State of Tennessee

Enhanced Elevation Business Plan

FINAL DELIVERABLE

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FOREWORD

This project was undertaken by the State of Tennessee, Department of Finance and Administration, Office for Information Resources, GIS Services (OIR-GIS). It was made possible with funding assistance from the Federal Geographic Data Committee (FGDC) Fifty States Initiative, Cooperative Agreements Program (CAP). The Fifty States Initiative is a joint effort between FGDC and the National States Geographic Information Council (NSGIC) to advance the National Spatial Data Infrastructure (NSDI) with planning and coordination of diverse stakeholders involved in geospatial data, applications and services. NSDI and its constituent parts are built by multiple levels of government and the private sector, comprising a collaborative effort to "map once, use many times," thereby reducing duplicate spending and economizing in the use of scarce and valuable financial resources.

ACKNOWLEDGMENTS

This effort was led by Dennis Pedersen, Director of GIS Services within OIR. The content for the plan would not have been possible without the input of the many Tennesseans who participated in interviews and regional forums as part of the planning process. A business plan steering committee was formed and helped to guide the process, including the following members:

Brock Hill (SC Chairman) – Assistant Commissioner, Tennessee Dept. of Environment and Conservation
Dan Hawk – Tennessee Economic and Community Development
Jim Waters –Tennessee Dept. of Transportation - Design Division
Keith McFadden – US Geological Survey
Jason Duke – US Fish & Wildlife Service, and Tennessee Geographic Information Council
Dave McMillen – US Dept. of Agriculture, Natural Resource Conservation Service
Jennifer Higgs – Nashville Metropolitan Planning Commission

Coincidental and complementary to the business plan project undertaken by Tennessee OIR-GIS, was a study by the US Geological Survey (USGS) for a National Enhanced Elevation Assessment (NEEA). The USGS Geospatial Liaison for Tennessee, Keith McFadden, helped to align the State's plan with this national effort, and also facilitated with FGDC in the State's successful application for funding assistance through the Fifty States Initiative for this Business Plan to be developed. Contractor support was led by Rich Grady of AppGeo with Zsolt Nagy of AECOM.

EXECUTIVE SUMMARY

What is this?

This business plan for acquiring high-resolution elevation data proposes a strategy to cover the state with a much better terrain model than currently available. The current low-resolution elevation data is not suitable for improved decision support on issues that involve billions of dollars in investment and spending. A statewide vision for the **Tennessee Base Mapping Program (TNBMP)** was provided in the Enterprise GIS Business Plan of 2008, and it still applies, today: [1]

> **"To create and maintain geospatial information to support State and local government business processes through a coordinated and centralized approach that results in reducing duplication of effort and a more effective and efficient government."**
>
> TNBMP Vision Statement
> Enterprise GIS Business Plan, 2008

While great progress has been achieved on 6 of the 7 TNBMP framework layers, one needs serious attention -- elevation. Elevation has lagged behind other layers in the TNBMP in being upgraded to higher accuracy and currentness. For example, orthoimagery, parcels, and streams are already being managed at high-resolution scales to support increased demands for accuracy.

Why is this important?

Tennessee needs high-resolution elevation data to more accurately map its terrain, and to achieve synergy with other updated map layers. Better terrain data helps to protect people and their future investments in property and land development by reducing the risk of potential damages due to decisions made with low-resolution data – both developers and regulators are in agreement on this point. Being able to more accurately predict the areas that will be inundated at different flood stages, in advance of big rain events in the future, will save lives, property, and money spent on damages. Better terrain data will more accurately answer the question, "Where will it flood?"

The merits of coordinated statewide acquisition are clear when it comes to achieving economies of scale and leveraging existing expertise and resources, such as the Tennessee Base Mapping Program (TNBMP)

[1] Tennessee Office for Information Resources, GIS Services, Enterprise GIS Business Plan, July 2008, p. 3.

with its proven track-record of producing results. Better terrain data is essential to support economic growth and ensure public safety, and current efforts to acquire it are not coordinated, and are driven by project-level, not enterprise-level, requirements.

This will be one of the most important geospatial data layers to meet 21st Century demands for making better decisions and growing the economy in a productive way, and will benefit Tennesseans in all of the Grand Divisions of the State. The accurate and current mapping of Tennessee's terrain requires enhanced elevation data using modern technology (i.e. Light Detection and Ranging, a.k.a. LiDAR) to achieve high-resolution.[2] It also requires leadership commitment, and State appropriations for funding support.

Valuable uses and benefits of enhanced elevation data include:

- Predicting the extent and impact of flood events
- Facilitating emergency management and public safety
- Ensuring fairness in code enforcement and property assessment
- Improving natural resource management and agriculture
- Discovering and preserving cultural resources
- Making decisions about flood insurance, damage mitigation measures, and public policy
- Site selection for new factories and industrial development
- Route planning and corridor management for transportation and utilities
- Promoting new skill development through the use of modern technology (i.e. LiDAR) to make Tennessee a center of excellence for such knowledge and related jobs

How much is this going to cost?

A companion piece to this plan is the "State of Tennessee Enhanced Elevation Technical Specifications," which describe the technical requirements in detail. For the high-accuracy quality level required to support the TNBMP, the rough order of magnitude (ROM) cost estimates based on expert opinion from multiple sources for the entire state are listed, below:

- TNBMP "Standard" Deliverable for Enhanced Elevation Data Sets: $10.4 million

[2] The term "enhanced elevation" is used to describe precise 3-D measurements of land or submerged topography, built features, vegetation structure, and other landscape detail. [*Source:* National Enhanced Elevation Assessment (NEEA) State Kickoff Meeting 18 April 2011, USGS National Geospatial Program]

- Optional Derived Products: $4.5 million

In addition, there will be a TNBMP "Upgrade" Deliverable for Enhanced Elevation Data Sets as a buy-up option.

The cost of not doing anything is amplified by the many millions of dollars in likely losses from damages that result because of future flood events – losses that could be reduced if high-resolution elevation data is available to support decision-making on property investments and public safety as Tennessee grows. It is not unreasonable to believe that some percentage of losses due to floods could be avoided in the future with better terrain data to support decisions about development in the flood plain. Hypothetically, if there was another flood event of similar magnitude of May 2010 when estimated damage costs were approximately $2 billion, even a 1% reduction would equate to $20 million in avoided costs. Going forward, better terrain data will lead to safer investment decisions and less risk to the public.

When will this begin?

This plan is the first step. Preliminary program activities will take place during calendar year 2012 to build the necessary partnerships and to continue education and outreach activities, with a pilot recommended for the first half of calendar year 2013. No new appropriations are requested until Fiscal Year 2014 (FY 2014), and these will be pursued through the formal budget process in the fall of calendar year 2012. The program is proposed to run through FY 2018, to complete the pilot and 4 production cycles of ¼ of the State each time, in phases aligned with the State's orthoimagery program. The accuracy of this orthoimagery can be enhanced by better elevation data -- another valuable and synergistic benefit of the proposed initiative.

1 PROGRAM GOALS & SITUATION ANALYSIS

1.1 WHAT DOES TENNESSEE NEED?

Tennessee needs high-resolution elevation data to more accurately map its terrain. This plan comprises the business case for **the coordinated statewide acquisition of better terrain data** than what the State is currently limited to using. This is essential to support economic growth and ensure public safety.

This is one of the most important geospatial data layers needed to meet 21st Century demands for making better decisions and growing the economy in a productive way, and will benefit Tennesseans in all of the Grand Divisions of the State. The accurate and current mapping of Tennessee's terrain requires enhanced elevation data using modern technology (i.e. Light Detection and Ranging, a.k.a. LiDAR) to achieve high-resolution.[3] It also requires **leadership commitment, and State appropriations** for funding support.

A conservative goal to reduce damages with better preparation and avoidance of recovery costs could yield a very favorable return on investment (ROI) from acquiring better terrain data**.** For a flood event of similar magnitude to what occurred in May 2010, a mere **1% reduction in estimated damage costs would equate to $20 million,** more than covering the cost of the enhanced elevation program.

What Has Been Done Already?

A coordinated base mapping effort has been ongoing in the State of Tennessee since at least 1996, helping to ensure informed decision-making for the betterment of Tennesseans. The purpose has been to **build and maintain a set of statewide base map data layers of suitable scale and accuracy, "upon which other specific data sets can be added and results of analysis be displayed."**[4] The Statewide GIS Base Mapping Business Plan (1998) made a number of key recommendations to fulfill the State's vision, and the following two are most relevant to the current planning effort[5]:

- Commit to establishing and completing the program from the highest level of State government. Identification of appropriate funding source(s) should be included. This

[3] The term "enhanced elevation" is used to describe precise 3-D measurements of land or submerged topography, built features, vegetation structure, and other landscape detail. [*Source:* National Enhanced Elevation Assessment (NEEA) State Kickoff Meeting 18 April 2011, USGS National Geospatial Program]
[4] Office for Information Resources, Statewide GIS Base Mapping Program Business Plan, December 1998, p.3.
[5] Ibid., p. 26.

commitment will allow the State to aggressively pursue partnerships for the remainder of the program.

- Establish the organizational structure within the Office for Information Resources (OIR) to provide for the execution of the program and development of data products (see Enhanced Elevation Technical Specifications document for details)

By most measures, the Tennessee Base Mapping Program (TNBMP) that grew out of the 1998 Plan has been a resounding success. The commitment of executive leadership was made to establish and fund the program, and to establish the organizational structure within OIR for GIS Services. OIR-GIS has creatively leveraged the improved technology and favorable cost trends in the geospatial industry since the start of the program.

> **"The Tennessee Base Mapping Program is the best thing the State has ever done – it is valuable for development in counties and utility districts –and the more accurate the elevation data, the better."**
>
> Larry Masters, Engineering/GIS Coordinator
> Jefferson-Cocke County Utility District

To pay for the TNBMP, State funding has been substantially leveraged through collaborative cost-sharing with local partners, delivering results well under original TNBMP budget estimates. This is a positive reflection of the careful stewardship by the OIR for GIS Services, and its fiscal responsibility to the taxpayers and executive leadership of Tennessee. The original TNBMP budget estimate, as planned in 1998, was $54M.[6] The actual TNBMP costs to produce the specified base map layers were $30M, through 2007.

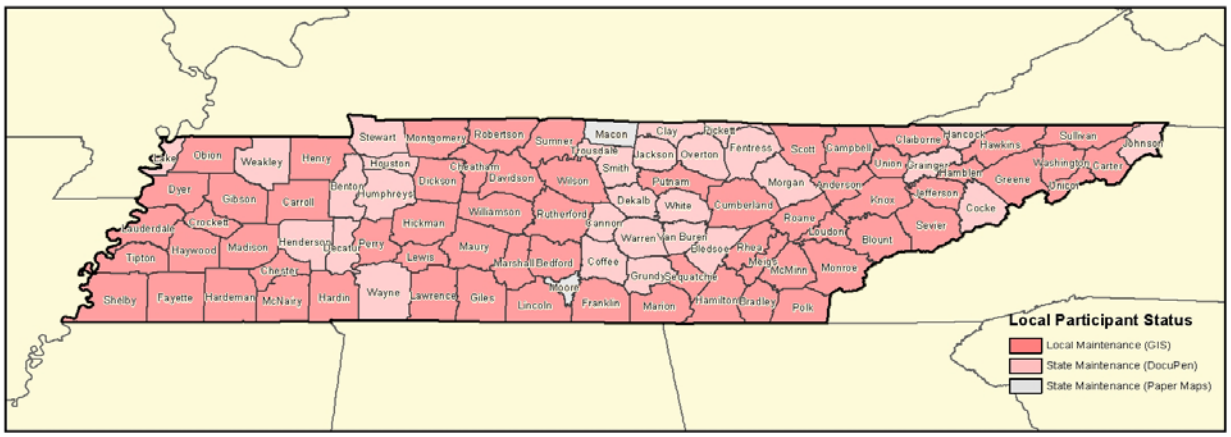
TNBMP Funding Participation 2000-07	Amount of Funding
State Government	$25 million
Local Government	$5 million
TOTAL	**$30 million**

The State's TNBMP is nationally prominent, with a rich data collection built between 2000 and 2007. Tennessee anticipated the advent of "geospatial platforms," as evidenced by its wide dissemination of data via the Internet and modern Web services. For example, Tennessee was one of the very first states

[6] Ibid., p.2.

to build a statewide property parcel layer -- a major achievement of national acclaim being emulated by other states -- and closely tied to the TNBMP orthoimagery and other data layers.

The TNBMP reaches every corner of the state. Over 275 local government entities representing all 95 counties are active participants in some capacity in the program. The following map illustrates the statewide relationships and the level of participation for maintenance of the property parcel (cadastral) data.



