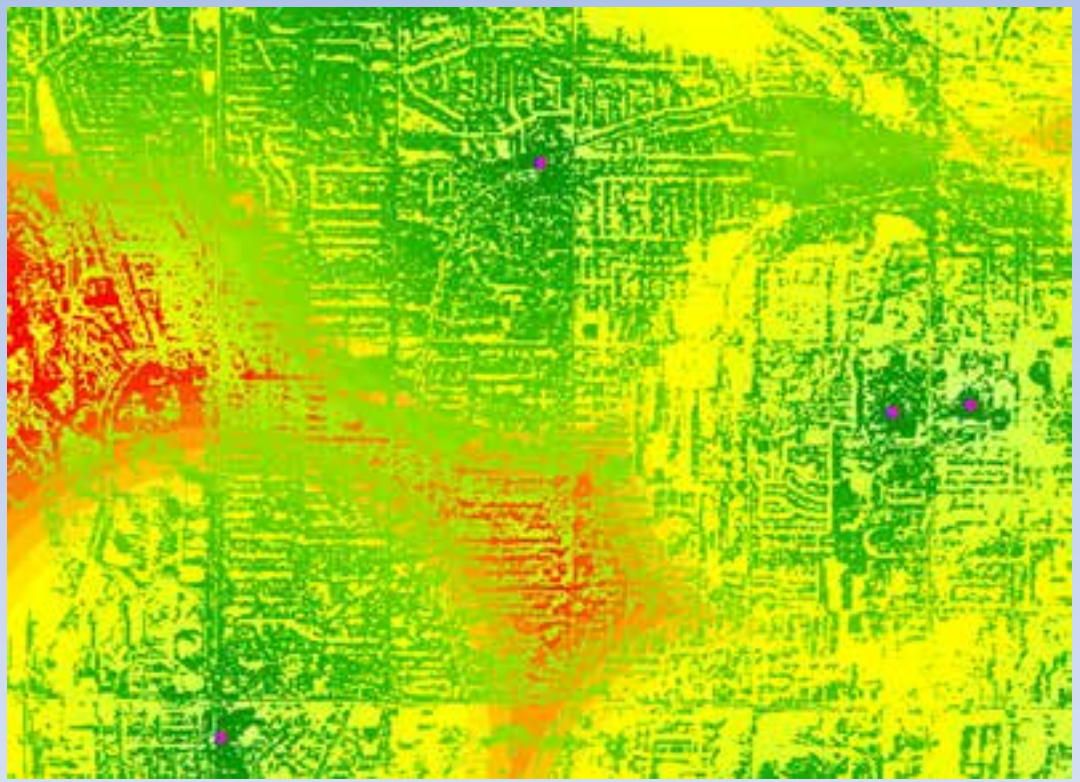
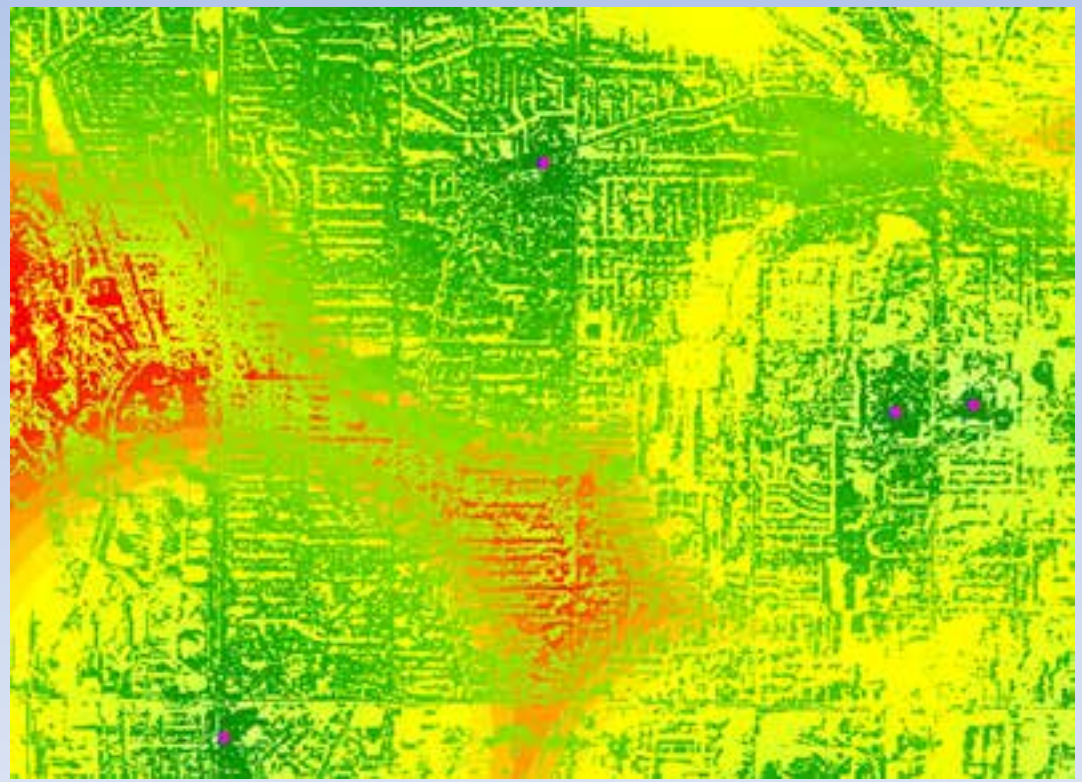
Seeing Geography Matters
Are We Ready for 4G?



Prepared by A.J. Allred, WPCS Site Plan Inc., 2014

This is what our smart phones 'see'.
If we want our phones to work, then we need to see as well.



Are We Ready for 4-G?

- Mobile communication services have swept the world.

- Advancing technology is redefining economic and social relationships.

- The quality of mobile communications is one benchmark for competitive standing among nations and individuals.

- The United States has led in technology development, yet ***is not the strongest*** in technology adoption.

Are We Ready for 4G?

- U.S. Federal policy promotes commercial wireless, but wireless services ***are deployed*** at the consumer level, where local government land use regulation is a constraint.

- Some evidence suggests that wireless technology is advancing much faster than the ***social technology*** that regulates the location of wireless facilities.

- There is evidence that, at the “street level”, consumers value wireless service on how it performs, but tend to regulate it on how it looks.

Using a common biblical reference, we have technology with a head of gold, but we run on feet of clay.

No wireless network is better than the constraints found at the street level where consumers need it.

The famous “last mile” to the consumer is constantly referenced in the wireless literature, but is seldom addressed as a ***human technology*** issue.

In some ways, problems at the street level are considered a necessary evil, something we ***try to work-around***.

The premise of this report is that ordinary desktop GIS software provides tools that can readily change the way in which local governments and citizens view commercial wireless services and equipment.

Using a test case, desktop GIS software provided an easy-to-use method for more fairly judging wireless service - - by making wireless signal as visible as the equipment that is so often the subject of controversy and delay in municipal regulatory control.

This test case suggests that wireless services, and its necessary facilities, ought to be seen as a vital community infrastructure like water, sewer, streets and electrical power.

My review of wireless industry newsletters indicates that local regulatory constraints have not changed in any structural way since 1996, when Federal telecom legislation promoted the still-burgeoning wireless industry.

Meanwhile, vast improvements in scientific and business technology have created burgeoning opportunity for mobile communications.

Why the disparity?

As recently as May, 2014 I found this quote in an article by Andrew Berg of Wireless Week magazine:

Congressmen Fred Upton (R-MI), and Greg Walden (R-OR) Thursday sent a letter FCC Chairman Tom Wheeler asking the commission to *streamline the approval process for wireless infrastructure deployments*.

- PCIA President and CEO Jonathan Adelstein praised the letter in a statement, saying he was grateful that the House leadership recognizes the urgency of streamlining infrastructure deployments.
- *"Removing **red tape** and clarifying the rules of the road are crucial for expanding wireless broadband – and to the many thousands of high-wage jobs such deployment spurs throughout the country," Adelstein said. "It will take a lot of infrastructure to address the wireless data crunch and meet the rising consumer demand for wireless data."*
- *"Regulations can make it tough to deploy infrastructure," Pai said, lamenting the fact that state and local municipalities decisions are often governed by antiquated one-size-fits-all rules and laws.*
- So, with the U.S. Constitution reserving police power to the States, wouldn't it be nice if Federal action were not needed to help modernize the approval process for wireless facilities.

Would ordinary people change their attitude toward “cell towers” if they were able to:

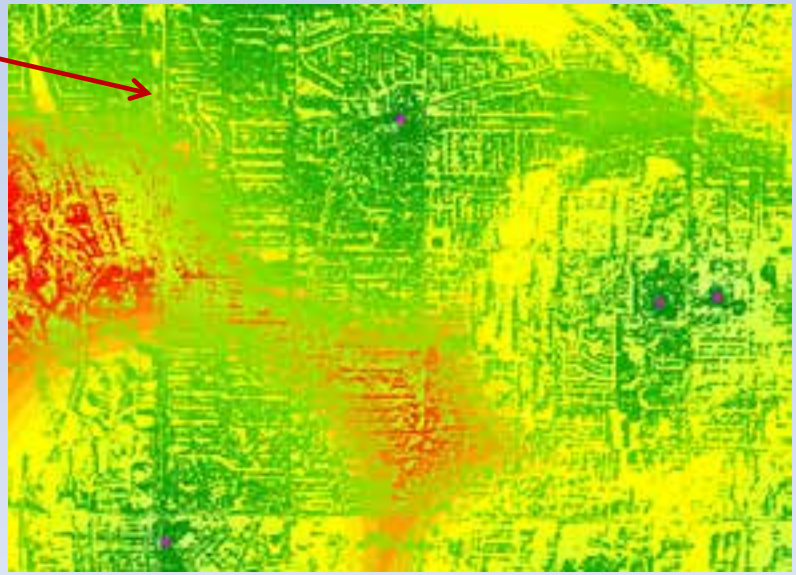
- More effectively visualize wireless networks as legitimate community infrastructure?
- Value mobile communications as a community asset, judged on how it works, rather than on how it look?
- Feel more involved and committed to seeing wireless business investment as an ***indicator of community wealth and value***, rather than as a nuisance or visual blight?

Instead of asking:

What do you think of this?

Why not ask:

Where do <u>you</u> want service?



GIS creates a framework for shared vision and shared outcomes.

Buy in. Win win.

I picked a project area surrounding my house and created a geodatabase with the following layers:

1. Lidar data for terrain 3-D terrain analysis.
2. An inventory of existing wireless antenna, with estimated or known elevations.
3. Land use zoning designations.
4. An inventory of buildings, water tanks and other built obstructions.

ArcUser magazine for Spring 2014 featured an article by Monica Pratt ***"GIS Spurs Innovation"*** that referenced Thomas Fisher, dean of the College of Design, University of Minnesota about work done to improve life in cities:

"Right now, cities are built to serve the needs of the people who run them, not the people who live in them. Opening up information to the public is a way to get processes and policies realigned to economic needs. He sees cities moving from rigid segregation of business, residential and leisure uses to design that has people working, living and playing in the same place." <page 14> "Fisher believes if we <u>map our assets</u>, we will realize the wealth of human, social, cultural, and environment capital cities possess that has the potential to solve many of these issues."

Federal Telecommunications Act of 1996

Seeing the future of wireless communication and mobility.

Yet, 18 years later, most wireless facilities are still regulated by local government on how they *look*, not on *how they work*.

What is 4G?

Ostensibly, 4th generation technology.

Aside from all the hype and marketing standards for speed and band width, the real question is simply – *is our mobile communication competitive, locally or across a shrinking world?*

WiMax, LTE, MIMO, GSM, HSPA, HSPA+...is marketing ahead of deployment?

Key to mobility is wireless – keys to wireless are *line-of-sight* and *proximity*.

Issues:

- ***multi-path***
- ***reflection***
- ***atmospheric moisture***
- ***vibration***
- ***path geometry & density***
- ***transmitter power***
- ***antenna direction & height***
- ***ground conductivity***
- ***beam tilt***
- ***earth curvature***
- ***other attenuation***
    - ***neighborhood NIMBY-->***

Customers want MAGIC

Mobile multi-media

Any-time, anywhere

Global mobility support

Integrated wireless solutions and

Customized personal service.”

Telecommunications Mapping and Analysis Package

New TMAP GIS Package Targets Stimulus Fund Requests

Esri's Telecommunications Mapping and Analysis Package (TMAP) is specialized to help you to develop successful applications for funding related to the BIP and BTOP.

TMAP combines cable boundary, wire center, and business intelligence data with GIS software that **allows you to**

- **Map** existing service provider areas in your state, region, or nation
- **Identify** rural and remote areas as required in your funding application
- **Analyze** demographics and business intelligence to determine new service areas

What You Get

Software	ArcGIS Desktop (ArcView, ArcEditor, or ArcInfo) Esri Business Analyst desktop
Data	Tele Atlas/TomTom Wire Center Premium MediaPrints Cable Boundaries American Roamer CoverageRight (optional)
Training	*GIS Tutorial Workbook for ArcView 9, Third Edition* Getting Started with GIS Learning ArcGIS Desktop Getting Started with Business Analyst

Contact Us

Need more information?

Ask Our Experts

To Order TMAP

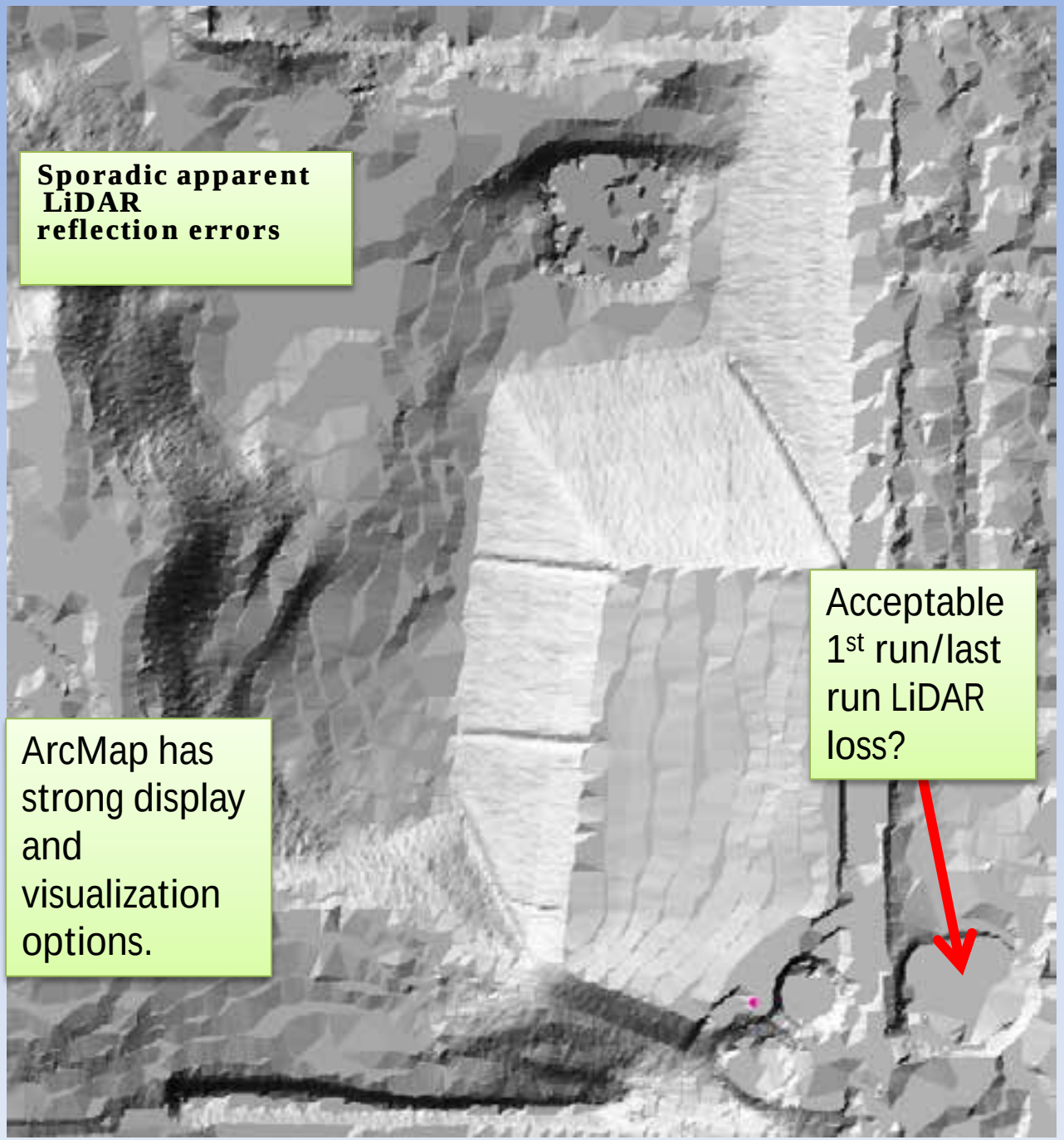
- 1-800-GIS-XPRT (1-800-447-9778)
- telecominfo@esri.com

