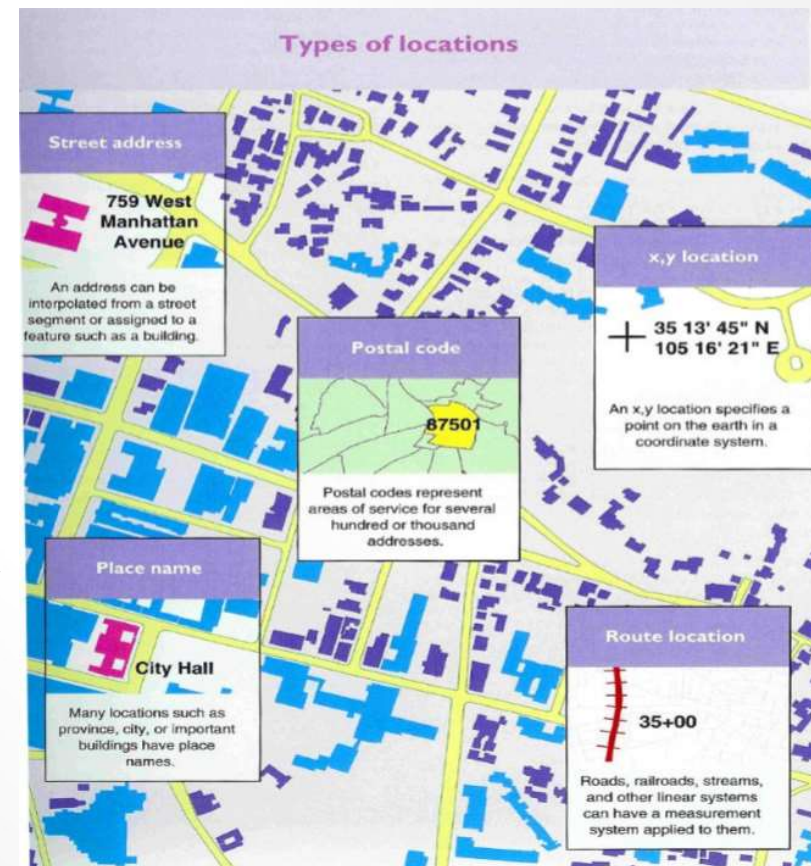
GEOGRAPHIC INFORMATION SYSTEMS

- Geographic Information Systems (GIS) is a collection of:
 - hardware, software, data and trained personnel
- Used to:
 - Store, manipulate, analyze and present information

GIS is the “Science of Where”

The key is linking data to location →

Estimated that 80% of all data has a spatial component



THE SCIENCE OF MAPPING REQUIRES CRITICAL SPATIAL THINKING

Critical Spatial Thinking:

“...using spatial data to understand problems, derive solutions and communicate effectively...”

“Many of the issues and situations addressed with a GIS do not have one single correct solution but may have explanations and better choices that can be informed by critical spatial thinking and abductive reasoning.”

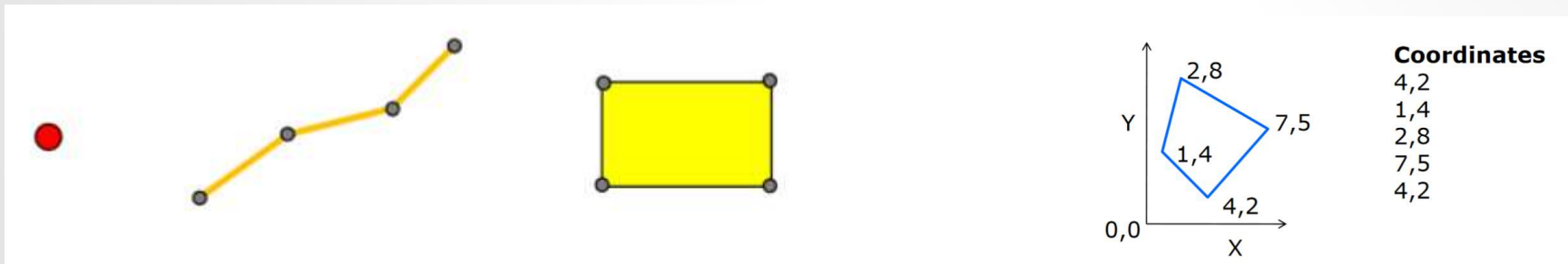
- Merely displaying spatially coincident datasets may yield incorrect assumptions regarding relationships. Most maps require some explanation.