Level 1 Parcel Maintenance: Local Maintenance (Local GIS)					Level 3 Parcel Maintenance: State Maintenance (local DocuPen support)			Level 4 Parcel Maintenance: State Maintenance (local Paper Maps)
Anderson	Dyer	Jefferson	Monroe	Sullivan	Benton	Houston	Weakley	Macon
Bedford	Fayette	Knox	Montgomery	Sumner	Bledsoe	Humphreys		Moore
Blount	Franklin	Lauderdale	Obion	Tipton	Cannon	Jackson		
Bradley	Gibson	Lawrence	Perry	Unicoi	Clay	Johnson		
Campbell	Giles	Lewis	Polk	Union	Cocke	Lake		
Carroll	Greene	Lincoln	Putnam	Warren	Coffee	Morgan		
Carter	Hamblen	Loudon	Rhea	Washington	Decator	Overton		
Cheatham	Hamilton	Madison	Roane	White	DeKalb	Pickett		
Chester	Hardeman	Marion	Robertson	Williamson	Fentress	Smith		
Claiborne	Hardin	Marshall	Rutherford	Wilson	Grainger	Stewart		
Crockett	Hawkins	Maury	Scott		Grundy	Trousdale		
Cumberland	Haywood	McMinn	Sequatchie		Hancock	VanBuren		
Davidson	Henry	McNairy	Sevier		Henderson	Wayne		
Dickson	Hickman	Meigs	Shelby					

Map Source: TN OIR GIS Services Website

1.2 IS THE ENTERPRISE GIS BUSINESS PLAN OF 2008 STILL RELEVANT?

Yes, it is, but there is work to be done to fulfill its intentions of leveraging the TNBMP foundation to meet the GIS data and services needs of the State. A statewide vision for GIS in Tennessee was provided in the Enterprise GIS Business Plan of 2008, and it still applies, today: [7]

[7] Office for Information Resources, GIS Services, Enterprise GIS Business Plan, July 2008, p. 3.

> **"To create and maintain geospatial information to support Federal, State and local government business processes through a coordinated and centralized approach that results in reducing duplication of effort and a more effective and efficient government."**
>
> TNBMP Vision Statement
>
> Enterprise GIS Business Plan, 2008

While great progress has been achieved on 6 of the 7 TNBMP framework layers, one needs serious attention -- elevation. Elevation has lagged behind other layers in the TNBMP in being upgraded to higher accuracy and currentness. Orthoimagery, parcels, and streams are already being managed at high-resolution scales. With the existing elevation data, the potential synergy of using it in an interoperable way with these layers is diminished by its low-resolution. Specifically, to strengthen and enhance the State's existing orthoimagery program, a high-resolution digital elevation model (DEM) is required. Acquiring a new, high-resolution DEM through LiDAR technology, would eliminate existing and future orthoimagery quality issues (e.g. spikes, smears, black holes, etc.) due to the outdated elevation data that is currently being used. This would ensure a high quality orthoimagery product being used by local government, E911 districts, State agencies, and others. The following table includes a list of TNBMP framework layers, and their status.

TNBMP Framework Layer	Status
Orthoimagery	Complete (ongoing updates)
Transportation (Street Centerline/Address Database)	Complete (ongoing updates)
Cadastral (Property Ownership)	Complete (ongoing updates)
Hydrography (Surface Water)	Complete (ongoing updates)
Administrative Boundaries	Complete (ongoing updates)
Geodetic Control	Complete (ongoing updates)
High Resolution Elevation Data	Planned (enhance accuracy and make current)

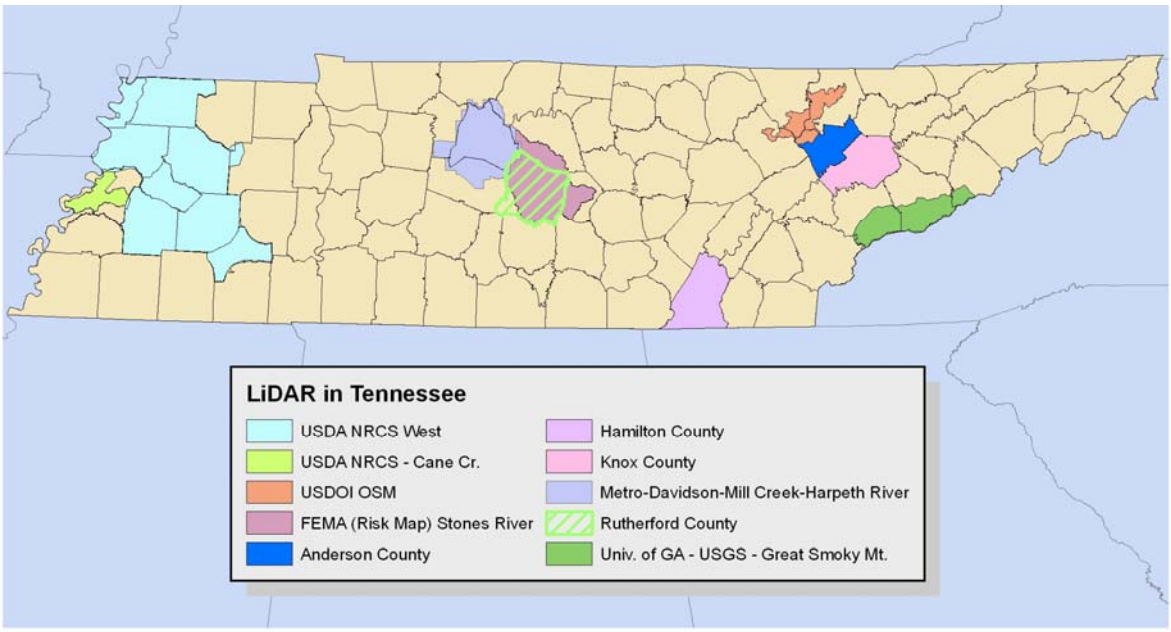
1.3 ANY PROGRESS ON HIGH-RESOLUTION ELEVATION DATA SINCE THE 2008 PLAN?

As noted earlier, measurable and ongoing progress has been made on the coordination and completion of most of the TNBMP framework layers. However, high-resolution elevation data has only proceeded on a project-by-project, piecemeal basis. For example, there are a number of project-level efforts that have taken place in Tennessee to enhance elevation data for specific areas and specific requirements.

The resulting data shows the value of modern technology, especially LiDAR (Light Detection and Ranging), for capturing better terrain data. Project summaries can be found at http://gis.tn.gov for the following ten projects across Tennessee using LiDAR to capture enhanced elevation data:

- US Department of Agriculture –Natural Resources Conservation Service, West
- USDA-NRCS, Cane Creek
- US Department of Interior, Office of Surface Mining
- Anderson County
- Hamilton County
- Knox County
- Metro-Davidson County-Mill Creek-Harpeth River
- Rutherford County
- Federal Emergency Management Agency (Risk Map) Stones River
- University of Georgia – US Geological Survey (USGS) Great Smokey Mtn. Project Summary

Map Showing Project Areas for Ten LiDAR Projects around the State



Map Source: http://gis.tn.gov/graphics/Lidar_Web_All_Hatch.jpg

These projects have helped to advance the state-of-the-art and understanding for achieving better terrain data in Tennessee. However, they have not been coordinated across jurisdictions, and are not achieving economies of scale by more effective procurement for efficient execution; and, there have been other LiDAR projects around the state besides these, amplifying the redundant costs of procurement across multiple jurisdictions. To enhance collaboration and efficiency, the following strategic goals were put forth in the 2008 Plan, and they are still relevant to the current situation[8]:

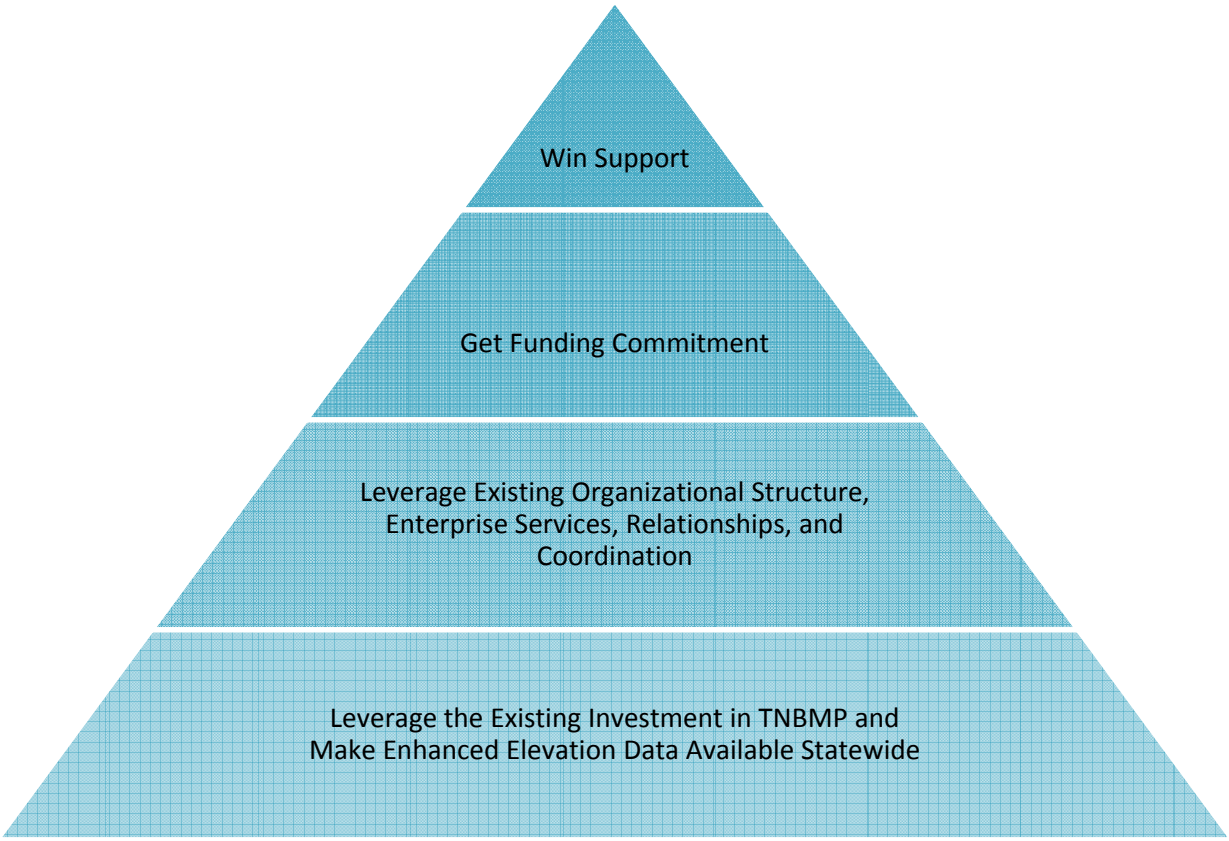
- Coordinate GIS Data Development – acquire, consolidate, and maintain the geospatial data needed by the State and local government
- Develop Enterprise GIS Infrastructure and Services – make the information accessible and useful through service provisioning
- Strengthen Enterprise Relationships – build a stronger GIS community in Tennessee

1.4 WHERE ARE WE NOW?

The situation today is not much different than 2008 in terms of what needs to get done on elevation; and funding remains limited. And yet, it is now much more important to finish and sustain the TNBMP effort, to make sure the State has accurate and current geospatial data to make informed decisions – not only to be better prepared for flood events, but also the myriad of other applications that need geospatial data to help produce job growth and economic development.

In order to maintain the value of geospatial data, it needs to be kept up-to-date; and new technological developments can support higher accuracy, too. **Of all the existing data, the elevation layer is most greatly in need of enhancement and modernization.** The key elements needed to move forward are summarized in the diagram, below:

[8] Ibid., p. 3.


Win Support
Get Funding Commitment
Leverage Existing Organizational Structure, Enterprise Services, Relationships, and Coordination
Leverage the Existing Investment in TNBMP and Make Enhanced Elevation Data Available Statewide

2 BENEFITS & JUSTIFICATION

2.1 WHY SHOULD THE STATE DO THIS?

Answering this question is at the crux of the matter. [9] The State's existing statewide elevation data is low-resolution, out-of-date, and not adequate for meeting the needs of modern society for factual and current data. Geospatial technology and science has advanced rapidly during the past decade, and greater precision is feasible for mapping the terrain. Elevation data that is faulty due to its lack of accuracy requires society to absorb the risk and consequences of decisions made based on its imperfections. This became evident in the flood events of both 2010 and 2011, which caused billions of dollars of damages. How much risk and potential for loss should the state accept?

> **"Flood models are only as good as the elevation data they use. Too much elevation data is old and coarse. The State needs better data before the next disaster."**
>
> Alan Spraggins, GIS Coordinator
> Tennessee Emergency Management Agency (TEMA)

Better terrain data would have helped to mitigate damages by informing decisions on flood plain management, both long before and during the events, proactively reducing the huge amount of individual and public assistance needed for the recovery effort. Going forward, **better data will help protect people and their future investments in property and land development by reducing the risk of potential damages due to decisions made with low-resolution data** – both developers and regulators are in agreement on this point. Being able to more accurately predict the areas that will be inundated at different flood stages, in advance of big rain events in the future, will save lives, property, and money spent on damages. Given that 24 lives were lost in the May 2010 flood event, with 1500 homes destroyed, and another 1150 homes with major damage, how much future risk is tolerable?

To quantify the risk in terms of population, both a coarse grain and fine grain estimate was made, as follows:

- Coarse Grain: Population is counted by Census Blocks. By taking the 2010 Census Blocks for Tennessee and intersecting the FEMA Digital Flood Insurance Rate Map (DFIRM) areas,

[9] Governor Haslam's "Ten Principles of Conservative Fiscal Leadership" (1st Principle), c.2009.

approximately 33% of Tennesseans – over 2 million – are at risk. This is probably unrealistically high, and should be factored down for a defensible risk assessment.

- Fine Grain: Since Census Blocks are areas, and not the actual addresses of where people live, a more realistic estimate was made using the Tennessee Information for Public Safety (TIPS) address points. This resulted in finding 68,220 structures with addresses that are at risk based on the intersection with DFIRM maps. Using 2.3 people per structure as a conservative estimator, the number of people at risk in this fine grain analysis is approximately 157,000. This is a more conservative number to use for risk assessment, but is still only an estimate.

