Appendix D – Nongovernmental (Not-for-profit and Private Companies)

The Nature Conservancy

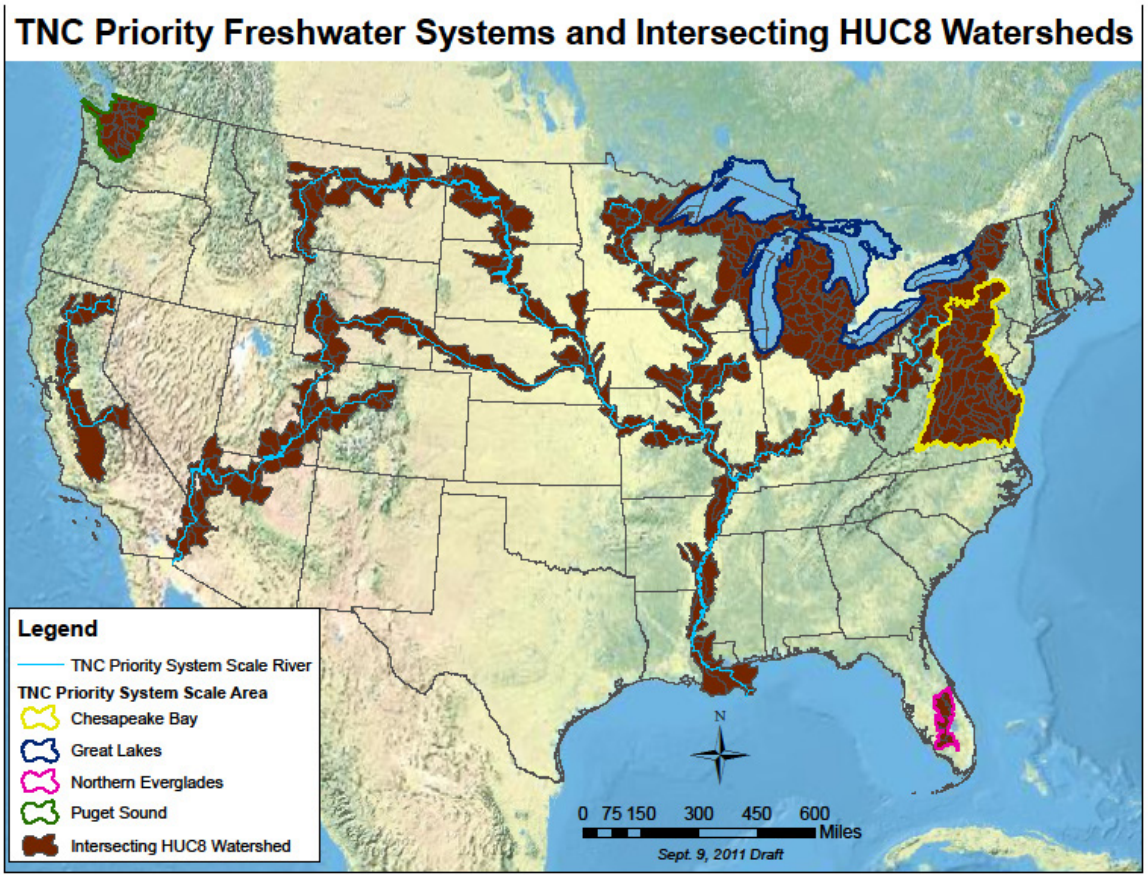
Point of Contact: Joe Fargione, (612) 331-0745

The mission of The Nature Conservancy (TNC) is to preserve the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive.

TNC's POC identified the following major Functional Activities with mission-critical requirements for enhanced elevation data.

1. Healthy Watersheds, under Business Use #1, Natural Resources Conservation, and Business Use #14, Flood Risk Management
2. Coastal Stewardship and Resiliency, under Business Use #4, Coastal Zone Management, and Business Use #15, Sea Level Rise and Subsidence
3. Forest Species Distribution Modeling, under Business Use #5, Forest Resources Management

The following map clearly shows TNC's priority freshwater systems and intersecting HUC8 watersheds.



Healthy Watersheds

Mission-Critical Requirements:

QL2 LiDAR is required of buffer areas around selected streams and ecosystems for restoration of natural and beneficial functions of floodplains and restoration of wetlands.

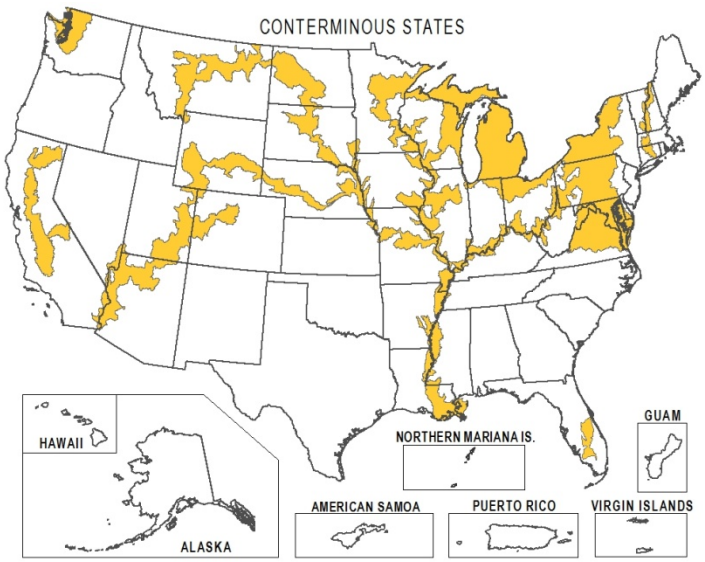
Update Frequency: 6-10 years

Business Use: Natural Resources Conservation, BU#1 and Flood Risk Management, BU#14

Estimated program budget: N/A

Quantifiable Benefits of Enhanced Elevation Data:

Enable TNC to evaluate levee setbacks or removal to restore natural and beneficial functions of floodplains, reduce overall flood damages, restore biodiversity, allow soil enrichment in the Mississippi Delta and other riparian areas, restore lost land areas, recharge groundwater and reduce salt water intrusion. Enable TNC to evaluate alternatives for restoring wetlands that filter out agricultural nutrients and animal waste that pollute our streams and key ecosystems like the Chesapeake Bay and the Gulf of Mexico. Estimated dollar benefits: **$10.07 million/year**



Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Agency: The Nature Conservancy

Functional Activity: Healthy Watersheds

Amid significant alterations of our major waterways to optimize commercial benefits and in the name of flood control, TNC and the Association of State Floodplain Managers (ASFPM) realize that flood losses have continued to rise each year. At the same time, environmental degradation, particularly of water-related resources, has increased, and anticipated changes in climate bring the potential for significant alteration of fragile ecosystems. Consistent with the National Environmental Policy Act (NEPA), which laid a foundation for protecting the environment amidst human development, both TNC and ASFPM wish to marshal forces to improve the natural and beneficial functions of floodplains while mitigating damages and losses that floods bring to society.

Levees are designed to exclude floodwaters from floodplains, but often have unintended consequences for the loss of ecological functions, potential damages to downstream property owners, and the externalized costs of levee maintenance. Furthermore, floodplains have been viewed as suitable sites for human development, with levees designed to keep water out of natural floodplains and away from people. Flooding is a natural process that forms and maintains floodplains. Periodic flows of water that overtop the banks of a river are the lifeblood of riparian corridors. Periodic floods increase soil fertility, support riparian vegetation, create essential habitat for waterfowl and fish and other aquatic species,

recharge groundwater, and create wetlands that filter impurities. When levees fail, damages are often worse than if they had never been built, with false expectations of protecting people, homes and businesses in floodplains.

It has long been known that farm chemicals and animal wastes are polluting our fragile ecosystems. TNC is interested in promoting an environmental strategy to restore riparian buffer areas from farm lands subject to runoff from farm chemicals and animal waste, so that these buffer areas could be used for restoration of wetlands that would filter out nutrients and wastes that pollute our ecosystems.

TNC requires LiDAR to perform watershed analyses, to quantify flood water storage potential, to identify active river areas and prioritize them for restoration and conservation planning, and to take practical steps to restore the natural and beneficial functions of floodplains and restore wetlands.

TNC seeks to use LiDAR to identify lands on which restoration of habitat and hydrological function would have the greatest benefit for people and nature. By removing nutrients and sediment from rivers, this improves water supply and quality (BU#2) and river and stream resource management (BU#3).

At expected costs of 80 cents/acre for LiDAR, TNC estimated that it would save over $302 million in not having to acquire its own LiDAR for this large project area. This total benefit, divided by 30, equals $30.07 million/year, allowing TNC to avoid what would otherwise be an estimated 30 year campaign to obtain funding to pay for its own LiDAR acquisition. Although TNC would have difficulty in acquiring funds to pay for its own LiDAR data every 30 years, its 6-10 year required update frequency is still legitimate -- thus the benefit of agencies working together to satisfy common needs.

Note: For more information on issues raised by TNC's first two Functional Activities, readers are encouraged to read a position paper prepared by the Association of State Floodplain Managers (ASFPM), entitled Natural and Beneficial Floodplain Functions: Floodplain Management – More than Flood Loss Reduction.

Coastal Stewardship and Resiliency

Mission-Critical Requirements:

QL2 LiDAR is required of coastal counties including the Great Lakes (out to the 30 foot contour line) for restoration of natural and beneficial functions of coastal wetlands, to mitigate the effects of sea level rise and subsidence, to mitigate the effects of human development that adversely impact our coastal zones, and promote coastal resiliency.

