Integrating Imagery
Remote Sensing for GIS Project Managers

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What is Remote Sensing?

- **The science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with it.**

- **Remote sensing is a tool - not an end in itself**

GENERALLY

- **Question on what the problem 'is' comes from detailed ground observation**

- **Remote sensing comes in at where, how much, and how severe the problem is.**

Considerations

- **Photograph scale is a function of terrain elevation - hence ortho-rectification needed**
- **Geometry - ground control**
- **Finer scales = higher costs & more photos**
- **Photo-interpreter - hard to maintain consistency**
  - Mental acuity + visual perception

Reference Data

GROUND TRUTH

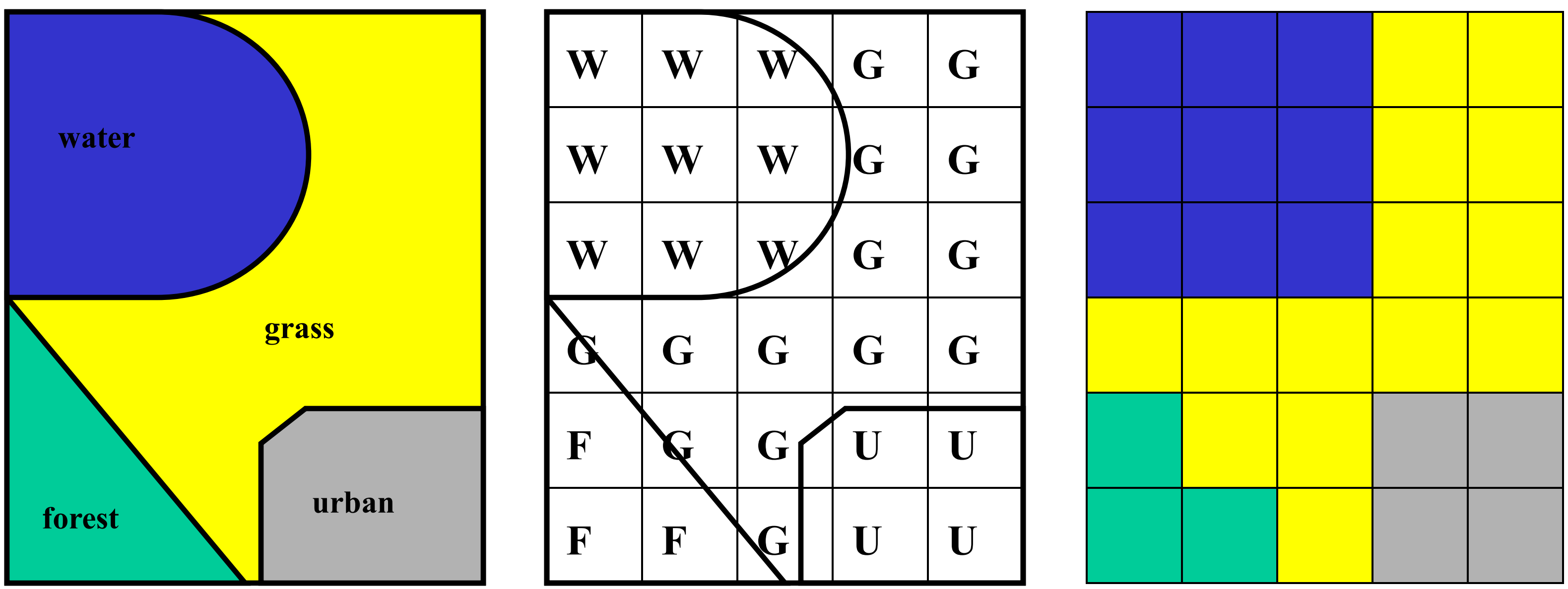
- **Collecting measurements or observations about the features being sensed**
- **Two types - time critical / time stable**
- **Three uses**
  - – Aid in analysis and interpretation of data
  - – Calibrate sensor
  - – Verify information extracted from image data

Raster Model

- **Divides the entire study area into a regular grid of cells in specific sequence**
  - The conventional sequence is row by row from the top left corner
  - Each cell (or picture element - PIXEL) contains a single value
  - Is space-filling since every location in the study area corresponds to a cell in the raster
  - One set of cells and associated values is a layer
    - There may be many layers in a database
    - Examples: soil type, elevation, land use, land cover
- **Tells what occurs everywhere - at each place in the area**

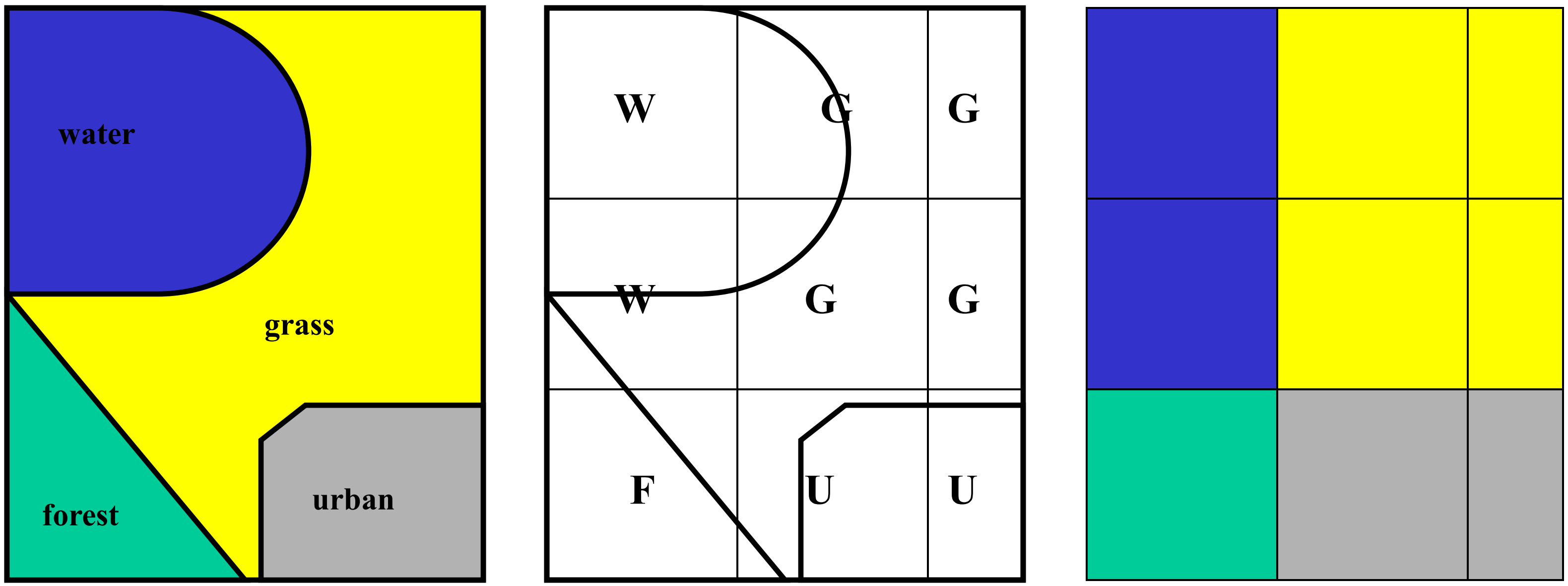
Creating a Raster

- **Consider laying a grid over a land cover map**
  - Create a raster by coding each cell with a value that represents the land cover type which appears in the majority of that cells area
  - When finished, every cell will have a coded value



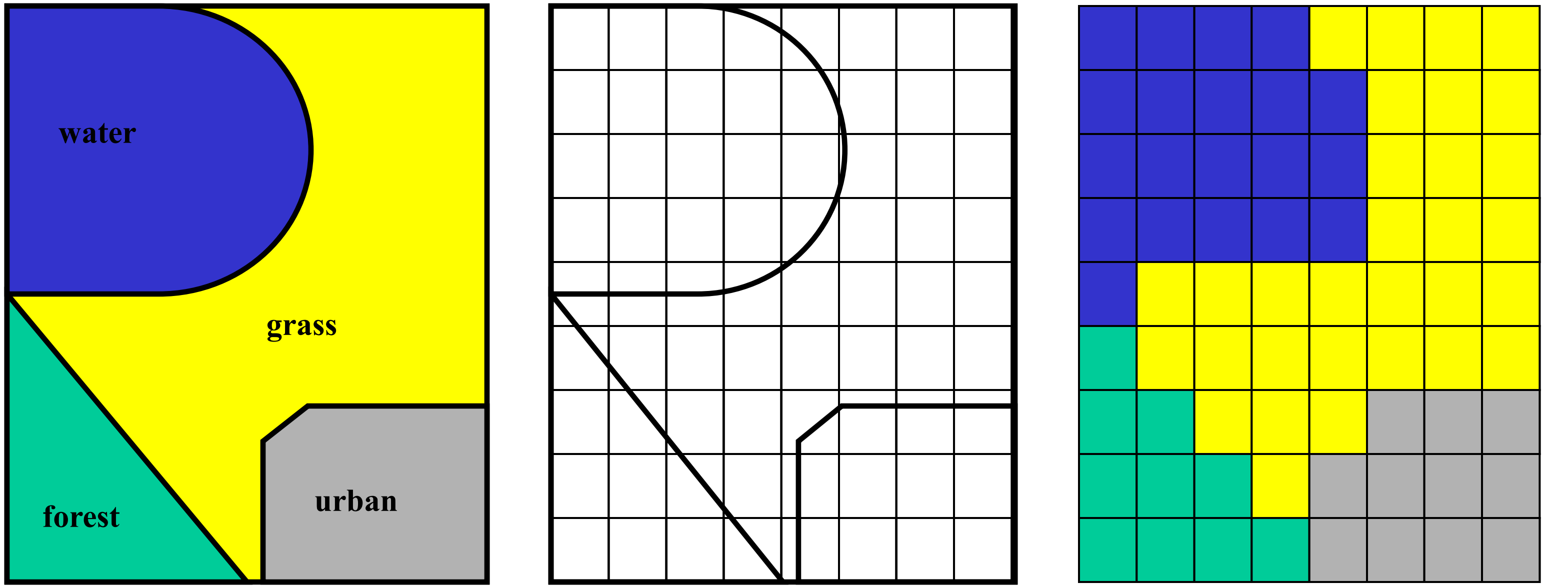
Influence of Spatial Resolution

- **Consider laying a coarser grid over our land cover map**
  - Problem of mixed pixels or cells
  - Implications when landscape is broken up into fine pieces

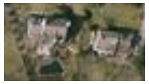


Influence of Spatial Resolution

- **Consider laying a finer grid over our land cover map**
  - Resolution needed to discriminate the smallest object to be mapped
  - Implications on file size and access times



Zoom Scale Change of a 1″=400′ Scale Features



Scale 1″=400′

Zoom Scale Change of a 1″=400′ Scale Features

Scale 1″=200′

Zoom Scale Change of a 1″=400′ Scale Features

Scale 1″=100′

Zoom Scale Change of a 1″=400′ Scale Features

Scale 1″=50′

Zooming an Image...