When you look at the estimated costs for the program, and just focus on the benefits for reducing flood risks – without any consideration for the value of other benefits that will be discussed later in this section – there is an interesting metric that results. Specifically, if you take the estimated at risk population to be 157,000, and you calculate a per capita cost for just that number of people, the cost to reduce future flood risk with better terrain data is $66 per person for the LiDAR data and basic products; and it is $95 per person if you include the optional derived products. If you use the coarse grain estimator of 2 million people at some potential risk from floods, and factor it down by 50% to be somewhat conservative, the resulting 1 million people divided into to the proposed program costs would result in approximately $10 per person for the basic, and $15 person to include the optional products. These are just a couple of ways to help answer the questions about how much risk is tolerable, and what can be done to reduce risks and avoid future losses by informing decisions about development and public safety with better terrain data.

The difference between low-resolution elevation and high-resolution elevation data is evident when looking at buildings that may or may not be in the floodplain, and this can be shown on a map. For example, the following maps show the floodplain boundaries in the vicinity of Stoners Creek in Davidson County, without and then with LiDAR enhanced elevation. Notice the homes that are shown as “in” on one map (without enhanced elevation) are in fact “out” when mapped with enhanced elevation data from LiDAR. These homeowners would still have the opportunity to purchase flood insurance, but they wouldn’t be required to, and this has bearing on the value of their property. The reverse might also be true in some cases, as determined by the more accurate mapping of the floodplain boundary with enhanced elevation data. The maps follow:

Stoners Creek Floodplain Boundaries (blue-shaded)
Without LiDAR Enhanced Elevation
Map Source: Tennessee OIR-GIS Services

Stoners Creek Floodplain Boundaries (blue-shaded)
With LiDAR Enhanced Elevation
Map Source: Tennessee OIR-GIS Services

"An Assessor can't do his job without GIS. In or out of the floodplain is just one example of an assessing issue -- and better data that shows this can stand-up in court when needed. LiDAR helps us with that need by producing accurate and current elevation data."

Bill Bennett, Assessor of Property
Hamilton County

2.2 WHAT IS THE POTENTIAL VALUE OF THIS INITIATIVE?

Avoided Costs

Another way to phrase the above question might be, "What fraction of damage costs could be avoided in the future from better terrain data for Tennessee?" A good place to start answering is with a rundown on the losses from recent flood events. According to a Fact Sheet from the Federal Emergency Management Agency on the flood event of May 2010, $612.5 million in total federal disaster assistance went to Tennessee in the form of disaster grants and low-interest loans.[10] Below is a brief summary of some numbers from the May 2010 flood event.

- Nearly 68,000 individuals applied for assistance
- 46 counties declared for Individual Assistance
- 49 counties declared for Public Assistance
- 24 fatalities
- 1,500 homes destroyed
- 1,150 homes with major damage
- As many as 10,000 persons displaced
- Estimated over $2,000,000,000 in damage to homes, businesses and infrastructure.

Given the large amount of money involved in recovering from a natural disaster, there is a compelling economic argument to be made that **anything Tennessee can do to better predict flooding can result in substantial reductions in damage costs, and faster recovery**. The total federal assistance of just over $600 million is only about 33% of the $2 billion of estimated damages to homes, businesses and infrastructure. These numbers are from the May 2010 flood event, and they give a sense of magnitude to what can actually happen. This is not to say that anything should have been done differently to mitigate damages in 2010. Rather, it is to point out the importance of having better terrain data in the future to support Tennessee's growth, and to reduce the risk of future damages. A photographic reminder of some of the flooding during May 2010 follows.

[10] FEMA and TEMA joint Fact Sheet, "One Year Later: Tennessee Flood Recovery By the Numbers," April 19, 2011.

Flooding in May 2010

Image Source: FEMA-1909-DR-TN on May 2010 Flood Event

For the severe storms and flood events of 2011, 5 Presidential Disaster Declarations have been made through October.[11] Final numbers are not available for the total damage estimates, but individual and public assistance and mitigation grants to-date are approximately $120 M[12] – roughly 20% of what was received for the May 2010 flood event. While two back-to-back years with severe storms and flooding might be unusual, Tennessee had 16 Presidential Disaster Declarations made during the ten years from 2000-2009.[13] During that period of time, the state received $18.1 million in Federal Emergency Management Agency (FEMA) disaster grants, for a combined 3000 projects, according to the Tennessee Emergency Management Agency (TEMA). Tennessee has a long history of flood events -- it is not a question of "if," but rather, "when" flooding will occur in the future. Again, anything that can reduce damages, proactively, will ultimately save large amounts of money and save lives.

[11] http://www.fema.gov/news/newsrelease.fema?id=56756
[12] TEMA presentation by Alan Spraggins, "Financial Impact Since May 2010," circa mid-2011.
[13] TEMA presentation by Alan Spraggins, "2010 Tennessee May Flood Impacts," circa early-2011.

Clearly, flood events have created a sense of urgency to acquire enhanced elevation data in many parts of the state. Better terrain data will help answer the question of "Will it flood, or won't it?" With better terrain data, it will be easier to assess how potential flooding affects insurance needs; evacuation needs; property values; and purchasing decisions.

As important and compelling as flooding is as a demand-driver for better terrain data in Tennessee, **there are many other applications besides flooding that will benefit**, as presented in the next section. In addition, there are savings associated with a state-run program, given that there are unnecessarily redundant efforts taking place as stakeholders move forward with their own independent initiatives to get enhanced elevation data. For example, the estimated cost of developing an RFP and corresponding procurement for LiDAR data and derived products at the county-level is coarsely estimated to be around $10,000 (i.e. 200 hours at $50 per hour). Given that 70 counties are participating in the TNBMP, currently, the likelihood of 50 counties eventually moving forward with their own initiatives is reasonably high. If they each spent approximately $10,000 to conduct their own procurement, that would amount to approximately $500,000 of redundant procurement costs – money that would be more beneficially invested in the data, directly.

> **"The closer the contours, the more accurate the drainage data and calculations for stormwater applications, and that's what better elevation data would give us. Better stormwater data will help us mitigate flooding problems in some areas as it pertains to high-frequency rain events, such as the May 2010 flood."**
>
> Shannon Reed, Director
> Tipton County Public Works

Applications in Addition to Flooding

The interviews and regional forums held across the state as part of the planning process revealed existing demand for enhanced elevation data to support many applications in addition to flooding. The following list is not necessarily exhaustive, but is based on stakeholder input.

Applications Needing Better Terrain Data	
Forestry	Emergency Response
Economic Development	Plume Modeling
Transmission Corridor Management	Landslide Mitigation

Applications Needing Better Terrain Data	
Vegetation Management	Code Enforcement
Stormwater Management	Historic Preservation
Hazardous Material Management	Assessing
Agriculture	Unmanned Airborne Vehicle Navigation (R&D)
Transportation	Solar Energy Potential (R&D)
Fish & Wildlife Habitat Management	Environment & Conservation

Selected Application Examples

All of the applications listed in the table above have value, but a few of them (Transportation, Environment and Conservation, and Agriculture) are singled out for elaboration, below, as examples of specific and strong interest within the state for enhanced elevation data.

Transportation

The Tennessee Department of Transportation (TDOT) is the data steward for the State's orthoimagery. Orthoimagery is considered an essential framework layer for the TNBMP. TDOT has primary responsibility for the acquisition and production of this data, and OIR-GIS is responsible for incorporating the orthoimagery into the state's enterprise GIS. As stated in a report by the American Society for Photogrammetry and Remote Sensing (ASPRS), **"the elevation model used to produce the orthoimage is as important to the final product as the raw imagery."**[14] There are also variations in the orientation of the airplane and its digital sensors that need to be corrected as part of the production of orthoimagery. However, the elevation model is of critical importance in order to rectify displacement in the raw imagery due to the distortion effects of flying over undulating terrain, so that a uniform scale can be produced for map measurements to be accurate. This greatly improves the utility of the orthoimagery as a GIS base map. **Without changing the specifications for the raw imagery, the state can get improved accuracy in its orthoimagery by using enhanced elevation data** to rectify terrain relief displacement, thereby producing a better orthoimage product.

Currently, TDOT is capturing enhanced elevation data when needed on a project-by-project basis, using both ground-based and airborne LiDAR as the remote sensing technology. TDOT finds that enhanced elevation data can be used for ground control, saving money by reducing field visits and error correction. It also saves money during project planning, where you can't just send out a survey crew to

[14] " ASPRS Report to the US Geological Survey on Digital Orthoimagery," Blue Ribbon Panel Study, Photogrammetric Engineering & Remote Sensing, February 2006, pg. 97.

check everything. Unfortunately, the project-specific data is not part of a seamless statewide mosaic, and it is not easily shareable. In addition to road projects, enhanced elevation data is needed by TDOT's Aeronautics and Rail divisions. There are many applications for enhanced elevation data in a transportation context, including:

Enhanced Elevation Applications in Transportation	
• Assess what roadways are vulnerable to flooding • Provide supplemental information for cross-sections to extend hydraulic modeling without additional field surveys • Respond to flood complaints (i.e. when/where road projects are thought to be the blame) • Innovative drainage solutions • Sink-hole modeling and treatment • Assessment of geohazards (e.g. rockfalls, landslides, sediments, slope, runoff) • Map structures • Identify Karst (correlated to sink holes and caves) • Alert inspectors to road safety issues • Safety audits	• Roadway design • Bridge elevations • Wetland updates • Find archeological sites • Find acid-bearing rocks (acid run-off detrimental to concrete and fish) • Outfall Stormwater mapping • Locate impervious surfaces (currently, no readily available source!) • Signal propagation • Line of sight and viewshed analysis • Better planning/siting of noise walls • Cost of freight movement • Flood studies • Drainage studies • Interstate improvements • Improving the accuracy of orthoimagery

Environment & Conservation

The Tennessee Department of Environment & Conservation (TDEC) has many different divisions with different missions, such as Water Pollution Control (WPC), Geology, Conservation, and the National Heritage Program. The WPC division is the data steward for the National Hydrography Dataset (NHD). Other activities across TDEC include watershed delineation, land acquisition, surveys, trail planning, archeology, park inventory, species & habitat studies, forest health, subsurface information, geohazards, coal mining, and oil & gas. Specific examples of where TDEC needs enhanced elevation data include the following:

Enhanced Elevation Applications in Environment & Conservation	
• NHD program • Identifying man-altered, channelized waterways • Finding topographic depressions • Searching for species habitat • Picking out small water bodies	• Determining elevation, slope, and aspect • Finding mineral resources • Elevation at "top of hole" • Finding seeps and catchment areas • Upper extent of streams • Native American burial sites

Enhanced Elevation Applications in Environment & Conservation	
• Finding geologic strikes and dips • Landslide risk assessment	• Civil War battlefields • Seismic risk zones

Agriculture

Better terrain data can help small town and rural development in a number of ways. Agriculture and forestry are substantial contributors in rural Tennessee in terms of economic importance. The State's own Department of Agriculture, Division of Forestry, has a strong interest in higher resolution elevation data. Tennessee produces revenue and jobs from timber sales. The forests are very resilient and are an important economic asset for Tennessee, which is mostly a hardwood state. Mapping of "priority watersheds" can help land owners keep land in forests for tax breaks. It is faster and more accurate to use LiDAR for measuring tree canopies and tree heights, for tree counts, and for biomass calculations. Here are some other uses of LiDAR and the products derived from it:

- Estimating transportation costs from wood lot to saw mill (slope is a cost factor)
- Estimating debris on forest floor for determining fire risk (debris is fuel for forest fires)
- Identifying slopes for cutting fire breaks (some slopes are too steep for a bulldozer)
- Identifying sensitive habitat for heavy equipment to avoid (slope and aspect are an indicator of species habitat)
- Determining gullies and drainage issues (gullies are often missed on current topographic maps)

The US Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) has a project underway where it is acquiring new higher resolution elevation data using LiDAR in western Tennessee, including the Cane Creek in Lauderdale County. Changes of 4 to 5 inches can make a big difference in flat areas when it comes to flooding, so higher resolution elevation data was needed than what the State currently has available. The data is used to support erosion studies, find altered landforms, and delineate flood-prone soil areas.

As mentioned in the context of "Education and Workforce Development," research is going on at the University of Tennessee in the use of LiDAR for precision agriculture. Companies such as John Deere are likely to be interested in this type of research, to help with innovative new product development for

agribusiness. In addition, better terrain data from LiDAR is going to help sportsmen and other outdoor recreation enthusiasts, conservation groups, and environmental organizations visualize and understand the terrain.

Jobs and Economic Development

The initiative to coordinate the statewide acquisition of enhanced elevation data is likely to generate high quality jobs in the geospatial industry, attract business, and support regional economic development strategies. This is consistent with Governor Haslam's goal to "make Tennessee the No. 1 location in the Southeast for high quality jobs."

The geospatial technology industry is considered by the US Department of Labor (DOL) to be a high-growth job producer for the next decade. DOL's Employment & Training Administration (ETA) has invested over $8.3 M in the geospatial industry, including $6.4 M in High Growth Job Training Initiative grants, $1.9 M in Community Based Job Training Grants, and leveraged additional resources from the grantees of $7.1 million. ETA also administers grants through the "Workforce Innovation in Regional Economic Development (WIRED)" program. [15]

Jobs in the geospatial field range from technicians to highly-specialized experts, representing diverse career opportunities. In order to meet growth demands for geospatially-educated workers, employers are examining alternatives such as recruiting young workers through internships, apprenticeships, and tapping nontraditional labor pools to diversify the workforce pipeline.