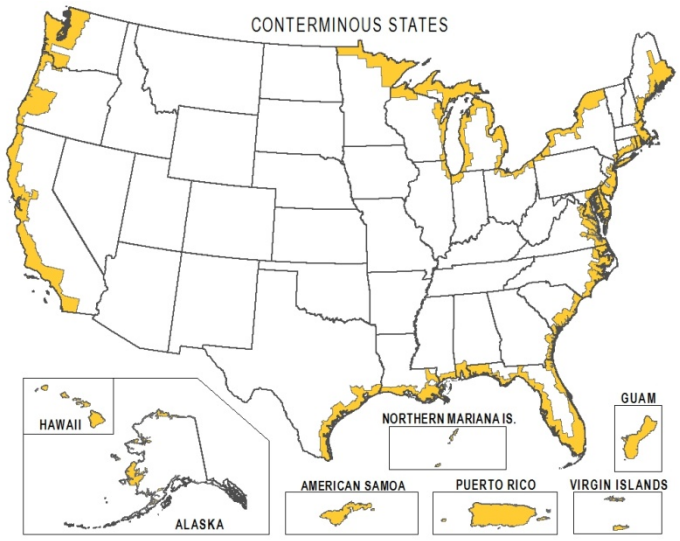
Update Frequency: 4-5 years

Business Use: Coastal Zone Management, BU#4 and Sea Level Rise and Subsidence, BU#15

Estimated program budget: N/A

Quantifiable Benefits of Enhanced Elevation Data:

Periodic updates of LiDAR data will enable TNC to evaluate the changes in coastal wetlands, coastal erosion, loss of land due to sea level rise and subsidence, and develop plans for mitigating the effects of SLR, subsidence and human development. Estimated dollar benefits: **$5.83 million/year**



Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Agency: The Nature Conservancy

Functional Activity: Coastal Stewardship and Resiliency

America is losing coastal wetlands at the rate of 25-35 square miles per year – wetlands that are needed to buffer and protect the land from hurricanes and storm surge. Sea level rise and subsidence of several feet this century will impact millions of Americans in coastal lowlands whose livelihood will be threatened without mitigation. Levees, dams, and reservoirs cut off the supply of sediment to coastal wetlands which then experience subsidence and intrusion of saltwater. The construction of navigation channels and canals in coastal areas, also contribute to saltwater intrusion. These are all coastal issues for which TNC requires LiDAR data to analyze the problems, track changes, and develop potential solutions that promote coastal resiliency.

At expected costs of 80 cents/acre for LiDAR, TNC estimated that it would save $175 million in not having to acquire its own LiDAR for this large project area. This total benefit, divided by 30, equals $5.83 million/year, allowing TNC to avoid what would otherwise be an estimated 30 year campaign to obtain funding to pay for its own LiDAR acquisition. Although TNC would have difficulty in acquiring funds to pay for its own LiDAR data every 30 years, its 4-5 year required update frequency is still legitimate -- thus the benefit of agencies working together to satisfy common needs.

Forest Species Distribution Modeling

Mission-Critical Requirements:

QL3 LiDAR is required of forested areas of the U.S. for modeling of forest species and their distribution. Forest species distribution modeling is used for a wide variety of forest conservation applications.

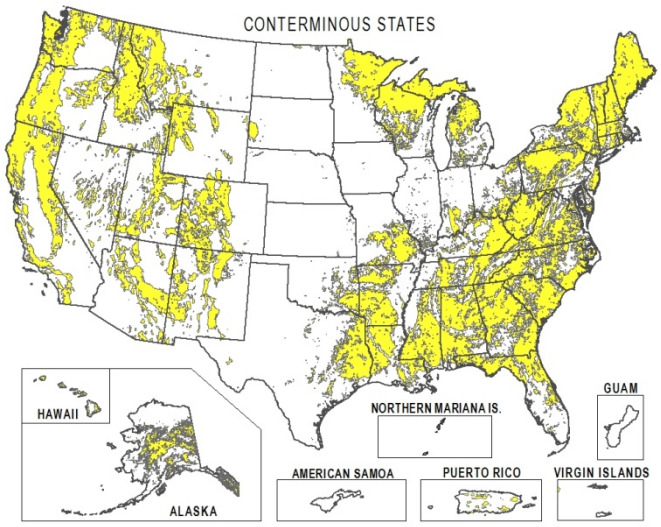
Update Frequency: 4-5 years

Business Use: Forest Resources Management, BU#5

Estimated program budget: N/A

Quantifiable Benefits of Enhanced Elevation Data:

Periodic updates of LiDAR data will enable TNC to evaluate the changes in forest species and their distribution. LiDAR enables the modeling of species for diseases such as the ongoing pine beetle outbreak; LiDAR enables the mapping of canopy height, understory and biomass; estimates of standing carbon, and wildfire management and modeling. Estimated dollar benefits: **$19.66 million/year**



Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Agency: The Nature Conservancy

Functional Activity: Forest Species Distribution Modeling

LiDAR data enables TNC to analyze land use/land cover and perform predictive modeling; to compare current and historic canopy heights; to estimate standing carbon for different species; and to perform diverse forest inventories and analyses. We note that numerous studies have shown that the distribution of tree species is strongly affected by small changes in topography, and associated microclimates, such that LiDAR data is essential for accurate predictions of species distributions. Such species distribution models have a wide range of uses, such as identifying high quality wildlife habitat, and predicting responses to pest outbreaks, drought, and climate change. LiDAR is also vital for wildfire modeling where terrain slope, fuel loading, wind speed and direction are key parameters in predicting the spread of wildfires and development of fire-fighting strategies, especially vital in wildland/urban interface areas.

At expected costs of 80 cents/acre for LiDAR, TNC estimated that it would save $590 million in not having to acquire its own LiDAR for this large project area. This total benefit, divided by 30, equals $19.66 million/year, allowing TNC to avoid what would otherwise be an estimated 30 year campaign to obtain funding to pay for its own LiDAR acquisition. Although TNC would have difficulty in acquiring funds to pay for its own LiDAR data every 30 years, its 4-5 year required update frequency is still legitimate -- thus the benefit of agencies working together to satisfy common needs.

Plum Creek Timber Company

Point of Contact: Alex Hinson, (706) 583-6747

Plum Creek is the largest and most geographically diverse private landowner in the nation, with approximately 6.8 million acres of timberlands in 19 states (AL, AR, FL, GA, LA, ME, MI, MS, MT, NH, NC, OK, OR, SC, TX, VT, WA, WV and WI). Plum Creek manages its forests for a sustainable harvest, today and into the future. Plum Creek also serves as stewards of natural resources (natural gas, oil, minerals, aggregates and stone) that reside beneath the surface. Plum Creek follows sustainable forestry and environmental and conservation best practices that protect water quality and wildlife habitat and provide recreational opportunities.

Plum Creek identified the following major Functional Activity with mission-critical requirements for LiDAR data.

- Sustainable Timberlands, under Business Use #5, Forest Resources Management

However, Plum Creek has a policy that it does not share its shapefiles of land holdings and thereby could not provide specifics as to where the benefits apply. In asking for QL1 LiDAR with annual updates, Plum Creek asked that $1M/year be applied to its total 6,771,000 acres of timber, but that the benefits be divided with one-fourth of its benefits ($250,000/year) to each of its four geographic areas. Because exact areas within each state could not be valued, these benefits were spread out over the entire forested areas of the 19 states involved, yielding the diluted benefits for the entire forested areas of these states as follows:

- Southern States: For Plum Creek's 3,565,000 acres in AL, AR, FL, GA, LA, MS, NC, OK, SC, TX and WV, $250,000/yr benefits were diluted to 0.15 cents/acre/year for the entire 167,561,957 acres of forested areas in those 11 states.
- Northwestern States: For Plum Creek's 1,422,000 acres in MT, OR and WA, $250,000/yr benefits were diluted to 1.23 cents/acre/year for the entire 20,283,151 acres of forested areas in those three states.
- Great Lakes States: For Plum Creek's 785,000 acres in MI and WI, $250,000/yr benefits were diluted to 0.80 cents/acre/year for the entire 31,329,816 acres of forested areas in those two states.
- Northeastern States: For Plum Creek's 999,000 acres in ME, NH and VT, $250,000/yr benefits were diluted to 0.91 cents/acre/year for the entire 27,596,501 acres of forested areas in those three states.

Sustainable Timberlands

Mission-Critical Requirements:

QL1 LiDAR is initially required of Plum Creek land holdings for forest inventory and assessment and planning for sustainable timberlands; thereafter, QL2 LiDAR is required annually to update canopy crowns.

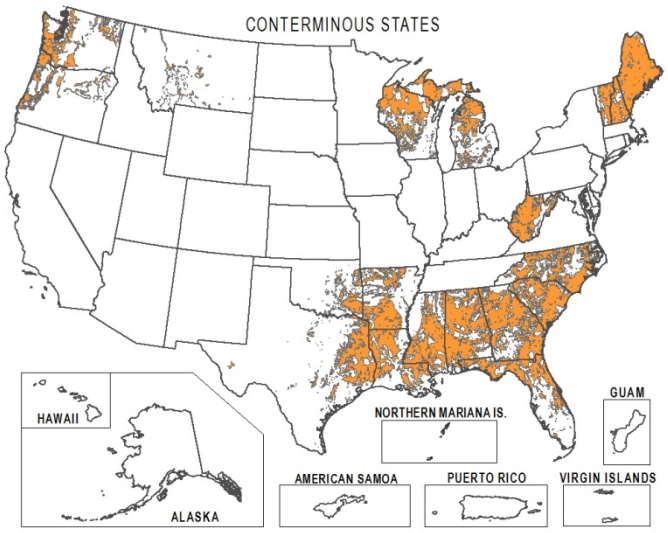
Update Frequency: Annually

Business Use: Forest Resources Management, BU#5

Estimated program budget: Unknown

Quantifiable Benefits of Enhanced Elevation Data:

Annual updates of LiDAR data will enable Plum Creek and other timber companies elsewhere to evaluate tree stand information, calculate forest metrics, assess forest health, plan for sustainable tree harvesting and regrowth, and perform wildfire modeling. Plum Creek estimates total benefits of **$1M/yr**; the LiDAR is actually worth $3/acre for the much smaller number of specific acres (~333,300) targeted each year for potential harvest.



Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Organization: Plum Creek Timber Company

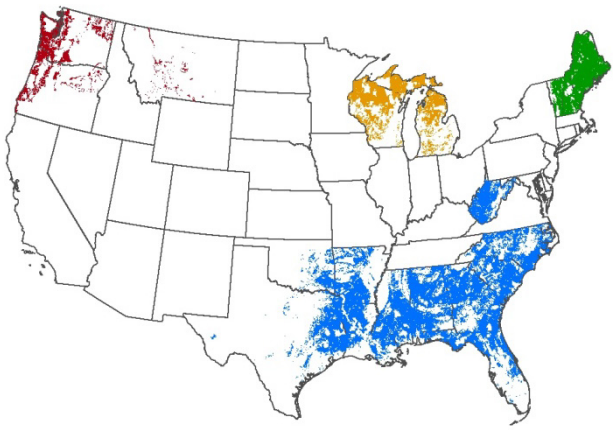
Functional Activity: Sustainable Timberlands

Plum Creek's current interests pertain to the 6.771 million acres of timberlands in the 19 states cited above. There are many other firms in the timber industry, with interests outside of geographic areas owned by Plum Creek, that require LiDAR for use by foresters, silviculturists, biometricians and other specialists in the timber industry.