GIS for Broadband

- Randy Frantz hosts Webinar on supporting broadband stimulus fund packages with GIS

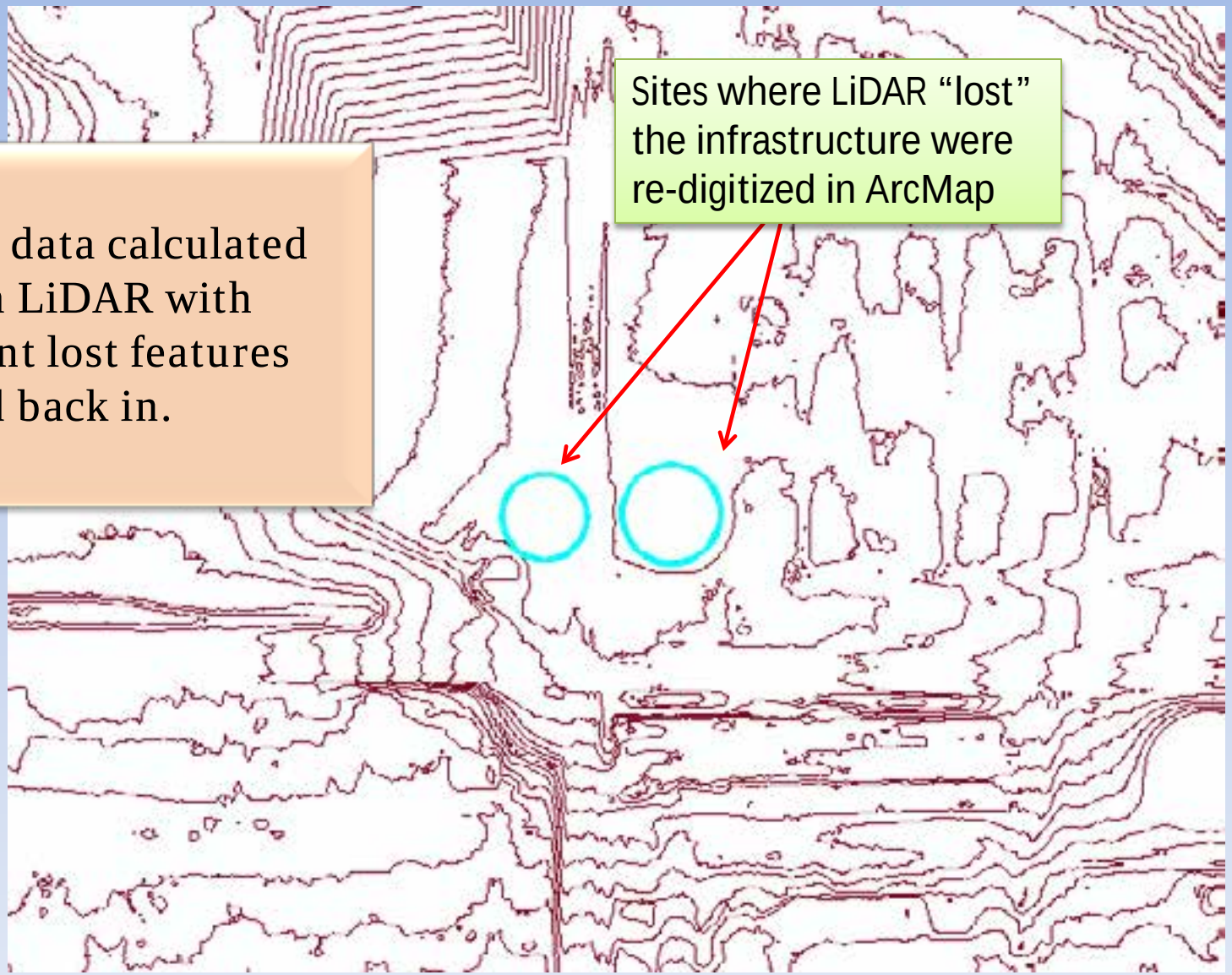
A suburban target area – terrain, traffic, growth

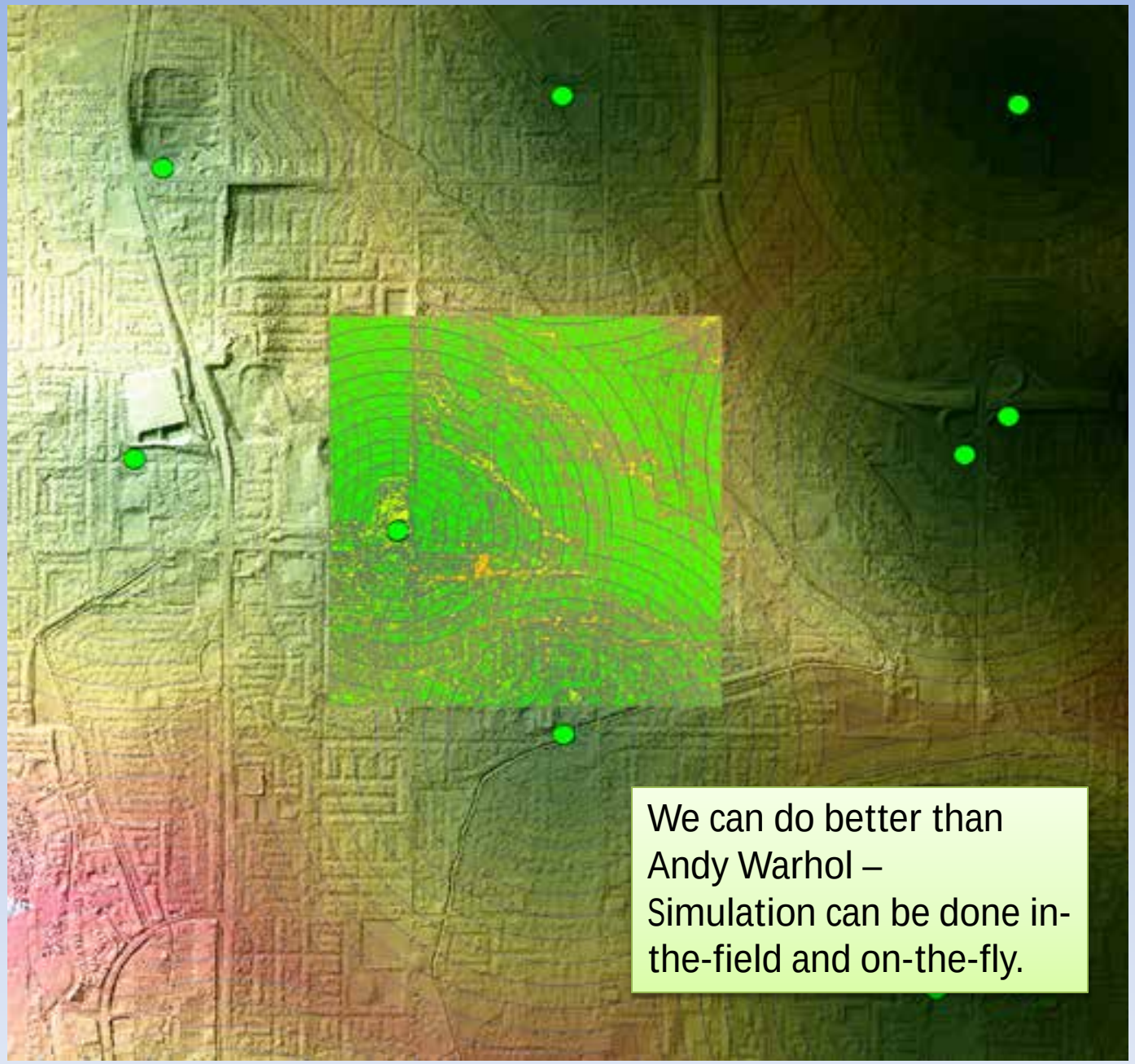
A wide variety of data sets is available from state GIS clearinghouse. We encountered few file conversion or compatibility problems.


Sporadic apparent LiDAR reflection errors
Acceptable 1st run/last run LiDAR loss?
ArcMap has strong display and visualization options.

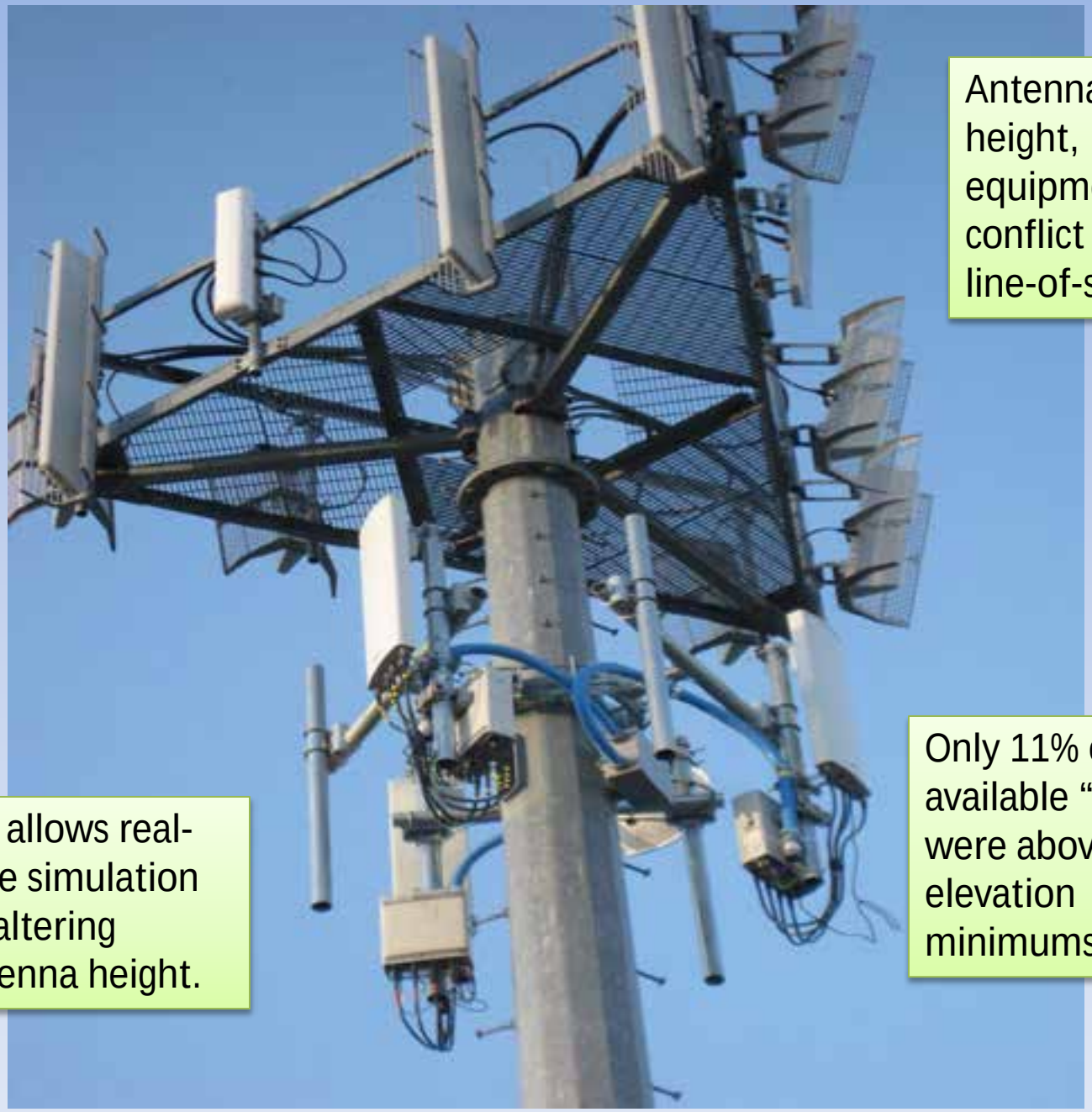

Crucial wireless features and obstacles. Re-insert lost LiDAR features by clipping contours and inserting concentric circles and edit elevations – both real and for modeling.

Contour data calculated from 2m LiDAR with important lost features digitized back in.




We can do better than
Andy Warhol –
Simulation can be done in-
the-field and on-the-fly.

More consistent use of GIS can help eliminate incomplete municipal records and cross-jurisdiction awareness.

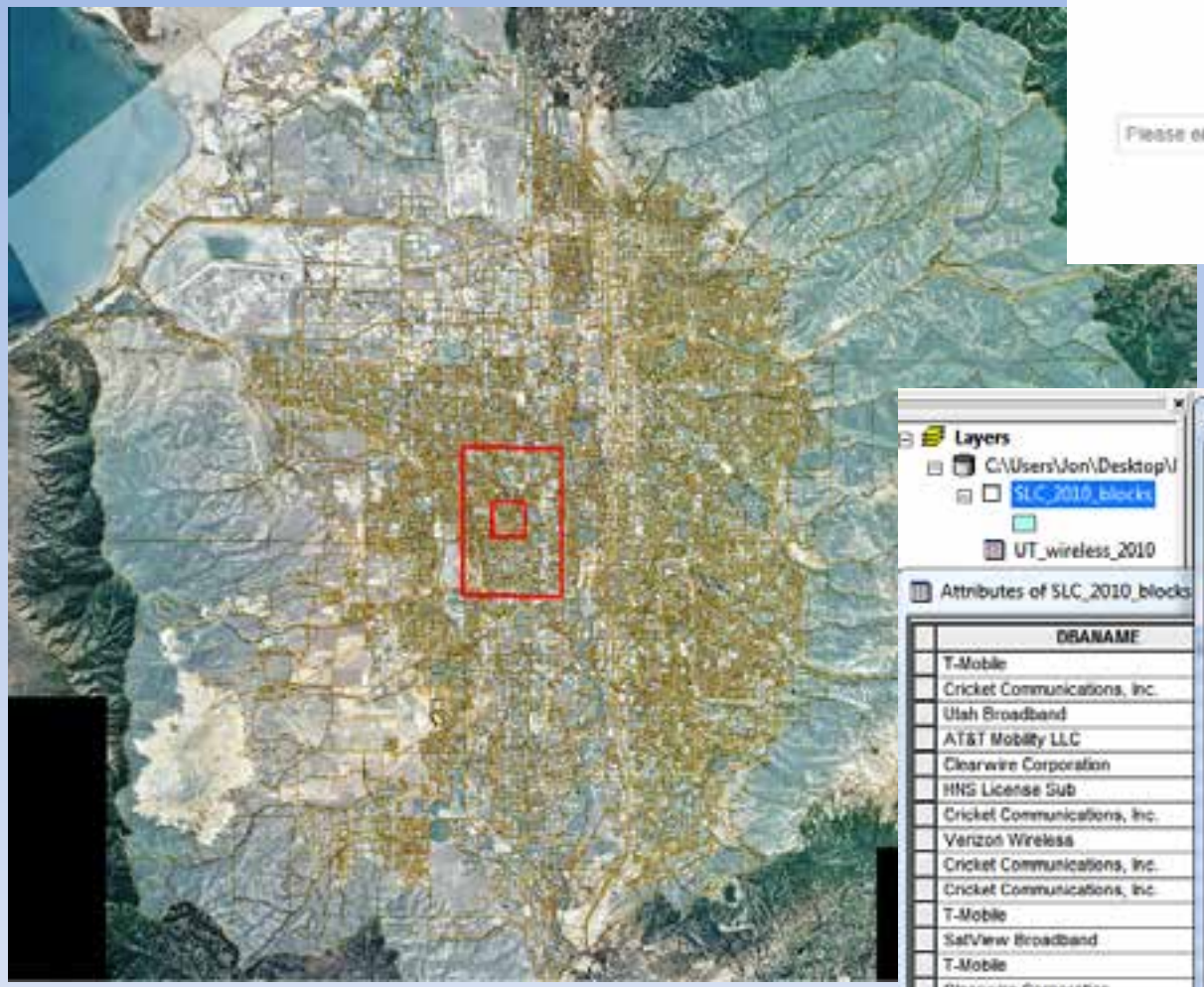


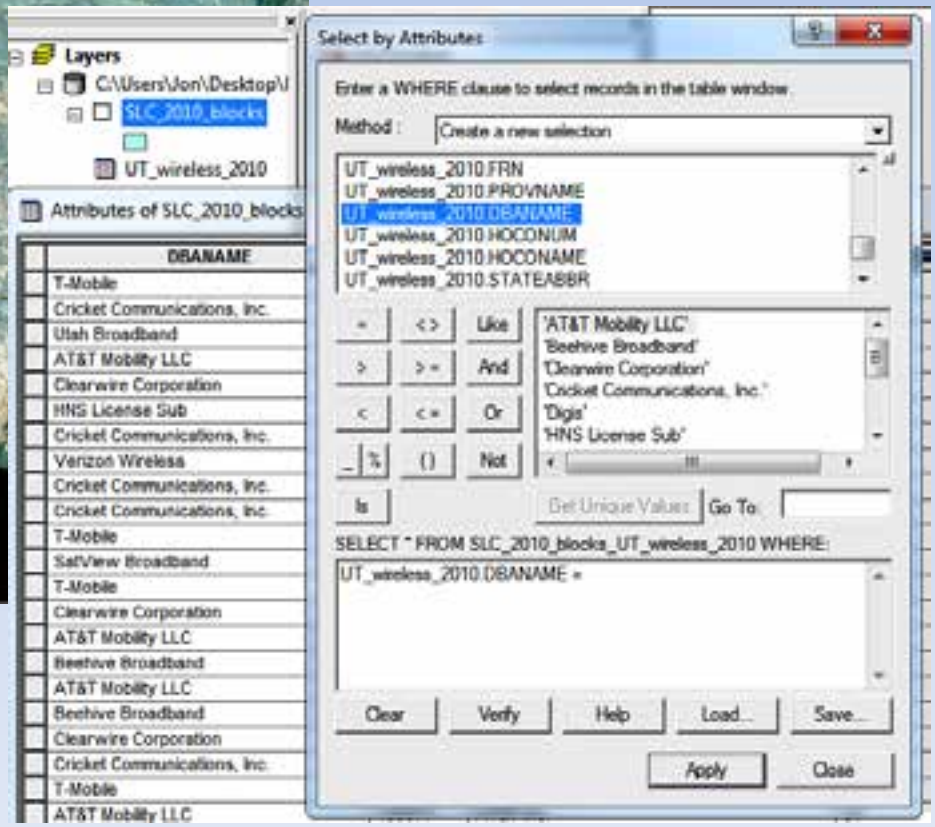
Antenna height, equipment conflict for line-of-sight.