- **Does not Change the Accuracy**
- **Does not Change the Resolution**
- **You merely enlarge or reduce your view of the images original Pixels**

Having Said All that...

What IS the Impact of Resolution?

Same Scale Image Viewed with Different Resolutions...

Resolution 0.5′/pixel

Scale 1″=50′

Resolution 1′/pixel

Scale 1″=50′

Resolution 2′/pixel

Scale 1″=50′

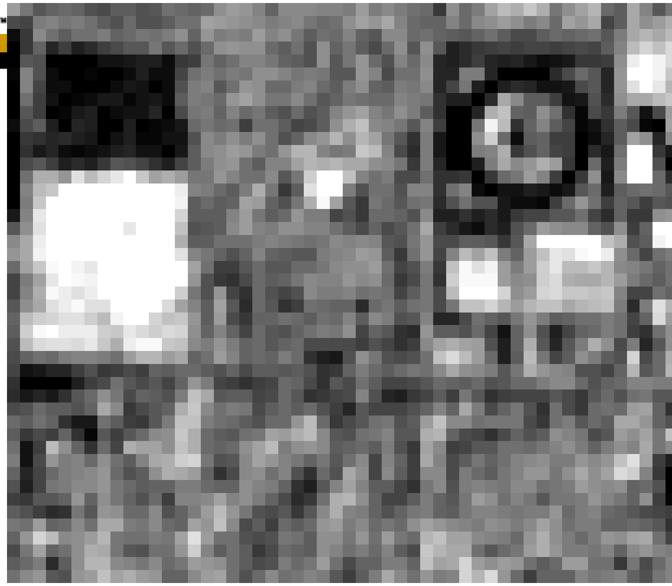
Resolution 4′/pixel

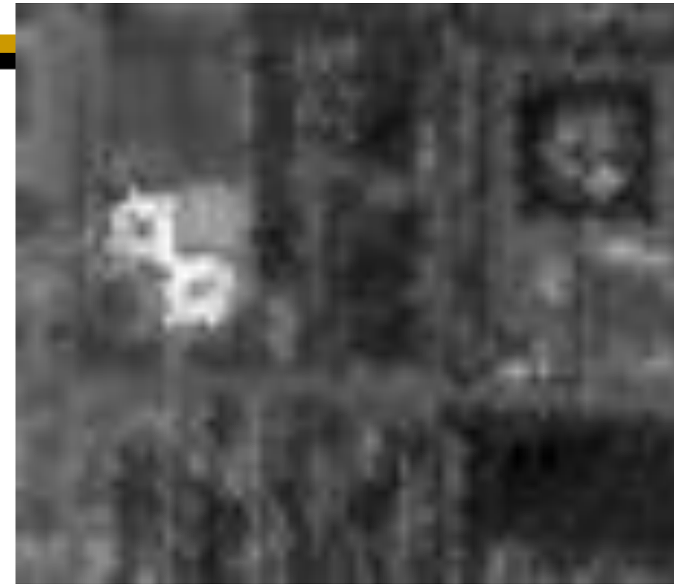
Scale 1″=50′

Impact of Resolution

- **Spatial resolution at which the imagery is actually acquired plays a key role in determining what you can use this imagery for.**
- **You can zoom in all you want but it can not change the resolution at which it was acquired!**

Landsat 7
ETM+
15 m

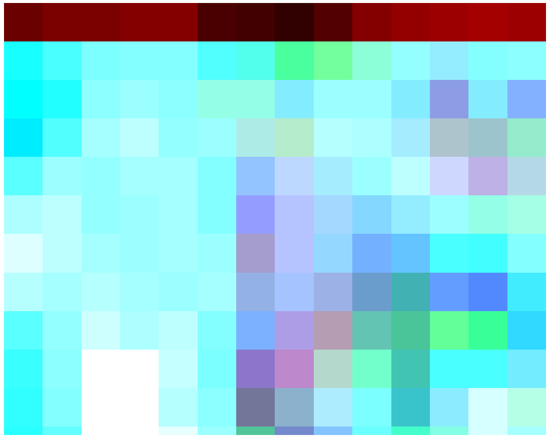




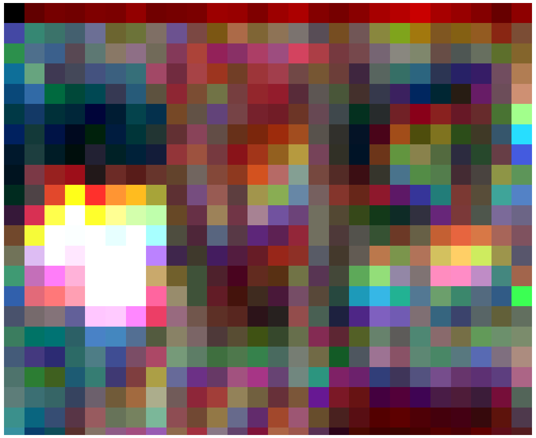
SPOT 10
m

Indian
Remote
Sensing
(IRS)
5 m

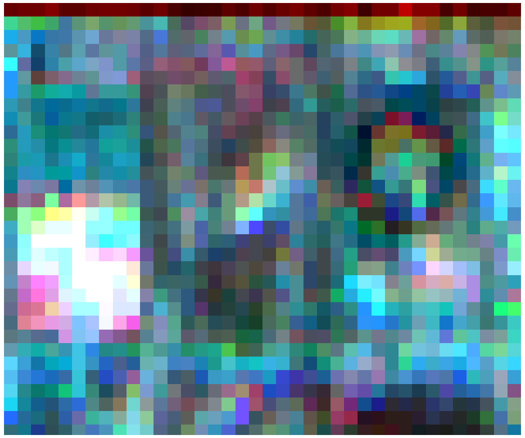
IKONOS
1 m



Landsat MSS
60 m



Landsat ETM +
30 m



Indian Remote Sensing
20 m

IKONOS
4 m

Positive Systems
0.7 m

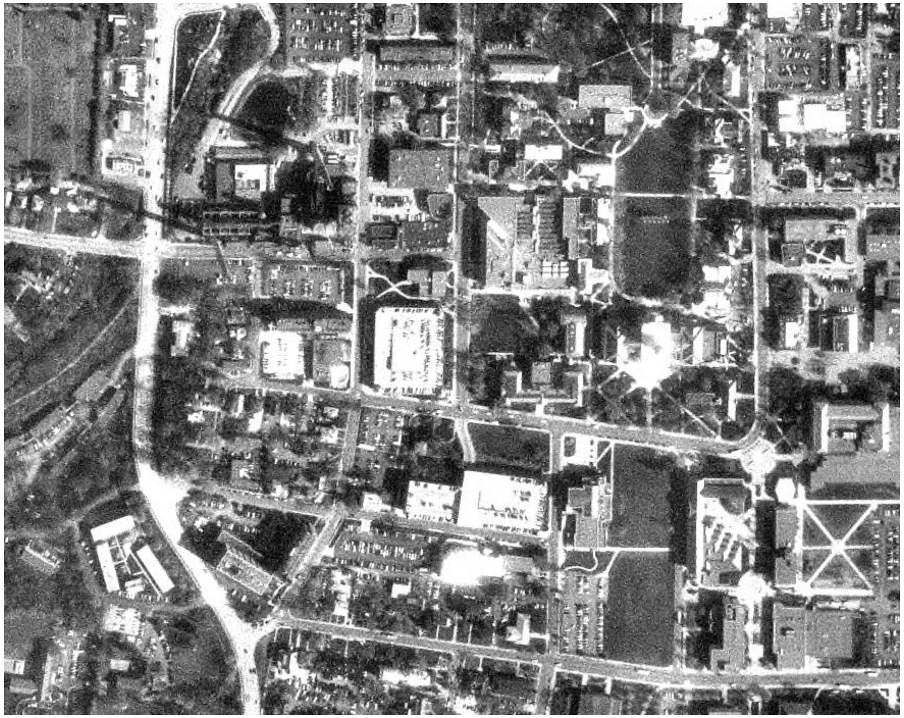
Other Resolution Concepts

- **Spatial**
  - Smallest resolution element
  - Areal coverage
- **Radiometric**
  - Number of brightness values detected
- **Spectral**
  - Number of bands
  - Bandwidth
  - Location of bands within the spectrum
- **Temporal**
  - Frequency of revisit
  - Time of day

IKONOS 1M Pan vs DOQQ 1M Radiometric Resolution Comparison

IKONOS

DOQQ



1 meter Pan image

4 meter Multi-spectral image

Data Fusion: Pan and MS

Sidewalks in pan image

Imagery as a Central Data Source

- In the past, imagery and spatial data was often separate

GIS Guys

vs.

Image Processing & Photogrammetry Guys

- Recent developments in technology have moved these much closer and they will increasingly be closer.

Trends in Remote Sensing Systems

- **Continuity of established programs (Landsat, SPOT)**
- **Higher spatial resolution**
- **Wide-field monitoring sensors**
- **Hyperspectral sensors (dozens to hundreds of bands)**
- **Radar and Lidar**
- **More commercial systems**

What is Needed to Estimate Project Costs?