Operational benefits to Plum Creek of LiDAR data for this Functional Activity:

Time/cost savings: Major	Mission Compliance: Moderate	$ Benefits: $1M/yr

- Major time/cost savings would be realized by having much more efficient methods for forest inventories and for measurements of ground elevations, tree canopy heights, and tree dimensions.
- The eleven southern states receive $250K/yr benefits for the Plum Creek areas included within the broader forested areas shown here in blue.
- The three northwestern states receive $250K/yr benefits for the Plum Creek



areas included within the broader forested areas shown here in red.

- The two Great Lakes states receive $250K/yr benefits for the Plum Creek areas included within the broader forested areas shown here in yellow.
- The three northeastern states receive $250K/yr benefits for the Plum Creek areas included within the broader forested areas shown here in green.

Customer service benefits from improved Plum Creek products/services:

Performance: Minor	Timeliness: Minor	Experience: Minor	$ Benefits: Unknown

- LiDAR data would enable Plum Creek to do a better job of planning for sustainable harvesting and providing better planning data to contractors who perform the harvesting.
- By being unable to share its shapefiles for Plum Creek areas, benefits/acre to its specific holdings are diluted; however, these diluted benefits are also applied to other forests within these 19 states where other timber track companies would also reap the benefits of LiDAR.

Other Benefits from Plum Creek's use of LiDAR data for this Functional Activity:

Public/Social: None	Environmental: None	Strategic/Political: None

Mendocino Redwood Company and Humboldt Redwood Company

MRC Point of Contact: Tom Bendure, (707) 463-5117

HRC Point of Contact: Eric Johnson, (707) 764-4198

Mendocino Redwood Company, LLC (MRC®) and Humboldt Redwood Company, LLC (HRC™) collectively consist of approximately 440,000 acres of redwood and Douglas-fir forestlands along the north coast of California. From the beginning, MRC and HRC's stated purpose has been to demonstrate it is possible to manage productive forestlands with a high standard of environmental stewardship, and also operate a successful business. The company names were chosen to reflect the nature of the business and to pay homage to the important role of the local community associated with a timber business.

MRC and HRC identified the following major Functional Activity with mission-critical requirements for LiDAR data.

1. Sustainable Forestlands, under Business Use #5, Forest Resources Management

Sustainable Forestlands

Mission-Critical Requirements:

QL1 LiDAR is required of MRC and HRC land holdings for redwood and Douglas fir timber inventory and assessment and harvest planning for sustainable forestlands.

Update Frequency: 6-10 years

Business Use: Forest Resources Management, BU#5

Estimated program budget: Unknown

Quantifiable Benefits of Enhanced Elevation Data: $139,454/year

$71,967 for MRC

$67,487 for HRC

Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Organization: Mendocino Redwood Company and Humboldt Redwood Company

Functional Activity: Sustainable Forestlands

Timber cruise evaluations enable timber companies to estimate the value of their standing timber. They are important when planning for a timber harvest or sale. Estimating future volumes, or growth projections, are an important part of evaluating timberlands and deciding whether to cut a stand of trees now or to let it continue to grow. Both MRC and HRC are also very selective in identifying trees

for harvesting so as to ensure sustainable forestlands and limit landslides that can occur when trees are harvested, weakening the root structure that limits soil erosion and landslides.

Operational benefits to MRC and HRC of LiDAR data for this Functional Activity:

Time/cost savings: Major	Mission Compliance: Moderate	$ Benefits: $139,454/year

- Major time/cost savings for timber inventories, cruise reporting, mapping of ground elevations and measurements of crown heights.
- Enables the development of annual growth models and identification of individual trees for harvesting.
- Maps the landscape and ground surfaces to determine where harvesting can occur without contributing to landslides.

Customer service benefits from improved MRC and HRC products/services:

Performance: Minor	Timeliness: Minor	Experience: Minor	$ Benefits: None

- LiDAR data would enable MRC and HRC to do a better job of planning for sustainable harvesting and providing better planning data to contractors who perform the harvesting.

Other Benefits from MRC's and HRC's use of LiDAR data for this Functional Activity:

Public/Social: Minor	Environmental: Minor	Strategic/Political: Minor

- LiDAR data would help MRC and HRC to execute sustainable forest management, reduce environmental concerns, and foster public support for their environmental stewardship.

J.R. Simplot Company

Point of Contact: Shawn Kasprick, (701) 352-0861

One of the largest privately held firms in the country, with annual sales of about $4.5 billion, the J.R. Simplot Company's mission statement – *Bringing Earth's Resources to Life* – pertains to a large array of services that include agriculture, food products, land and livestock, turf and horticulture. They produce fertilizers and perform food processing and packaging. They also assist small, medium and large farms with production agriculture, including "Precision Ag."

Shawn Kasprick, the Red River Valley Precision Ag Manager for the J.R. Simplot Company, was interviewed for this assessment. He identified the following major Functional Activity with mission-critical requirements for enhanced elevation data.

- Precision Agriculture, under Business Use #8, Agriculture and Precision Farming.

Precision Agriculture

Mission-Critical Requirements:

QL3 LiDAR is required for all agricultural land areas of the U.S. for topographic analysis of slope, aspect, curvature and soil wetness (surface and subsurface), and resultant site-specific application of seed, fertilizer, lime, pesticides and water to optimize farm yields.

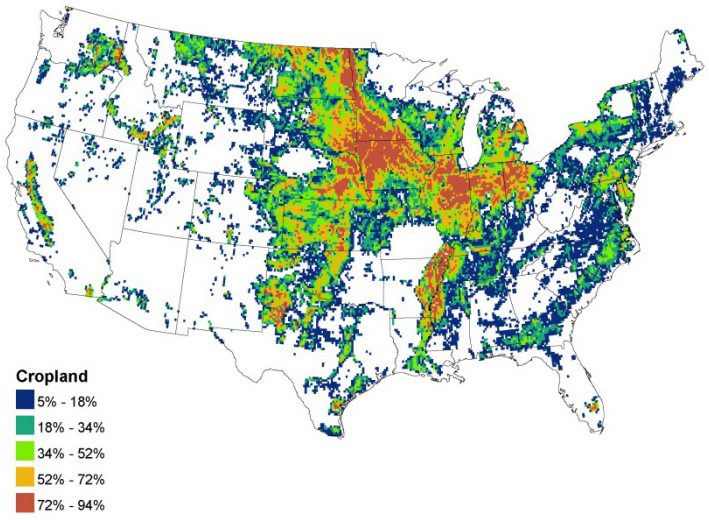
Update Frequency: 6-10 years

Business Use: Agriculture and Precision Farming, BU#8

Estimated program budget: N/A. In 2010, an estimated 262.3 million acres of farm lands were harvested in the U.S. at total product values of $356.2 billion.

Quantifiable Benefits of Enhanced Elevation Data:

With estimated savings of $50M/year in the Red River Valley (parts of ND and MN) for corn and wheat alone, the value to America's farmers of public domain LiDAR, for all crops nationwide, is believed to be worth up to **$2 billion annually**[3] – plus nearly $1.5B (one-time savings) if LiDAR is worth $5/acre for not having to hire surveyors to solve common drainage problems.



This map shows five broad bands of crop land density as a percent of total land area on USGS 7.5-minute quad maps. QL3 LiDAR is required of all agricultural lands, but the value of the LiDAR varies as a function of crop land density, compared with the entire area of each quad map. Although this map shows crop percentages in large bands, actual benefits of LiDAR are computed per quad map area as a percentage of crop lands for each quad map area. Image courtesy of USGS.

Organization: J.R. Simplot Company

Functional Activity: Precision Agriculture

[3] For the Benefit/Cost Analysis, because of uncertainty in the rate at which LiDAR will be used for Precision Ag and drainage, Dewberry used $116.7M/year as the conservative benefit and $2B/year as the potential benefit. This was computed as the cost of LiDAR QL3 data ($252.67/mi^2) times the 461,875 square miles of agricultural lands.

Simplot relies on LiDAR, where available, for Precision Ag applications – enabling small, medium and large sized farms to benefit from improved knowledge of the terrain for site-specific application of seed, fertilizer, lime, pesticides, and water -- resulting in increased farm yields. This includes knowledge of soil type, soil wetness, drainage, and topographic variations within farm fields (slope, aspect and curvature) that can affect crop yield. Without site-specific methods, the uniform treatment of wheat, corn, soybean and cotton fields, for example, is wasteful and uses an excess of costly resources in the form of fertilizers, pesticides, and herbicides with potentially excessive farm run-off. In wetter areas, LiDAR is largely used to identify areas that need surface ditching, tile drainage, or grass waterways, to reduce saturated soils and crop damage. In dryer areas, LiDAR is used to design farm terraces to retain moisture and reduce runoff.

LiDAR derivative products are very important for Precision Ag: (1) slope data are used to minimize soil erosion; (2) aspect data are used to identify areas of solar heating where soils are more wet or dry; and (3) landscape position (curvature) data are used to identify areas of high/low soil moisture content.

Not accounting for topographic variations, soil wetness, nutrient availability, and other variables can result in needless costs for chemical treatments and major losses of productivity.

Referencing a Red River Valley drainage study[4] in 1988, Mr. Kasprick provided updated data for 2010 in the first four columns in the table below that assesses the impact of crop losses due to potentially-avoidable drainage issues. The numbers in the 5th column are from the National Agricultural Statistics Service (NASS) that provides statistics on acres planted, by crop, along the Red River Basin in North Dakota and Minnesota in 2007. The numbers in the right column identify the value of these two crops alone that could potentially be saved with improved grading and modern treatment of drainage issues identified by LiDAR. Obviously, there are many other crops planted annually in the U.S. that also experience drainage issues that adversely impact farm yields.