The technology and methodology required for capturing enhanced elevation data with LiDAR is proven, but still growing in its widespread potential. Some of the most innovative applied research putting LiDAR data to productive use is happening in Tennessee. For example, Oak Ridge National Laboratory (ORNL) is a recognized leader in the application of LiDAR to estimate population based on the detection of structures and impervious surfaces. ORNL is also supporting the National Renewable Energy Laboratory (NREL) in estimating the solar energy potential of homes based on the reflectance, slope, orientation and aspect of roofs as determined from LiDAR. The following images are from a presentation by Dr. Budhendra Bhaduri of ORNL at the Homeland Infrastructure Foundation Level Data (HIFLD) Working Group meeting on 14 September 2011 in Reston, Virginia.

[15] http://www.doleta.gov/BRG/Indprof/Geospatial.cfm

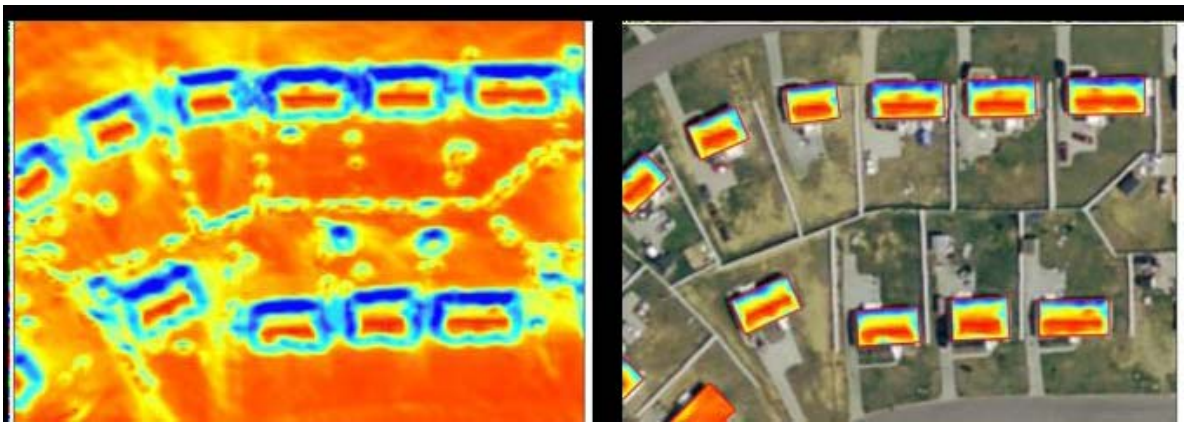


Image Source: Dr. Bhaduri, ORNL, showing solar radiation on rooftops derived from LiDAR

The applied research associated with discovering innovative new applications is going to produce new jobs and economic development. In this regard, the following comments and observations were made by Tennesseans during the 5 regional forums conducted as part of the planning process.

- Drones and UAVs are being used and tested in Tennessee, and they require enhance elevation data for navigation
- There is widespread interest in hands-on training with LiDAR data and its applications
- There is university-level R&D going on to develop new applications and techniques for using LiDAR data
- It represents an opportunity for skill development and “next generation” professionals
- New ways of doing things evolve, and the perception of needs will change (i.e. some experienced LiDAR users are already “beyond needing contours” and would “rather have the raw elevation model” to use in their applications, or to derive their own products)
- Oak Ridge National Lab (ORNL) is a leader in the use of LiDAR for identifying structures and impervious surfaces as indicators of populated areas, and this has applicability to calculating stormwater metrics, too, in the opinion of ORNL and other experts
- The neighboring State of North Carolina was one of the first states to use LiDAR to capture enhanced elevation data, and their program was successful, with lessons-learned that Tennessee can leverage

Currently, state agencies and localities, and industries such as utilities, telecommunications, transportation and defense are the largest consumers of GIS and geospatial technology.[16] However, utilization of geospatial data has exploded with the proliferation of consumer devices such as smart phones and tablets, and most citizens have some amount of familiarity with this technology (e.g. Google Maps, MapQuest, etc.). This is increasing the expectations of professionals and citizens alike when it comes to things such as 3D immersive GIS applications, increasing demand for high-resolution elevation data. The gaming industry has simulated reality, but a geo-professional's job is to map reality to provide the geospatial data infrastructure that is needed for modern society.

Education and Workforce Development

The geospatial technology sector is growing, and demand is high for talent to fill high-quality jobs. As well as a growing market, there are ongoing breakthroughs in the technology and its applications. One of the best examples of this is LiDAR technology for mapping terrain and other features of the earth, both manmade and natural, in three-dimensions (3D).

Tennessee needs workers with the education and skills to compete and succeed in growing, high-quality jobs in the geospatial sector of the economy. Community colleges and universities can work with the state's public and private sectors to design education and research programs to meet emerging need for graduates in the geospatial sciences. Giving students the know-how required to obtain professional jobs and advance along a career path in the geospatial industry will also attract businesses to Tennessee.

The GIS Center at Austin Peay State University is a case in point. The center graduates students with ready-to-work GIS job skills, and they have been highly successful in getting jobs in both the public and private sectors. They heavily leverage the geospatial data available through the TNBMP, and are anticipating high-resolution elevation data with great interest.

In addition to Austin Peay State University, several other university representatives participated in the current planning process. Specifically, the University of the South, University of Tennessee, and Middle Tennessee State University attended regional forums in Chattanooga, Alcoa, and Murfreesboro, respectively. They voiced strong interest in enhanced elevation data for their educational and research missions as well as to provide the right skills and knowledge for the 21st Century workforce. Their efforts

[16] Daratech, GIS/GIS Markets and Opportunities, as cited on US DOL ETA website [http://www.doleta.gov/brg/Indprof/geospatial_profile.cfm]as of October 2011

reflect the importance of staying ahead of demand by researching and developing new methods of applying geospatial data. For example:

- University of Tennessee in applications of LiDAR data to precision agriculture
- Middle Tennessee State University in applying LiDAR data to archeology and historical preservation, including the potential discovery of Civil War artifacts

Even at the K-12 level, there is value and opportunity in teaching about GIS and geospatial technology. As testament to this point, talented youth from the 4-H Club of Tennessee won first place in the K-12 national competition at the Esri International Users Conference, and received their award in San Diego, California, in July 2011 for their map of the Appalachian Trail in Unicoi, Tennessee (map follows).[17]

Image Source: Esri Map Gallery of First Place Winner, K-12

A list of requirements for education and workforce development was compiled from input from both the interviews and the regional forums that were conducted as part of this planning process, as follows:

- Anticipate and encourage innovation -- as people become more familiar with enhanced elevation data, better ways of doing their jobs will evolve

[17] First Place, Esri International User Conference Map Competition, K-12: "Appalachian Trail in Unicoi, Tennessee," by Ty Petty, Stephen Moughon, Dara Carney-Nedelman, and Tim Prather (National 4-H GIS Leadership Team)

- Support and encourage geospatial skill development, job enrichment, academic research, economic growth and competitiveness
- Provide hands-on training with LiDAR data and enhanced elevation products
- Adopt a Charter School to foster GIS education at the K-12 level

Broadband Infrastructure

Connected Tennessee (http://www.connectedtn.org/) is a non-profit corporation supporting the expansion and adoption of Broadband high-speed Internet connectivity in the state. They leverage the TNBMP extensively to map the existing Broadband service in the state. They need high-resolution elevation data for a number of specific applications, including:

- Wireless signal propagation and coverage areas
- Equipment placement
- Ground clutter classification
- Fixed wireless service areas
- To cut down on field visits to validate data, thereby saving money and time

2.3 CONGRUITY AND SYNCHRONICITY WITH FEDERAL PROGRAMS

The timing of Tennessee's business planning effort for enhanced elevation data coincides with strong interest at the federal level in acquiring LiDAR data for many uses. A rundown on some of the interested federal agencies, and a brief description of their LiDAR activities in Tennessee, follows.

- **US Geological Survey (USGS)**, an agency within the US Department of Interior (DOI), is leading a National Enhanced Elevation Assessment (NEEA), which should be done by the end of 2011. The USGS held an NEEA workshop in Tennessee in June 2011 to gather input from stakeholders within the state. NEEA is identifying common requirements for enhanced elevation as input to a notional national program. From an application standpoint, USGS Water Resources participates in the Tennessee LiDAR Working Group, and is supporting a number of river projects to assess damages from floods using enhanced elevation data, including the Metro Nashville flood inundation map project, and projects on the Cumberland and Red rivers. USGS is also coordinating with the Department of Homeland Security (DHS) and the National Geospatial-intelligence Agency (NGA) on acquiring LiDAR for certain urban areas that are designated as part

of the Homeland Infrastructure Protection (HSIP) program, including Nashville, Memphis, and Chattanooga. USGS also has a contract vehicle that can be used, i.e. Geospatial Product and Service Contracts (GPSC), for Federal, State, and municipal government entities to partner with the USGS for purpose of fulfilling their common geospatial data requirements. The USGS is also a participant in the multi-agency collaborative Nashville Situation Awareness for Flood Events (SAFE) program.

- **US Department of Agriculture, Natural Resources Conservation Service (NRCS)** is sponsoring enhanced elevation data capture in west Tennessee using LiDAR for high-resolution data that meets USGS Quality Level 2 specifications (see separate TNBMP Technical Specifications document, Table 1 on Quality Levels). NRCS is initially focused on heavy engineering areas in Lauderdale County, such as Cane Creek, but eventually plan to acquire LiDAR for a larger number of counties in west Tennessee. Their applications include conservation planning; identifying sensitive areas (e.g. sink holes, wetlands) and threatened species habitats; grass management; watering facilities; stream restoration; and watershed protection.
- **US Department of Homeland Security (DHS), Federal Emergency Management Agency (FEMA)**, Flood Insurance and Mitigation Administration (FIMA), manages the National Flood Insurance Program (NFIP). The three components of the NFIP are:
    - Flood Insurance
    - Floodplain Management
    - Flood Hazard Mapping (Risk MAP)

  Risk Mapping, Assessment, and Planning **(Risk MAP)** is the FEMA multi-year plan to deliver quality data that increases public awareness and leads to action that reduces risk to life and property from flooding. The initial focus was on converting paper flood maps for each community to digital form; enhanced elevation data could be used to improve the accuracy of these maps.
- **US Army Corps of Engineers (USACE)** is active in Tennessee on waterway-oriented projects. They have considerable experience and expertise with LiDAR data for enhanced elevation, but primarily on a project-specific basis, and not statewide. They have in-house terrain modeling generation capabilities, and are interested in raw LiDAR imagery as an input. They use both Esri ArcGIS and Bentley MicroStation in their work flows. One example of where they need high-resolution elevation data is for improved surface representation for hydrologic modeling, for

which the primary inputs are elevation, impervious surfaces, stream cross-sections, inundation areas, and soils for specific study areas. They have found that using LiDAR to create cross-sections is more affordable than conventional field surveys. The USACE expressed overall support for a statewide program with federal partnerships, and its St. Louis District has an existing contract that can be used for LiDAR acquisition; NRCS is using this contract for their enhanced elevation projects in western Tennessee, with their own funding. The USACE is also a participant in the multi-agency collaborative Nashville Situation Awareness for Flood Events (SAFE) program, which uses high-resolution elevation data as well as other data inputs for the project area.

> **"The Nashville SAFE program is a partnership between Metro Water Services (MWS), Metro Office of Emergency Management (OEM), Metro Planning Department (Planning), the US Army Corps of Engineers (USACE), the US Geological Survey (USGS), the National Weather Service (NWS), and AMEC Earth & Environmental, the purpose of which is to provide Metro emergency management personnel with myriad of internal tools to assist in decision making during a flood event."**
>
> Bradley Heilwagen
> AMEC

- **Tennessee Valley Authority (TVA)** has a long history of using GIS and elevation data, and advanced applications. Key areas where they are seeing a positive return on investment in LiDAR projects, for example, include:
    - Emergency management
    - Vegetation management (i.e. along utility transmission corridors)
    - Flood mapping and mitigation
    - Planning prospective transmission line routes

TVA believes there would be specific benefits from pilot projects that use enhanced elevation data form LiDAR, and suggested several possible scenarios that might focus on power plants, waterways, or mining operations.

- **US Fish & Wildlife Service** is also within the US Department of Interior (DOI), like USGS. They are focused on the protection of wetlands, aquatic species, migratory birds, and high bio-diversity environments. As an agency, they have experience with LiDAR in coastal areas of the US, but are not using it in Tennessee, yet. They get involved in the assessment of projects that use federal dollars, to determine the impact on wetlands and species. Enhanced elevation data would help them in their determinations. While they see flooding as a big issue – especially when a big rain event occurs – other issues that would benefit from enhance elevation data on a regular basis include drainage, deforestation, and habitat loss.

