Web3D Collaborative Naval Visualization Workshop

6 Dec 2019

Virginia Tech Research Center

Peter Sforza
Director, Center for Geospatial Information Technology
Virginia Tech
sforza@vt.edu

Global Agroclimatology

Vineyard Site Suitability

DMV Crash Geolocation

Extension

NRV 911

Hazard Mitigation

Center for Geospatial Information Technology

VirginiaTech
Invent the Future

Local Research & Outreach

Virginia Veterans

Broadband

Geography

Computer Science

Civil Engineering

Urban Affairs & Planning

Extension

Plant Pathology

Meteorology

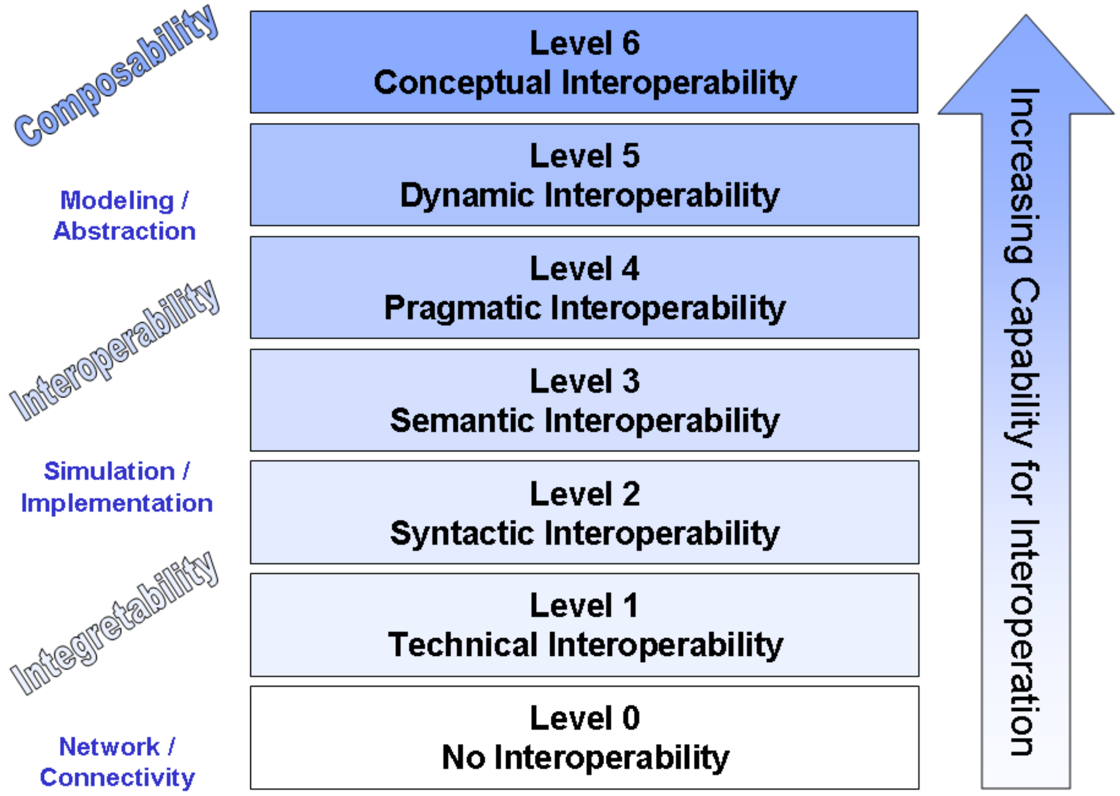
Electrical Engineering

Center for Geospatial Information Technology

VirginiaTech
Invent the Future

MOD-SIM Platform

- Meta-modeling
- Workflow management for CGIT-NECTAR
- Cloud
- Computing: HPC
- Data
- Integration points (python notebooks, MATLAB, SAS, etc)
- Code management



The Levels of Conceptual Interoperability Model: Applying Systems Engineering Principles to M&S https://arxiv.org/ftp/arxiv/papers/0908/0908.0191.pdf

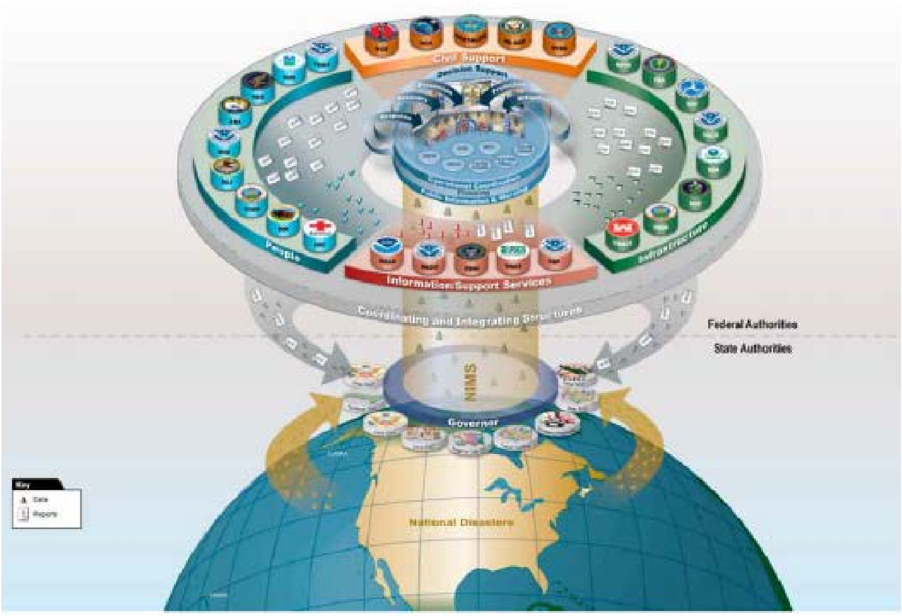


Figure 1.1: Disasters Geospatial Concept of Operations: Department of Homeland Security, USA

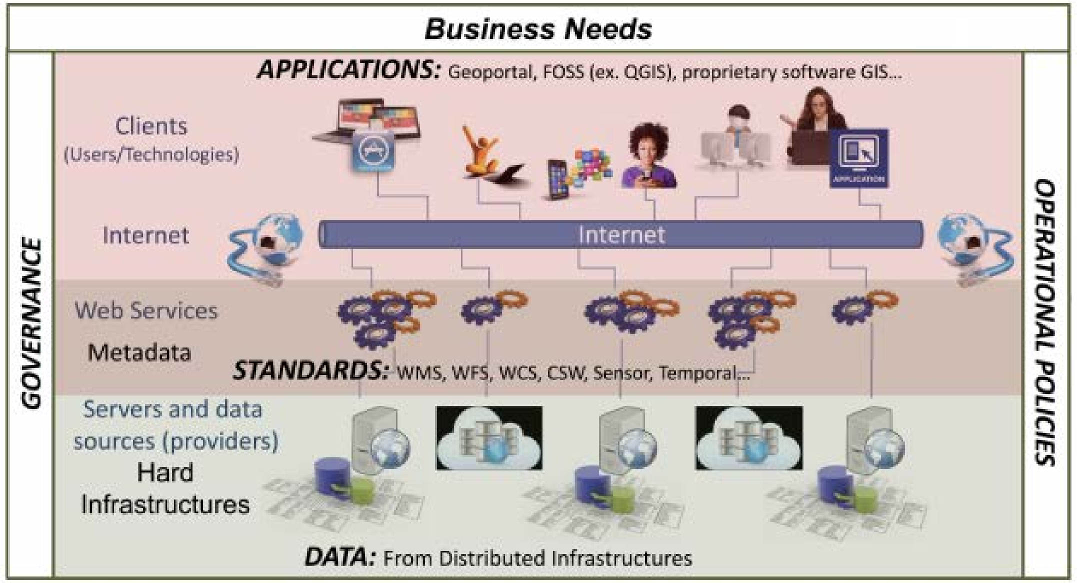


Figure 1.2: Aspects of an SDI (Source: Natural Resources Canada)

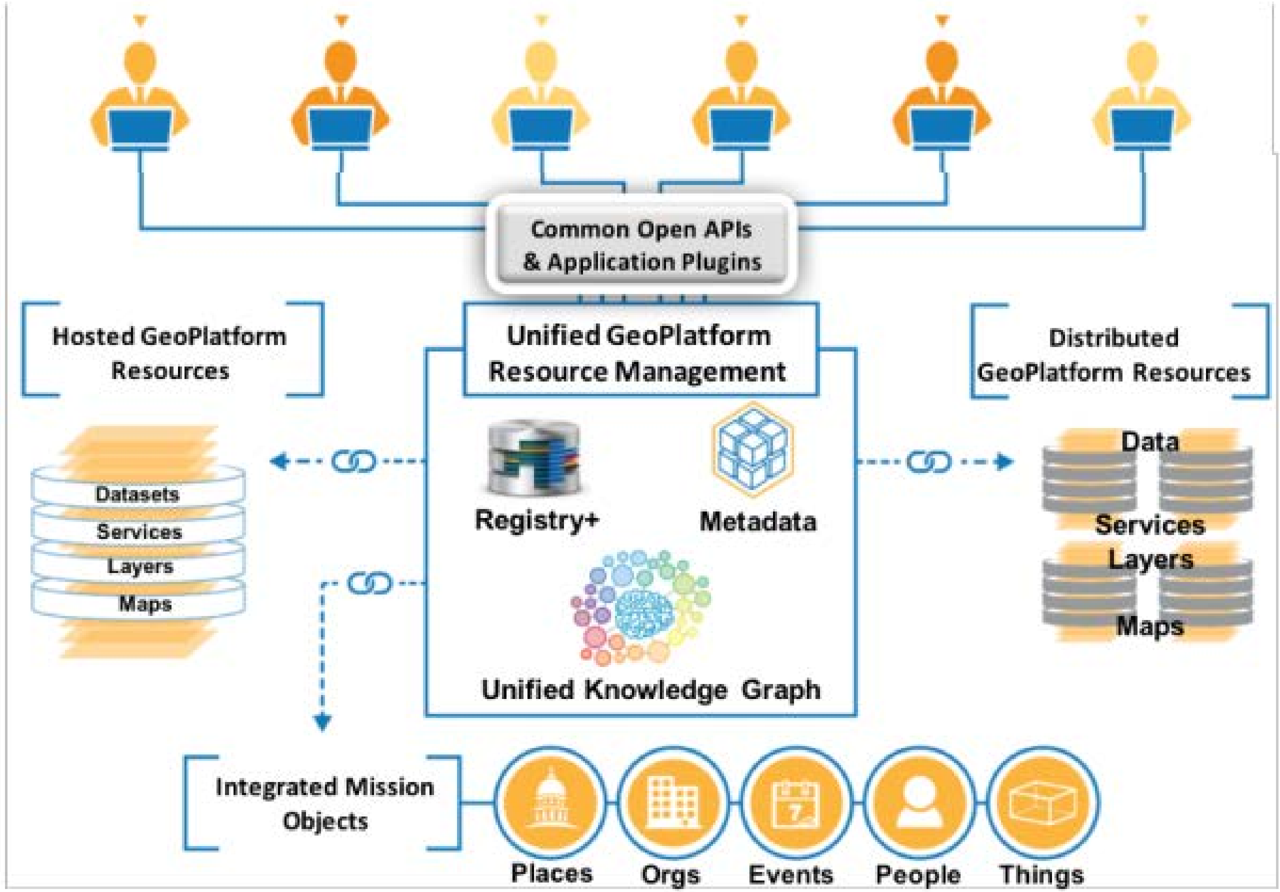
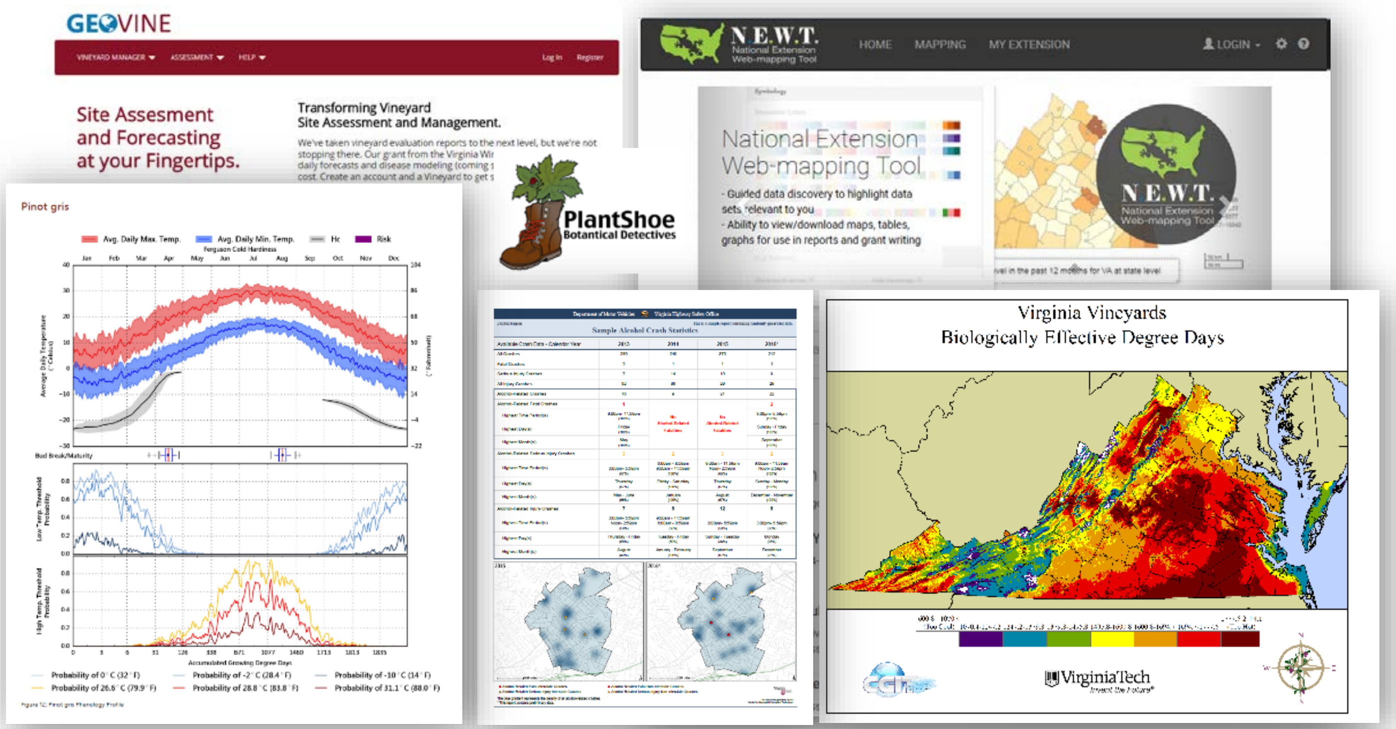


Figure 1.3: US National Spatial Data Infrastructure — GeoPlatform Architecture

Geospatial Information Science for Decision Making



Applied geospatial research programs engaging broad communities of stakeholders with data, modeling and simulation, and translational interfaces to support decision making.

Practice
- Spatial Data Infrastructures
- MaaS/Cloud/HPC
- Research to Operations
- Automation
- Data fusion
- Mod-Sim-Viz
- Web/AR/VR
- Translation and Decision Making

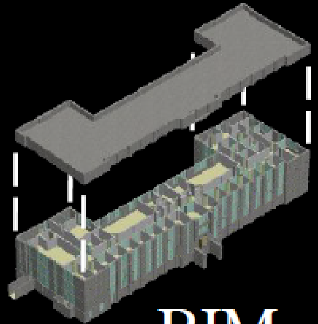
Future
- Interdisciplinary Methods
- Synthesis and Integration
- Network Analysis
- Economic Development
- Community Resilience
- Knowledge Management Systems

Challenges
- Complex variety of community needs and considerations for data, models and analytics, user interfaces.
- Urban-Rural / Digital Divides
- Too much data, yet never enough data
- Sustainable org/cyberinfrastructure
- Blackboxes

Current Projects: Geovine.org, Geohops, Virginia Broadband Mapping Initiative, National Extension Web Mapping Tool (NEWT), PlantShoe, VA Highway Safety Office, VA Veterans, Renewable Energy Siting, NRV911, Hazard Mitigation / Resilience, United Way SWVA, Bike Sensors for Air Quality, SmartFarm

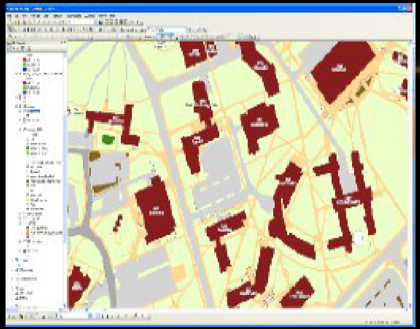
Peter Sforza sforza@vt.edu
www.cgit.vt.edu

Technology convergence

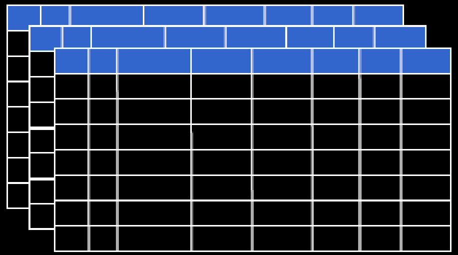


BIM

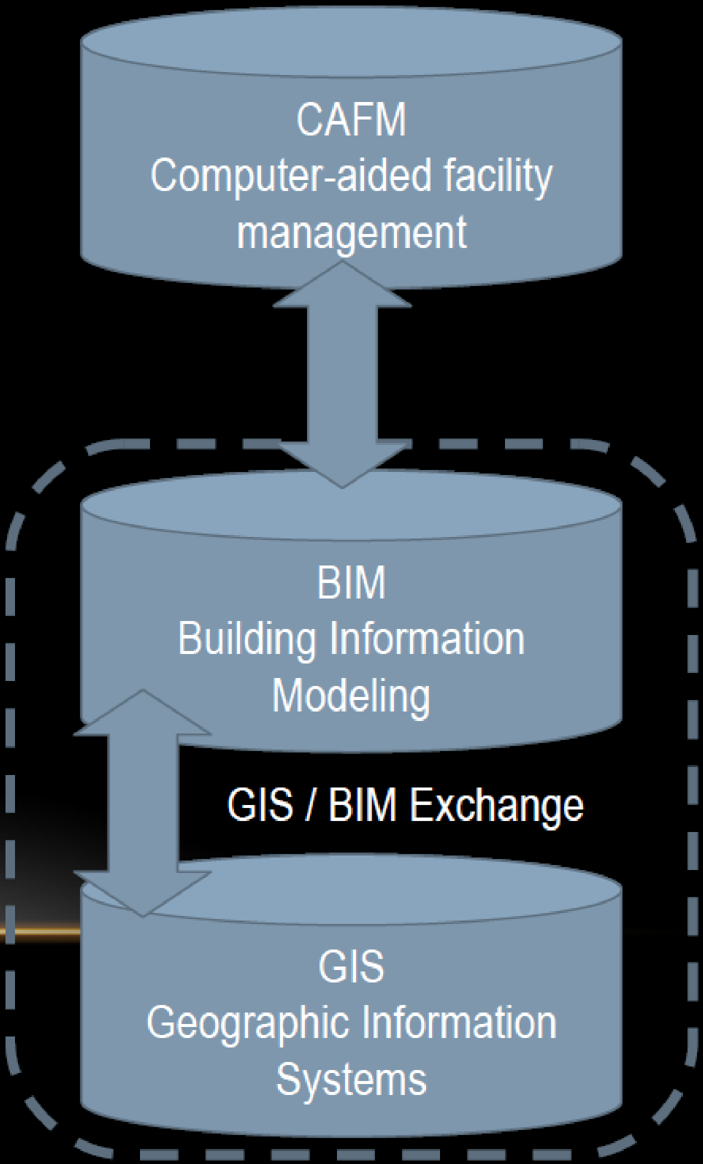
CAD



GIS



Tabular
Data



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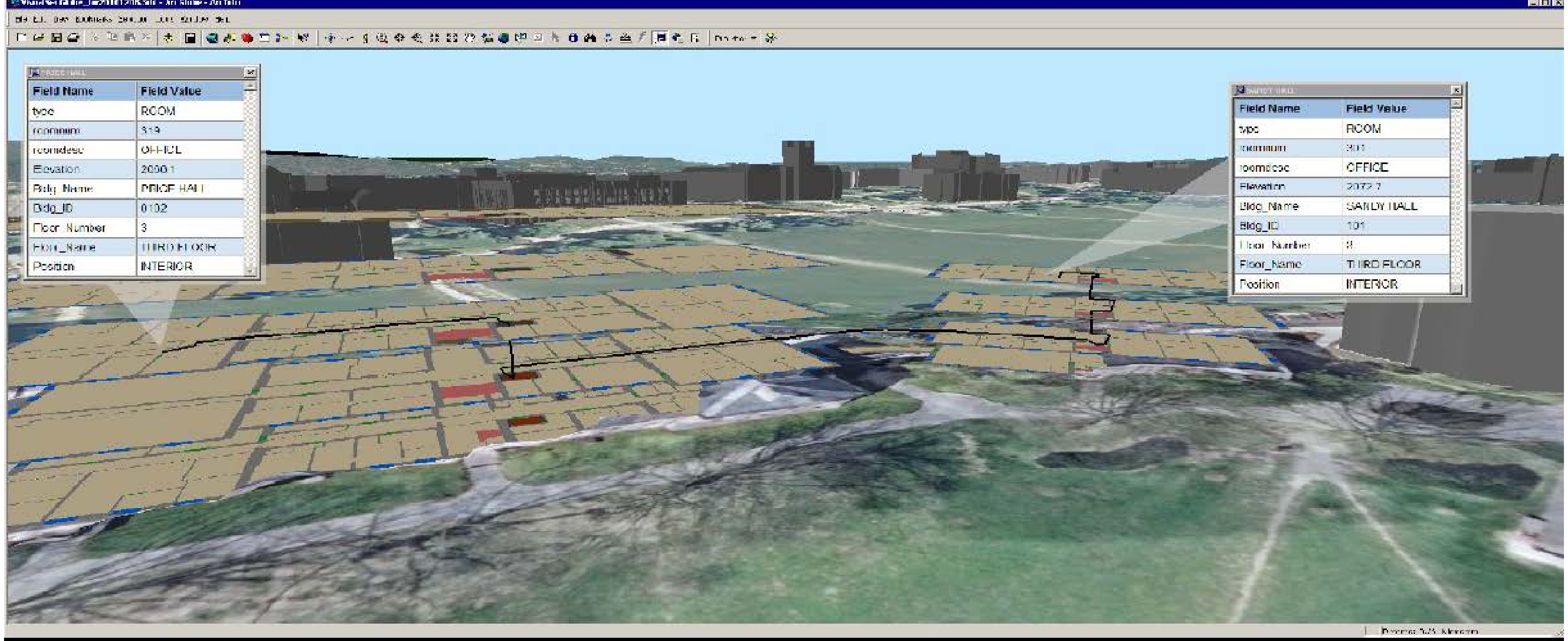
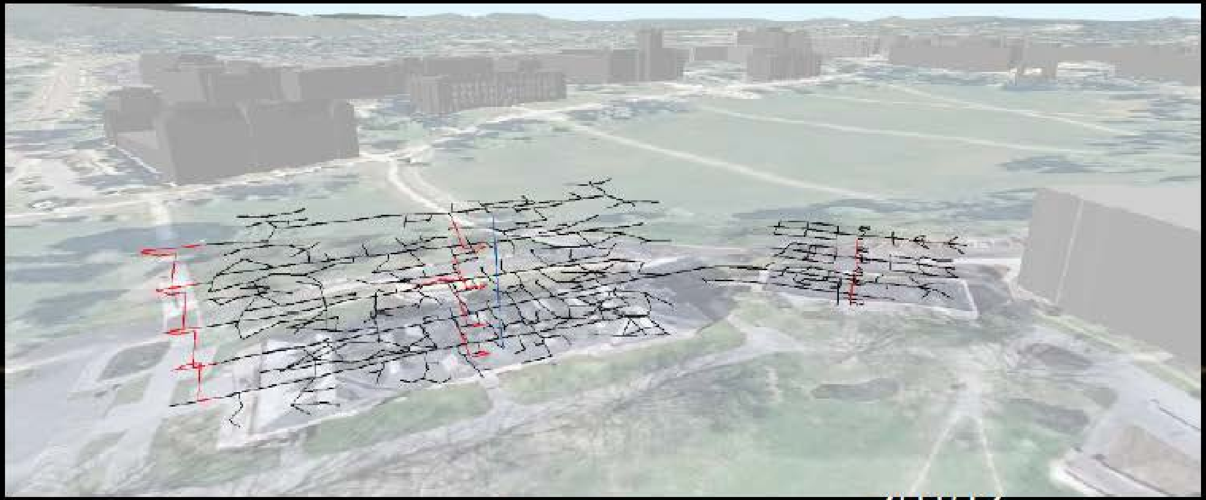