Estimated Corn/Wheat Crop Loss Impact in Red River Valley from Farm Drainage Issues

Crop	Input Costs $/Acre	Lost Yield/Acre	Lost $/Acre	2007 Acres Planted	Potential Value of Lost Yields
Corn	$275 - $375	24.5 bushels	$91.87	3,821,000	$351,035,027
Wheat	$150 - $250	11 bushels	$52.25	4,129,800	$215,782,050

It is clear that farm drainage issues cost American farmers many hundreds of millions of dollars annually in crop production losses. While not suggesting that LiDAR alone would prevent such losses, Simplot has demonstrated that LiDAR data and Precision Ag technologies dramatically reduce drown outs and over-saturated soils while addressing the other benefits of Precision Ag. If nationwide LiDAR could solve just 10% of the farm drainage problems for these acres of corn and wheat in the Red River Valley alone, the value to American farmers would be over $50 million annually. Major cost reductions for chemical treatments, and similar savings for other crops nationwide outside the Red River Valley, could easily multiply these benefits to $2 billion annually. Furthermore, if LiDAR data were readily available nationwide, it is believed that John Deere and/or other equipment manufacturers would develop LiDAR-specific applications as they now have for variable-rate fertilizing, spraying, etc. Because LiDAR data is

[4] Steven Edwardson, David Watt, and Lowell Disrud, "Laser-controlled land grading for farmland drainage in the Red River Valley: An economic evaluation," *Journal of Soil and Water Conservation*, 1988 43(6); 486-490

currently available only for a small percentage of total farmlands in the U.S., the full benefits of LiDAR for Precision Ag cannot be fully realized.

Max Fuxa of Ellingson Drainage (701-238-1946) was sent a copy of the information (above) provided by Mr. Kasprick. When asked to comment on the credibility of the cost savings estimates cited above, Mr. Fuxa replied that these numbers are realistic, stating that the benefits of LiDAR are "huge" and could be even larger because "We haven't yet figured out all the applications of LiDAR for agriculture." He said that drainage issues pertain almost everywhere, except in sandy soils that need irrigation; recognizing that drainage issues are very costly, as cited above, he said that LiDAR would save $5/acre in not having to hire a surveyor to help determine the best way to drain agricultural fields after heavy rains occur.

Agren

Points of Contact: Stan and Tom Buman, (712) 792-6248

A small business agricultural and natural resources consulting firm based in Iowa, Agren responds to agricultural and environmental challenges by providing comprehensive, integrated services to groups and individuals to positively impact our natural resources.

Stan and Tom Buman of Agren were interviewed for this assessment. They are former employees of the USDA-NRCS. Agren's business model supports the NRCS Performance Results System (PRS) to include numerous Conservation Practices, Conservation Systems, and Conservation Programs for which Agren has developed GIS-based tools.

Agren's POCs identified the following major Functional Activity with mission-critical requirements for enhanced elevation data.

- Agricultural and Environmental Services, under Business Use #1, Natural Resources Conservation, Business Use #2, Water Supply and Quality, and Business Use #8, Agriculture and Precision Farming.

Agricultural and Environmental Services

Mission-Critical Requirements:

QL2 LiDAR is required of 49 states for an array of GIS-based agriculture and environmental services pertaining to croplands, grasslands, rangelands, and forests, including development of wetlands, ponds, basins, and waterways.

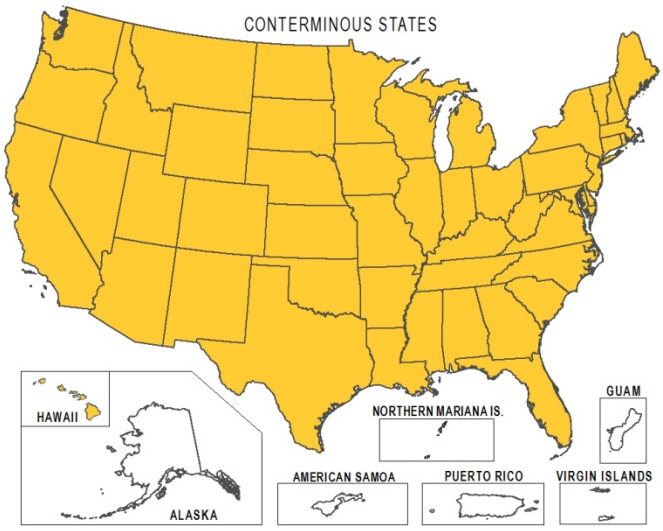
Update Frequency: 6-10 years; more recent if major erosion event

Business Use: Natural Resources Conservation, BU#1, Water Supply and Quality, BU#2, and Agriculture and Precision Farming, BU#8.

Estimated program budget: N/A

Quantifiable Benefits of Enhanced Elevation Data:

With GIS-based tools such as RUSLE2, PondBuilder, WetlandBuilder, BasinBuilder, and WaterwayBuilder, LiDAR data enables conservation planning and implementation tasks to be performed in 30-60 minutes that would typically require 10-20 hours without LiDAR, and avoids the need for on-site field surveys; dollar benefits to landowners nationwide are major, but cannot be estimated.



Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Organization: Agren

Functional Activity: Agricultural and Environmental Services

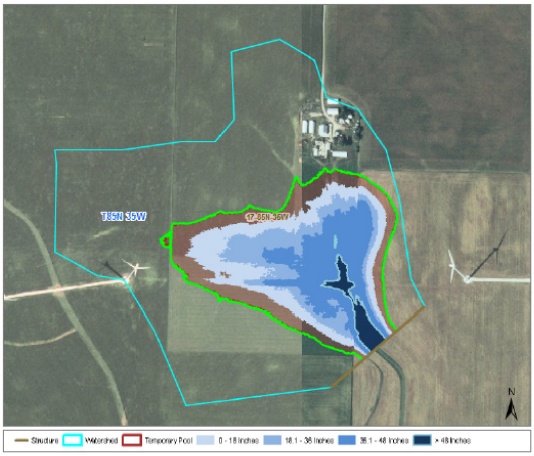
Agren relies on LiDAR data, where available, for its GIS-based tools (WetlandBuilder, PondBuilder, BasinBuilder, and WaterwayBuilder) used for the development of conservation practice plans to NRCS standards. In addition to an on-line, GIS-based RUSLE2 (Revised Universal Soil Loss Equation) calculator, Agren has 4-5 additional tools under development where LiDAR would help landowners to be better stewards of their croplands, grasslands, rangelands and forests:

- LiDAR data would enable conservation planning tools to assist the large percentage of absentee landowners to see what is happening to their land (via webinars) and make decisions on how to reduce soil erosion, loss of soil health, or degradation of rangelands, for example.
- LiDAR data would enable effective smoke and fire modeling.
- LiDAR data would improve plans for prescribed fires, intentionally set for ecological reasons.
- LiDAR data would enable watershed assessments.
- LiDAR data would enable the efficient analysis of bio fuels to determine (1) if removal of residue off the ground would create more erosion and (2) where harvesting can take place.

QL3 LiDAR (2-foot contour accuracy and DEM point spacing of 1-2 meters) is minimally acceptable for some of Agren's tools, but QL2 LiDAR (1-foot contour accuracy and sub-meter point spacing) is required for best results.

LiDAR has made it possible for Agren to develop new technology that rapidly increases the ability of agencies and organizations to provide conservation alternatives to landowners. For example, with Agren's WetlandBuilder, a Soil and Water Conservation District can provide an accurate wetland estimate to a landowner in 30 minutes (see adjoining image) when it now takes 10 hours with current methods. If LiDAR was available nationwide it would allow conservation planning tools to be deployed to a much larger audience. In addition, it would allow Agren to develop considerably more applications for other conservation practices like irrigation and range management. The savings to conservation planning agencies and organizations is enormous. Wetlands are especially relevant because they can be used to remove nitrogen from farm and pasture surface and tile runoff to improve water quality. Wetlands can also be used for flood control. They can be used to settle the sediment out of water from agriculture or urban erosion, and wetlands are terrific for wildlife habitat.

Aerial View of WetlandWithStructure



Information and Estimated Cost

Spillway type:	In line pipe
Pool surface area:	22.0 ac
Pool depth 18 inches or less:	45 %
Maximum pool depth:	7.0 ft
Volume of permanent pool:	47.6 ac-ft
Berm width:	0 ft

Item	Quantity	Units	Cost Per Unit	Subtotal
Constructed fill (including any berms and secondary dikes):	1,782	cu yd	$1.90	$3,390.00
12 inch diameter in-line structure height:	10	ft	$1,351.35	$1,351.35
12 inch diameter pipe (inlet + outlet):	47	ft	$35.90	$359.00
Grubbing:	0.0	ac	$740.33	$0.00
Seeding:		ac		$0.00
Central Mesic	2.0	ac	$607.00	
Central Wet-Mesic	5.0	ac	$329.00	
Fencing:	0	ft	$2.83	$0.00
Tile investigations:	2	investigation(s)	$200.00	$400.00
Tile breaks:	1,250	ft	$1.50	$1,875.00

Using LiDAR data, Agren's tools will produce a variety of accurate estimates in less than one hour. This saves extensive time and costs for private consultants or government entities such as NRCS or state/local agencies, by not having to travel to distant locations for on-site assessments and field surveys. The user can provide a multitude of realistic visualizations of a given practice and its resulting footprint on the land. This allows users to provide more options to landowners, giving them the information they need to make better decisions. Via webinars, these users can even communicate effectively with absentee landowners throughout the nation. Subsequently, LiDAR data enables conservation planning and implementation tasks to be performed in 30-60 minutes that would typically require 10-20 hours without LiDAR. LiDAR also allows for the timely development of conservation practice plans and estimates instead of waiting until field conditions are suitable for a field survey. Some examples of unsuitable field conditions include leaves on trees, agricultural crops growing, snow cover on the ground, and mud. The dollar benefits to landowners nationwide are major, but cannot be estimated.

NextEra Energy Resources

Point of Contact: Michael Rose, (561) 304-5191

NextEra Energy Resources is the largest generator of renewable energy from the wind and sun in North America, operating 85 wind facilities in 17 states and Canada and producing more than 8.298 megawatts of electricity, or enough power for more than 2 million average homes. The company co-owns and operates the largest solar field in the world in California's Mojave Desert.

NextEra identified the following major Functional Activity with mission-critical requirements for enhanced elevation data and referred our assessment team to WindLogics in the section below.

- Wind Farm Siting and Design, under Business Use #11, Renewable Energy Resources

Wind Farm Siting and Design

Mission-Critical Requirements:

QL5 IFSAR is required (both DTMs and DSMs) for non-forested areas of 48 states for siting and design of wind farms for which topography, slope and surface roughness are important in Computation Flow Dynamics (CFD) models and maximization of wind farm efficiency.