(Source: Stinton et al. 2013)

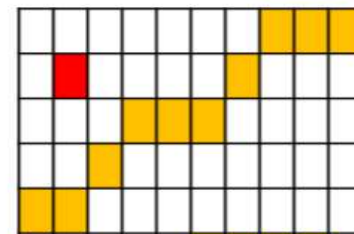
ESSENTIALLY ALL MAPS ARE JUST:

Points, **Lines** and **Polygons** stored and represented by coordinates



- **Points** are single coordinate pairs,
- **Lines** are ordered sets of coordinate Pairs
- **Polygons** are closed sets of lines (areas) that have interiors and share edges (adjacency) with other polygons.

Maps also employ backgrounds “cells” (such as pixels in an aerial photo) stored and represented by a grid.



GIS FEATURES HAVE ATTRIBUTES

- Attributes are stored as rows and columns in a table
- They define/describe a spatial feature (qualitative or quantitative)
- Every row corresponds to a point, line or polygon feature

Point example: Census individuals

The screenshot shows the ArcMap interface with a map of census points. A table of attributes is displayed below the map, showing columns for various demographic and geographic variables.

Address	Street	Last Name	First Name	Relation	Property	Home Value	Race	Sex	Age	Marital	Age at Marriage	Attended School	Literacy	Birthplace	Birth Father	Birth Mother	Language	Immigration	Naturalization	English	OC	
1100	Scamerson Street	Sukunda	Adnan	Head	Owned	1900	No	Male	30	1951	Married	24	Yes	Yugoslavia	Yugoslavia	Yugoslavia	Croatian	1912	Allen	Yes	Crime Ct	
1100	Scamerson Street	Sukunda	Latida	Wife	-	-	-	Female	36	1914	Married	19	No	Yes	Yugoslavia	Yugoslavia	Slovenian	1912	Allen	Yes	-	
1100	Scamerson Street	Kenic	Bozidar	Head	-	-	-	Male	41	1909	Single	-	No	Yes	Yugoslavia	Yugoslavia	Croatian	1905	Allen	Yes	Crime Ct	
1100	Scamerson Street	Henrich	Heck	Roomer	-	-	-	Male	19	1911	Married	17	No	Yes	Pennsylvania	Yugoslavia	Yugoslavia	Croatian	-	Male	Yes	Red Gang
1100	Scamerson Street	Henrich	Anna	Roomer	-	-	-	Female	21	1909	Married	19	No	Yes	Yugoslavia	Yugoslavia	Croatian	1930	Allen	Yes	Examiner	
1100	Scamerson Street	Ograsewich	Stojan	Roomer	-	-	-	Male	40	1900	Single	-	Yes	Yugoslavia	Yugoslavia	Yugoslavia	Croatian	1900	Free Papers	Yes	Industrial	
1102	Scamerson Street	Cresden	Louis A	Head	Owned	5500	No	Male	33	1907	Married	22	No	Yes	Pennsylvania	Pennsylvania	Pennsylvania	-	-	-	Yes	Photoeng
1102	Scamerson Street	Cresden	Margaret A	Wife	-	-	-	Female	32	1898	Married	20	No	Yes	Pennsylvania	Ireland	-	-	-	-	Yes	-
1102	Scamerson Street	Cresden	Josephine H	Daughter	-	-	-	Female	11	1919	Single	-	Yes	Pennsylvania	Pennsylvania	Pennsylvania	-	-	-	-	Yes	-
1102	Scamerson Street	Cresden	Louis A	Son	-	-	-	Male	9	1921	Single	-	Yes	Pennsylvania	Pennsylvania	Pennsylvania	-	-	-	-	Yes	-
1102	Scamerson Street	Cresden	Rita Ann	Daughter	-	-	-	Female	5	1925	Single	-	-	-	Pennsylvania	Pennsylvania	Pennsylvania	-	-	-	-	-
1102	Scamerson Street	Cresden	Paul J	Son	-	-	-	Male	0	1930	Single	-	-	-	Pennsylvania	Pennsylvania	Pennsylvania	-	-	-	-	-
1104	Scamerson Street	Egrasheitz	John	Head	Owned	5500	No	Male	36	1892	Married	23	No	Yes	Austria	Austria	Austria	Slovak	1912	Allen	Yes	Laborer
1104	Scamerson Street	Egrasheitz	Theresa	Wife	-	-	-	Female	36	1894	Married	21	No	Yes	Austria	Austria	Austria	Slovak	1912	Allen	Yes	-
1104	Scamerson Street	Egrasheitz	Joseph	Son	-	-	-	Male	12	1918	Single	-	-	Yes	Pennsylvania	Austria	Austria	-	-	-	Yes	-
1104	Scamerson Street	Egrasheitz	Frank	Son	-	-	-	Male	11	1919	Single	-	Yes	Pennsylvania	Austria	Austria	-	-	-	-	Yes	-