Only 11% of available “slots” were above elevation minimums.

GIS allows real-time simulation by altering antenna height.

Allred's Project





GIS mapbuilding issue:

2000 Census Data

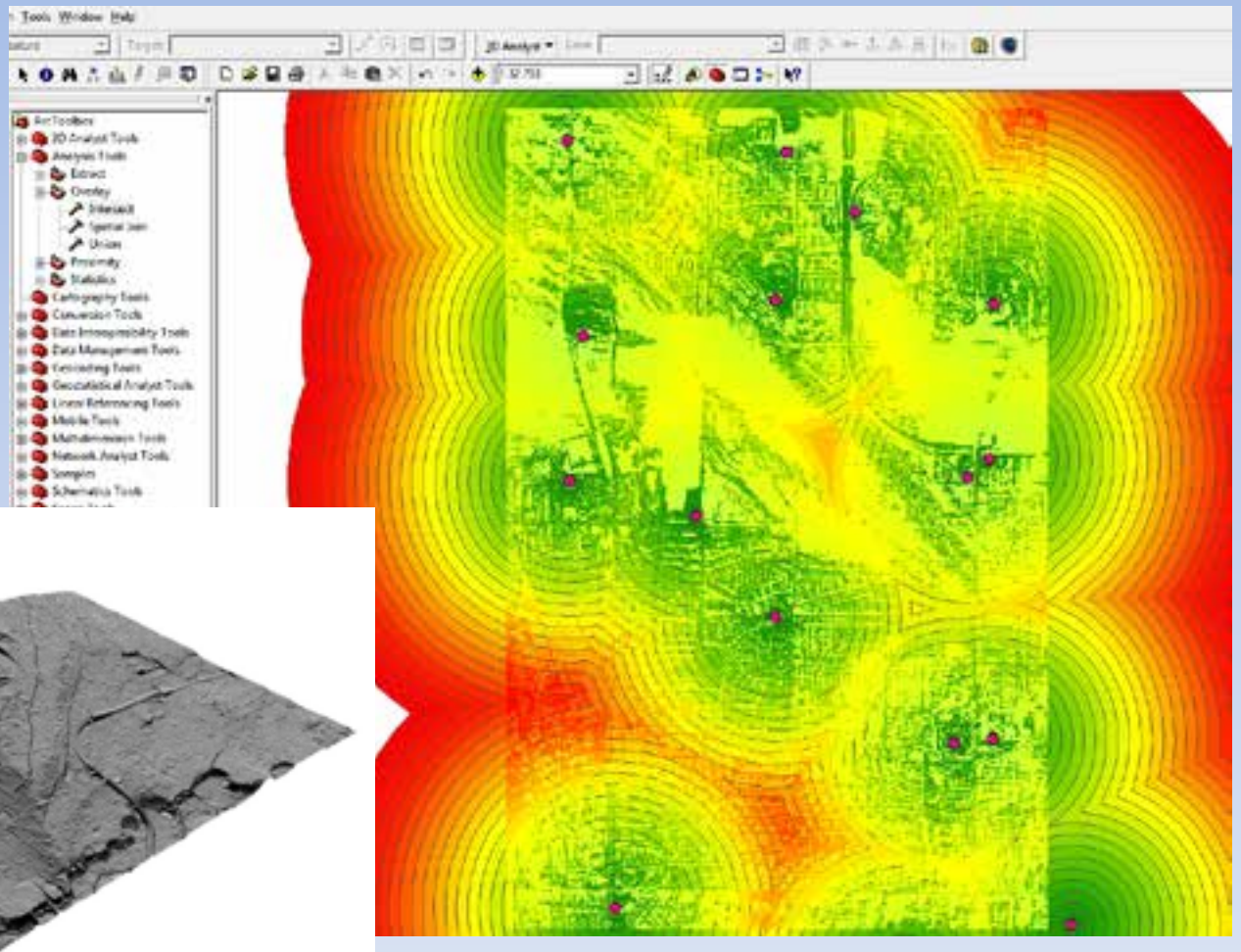
2010 Census Data

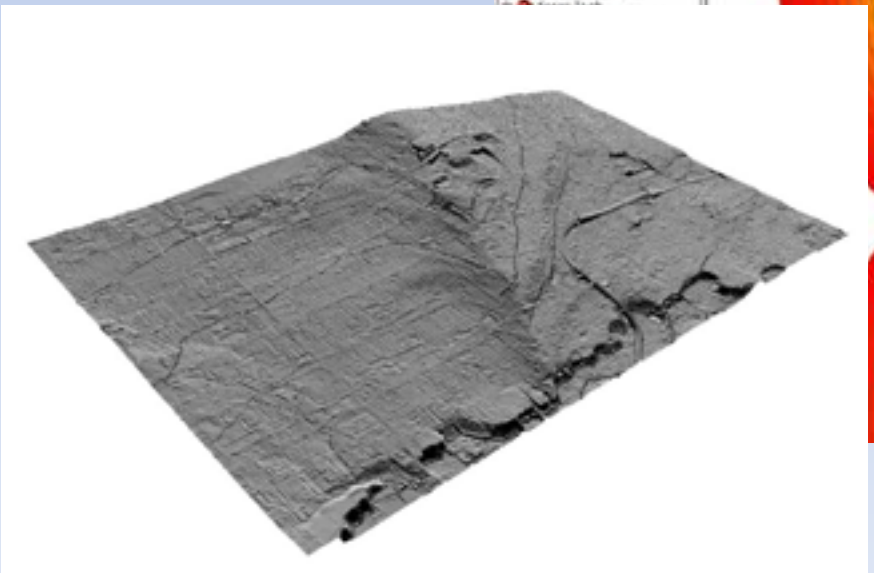
Data resources should
be regarded with care

Tower Analysis Process

Inputs:

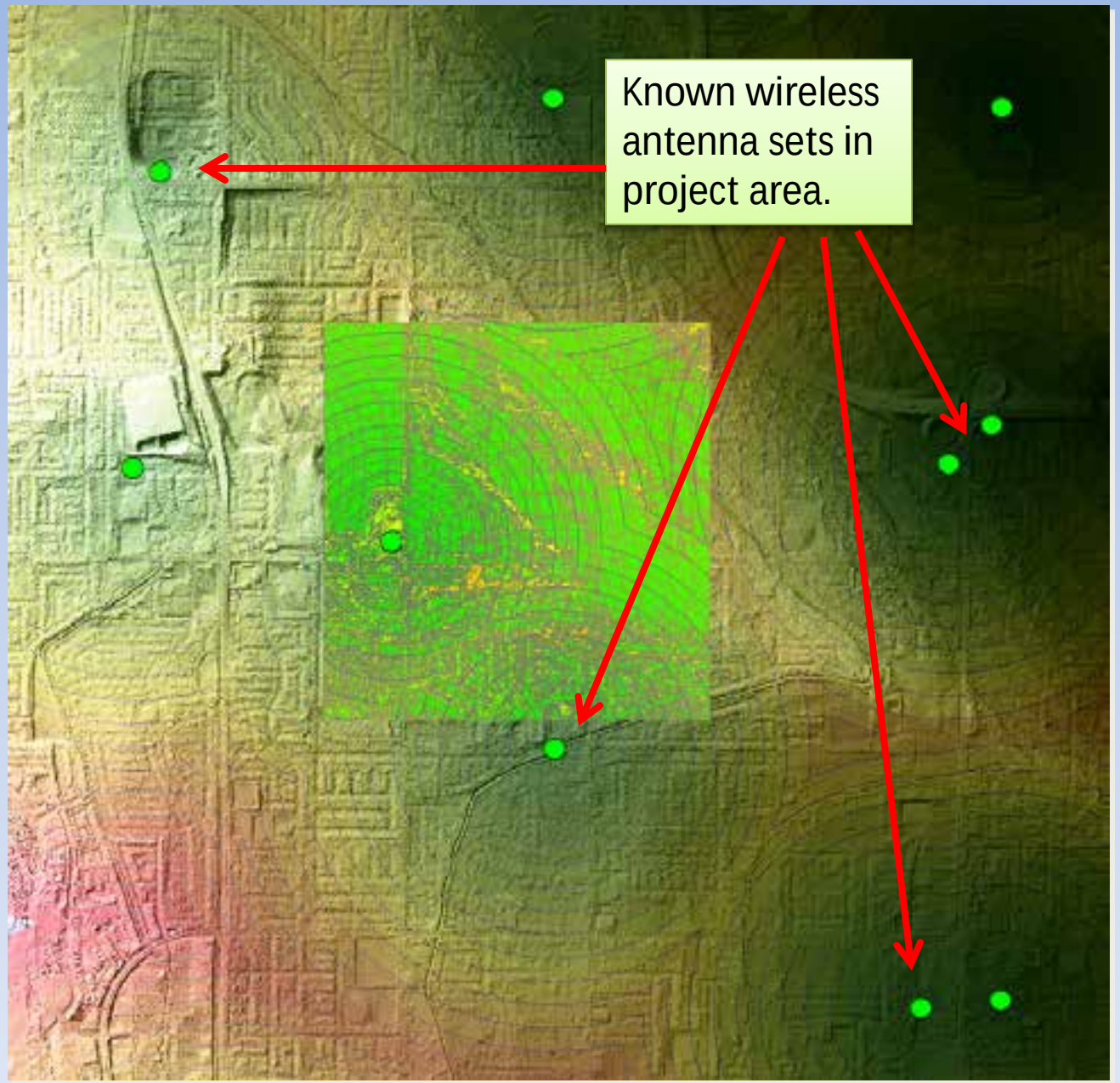
- Tower x, y, z – NAIP
- Industry decay stds meter buffer rings (dissolve function replicates handoffs)
- 2 meter LiDAR – bare earth.





Playing with the data, searching for relationships, testing alternatives based on common framework wireless industry standards

Intersect Tool in ArcToolbox was key



3D analysis

Viewshed for two simulations using 2 meter bare-earth LiDAR data:

1. Minus eight meters to account for generalized suburban tree and building heights – 15 cellular tower observer points

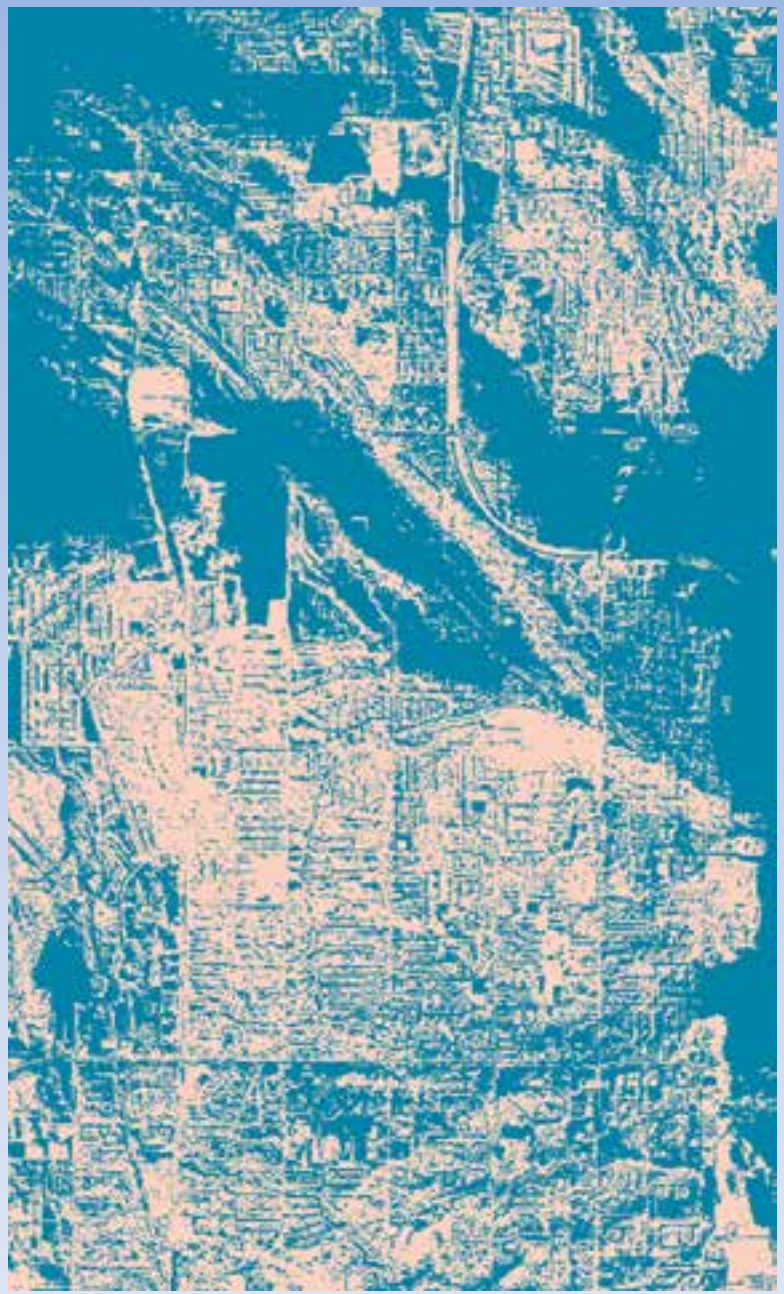
2. Plus eight meters to investigate potential improvement in line-of-sight results – 17 tower observer points (two added for improved coverage)

Using 3D Analyst calc'd viewsheds for varying height profiles

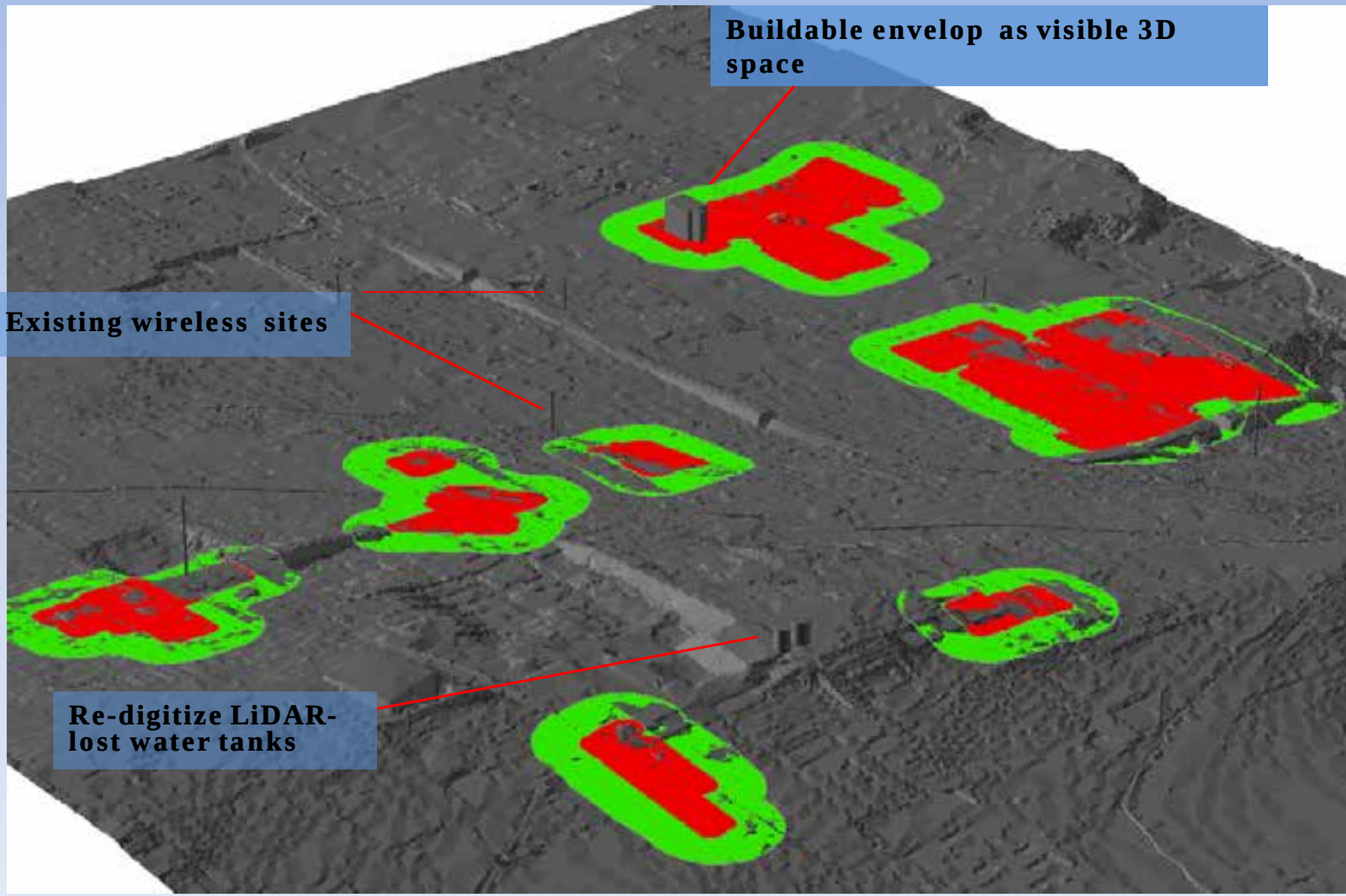
Reclassified into separate visible/non-visible layers and converted into vector contours.