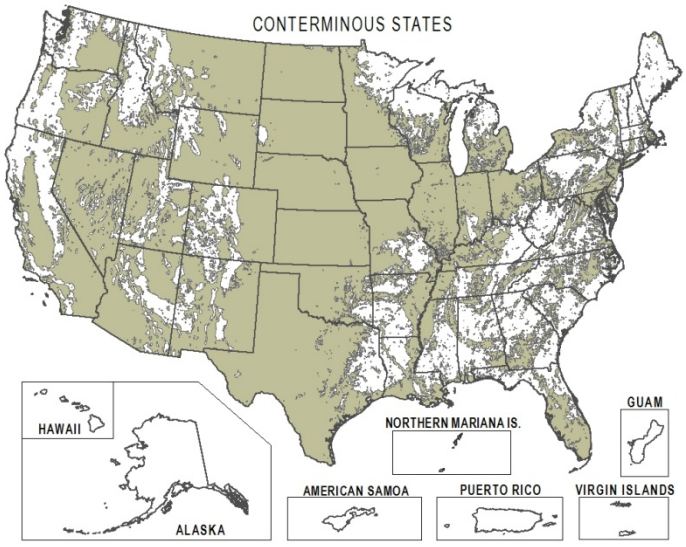
Update Frequency: 2 years, though NextEra could potentially study different areas of the country based on an established data acquisition cycle, knowing when new IFSAR data would become available.

Business Use: Renewable Energy Resources, BU#11

Estimated program budget: Unknown

Quantifiable Benefits of Enhanced Elevation Data:

IFSAR data will enable NextEra to site and design wind farms for maximum efficiency. Wind farms planned for the coming decade could save up to **$100M/year** [5] if IFSAR succeeds in achieving a 1% improvement in efficiency.



Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Organization: NextEra Energy Resources

Functional Activity: Wind Farm Siting and

[5] For the Benefit/Cost Analysis, because of uncertainty in NextEra's ability to meet its goal of 1% improved efficiency from IFSAR, Dewberry used $10M/year as the conservative benefit and $100M/year as the potential benefit.

NextEra currently uses COTS GIS software and 10 meter DEMs from the NED and ESRI raster data for wind farm site selection and wind farm designs, but NED data are deficient in terms of accuracy, resolution, and currency, and because NED DEMs map the bare-earth terrain rather than the top reflective surfaces (including trees and buildings) that impact wind speeds. NextEra needs higher accuracy and higher resolution DSMs to model wind regimes. Accurate estimations of wind speeds are of obvious importance in reducing the uncertainty in the predicted energy production of a potential wind energy project. To understand wind regimes, time series wind data are collected from local airports and NOAA, and wind flow models are built to produce a wind resource grid that takes topography, slope and surface roughness into account. Computation Flow Dynamics (CFD) models must be acceptable to gain site approvals.

NextEra evaluates about 500 potential wind farm sites per year, with 8-32 potential layouts per site. Most sites are rejected, resulting in actual construction of about 20 wind farms per year by NextEra. A typical wind farm has about 100 turbines, each turbine requiring about 40 acres of land free of trees, buildings, silos, etc. Surface roughness data from DSMs must be current within the past two years to ensure that buildings have not been built or trees grown that would interfere with wind farm efficiency.

Many renewable energy projects funded and built in the last 20 years underperform projected estimates by as much as 10 percent. A 1% change in a renewable energy project's net capacity factor can mean $500,000 in annual net income for a typical 100 MW wind farm (or solar farm) project. Thus, if accurate, high-resolution elevation data used for wind farm site selection enables a 1% improvement in energy production performance per site, this could be worth $10 million for 20 new wind farms constructed annually, and the dollar benefits would continue to accrue in subsequent years of operation. At the rate of 20 new 100 MW wind farms constructed annually for a decade, the cumulative benefits over 10 years would be $550 million. After this first decade, those 200 (100 MW) wind farms would continue to save about $100 million per year – but only if enhanced elevation data succeeded in achieving a 1% improvement in wind farm performance. Although the true impact of elevation data is unknown, it is a fact that accurate and current high-resolution elevation data are critical in wind farm site selection and layout in hilly and mountainous terrain, but not on flat farmlands and prairielands where subtleties in topography are not an issue.

NextEra has evaluated IFSAR data from Intermap and found it superior to the NED in many respects – seeing key features in IFSAR data not seen in NED data. NextEra has also evaluated LiDAR data and found the point cloud data beneficial, but more data than necessary, requiring thinning and smoothing. IFSAR data with 5-meter point spacing is ideal for preliminary site selecting, cut/fill estimating and construction planning; but field surveys are still needed for taking ground photos of the terrain, evaluation of soil and ground conditions, verification of receptors, micro-siting, and final engineering and construction.

WindLogics

Point of Contact: Stacy Fleenor, (651) 556-4204

WindLogics combines industry leading scientific analysis and deep expertise in planning, developing and operating renewable energy projects. WindLogics is the lead wind and solar advisor to NextEra Energy Resources which operates the largest solar field in the world in California's Mojave Desert.

WindLogics identified the following major Functional Activity with mission-critical requirements for enhanced elevation data:

- Solar Farm Siting and Design, under Business Use #11, Renewable Energy Resources

Solar Farm Siting and Design

Mission-Critical Requirements:

DSMs and DEM derivative products from QL3 LiDAR are required for non-forested areas of 49 states for siting and design of solar farms for which topography, slope and aspect, as well as top surfaces of individual buildings and trees are important for identifying areas shaded from the sun.

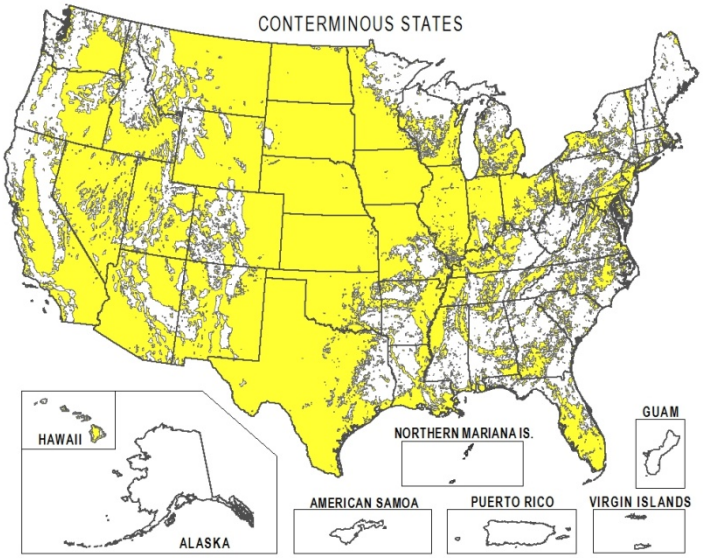
Update Frequency: 2 years, though WindLogics could potentially study different areas of the country based on an established data acquisition cycle, knowing when new LiDAR data would become available.

Business Use: Renewable Energy Resources, BU#11

Estimated program budget: Unknown

Quantifiable Benefits of Enhanced Elevation Data:

LiDAR data will enable WildLogics and NextEra to site and design solar farms for maximum efficiency. Estimated savings from the use of LiDAR for improved efficiency of solar farms cannot be estimated at this time.



Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Organization: WindLogics

Functional Activity: Solar Farm Siting and Design

WindLogics does not currently use LiDAR for planning of solar farms. However it is fully recognized that LiDAR, where available, including derived slope and aspect data, would be ideal for identification of horizon profiles (shading profiles) vital for solar farm siting and design and maximization of solar farm efficiency.

Anonymous Oil and Gas Company

Compared to the global giants, a relatively-small oil and gas company, that asked to remain anonymous, identified the following major Functional Activity with mission-critical requirements for enhanced elevation data:

- Oil and Gas Operations, under Business Use #12, Oil and Gas Resources

Oil and Gas Operations

Mission-Critical Requirements:

QL3 LiDAR, plus QL5 IFSAR for Alaska and U.S. territories, is required for mapping, 3-D visualizations, and geospatial analyses of slopes, hillshades, contours and viewsheds, used for well site location suitability analyses, pipeline and road route selections, seismic program planning, hazard identification, and timber cut estimations.

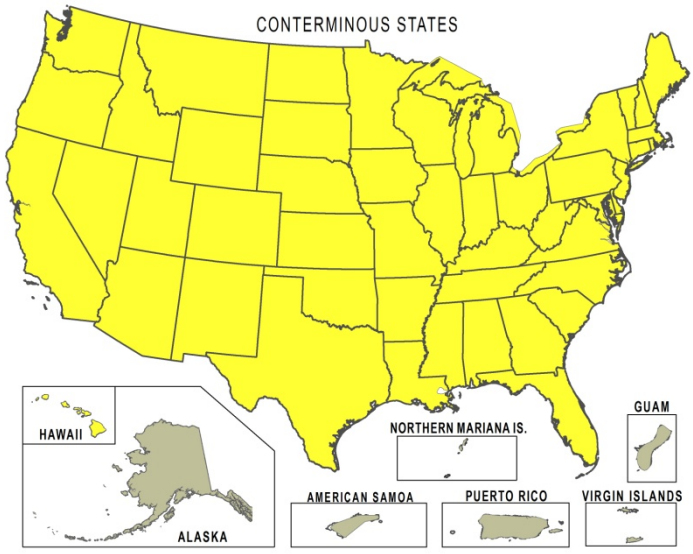
Update Frequency: 6-10 years.

Business Use: Oil and Gas Resources, BU#12

Estimated program budget: N/A

Quantifiable Benefits of Enhanced Elevation Data:

Moves a significant amount of work from the field to the office. Allows a reduction in number of field staff required while greatly reducing time required to gather data and perform analyses. Potential savings (for this relatively small company): $100,000's to $1,000,000's annually depending on number and size of projects the company undertakes. When considering other global industry giants, benefits are easily **$10M/year.**



Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Organization: Anonymous

Functional Activity: Oil and Gas Operations

Operational Benefits: Major. Saves significant amount of field visits and survey time. Better results in shorter time. Large impact on employee and contractor safety. Less requirement to visit the field, and when we do, we know exactly what to expect and where potential dangers exist.

Customer Service Benefits: Potentially Major. Higher accuracy data provides higher confidence in analysis results and better mapping products. Allows for more focused efforts by planning and engineering teams.

Public/Social Benefits: Moderate. Less intrusion on members of the public; less trespassing on private lands; better selection of well, facility and pipeline locations to reduce impact on the public, including safety concerns.

Environmental Benefits: Moderate. Reduced environmental “footprint” by conducting the work in the office rather than in the field.