Polygon example: Census block groups

The screenshot shows the District Builder application interface. A map of Pittsburgh is displayed with census block groups highlighted in various colors. A table of district data is shown on the left, and a legend for block groups is on the right.

Districts	Number	Population	Deviation	Race	Comp.
0	10,721,496	+10,721,496			
1	526,256	-179,432	24%		
2	707,618	+1,930	39%		
3	747,009	+41,321	26%		
4	0	-705,688			
5	0	-705,688			
6	0	-705,688			
7	0	-705,688			
8	0	-705,688			
9	0	-705,688			
10	0	-705,688			
11	0	-705,688			
12	0	-705,688			
13	0	-705,688			
14	0	-705,688			
15	0	-705,688			

Blockgroup #6580
 Pop. 362
 White 87%
 Black 9%
 Asian 4%
 Hispanic 4%
 Other 2%

Source: <https://app.districtbuilder.org>

TYPES OF GIS SPATIAL ANALYSIS

- **Understanding where** ...boundaries between and/or around demographic groups
- **Measuring size, shape and distribution** ...of population contained within polygons
- **Determining how places are related** ...boundaries aligned with census demographic data
- **Finding the best locations and paths** ...route to voting location
- **Detecting and quantifying patterns** ...of voter turnout or population changes
- **Making Predictions** ...based on past location data

A GIS works with thematic layers of spatial data



Answer questions by comparing different layers of data

Types of spatial questions:

Which peaks are **near** trails?



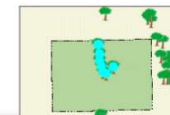
Which highways **intersect** Highlands County?



