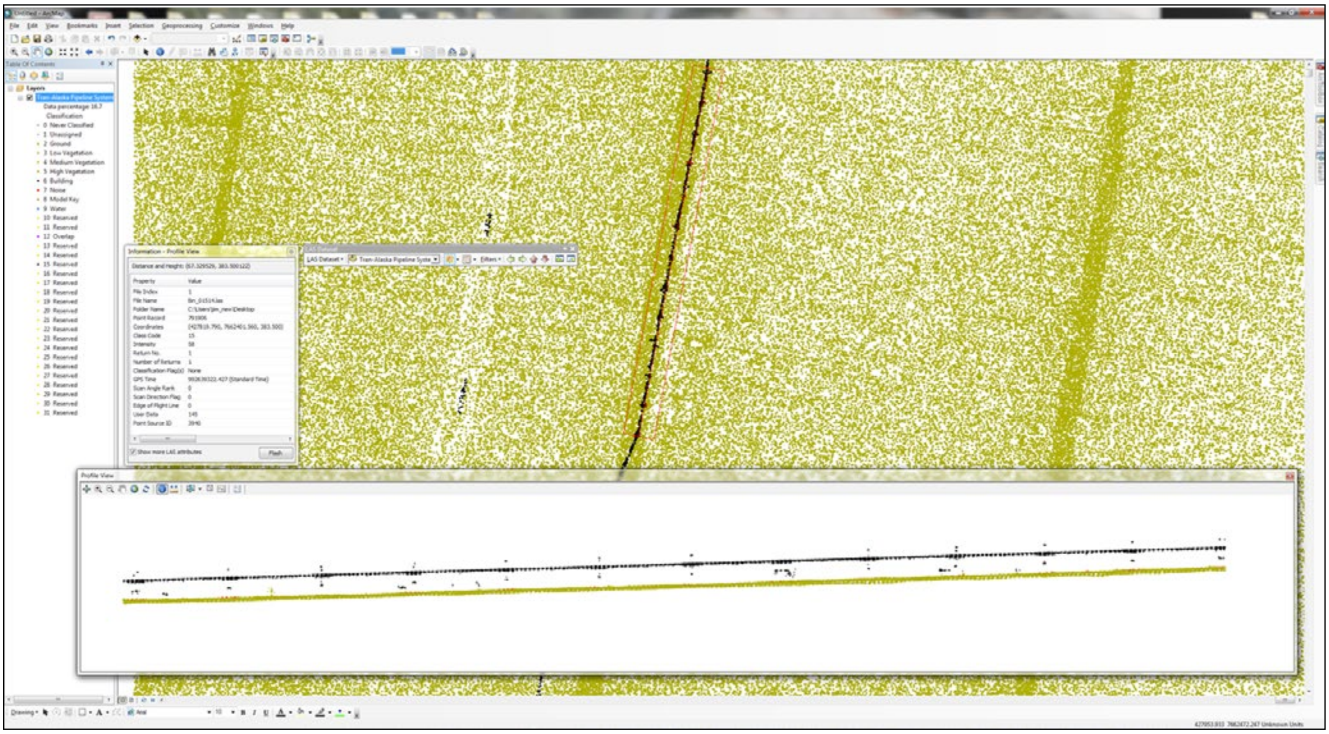


Viewing the LAS dataset along the Trans-Alaska Pipeline System (TAPS) in ArcGIS.