Viewshed for total visibility – Line of Sight for vantage point scenarios often requested by local planning committees;

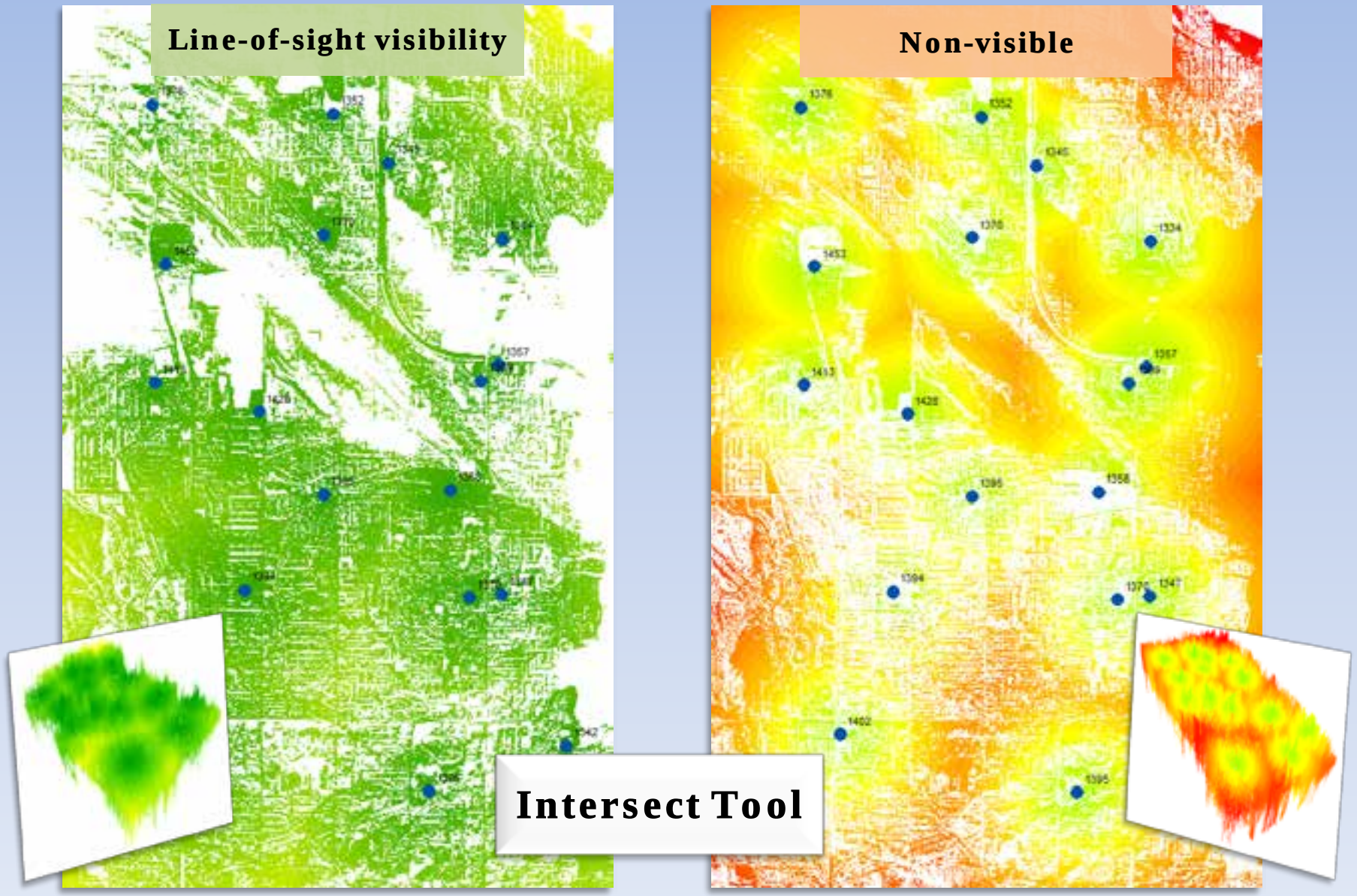
Photo sims for visualization



LiDAR to contour to TIN

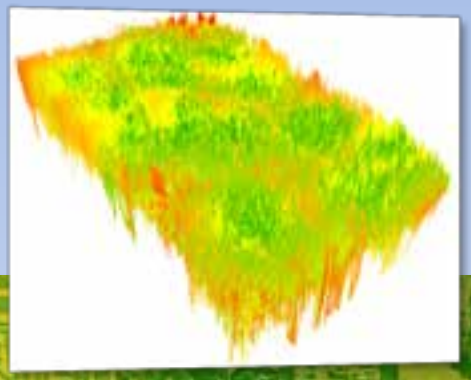


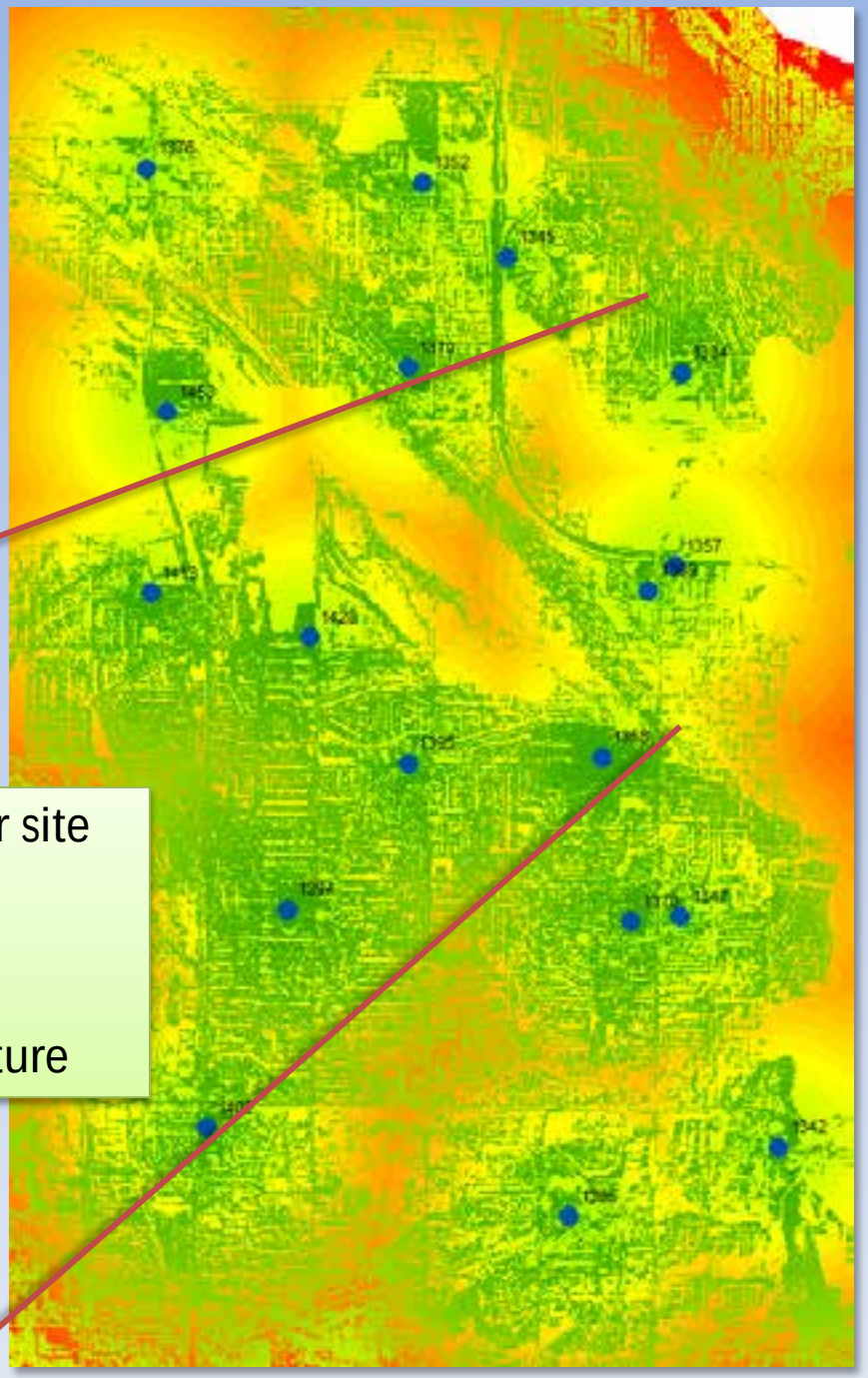
On/Off vector data intersected with multi-ring buffer & color symbolization to simulate signal decay.



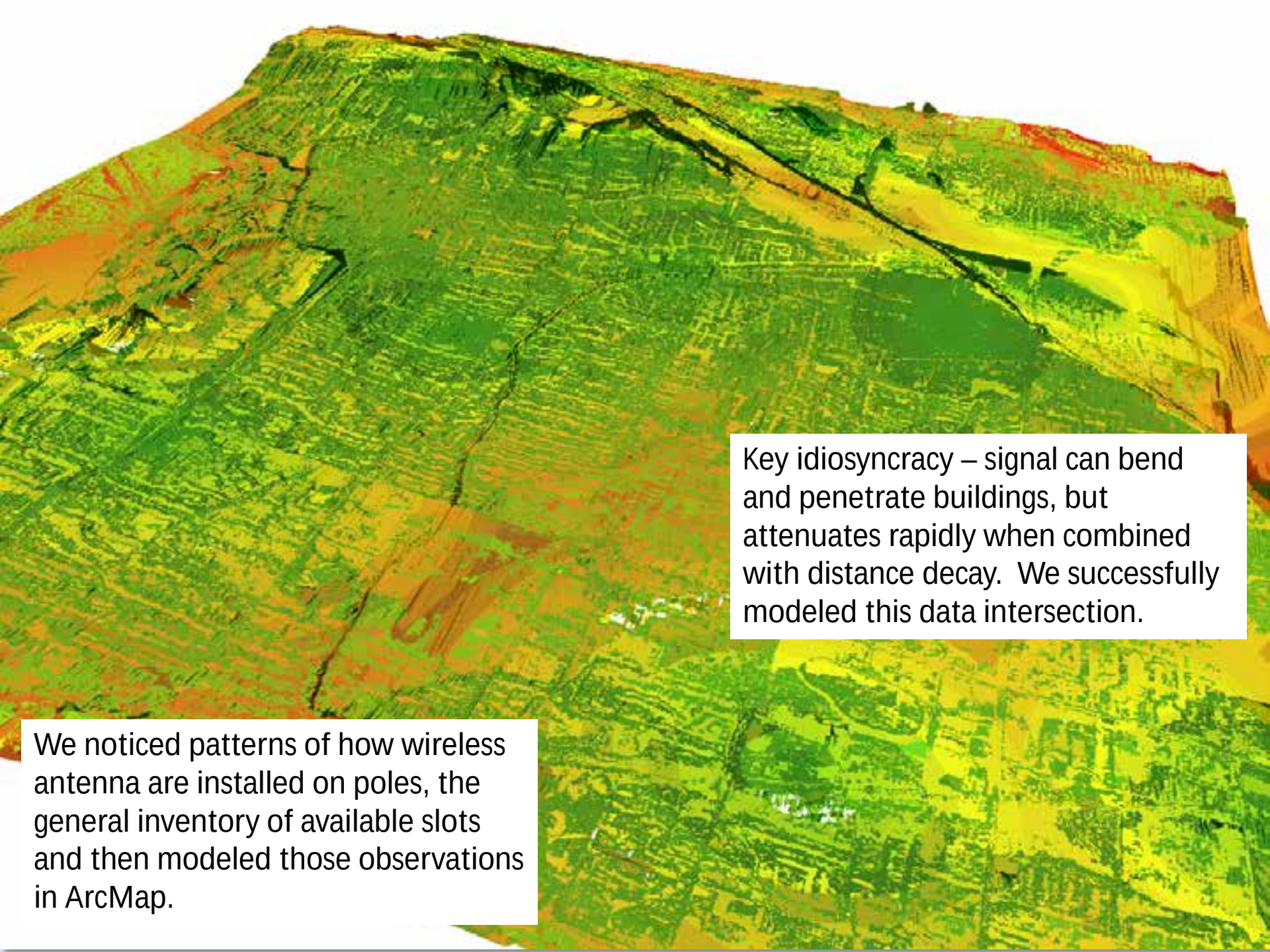
Combined visibility

(ramp cellular tower heights in meters AGL, with and without obstructions)





Zoom for site specifics versus network architecture



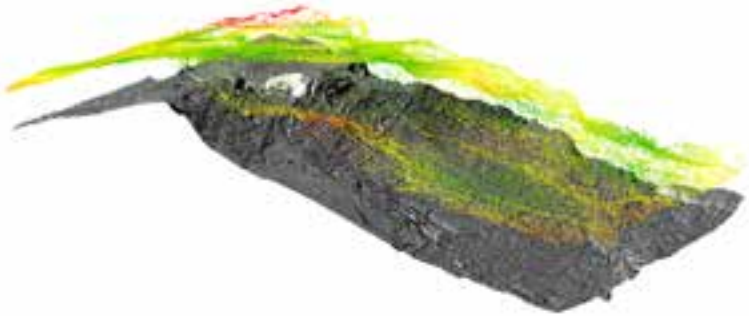
Key idiosyncracy – signal can bend and penetrate buildings, but attenuates rapidly when combined with distance decay. We successfully modeled this data intersection.

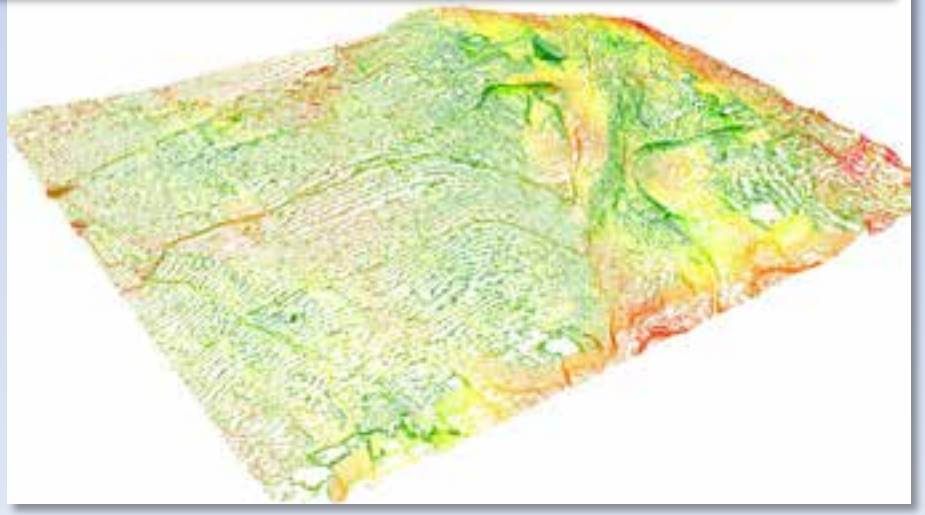
We noticed patterns of how wireless antenna are installed on poles, the general inventory of available slots and then modeled those observations in ArcMap.