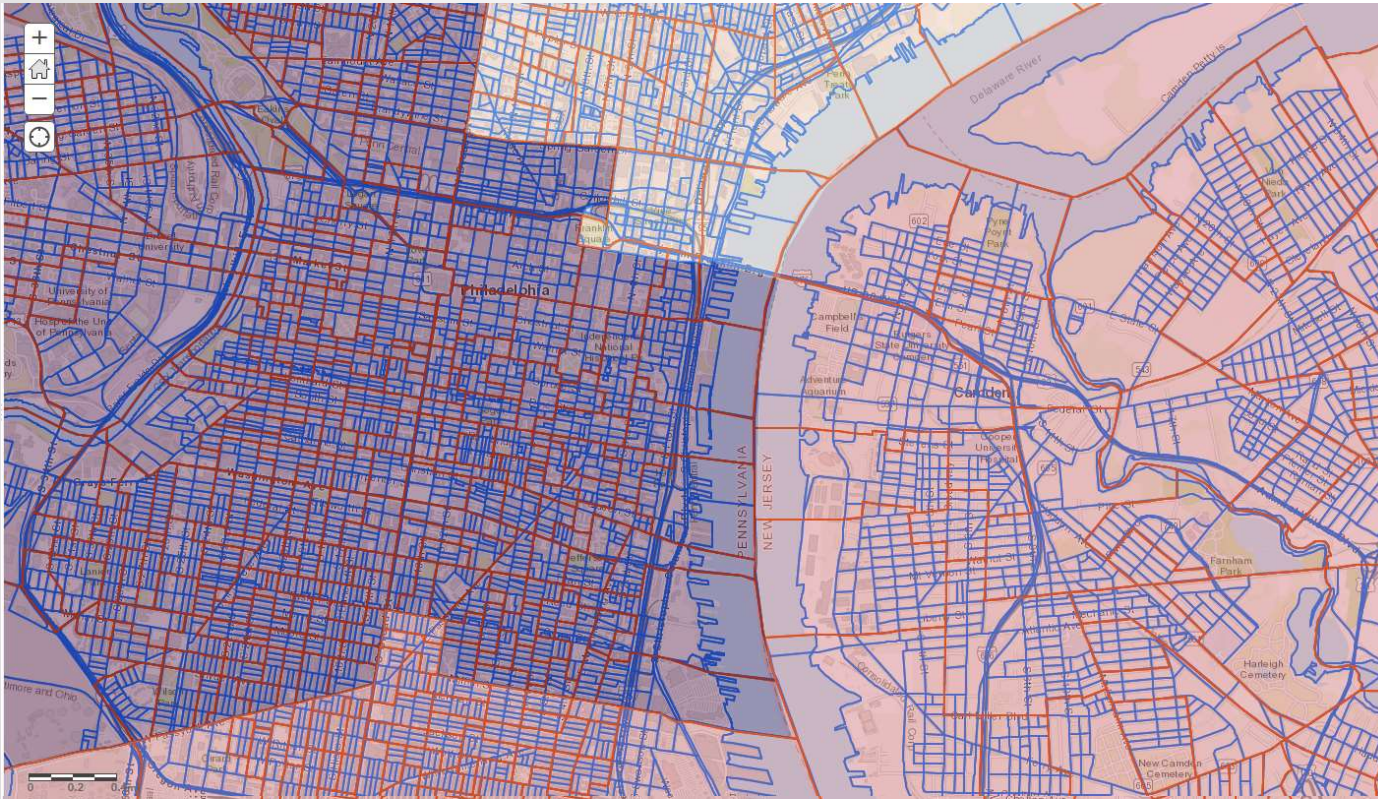
Which counties are **adjacent to** Highlands County?



Which trees are **inside** the park?



BOUNDARY AND POLYGON OVERLAP