2.4 ENHANCED EFFICIENCY AND EFFECTIVENESS WITH A COORDINATED PROGRAM

The interest in a coordinated statewide program is very high, and the existing management and technical expertise within OIR-GIS Services can help make this happen. This group has been running the TNBMP since its conception, with valuable support from other State agencies in recognition of the need to economize and make the best use of resources. The following benefits are expected from a coordinated statewide program:

- Economies of scale whereby the costs per square mile for high-resolution data and products will be reduced; and also, less redundant effort in overlap areas at county boundaries (i.e. fewer square miles overall with a statewide project)
- Coordinated procurement to cut down on the inefficiency of multiple procurements for the same type of data and services within a jurisdiction and across jurisdictions; a single, state-run procurement could save as much as $500,000 or more on RFP costs (see page 19) – this does not include savings from the economies of scale associated with actual data costs
- Coordinated project management to concentrate resources and streamline production cycles
- New opportunities for funding, cost-sharing, and partnerships to achieve maximum leverage

2.5 WHAT DO STAKEHOLDERS AROUND THE STATE HAVE TO SAY ABOUT IT?

The planning process included extensive outreach to stakeholders around the state, from different levels of government, the private sector, and academia. In addition to interviews with approximately 20 organizations (see Appendix for list), 5 regional forums were conducted in all three Grand Divisions of the State. The following is a brief summary of findings:

Regional Forums

The total number of interested stakeholders who attended the regional forums was 160. The sector with the most interest in terms of number of participants was "City/Town Government," followed by "Private Sector" interest. Overall, the diversity of the turn-out was very good, representing over 10 different sectors. A separate report on the regional forums was provided as part of this planning project, along with copies of the presentation materials. Both are available on the OIR-GIS website: http://gis.tn.gov/

Regional forums were in all three Grand Divisions of the State

- Chattanooga, 23 August 2011
- Alcoa, 24 August 2011
- Blountsville, 25 August 2011
- Murfreesboro, 31 August 2011
- Jackson, 1 September 2011

Top Benefits of Enhanced Elevation Data Based on Input from Regional Forums

- Flood events are driving the need for enhanced elevation data
- Other applications are important, too, in addition to flooding
- It will support innovation and economic development
- There is an opportunity for enhanced efficiency and effectiveness from statewide coordination
- Standardized, statewide, enhanced elevation data with LiDAR could be a more defendable, scientific approach when compared to low-resolution data
    - Data should support fair and equitable property assessments, insurance rates, and fees (e.g. stormwater assessment and code enforcement)
    - Reduce disputes and appeals
    - Support better decisions on floodplain management at the local level
- Improve efficiency of necessary field visits and allow more in-office analysis with better data
- Attract business relocation with better terrain data for site selection and location
- Enhanced elevation data can feed other processes and workflows, e.g. mitigation planning, which opens-up access to other funding sources to local government

3 REQUIREMENTS & COST

A detailed Technical Specifications document was delivered as part of this planning project, comprising an update and revision of the State of Tennessee LiDAR Mapping Program Technical Specifications of 2010. Selected excerpts from these specifications are included below, but the actual Technical Specifications document is the authoritative source.[18]

3.1 ORGANIZATIONAL APPROACH

The program will be managed by existing OIR-GIS Services staff, leveraging lessons-learned from the TNBMP, including statewide orthoimagery acquisition insights experience. A summary of the OIR-GIS management philosophy follows:

- Different areas of the state may have different needs, depending on topography, population, and application requirements
- An incremental approach would be better than nothing, as long as it is coordinated on a statewide basis to avoid duplicate spending and promote standard specifications
- Allowing participants to "buy-up" for higher resolution or specific products is important
- Setting expectations and increasing awareness by developing and distributing sample enhanced elevation products will be important
- Make sure the statewide big picture is considered -- "elevation doesn't stop, and water doesn't flow uphill, at county borders" (nor at state borders, which is a consideration for compatibility with national data sets and federal support)
- Evaluate data capture by watershed coverage vs. political jurisdiction, especially where flooding is concerned
- Achieve synergy and integrate with existing efforts, such as the FEMA Risk Map program and the State's orthoimagery program
- Solicit and finalize federal cost-sharing partnerships
- Find political support and a champion for the initiative
- Avoid "hit or miss" LiDAR acquisition on a piecemeal basis

[18] State of Tennessee LiDAR Mapping Program, "Technical Specifications," OIR/Services, December 2011.

- Help build a common vocabulary and operating picture for flood events and other disasters in the future

3.2 SUITABILITY ASSESSMENT OF EXISTING STATEWIDE ELEVATION DATA

Currently, the available statewide Digital Elevation Model (DEM) is outdated and not accurate enough for most state, county, municipal, federal, and private sector applications. The State's existing elevation data is summarized, below.

- Standard DTM = +/- 7 foot vertical accuracy
- 10 foot contour interval (ASPRS class II)
- Better than USGS 10 meter DEM, but doesn't meet all stakeholder needs
- 10 + years old in some counties
- Using contours and topographic features from 40-50 year old USGS quadrangle maps in some places

The OIR-GIS "Enterprise GIS Business Plan" (2008) listed the following reasons why new elevation data was needed, considering some of the deficiencies of the existing data and the consequences; some updates have been made to the text, based on recent developments:[19]

- Tennessee and the Federal Emergency Management Agency (FEMA) need to develop a maintenance plan for the Digital Flood Insurance Rate Maps (DFIRM) and need to acquire new data to support the ability to manage and update the location of floodplains in the state. Flooding is Tennessee's #1 hazard, as identified by the Tennessee Emergency Management Agency (TEMA).
- The state works with FEMA in support of the National Flood Insurance Program (NFIP) and flood hazard mapping, which is coordinated by Economic and Community Development and F&A, OIR-GIS.
- Citizens buy flood insurance that may not need it because floodplains are not properly mapped in all areas.
- Citizens do without protection because the floodplain is not properly mapped in all areas.

[19] Op. Cit. "Enterprise GIS Business Plan," 2008, p. 17.

- TEMA, National Weather Service (NWS), U.S. Army Corps of Engineers (USACE), TVA, USDA, counties, and other agencies **cannot accurately predict flooding risk for major and minor storm events due to incomplete and inconsistent statewide elevation data.**

3.3 DATA , APPLICATION, & PRODUCT REQUIREMENTS

Below are some of the application and product requirements that are driving the need for data, summarized form. They are based on specific input from Tennessee stakeholders during the development of this plan.

Data Requirements

As mentioned earlier, the **detailed "Enhanced Elevation Technical Specifications" document was delivered separately as part of this planning project**, comprising an update and revision of the State of Tennessee LiDAR Mapping Program Technical Specifications of 2010.[20] LiDAR data acquired for the State of Tennessee's Mapping Program is required to meet or exceed the specifications in this abovementioned document. These specifications are the authoritative source for data requirements, and should be referred to for the details.

Application Requirements

- Application to flood preparedness and mitigation is key; changes of 4-5 inches in elevation on the ground can make a big difference in flood prone flat areas
- Local government and the private sector both need better terrain data for land development and floodplain management and modeling
- The public demands better data, for their own property investigations and self-sufficiency
- Statewide, there is inconsistent policy and procedures for the calculation and assessment of Stormwater fees at the local level – "Stormwater fees are not equitable" – and enhanced elevation data with LiDAR intensity images could be a more defendable, scientific approach
- Elevation data is fundamental to numerous applications besides flooding (See table of applications in Section 2, "Benefits & Justification")

[20] See separate OIR-GIS LiDAR Technical Specifications document, previously referenced.

Product Requirements

- The perception of the required quality level for raw data and products varied, but there were some consistent views:
  - One view that was echoed across the regional forums was: "Quality Level 3 or better" (i.e. point density of 1-0.25 pts/m2 as described by USGS in their National Enhanced Elevation Assessment materials – see Table 1 of the separate State of Tennessee LiDAR Mapping Program Technical Specifications)
  - Another was: "a 2-foot contour interval is needed for most local applications"
- The need for contours as an elevation product may diminish in favor of the bare earth elevation model, or in some cases, the elevation point cloud itself; some sophisticated users with existing experience voiced this opinion
- Currently, "most people are familiar with contour lines and still see a need for them" in their applications; and, "they are easy to cache and serve on the Web as a map service," which OIR-GIS Services has experience hosting

3.4 TECHNOLOGY REQUIREMENTS

New, cost effective technology advancements make high-resolution elevation data feasible, using LiDAR (Light Detection and Ranging) technology.

- LiDAR is required to create the enhanced elevation data and products required to meet the goals of this plan
- There are many qualified photogrammetric, engineering, and surveying firms who are experienced with this technology, and interested in competing for the State's business
- The detailed Technical Specification that is a companion piece to this plan is the authoritative source of details
- An educational LiDAR flow chart follows, to describe the process

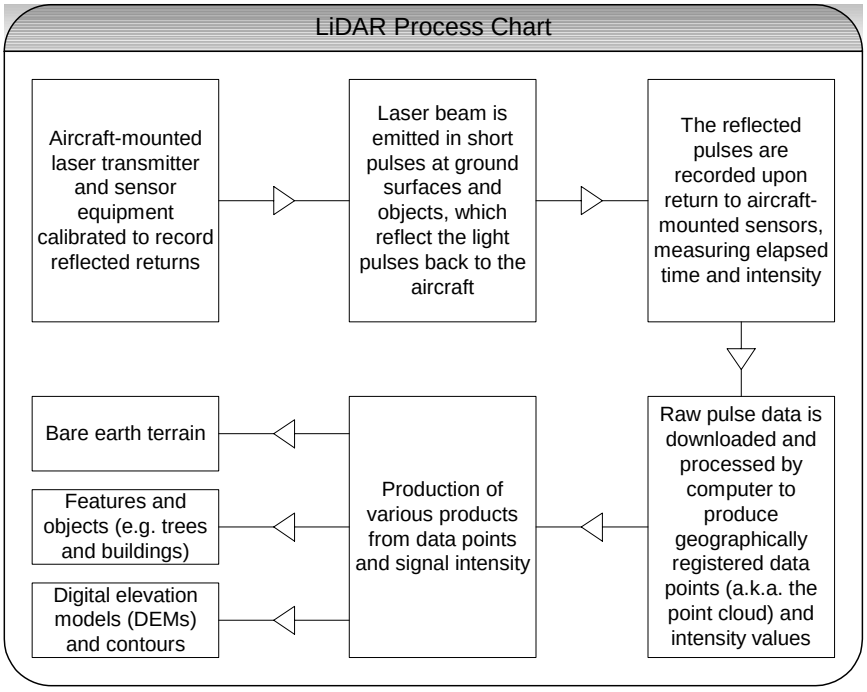


Diagram Source: State of Kansas, "Geographic Information Systems Business Plan: Improved Elevation Data for Statewide Applications," May 2008

3.5 STANDARDS

All required standards are specified in the "State of Tennessee LiDAR Mapping Program Technical Specifications: Revised" (December 2011). A few are described here, but the full Technical Specification document is authoritative and complete.

Quality Level

The TNBMP "Standard" quality level for enhanced elevation data sets is described in the separate Technical Specifications document, which is the minimum level of elevation data to support the majority of Tennessee stakeholder requirements. It is a modified version of the USGS QL 3 specification (see Table 1 on Quality Levels in the separate Technical Specifications document), with higher vertical accuracy required by TNBMP, meets the USGS LiDAR Specification (V13).[21] There is also a TNBMP

[21] USGS NGP LiDAR Guidelines and Base Specification Version 13 – ILMF, February 2010.

"Upgrade" specification," which is higher accuracy than the "Standard" specification, and will be offered as a buy-up option for stakeholders in need of the upgraded accuracy, closer to USGS QL2 (see Table 1 on Quality Levels in the separate Technical Specifications document).

Metadata

Data for the State is required to be documented with project and group-level metadata in compliance with FGDC Digital Content Standards for Geospatial Metadata.

Digital Elevation Model (DEM)

DEMs intended for incorporation into the National Elevation dataset must be hydro flattened. Hydro flattening refers to the process of 'flattening' water bodies in the DEM with further definition offered in USGS NGP LiDAR Guidelines and Base Specification February 22, 2010 Version 13 – ILMF 2010.

Survey Control

The horizontal and vertical control shall be based on direct ties to National Geodetic Survey (NGS) control stations, National Spatial Reference System (NSRS), the Tennessee Geodetic Reference Network, and the TDOT GNSS Reference Network. All geodetic control surveys, both horizontal and vertical, shall conform to the Standards and Specifications for Geodetic Control Networks (1984), Federal Geodetic Control Committee (FGCC).

3.6 RESOURCE REQUIREMENTS FOR PROGRAM SUPPORT

The resource requirements for supporting the performance of this plan are part of the State's existing infrastructure, given OIR/ GIS Services capacity for managing the TNBMP, and existing State procurement capabilities. Any new costs required for the program are included in section 3.7 on "Overall Costs."

3.7 OVERALL COSTS

Costs are estimated based on a range of "Rough Order of Magnitude" (ROM) opinions from recognized industry experts. An actual procurement based on a Request for Proposals (RFP) with a clear Statement of Work (SOW) and specification of deliverables is needed for actual pricing, but the ROM estimates are suitable for the State's budgetary planning. They are divided into separate tables for basic deliverables, optional deliverables, and internal program costs.

Basic Deliverables (i.e. "TNBMP Standard")

Basic Cost Items	TNBMP "Standard" ROM Estimate (1)
TNBMP Standard Specification: Data Acquisition and Basic Deliverables (2)	$10 million
Derived Products: Contours Auto-Generated	$0.4 million
TOTAL: Standard Data & Products (3)	**$10.4 million**

NOTES:

1. ROM = Rough Order of Magnitude; see separate "State of Tennessee LiDAR Technical Specification" on Standard deliverable details.
2. Includes point cloud, classified points, bare earth hydro-flattened elevation model, 3D "breaklines,'' Intensity images, and project-level metadata.
3. There will also be a **buy-up option** for higher accuracy – i.e. the **TNBMP " Upgrade"** specification is in the separate Technical Specification document

Optional Deliverables for "Standard" Specification

Optional Cost Items	Quality Level 3 ROM Estimate
Derived Products: Contours Auto-Generated with High-Quality Cartography	$1.3 million
Hydro-Enforced Elevation Model	$3.2 million
TOTAL: Optional Products	**$4.5 million**

Internal Program Costs

Program support will be provided by OIR-GIS with existing personnel and infrastructure.

3.8 RISKS

Without high-resolution elevation data, the following risks are absorbed by the State:

- The opportunity to reduce losses from future damages from flooding is much smaller
- The risk to public safety and property remain higher than necessary without more accurate flood models, which are currently limited to the quality of the available elevation input data
- The quality of available elevation data increasingly varies across the state from uncoordinated projects, and the opportunity to achieve economies of scale and standardization is lost.