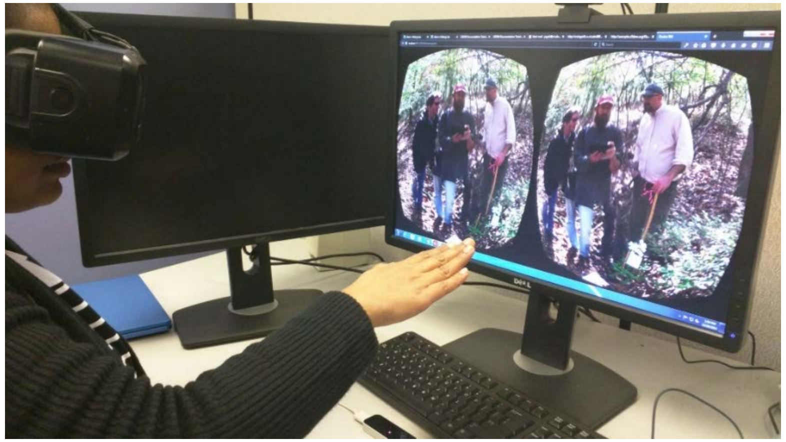
Sample Route Solution

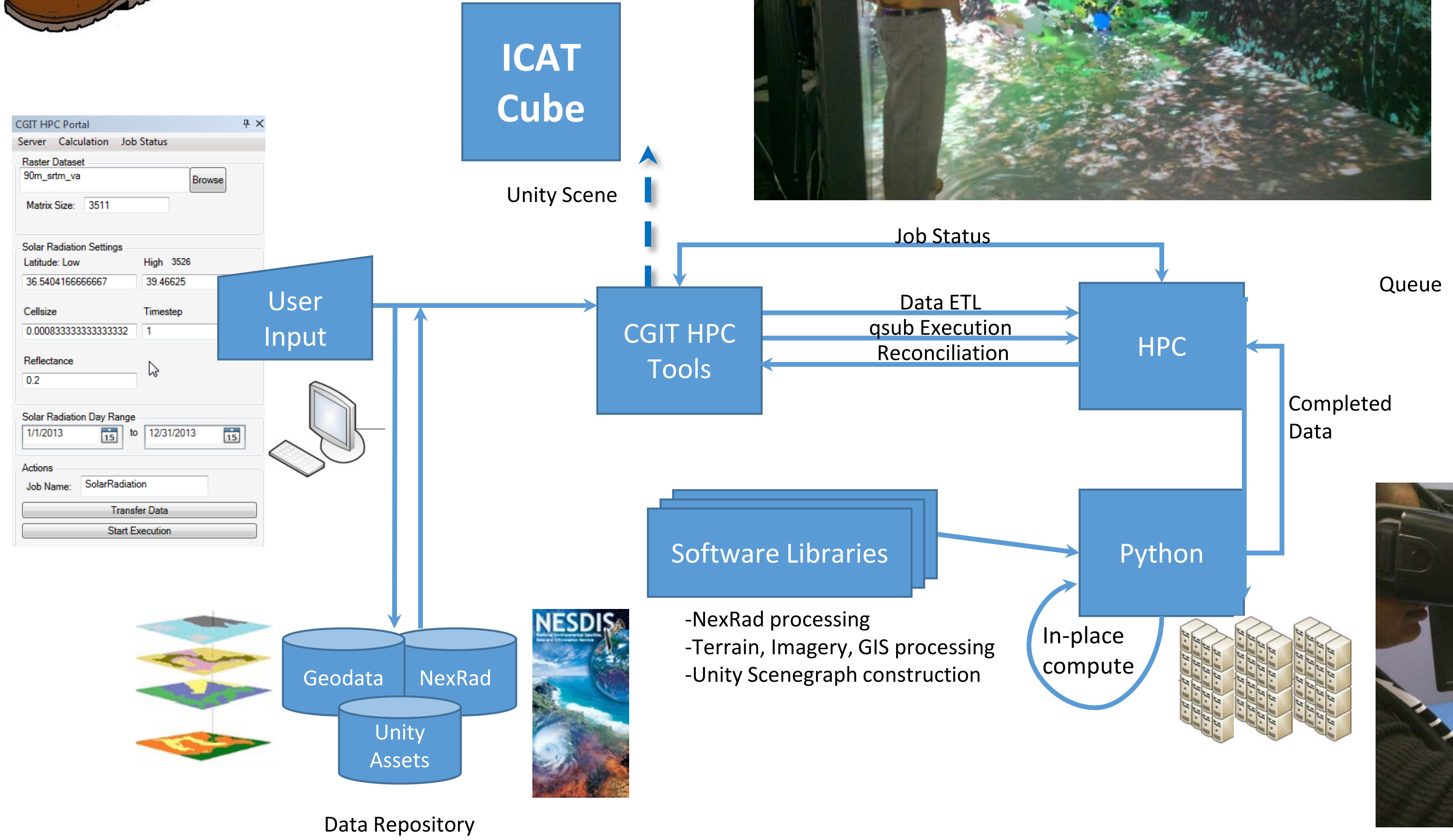


Routing Network

Innovation
Visualization

PlantShoe
Botantical Detectives
www.plantshoe.org





Virginia Department of Motor Vehicles

Standardizing crash location attributes according to spatial reference data for use across all jurisdictions and organizations.

VGIN Road Centerlines

VDOT Linear Referencing System

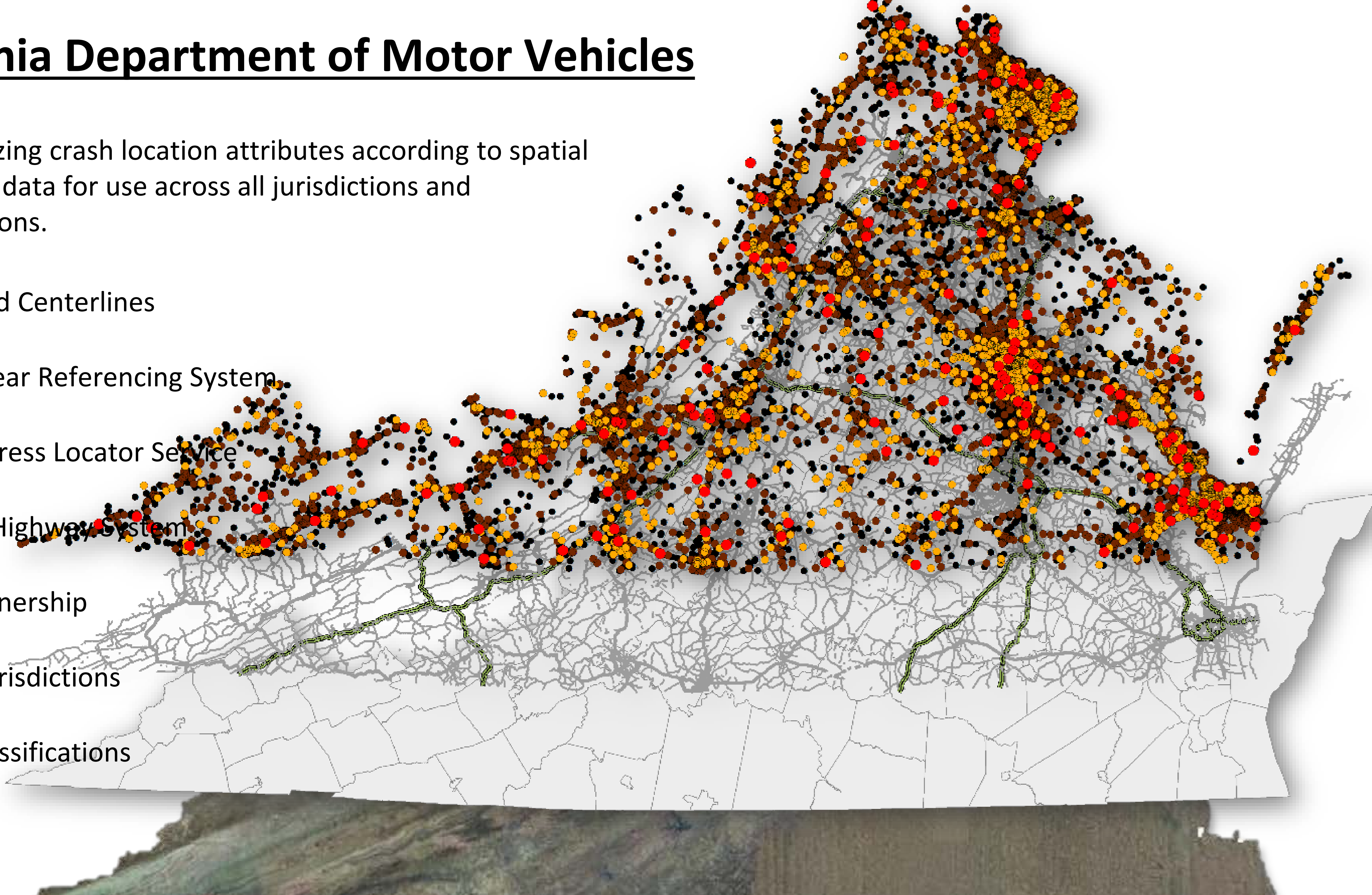
VGIN Address Locator Service

National Highway System

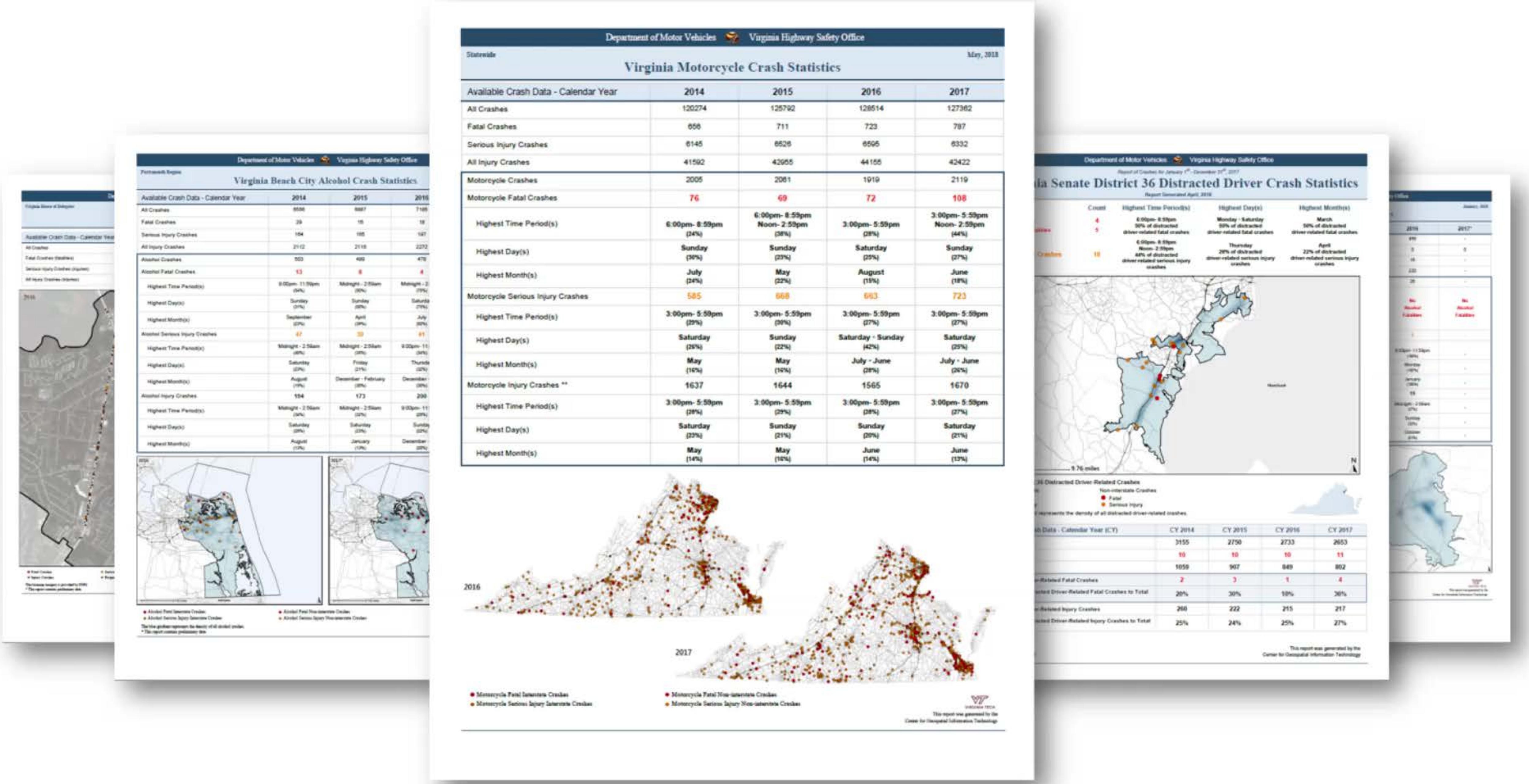
VDOT Ownership

Census Jurisdictions

Urban Classifications



Crash Statistics Reports



Department of Motor Vehicles | Virginia Highway Safety Office

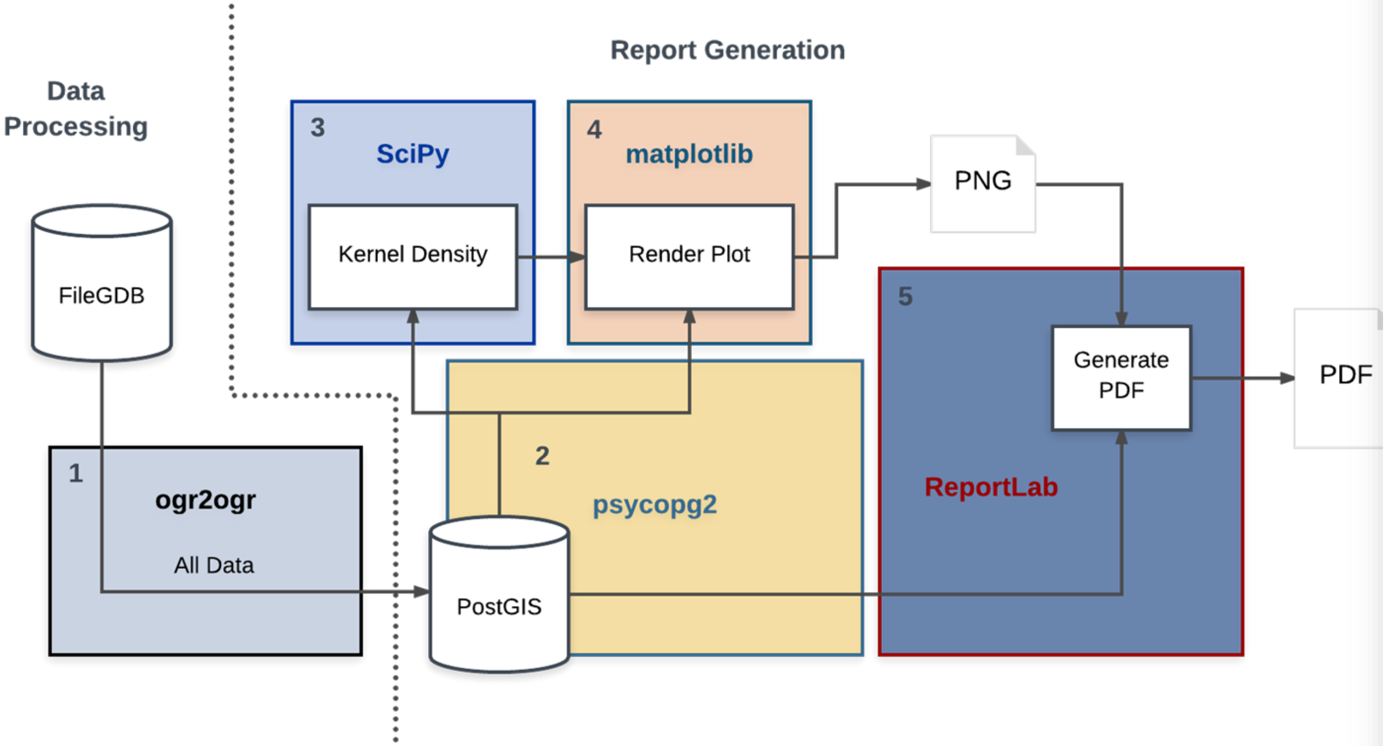
Statewide | May, 2018

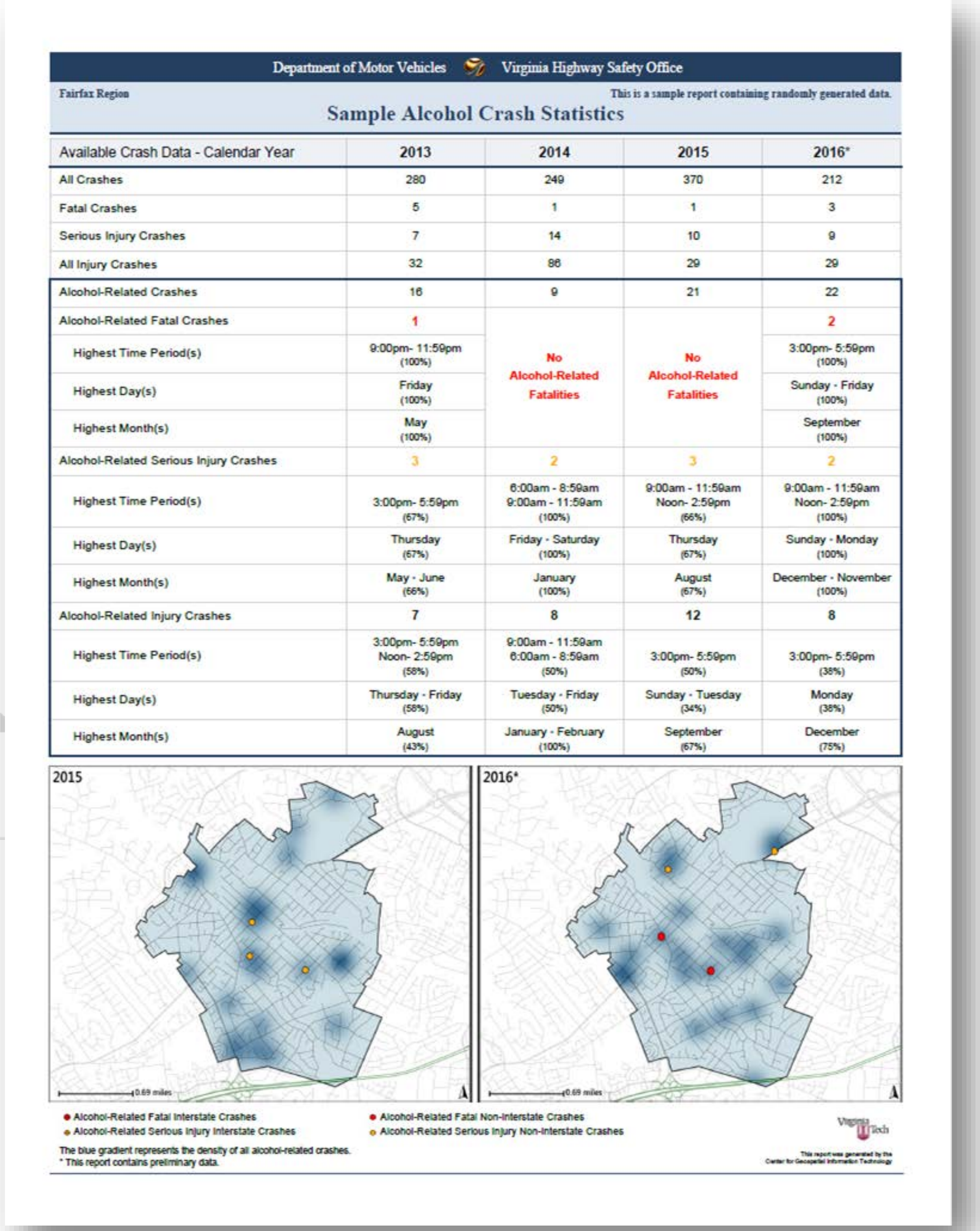
Virginia Motorcycle Crash Statistics

Available Crash Data - Calendar Year	2014	2015	2016	2017
All Crashes	120274	125792	128514	127362
Fatal Crashes	656	711	723	787
Serious Injury Crashes	6145	6526	6595	6332
All Injury Crashes	41592	42955	44155	42422
Motorcycle Crashes	2005	2061	1919	2119
Motorcycle Fatal Crashes	76	69	72	108
Highest Time Period(s)	6:00pm- 8:59pm (24%)	6:00pm- 8:59pm Noon- 2:59pm (38%)	3:00pm- 5:59pm (28%)	3:00pm- 5:59pm Noon- 2:59pm (44%)
Highest Day(s)	Sunday (30%)	Sunday (23%)	Saturday (25%)	Sunday (27%)
Highest Month(s)	July (24%)	May (22%)	August (15%)	June (18%)
Motorcycle Serious Injury Crashes	585	668	663	723
Highest Time Period(s)	3:00pm- 5:59pm (29%)	3:00pm- 5:59pm (30%)	3:00pm- 5:59pm (27%)	3:00pm- 5:59pm (27%)
Highest Day(s)	Saturday (26%)	Sunday (22%)	Saturday - Sunday (42%)	Saturday (25%)
Highest Month(s)	May (16%)	May (16%)	July - June (28%)	July - June (26%)
Motorcycle Injury Crashes **	1637	1644	1565	1670
Highest Time Period(s)	3:00pm- 5:59pm (28%)	3:00pm- 5:59pm (29%)	3:00pm- 5:59pm (28%)	3:00pm- 5:59pm (27%)
Highest Day(s)	Saturday (23%)	Sunday (21%)	Sunday (20%)	Saturday (21%)
Highest Month(s)	May (14%)	May (16%)	June (14%)	June (13%)

Automated Method for Crash Statistics Reports

Open-source python workflow:





Department of Motor Vehicles Virginia Highway Safety Office

Fairfax Region

This is a sample report containing randomly generated data.