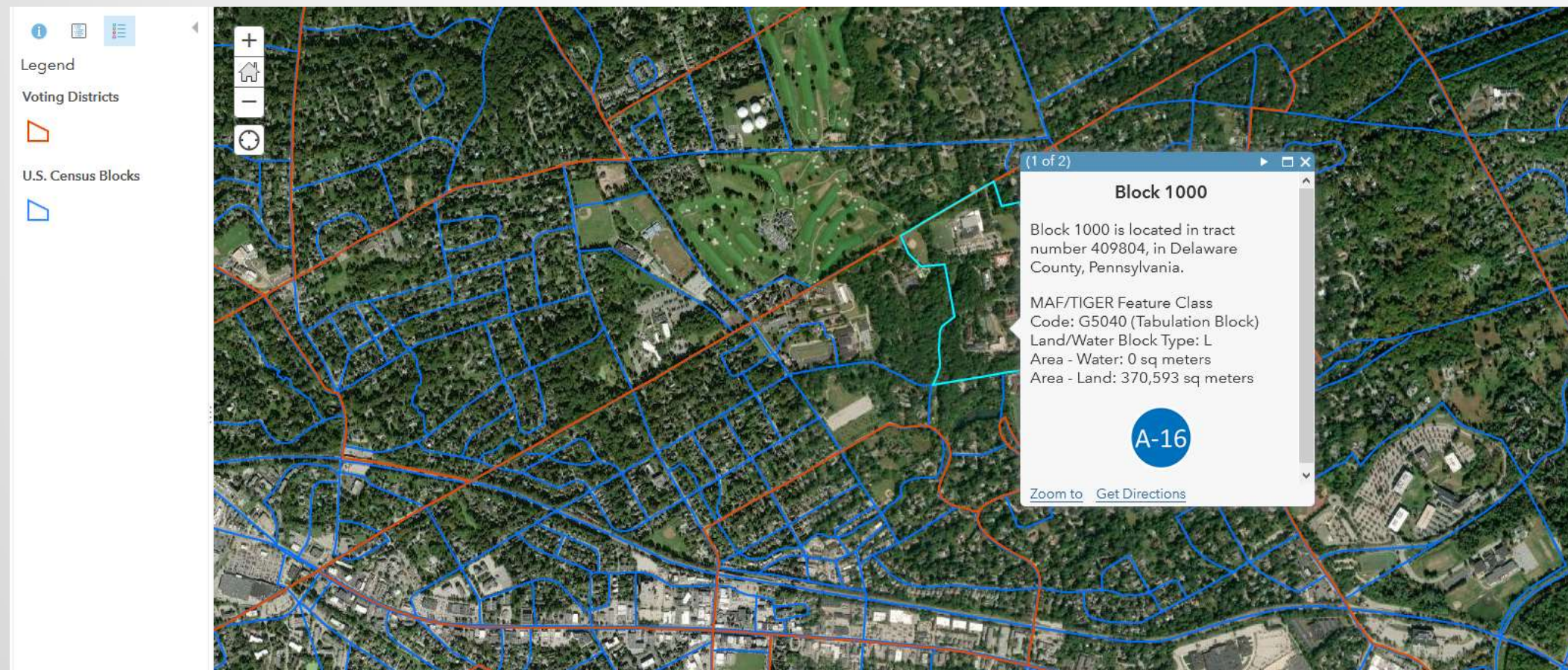
How many census block groups (blue), and their combined population are contained within a voting district (red)?