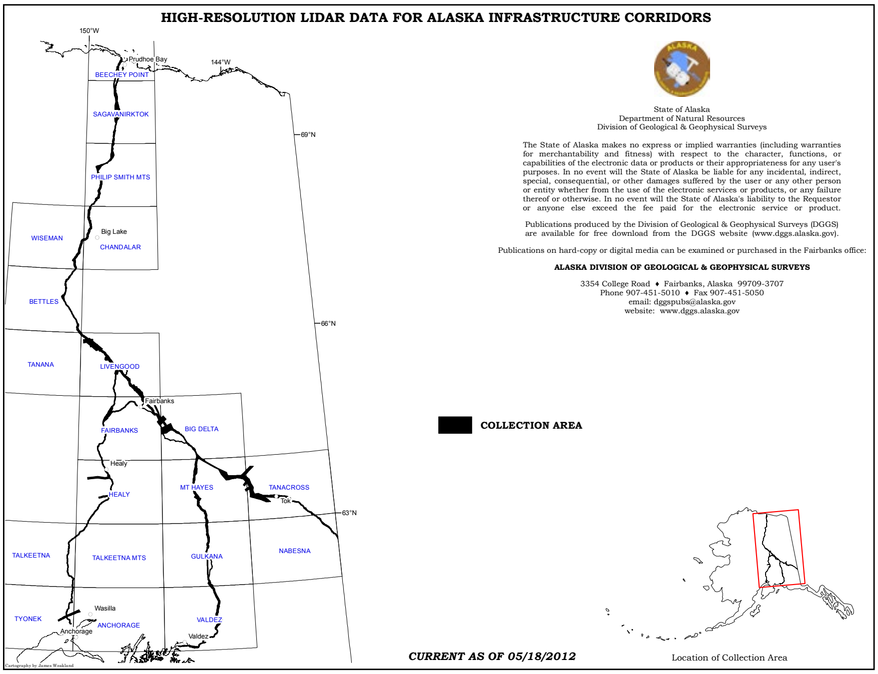
Ensuring Data Quality for Alaska's North Slope

Alaska Division of Geological & Geophysical Surveys uses ArcGIS to evaluate 3,000 square miles of LiDAR data for proposed natural gas pipeline routes

The Alaska Department of Natural Resources, Division of Geological & Geophysical Surveys (DGGS) collected high-resolution LiDAR topographic data for swaths of land that would likely be used if new natural gas pipelines were constructed in Alaska. The pipelines would be designed to deliver Alaska North Slope natural gas to out-of-state and Alaska customers. Collection of LiDAR data was supported by the State of Alaska Gas Pipeline Project Office, the Office of the Federal Coordinator, and the Alaska Gasline Development Corporation.

The data—covering approximately 3,000 square miles along the proposed pipeline routes—were acquired to facilitate analysis during the design, permitting, and construction of the pipelines, including evaluation of active faulting, slope instability, thaw settlement, erosion, and other engineering constraints along the proposed pipeline routes. The data

BY JAMES **WEAKLAND**



Alaska DGGS collected LiDAR topographic data covering approximately 3,000 square miles of proposed natural gas pipeline corridor.

will also provide an Esri ArcGIS base layer for the state–federal GIS database and will be used to evaluate permit applications and construction plans.

LiDAR was chosen as the preferred data format because it has proven to be one of the most useful forms of remotely sensed data for identification and characterization of potentially active faults and many other surficial-geologic landforms and hazards, especially in areas of heavy vegetation where access may be difficult and other forms of remotely sensed data are ineffective.

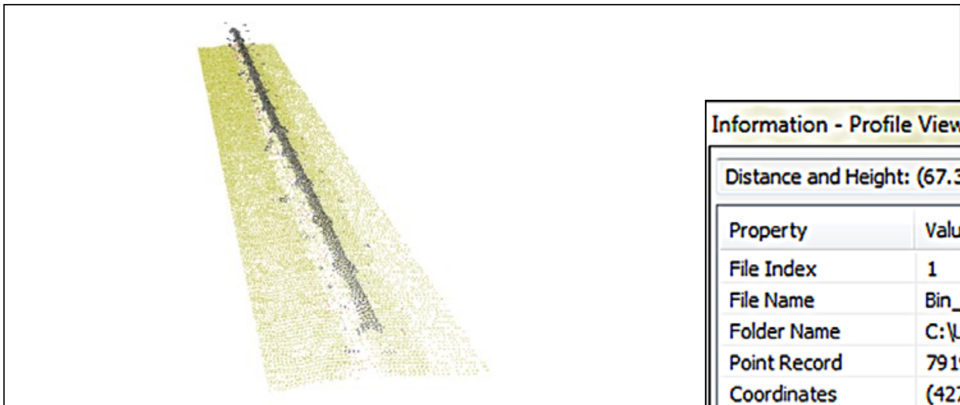
Acquiring LiDAR data

LiDAR data were acquired and processed by Watershed Sciences, Inc. (WSI), based in Corvallis, Oregon. The data consist of continuous 1-mile-wide minimum coverage of existing infrastructure along the entire length of the proposed natural gas pipeline corridors from Prudhoe Bay, Alaska, to the Canada border along the Trans-Alaska Pipeline System (TAPS) and Alaska Highway; Delta Junction to Valdez, Alaska along the TAPS corridor, and Livengood to Point McKenzie, Alaska along the George Parks Highway. LiDAR data were collected between September 21 and October 1, 2010, for an area that included portions of the Alaska Highway east of Johnson River to Robertson River, and included 117,357 acres within the requested area. This area was expanded to include a 100-meter buffer to make sure coverage was complete and there were adequate point densities around survey boundaries, resulting in 121,746 acres of delivered data.