Sample Alcohol Crash Statistics

Available Crash Data - Calendar Year	2013	2014	2015	2016*
All Crashes	280	249	370	212
Fatal Crashes	5	1	1	3
Serious Injury Crashes	7	14	10	9
All Injury Crashes	32	86	29	29
Alcohol-Related Crashes	16	9	21	22
Alcohol-Related Fatal Crashes	1	No Alcohol-Related Fatalities	No Alcohol-Related Fatalities	2
Highest Time Period(s)	9:00pm- 11:59pm (100%)			3:00pm- 5:59pm (100%)
Highest Day(s)	Friday (100%)			Sunday - Friday (100%)
Highest Month(s)	May (100%)			September (100%)
Alcohol-Related Serious Injury Crashes	3	2	3	2
Highest Time Period(s)	3:00pm- 5:59pm (67%)	6:00am - 8:59am 9:00am - 11:59am (100%)	9:00am - 11:59am Noon- 2:59pm (66%)	9:00am - 11:59am Noon- 2:59pm (100%)
Highest Day(s)	Thursday (67%)	Friday - Saturday (100%)	Thursday (67%)	Sunday - Monday (100%)
Highest Month(s)	May - June (66%)	January (100%)	August (67%)	December - November (100%)
Alcohol-Related Injury Crashes	7	8	12	8
Highest Time Period(s)	3:00pm- 5:59pm Noon- 2:59pm (58%)	9:00am - 11:59am 6:00am - 8:59am (50%)	3:00pm- 5:59pm (50%)	3:00pm- 5:59pm (38%)
Highest Day(s)	Thursday - Friday (58%)	Tuesday - Friday (50%)	Sunday - Tuesday (34%)	Monday (38%)
Highest Month(s)	August (43%)	January - February (100%)	September (67%)	December (75%)

2015

2016*

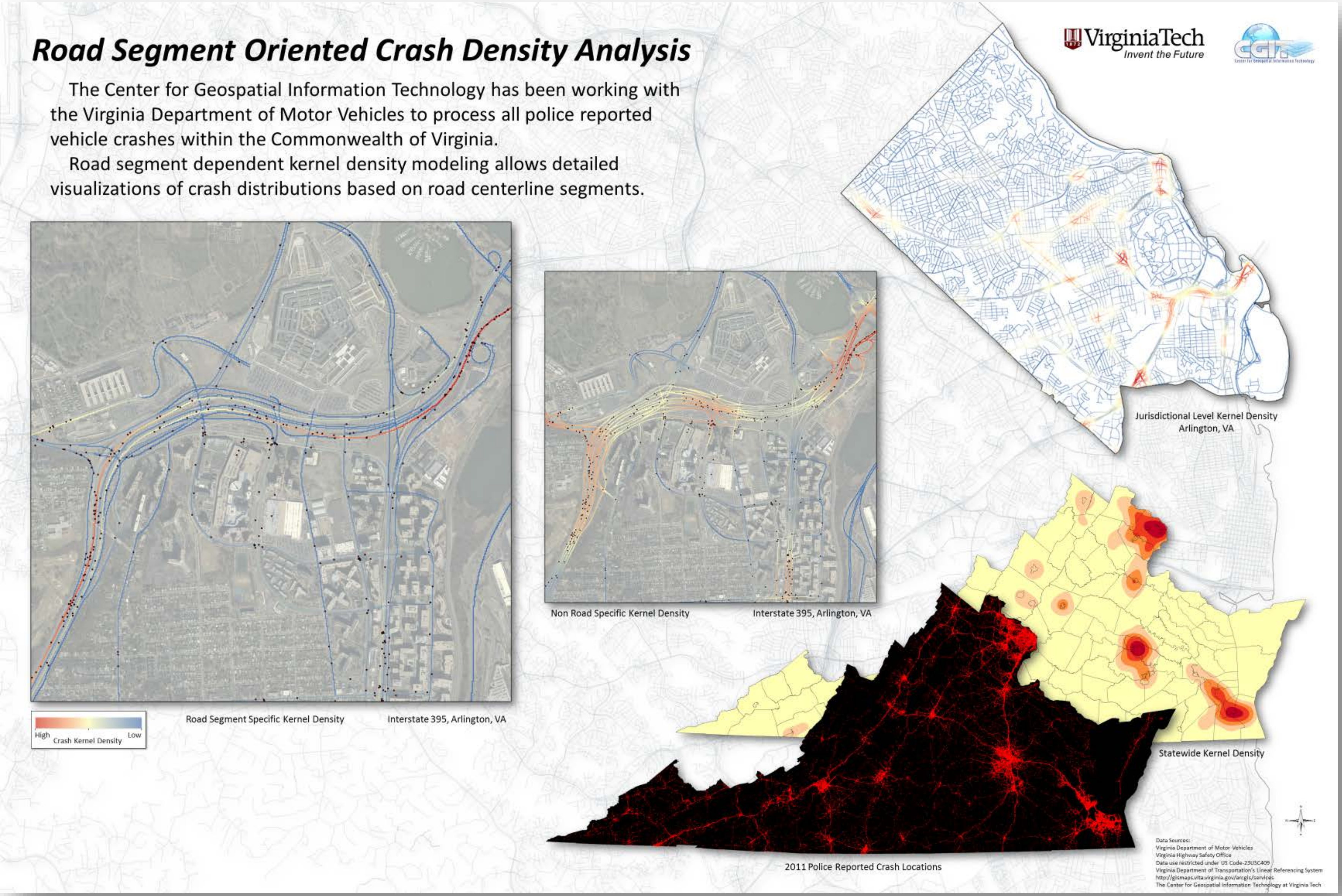
0.69 miles

● Alcohol-Related Fatal Interstate Crashes
● Alcohol-Related Serious Injury Interstate Crashes
● Alcohol-Related Fatal Non-Interstate Crashes
● Alcohol-Related Serious Injury Non-Interstate Crashes

The blue gradient represents the density of all alcohol-related crashes.
* This report contains preliminary data.

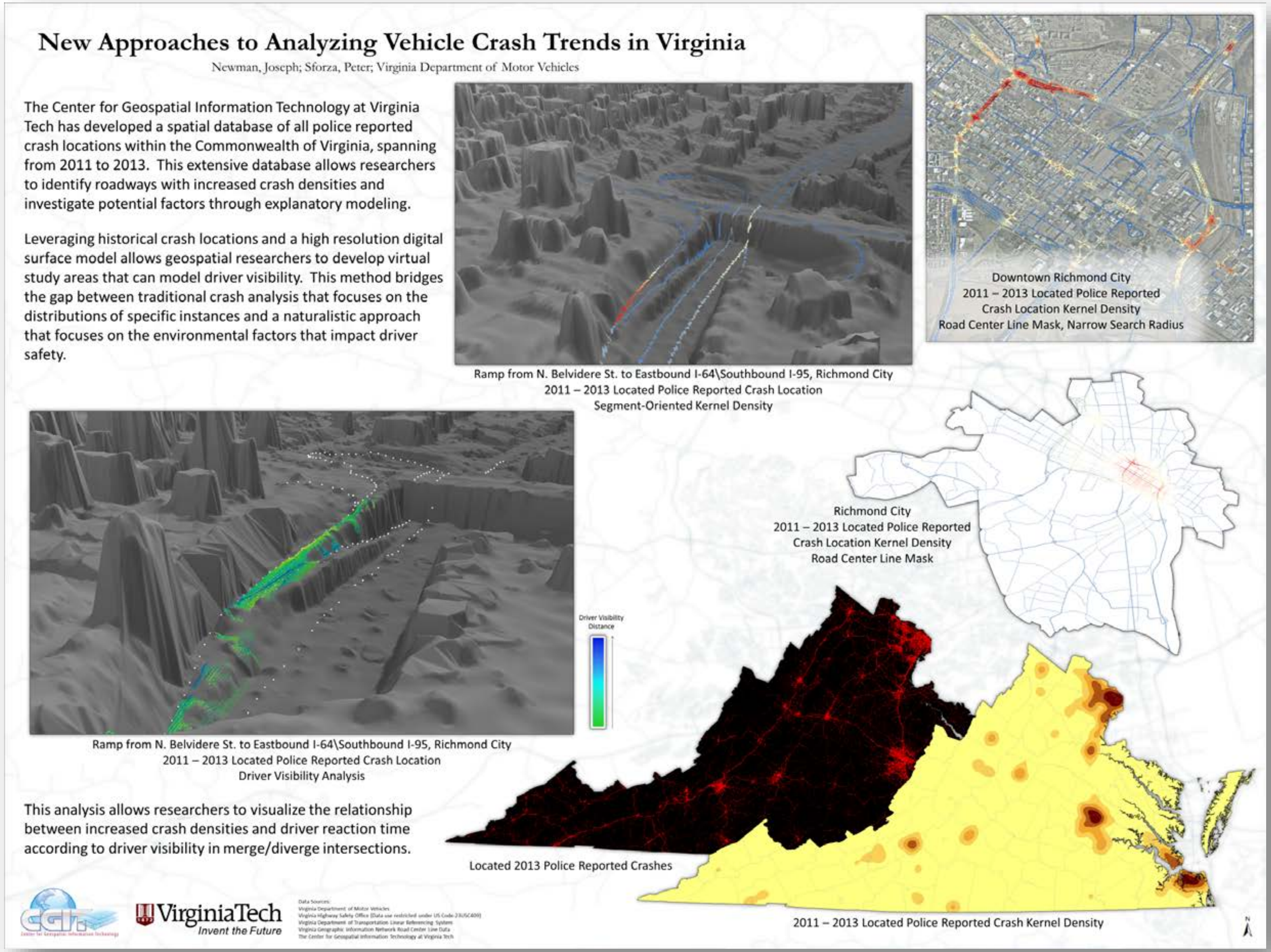
This report was generated by the Center for Geospatial Information Technology

Research and Analysis



Newman J. "Road Segment-Oriented Crash Density Analysis". ESRI Map Book, Volume 29. Redlands, CA: ESRI, June 14, 2014. 44. Print.

Crash Location and Surrounding Environment

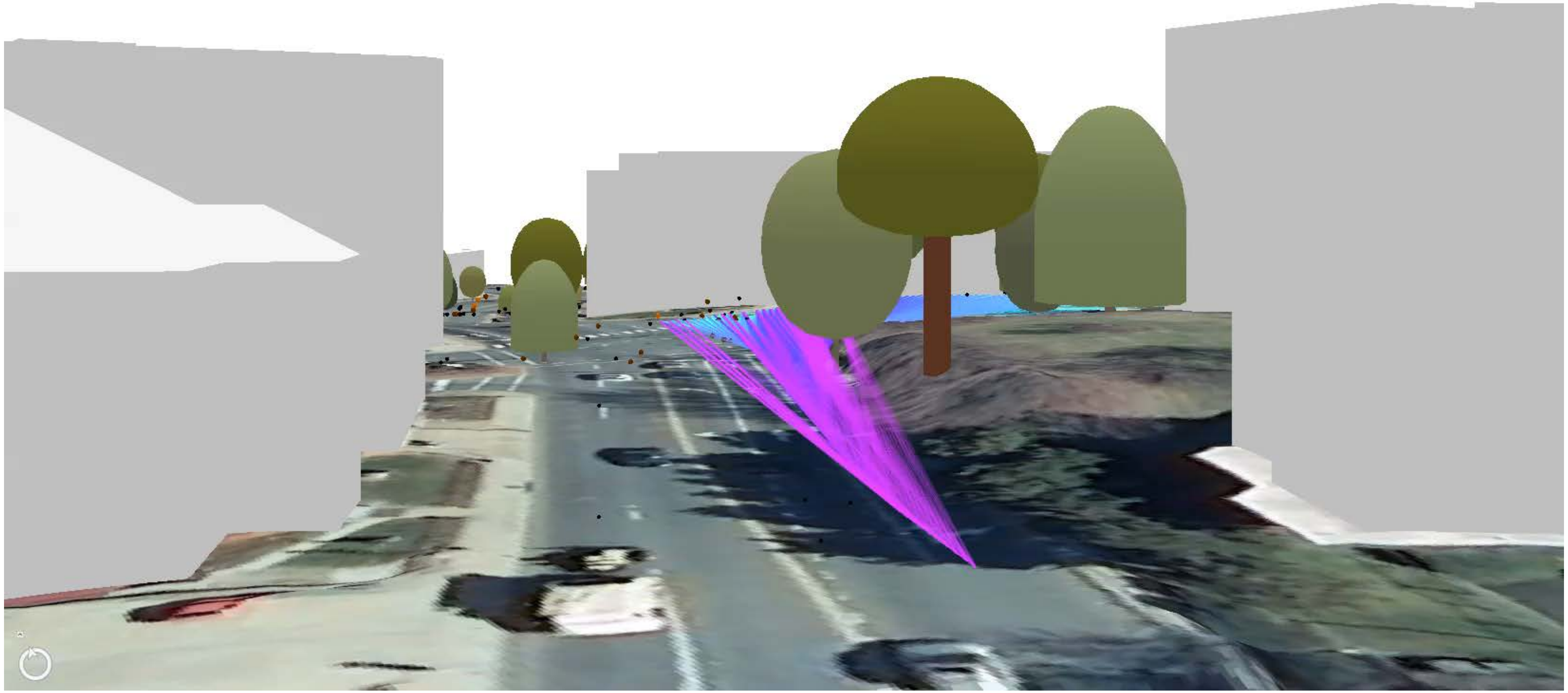


Newman J. "New Approaches to Analyzing Vehicle Crash Trends in Virginia". Virginia GIS Conference, Richmond, VA. September 16, 2014. Conference Poster.

3D Analysis Capabilities

Crash Density Analysis | Automated LiDAR Processing | Building & Tree Form Extraction | Driver Visibility Analysis

3D Analysis Capabilities



Crash Density Analysis | Automated LiDAR Processing | Building & Tree Form Extraction | Driver Visibility Analysis

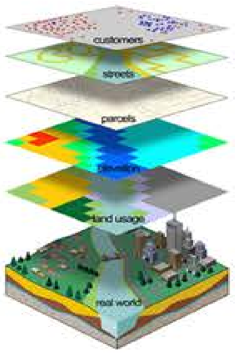
HAZARD MITIGATION PLANNING

Hazard is an act of phenomenon that has potential to produce harm or other undesirable consequences to a person or thing

Hazards in Virginia

Risk Mitigation Planning

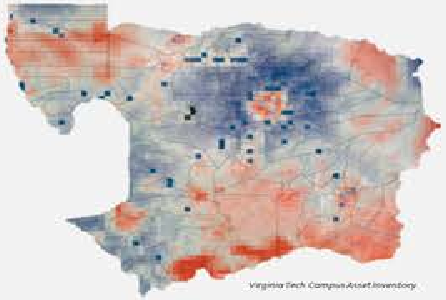
is the process of developing options and actions to enhance opportunities and reduce threats to project objectives



Geospatial Information System

is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data

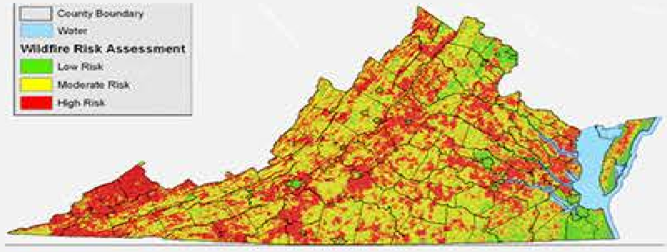
Social Vulnerability



Virginia Tech Campus Asset Inventory

Social vulnerability refers to the socioeconomic factors that affect the resilience of communities. Mapping the vulnerability helps with mitigation planning

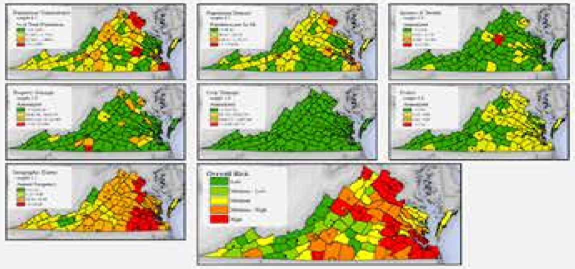
Risk Assessment (HIRA)



State of Virginia: Wildfire Risk Assessment

Risk Assessment is the process of measuring potential loss of life, personal injury, economic injury, and property damage resulting from hazards

Ranking



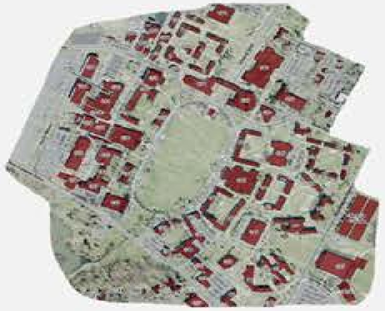
State of Virginia: Tornado Hazard Ranking Parameters and Risk Map

Risk Assessment is the process of measuring potential loss of life, personal injury, economic injury, and property damage resulting from hazards

Determination of Planning Area and Resources → Building Planning Team → Community Capability Assessment → Hazard Identification and Risk Assessment → Develop Mitigation Strategies → Plan Adoption and Review → Plan Maintenance and Update

Asset Inventory

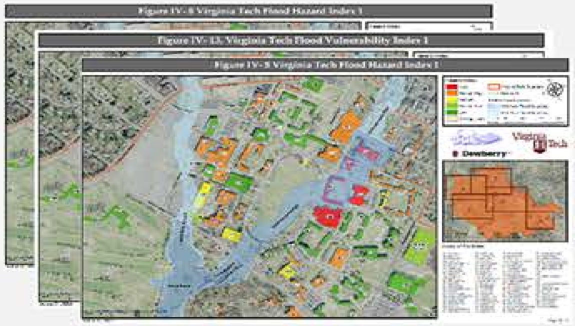
Assets are the people, property, and activities in a community. Assets mapping enables hazard mitigation planning teams to understand what can be affected by different hazard events



Virginia Tech Campus Asset Inventory

Hazard Index

Assets are the people, property, and activities in a community. Assets mapping enables hazard mitigation planning teams to understand what can be affected by different hazard events



Virginia Tech Flood Hazard Index

Community Engagement

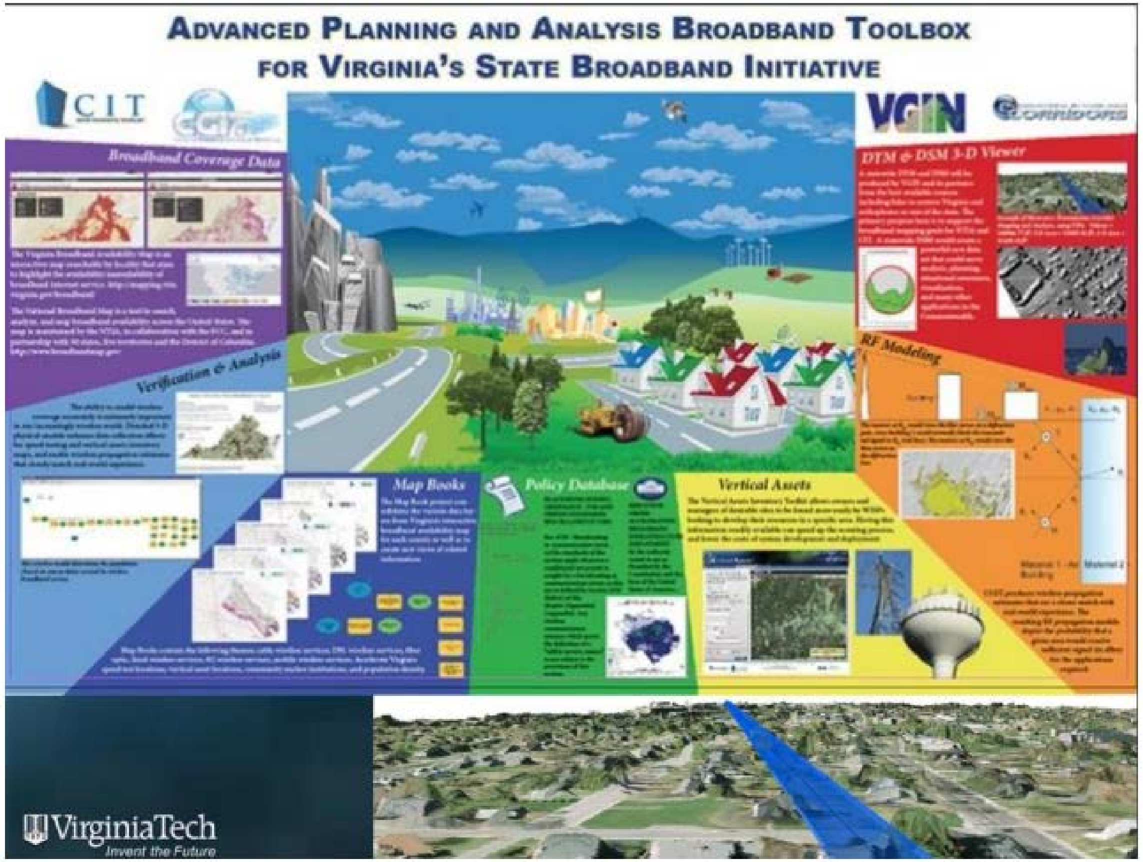
Sharing the plan updates and assessments through a web platform. Giving a narrative form to geographic information impresses it with realistic character that just doesn't come across in charts or graphs