Estimates of Project Area in Square Miles

Estimates of Image Costs per Square Mile

A Set of Business-based Assumptions

Image Specifications

Mixing Alternate Scales

- **You can reduce the project costs by changing the projects scale requirements or by mixing scales.**
- **This concept matches the appropriate scale to a corresponding subject area.**

Basic Issues to Integration

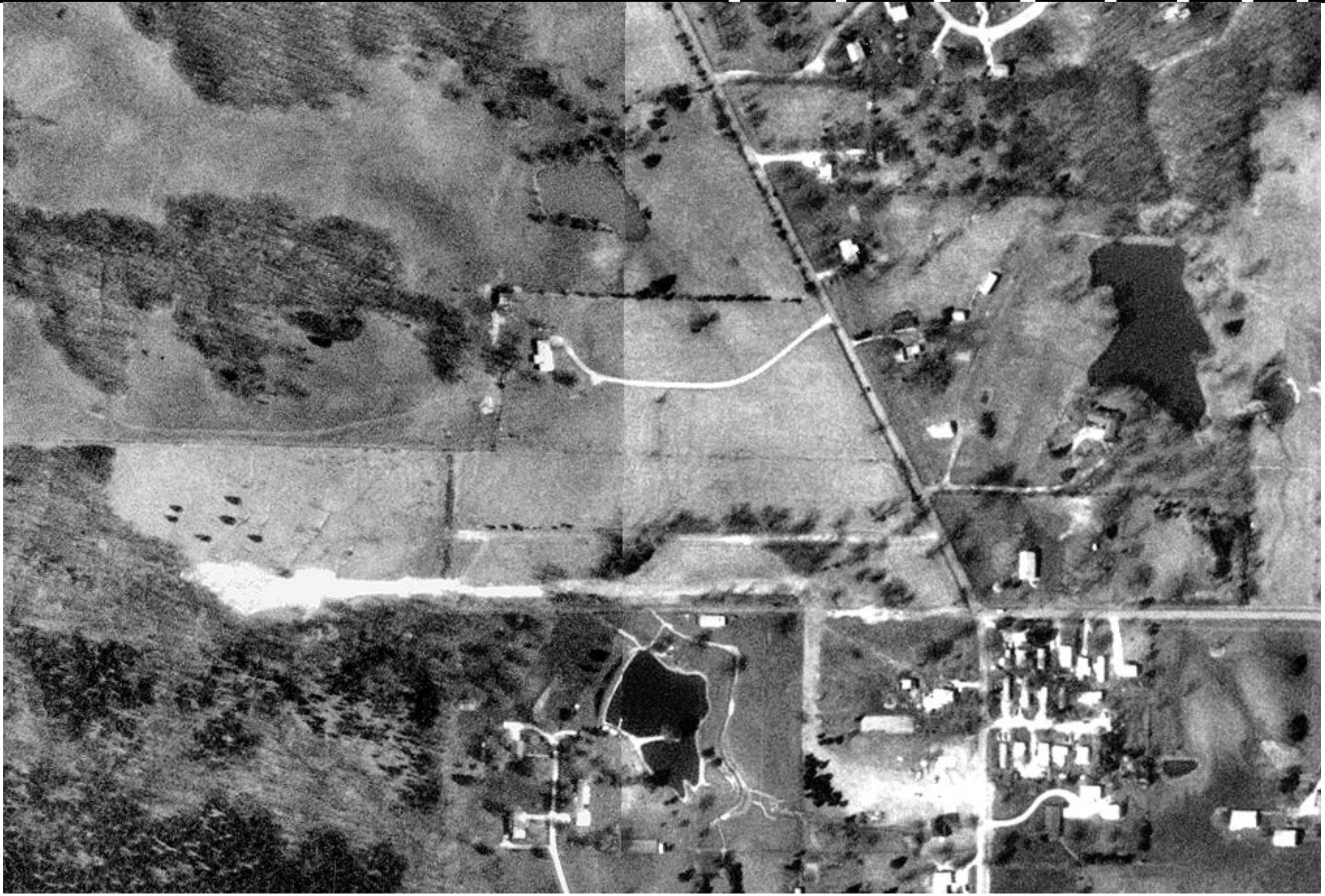
- **What follows in the next few slides are examples of simple imagery integration issues that the GIS Project Manager will face.**

DOQQ 1M
Shift Differential

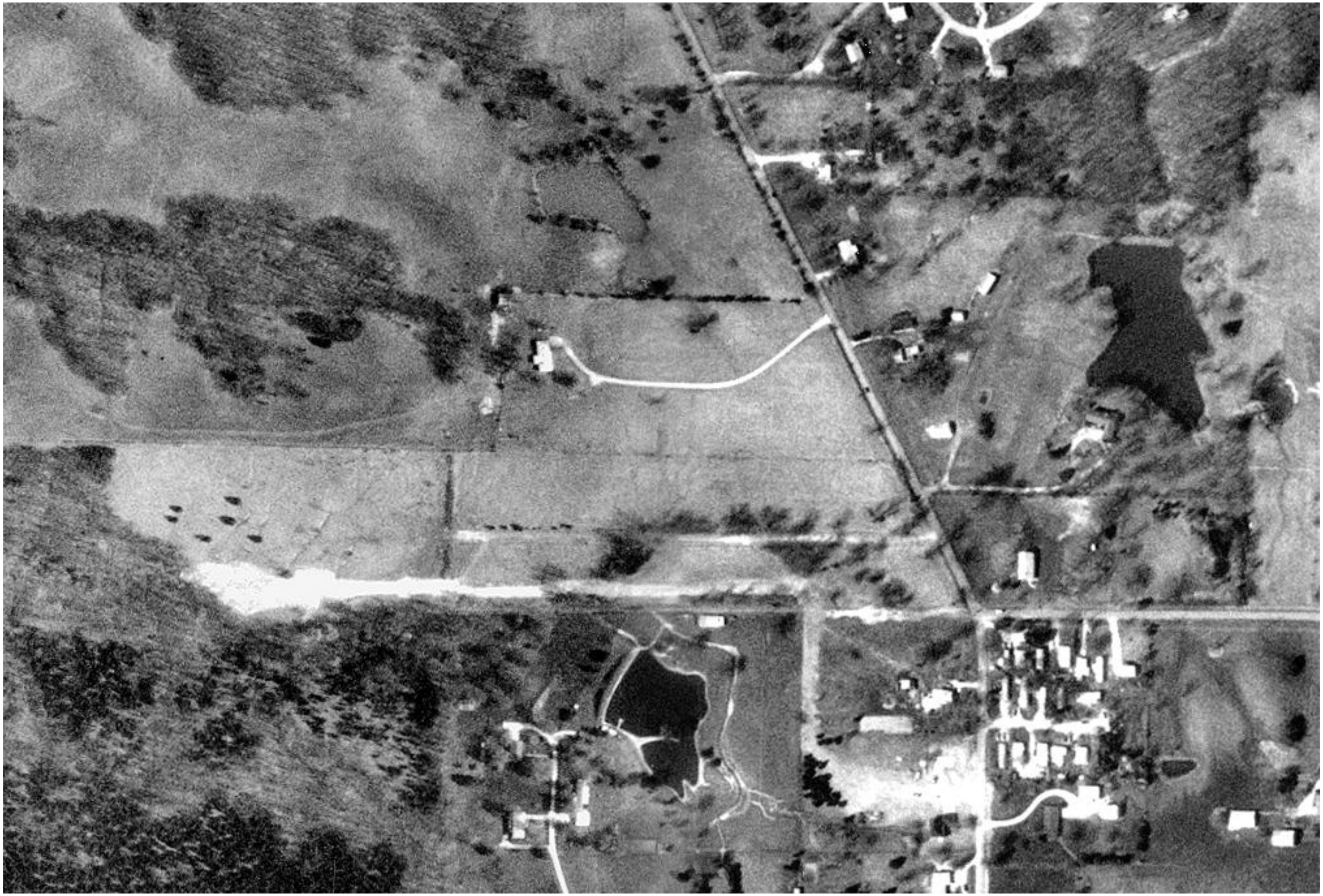
IKONOS 1M Pan
Shift Differential

Example of Control Point Selected from IKONOS Imagery

DOQQ Match



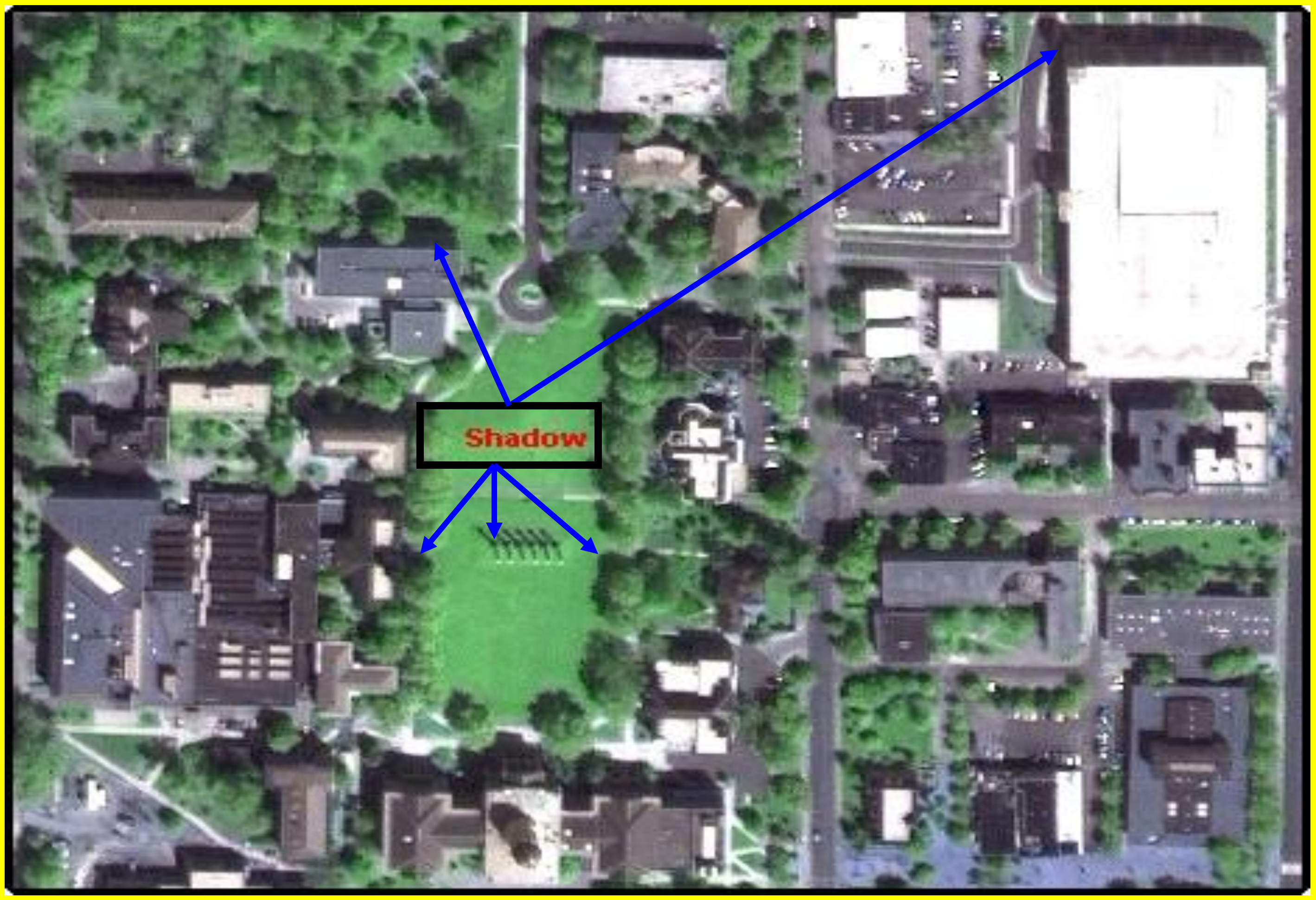
Histogram Matched DOQQ’s



Spatial Resolution: Limitations

- Less area covered: with minimum strip of 11km x 11km
- Columbia metro area covered in two images (necessarily collected on different dates)
- Requires lots of time for processing: ex. Mosaicing
- Tones do not match properly because imagery was taken at different times