Potential for Community Decision Tools

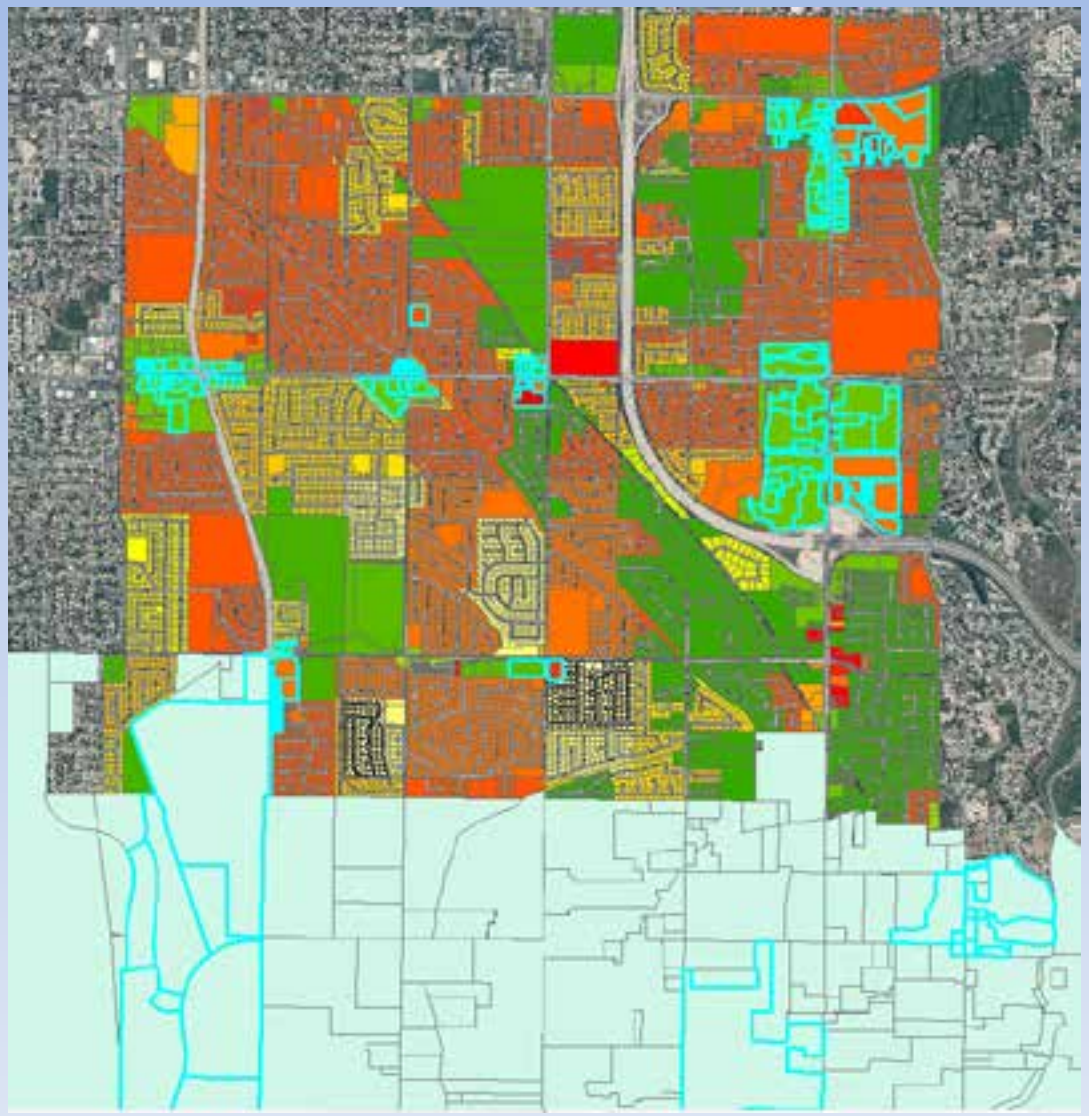
"Red Balloon" Tests – often helpful for visualizing wireless options.

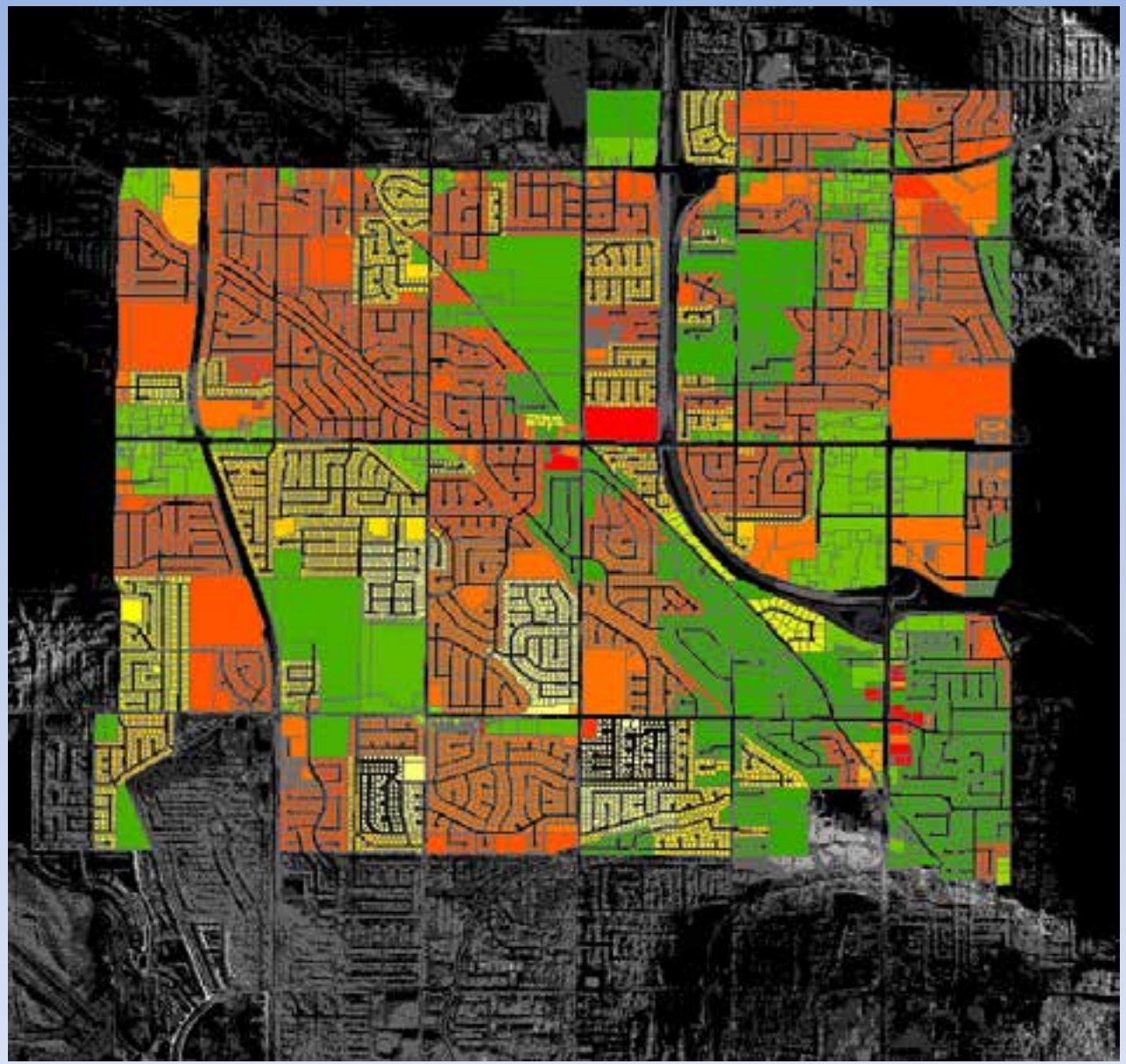
We had trouble integrating raster and vector, and GIS functionality is not universal across 3D and ArcScene.





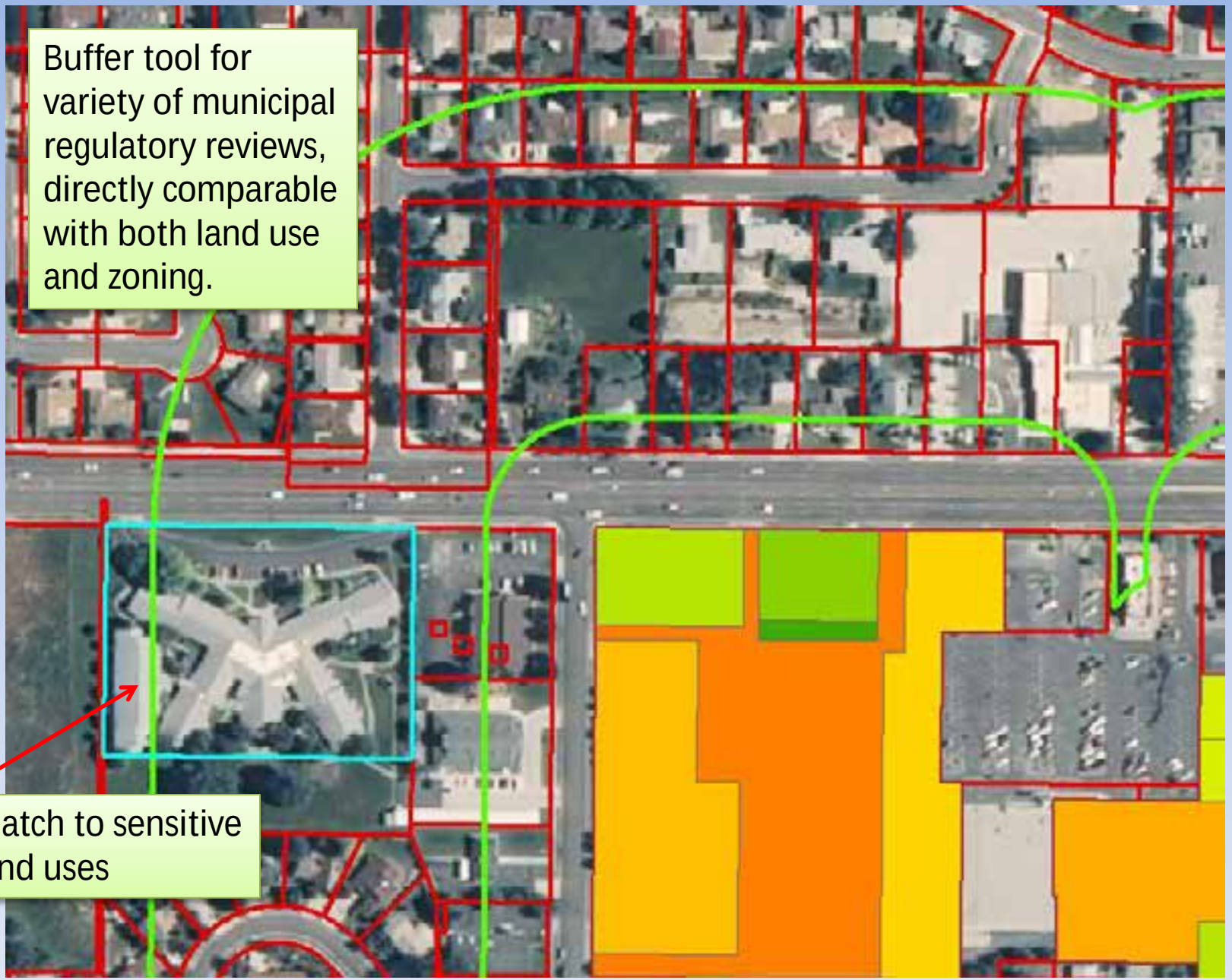
- Integrate zoning and land patterns across jurisdictions
- Converting “dry” language text into visual terms
- How well do neighborhood standards match network architecture?