Every adjustment to a voting district boundary alters the demographic composition of the new **AND ADJACENT** voting district polygons.

Polygon shape and attribute accuracy is crucial! Job for GIS!

OVERLYING POLYGONS – AGGREGATED POPULATION

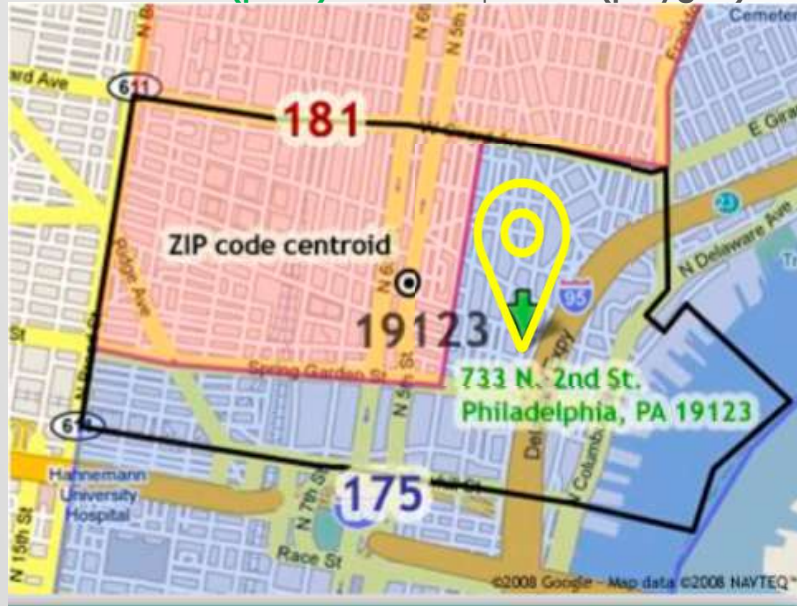
CHANGING AN OVERLYING POLYGON ALTERS THE NUMBER UNDERLYING POLYGONS



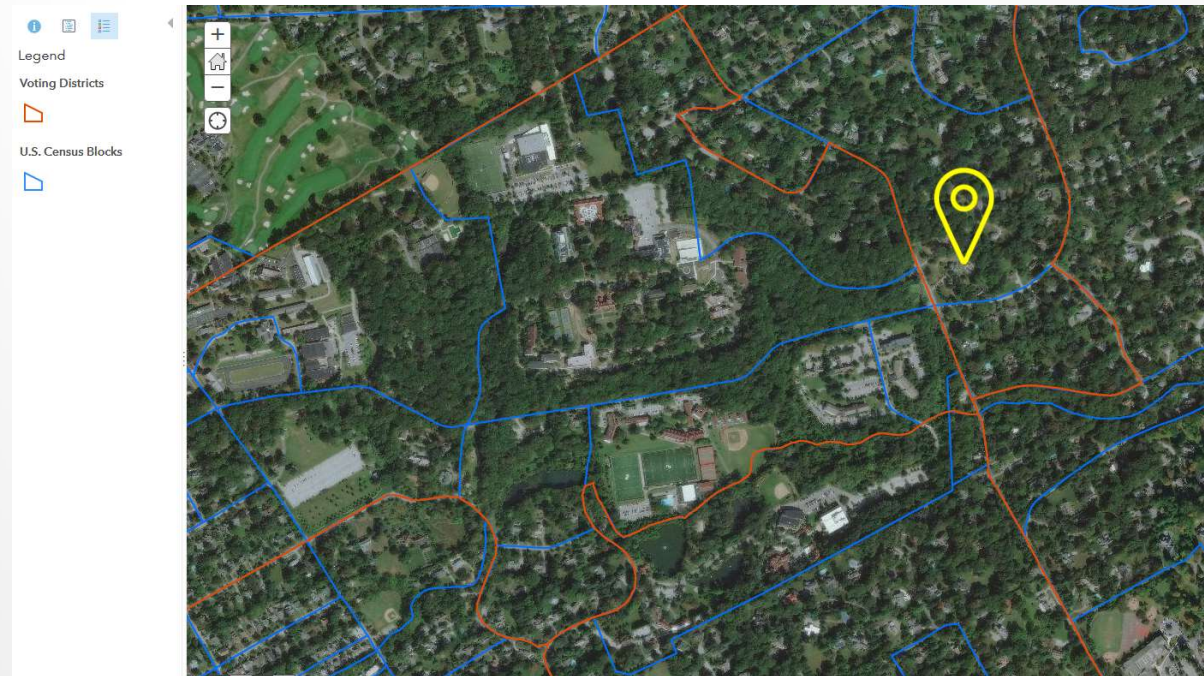
VOTER LOCATION ACCURACY (GEOCODING)

Geocoding in GIS is the process of associating an x,y coordinate to a geographic feature such as an address.

Street address (**point**) within a zip code (**polygon**)



Ensures accurate placement of voters within districts

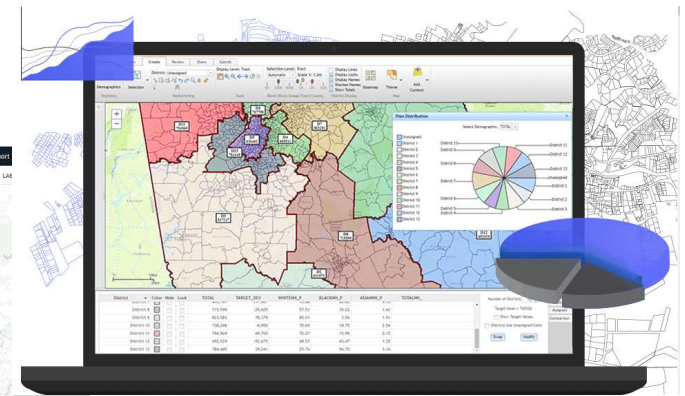
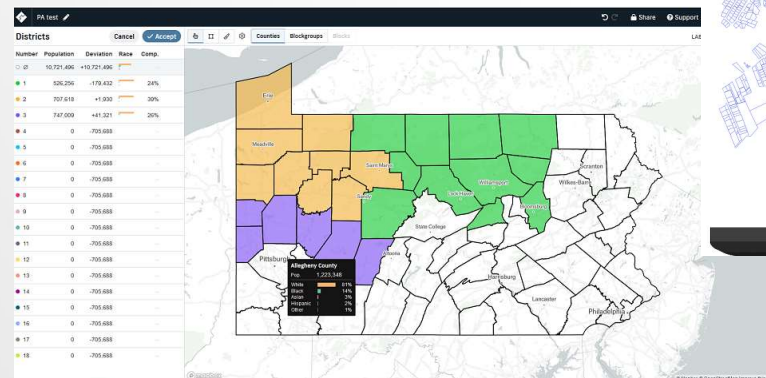