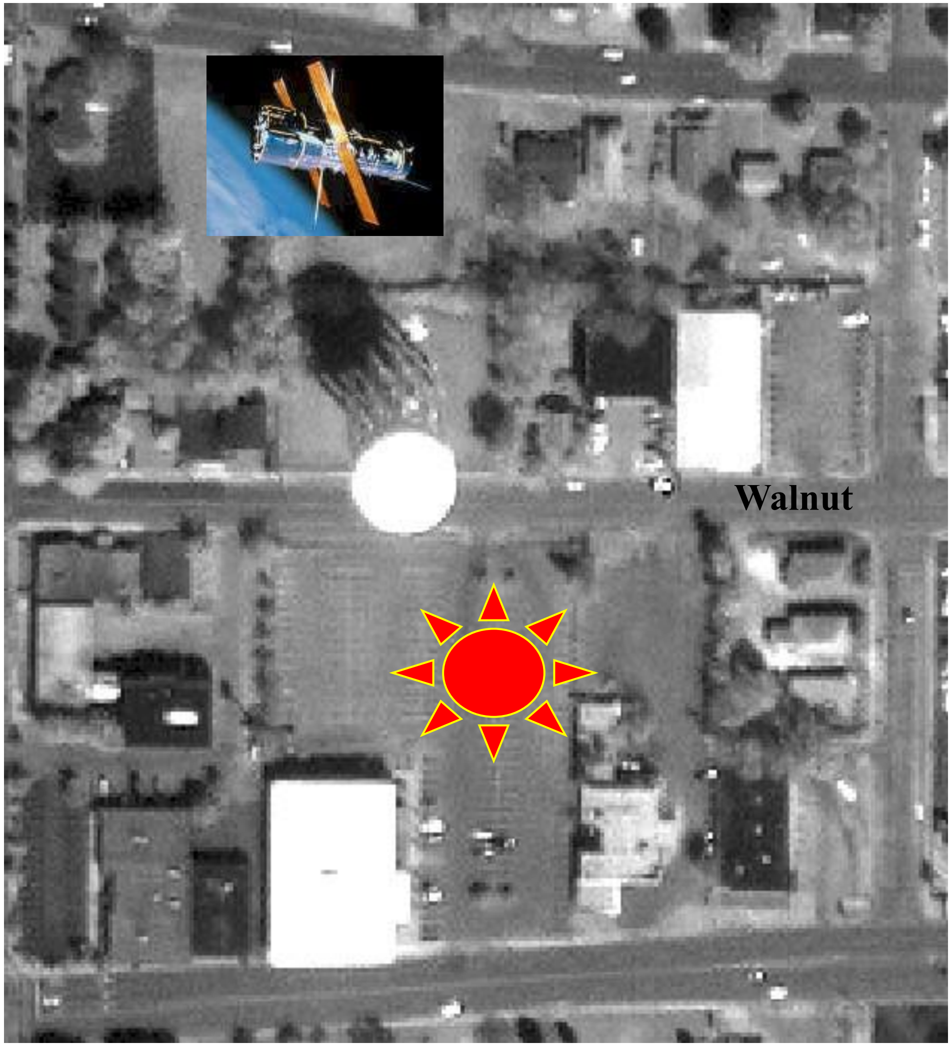
Shadow Effects



Cloud cover

- Frequent revisit helps in easy update and more chances for acquiring cloud free data.
- Minimum cloud cover is 20 %. You have to pay extra money.
- PE: It can take many months to get cloud free data.
- Suggestion: Ordering the data between known cloud-free dates would help

Azimuth



- IKONOS satellite allows to specify the specific image acquisition angle
- But, it will be treated as a nonstandard order and may result in a longer delivery time frame and additional surcharge

More Involved Integration Issues

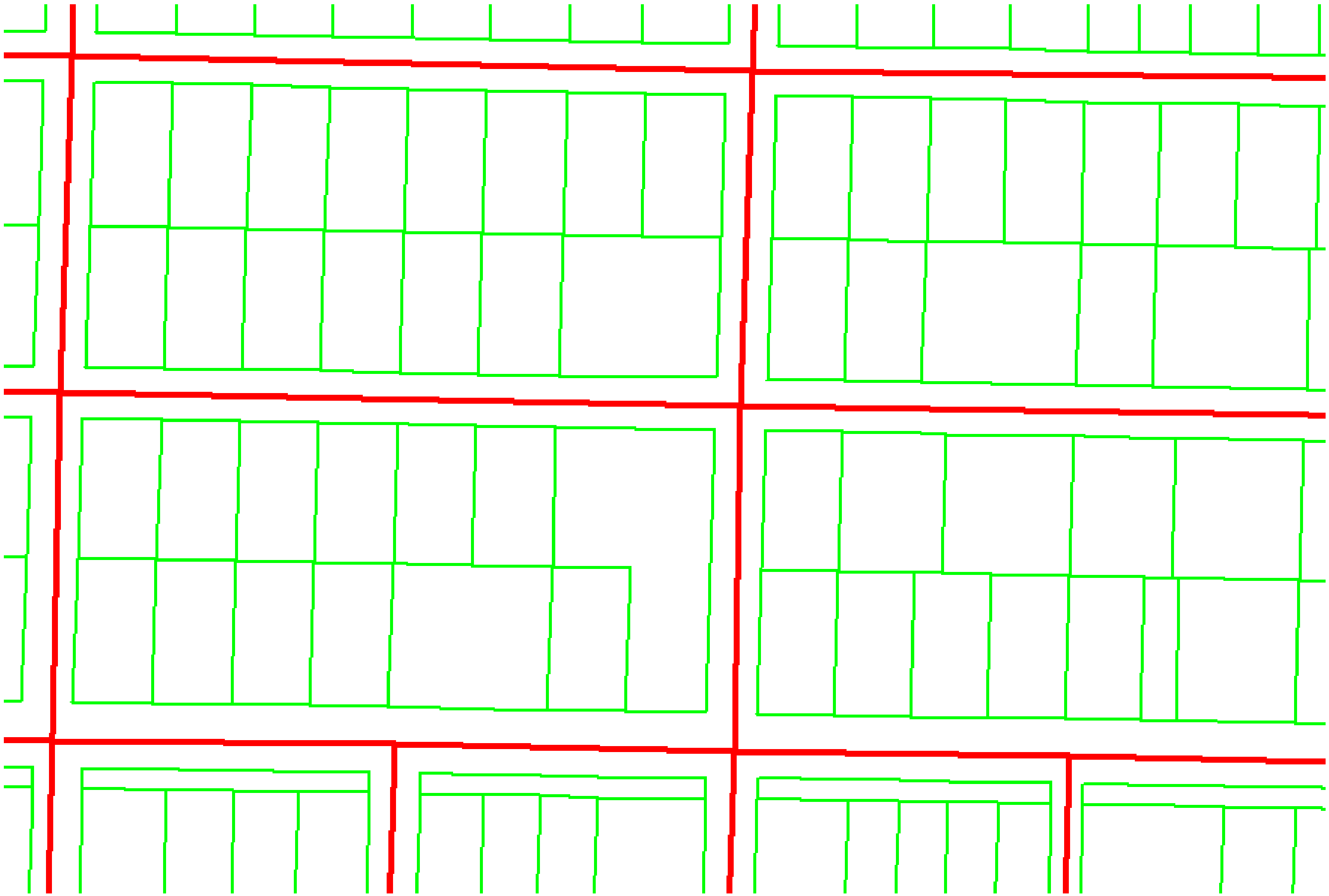
The next series of slides will present a tool used to integrate legacy GIS vector information with newer and more accurate imagery data

Integrating Imagery

The Local Problem

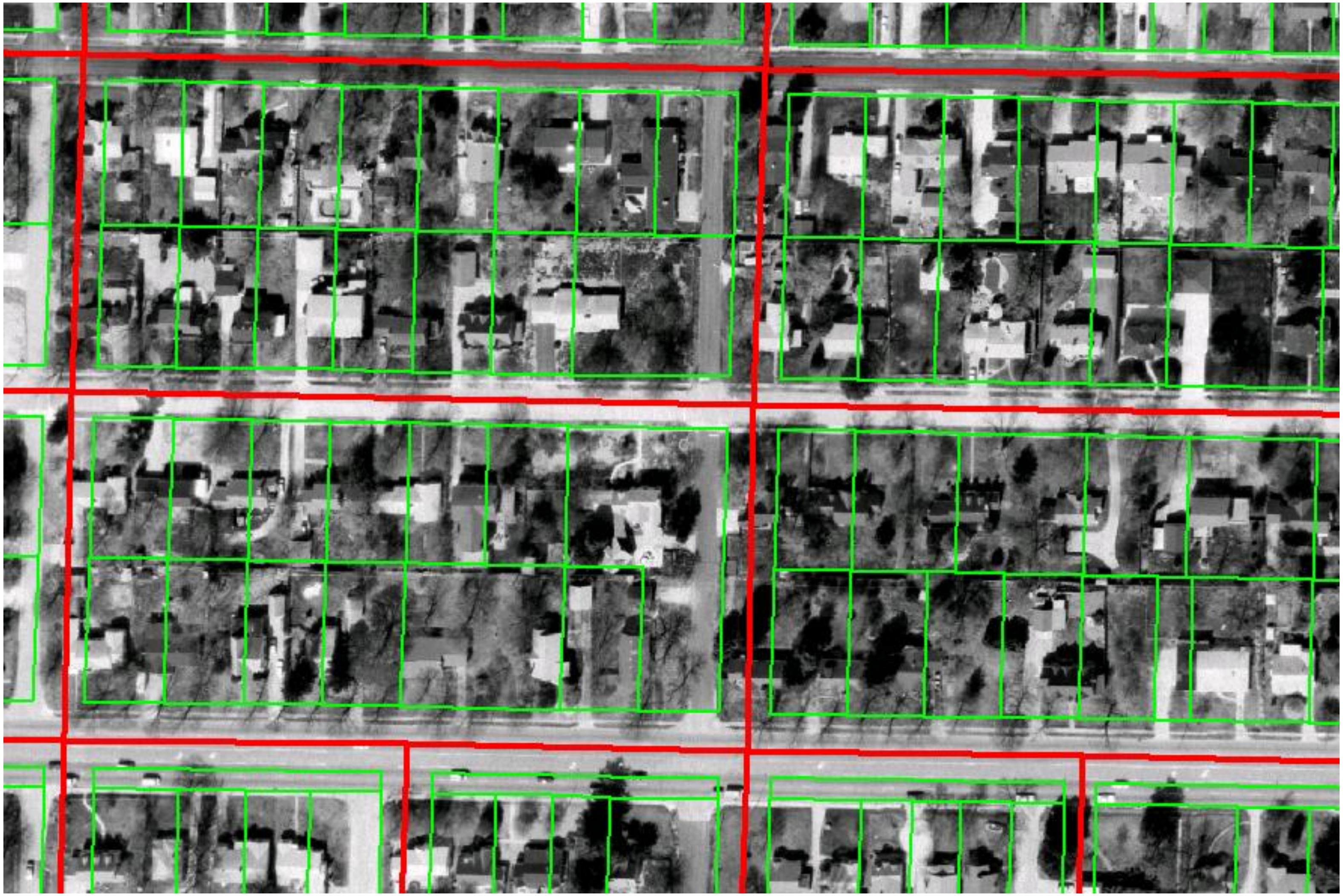
- Vector GIS data lineage may preclude direct integration with image data sets
  - **Mapping pre-dates computers**
  - **Stand-alone system organized by tiles**
  - **Integration with other data – GPS**
  - **Huge investments in GIS data**
- Imagery can provide the accurate base map materials to meet these needs