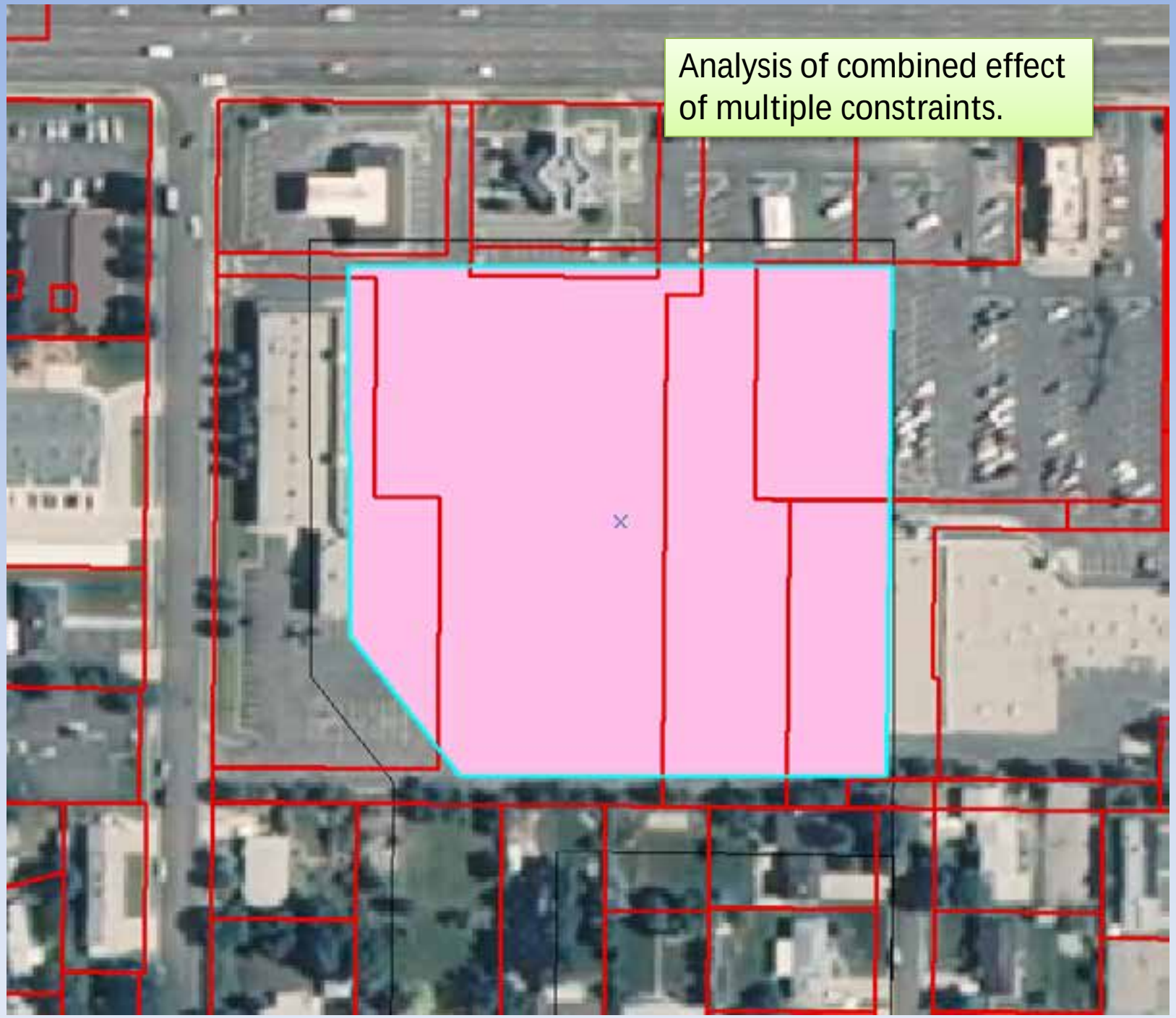


Integrating land use with terrain

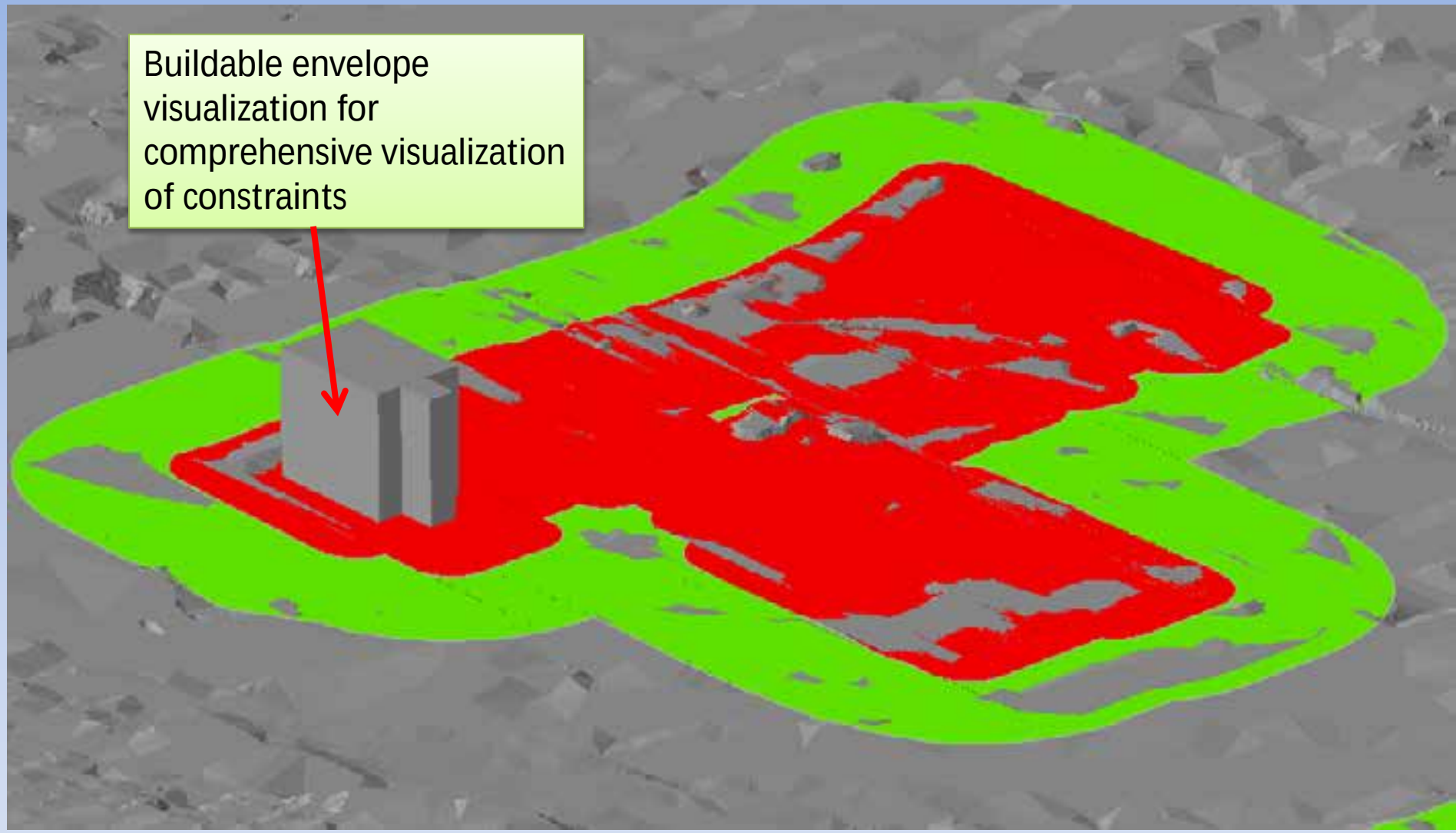
Rapid iteration modeling to evaluate selections based on intersections or unions of criteria: terrain, RF signal, land use controls, lease availability

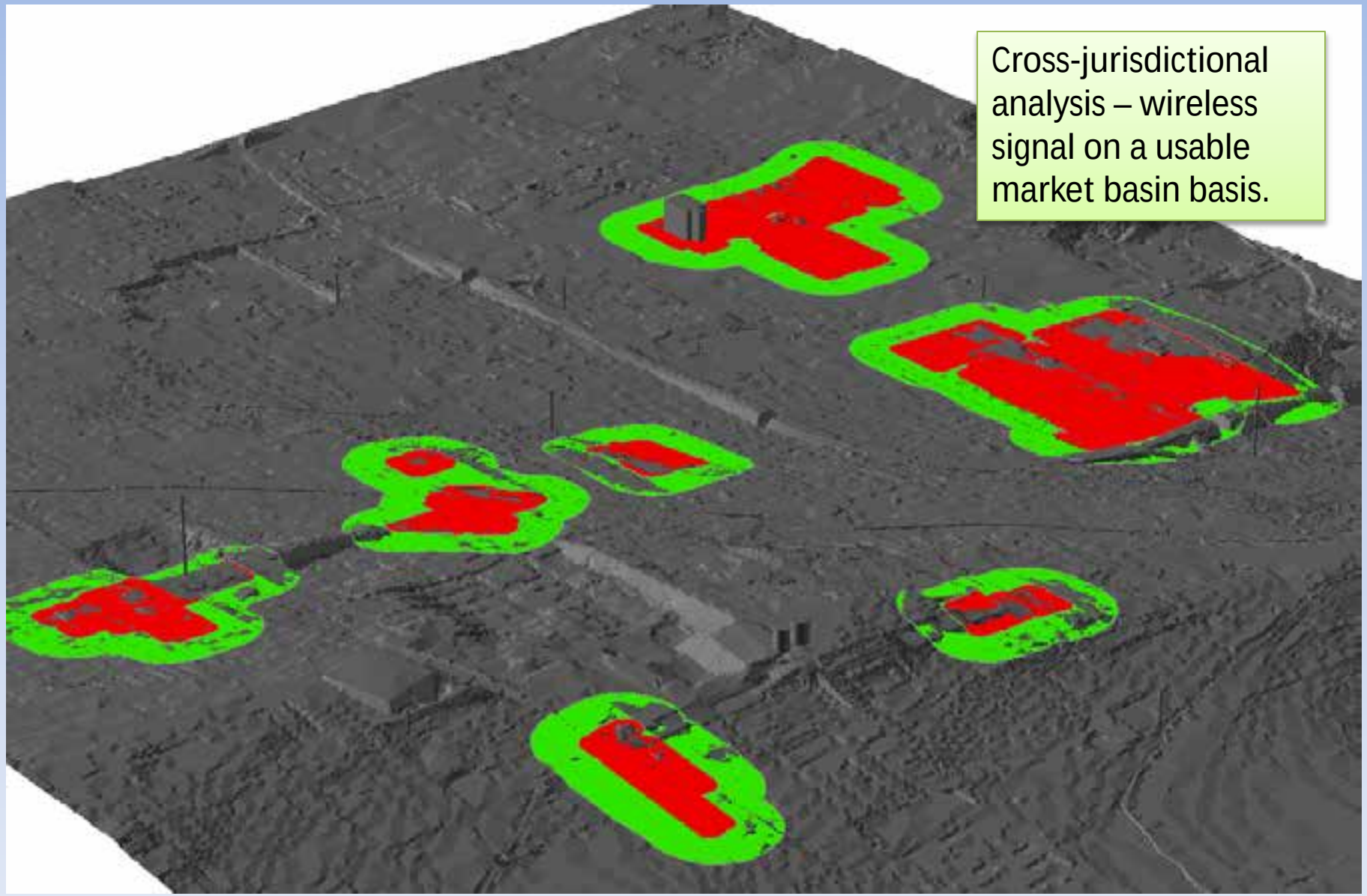

Buffer tool for variety of municipal regulatory reviews, directly comparable with both land use and zoning.
Match to sensitive land uses

Integrate with existing query functions for public notice mailings, etc.


Analysis of combined effect of multiple constraints.

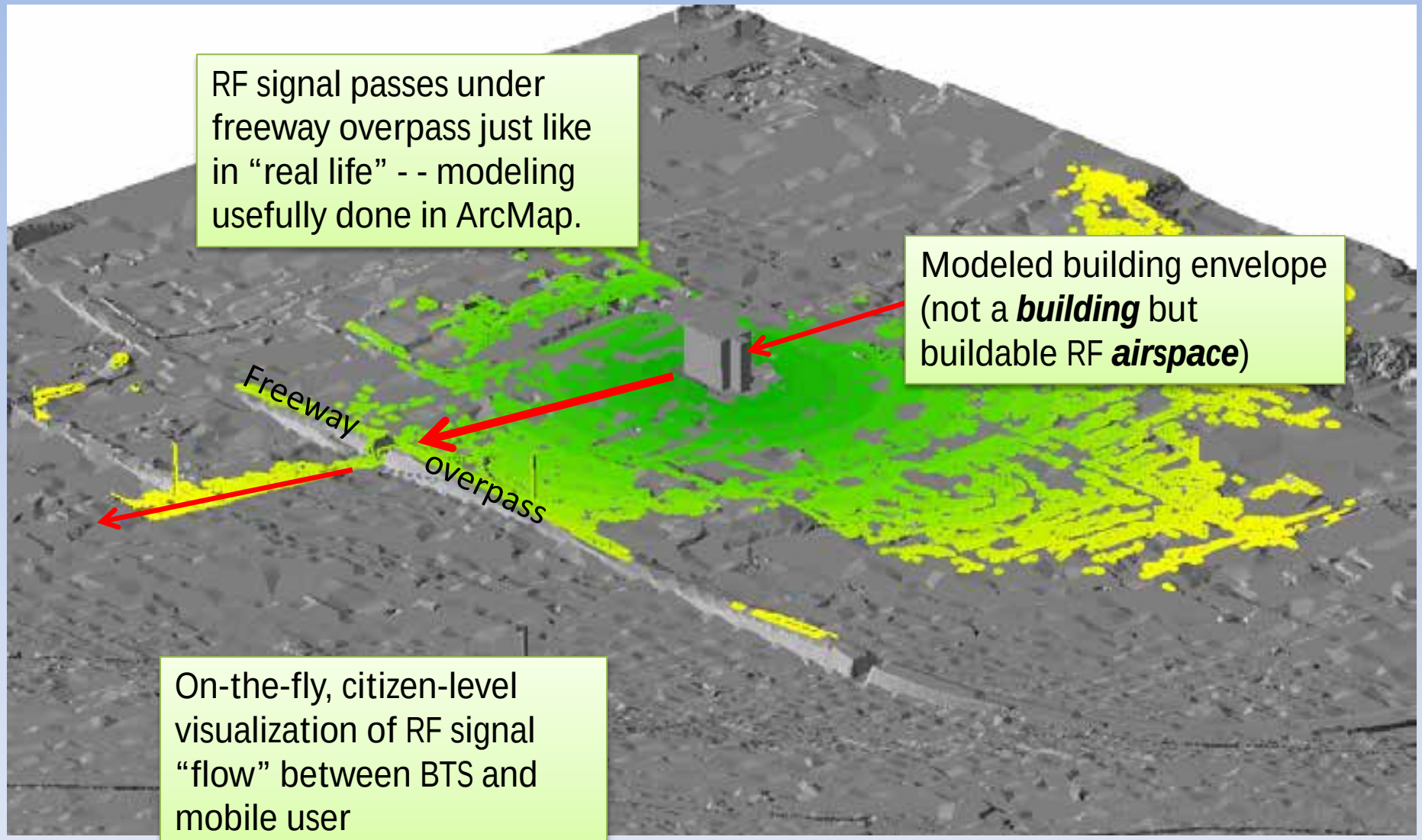
The confluence of all constraints can be made visible

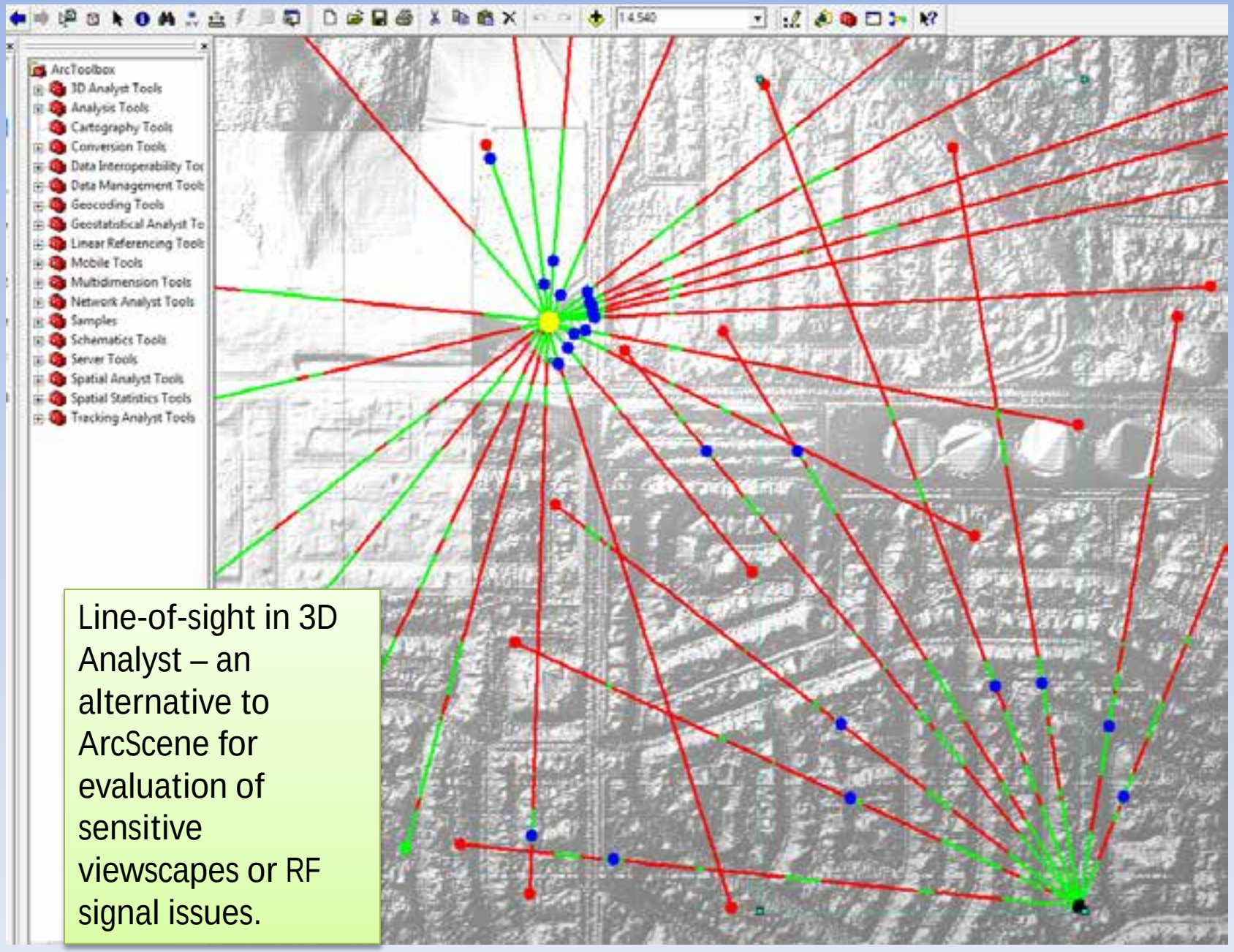

Buildable envelope visualization for comprehensive visualization of constraints



Cross-jurisdictional analysis – wireless signal on a usable market basin basis.