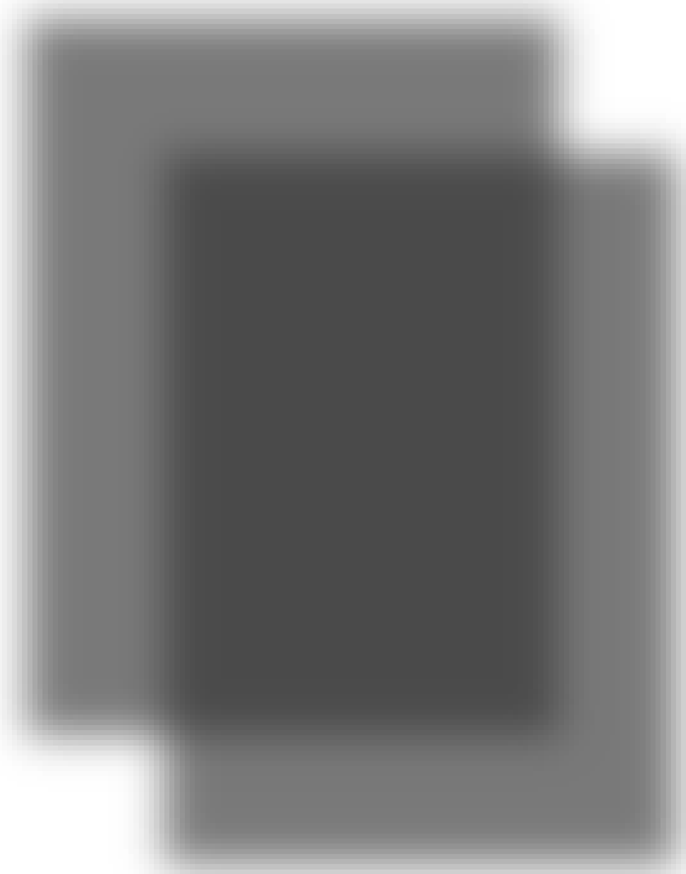
El Nino: Mapping Disaster Risk

Broadband Planning and Analysis Toolkit

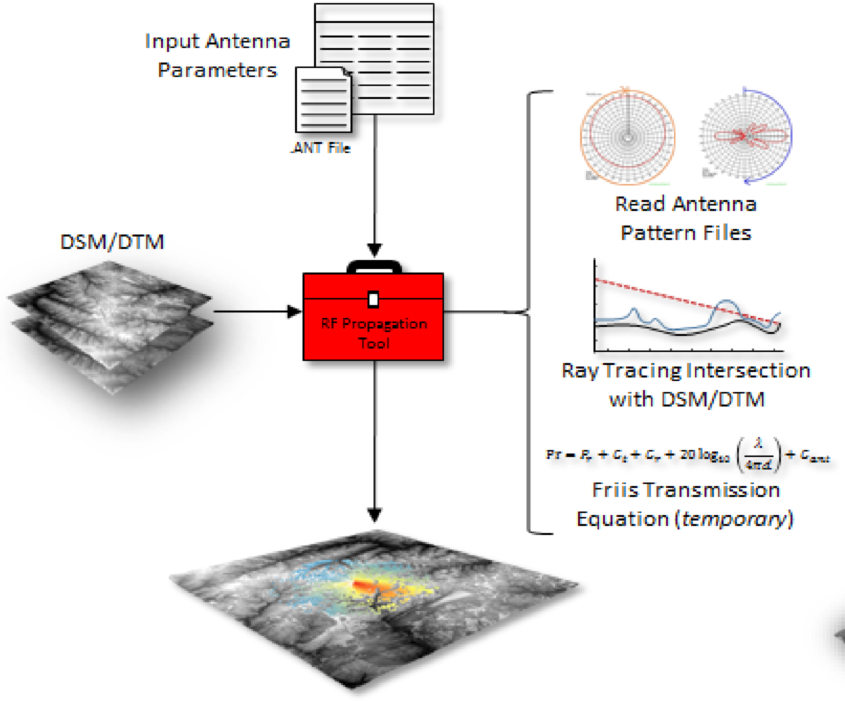
http://www.cgit.vt.edu/broadband

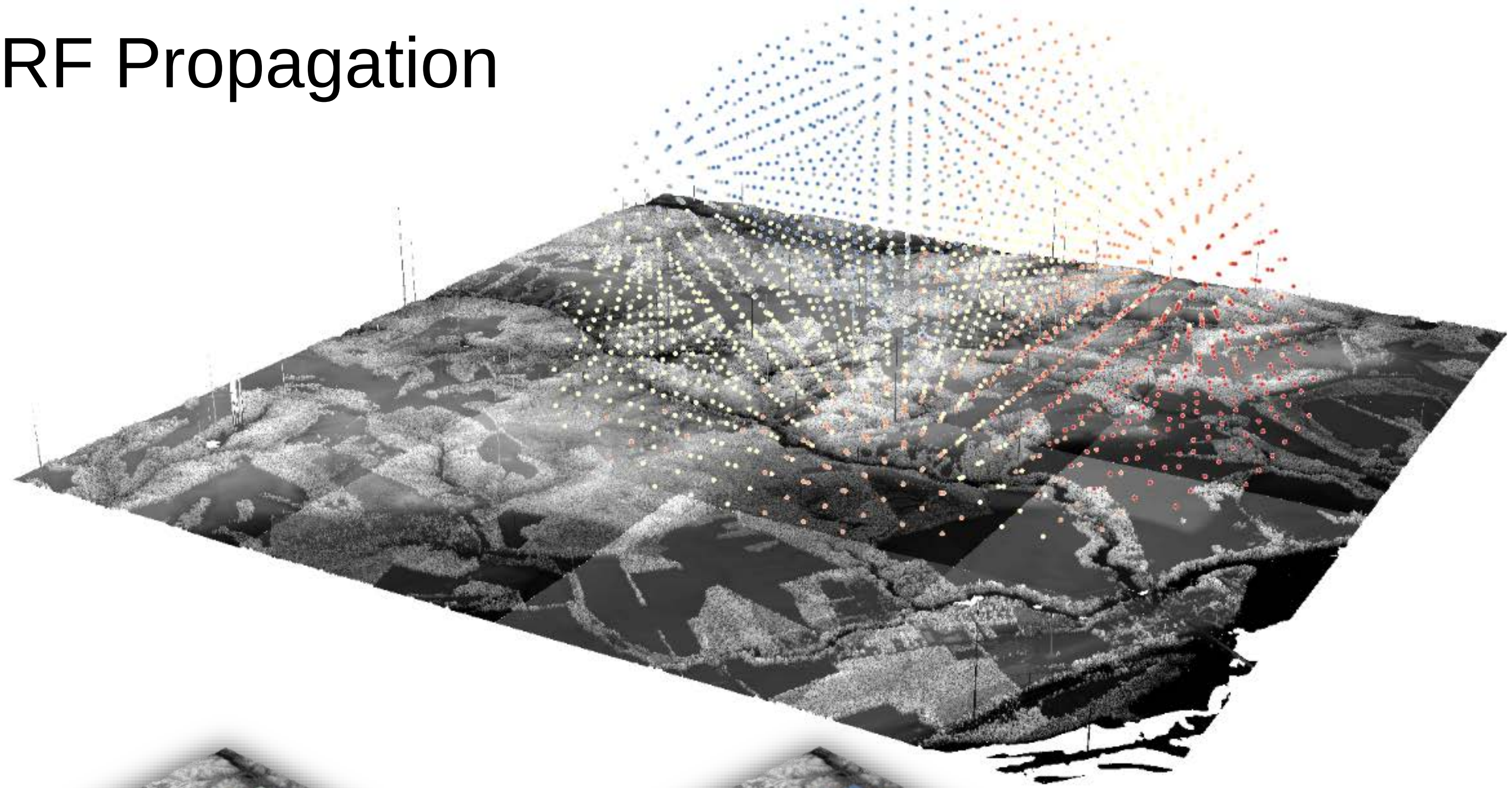
Broadband Policy Database: Generates a report based on user-selected location. The report highlights policies at multiple jurisdictional levels that may affect broadband deployment at that location.

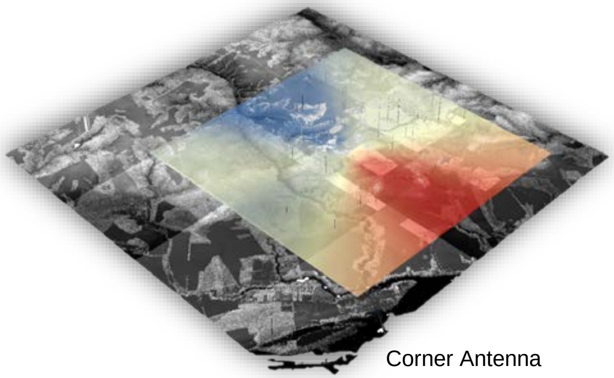




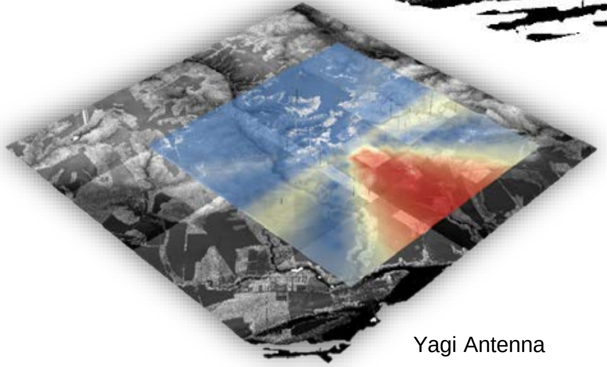
3D Virginia:
Statewide Broadband and RF Propagation







Corner Antenna

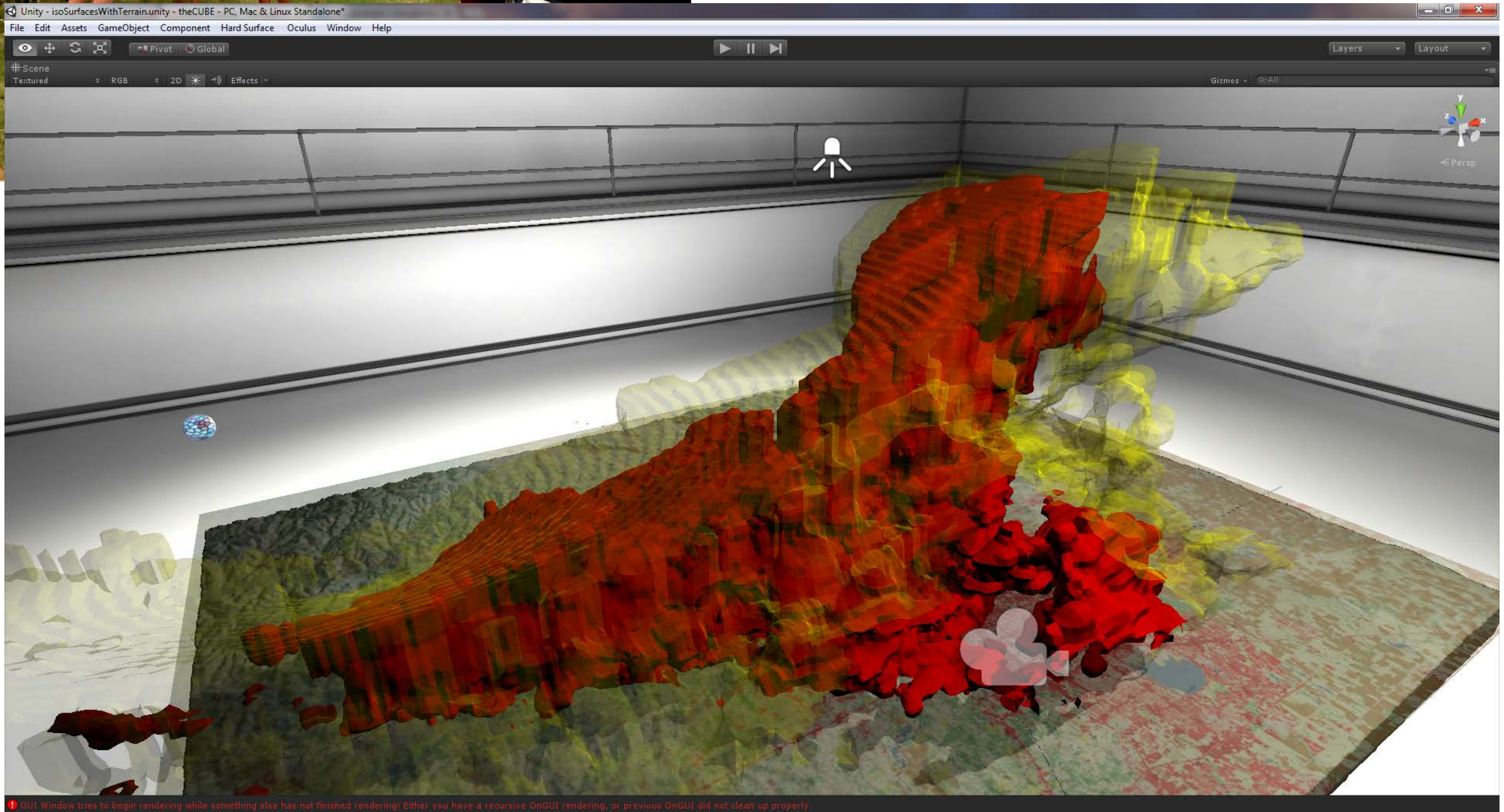


Yagi Antenna

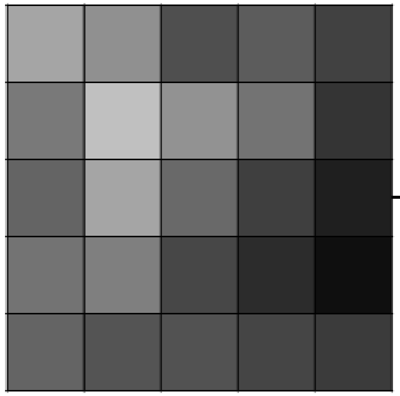
Human-Computer Interaction

Virginia Tech ICAT Scientific Visualization Moore, OK Tornado

a. Dave Carroll – Instructor of Meteorology
b. Bill Carstensen – Professor of GIS
c. Drew Ellis – Professor of Meteorology
d. Kenyon Gladu – undergraduate student in Meteorology
e. Peter Sforza – Director of the Center for Geospatial Information Technology
f. Trevor White – Graduate student in Business Information Technology (but presently transferring to Geography)
g. Run Yu – PhD. student in Computer Science



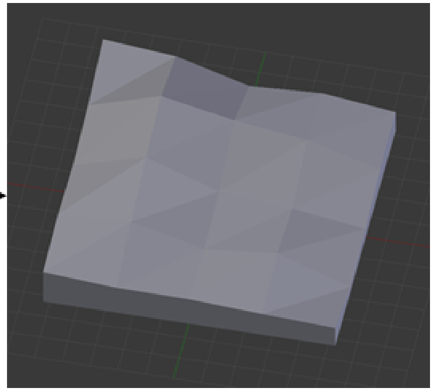
3D Printing



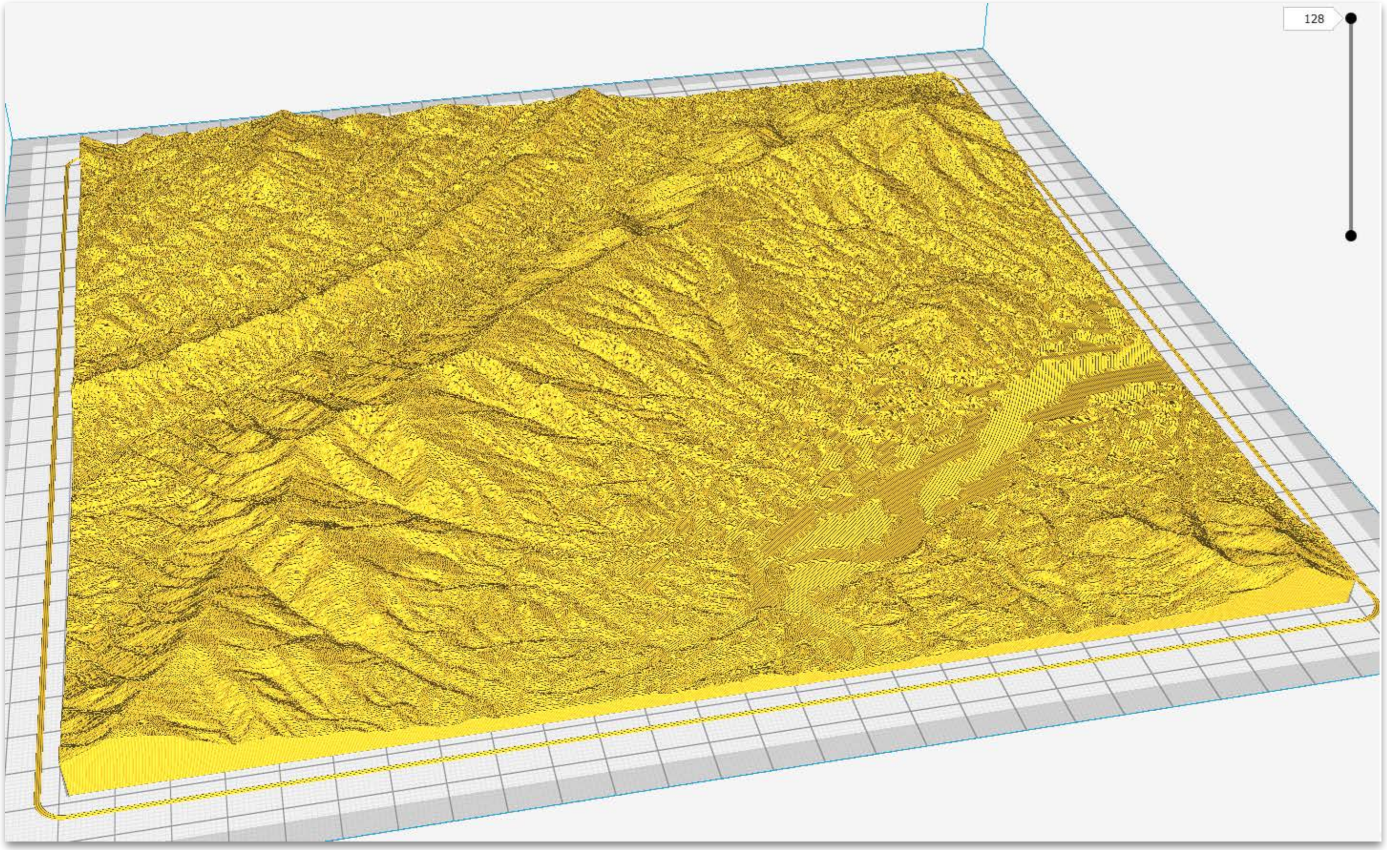
Load the Data (geotif file)

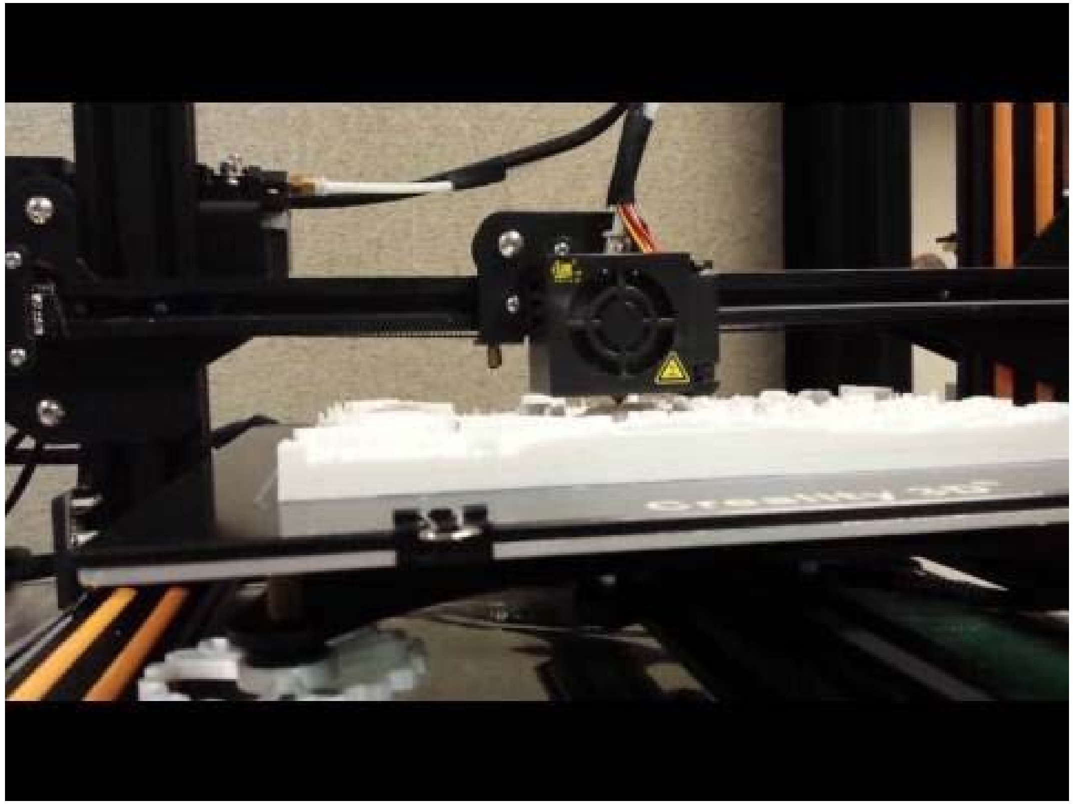
8.47	7.29	3.62	4.35	2.82
5.99	10.0	7.40	5.65	2.09
4.80	8.47	3.90	2.71	0.90
5.65	6.33	3.16	4.46	0.00
4.80	3.90	3.79	3.05	2.49

Scale the Raster



Generate STL (stereolithography file)