The LiDAR survey data were collected with Leica ALS60 sensors in a Cessna Caravan 208B and Partenavia P-68 aircraft. The Leica systems were set to acquire 200,000 laser pulses per second and flown at 900 or 1,300 meters above ground level, depending on cloud ceiling and terrain, capturing a scan angle of plus/minus 14 degrees from nadir. The system achieved a minimum survey density of 8 pulses per square meter and up to four returns per pulse. The data included minimum 1-mile-wide corridors covering gas-pipeline routes being considered by applicants, and half-mile-wide coverage of existing primary pipeline-support roads outside the main corridor. Other expanded coverage included areas where data are needed for evaluation of active faults, slope instability, and other geologic hazards.

To facilitate processing and product delivery, WSI grouped the data into delivery areas (subsets of the entire data collection region) in the order in which they were collected and processed. Files for each delivery area were organized by 1:63,360-scale quadrangle. Next, WSI sent the data for each delivery area to the State of Oregon Department of Geology and Mineral Industries (DOGAMI) for independent quality-control analysis under separate contract with DGGS. DOGAMI is a proven leader in the collection and use of LiDAR data, with vast experience in these types of analyses.

After correcting any errors identified by DOGAMI, WSI sent the revised data set to DGGS along with a delivery report describing details about LiDAR acquisition, accuracy, and quality for the delivery area. DOGAMI also provided a separate report for each delivery area, summarizing their methodologies and the results of quality control checks.



Oblique view of the Trans-Alaska Pipeline System.

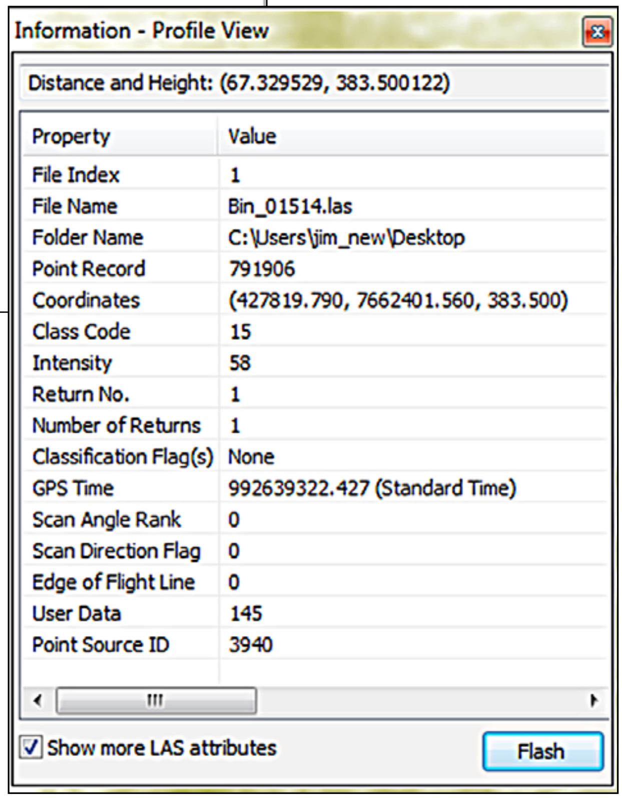
LiDAR points were classified as ground, low and medium vegetation, buildings or manmade structures, noise/error points, water, snow, and pipeline. Contour lines were derived at 1 meter intervals from ground-classified LiDAR point data using TerraSolid processing software and Microstation. For the derived DEMs, lakes and other closed water bodies with surface areas of greater than 150 square meters were flattened to a consistent water level using a hydroflattening procedure to ensure stream channels break at culvert locations and the sinks and pits in the data are removed.