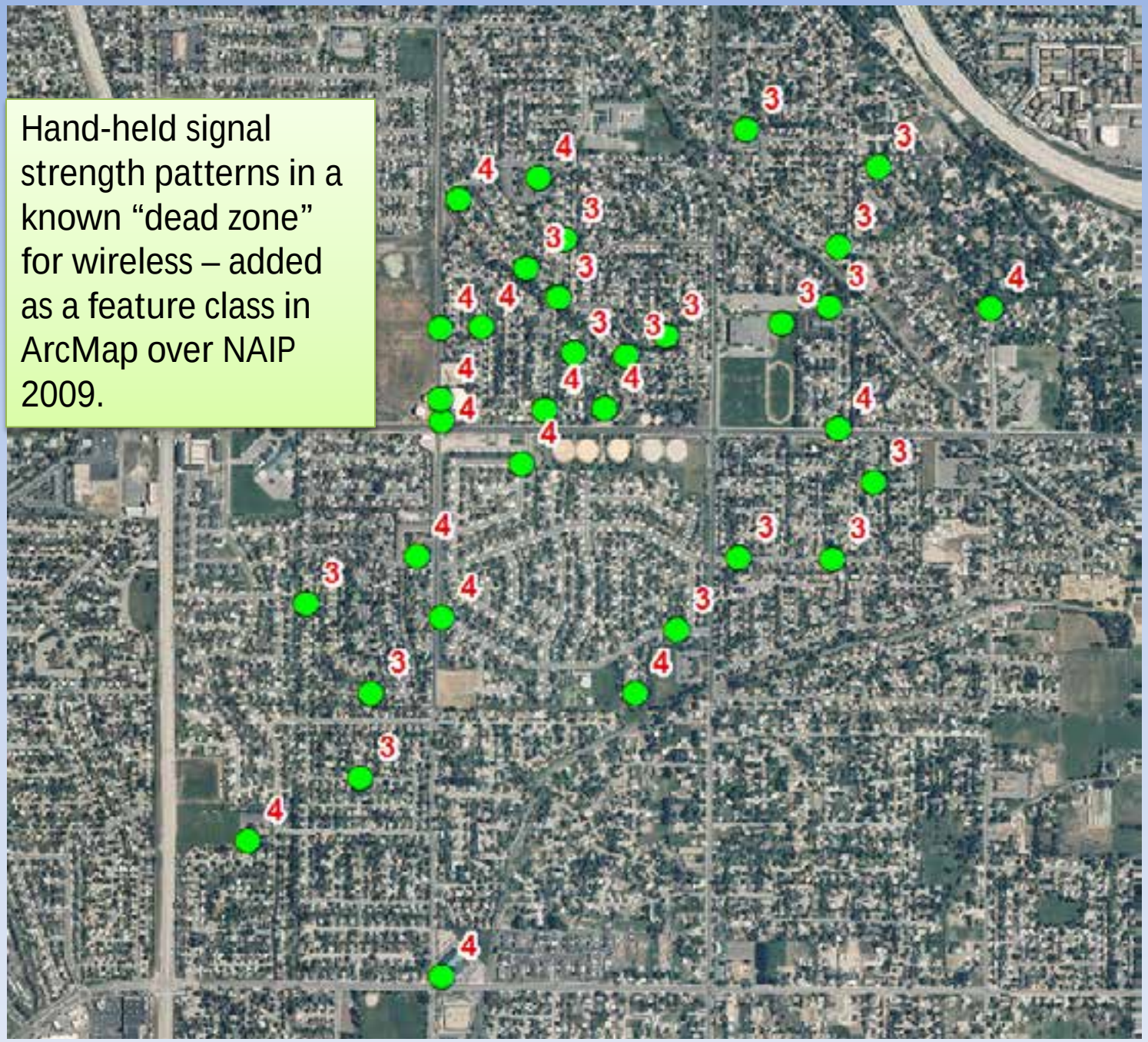
Using LiDAR-based terrain, ArcMap “signal” can replicate “look down” on roadways and under freeway overpasses - - more implications for “line-of-sight” and distance decay

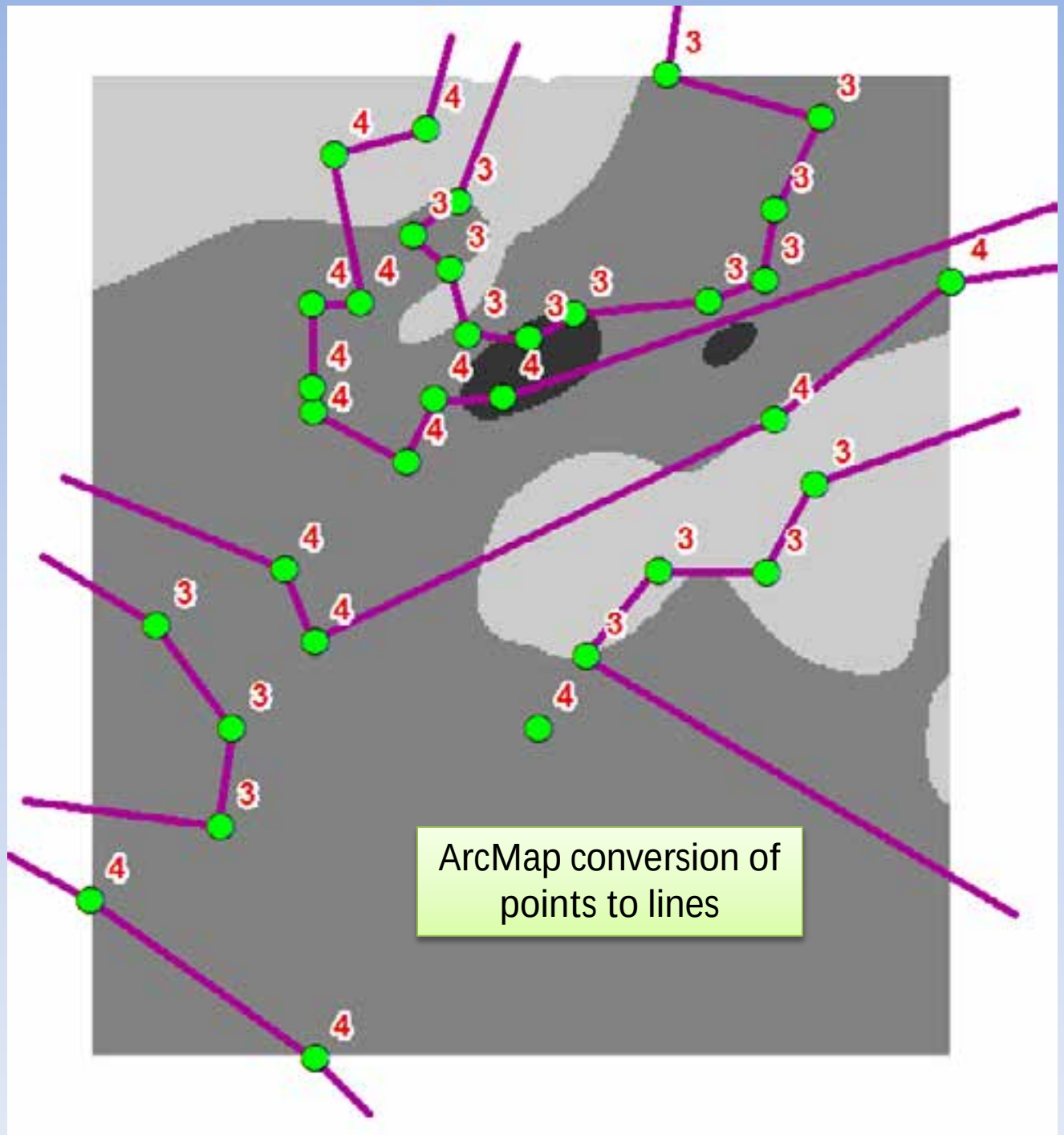


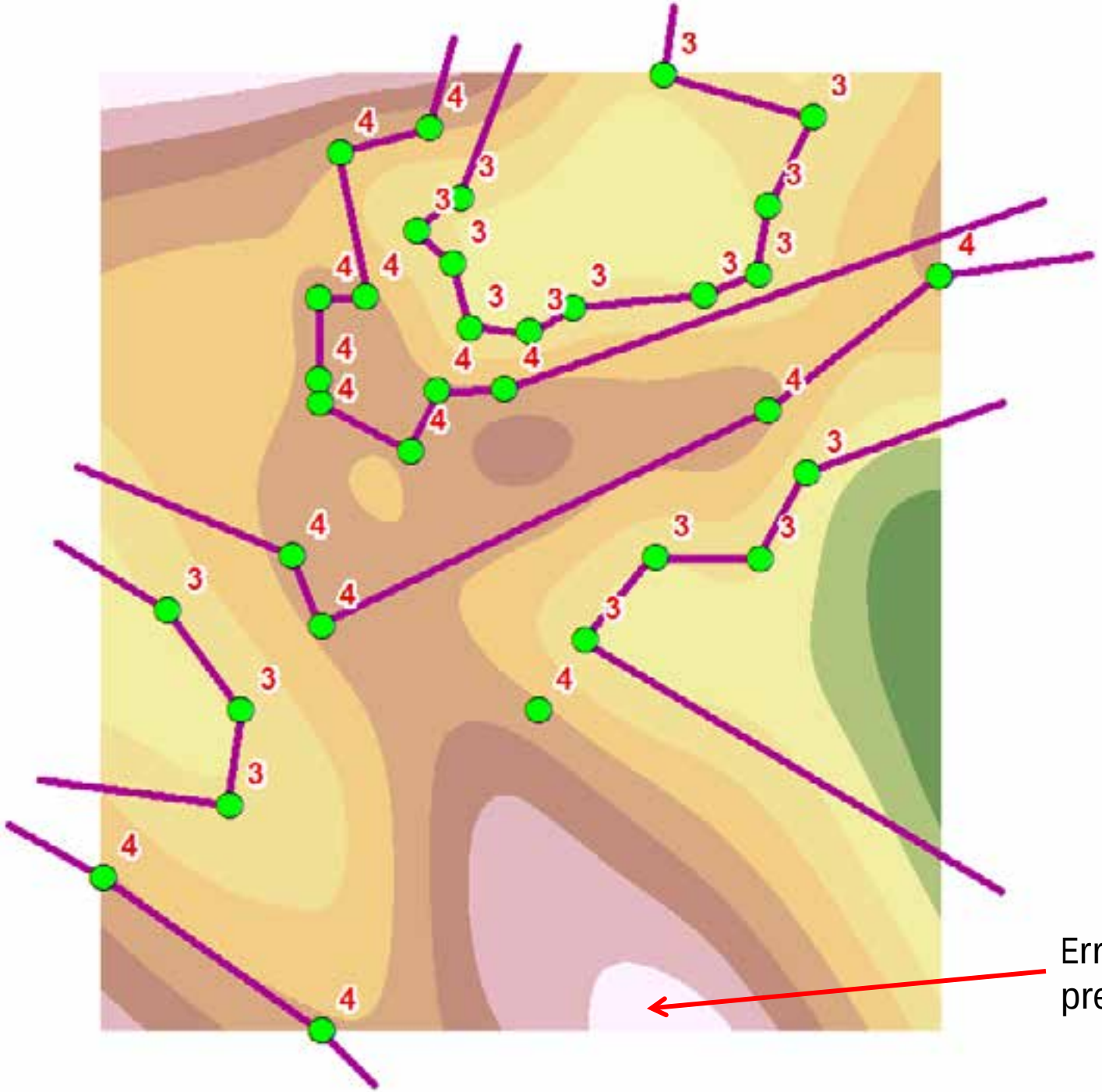


Line-of-sight in 3D Analyst – an alternative to ArcScene for evaluation of sensitive viewscapes or RF signal issues.

Hand-held signal strength patterns in a known “dead zone” for wireless – added as a feature class in ArcMap over NAIP 2009.




ArcMap conversion of points to lines

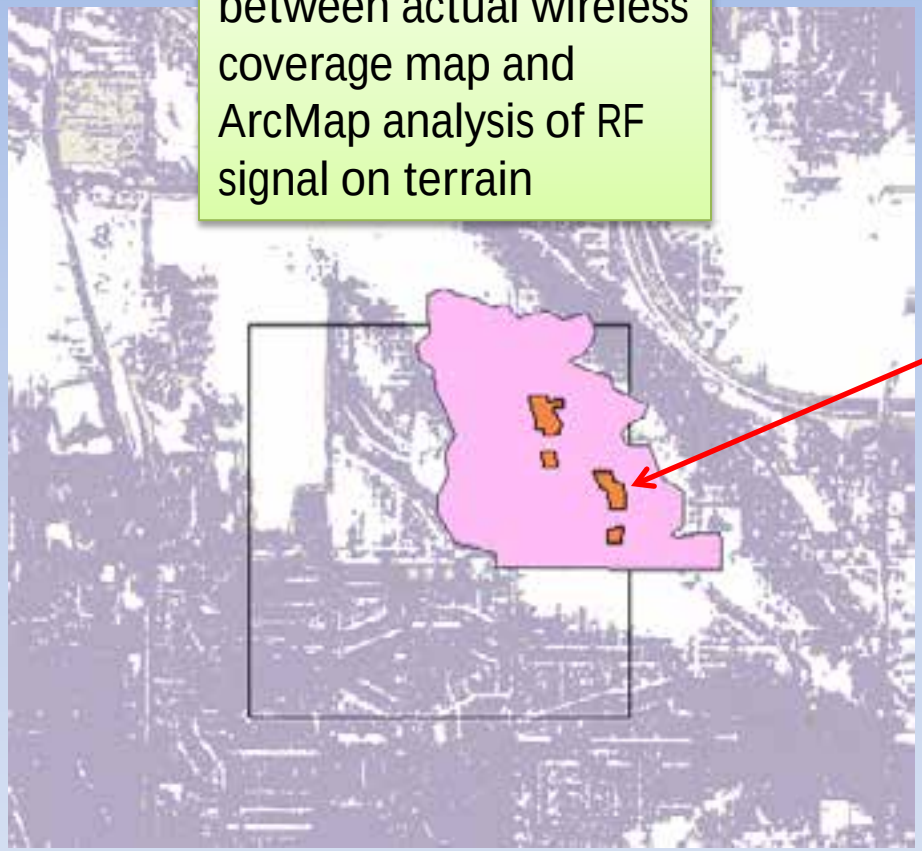


VGI – “crowd-source” could resolve the apparent shortage of data points for effective thematic map of “dead zone.”

Apparent level of accuracy is not warranted by the data.


Georeferencing accuracy at
wireless signal relevancy

Strong correspondence between actual wireless coverage map and ArcMap analysis of RF signal on terrain



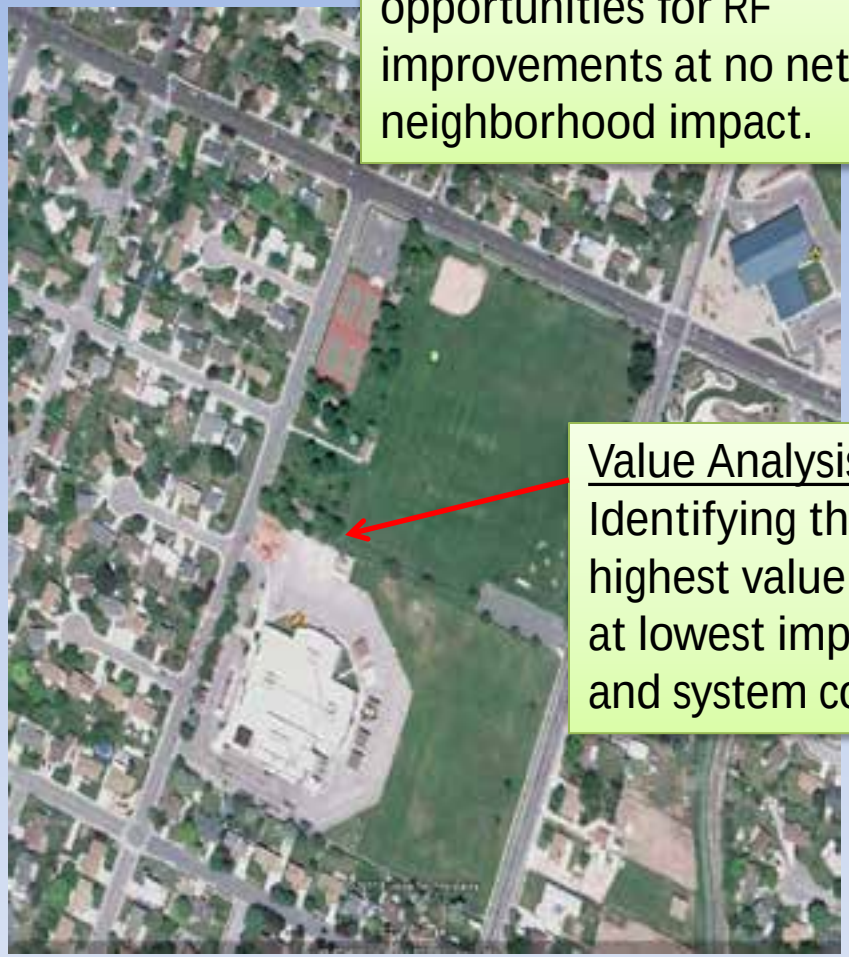
Alleged 4G spot shortage?

Evidence that a first-cut use of GIS can provide analyze and display RF signal in conjunction with constraints.