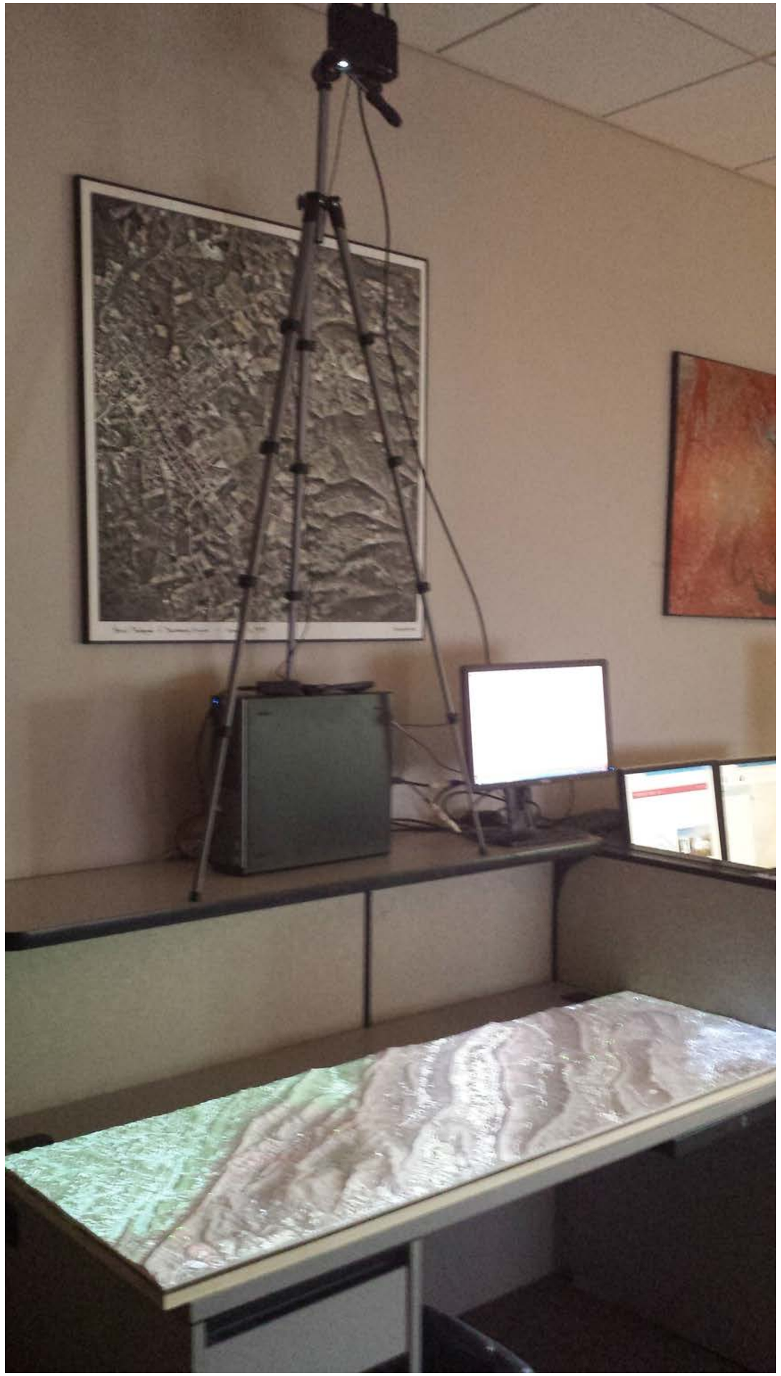




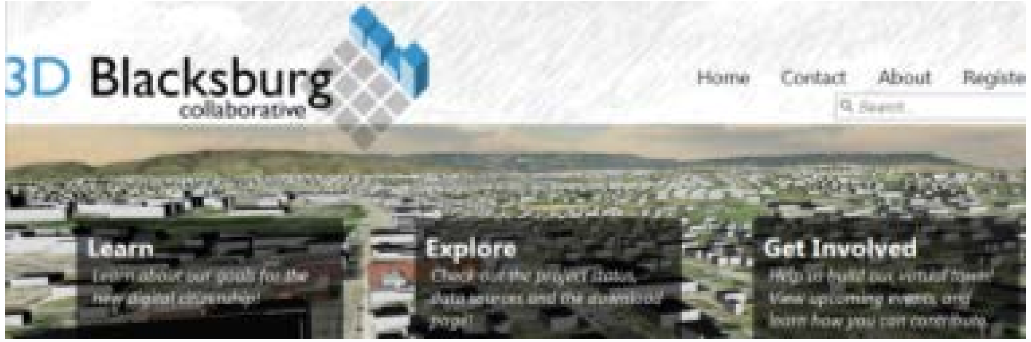
AR

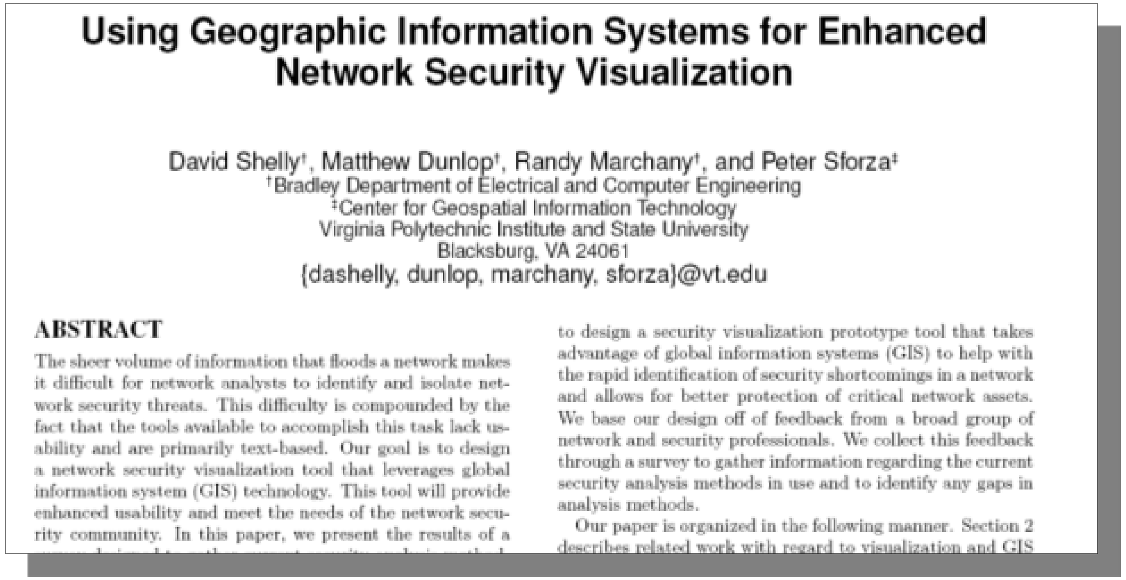
3D print of the AT, from Daleville to Narrows

Overlay projection displaying data from web services



3D Blacksburg




Using Geographic Information Systems for Enhanced Network Security Visualization

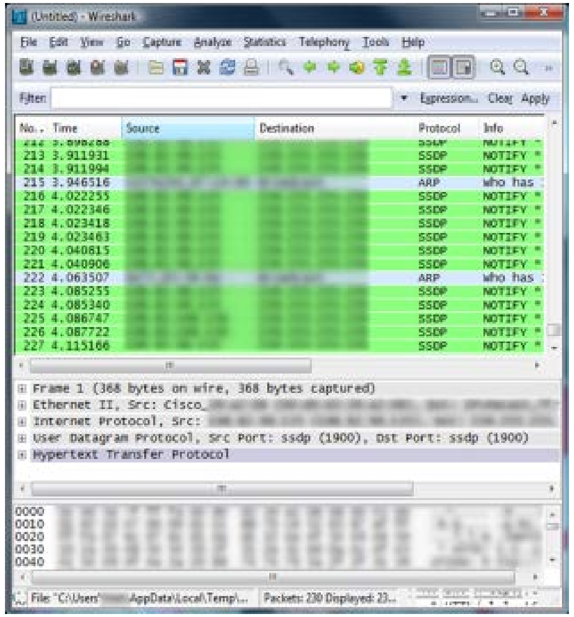
David Shelly†, Matthew Dunlop†, Randy Marchany†, and Peter Sforza‡
†Bradley Department of Electrical and Computer Engineering
‡Center for Geospatial Information Technology
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061
{dashelly, dunlop, marchany, sforza}@vt.edu

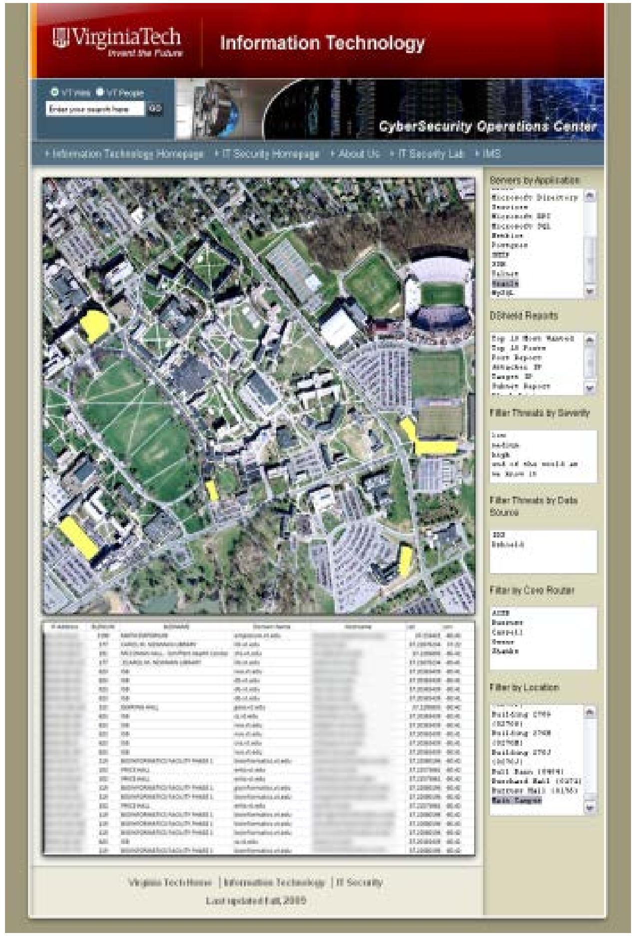
ABSTRACT

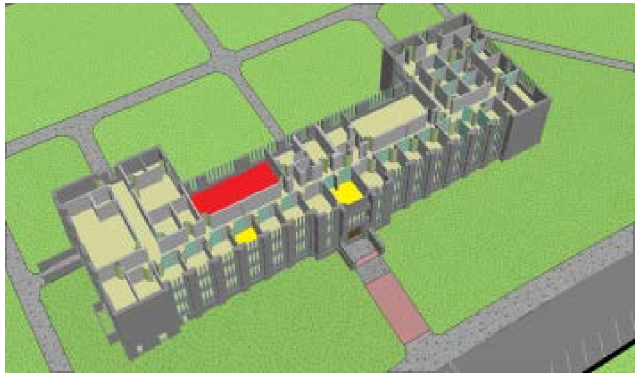
The sheer volume of information that floods a network makes it difficult for network analysts to identify and isolate network security threats. This difficulty is compounded by the fact that the tools available to accomplish this task lack usability and are primarily text-based. Our goal is to design a network security visualization tool that leverages global information system (GIS) technology. This tool will provide enhanced usability and meet the needs of the network security community. In this paper, we present the results of a

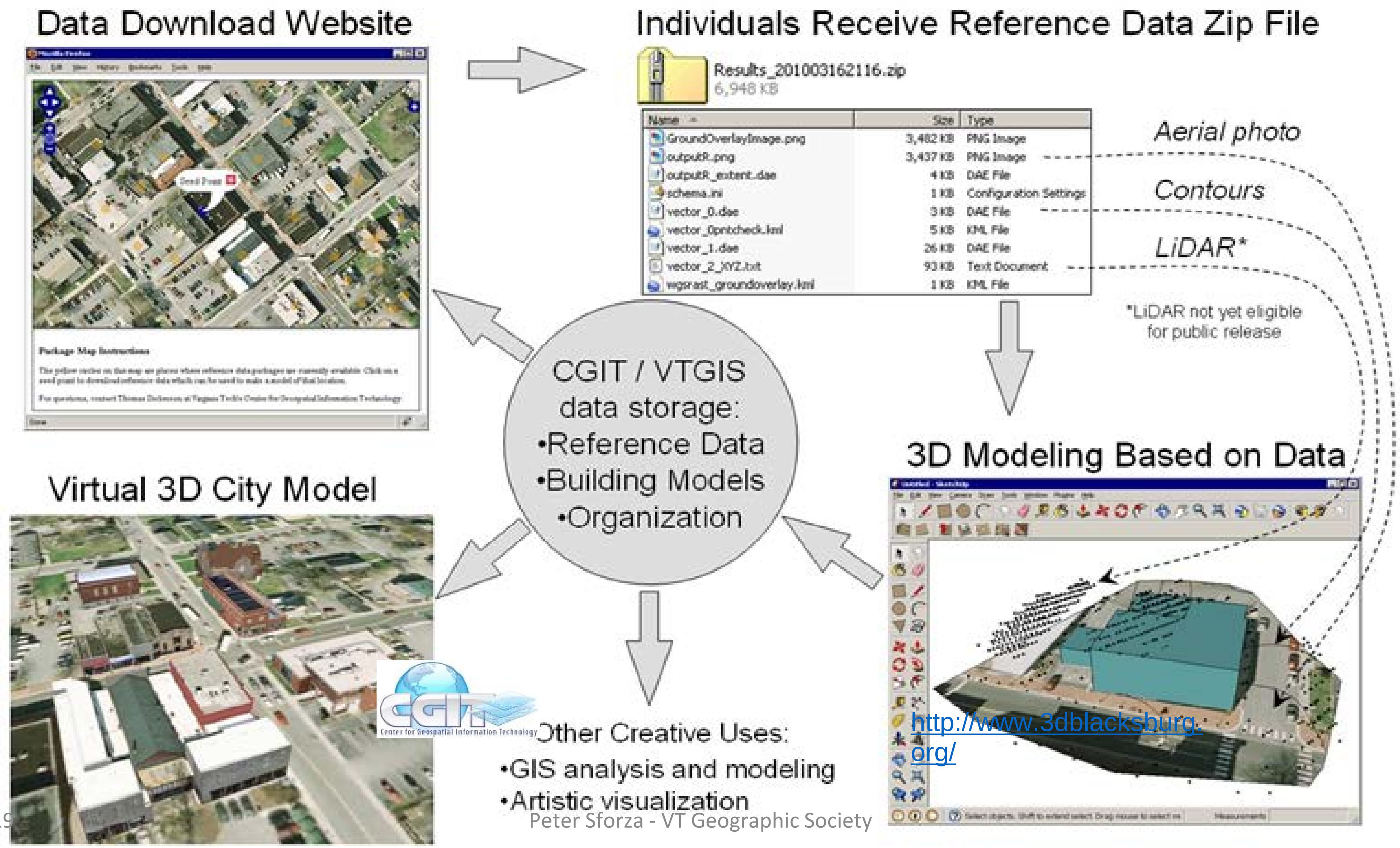
to design a security visualization prototype tool that takes advantage of global information systems (GIS) to help with the rapid identification of security shortcomings in a network and allows for better protection of critical network assets. We base our design off of feedback from a broad group of network and security professionals. We collect this feedback through a survey to gather information regarding the current security analysis methods in use and to identify any gaps in analysis methods.

Our paper is organized in the following manner. Section 2 describes related work with regard to visualization and GIS









http://www.3dblacksburg.org/

Historical 3D Blacksburg

iCanSeeYouTweet.com

Situational Awareness via Video Analytics: incorporating video metadata into 3D models

Integrating video footage with geospatial data can enhance the interpretation of information contained in the video.

By calibrating video camera footage, a mapping between video frame coordinates and real-world geospatial coordinates is established. Features tagged in the video footage can be viewed on a map, and vice-versa.

Aerial Imagery © 2009
Commonwealth of Virginia

VT CGIT, VT ARC and IBM Watson Exploratory Video Analytics Research Group

Center for Geospatial Information Technology

VirginiaTech
Invent the Future

iCanSeeYouTweet.com

#ICSYT Follow @icsyt 9 followers

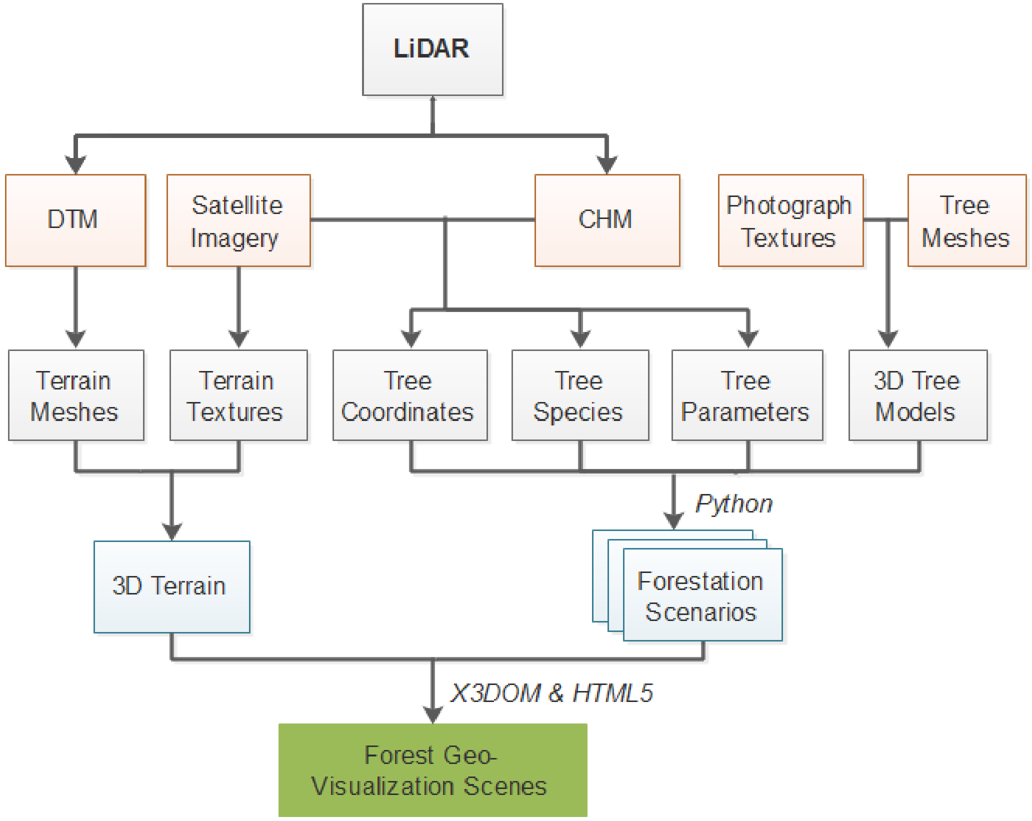
Home Webcam List Recent Mentions

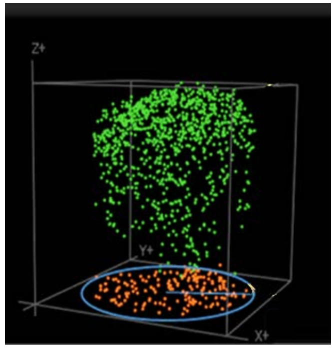
Connect with twitter

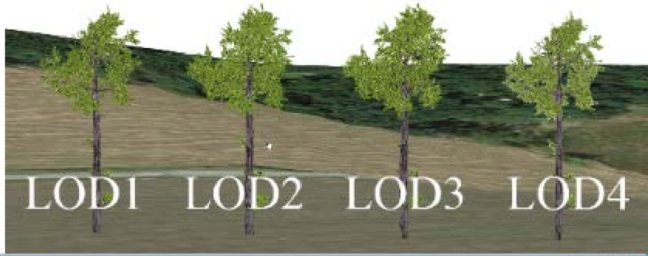
Center for Geospatial Information Technology

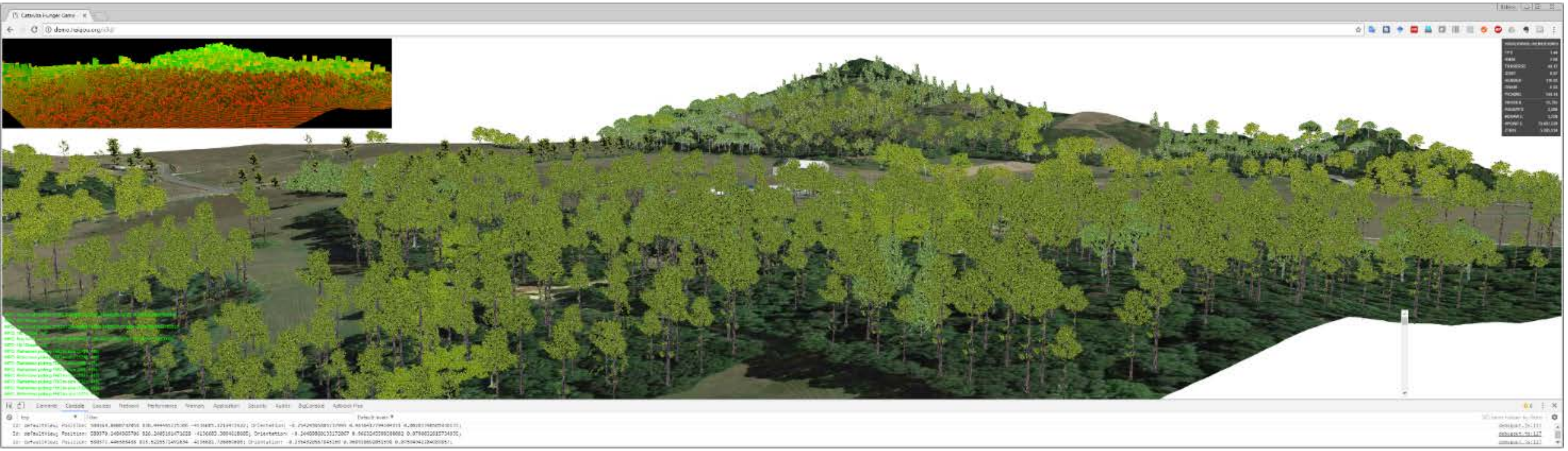
User	Album	Last Mentioned
@Dpesin	Link	11:20am on Monday 10th September 2012
@RLBASDEN	Link	9:33am on Monday 10th September 2012
@Ashley_Boland	Link	8:23am on Monday 10th September 2012
@PeterSforza	Link	7:41am on Monday 10th September 2012
@MegAnn6591	Link	12:37am on Monday 10th September 2012
@wickham_myles	Link	6:07pm on Sunday 9th September 2012
@Em_Barb09	Link	4:57pm on S
@devdavis	Link	4:22pm on S
@Javian_x3	Link	4:04pm on S
@Steve_Chandler	Link	1:46pm on S
@HolaBrody	Link	11:57am on S
@VT_Lauren	Link	10:36am on S
@AddieOldham	Link	9:38am on S
@TheMammovan	Link	8:14am on S
@TriCenter	Link	5:36am on S
@typicalsquirrel	Link	5:07am on S
@CompetitorDC	Link	4:40am on S
@CGIprguy	Link	4:38am on S
@heartcallah	Link	6:32pm on Sa
@CLAUDIALOPEZTV	Link	6:17pm on Sa
@Eduography	Link	5:10pm on Sa
@jshake	Link	4:21pm on Sa
@nathanielcline	Link	4:07pm on Sa
@kaydee_64	Link	7:17am on Sa