Strategic/Political Benefits: Minor

TomTom

Point of Contact: Maureen Williams, (603) 643-0330, X13266

TomTom is the world's leading provider of in-car location and navigation products and services focused on providing all drivers with the world's best navigation experience. TomTom products include portable navigation devices, in-dash infotainment systems, fleet management solutions, maps and real-time traffic solutions.

TomTom identified the following major Functional Activity with mission-critical requirements for enhanced elevation data:

- Location and Navigation Services, under Business Use #18, Land Navigation and Safety, and Business Use #26, Recreation

Location and Navigation Services

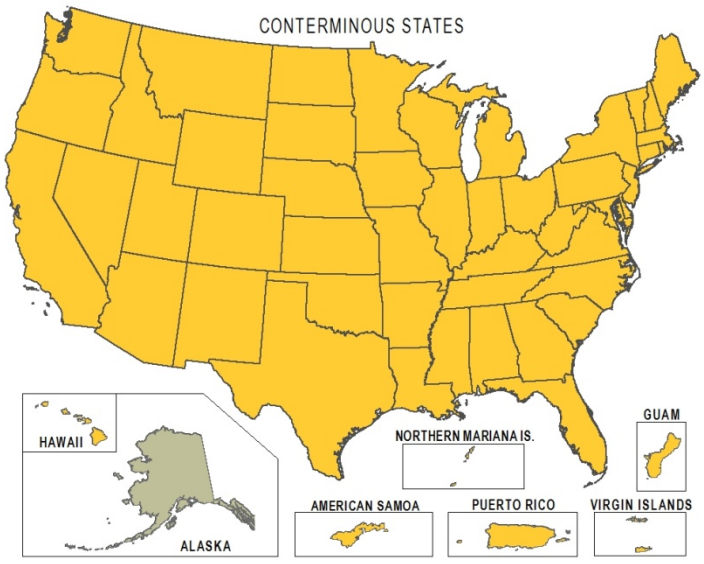
Mission-Critical Requirements: QL2 LiDAR nationwide (except QL5 IFSAR in Alaska) will enable cars and trucks, under development, to be safer and more fuel efficient; and enable new products and services for golfers, runners, bikers, rock climbers, skiers, and drivers of all-terrain vehicles and snowmobiles.

Update Frequency: 4-5 years

Business Use: Land Navigation and Safety, BU#18, and Recreation, BU#26

Estimated program budget: N/A

Quantifiable Benefits of Enhanced Elevation Data:
Research programs and car manufacturers have estimated that road elevation/slope data, combined with transmission-control technology and in-vehicle location and navigation products, will enable fuel consumption to decrease by 4-12%, **saving billions of dollars annually**[6] for American drivers. Driver alertness tests, based on 3-D road information such as "steep curves ahead," could save many of the thousands of deaths annually caused by driver fatigue.



Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Organization: TomTom

Functional Activity: Location and Navigation Services

[6] For the Benefit/Cost Analysis, because of uncertainty in the dates and rates of the automotive industry's introduction of Intelligent Transportation System (ITS) and Advanced Driver Assistance Systems (ADAS) initiatives based on LiDAR for roadway geometry, Dewberry used $0/year as the conservative benefit and $6.125B/year as the potential benefit based on 1% fuel savings of 1.75 billion gallons of gasoline and diesel fuel at $3.50 per gallon (see http://www.fhwa.dot.gov/policyinformation/pubs/pl10023/fig5_2.cfm for fuel consumption statistics.). Even this 1% is a conservative estimate compared with the 4-12% savings estimated by TomTom.

Fuel Efficiency. In anticipation of increased fuel efficiency standards, and based partly on research performed by engineers at the University of Berlin, car and truck manufacturers have determined that they can reduce fuel consumption between 4% and 12% by building vehicles that use elevation and slope data from LiDAR, combined with transmission-control technology and in-vehicle location and navigation products, to down-shift and up-shift transmissions in anticipation of gradients ahead. The trucking industry is apparently supportive of such Advanced Driver Assistance technology. Americans currently drive approximately 3 trillion miles per year and consume 175 billion gallons of gasoline and diesel fuel per year; at $3.50/gallon, a 4% reduction in fuel consumption would save 7 billion gallons of fuel annually or $24.5 billion for consumers. Even if the reductions in fuel consumption are only 1%, the annual savings for American drivers would still be $6.125B/year.

Driver Safety. The National Highway Traffic Safety Administration conservatively estimates that 100,000 police-reported crashes are the direct result of driver fatigue each year. This results in an estimated 1,550 deaths, 71,000 injuries, and $12.5 billion in monetary losses. Even greater losses are attributable to drunk drivers. TomTom is working with car and truck manufacturers to build vehicles that notify or warn drivers when there are steep curves or other dangerous conditions ahead. The same LiDAR datasets used to reduce fuel consumption would also be used to reduce accidents and deaths. With the fatigue testing feature, drivers would receive a message to push certain buttons when there is a dangerous road ahead; and the amount of time taken to respond correctly would be an indicator of potential drowsiness so that warnings can be made that would alert drivers that respond poorly. Assuming this new technology succeeds in preventing a portion of such accidents, this too could be an innovation worth hundreds of millions of dollars annually, if not billions.

Sports and Recreation. TomTom is developing applications that combine GPS positioning with elevation data. Similar to a Sports Watch for runners, TomTom expects the introduction of LiDAR-based innovations to be incorporated in a variety of recreational tools so that users know the steepness of slopes, vertical feet of climb, etc.

E-Terra LLC

Point of Contact: Steve Colligan, (907) 562-1500

E-Terra is a company dedicated to mapping and the development and support of GIS, CAD, and database applications, specializing in the development of aviation safety solutions for Alaska

The Problem with Poor Mapping in Alaska

In nearly 600,000 square miles of Alaska's land there are less than 5,000 miles of roads, and only one single-track railroad-line; 82% of the villages in Alaska have no connection to the national road system. All commerce and essential services, all personal transportation with these villages, is done by airplane. These are mostly small, piston-engine airplanes that are not pressurized and cannot go into known icing conditions. With these and other factors, they cannot reasonably fly straight over the mountains (up to 20,000 feet high in Alaska). Instead, the planes fly through mountain passes and they cannot use Instrument Flight Rule IFR-airways or line-of-sight (VOR) radio-navigation while doing that. These tools work only for turbine aircraft such as airliners flying high over the terrain.

Whereas all other states have been mapped at 1" = 2000' to National Map Accuracy Standards (NMAS), Alaska has only been mapped at a small scale of 1" = 1 mile, and not to NMAS standards. Alaska is also the only state that does not have digital orthophotos – because the National Elevation Dataset (NED) data for Alaska has mountains mapped miles away from their true locations in some places. Figure 1 shows how imagery draped over the NED results in rivers that appear to go up and over the mountains – because the mountains are mapped in the wrong place in the NED. Such inaccuracies do not pertain everywhere. The NED is reasonably accurate for major areas of Alaska, leading to false assumptions that the NED data is accurate everywhere, when it is not. When USGS topographic quad maps of Alaska (1" = 1 mile) were produced in the 1950s, mapping inaccuracies occurred because of the vast expanse of areas to be mapped, the near-total absence of survey control points, and the unavailability of any GPS and statistical bundle-block aerotriangulation procedures which were not developed until decades later.

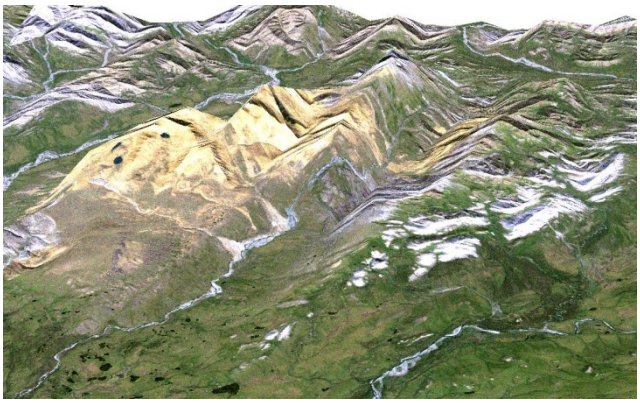


Figure 1. Some data in the NED is so inaccurate that mountains are miles away from their true location, and rivers appear to flow up and over hills – all because the NED is so inaccurate in some locations. This image was provided by the University of Alaska Fairbanks (UAF).

Major Aviation Safety Issues

Alaska has not been mapped accurately enough in 3-D to use GPS in aircraft for terrain avoidance. But modern moving-map-GPS makes the dangerous appearance that it is good enough by using terrain databases that have errors. With poor visibility common, and with weather such as icing and clouds above the mountain passes, a flight through a pass is like flying through a tunnel that has numerous

dendritic dead end junctions. One wrong turn can lead into a dead-end box canyon, too narrow to turn around in and too steep to climb out of. As a result, Alaska has an extremely high incidence of Controlled Flight Into Terrain (CFIT) accidents of which the FAA is well aware. CFIT crashes occur when failures occur at all levels, and backup safeguards are inadequate, resulting in the pilot flying a technically 100% operational aircraft into a situation in which he is not aware of his surroundings and thus flies into a mountain.

Alaska has approximately 10 percent of the nation's air transport operators. Historically, this 10 percent generates approximately 35 percent of the nation's air transport accidents. From 1994 to 1996, there were 112 accidents in Alaska involving these kinds of operations. The flying challenges posed by Alaska's mountainous terrain and fierce winter climate together with the higher-than-average accident rate has made the quest for improved aviation safety in Alaska a major goal for the FAA and the Alaskan aviation community.

The *FAA Flight Plan* (FAA's Strategic Plan) has a goal to achieve the lowest possible accident rate and constantly improve safety. This plan specifically mentions Alaska eight times, while mentioning no other state by name. It mentions Alaska with reference to the satellite-based Capstone navigation and terrain awareness avionics as well as the Circle of Safety and Alaska Flight Service Safety programs. The Circle of Safety document refers to 100 occupation pilot deaths in Alaska between 1990 and 1998, stating: "Most CFIT crashes are attributed to pilot error."

Studies conducted in Alaska indicate that 38 percent of the 112 accidents from 1994 to 1996 might have been avoided by the availability of advanced avionics in the aircraft that track the aircraft's position relative to the terrain. Unfortunately, aircraft positioning and navigation systems can lead to a false sense of security when the aircraft's position is precisely known but the terrain information may be in error by miles. A 2004 study by MITRE and the University of Alaska at Anchorage found that, from 2000 through 2004, the rate of accidents for Capstone-equipped aircraft was reduced by 47 percent, by improving aircraft positioning. Although the Capstone avionics onboard aircraft improve the pilot's knowledge of where the airplane is positioned at all times, the topographic data may be so inaccurate that the pilot does not know where the aircraft is positioned relative to the terrain. How many more accidents would be reduced if these aircraft also had accurate terrain information so pilots could track their aircraft's position relative to the actual terrain?