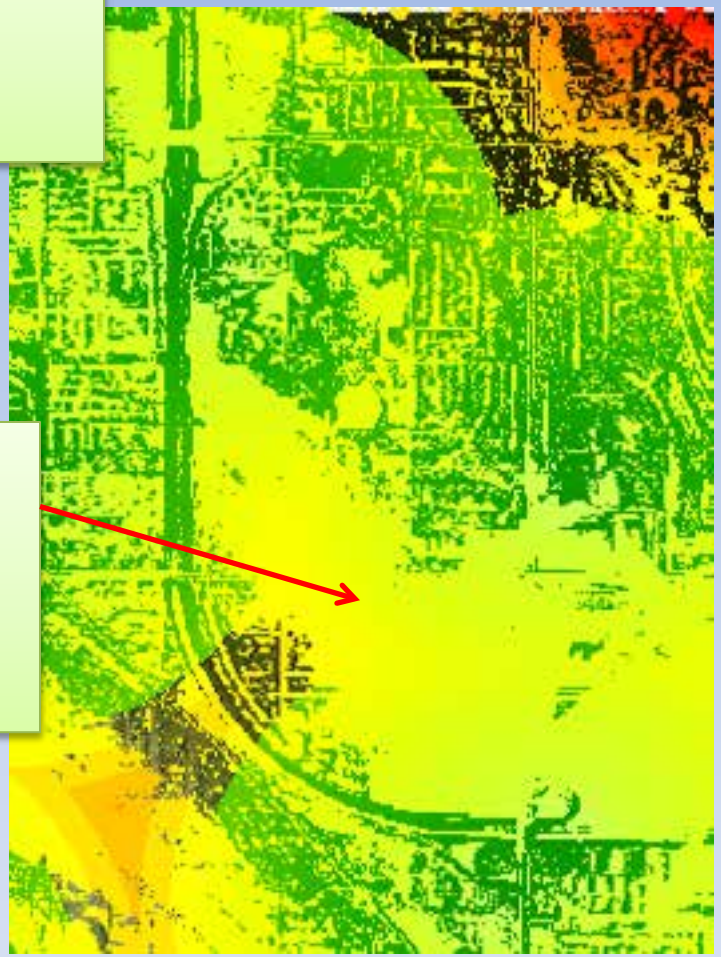
Some of our best community facilities have been relegated to "non-conforming" status – our system could get weaker before it gets stronger

Relevancy of line-of-sight as a genuine constraint on signal more than aesthetics.

Visualization for hidden opportunities for RF improvements at no net neighborhood impact.



<u>Value Analysis</u>: Identifying the highest value site at lowest impact and system cost.



Solo amateur “ham” radio operators are sometimes accorded more “envelope” than commercial providers that serve mass customers

Local Land Use Planning Policy and Law

- The history of land use planning in the United States has been “Euclidean” – separating land uses. In contrast, GIS inherently integrates.

- We did not find any Utah municipal comprehensive plan that provided enabling language or policy to guide land use controls, including zoning. Aside from questions of planning law, if the broad design of communities ignores wireless, then it is not surprising if zoning ordinances often do also. Where zoning does control, the language is strongly conservative.

- Most regulatory language is scattered across definition sections, supplementary and qualifying and through-out widely varying zoning types. GIS provides easy tools for visualizing these in combination.

- We found that GIS symbolization tools were the strongest aspect of using GIS to integrate wireless with terrain and land use controls.

Competing Policy Issues

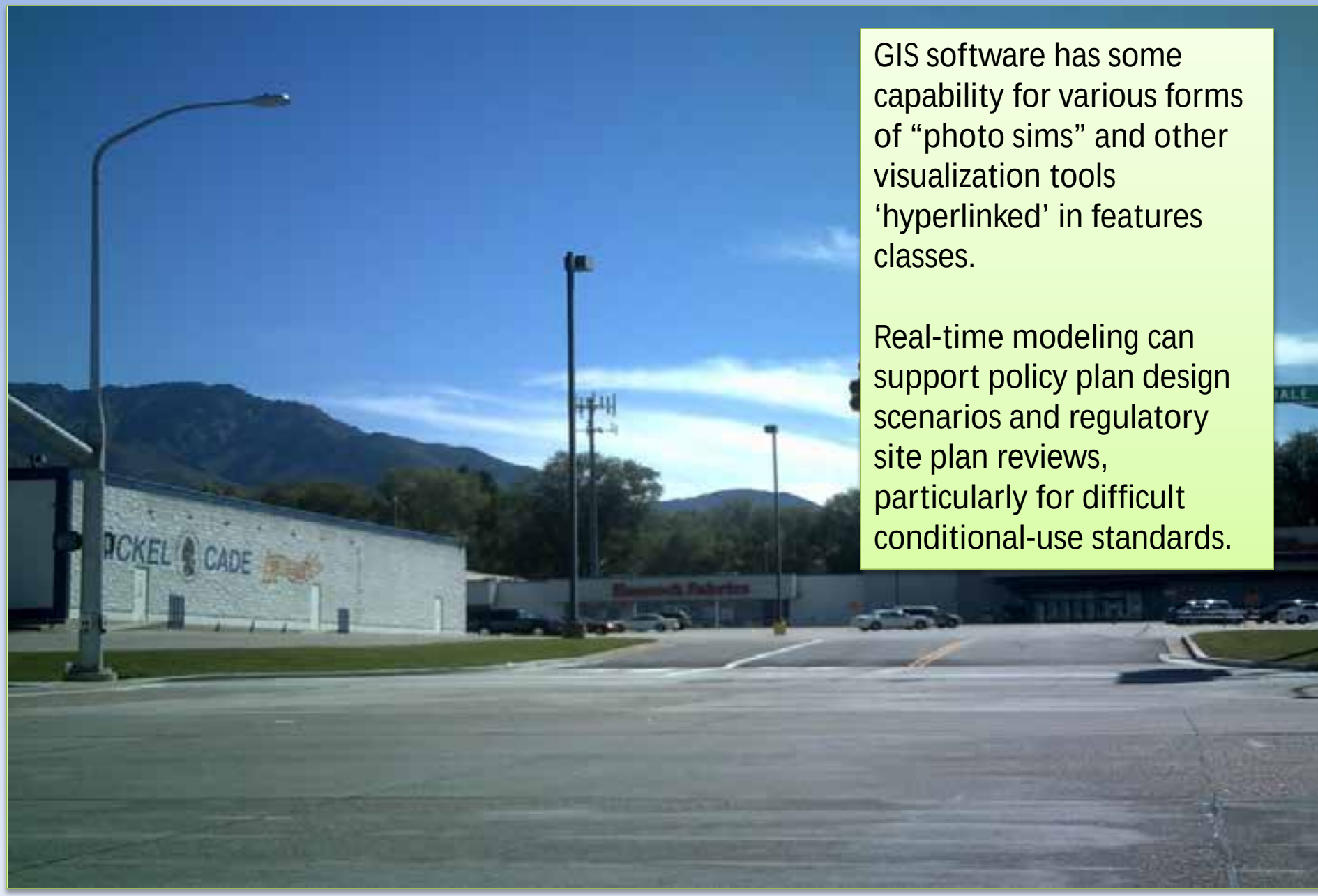
- Wireless providers appear very interested in quickly reinvesting cost savings into systems that are vulnerable.

- Restrictions to building mounts do not help if there are no buildings.
- Buildings create obstructions that limit their value as mounts.

- Many ordinances require submission of wireless plans, very different from requirements for establishing a shoe store.

- Few local units of government have GIS or other databases that focus on the range of needs inherent to wireless. There is no “champion” for inventories and network tracking for communications parallel to more traditional networks for water, sewer and roads.

- Enterprise-level GIS can apply to municipalities as well as private business - disconnects abound in both: wireless engineers have to filter through marketing, site management, and sales. The same is true within City Hall. GIS is a bridge.



GIS software has some capability for various forms of “photo sims” and other visualization tools ‘hyperlinked’ in features classes.

Real-time modeling can support policy plan design scenarios and regulatory site plan reviews, particularly for difficult conditional-use standards.

(1st Run Sample) Park City, UT – related Telecommunication Ordinances

Chapter 17.76 WIRELESS TELECOMMUNICATIONS FACILITIES

Sections:

(5) A visual impact study, graphically simulating through models, computer enhanced graphics or similar techniques, the appearance of any proposed Telecommunications Facility and indicating its view from at least five (5) locations around and within one (1) mile of the proposed Telecommunications Facility will be most visible.

Section 611 Exceptions to Height Limitations.

Penthouse or reef structures for the housing of elevators, stairways, tanks, ventilating fans, or similar equipment required to operate and maintain the building and fire or parapet walls, skylights, towers, steeples, flagpoles, chimneys, smoke stacks, water tanks, wireless or television masts, theater lofts, silo, or similar structures may be erected above the height limits herein prescribed, but no space above the height limit shall be allowed for the purpose of providing additional floor space.

Ogden City – related Telecommunication Ordinances

5-2B-3: TAX RATE:

The rate of the tax levy imposed in this article shall be four percent (4%) of the telecommunication provider's gross receipts from telecommunications service that is attributed to this municipality, subject to the requirements of section 10-1-407, Utah Code Annotated, or its successor provision.

(Ord. 2004-35, 5-25-2004)

7-15-22: NEW DEVELOPMENTS:

It shall be the policy of the City to liberally amend this Chapter, upon application of a provider, when necessary to enable the provider to take advantage of any developments in the field of telecommunications which will afford the provider an opportunity to more effectively, efficiently, or economically serve itself or the public.

(1979 Code § 12.46.220; Ord. 97-69, 9-23-1997)

D. Finding Regarding Promotion Of Telecommunications Services: The city finds that it is in the best interests of its taxpayers and citizens to promote the rapid development of telecommunications services, on a nondiscriminatory basis, responsive to community and public interest, and to assure availability for municipal, educational and community services.

2. Design And Placement Of Tall Buildings: Any building or structure proposed to be in excess of thirty five feet (35') tall that is next to a residential or open space zone shall be set back thirty five feet (35') plus one foot (1') for every foot the building is taller than thirty five feet (35'). A building or structure may stagger the height as long as the height of the section that is over thirty five feet (35') meets this setback from the residentially zoned property line.

7. Ensures that no barriers to entry of telecommunications providers are created and that such franchising is accomplished in a manner that does not prohibit or have the effect of prohibiting telecommunication services, within the meaning of the telecommunications act of 1996 ("Act") (public law no. 96-104).

Freestanding utility or communication facilities, e.g., substations, relay towers, commercial transmitting towers.	C	C	C	C	C

Utah County

G. HEIGHT REQUIREMENTS

The height requirements within the RA-5 Zone shall be as follows:

1. The maximum permissible height of any structure shall be forty (40) feet as determined by the currently adopted building construction codes of Utah County or by any future edition of these codes that may be adopted.

Exception 1: An antenna of a "stealth telecommunications transmission facility" which is attached to an existing pole of an electrical (or other utility) line (or placed on a replacement pole therein) may exceed the initial elevation of such pole by no more than 10 feet.

Exception 2: For large scale utility line structures, there shall be no maximum height.

Exception 3: Otherwise, a height in excess of 40 feet, if for unoccupied structures, may be approved by the Board of Adjustment as a conditional use granted according to the terms of chapter 7 of this land use ordinance.

City of Orem

Article 22-13. Wireless Telecommunications.

22-13-1. Title.
22-13-2. Purpose.
22-13-3. Findings.
22-13-4. Definitions.
22-13-5. Applicability.
22-13-6. Application Requirements.
22-13-7. Approval Process.
22-13-8. Building Permits Required.
22-13-9. Location and Type Priority.
22-13-10. Permitted Uses and Locations.
22-13-11. Specific Regulations by Type.
22-13-12. Additional Conditional Use Permit Considerations.
22-13-12. Lease Agreement.
22-13-13. Safety.
22-13-14. Additional Regulations.

City of Moab

17.76.010 Purpose.

In order to accommodate the communication needs of residents and businesses while protecting the public health, safety, and general welfare of the community, the council finds these regulations are necessary in order to:

A. Facilitate the provision of wireless telecommunication services to the residents and businesses of the city;

B. Minimize adverse visual effects of towers through careful design and siting standards;

C. Maximize the use of existing and approved towers and buildings to accommodate new wireless telecommunication antennas in order to reduce the number of towers needed to serve the community.

(Ord. 01-04 (part), 2001)

SECTION 1. Section 17.6.112-C-1-e establishing minimum allowable distances between monopole cell towers and adjacent residences is hereby amended to read as follows:

e. Distance from Residences

(1) New Monopole - No monopole structure shall be located closer than six hundred and fifty (650) feet from any residence when the pole is located in a residential zone, or six hundred and fifty (650) feet from any residential zone boundary when proposed for placement in a professional office, commercial, industrial or public facilities zone. *(Subparagraph e. amended by Ordinance 2008-12-48)*

This "model" community actually has much more restrictive separation requirements than most.

(2) Additional Antenna on Existing Monopole - Notwithstanding the provisions of Sub Paragraph 1 above, additional antenna may be added to an existing monopole structure located in any commercial or industrial zone provided, that the existing pole is located not closer than four hundred (400) feet from any

No surprise that wireless planner laments that the 'model' is not getting used.

Sample Ordinance Modifications

- **"**Transportation Objective 4.5.1: Develop a greater recognition and understanding of the relationships between land use, economic development, community identity and transportation *and communication facilities*.
- Community planning is heavily involving in marketing for business investment. We found no evidence that communities want business investment by the wireless industry, perhaps because the service is not "visible" but the antennae are.
- Planning language may tout a community as *"#1 in community baseball"* or *"business-friendly"* – visualization could make such marketing terms more inclusive. It's great to be the sugar beet capitol of the world - - what about the being fastest wireless network in the west.
- Instead, wireless providers routinely disclaim with *"not available in all areas."*
- "Free-standing wireless antennae may not extend above heights for all uses in <zone> or 70 feet, whichever is less." <by definition, antennae may not rise above line-of-sight obstacles, or worse.
- Utah League of Cities and Towns has model ordinances and other tech help for such things as street trees and wind generators. No evidence was found in support for communication technology design allowances.

PART II
PENALTY AND ADOPTION

SECTION 1. - Conflicting Provisions. Whenever the provisions of this Ordinance conflict with the provisions of any other ordinance, resolution or part thereof, the more stringent shall prevail.

In many ordinances, wireless facilities are regulated with much of the same language and terms for such things as *"Class A Beer"* outlets and 'dog and cat grooming."

A Few Conclusions

- Regulatory reform could have a multiplier effect on reducing some very costly aspects of networks: being held “hostage” by land owners for prime sites in markets that are more constrained than they appear.
- Consistency across jurisdictions in plan approval requirements can reduce business cost by bringing time-saving economies-of-scale in preparing and negotiating land use entitlements..
- Inherently, private companies do not want to reveal sensitive information about apparent business weakness in order to make an argument for business approval.
- Buying shoes at a shoe story doesn’t depend on how many shoe stores are nearby – but for people buying wireless service, the network of service outlets is crucial. This unique condition begs the question of regulating wireless using different tools. GIS visualization could be one of those tools.
- desktop software and hardware can go a long way if umbrella organizations assist in development of “apps” and specifications for spatial modeling. ESRI is moving in that direction on many other fronts, including utility networks that could easily include wireless.

Conclusions, con't.

- Being able to take control of visualizing wireless networks makes the consumer and local government more able to take responsibility for a neglected aspect of system evolution.
- Visualizing wireless creates a "negotiable landscape" that is more textured, more responsive and provided more options.
- Land use control can be more viewed as "land use opportunity" when wireless can be visualized by how the service looks rather than just on how the antenna looks.
- Regional organizations that routinely maintain inventories of land uses and promote regional policy cooperation could include wireless as a community asset rather than a neighborhood-level NIMBY nuisance.
- GIS groups already have relationships with allied organizations: AIA, APA, ASLA, LCT, ICMA, CPP, Envision Utah, AGRC, COGS. The structure exists.
- Our own workflow begs for continued development for workflow, scripting and model building.

Conclusions, con't.

- Land use reviews can involve as many as four different sets of reviewers, including citizen groups, review committees, quazi-judicial commissions, legal counsel, and elected officials.
- Reviews can take months, adding to uncertain and overhead cost. Meanwhile, technology and customers move on.
- Improvements in wireless BTS entitlements can promote readiness for DAS systems that will require much more complex reviews. Once again, GIS is already well-developed for mapping, displaying and modeling underground networks.
- Ironically, developing countries may be moving faster at deploying 4G because they are not burdened by legacy systems and local regulatory complexities.
- International money may find developing markets more profitable.

State of Utah

Benchmarking City Performance

Emerging & Sustainable Tech

Wireless & Mobile Broadband

Digital Communities

Apparent strong awareness of leading-edge technologies but no direct support for wireless architecture at community level.

Smart Highways, Smarter Drivers

We may never get to a point where a city boasts of having the best darn sewers in town.

But we certainly might do better at promoting high standards for community design based on sharing the tools of design.

Get rid of the black box.
Remove adversarial conditions.

Perhaps it was just a happy coincidence, but very soon after this project was first shared with the broadband community, two new wireless base stations were installed that completely bracketed the area we identified as being particularly weak for signal.

When we quickly (easily) ran our own simulation, by inserting the new antenna sites into our signal simulator, we found the gap in wireless coverage completely disappeared.

Reprise

"Consumers ***as regulators***" respond better when:

1. they can see effects of their own work;
2. they feel responsible for their own outcomes.

- GIS supports fluid, real-time imagination.
- GIS promotes shared interest based on shared ***vision***.
- Imagination merges responsibility with authority.

Why plan for minimum community communication service when:

- natural disasters could severely test our ability to communicate at crucial moments?

- the “internet of Things” is fast-approaching?

- being competitive in a shrinking world is ever more important?