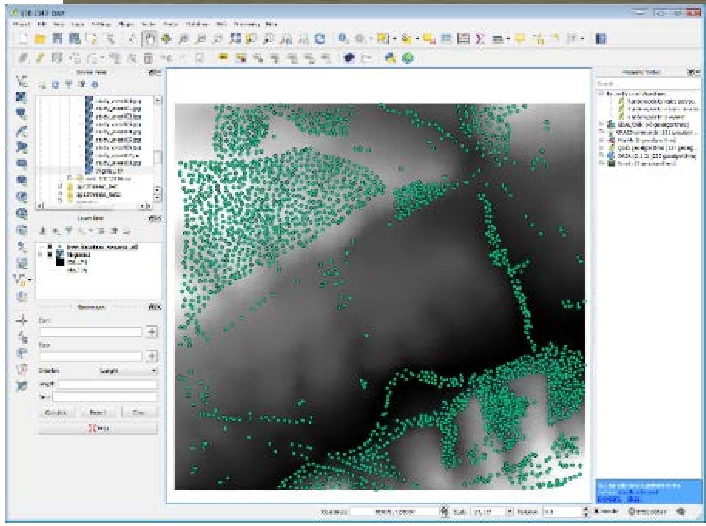
Reconstruction Web3D Geo-Visualization

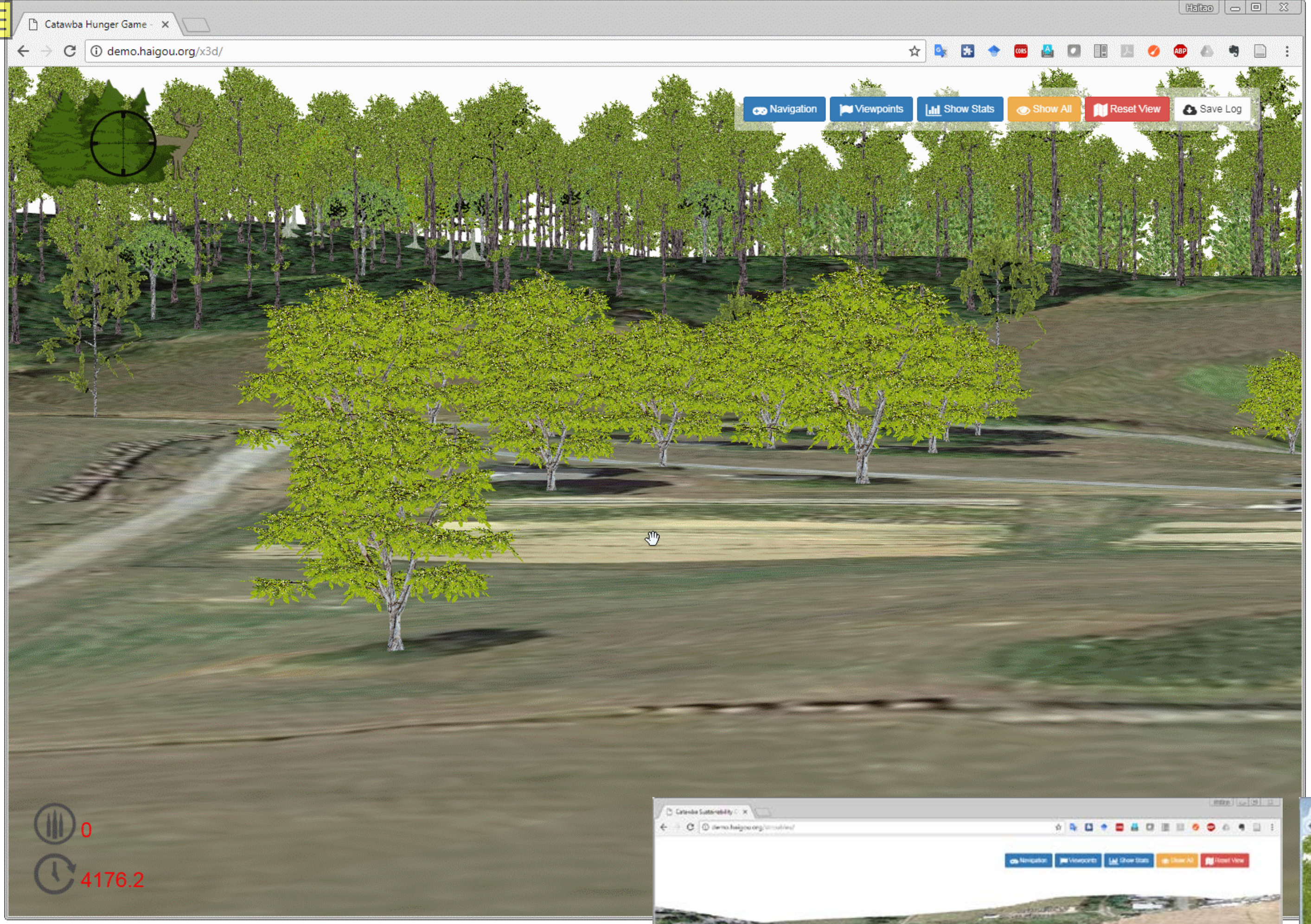


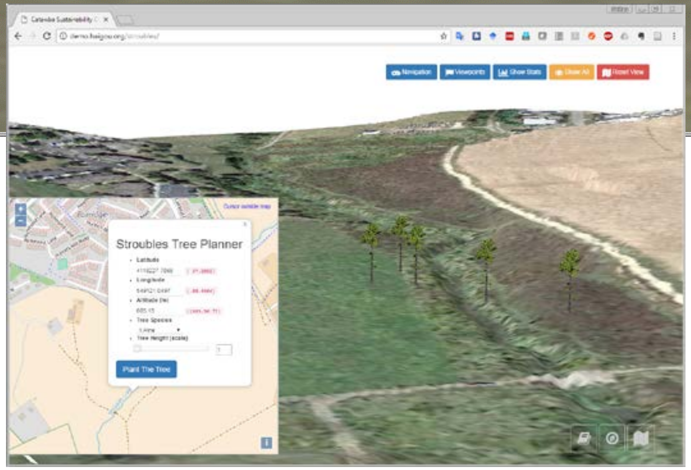


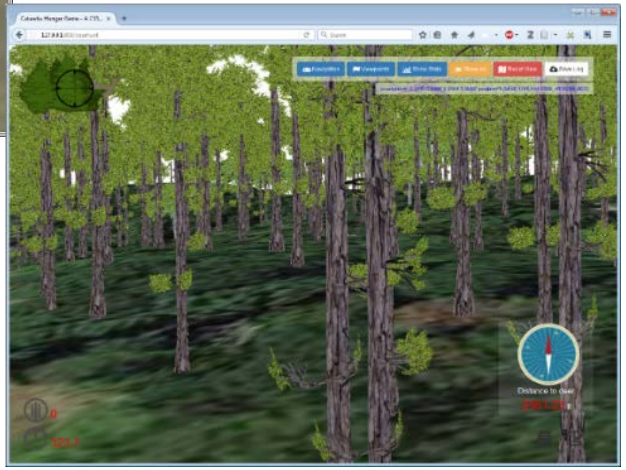






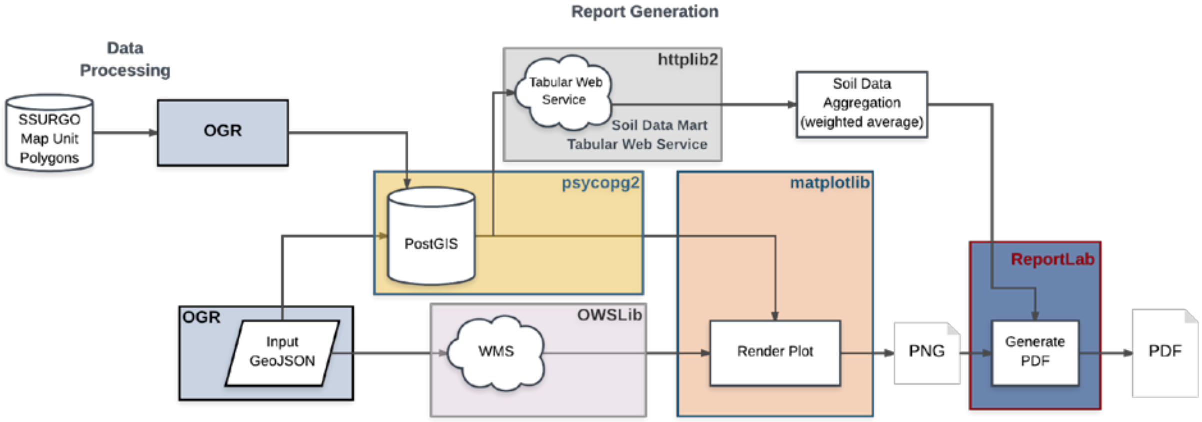


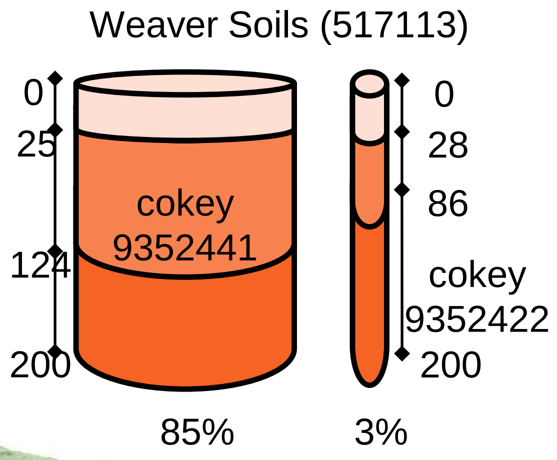


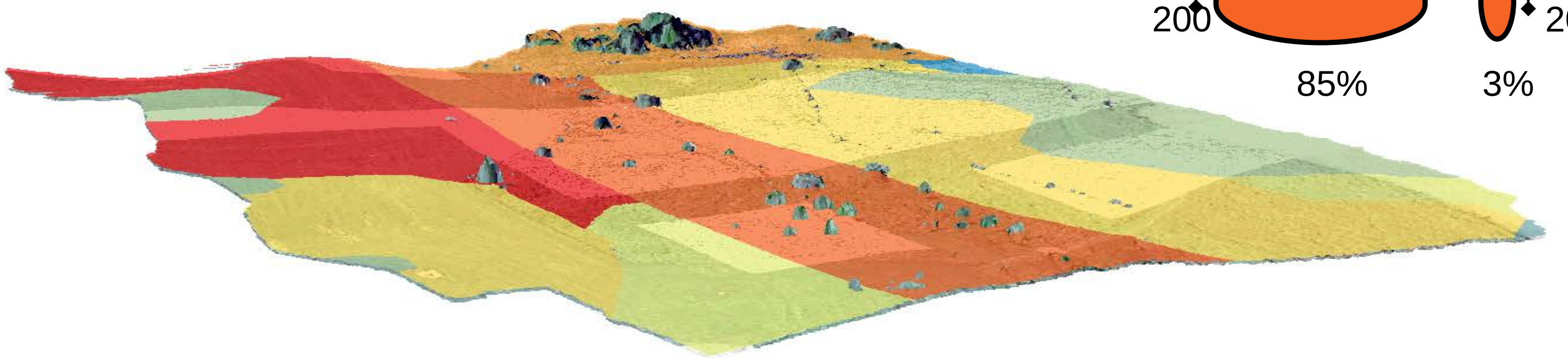


Haitao Wang, Xiaoyu Chen, Nicholas Polys, and Peter Sforza. *A Web3D forest geo-visualization and user interface evaluation*. Web3D '17, 2017.

3-D Soils



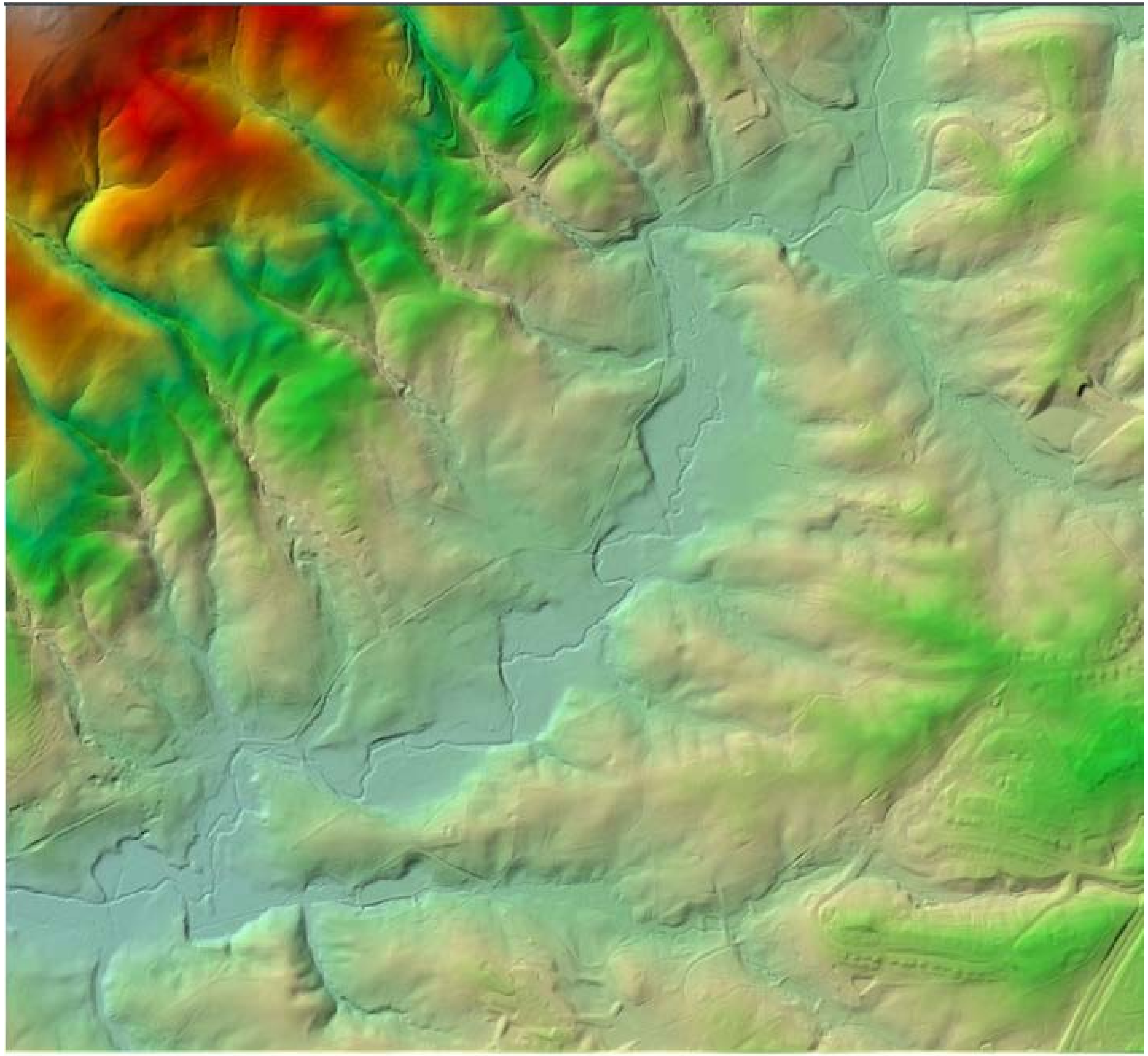




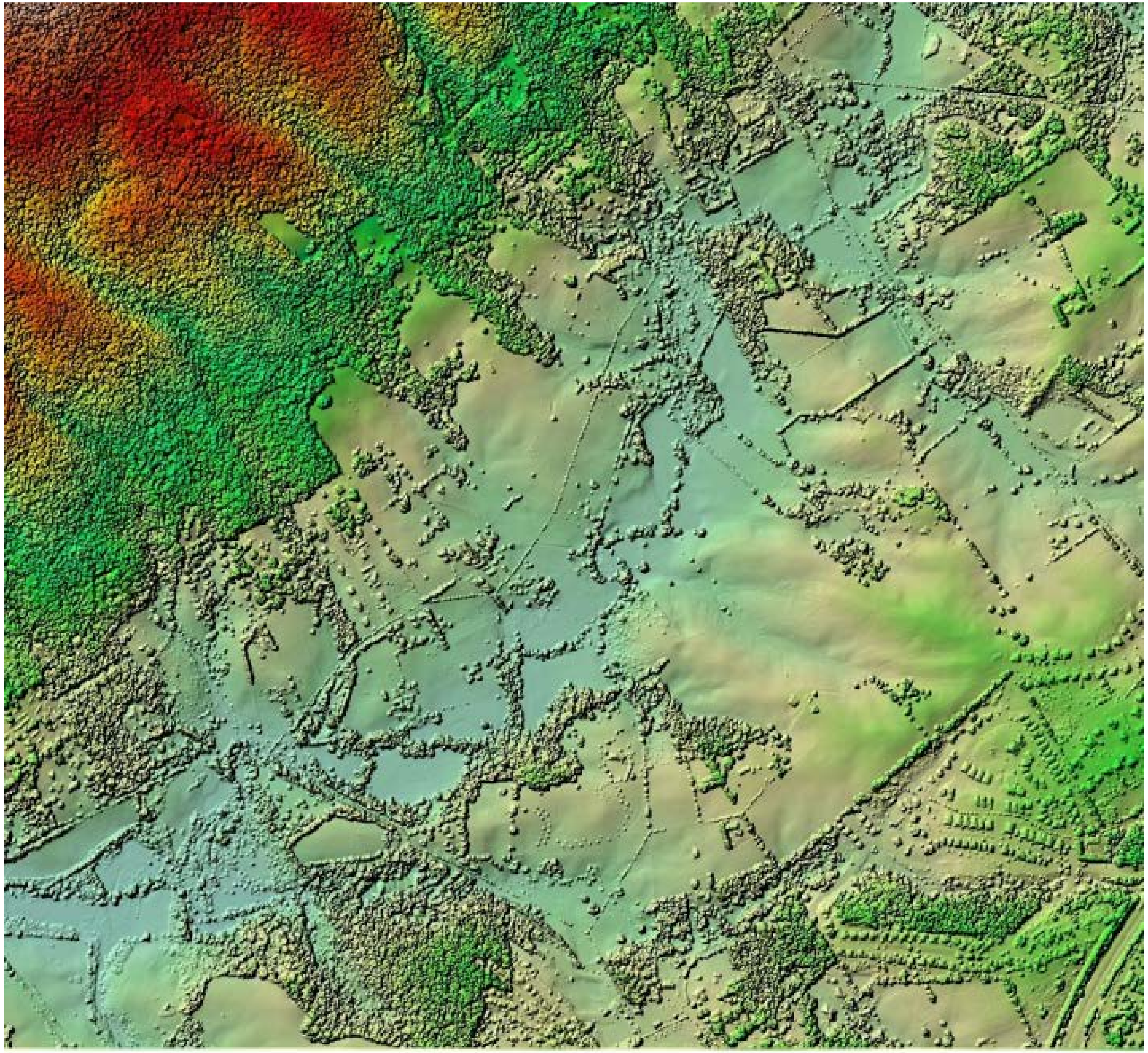
mukey	muname	cokey	comppct_r	corcon	chkey	hzdept_r	hzdepb_r	ksat_l	ksat_r	ksat_h	awc_l	awc_r	awc_h	dbthirdbar_r	ph1to1h2o_r	om_r	cec7_r	cec7_l	cec7_h	resdept_r
517113	Weaver soils	9352422	3	High	26255060	0	28	1.4	2.7	4	0.18	0.21	0.24	1.4	4.6	1	9	7	18	
517113	Weaver soils	9352422	3	High	26255061	28	86	0.42	0.9	1.4	0.12	0.15	0.18	1.45	4.6	1	17	12	20	
517113	Weaver soils	9352422	3	High	26255062	86	200	0.42	0.9	1.4	0.1	0.13	0.16	1.45	4.6	0.25	14	11	19	
517113	Weaver soils	9352441	85	Low	26255122	0	25	4	9	14	0.15	0.18	0.2	1.43	7.5	3	16	9	19	127
517113	Weaver soils	9352441	85	Low	26255123	25	124	4	9	14	0.15	0.18	0.2	1.43	7.5	1.5	16	9	17	127
517113	Weaver soils	9352441	85	Low	26255124	124	200	4	9	14	0.15	0.18	0.2	1.43	7.9	0.75	12	8	15	127

3D Site Model

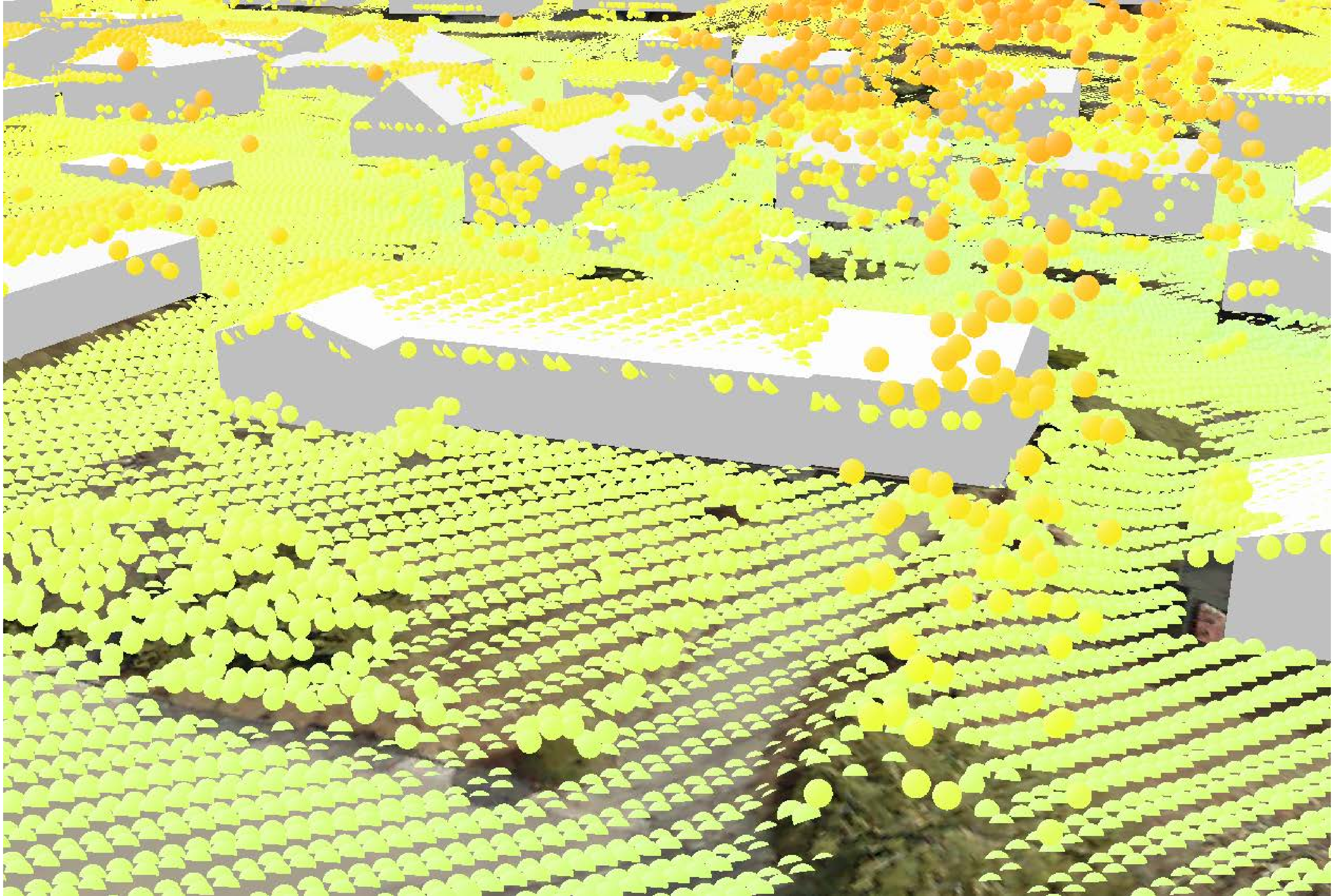
CGIT SmartFarm project https://cgit04.cc.vt.edu:2003/map/