4 IMPLEMENTATION PLAN

This section lays out the detailed steps necessary to implement the coordinated statewide program for enhanced elevation data in Tennessee.

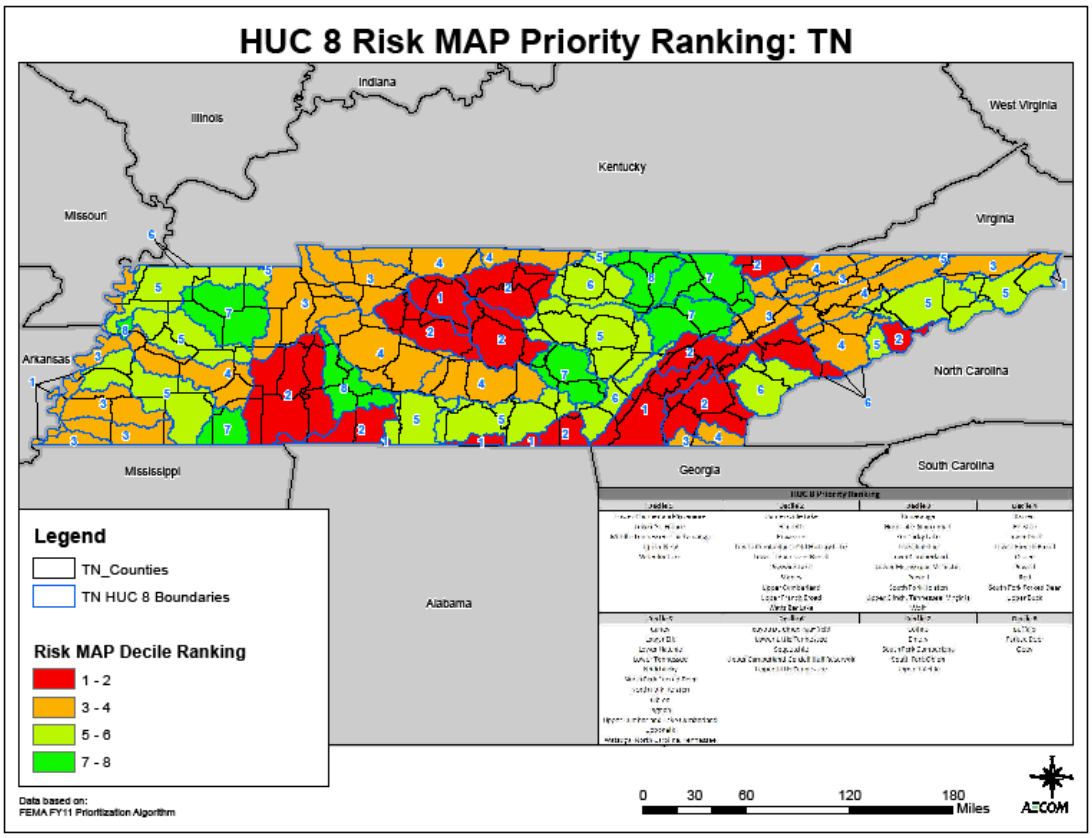
4.1 IMPLEMENTATION DETAILS

The following is a list of the steps to implement this plan:

- Present this plan to the State's Information Systems Council (ISC) in January 2012
- Sponsor hands-on training workshops on using LiDAR data in collaboration with TNGIC and other statewide organizations during 2012
- In calendar 2012, solicit funding support for cost-sharing on the:
    - Development of sample enhanced elevation products from existing LiDAR to support refinement of specification requirements based on application results
    - Performance of a pilot in some high priority county or HUC 8 (see map on FEMA Risk Map priorities for HUC 8 sub-basins, below), in the spring of 2013[22]
- Seek appropriations from the State legislature for FY 2014 through the formal budget process; be ready for budget hearings in FY 2014, which begin in the fall of calendar year 2012 (FY 2013)
- Develop a Request for Proposals (RFP) and conduct a competitive procurement in the second half of 2012 (FY 2013) and make award to qualified contractor(s)
- Begin 5-year acquisition and production program for enhanced elevation data using LiDAR in calendar year 2013, in alignment with the State's orthoimagery program (i.e. TDOT Regions)

[22] Hydrologic Unit Code (HUC), is a unique identifier for watersheds in the US; HUC-8 means the area covered is a sub-basin, which is a larger area than a watershed.

Map Source: Tennessee OIR-GIS Services



4.2 PHASING & MILESTONES

The recommended approach is to schedule implementation in alignment with the State's orthoimagery program, by producing data and products for one-quarter of the state at a time, beginning in January 2014. Prior to beginning production, a pilot project is proposed for a priority county or HUC 8 area in the spring of 2013, to validate the LiDAR technical specification and to produce products for evaluation and application development.

Program Element	Duration	FY 11	FY 2012		FY 2013		FY 2014		FY 2015		FY 2016		FY 2017		FY 18
		Jan-11	Jul-11	Jan-12	Jul-12	Jan-13	Jul-13	Jan-14	Jul-14	Jan-15	Jul-15	Jan-16	Jul-16	Jan-17	Jul-17
Planning	Feb 2011-Jan 2012														

Program Element	Duration	FY 11	FY 2012		FY 2013		FY 2014		FY 2015		FY 2016		FY 2017		FY 18
		Jan-11	Jul-11	Jan-12	Jul-12	Jan-13	Jul-13	Jan-14	Jul-14	Jan-15	Jul-15	Jan-16	Jul-16	Jan-17	Jul-17
Training and Sample Products	Jan 2012-July 2012														
Procurement	July 2012-Jan 2013														
Pilot in Priority County or HUC 8	Jan 2013-July 2013														
Prod. Cycle 1	Jan 2014-Dec 2014														
Prod. Cycle 2	Jan 2015-Dec 2015														
Prod. Cycle 3	Jan 2016-Dec 2016														
Prod. Cycle 4	Jan 2017-Dec 2017														

4.3 BUDGET PLAN

State Appropriations

The initial Tennessee Base Mapping Program was funded significantly through a legislative appropriation. Starting in FY 2000, the Department Finance & Administration received annual funding of $5 million dollars. Funding levels fluctuated throughout the next ten years (see table below) to support the initial development of the statewide digital base map data, infrastructure and program management, and other statewide mapping initiatives. In FY05 and FY06, in addition to the recurring funding of $2.275 million, F&A requested and received a budget improvement of $5.5 million and $1.5 million respectively, to expedite and complete the statewide production efforts. Starting in FY08, funding was reduced, and was ultimately eliminated from the State budget in FY10.

State Legislative Funding History for TN Base Mapping Program (in millions)

	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10
Requested	$5.0	$5.0	$5.0	$2.5	$2.275	$7.775	$3.775	$2.275	$1.475	$.675	$ 0
Allocated	$5.0	$5.0	$2.5	$2.275	$2.275	$7.775	$3.775	$2.275	$1.475	$.675	$ 0

Enhanced Elevation Budget Projections

Taking the same approach as the TNBMP, and funding the enhanced elevation data through legislative appropriation, the following table provides a breakdown of estimated funding by fiscal year to support the projected $10.4 million dollars (see page 38) for the standard enhanced elevation data products over the five year projected production cycle (see page 41, 42). Given the State's budget cycle and the timing of the planning process, the budget request for the full program will be made as part of the FY 2014 budget hearings. The budget hearings for FY 2013 were underway before the completion of this plan.

Projected State Appropriations for Enhanced Elevation (in millions)

	FY13	FY14	FY15	FY16	FY17
Funding for Standard Products	$0.2	$2.6	$2.6	$2.6	$2.6

In FY13, the estimated $200,000 is needed to support the development of a pilot project in one county and/or watershed in Tennessee. As stated earlier, the subsequent production schedule (FY14-FY17) will be based on developing the enhanced elevation data products for a quarter of the State that aligns with the existing orthoimagery program managed currently by TDOT.

Budget for Upgrade and Optional Products

The business plan and the companion technical specification document identify other optional data products and/or "upgraded" elevation data that federal agencies and other stakeholders may be interested in acquiring. It is recommended that the State partner with these agencies, provided that they fund 100% of any of the "upgrade" data products that support their mission. With a State funding commitment, this can be used as leverage to secure federal funds, or to secure funding for additional

mapping activities that would benefit the citizens of Tennessee. For example, in 2002 the State of North Carolina appropriated approximately $17 million dollars to fund their statewide LiDAR mapping program. Using this as leverage, DHS/FEMA was able to provide additional funding to support detailed engineering work to develop new flood maps for North Carolina. This concept of collaboration on statewide mapping initiatives is not new, and is now even more critical given the nation's current economic climate.

Impact to State Agencies

The projected $10.4 million dollar cost to fund a statewide program only reflects the initial development associated with acquiring the enhanced elevation data. Recurring operational costs associated with OIR GIS Services' infrastructure support and managing/hosting the enhanced elevation data and related map services in the "TNMap" enterprise GIS are funded through existing agency desktop GIS and application hosting fees. These enterprise GIS consumer fees will not increase as a result of developing the statewide enhanced elevation LiDAR data. State agencies will not be asked to budget for and/or fund the initial data acquisition efforts. This new resource will complement the existing geospatial data currently available to State agencies via TNMap.

4.4 MARKETING OUTREACH

The marketing and outreach elements of the business plan are already underway. The primary focus is to engage potential cost-sharing partners, primarily at the federal level. To this end, the marketing efforts of the business plan are directed to FEMA in the Department of Homeland Security, US Department of Agriculture – NRCS, Tennessee Valley Authority, US Army Corps of Engineers, and the US Geological Survey. The intent is to communicate to these federal agencies the value of GIS coordination and the benefits of cost sharing with the State for developing enhanced elevation data for Tennessee.

In addition to these efforts, in 2012 and beyond, the marketing efforts will include promoting the program to local government and decision makers in the state. Other key elements of the marketing plan include:

- Avoid GIS "shop-talk" with elected officials and decision-makers (e.g. "breaklines")
- Emphasize the advantages of better terrain data (a.k.a. enhanced elevation data)
- Increase awareness of LiDAR technology as modern geospatial measurement science

- Consider adopting a Charter School as a center of excellence for K-12 geospatial education
- Plan a GIS Day event at a state university on emerging applications for high-resolution elevation data
- Continue outreach to interested statewide organizations and associations

- Provide workshops and Webinars on LiDAR and its applications in conjunction with TNGIC and other statewide organizations

5 MEASURING SUCCESS & FEEDBACK FOR RECALIBRATION

One of Governor Haslam's ten principles of conservative fiscal leadership is to ***"Ensure every initiative of state government is producing a measurable, positive outcome."*** [23] The following sample "scorecard" is a way to track progress on this program going forward, by color-coding the cells of the chart with red, yellow, or green, depending on status. The years can be extended out to match the program duration.

Progress Matrix	Current Qtr.	Calendar Year 2012				Calendar Year 2013			
	Oct 2011	Jan 2012	Jan. 2012	April 2012	July 2012	Jan 2013	April 2013	July 2013	Oct 2013
Running Assessment									

Rating Scheme:

Color: Rating
Green: Fully meets expectations and requirements (e.g., on schedule and achieving desired outcome)
Yellow: Partially meets expectations and requirements (e.g., behind schedule, but making reasonable progress toward desired outcome)
Red: Not meeting expectations and requirements (e.g., behind schedule and very little or no progress toward desired outcome)

[23] Op. Cit., Gov. Haslam's "Ten Principles of Conservative Fiscal Leadership" c. 2009.

6 APPENDIX A: PROJECT INFORMATION

Organizations Interviewed

- Office for Information Resources
- US Geological Survey
- Tipton County
- TN Dept. of Safety
- TN Dept. of Transportation (TDOT)
- TN Emergency Management Agency (TEMA)
- Rutherford County
- TN Dept. of Ag., Div. of Forestry
- TN Economic & Community Dev.
- Bradley County
- Plans & More LLP
- USDA – Natural Resource Conservation Service (NRCS)
- USDA – Farm Service Agency
- US Fish & Wildlife Service
- TN Dept. of Environmental Conservation (TDEC)
- Austin Peay University
- ConnectedTN
- US Army Corps of Engineers

Regional Workshops Conducted

- Chattanooga 8/23/11
- Alcoa 8/24/11
- Blountsville 8/25/11
- Murfreesboro 8/31/11
- Jackson 9/1/11

Project Reports and Artifacts

- Kick-off Meeting and Interview Report 13-15 June 2011

- Interview Report 27-30 June 2011
- Regional Forum Report 9 September 2011
- Updated LiDAR Technical Specification (WIP)
- Project Contact List
- Regional Forum Invitation and On-Line Registration Survey
- Regional Forum Registrants and Attendee List

Presentation Materials

- Regional Forum PowerPoint Slides (Three Parts, Final Versions from September 2011)
- Tennessee Geographic Information Council (TNGIC) Mid-Tennessee Meeting: Draft Plan Summary (2 November 2011)

7 APPENDIX B: LETTERS OF SUPPORT

Letters Received (Reproduced, Below):

- State Agencies:
  - Tennessee Emergency Management Agency
  - Tennessee Department of Safety and Homeland Security
  - Tennessee Department of Environment and Conservation
- County Utility District:
  - Jefferson-Cocke County
- Statewide Organizations:
  - Tennessee Association of Utility Districts
  - Tennessee Stormwater Association
  - Tennessee Association of Floodplain Management
  - Tennessee Geographic Information Council
  - Tennessee Association of Assessing Officials
- Electric Cooperative:
  - Appalachian Electric Cooperative
- Federal Agencies:
  - US Department of Agriculture – NRCS
  - US Geological Survey

THE STATE OF TENNESSEE
TENNESSEE EMERGENCY MANAGEMENT AGENCY
EMERGENCY OPERATIONS CENTER
MILITARY DEPARTMENT OF TENNESSEE
3041 SIDCO DRIVE, P.O. BOX 41502
NASHVILLE, TENNESSEE 37204-1502
(615) 741-0001

December 2, 2011

Commissioner Mark Emkes
Department of Finance & Administration
Tennessee Towers
Nashville, TN

Dear Commissioner Emkes,

As one of the agencies whose mission would see significant beneficial improvements from the acquisition of high-resolution elevation data, TEMA would like to see funding restored to allow the Department of Finance & Administration's Office for Information Resources, GIS Services (OIR/GIS), to proceed with its strategy to cover the state with a much better terrain model than is currently available by acquiring enhanced elevation data.