GIS Vector Linework



Imagery Acquired

The Pervasive Problem



Creating Image to Vector Linkages

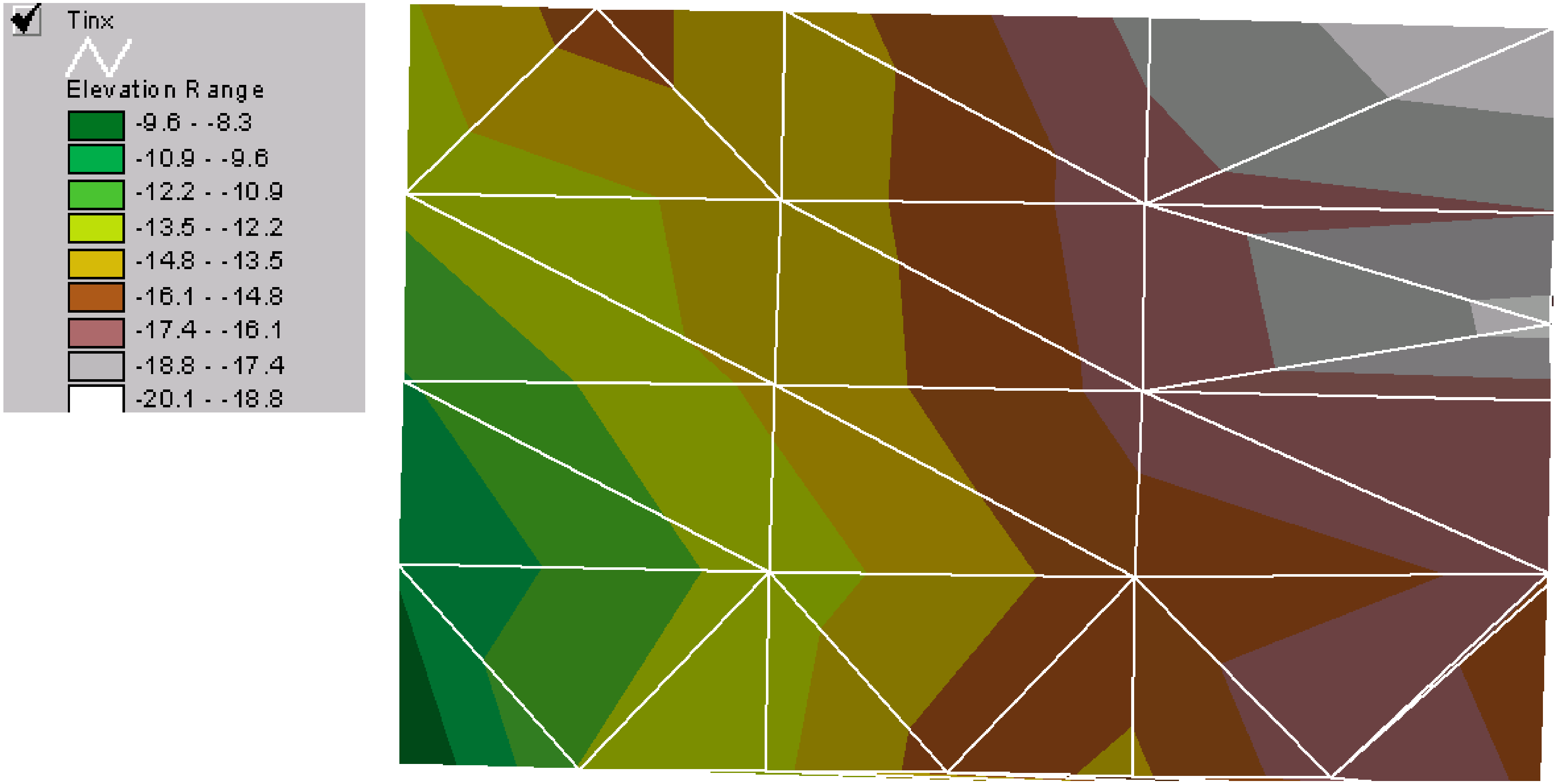
- **Extracting the nodes from the image based road centerlines file**
- **Building or acquiring a centerline vector file from within the current local GIS and building a node file from this source**
- **Conducting a local-area search to establish the positional relationships between these two sets of nodes.**