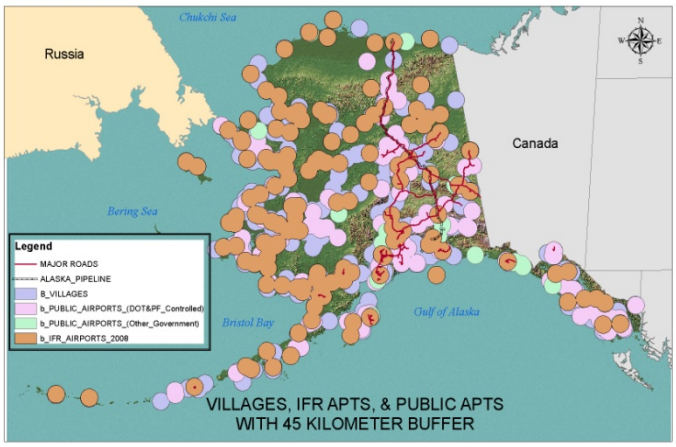


Figure 2. . In 2008, the FAA identified the urgent need to acquire airborne IFSAR of the 1,000+ airfields in Alaska to satisfy Area 2 requirements of the International Civil Aviation Organization (ICAO). This map was produced from shapefiles provided by the FAA. This graphic also shows the sparse road network in Alaska.

Alaska DEM Whitepaper

In 2008, The Alaska Geographic Data Committee (AGDC), which includes Alaska Mapped (representing the Statewide Digital Mapping Initiative — SDMI), the Bureau of Land Management (BLM), the Geographic Information Network of Alaska (GINA) and the University of Alaska Fairbanks (UAF), sponsored a series of DEM workshops and a major study that resulted in a document known as the *Alaska DEM Whitepaper.* During this study, the FAA indicated that airborne IFSAR, with 20-foot contour accuracy, is required for the areas circled in Figure 2 in order to satisfy requirements of the International Civil Aviation Organization (ICAO). The ICAO standards for Electronic Terrain and Obstacle Database (eTOD) were developed to minimize the risk of CFIT crashes, and Alaska remains the only state in non-compliance with these ICAO requirements.

Prior to acceptance of the *Alaska DEM Whitepaper*, the draft findings and conclusions of the study were presented to the National Digital Elevation Program (NDEP) members that met in Anchorage in the autumn of 2008. NDEP members from BLM, NRCS, USFS, USGS, NOAA, NGA, USACE, FEMA, and NSGIC (National States Geographic Information Council) unanimously agreed with the following consensus points:

- Alaska has no time to waste. ICAO Area 2 requirements were then scheduled to become effective on 11/20/2010. Other urgent statewide DEM user requirements included the immediate need for orthorectification of optical imagery for production of digital orthophotos. Representatives of diverse Federal and state government agencies had their own requirements for DEMs of the same accuracy level specified by the FAA.
- All must remain true to Alaska's requirements. Alaska needs elevation data with 20-foot equivalent contour accuracy or better. Alaska needs both DSMs and DTMs, especially of mountain peaks, ridgelines and hydrology. Alaska needs to be mapped with technology that overcomes adverse weather conditions (maps through clouds and fog), technology that maps snow-capped mountains and glaciers and is cost-effective. Elevation data produced from satellite technology does not satisfy Alaska's requirements.
- Alaska must find a timely, cost-effective solution. Only airborne mapping options can satisfy Alaska's technical and accuracy requirements. Airborne IFSAR costs are significantly less than airborne LiDAR or photogrammetry. Multiple contracting options for airborne IFSAR are available to obtain the most cost-effective solution for timely delivery of quality products. Both Federal and state funding is required because the U.S. government owns nearly 75% of the land area of Alaska (primarily lands belonging to BLM, FWS, NPS and USFS).

Alaska DEM Funding and Implementation Plan

In 2009, an *Alaska DEM Funding and Implementation Plan* was developed by USGS. Cost estimates were originally as high as $90M but estimates were uncertain because the two IFSAR providers in the U.S. were reluctant to share their pricing estimates when potentially competing against each other. When multiple Federal and state agencies were able to identify nearly $6M in available funding, the two IFSAR providers competed seriously and both submitted best and final offers that allowed about 10% of Alaska to be mapped with IFSAR with available funds of nearly $6M.

Aircraft Search, Rescue, and Recovery in Alaska

Like nowhere else, aircraft crashes are common in Alaska. In the autumn of 2010, after 28 1-degree IFSAR cells had just been acquired but not yet processed, there were two tragic aircraft accidents in Alaska. In September of 2010, an NPS aircraft disappeared with four persons on board, enroute to the Katmai National Park & Preserve. IFSAR was not available of the search area, so extensive searches were conducted without the benefit of accurate elevation data. Figure 3 shows the aerial search map with flight paths used in an attempt to locate the downed aircraft. The search was very expensive and ultimately unsuccessful. Portions of the aircraft have been subsequently washed ashore.

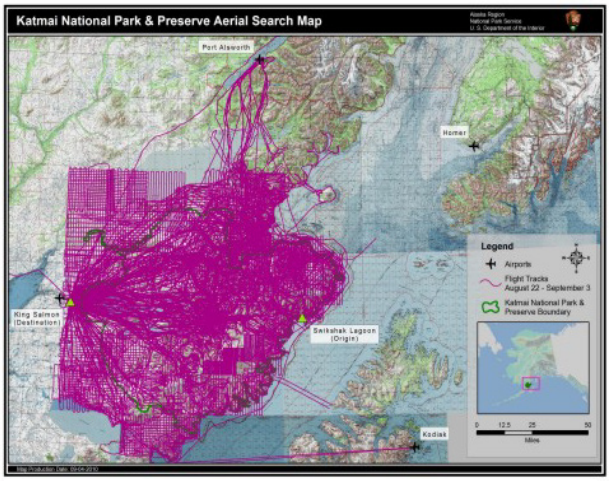


Figure 3. Aerial search map of the area in which the NPS aircraft was assumed to have gone down trying to reach Katmai national Park & Preserve during adverse weather conditions. This map shows flight lines used for extensive search and recovery operations that never found the aircraft until parts washed ashore. This graphic was provided by NPS.

In November, 2010, a $150M F-22 from Elmendorf AFB crashed, killing the pilot. It crashed in rugged terrain, 15 miles southwest of Denali Highway, on land managed by BLM. The crash site is located adjacent to a creek. The incident was environmentally sensitive due to composite materials of the F-22, considered HAZMAT upon breakup. Winter snow and runoff would expose other hazardous parts that contained highly pressurized gasses or dangerous flammable components with toxic content.

The initial search and rescue operation became a recovery operation on November 20th. The USAF's 3rd Wing, 673rd Air Base Wing was involved, as was the Alaska 3rd Maneuver Enhancement Brigade of the U.S. Army. The 6th Engineer Battalion provided logistical and mobility support for recovery operations, and the commander reported: "Weather and terrain were particularly challenging, and presented extreme mobility challenges for our vehicles and soldiers." Heavy snow and snow storms in steep mountain terrain raised avalanche concerns, especially with Blackhawk and Chinook helicopters with increased rotor wash and sound. The existing USGS NED was insufficient to aid in identification of ground safety hazards, establishment of landing zones and slope analysis for potential avalanche zones. Errors of >90 meters were identified in the NED. Current imagery was not available; sun elevations at this latitude limited commercial imagery collection until late February.

USGS learned that the crash site was on one of the IFSAR cells recently collected under USGS contract but not yet processed. The "as is" IFSAR, DTM, DSM and ORI was FedEx'd to Elmendorf AFB where accurate base elevations were used for 3-D modeling and visualization of the surrounding crash site. Analysts added and eliminated landing zones previously identified. Detailed terrain analysis was performed with increased reliability over the NED. Secondary products were created including the establishment of avalanche safety zones and ingress/egress route planning. The IFSAR data was also vital for line of communications analysis and radio repeater deployment.

Although $60M is a lot of money for IFSAR mapping of Alaska, statewide, this price pales in comparison with the $150M value of the single aircraft that was lost; the IFSAR data was vital for the success of recovery operations. Most significantly, similar crashes of civil and military aircraft (as well as numerous accidents that do not involve aircraft) occur regularly throughout the vast state of Alaska – and normally do so without the benefit of IFSAR data to assist with search, rescue and recovery operations.

FAA Nationwide Requirements

In 2011, in response to interviews for the National Enhanced Elevation Assessment, the FAA identified a requirement for QL5 IFSAR nationwide for enroute navigation and safety. The means that the FAA has identified a requirement for IFSAR data statewide in Alaska for enroute Instrument Procedures, and not only for the 1,000+ areas circled in Figure 2 above.

Alaska Flight Simulators

Due to all the complex factors described above, Alaska's pilots require different skill sets than pilots elsewhere. Most flight-training in the U.S. is done with Common Flight Simulators made to simulate IFR conditions and aircraft system failures, rather than Visual Flight Rule (VFR) procedures common in Alaska. Most Common Flight Simulators are made to train the turbine-engine-airline-IFR environment (high above all terrain and weather). In harsh contrast, aircraft simulators for Alaska are made to simulate Alaska's unforgiving mountains and passes in photo-realism and harsh weather conditions that too-often lead to Controlled Flight Into Terrain (CFIT) accidents. Simulators, such as shown at Figure 4, require elevation data draped with imagery. In a sense of "look-before-you-fly," Alaska's pilots learn their way through the mountains in the simulator and gain experience necessary for flight safety.

Figure 4. Flight Simulator used by E-Terra in Alaska. Image courtesy of E-Terra.

E-Terra's Mission Critical Requirements

E-Terra identified the following major Functional Activity with mission-critical requirements for IFSAR data of Alaska:

- Alaska Aviation Safety Project, under Business Use #20, Aviation Navigation and Safety

IFSAR data for this project are also used for FAA Cue Based Training, wireless communications research, airspace training, DOD site approach training, and ISSECMP implementation.