The proposed improvement in contour elevation data for Tennessee would enable the state to more accurately plan for, mitigate against, and respond more effectively to future flood events in the state.

In 2010, the state experienced historic flooding along the tributaries to the Cumberland River that led to the largest, most costly natural disaster in the modern history of Tennessee. A historic flood on the Mississippi River in 2011 resulted in major damages to many of the state's western counties, some of which were more than 50 percent underwater for a period of several weeks. During response to those events, forecasting the spread of flood waters was greatly hampered due to a lack of quality elevation data in many areas of the state.

The state's current elevation data presents many challenges. It is inaccurate and inconsistent and is leading to individual communities to acquire their own data with inconsistent standards at a greater cost than it would be for a statewide acquisition. The margin of error these large sections of uncertainty introduced into a GIS/mapping process

make it difficult to provide timely and accurate flooding information to the public and response agencies.

In some areas of greatest risk, forecasted flood levels do not translate into actionable intelligence that local authorities need to make timely decisions on whether or not to evacuate residents from high-risk areas well ahead of the danger. Instead, we are forced to rely on historical precedent for planning in the absence of quality elevation data.

An increase of accuracy to plus or minus 1-2 feet would allow better predictions of where water may rise, based on environmental and geographic data. This would allow for the creation of better warning products, such as maps, and be a significant help in saving lives and property. According to the Center for Disease Control, flooding accounts for more deaths annually than any other severe weather related hazard and most of these deaths are preventable.

Sincerely,

JAMES H. BASSHAM
Director,
Tennessee Emergency Management Agency

STATE OF TENNESSEE
DEPARTMENT OF SAFETY AND HOMELAND SECURITY

312 ROSA L. PARKS AVENUE
25TH FLOOR TN TOWER
NASHVILLE, TN 37243

BILL HASLAM
GOVERNOR

BILL GIBBONS
COMMISSIONER

DAVID W. PURKEY
ASSISTANT COMMISSIONER
HOMELAND SECURITY ADVISOR

January 6, 2012

Commissioner Mark Emkes
Department of Finance & Administration
Tennessee Tower
Nashville, TN 37243

Dear Commissioner Emkes,

As Assistant Commissioner and Tennessee's Homeland Security Advisor I wish to express our agency's support of the enhanced elevation (LiDAR) GIS Business Plan.

GIS Services provide digital map data products (ortho imagery, street centerlines, parcels, hydrography and other geospatial services. Enhanced Elevation data is needed to sustain ortho imagery program and the Office of Homeland Security's use of GIS Services. Currently the Tennessee Fusion Center is leveraging GIS and Finance and Administration's investment in the Tennessee Base Mapping Program.

The proposed improvements of LiDAR elevation GIS data will benefit both the Office of Homeland Security and the state's citizens by providing the following:

- 3D modeling of urban landscape
- Improved flood modeling
- Land-use change detection
- View Shed Analysis
- Critical Infrastructure Protection
- Improved situational awareness
- Integration with other geospatial data

The Office of Homeland Security fully supports the development and distribution of LiDAR Elevation Data and your business development initiative. If you have any questions please feel free to contact my office at 615-532-7825.

Sincerely,

David W. Purkey
Assistant Commissioner
Homeland Security Advisor

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
NASHVILLE, TENNESSEE 37243-0435

ROBERT J. MARTINEAU, JR.
COMMISSIONER

BILL HASLAM
GOVERNOR

December 22, 2011

Mr. Dennis T. Pedersen, GISP
Director, GIS Services
Office for Information Resources
Finance and Administration
312 Rosa L. Parks Ave, Suite 1600
Nashville TN 37243

Dennis,

As a member of the GIS Steering Committee, I would like to express my support in the continued effort to obtain high resolution elevation data for the state. The benefits are widespread, but for those of us who are involved in regulatory oversight and natural resource management, many benefits can be found in:

- Forest and Terrain Inventory
- Individual Tree Assessment
- Fire and Fuels
- Species Habitat Condition and Modeling
- Geology
- Surface Hydrology
- Watershed Modeling
- Hydrological Determinations

I look forward to being involved in the ongoing discussions concerning this plan.

Sincerely,

Brock Hill
Deputy Commissioner

BH:cm

JEFFERSON-COCKE COUNTY UTILITY DISTRICT

September 14, 2011

Office for Information Resources
WM Snodgrass TN Tower, Suite 1600SE
312 Rosa L. Parks Avenue North
Nashville, TN 37243

Attn: Mark Bengel, Chief Information Officer

RE: SUPPORT FOR THE CURRENT TNBMP AND FUTURE LIDAR/ADVANCED ELEVATION DATA PROGRAM

Mr. Bengel:

Please accept this letter as a formal recommendation for the state to proceed with the development and distribution of the statewide advanced elevation/LiDAR data.

Jefferson-Cocke County Utility District (**JCCUD**) is a distributor of natural and LP gas in Cocke and Jefferson Counties with a combined customer base of 12,100. The demographics of our service area trend towards the middle to lower class in our rural areas so the need for our utility to provide the cleanest and most dependable energy to our customers as efficient and cost effective as we can is imperative. Our initial investment into the original TNBMP program has been invaluable in our pursuit of this goal.

The acquisition of the data the TNBMP provided our utility was in the magnitude of something to which we could not have imagined before. The new LiDAR program will be just as valuable to our customers. The technical expertise that the state's staff has, and the ability to generate this data all the way from the RFP to the deliverable data is extremely helpful. Our utility can purchase this data from the state and receive it in a format that can be used on day one, thus saving our rate payers the cost burden of generating this data in house. Using the

JCCUD

CLEAN, DEPENDABLE NATURAL GAS

122 HIGHWAY 25E NEWPORT, TN 37821
Phone: 423-623-3069 Fax: 423-623-1784

JEFFERSON-COCKE COUNTY UTILITY DISTRICT

parcel, blue line, streets, and ortho imagery can save an enormous amount of money just by saving trips to the court house for dead research, TDEC applications, engineering and surveying costs as well as other ways. All this engineering and design layout can initially be done "in house" thus saving money for infrastructure expansions and upgrades. This savings can and does result in some projects moving forward, while earlier they would not. LiDAR/Advanced Elevation data will increase the leverage that the local utilities, governments and small businesses can use exponentially. Agriculture (producing yield zones in fields), forestry (types and sizes of canopies), environmental (erosion control, accurate blue lines, water sheds) infrastructure (communications, electric, gas, water, storm water, sewer, roads), emergency management (accurate flood zones, evacuation zones for disasters) are just a few examples of how this data will be able to benefit the citizens in our state.

With ever increasing regulations and mandates from the state and federal governments on local utility districts and local governments this type of data is one way of leveling the playing field. I do understand the tough economic times we are in and the need for extreme efficiency in all departments. However, if the state does proceed with this project and continues to lead the way in pooling all the resources into a single, uniform data collection, the end results in dollars will be astonishing. The ripple effect that having this data in a standard format will be something that future generations will reap the benefits from.

JCCUD is committed to supporting this initiative. If we can be of assistance, please to not hesitate to call. If you have any questions and or comments please feel free to call or write.

Respectfully,

JEFFERSON COCKE COUNTY GAS UTILITY DISTRICT

Larry Masters
Engineering/GIS Coordinator

JCCUD

CLEAN, DEPENDABLE NATURAL GAS

122 HIGHWAY 25E NEWPORT, TN 37821
Phone: 423-623-3069 Fax: 423-623-1784

September 13, 2011

Mr. Mark Bengel
Chief Information Officer
Office of Information Resources
WM Snodgrass TN Tower
Suite 1600SE
312 Rosa L. Parks Avenue North
Nashville, TN 37243

Re: Statewide LiDar/Elevation Business Plan Development

Dear Mr. Bengel:

As Executive Director of the Tennessee Association of Utility Districts I wish to express our association's support of the LiDar/Elevation Business Plan Development initiative. We believe this project will provide tremendous benefit to the citizens of Tennessee in a multitude of ways including:

- Stormwater Compliance
- Wastewater Collection System Analysis
- Water Storage Optimization
- Source Water Recharge Delineations
- Pressure Zone Determinations
- Location of Key Distribution & Collection System Assets such as Pump Stations
- Flood Mitigation
- Emergency Response

Each agency is faced with the continual struggles of compliance with unfunded mandates, the need to provide safety for the general public and the need to operate in a fiscally responsible manner. Furthermore, each agency strives to improve upon the communication, cooperation and coordination with surrounding agencies. This initiative will assist is all of these areas as well as provide a consistent reliable source of information for the State of Tennessee.

For these reasons TAUD fully supports the development and distribution of LiDar elevation data and your business development initiative. Feel free to contact this office should you need additional information.

Sincerely,

Bob Freudenthal
Executive Director

Cc: Mark Emkes, Commissioner, Finance and Administration
Dennis Pederson, Director, GIS Services

July 19, 2011

Mark Bengel, Chief Information Officer
Office for Information Resources
WM Snodgrass TN Tower, Suite 1600SE
312 Rosa L. Parks Avenue North
Nashville, TN 37243

Dear Mr. Bengel,

On July 13, 2011, Dennis Pedersen addressed our Tennessee Stormwater Association (TNSA) quarterly Board Meeting to make us aware of the Statewide LiDAR/Elevation Business Plan Development initiative. As President of TNSA, I want to express to you our support of the project and highlight the benefits that the project would provide.

TNSA was established three years ago to assist municipalities and other permitted entities comply with increasing State and federal mandates on water quality protection. Our membership currently is made up of over 80 permitted Municipal Separate Storm Sewer Systems (MS4s) including local governments (city and county), military installations, Universities and other entities, such as, TN Department of Transportation (TDOT). As most public service entities, our members struggle to perform the required tasks of an unfunded mandate in the most economical way. The LiDAR elevation GIS data products produced by this project would help the small rural MS4s by providing information and useful tools that they would never be able to acquire on there own. Even the largest cities and entities do not have this information or it is dated and does not cover parts of watershed basins outside their arbitrary political boundary.

With two years in a row of statistical "mega-flood" events of almost 1000 year storms, the need for this information to better plan and respond to the impacts of stormwater is crucial to the citizens of Tennessee. The data produced by this project could be used to perform hydrologic modeling, determine and map floodplain inundation, dam breach analysis, and emergency response planning.

Tennessee Stormwater Association
605 Airways Boulevard, Suite 109
Jackson, Tennessee 38301

In more common, every-day use the information could be used to determine tree canopy locations, delineate building structures, impervious surface areas and mapping of utility line locations. This data could be used to locate streams, lakes and wetlands, as well as, transportation assets. The contour information allows the stormwater program managers to quickly delineate ridgelines and drainage basins at any point of interest, to determine sources of pollutions and volume and velocity values which determine erosion and soil loss potential. Additionally, the elevation data is essential for detention and retention facility design.

The LiDAR/elevation data produced by this project will be a valuable asset to MS4s, both small and large, across the State of Tennessee. This information can be used for a multitude of applications including pollution prevention, erosion and sediment control and flood water management. **This project will save individual MS4s untold dollars in planning, construction and management costs, to say nothing about the potential to save more in private property and human lives.** TNSA whole-heartily supports the development and distribution of this LiDAR elevation data and our members are committed to supporting your business planning effort.

Sincerely,

Chris Masin, TNSA President

Tennessee Stormwater Association
605 Airways Boulevard, Suite 109
Jackson, Tennessee 38301

TN AFPM

TN Association of Floodplain Management

Tennessee Association of Floodplain Management (TN AFPM)
P. O. Box 1219
Covington, TN 38019

8 September, 2011

Mark Bengel, Chief Information Officer
Office for Information Resources
WM Snodgrass TN Tower, Suite 1600SE
312 Rosa L. Parks Avenue North
Nashville, Tennessee 37243

Dear Mr. Bengel,

During our recent Annual Conference Mr. Dennis Pedersen presented to our membership the Statewide LiDAR/Elevation Business Plan Development initiative. Post his presentation, our membership considered his request for support and voted unanimously to support his initiative. This vote represented input from over 50 communities throughout Tennessee. As the Chairman of the Tennessee Association of Floodplain Management I hereby express the support of our Association for the creation of Statewide LiDAR/Elevation Data.

Every day throughout Tennessee, floodplain administrators must provide information and make decisions relative to the construction of homes or business in or near special flood hazard areas. Often this advice is given using obsolete information. This is especially true for the smaller rural jurisdictions throughout the State. It is imperative that our floodplain administrators have the most current information to provide sound advice. As we have seen in recent history, flooding is devastating. Failure to provide sound advice results in development in areas that are subject to flooding, which is devastating to a community in terms of life safety, personal loss and economic loss to communities and individuals.