Example of Linkage

GIS Vector to Image

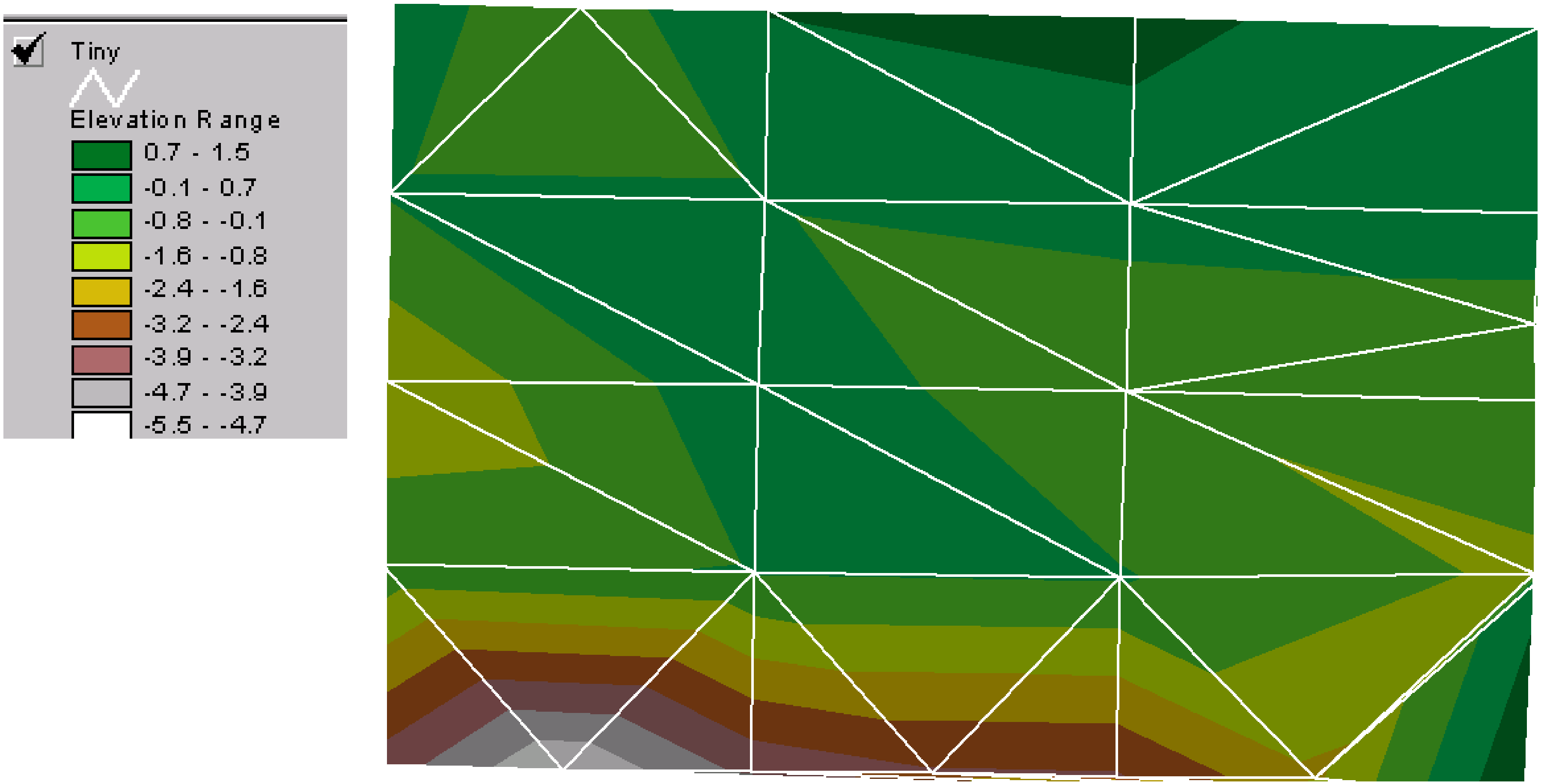
X-Shift Surface

Depicted as Tin



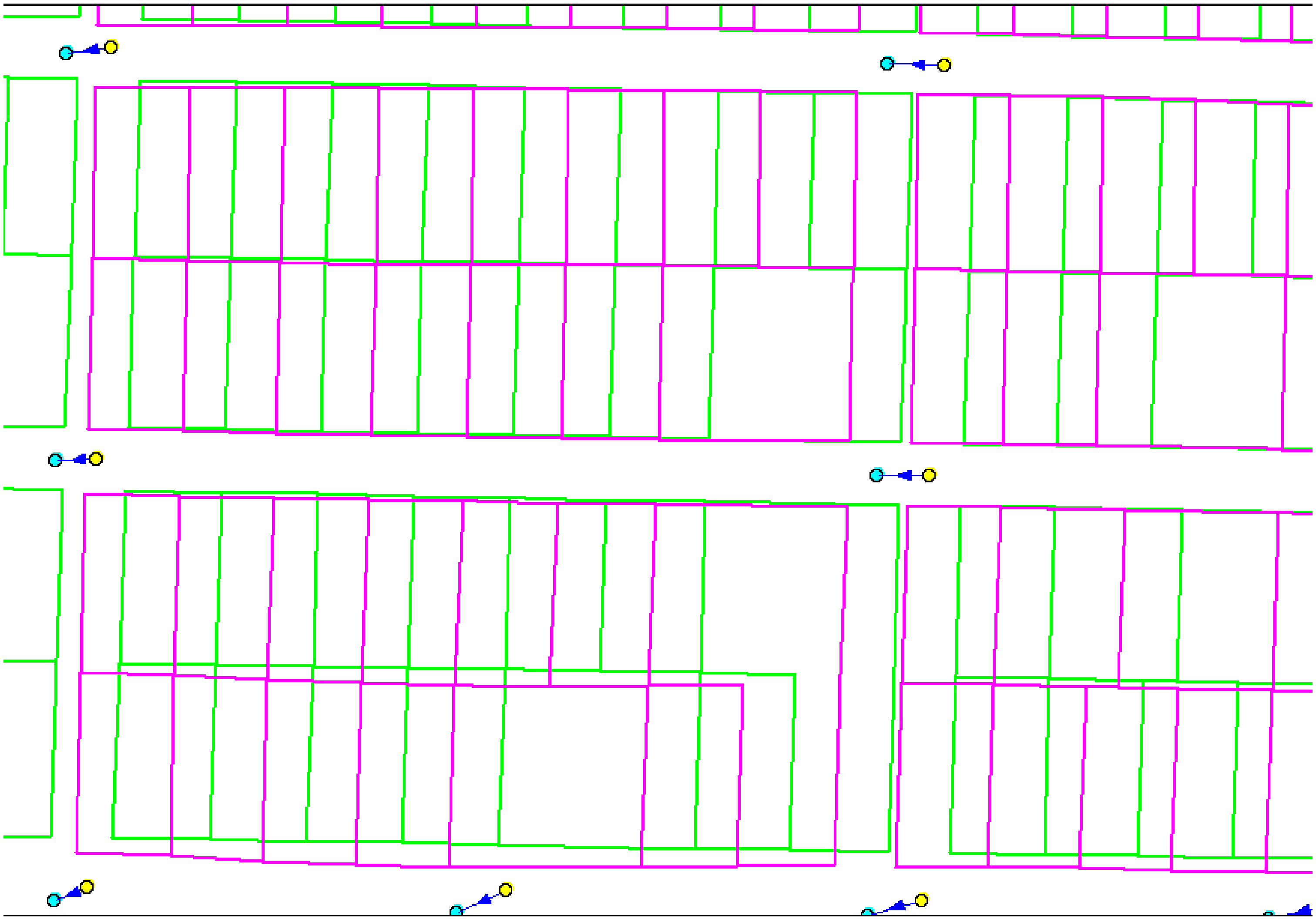
Y-Shift Surface

Depicted as Tin



Resulting Adjustment

Parcel Data Layer



Resulting Imagery Overlay

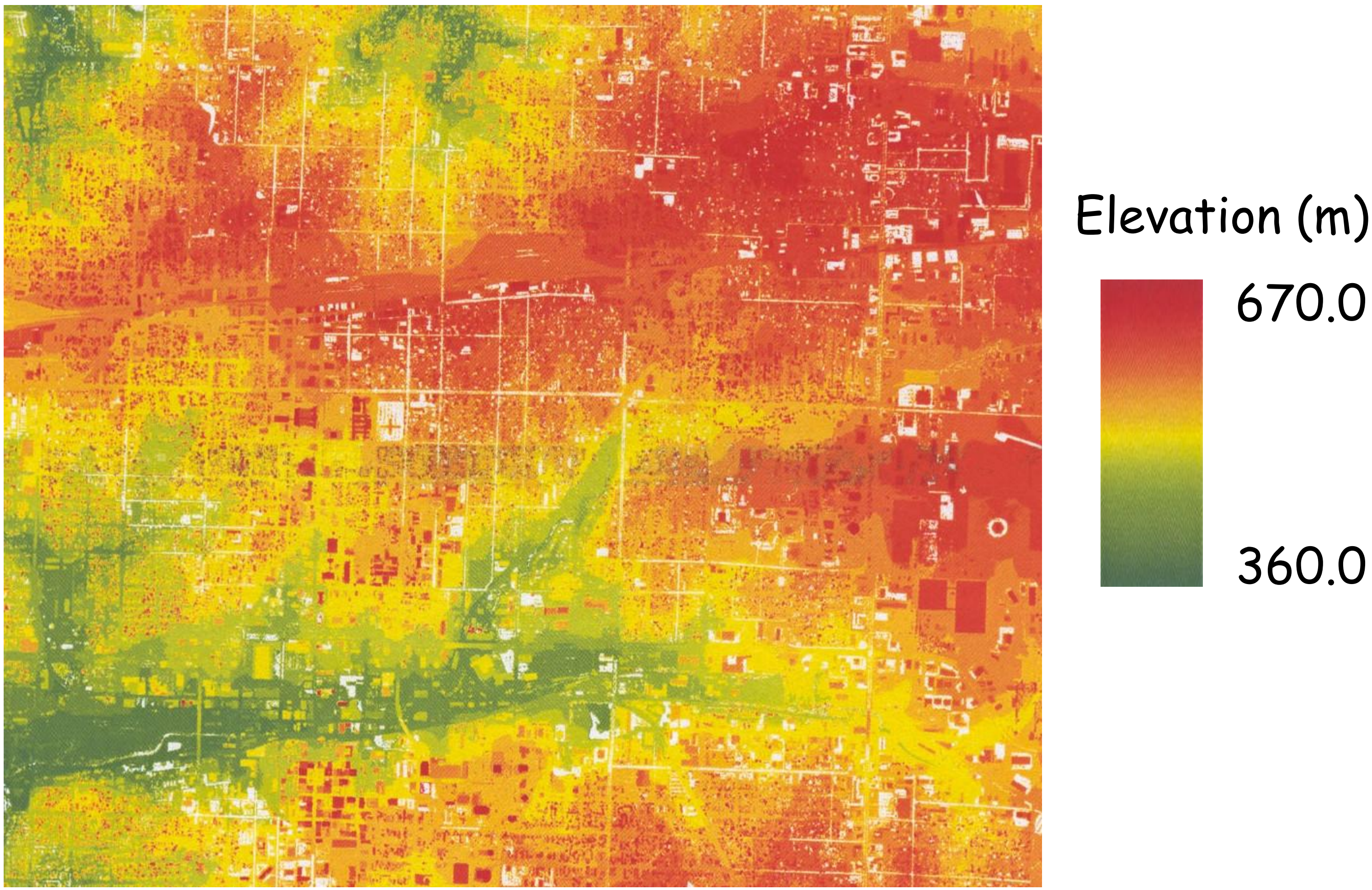
Resulting Options

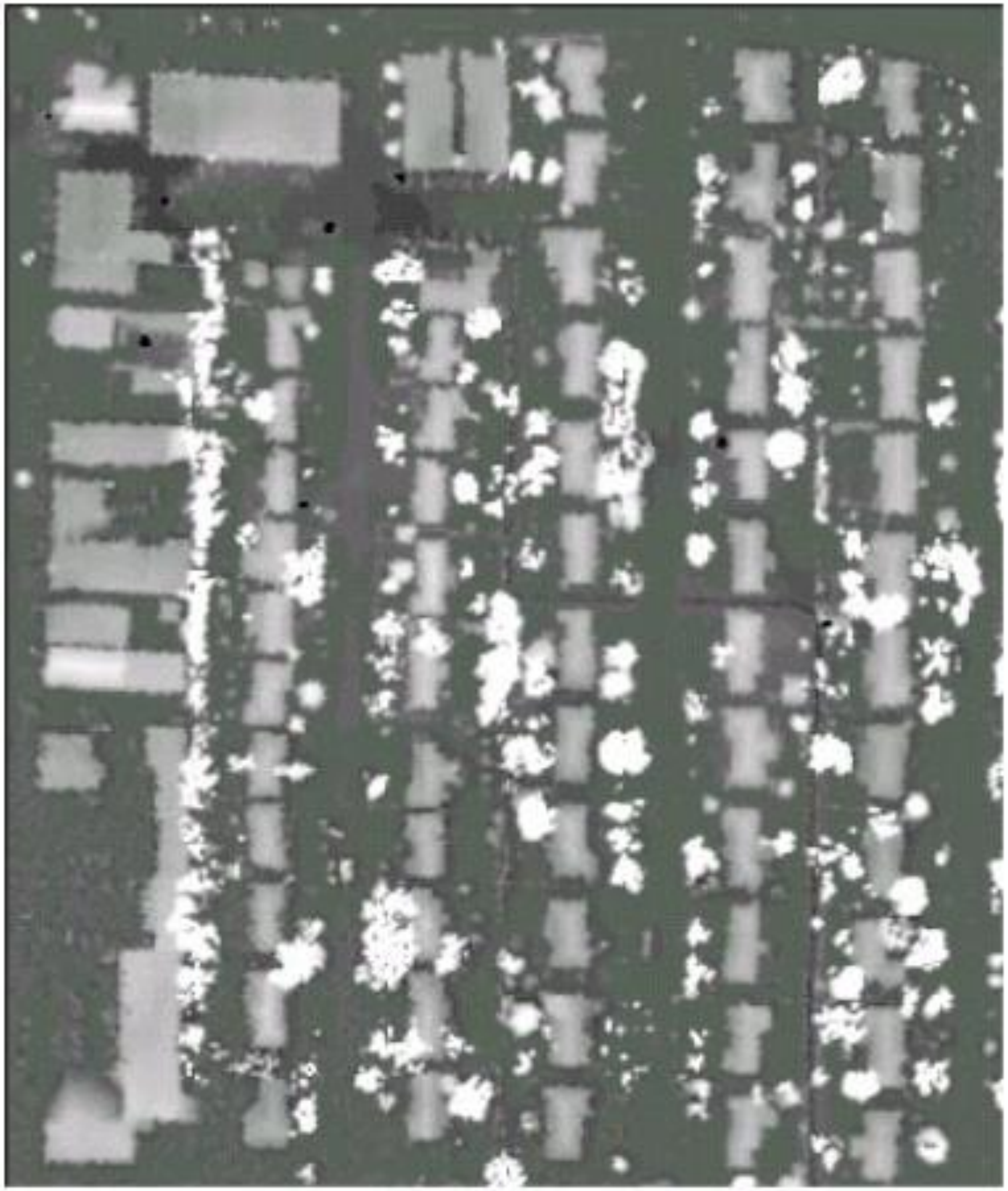
- From these spatial relationships two surfaces are created to allow:
  - Consistent positional recalculation of vector points, lines, and polygons based on imagery
  - Visualization of the variation in error magnitude across ‘old’ vector database
  - Prioritization of resurvey work by local jurisdictions
  - Pathway for all associated databases built on the vector base