RESOURCES FOR GIS AND ELECTIONS

- [National States Geographic Information Council](#)
 - Best practices for **Geo-enabling elections**
- [Federal Geographic Data Committee](#)
 - Geospatial Data Act of 2018 – supports development of **consistent and authoritative** spatial data
 - National Spatial Data Infrastructure (NSDI)
 - **Define standards** for spatial data themes



- Software Tools
 - ArcGIS, ESRI Redistricting, District Builder, etc



GEO-ENABLED ELECTIONS

NATIONAL STATES GEOGRAPHIC INFORMATION COUNCIL (NSGIC)

GIS HELPS TO:

AVOID LOCATION ERRORS

ELECTION ERRORS CAN LEAD TO LENGTHY LEGAL PROCESSES AND COSTLY DO-OVERS. MODERN GIS TECHNOLOGY TRANSFORMS VOTER LISTS INTO GEOSPATIAL PINPOINTS AND ENSURES THAT VOTERS AND CANDIDATES ARE PLACED IN THE RIGHT PRECINCT.

SAVE TIME AND WORK EFFORT

GEOSPATIAL DATA MADE VISUAL ON A MAP ARE MUCH EASIER TO CHECK FOR ACCURACY THAN LENGTHY VOTER ADDRESS LISTS. SIMILARLY, ASSIGNING VOTERS TO A NEW VOTING DISTRICT AND CREATING PRECINCT DEFINITIONS CAN BE DONE IN MINUTES WITH GIS.

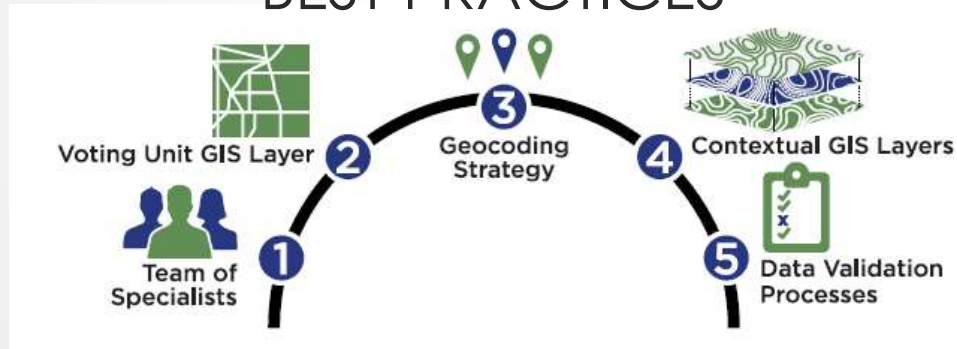
BOOST VOTER CONFIDENCE

WHEN FEWER ERRORS ARE REPORTED AFTER AN ELECTION, VOTERS' CONFIDENCE THAT THEIR VOICES ARE BEING HEARD INCREASES, AND THEIR FAITH IN THE DEMOCRATIC SYSTEM IS STRENGTHENED.



Source: <https://elections.nsgic.org/>

NSGIC – GEO-ENABLED ELECTIONS BEST PRACTICES



1. Convene a team of specialists

- Collaboration between leaders, information technology, database administrators and GIS professionals

2. Collect and sustain a statewide voting unit GIS Layer

- Comprehensive, authoritative, and accurate boundaries

3. Implement a statewide geocoding strategy

- Assign accurate coordinates to each residential address

4. Assemble best available contextual GIS layers

- Relevant, accurate, verified and accessible for boundary alignment

5. Define and implement data validation processes

- Create spatial auditing processes for precinct creation and assignment

SUMMARY

- GIS is a powerful tool to help make **accurate maps** so that the best, spatially-based, decisions can be made.
- For GIS to be useful it requires **accurate and well-maintained data**.
- GIS requires **trained users** who use **critical spatial thinking** to evaluate implications of **mapping decisions**.
- Many **resources exist** to support the spatial element of elections.