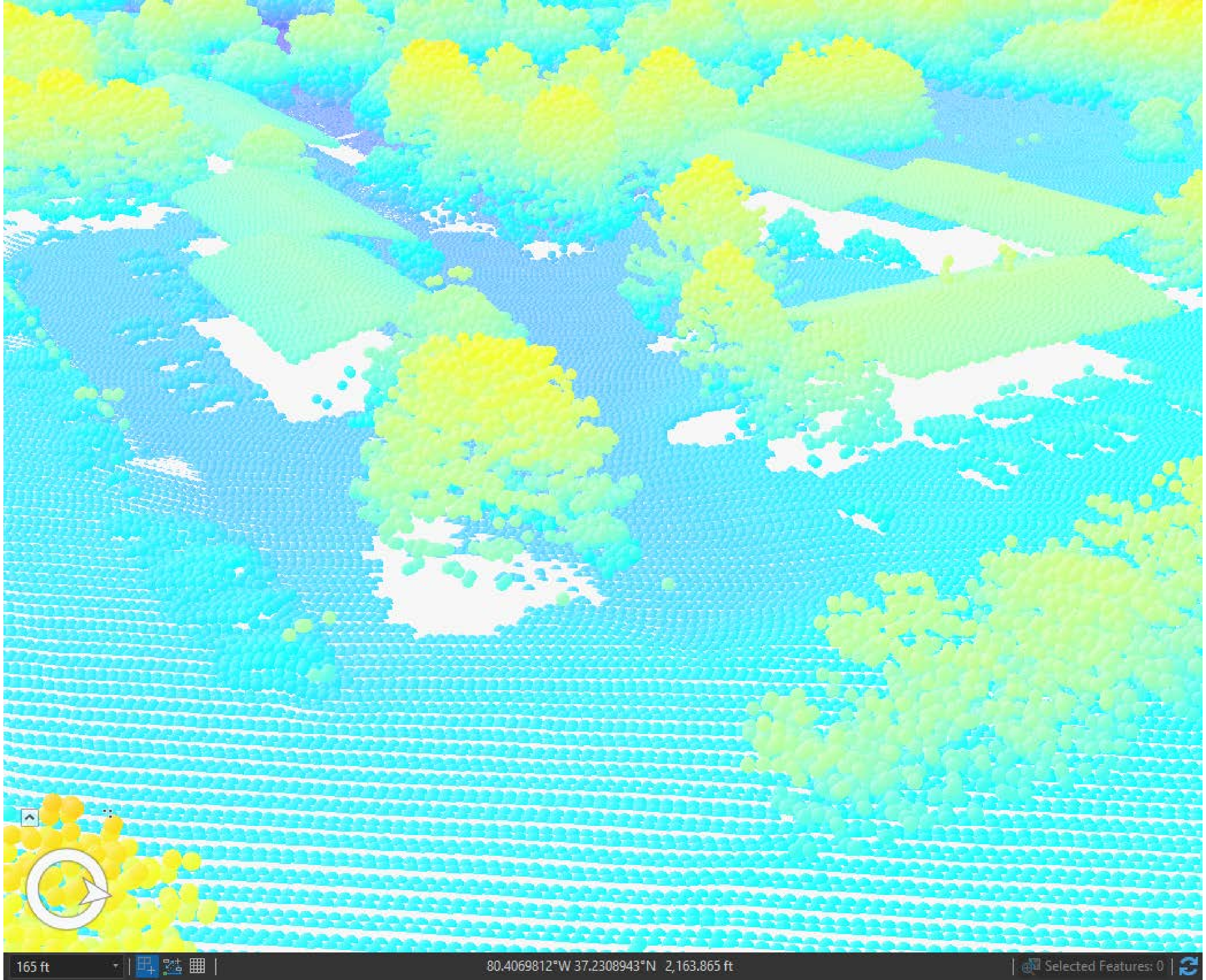


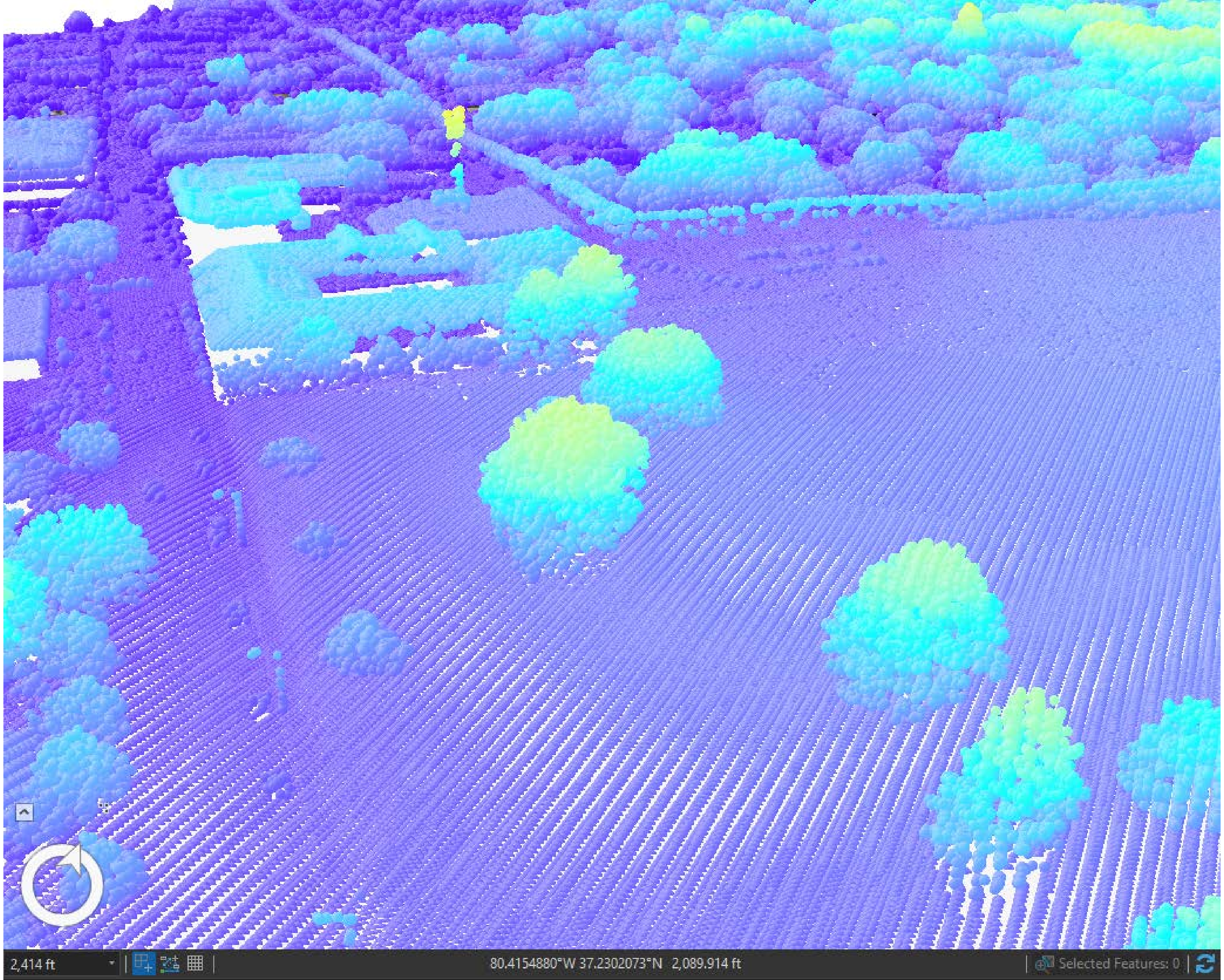
Digital Terrain Model (DTM)

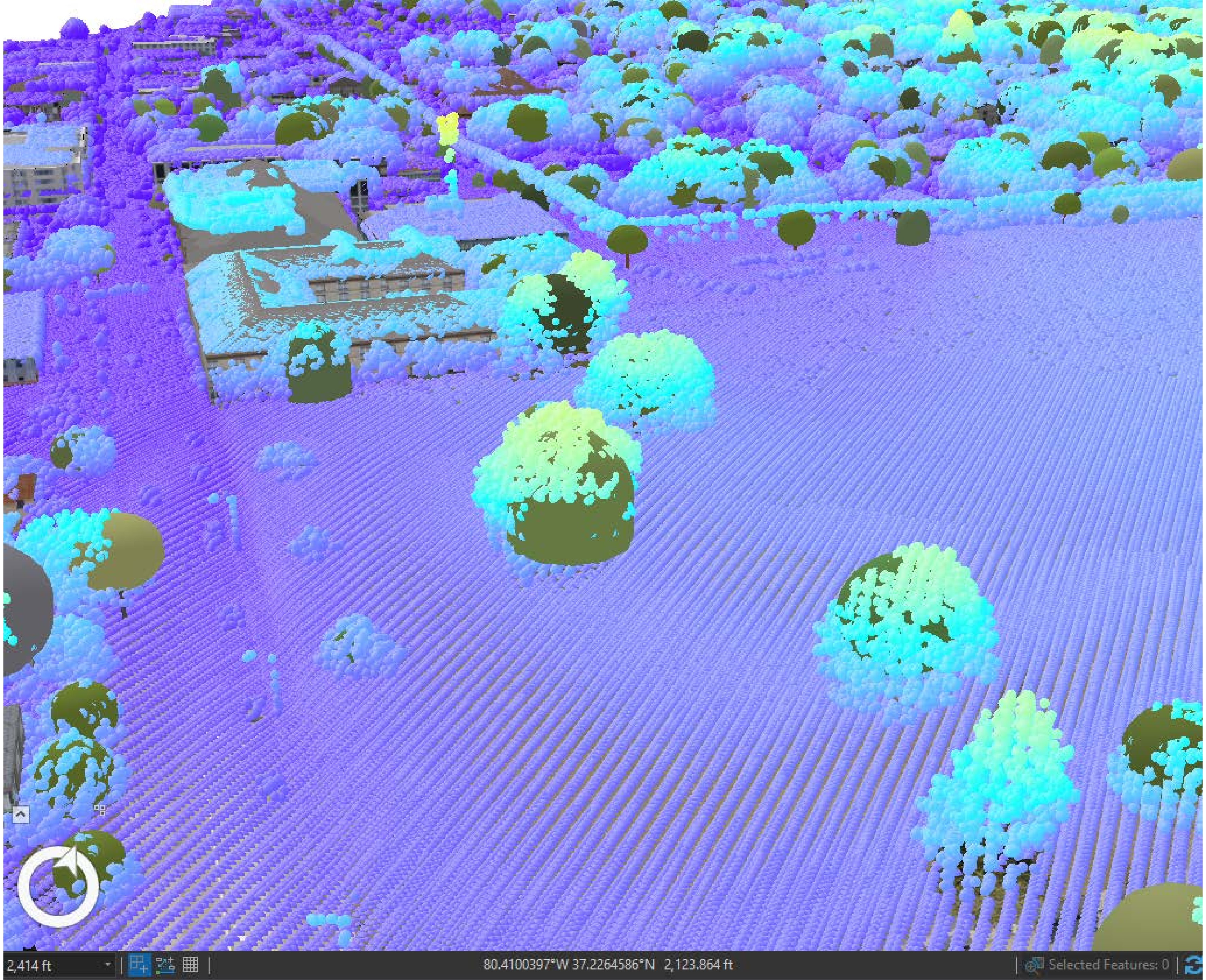


Digital Surface Model (DSM)




165 ft
80.4069812°W 37.2308943°N 2,163.865 ft
Selected Features: 0

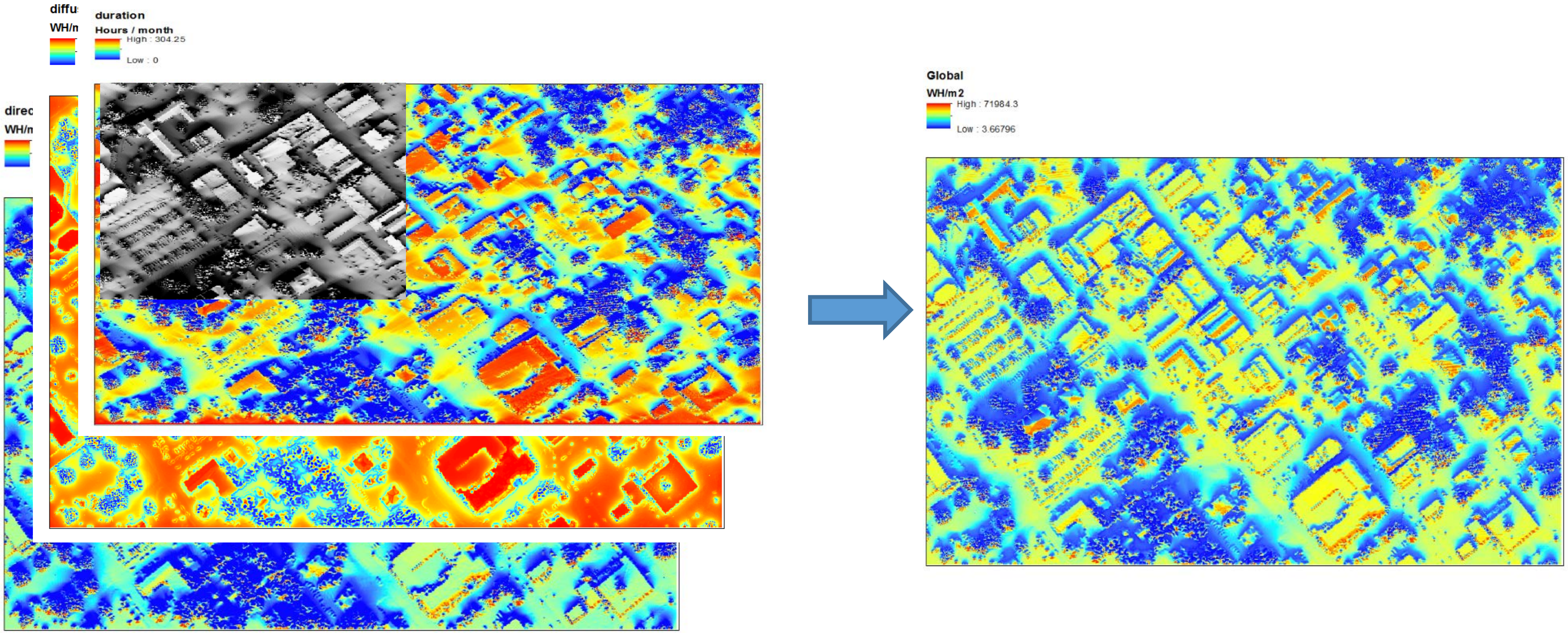

2,414 ft
80.4154880°W 37.2302073°N 2,089.914 ft
Selected Features: 0


2,414 ft
80.4100397°W 37.2264586°N 2,123.864 ft
Selected Features: 0

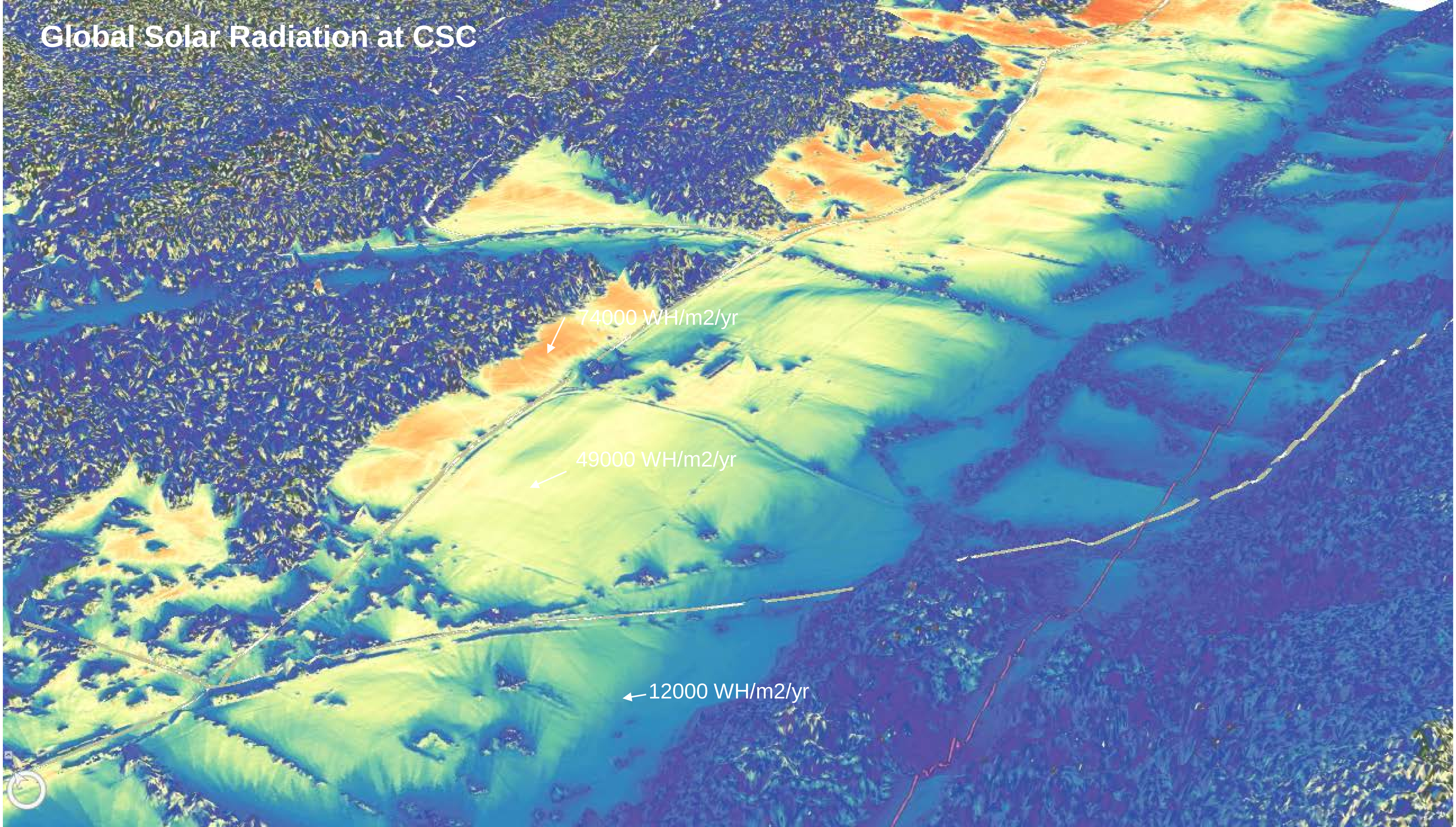
Turbine and solar panel models

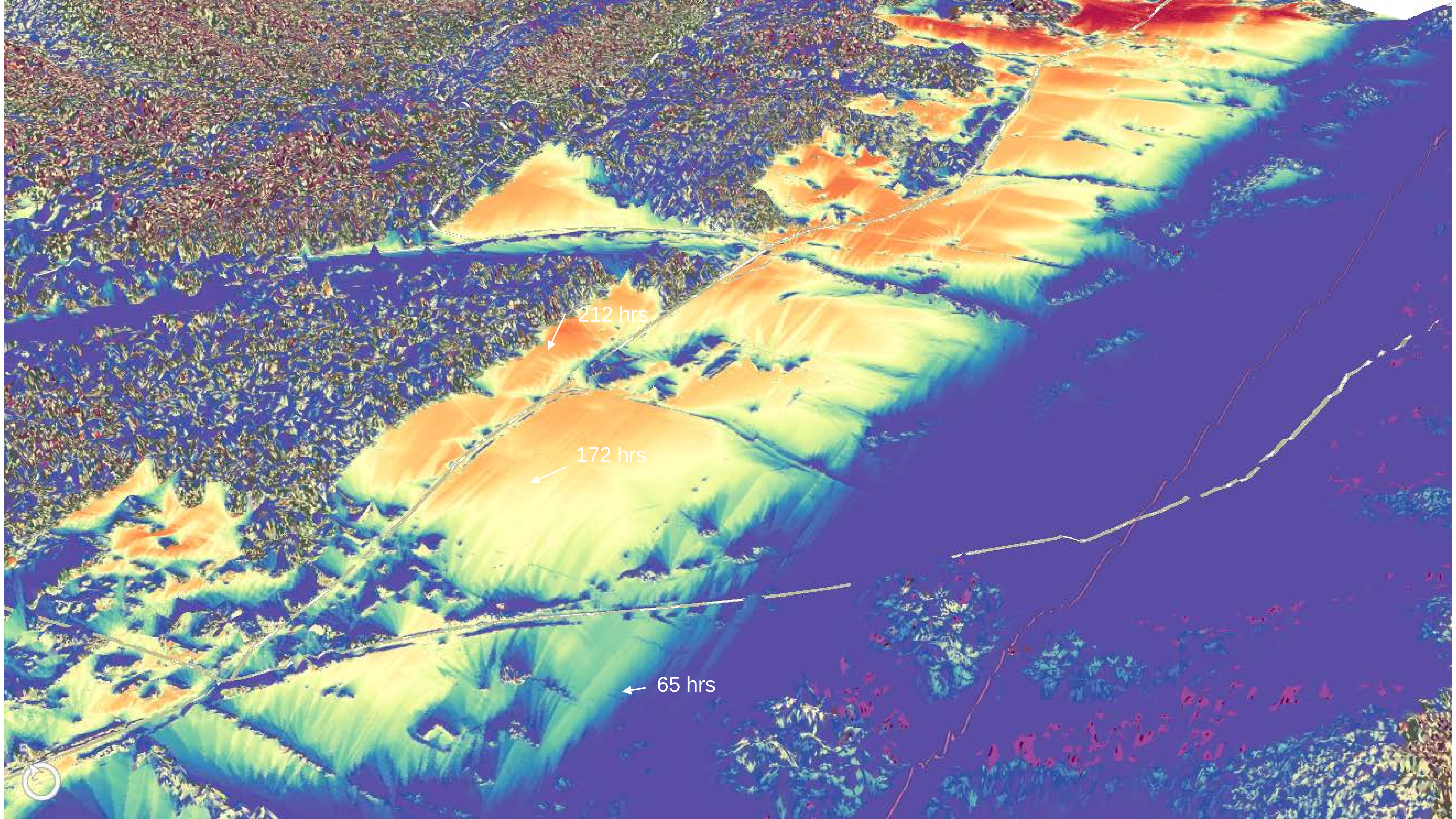
Solar

Solar radiation models calculate global radiation (WH/m^2) from direct, diffuse and duration components.