LIDAR Data Analysis

The next series of slides will show what newer technologies associated with LIDAR data and Extraction can derive from imagery data

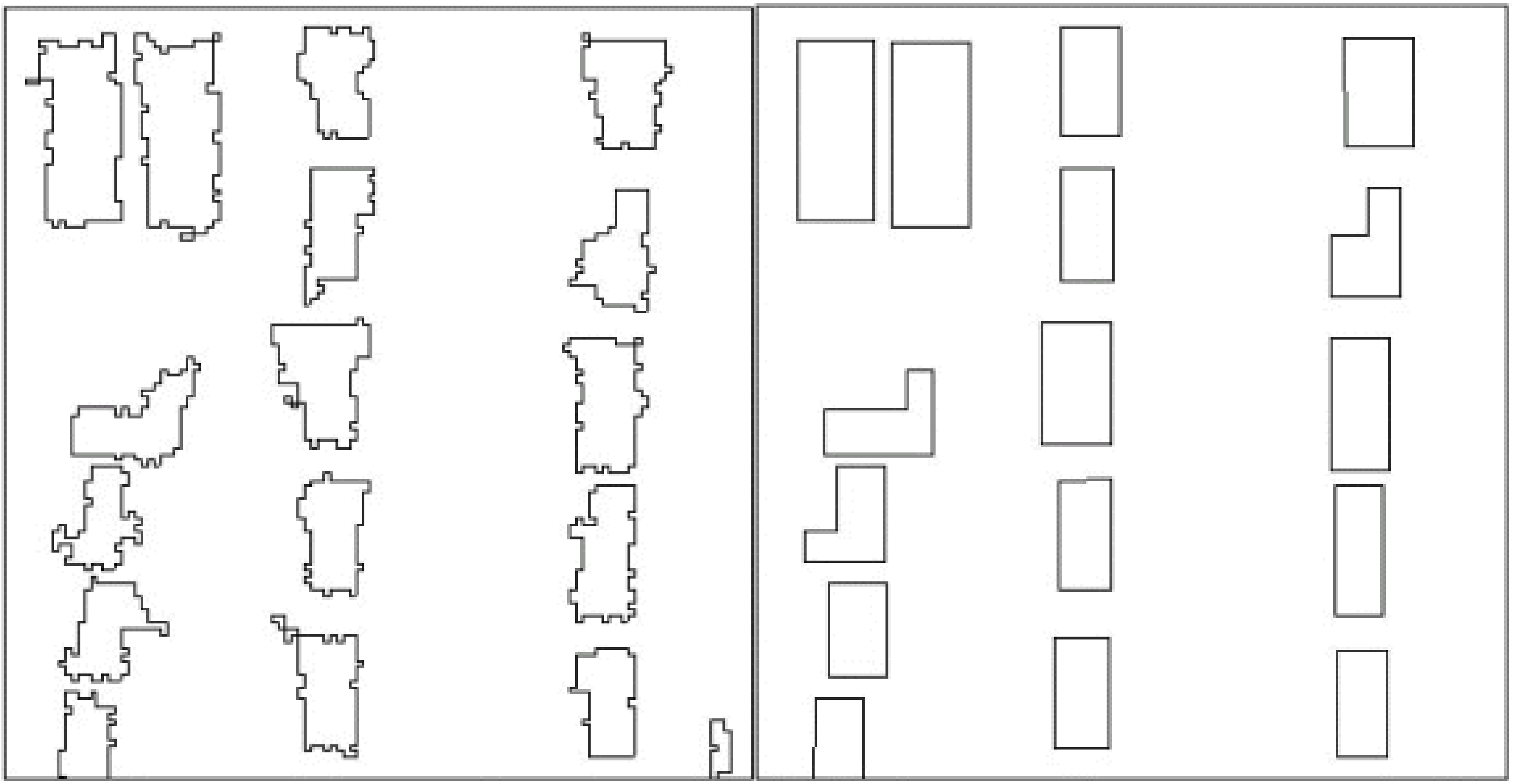
1 m Laser DEM
Springfield, MO





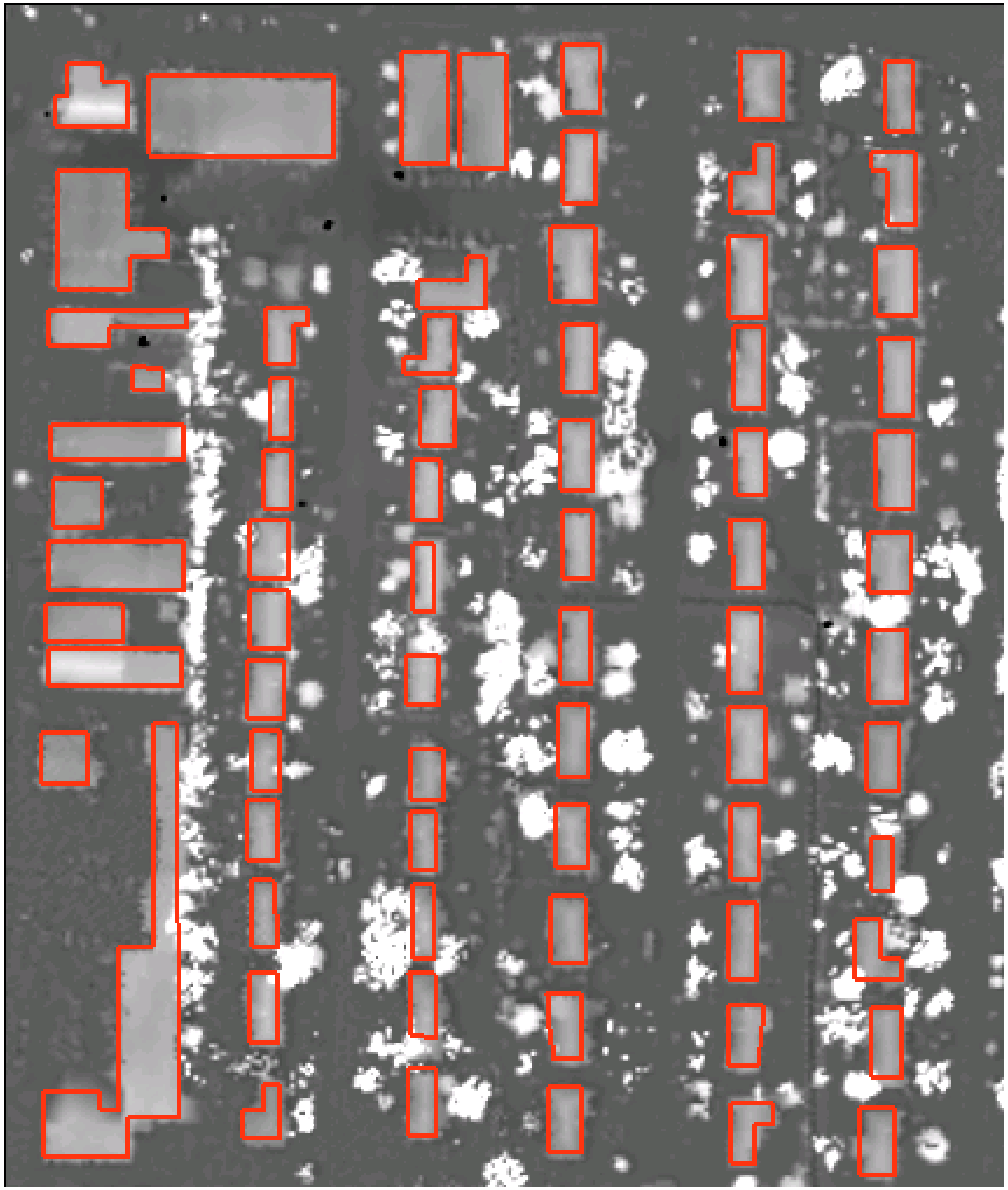
Normalized DSM of a residential area

Building Extraction

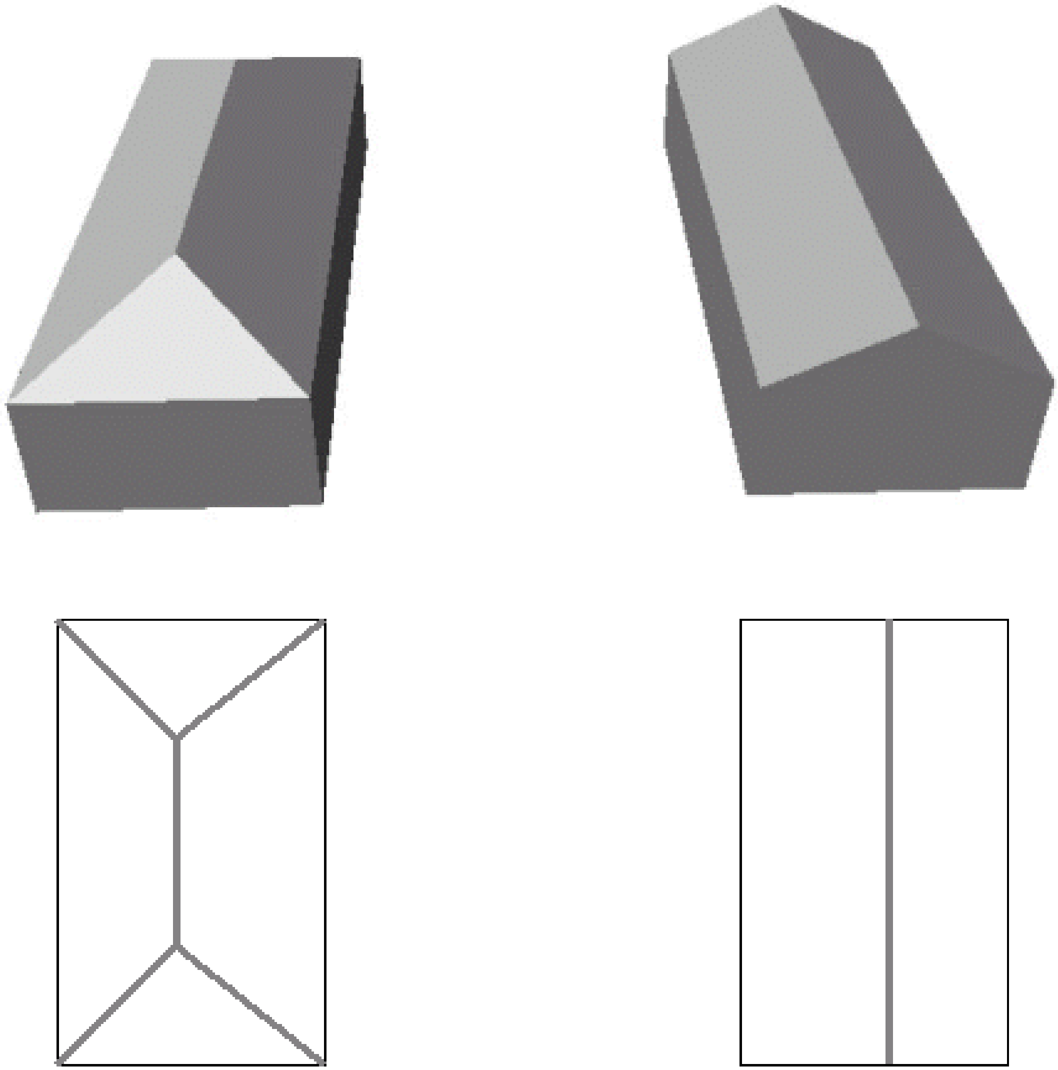


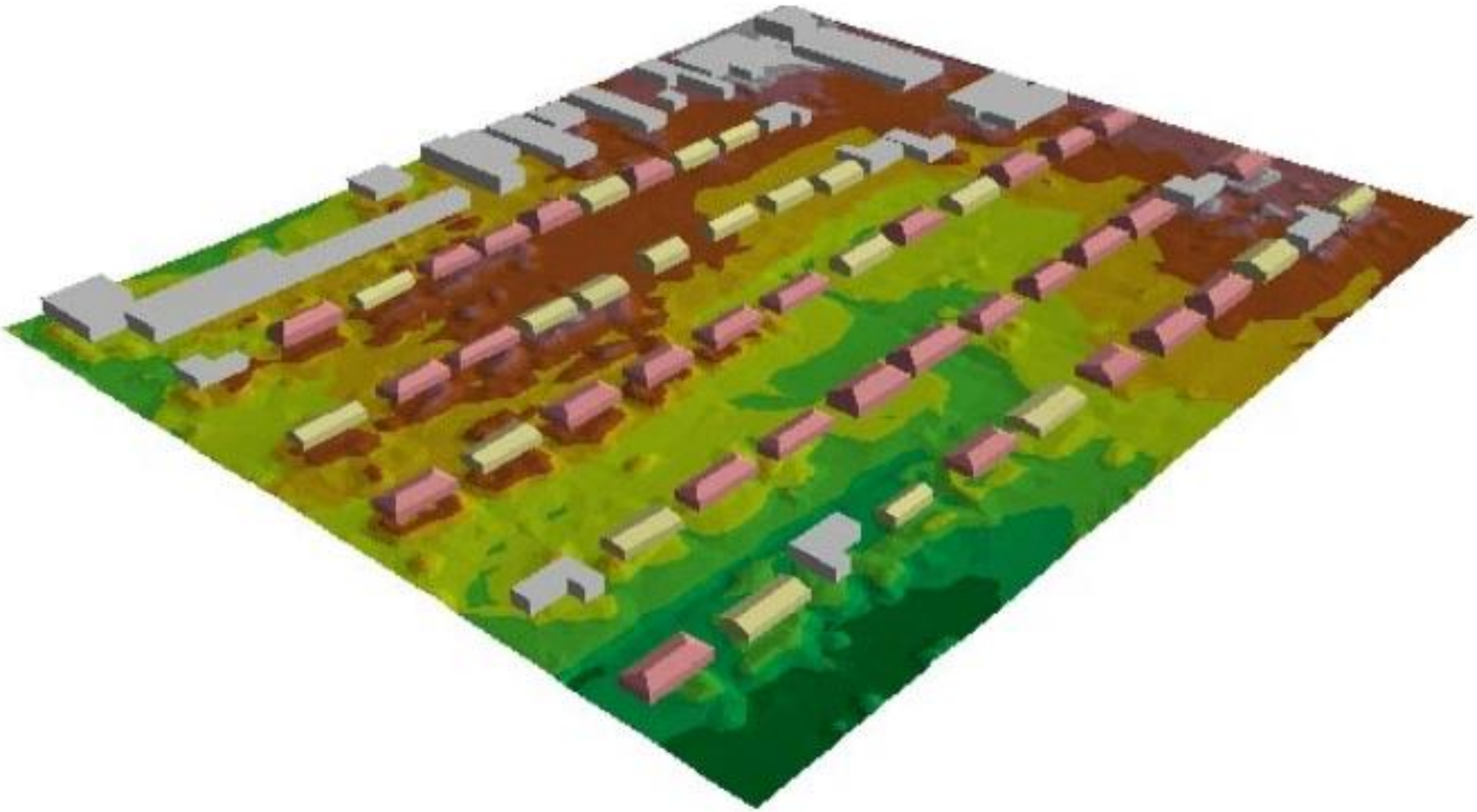
(a) (b)

Building simplifying: (a) before; (b) after

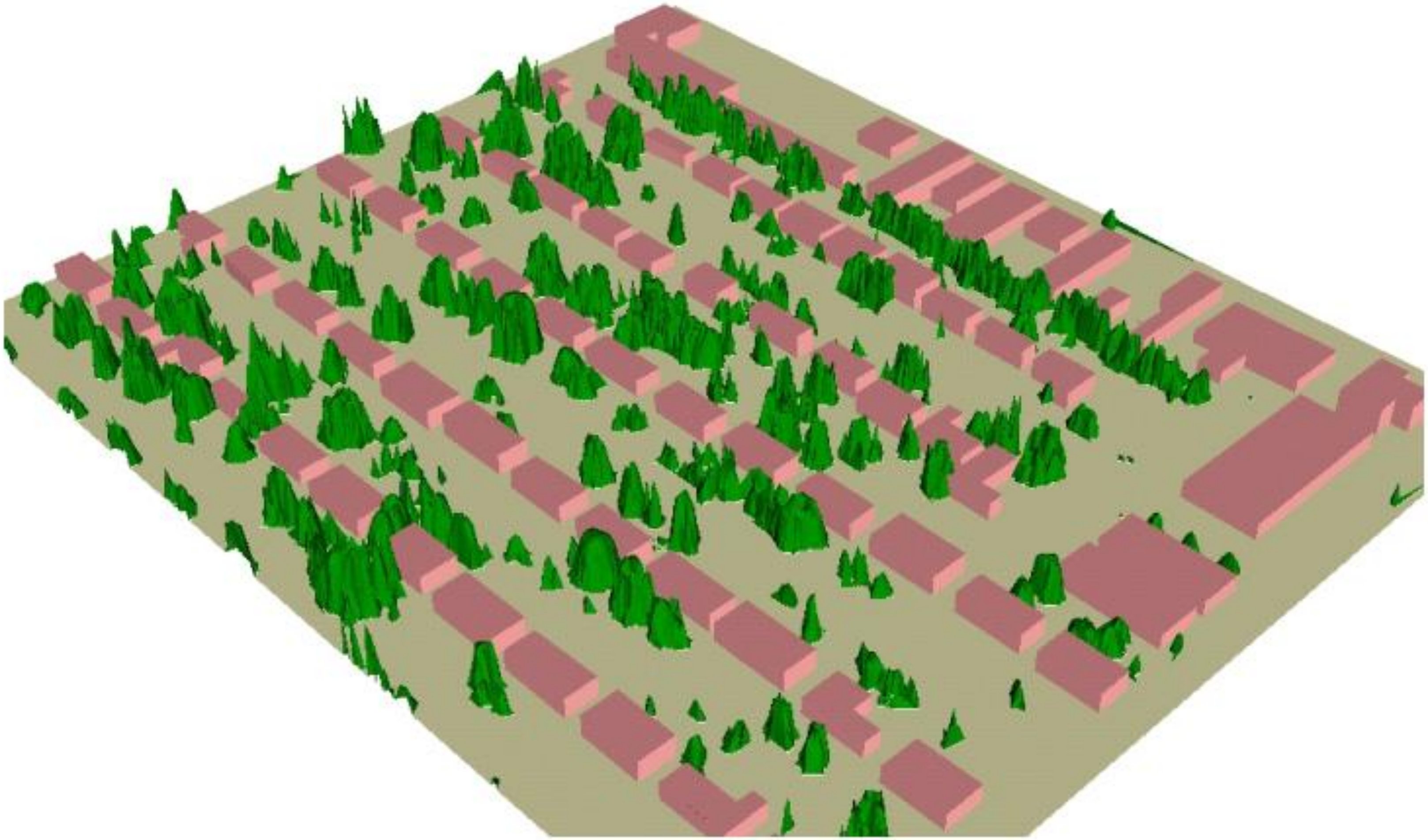

Extracted Building Outlines

Comparing Hipped (L) and Gabled (R) Buildings





3D view of extracted buildings



Tree Extraction

Then there is always Policy Issues

- **Data Ownership**
  - public - free access
  - private - limited license
- **Privatization**
  - ownership of launch vehicles, satellites, sensors, and distribution rights
- **Cost of data**
  - cost of filling user requests
  - partial government subsidy
  - full cost recovery
- **Data archives**
- **National Security**
  - spatial resolution limits
  - shutter control

- **Overall Benefits Include:**
  - Imagery/Basemaps for use in GIS systems
  - **New** information product(s) not available previously
  - Improved accuracy/utility over existing products
  - Increased speed of access for updating baseline information
  - Personnel time savings in workflow
  - Cost effective solutions
  - **Improved planning/decision making processes!!**

Conclusions

Unique, Timely, Cost Effective Solutions to Positively Impact Planning, Management, and Decision Making Processes in Local Government

Thank You

Questions, comments, or suggestions:

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