Surely the last two years have taught us that repeating development mistakes of the past is wasteful and has cost our taxpayers BILLIONS of dollars. The highlighted areas below are some examples of the reported costs in just 2010 and 2011 alone as reported by the National Climatic Data Center (NCDC):

- **Mid-South Flooding and Severe Weather, April-May 2010** Flooding, hail, tornadoes, and severe thunderstorms occurred across many Southern states (TN, AR, AL, KY, MS, GA) on April 30-May 2. Flooding in the Nashville, TN area alone contributed more than $1.0 billion in damages. Western and Middle Tennessee were hardest hit with local rainfall amounts of 18-20 inches to the

south and west of Greater Nashville. Total losses exceeded $2.3 (2.4) billion in damages/costs; 32 deaths. Special Report

- **Mississippi River flooding, Spring-Summer, 2011** Persistent rainfall (nearly 300 percent normal precipitation amounts in the Ohio Valley) combined with melting snowpack caused historical flooding along the Mississippi River and its tributaries. Estimated economic loss ranges from $2.0-4.0 billion; at least 2 deaths. Below are more detailed stats, which are preliminary, as the event continues to unfold (as of 8/15): $500 million to agriculture in Arkansas; $320 million in damage to Memphis, Tennessee; $800 million to agriculture in Mississippi; $317 million to agriculture and property in Missouri's Birds Point-New Madrid Spillway; $80 million for the first 30 days of flood fighting efforts in Louisiana.

Accurate elevation data in turn can inform better floodplain mapping which will result in less loss when applied through our floodplain administrator's decision making process. Our association is attempting to fill the educational void throughout our State in terms of floodplain management administration. It is imperative that our floodplain administrators are provided the best information possible to enable sound decisions. From my perspective this improved elevation data would not only have the potential to improve floodplain management, but would also benefit TDOT, Stormwater Managers, TEMA and Emergency Management efforts throughout our State. Improved elevation data feeds into improved HAZUS data which informs community's Hazard Mitigation Plans. (Currently TEMA is working with a communities across the State to update their required Hazard Mitigation Plans) These hazard mitigation plans are essential to the community's ability to gain State and Federal grants to mitigate losses and pursue more sustainability for their community.

The Tennessee Association of Floodplain Management (TN AFPM) offers this letter of support for the LiDAR/elevation imitative. Better data can only result in a more informed decision making process and will be of invaluable benefit to the 379 communities in Tennessee who are enrolled in the National Flood Insurance Program. Billions of taxpayer's dollars have been spent in just the last two years for damages caused from flooding in our State. Providing the tools to eliminate these damages just seems to make good fiscal sense. Further support with taxpayer's dollars will allow the State to develop the data, and provide it to communities throughout the state without cost to the individual jurisdictions.

Sincerely,

Alan M. Armstrong
Chairman, TN AFPM

APPALACHIAN ELECTRIC COOPERATIVE
P.O. Box 400
New Market, Tennessee 37820-0400
(865) 475-2032 • (865) 828-5225 • (423) 586-4755

September 13, 2011

Office for Information Resources
Finance and Administration
312 Rosa L Parks Ave, Suite 1600
Nashville, TN 37243

Dear Mr. Pederson,

I am sending this correspondence in support of the development of a Statewide LiDAR/Elevation dataset. Appalachian Electric Cooperative is enthusiastic about the opportunity to use this advanced technology in a variety of the daily activities necessary for providing electricity to its 45,000 Tennessee members, including power restoration, system maintenance, vegetation and right-of-way management, and asset documentation.

Appalachian has previously funded collection of a target LiDAR dataset to analyze the proposed route for a new high-voltage transmission line that could span through an environmentally sensitive area. Combined with other programs such as PLS-CADD, we can more effectively design distribution lines and test in the office their ability to withstand environmental stress before they are constructed in the field. LiDAR can literally give Appalachian "eyes" into their four-county service area, now spanning over 600 square miles.

As a member of the Jefferson County GIS Consortium of grateful users who bought and actively use data from the Tennessee Basemap Project, we understand the value of a seamless dataset that transcends local red tape and county boundaries. Without a State/Local cost share, these valuable products and the reciprocal services they make possible would have been unattainable at a fraction of the same implementation level that we now employ. The usage statistics and number of visitors on the Jefferson County GIS Website speak for themselves.

In much the same way that the Tennessee Basemap Project benefits so many users, we believe LiDAR can provide an even greater benefit to a diverse industry of users in the public, private and governmental sectors. In order to avoid waste and to help guarantee long-term preservation of the product, however, pooling of State, Federal and local resources will be essential. Appalachian Electric Cooperative fully supports the Statewide LiDAR/Elevation dataset initiative.

Sincerely,

Charla Hurst
GIS Coordinator
Appalachian Electric Cooperative
Jefferson City, Tennessee

TnAAO
TENNESSEE ASSOCIATION OF ASSESSING OFFICERS

February 2, 2012

Mr. Mark Bengel
Chief Information Officer
Office of Information Resources
WNM Snodgrass TN Tower
Suite 1600SE
312 Rosa L Parks Avenue North
Nashville, TN 37243

RE: Statewide LiDar/Elevation Business Plan Development

Dear Mr. Bengel:

As current President of the Tennessee Association of Assessing Officers I wish to express our association's support of the LiDar/Elevation Business Plan Development initiative. We believe this project will provide a tremendous tool for the Tennessee Property Assessor as we strive to do our jobs, both efficiently and economically. In an effort to assess property for tax purposes it is very important to know every aspect of the property, such as the terrain and possible flooding. The LiDar/Elevation project will not only benefit Tennessee Property Assessors, but in turn be a benefit to the citizens of Tennessee in several ways including:

Emergency Response
Planning
Storm water Compliance
Wastewater Management Flood Mitigation

For these reasons TNAAO fully supports the development and distribution of the LiDar elevation data and business development initiative. Feel free to contact me if I can be of further assistance.

Sincerely,

Stanley M. Thompson

Stanley M. Thompson
TNAAO President

P.O. BOX 331697 — NASHVILLE, TN 37203 — 615.598.2727 — WWW.TNAAO.COM

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
675 U.S. Courthouse
801 Broadway
Nashville, Tennessee 37203

February 2, 2012

Mr. Mark Bengel, Chief Information Officer
Office for Information Resources
WM Snodgrass TN Tower
312 Rosa L. Parks Avenue North, Suite 1600SE
Nashville, Tennessee 37243

Dear Mr. Bengel:

I am writing this letter in support of the State of Tennessee's "Enhanced Elevation Business Plan" to procure state-wide Light Detection and Ranging (LiDAR) elevation data.

As a federal agency heavily involved with private lands conservation for over 75 years, NRCS has carried out its mission statement of "Helping People Help the Land". Elevation and terrain models are part of our everyday business process including gathering base information, such as slope and terrain, to model water flow for determining appropriate conservation practices. The expected benefits of enhanced elevation data will include more accurate and efficient updates of soil survey data and more accurate and efficient cost estimates and designs for conservation practices requiring engineering data – especially for those that require flow accumulations. Enhanced elevation data would also provide efficient methods to rehabilitate aging watershed structures as well as design site specific conservation measures in small on-farm watersheds.

During the $12 million stabilization project of Cane Creek in Lauderdale County, NRCS purchased LiDAR for the watershed to efficiently model the best structures to stabilize the degrading creek channel. In the last three years, we also purchased an additional 5,500 square miles of LiDAR for West Tennessee. Tennessee NRCS supports the State's enhanced business plan and goal of providing LiDAR coverage for all of Tennessee.

Sincerely,

Kevin Brown
State Conservationist

cc:
Carol Chandler, NRCS, State Resource Conservationist, Nashville, TN
Kevin Davis, NRCS, State GIS Specialist, Lewisburg, TN
David McMillen, NRCS, State LiDAR Steering Committee Member, Murfreesboro, TN
Dennis Pedersen, State of Tennessee OIR-GIS Services, Director, Nashville, TN

Helping People Help the Land

An Equal Opportunity Provider and Employer

Tennessee Geographic Information Council (TNGIC)

February 14, 2012

Dennis T. Pedersen, GISP
Director, GIS Services
Office for Information Resources
312 Rosa L. Parks Ave, Suite 1600
Nashville TN 37243

Dear Mr. Pedersen,

The Tennessee Geographic Information Council Board of Directors unanimously lends its support to the development of LiDAR for Tennessee through the Enhanced Elevation Business Plan. Our 400+ members represent a wide dichotomy of GIS users throughout the State and our daily struggles with elevation matters would be alleviated through the acquisition of high-resolution accurate elevation data.

LiDAR data that would be collected as a result of this project will enable our members to: better respond to flood events by planning for what areas would be inundated and what structures would be affected, determine slope, derive canopy cover, ability to map aspect of farmland, being able to determine solar irradiation for rivers and streams, measuring biomass, registering aerial images through orthorectification and for improving public safety.

Acquiring LiDAR for Tennessee is a top priority for our group and we are committed to providing support to help achieve this worthwhile endeavor. We know that by working together that there is hope that this project will come to fruition.

The Tennessee Geographic Information Council was established in 1994 and is the professional GIS organization in Tennessee. TNGIC is a non-profit group of GIS users, designers, and professionals within federal, state, and local governments and the private sector. TNGIC was established to:

- Stimulate and encourage the advancement of an interdisciplinary, professional approach to the planning, design, operation, and use of Geographic Information Systems in Tennessee.
- Promote professional and educational development of the membership by providing networking and training opportunities for the exchange of knowledge and information.
- Improve communication and coordination among the various professional disciplines utilizing GIS technology in Tennessee. Promote and facilitate data sharing among TNGIC members and advocate communication with other regional GIS organizations.

Sincerely,

Jason Duke

Jason Duke, TNGIC President
US Fish & Wildlife Service
446 Neal Street
Cookeville, TN 38501

www.tngic.org p.o. box 330906 Nashville, TN 37203

United States Department of the Interior

Geological Survey

NSDI Partnership Office

January 23, 2012

RE: Tennessee High-resolution Elevation Data Business Plan

Accurate elevation data is a critical component to a community's spatial-data infrastructure; be it local, regional, statewide, or a national in scope. This data is important for accurate decision making in applications such as planning and development, land, environment and resource protection, flood mapping, emergency planning and response, and many other uses relevant to local, state and federal authorities as well as the general public. Most important, this data has the potential to save lives and property.

The acquisition of high-resolution elevation data is no simple task and can be quite costly. Having a business plan that accommodates these variety of uses, consolidates otherwise disparate and un-coordinated efforts, and focuses on the needs of users at all levels will provide a major benefit by reducing cost, improving data quality and availability, and eliminating duplication of efforts. The business plan and resulting data produced by the State of Tennessee will align with local, State and Federal efforts at improving the National Spatial Data Infrastructure (NSDI) and is considered an important national asset by the U.S. Geological Survey. This plan will ensure that the public, the State, and the Nation are being well served with a cost-effective approach to acquiring high-resolution elevation data.

Keith W. McFadden

U.S. Geological Survey

Geospatial Liaison for Georgia and Tennessee

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
SUITE 700, JAMES K. POLK BUILDING
505 DEADERICK STREET
NASHVILLE, TN 37243-0349
(615) 741-2848

JOHN C. SCHROER
COMMISSIONER

BILL HASLAM
GOVERNOR

Memorandum

TO: Mark Emkes, Commissioner
Department of Finance & Administration

FROM: John C. Schroer, Commissioner
Department of Transportation

DATE: February 27, 2012

SUBJECT: Support of State of Tennessee Enhanced Elevation Business Plan

The Tennessee Department of Transportation (TDOT) has participated in the development of a plan, administered by the Office of OIR GIS Services, for creating a high accuracy, statewide dataset of elevation. This business plan for acquiring high-resolution elevation data proposes a strategy to cover the state with a terrain model greatly superior to anything currently available. The current low-resolution elevation data is not suitable for improved decision support on issues that involve billions of dollars in investment and spending by Tennessee governments.

TDOT believes such a comprehensive dataset of accurate elevation data should improve operational efficiencies by streamlining our planning and design process. TDOT will realize other direct benefits from improved elevation data such as improving the accuracy of the imagery we provide to all of the state as part of the Tennessee Base Mapping Program (TNBMP). Additionally, this improved data will enable us to better predict flooding potential for state roadways so that TDOT can better ensure state roads are always open and are as safe as possible. There are numerous other benefits that TDOT will receive from this dataset, once it has been created, that are described in the Tennessee Enhanced Elevation Business Plan, which TDOT was an active participant in creating.

TDOT strongly supports the adoption of this plan and the appropriation of the funds that will make it a reality. Creation of this high resolution elevation dataset will be a key factor in the continuing economic progress of Tennessee.

JCS:JCJ:jc

ATTACHMENT: State of Tennessee Enhanced Elevation Business Plan

8 APPENDIX C: DOCUMENT HISTORY

Version	Brief Description	Date	Responsible Party
Draft V1	Preliminary draft for OIR-GIS preview with placeholders for additional content	10/24/11	AppGeo (Contractor)
Draft V2	Draft deliverable for official review and comment	10/31/11	AppGeo (Contractor)
Final Draft	Final Draft for OIR-GIS review and comment	12/12/11	AppGeo (Contractor)
Final Deliverable	Final version incorporating edits from OIR-GIS	12/16/11	AppGeo (Contractor)
Final Deliverable Revision	Incorporating additional letters of support	1/6/12	AppGeo (Contractor)
Final Version amendment	Incorporating additional details in section 4.3 State Agency Impacts	1/11/12	OIR – GIS Services
Final Version amendment	Incorporating additional 'letters of support' in Appendix B	2/14/12	OIR – GIS Services