Global Solar Radiation at CSC

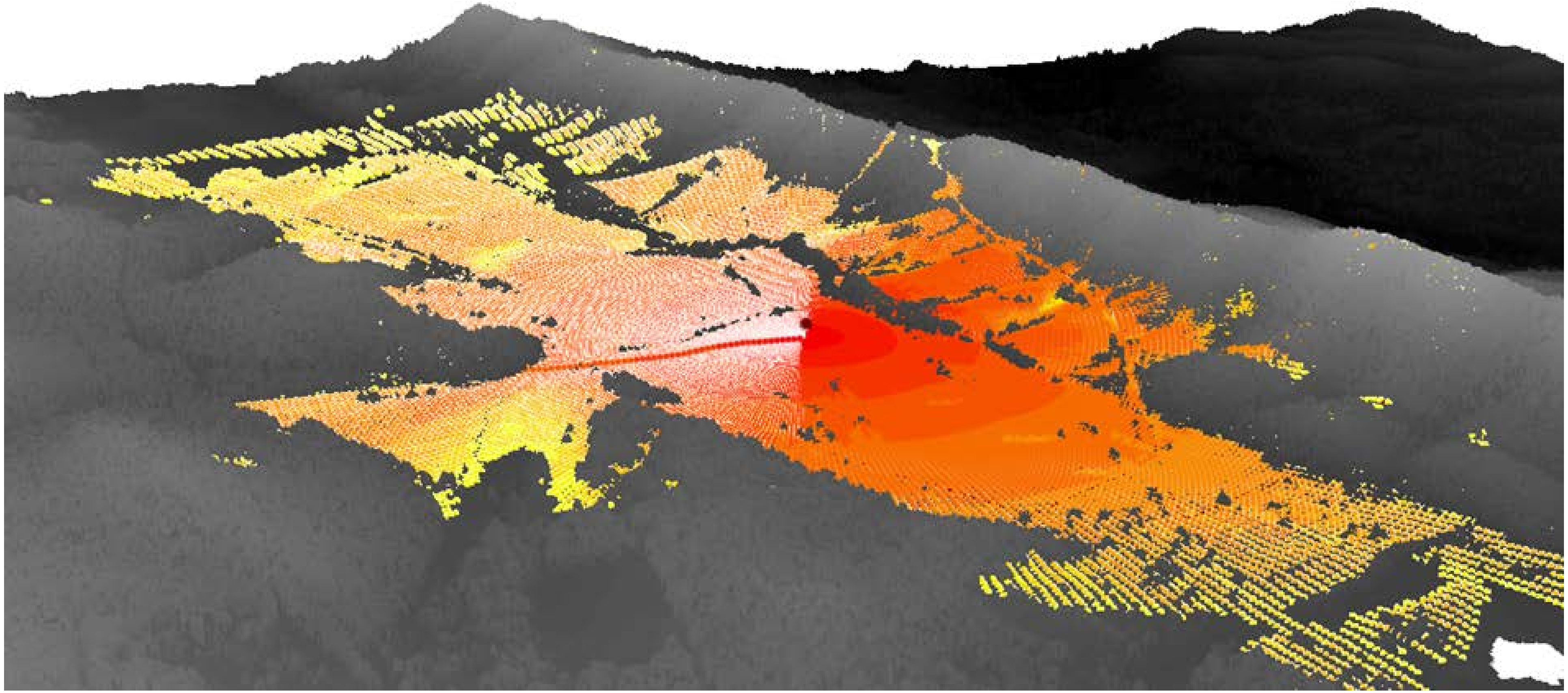



212 hrs
172 hrs
65 hrs

Renewable Energy Facility Siting

http://arcgis-research.gis.vt.edu/cgit/ref_demo/

Sound propagation estimation for farm scale turbine



VT CGIT model: Low-level calculation of shadow casting

```
class Triangle(object):
    def __init__(self, origin, p0, p1, p2):
        """Takes in three point tuples with x/y/z coordinates and calculates the relevant information"""
        self.p0 = np.array(p0)+origin
        self.p1 = np.array(p1)+origin
        self.p2 = np.array(p2)+origin
        self.u = self.p1 - self.p0
        self.v = self.p2 - self.p0

        self.normal = np.cross(self.u, self.v)
        self.uu = np.sum(self.u*self.u)
        self.uv = np.sum(self.u*self.v)
        self.vv = np.sum(self.v*self.v)
        self.denom = self.uv*self.uv - self.uu*self.vv

class Shadowcast(object):
    def __init__(self, angle):
        """Read in data and calculate the physical characteristics of a terrain to calculate shadows"""
        self.angle = angle
        source_data = json.load(open('shadows\\shadow_test_data_{}.json'.format(self.angle),'r'))

        self.x = np.array(source_data['x'])
        self.y = np.array(source_data['y'])
        self.elevation = np.array(source_data['elevation'])
        self.h0 = np.array(source_data['h0'])
        self.A0 = np.array(source_data['A0'])

        coords = [(100,50),(100,150),(50,100)]
        origin = [self.x[coords[0]], self.y[coords[0]], self.elevation[coords[0]]]
        origin1 = [self.x[coords[1]], self.y[coords[1]], self.elevation[coords[1]]]
        origin2 = [self.x[coords[2]], self.y[coords[2]], self.elevation[coords[2]]]

        self.meshes = [Mesh(origin),Mesh(origin1),Mesh(origin2)]

        theta = np.mod((math.pi*3/2.0)+np.where(self.angle>0, math.pi*2-self.A0, self.A0), math.pi*2)
        phi = math.pi/2 - self.h0

        self.x_component = np.sin(phi) * np.cos(theta)
        self.y_component = np.sin(phi) * np.sin(theta)
        self.z_component = np.cos(phi)

    def generate_shademap(self):
        point = np.array([self.x, self.y, self.elevation])
        dir = np.array([-self.x_component, -self.y_component, self.z_component])

        results = np.zeros_like(self.x)
        for mesh in self.meshes:
            for tri in mesh.triangles:
                w0 = point - tri.p0[:,np.newaxis,np.newaxis]    #array of (3,y,x)
                a = -np.sum(tri.normal[:,np.newaxis,np.newaxis] * w0, 0)    #array of (y,x)
                b =  np.sum(tri.normal[:,np.newaxis,np.newaxis] * dir, 0)   #array of (y,x)
                r = np.divide(a, b, out=np.zeros_like(a), where=b!=0)

                intersect = point + r*dir
                w = intersect - tri.p0[:,np.newaxis,np.newaxis]
                wu = np.sum(w * tri.u[:,np.newaxis,np.newaxis],0)
                wv = np.sum(w * tri.v[:,np.newaxis,np.newaxis],0)
                s = (tri.uv * wv - tri.vv * wu)/tri.denom
                t = (tri.uv * wu - tri.uu * wv)/tri.denom

                shaded = np.logical_or(np.logical_or(s<0, s>1), np.logical_or(t<0, (s+t)>1))
                shadow = np.where(np.logical_or(r<0, shaded), 0, 1-mesh.transmissivity)

                results = np.where(shadow>0,shadow,results)
```

Shadows are calculated using trig and vector geometry to determine which mesh triangles intersect the rays between the sun and each raster cell.

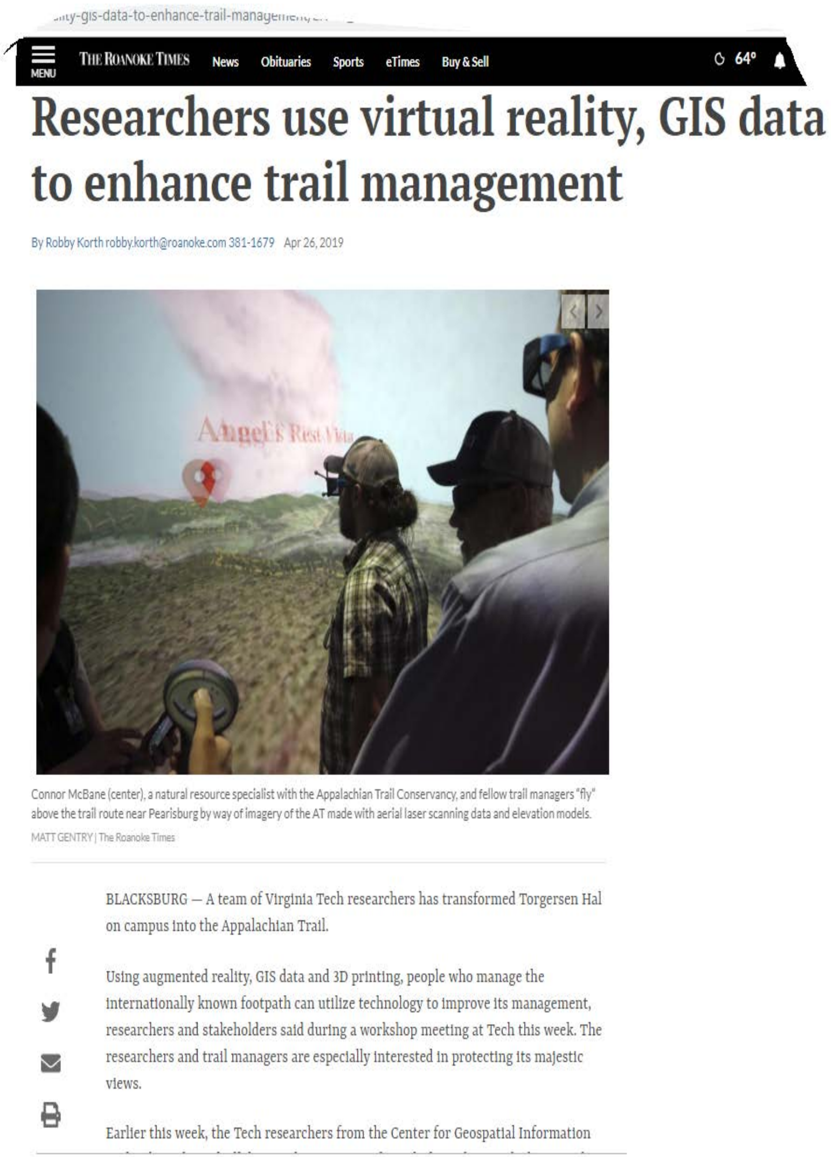
Calculations done in Python using the numpy library to handle arrays.

Cells	Triangles	Time
200x200	92	1.31 s
200x200	276	3.21 s
800x800	92	23.88 s
800x800	276	65.92 s

37.27N, 79.98W, Mar 18
Solar noon ± 3 hours, 20-min steps

Renewable Energy Facility Siting

Line of sight from building footprints


THE ROANOKE TIMES News Obituaries Sports eTimes Buy & Sell 64°

Researchers use virtual reality, GIS data to enhance trail management

By Robby Korth robby.korth@roanoke.com 381-1679 Apr 26, 2019

Connor McBane (center), a natural resource specialist with the Appalachian Trail Conservancy, and fellow trail managers "fly" above the trail route near Pearisburg by way of imagery of the AT made with aerial laser scanning data and elevation models.

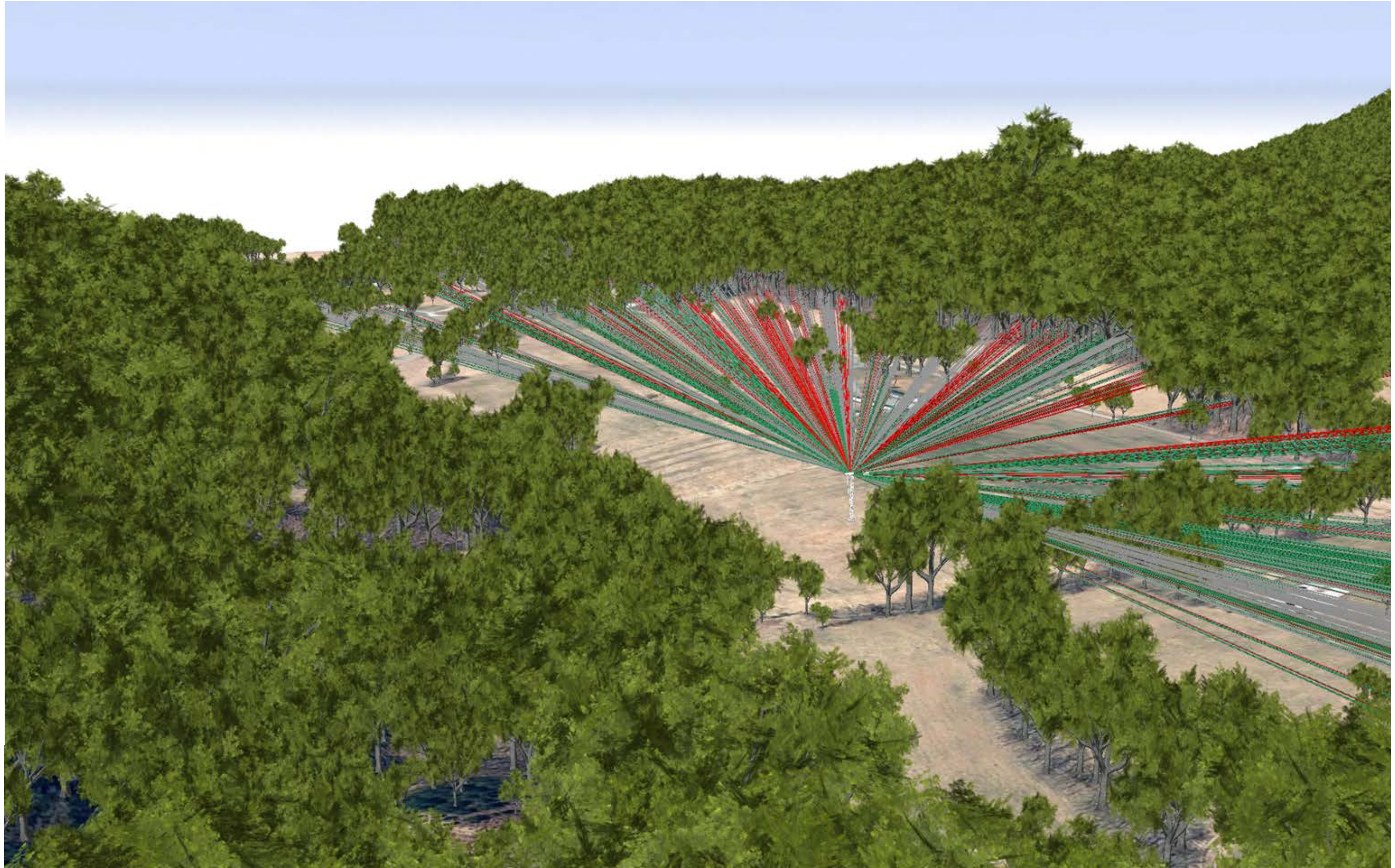
MATT GENTRY | The Roanoke Times

BLACKSBURG — A team of Virginia Tech researchers has transformed Torgersen Hall on campus into the Appalachian Trail.

Using augmented reality, GIS data and 3D printing, people who manage the internationally known footpath can utilize technology to improve its management, researchers and stakeholders said during a workshop meeting at Tech this week. The researchers and trail managers are especially interested in protecting its majestic views.

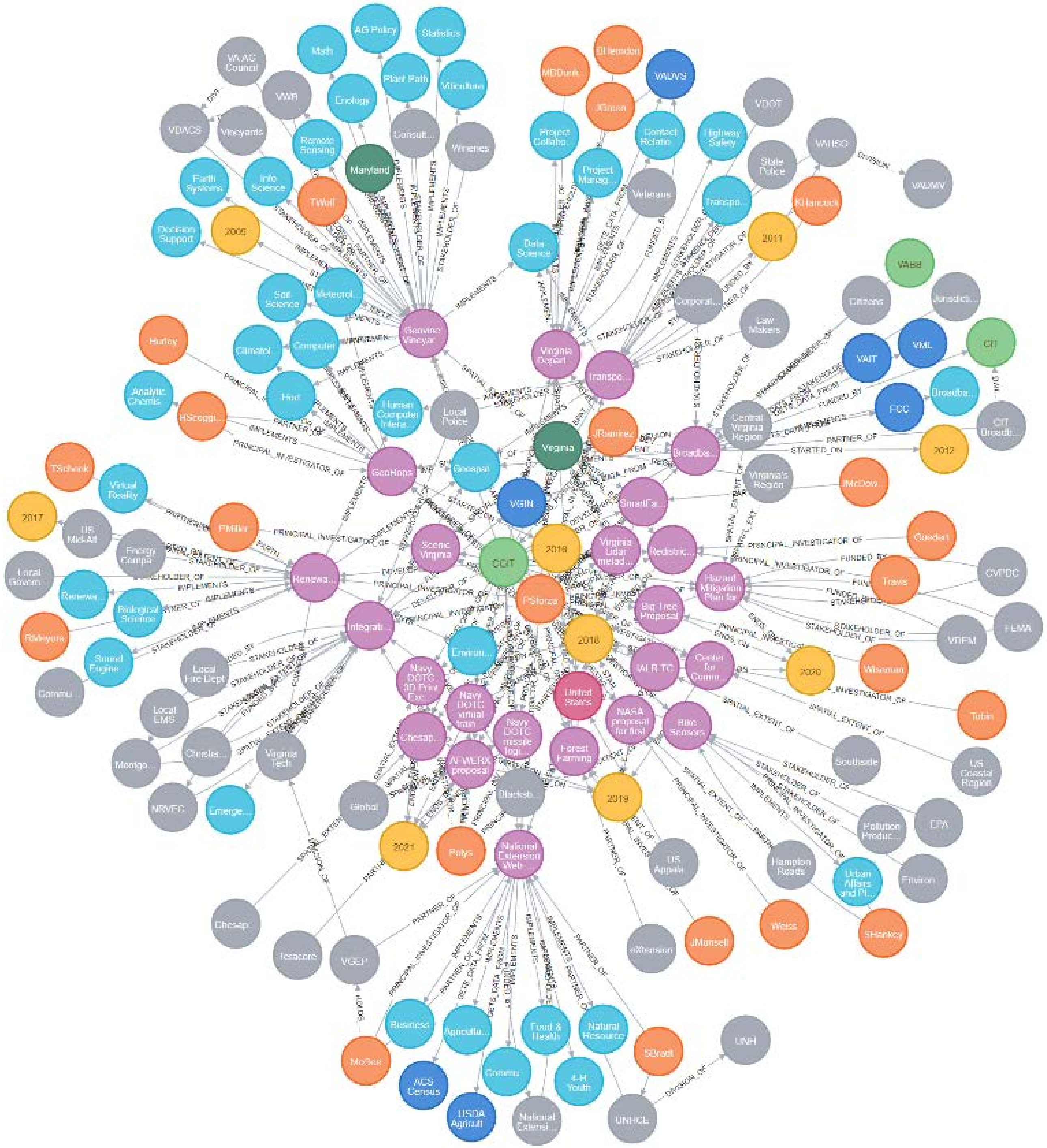
Earlier this week, the Tech researchers from the Center for Geospatial Information

https://www.roanoke.com/news/education/researchers-use-virtual-reality-gis-data-to-enhance-trail-management/article_ac186080-f099-5bf9-b010-db77daef89e8.html



Organizational Network Analysis

Sforza, 2019

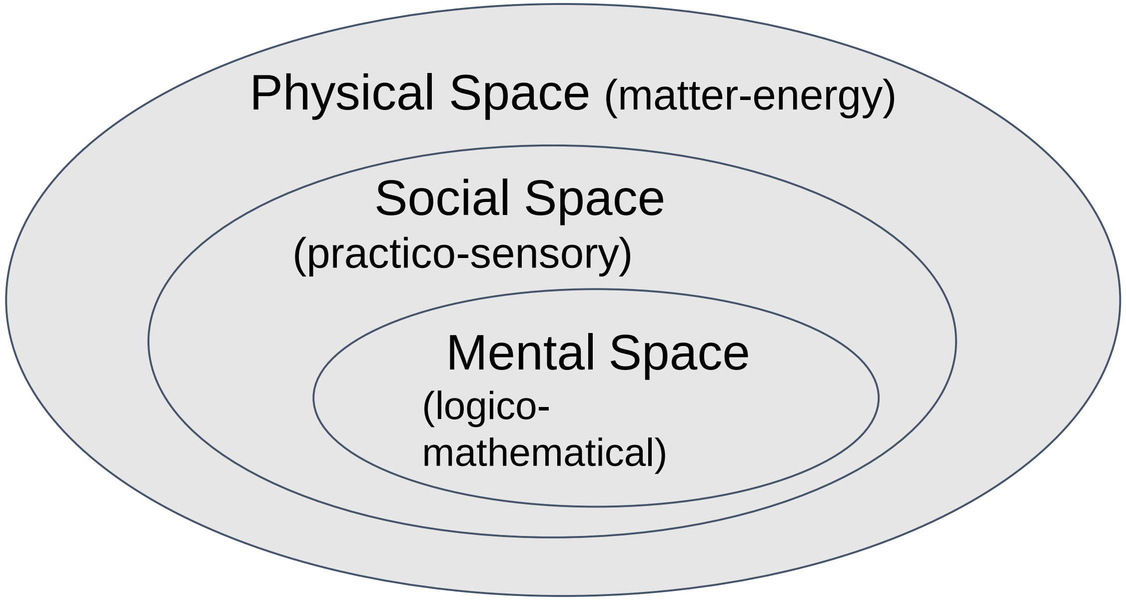


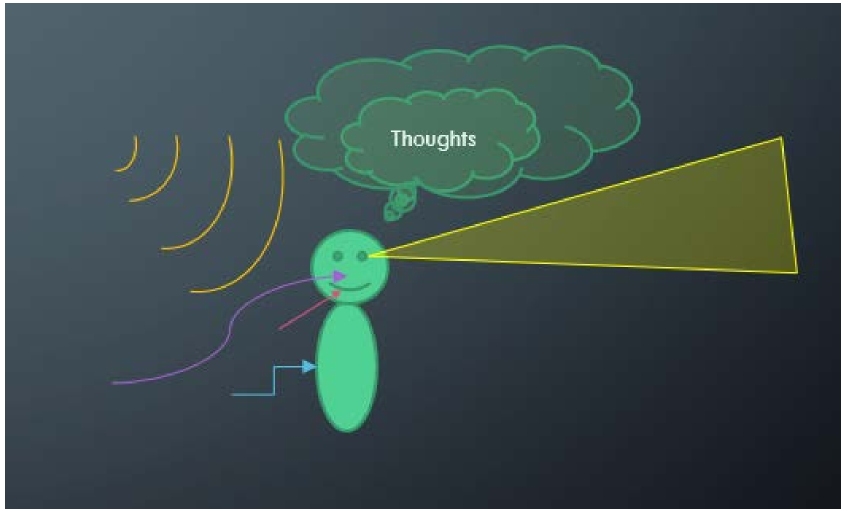
What next? Convergence Research

Theory + Practice

A **psycho-geographic** framework represents human-natural environment as external space (senses the physical world) and internal space (psychological and cognitive factors).

More recently, **unified theories** developed by philosophers describing the production of space (i.e. Lefebvre) further distinguishes *mental space* (logico-mathematical), *social space* (practico-sensory), and *physical space* (matter-energy).





Lefebvre (1974) discusses a ‘unitary theory’ with the aim to discover tor construct a theoretical unity between ‘fields’ which are apprehended separately.

Current efforts at VT CGIT to discover and develop methods for bridging between theory and practice through a unified theoretical framework.

Sforza, 2019