Alaska Aviation Safety Project

Mission-Critical Requirements: QL5 IFSAR is required for all of Alaska for: (1) enroute instrument procedures including Capstone navigation and terrain awareness avionics, (2) ICAO Area 2 compliance for terminal safety approaching over 1000 (mostly very small) airfields in Alaska, (3) aircraft search, rescue and recovery operations, and (4) realistic flight simulators for training pilots on the harsh realities of flight in Alaska

Update Frequency: >10 years

Business Use: Aviation Navigation and Safety, BU#20.

Estimated program budget: $1M, AK State DOT, FAA Aviation Safety Team

Quantifiable Benefits of Enhanced Elevation Data: There is a direct dollar for dollar reduction in costs by having accurate terrain provided from other sources to build aviation products. With the lack of any accurate terrain, each project is a data collection project rather than a technology integration project. More abstract, as more of these types of products are available for training and navigation, each loss of life avoided equates to $1M to $2M per life. As accurate data is used in training and navigation direct cost avoidance, resulting in many millions of dollars per year savings in injury, life and property. Cost avoidance is **between $3M and $24M/year**[7].

Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Organization: E-Terra

Functional Activity: Alaska Aviation Safety Project

The Alaska Aviation Safety Project (AASP) is a cooperative effort between E-Terra, NASA, the State of Alaska, and many other stakeholders to build innovative remote sensing based aviation safety solutions. With technologies ranging from advanced terrain management solutions to 3-D animations, interactive mapping products, and real-to-life aviation navigation training applications, the AASP has been able to offer extensive value to the General Aviation (GA) and Scheduled Flight operators around Alaska. The map portal segment of AASP research focuses on compiling aviation safety related textual, graphical, and spatial information, integrating these products with remote sensing data for context. This data is then published as an aggregate web solution to offer an intuitive method for pilots to study and retain the information before attempting to fly a new path. IFSAR data is vital for the success of the AASP.

[7] For the Benefit/Cost Analysis, Dewberry used $3M/year as the conservative benefit and $24M/year as the potential benefit

The dollar benefits of receiving statewide IFSAR for the AASP are estimated as follows: Direct: Each dollar spent collecting accurate terrain data for general purpose within the State of Alaska, is a dollar that will be alleviated from the AASP project to acquire data for training and navigation purposes. A major portion of each navigation project is consumed collecting or buying data because it is currently not available. Sharing these costs for these base products (accurate terrain) allows the creation and proliferation of more and better training and navigation products at an accelerated rate over current plans and budgets. This would reduce product development costs by 25-30%, while at the same time provide a high overall product quality and use by industry.

Abstract: From a cost avoidance perspective alone, based on the value of a life saved (currently $2.0M), the cost of terrain data can support the collection of high resolution terrain from AASP's own business model. Avoided costs of search and rescue can be multiple millions per incident. Any incident avoided, each life protected, or injury avoided is a cost avoided. AASP believes that this avoided cost is conservatively between $3M and $24M dollars per year. This is supported in cost of life calculations, not including search and rescue and other costs as follows. There were 1186 aviation accidents in Alaska between 2000-2009; 107 were fatal crashes that resulted in a total of 236 fatalities, on average 12 lives per year at $2M per year not including collateral damage can be attributed each year.

The end goal is to change the culture through training, enhance navigation with usable accurate data, avoiding costs by reducing incidence and mortality.

Dollar benefits estimated by E-Terra were validated as reasonable by the Project Manager, State of Alaska Department of Transportation, Aviation Division, who also supports the AASP.

Duquesne Light Company

Point of Contact: Bill Radomski, (412) 393-8118

Duquesne Light Company is a leader in the transmission and distribution of electric energy, offering superior customer service and reliability to more than half a million customers in southwestern Pennsylvania. Although it serves a relatively small portion of the U.S., it is one of the early users of LiDAR for transmission line vegetation management and other purposes within the electric power industry and is representative of nationwide requirements for other electric utility companies.

Duquesne identified the following major Functional Activity with mission-critical requirements for LiDAR data.

- Transmission Line Vegetation Clearance, under Business Use #21, Infrastructure and Construction Management

Transmission Line Vegetation Clearance

Mission-Critical Requirements:

Duquesne Electric Light and other electric transmission line companies nationwide require QL1 LiDAR for transmission line vegetation clearance to satisfy NERC requirements, for ensuring that actual line sag equals the design sag, and for detection of encroachments on company rights-of-way.

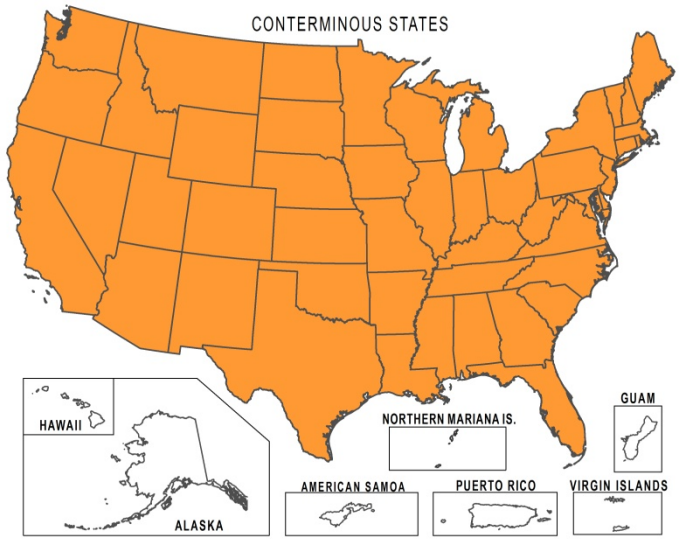
Update Frequency: 4-5 years minimum; annually preferred

Business Use: Infrastructure and Construction Management, BU#21

Estimated program budget: Unknown

Quantifiable Benefits of Enhanced Elevation Data:

Extrapolated nationwide to other companies, annual updates of QL1 LiDAR data will enable the electric utility companies to save up to **$675M/year** [8] in not having to acquire their own LiDAR data to satisfy NERC requirements.



Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Organization: Duquesne Light Company

Functional Activity: Transmission Line Vegetation Clearance

The North American Electric Reliability Corporation (NERC) regulates the *bulk power system*, the facilities and control systems necessary for operating an interconnected electric energy supply and

[8] For the Benefit/Cost Analysis, because of uncertainties in the rate of implementation of LiDAR for transmission line vegetation clearance, Dewberry used 10% ($67.5M/year) as the conservative benefit and the full 100% ($675M/year) as the potential benefit.

transmission network, including over 450,000 miles of bulk transmission lines but excluding smaller lines used for local distribution of electricity. Without specifically requiring LiDAR, NERC standards are commonly interpreted to endorse the use of airborne LiDAR for: (1) *line rating*, based on actual field conditions that determine changes in power line catenaries due to thermal and mechanical loads, and (2) *transmission line vegetation management*, based on monitoring of transmission line vegetation clearance to proactively prevent line-vegetation arcs and subsequent cascade system failures. NERC Standard FAC-003-2, Requirement 7, states: "Each Transmission Owner shall execute a flexible annual vegetation work plan to ensure no vegetation encroachments occur within the MVCD (Minimum Vegetation Clearance Distance)."

For LiDAR surveys of bulk transmission lines, the acquisition date and time for each flightline must be available so that operators can reconstruct the ambient temperature and power line loading at the time the LiDAR was acquired because these factors all impact the transmission line sag which is compared with the designed sag.

Operational benefits to Transmission Line Companies of LiDAR data for this Functional Activity:

Time/cost savings: Major	Mission Compliance: Major	$ Benefits: $675M/year

- Satisfied most cost-effectively with LiDAR, Lewis Graham of GeoCue estimates that all required LiDAR acquisition would cost $675 million/year for America's electric utility companies and consumers who pay their electric bills. These costs would be greatly reduced whenever there is a fresh collect of nationwide LiDAR for individual areas. The Tennessee Valley Authority (TVA) alone estimates that it would save $600,000/year from such LiDAR.

Customer service benefits from improved Transmission Line products/services:

Performance: Minor	Timeliness: Minor	Experience: Minor	$ Benefits: Unknown

- Reliable service benefits all customers, and trees falling into power lines is the major cause of power outages.

Other Benefits from the use of LiDAR data for this Functional Activity:

Public/Social: None	Environmental: None	Strategic/Political: Major

- There are major political benefits when electric service is reliable; or more pointedly, there are major political issues when electric service is unreliable.

Insurance Services Organization (ISO)

Point of Contact: Ralph Dorio, (201) 469-2463

The Insurance Services Organization (ISO) is a leading source of information about property/casualty insurance risk, providing data, analytics, and decision-support services for the property/casualty insurance industry.

ISO currently has no known mission-critical requirement for enhanced elevation data, but uses the best available information to assess property/casualty insurance risk. In many cases, risk is assessed on the basis of historical insurance claims filed by zip code, rather than predicting where claims from various natural hazards may occur in the future.

In assessing four basic types of natural hazards, ISO recognizes that LiDAR data could provide superior sources of information about property insurance risk:

1. Geophysical Hazards: ISO recognizes that LiDAR is used by USGS and others for determining risks from earthquakes, tsunamis and volcanoes. ISO accepts USGS requirements for LiDAR data for identification of seismic faults and other geophysical hazards without considering such data as mission-critical at this time for ISO or its insurance company clients.
2. Meteorological Hazards: ISO recognizes that LiDAR is used by NOAA and FEMA for determining risks from hurricanes, and ISO sees the potential for LiDAR to also be used in future modeling of risks from tornadoes. ISO accepts NOAA and FEMA requirements for LiDAR data for such meteorological hazards without considering such data as mission-critical at this time for ISO or its insurance company clients.
3. Hydrological Hazards: ISO recognizes that LiDAR data is already widely used by FEMA for determining risks from floods; and ISO recognizes that LiDAR data is already used by USGS for determining risks from landslides often caused by saturated soils. ISO accepts FEMA and USGS requirements for LiDAR data for such hydrological hazards without considering such data as mission-critical for ISO or its insurance company clients.
4. Climatological Hazards: ISO recognizes that LiDAR data is used by the National Interagency Fire Center (NIFC) and other Federal/state agencies for wildfire modeling. ISO accepts NIFC requirements for LiDAR data for determining such climatological hazards without considering such data as mission-critical at this time for ISO or its insurance company clients.

Currently, only flood insurance premiums are assessed differently by FEMA actuaries as a function of elevation data for individual properties. Whereas LiDAR is a mature technology for assessment of flood risks, its value for assessment of other insurable risks is still evolving. ISO may reconsider as improved computer models evolve.