Ensuring quality using ArcGIS

Bare-earth and highest-hit grids were delivered in ArcGIS grid format with 1 meter cell size. LiDAR point data were delivered in LAS binary format for ground classified returns as well as the entire LiDAR point cloud. Georeferenced intensity images of 1 meter cell size were supplied in geoTIF format. Supplementary data include 1-meter-cell-size vegetation rasters displaying canopy and other vegetation metrics. Real-time kinematic ground survey data that are used for absolute vertical adjustment were supplied in shapefile format.

All data associated with the delivery were loaded and viewed to ensure completeness. Raster imagery such as elevation grids and intensity geoTIFFs were viewed in ArcGIS and cross referenced with the delivery area. These grids were loaded into ArcGIS software for visual analysis. Data were examined through slope and hillshade models of bare earth returns. Hillshades of the highest-hit models were used to identify areas of missing ground. Both bare-earth and highest-hit models were examined for calibration offsets, tiling artifacts, seam-line offsets, pits, and birds (both real and anomalous).

Errors noted during visual analysis were digitized for spatial reference and stored in Esri shapefile format. Each feature was assigned an ID value and commented to describe the nature of the observed error. The shapefile was delivered to WSI for locating and fixing apparent errors. Upon receiving the observed error locations, the vendor


Information - Profile View

Distance and Height: (67.329529, 383.500122)

Property	Value
File Index	1
File Name	Bin_01514.las
Folder Name	C:\Users\jim_new\Desktop
Point Record	791906
Coordinates	(427819.790, 7662401.560, 383.500)
Class Code	15
Intensity	58
Return No.	1
Number of Returns	1
Classification Flag(s)	None
GPS Time	992639322.427 (Standard Time)
Scan Angle Rank	0
Scan Direction Flag	0
Edge of Flight Line	0
User Data	145
Point Source ID	3940

Show more LAS attributes

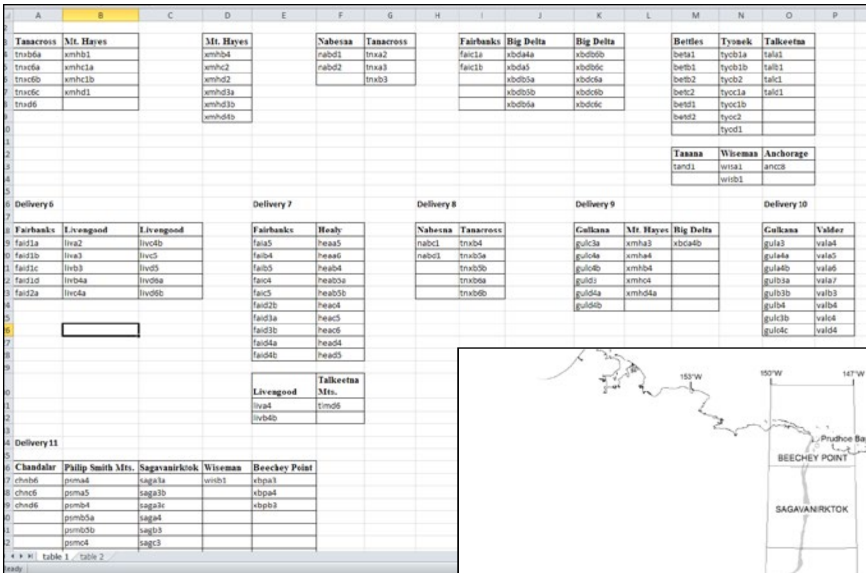
Flash

ArcGIS pop-up window identifying a LAS point in the profile view.

performed an analysis to conclude whether the error was valid, and reprocessed if necessary.

Delivering the goods

DGGS has made this LiDAR data available free to the public at its website (www.dggs.alaska.gov/pubs/id/22722). The data are arranged by U.S. Geological Survey (USGS) quadrangle in the order that delivery areas were received from WSI. A single data delivery from WSI typically covered portions of several 1:250,000-scale quadrangles. Individual delivery reports from WSI were combined into a comprehensive report organized by delivery area. Section 1 of



Tanacross	Mt. Hayes
tnxb6a	xmhb1
tnxc6a	xmhc1a
tnxc6b	xmhc1b
tnxc6c	xmhd1
tnxd6	

Mt. Hayes
xmhb4
xmhc2
xmhd2
xmhd3a
xmhd3b
xmhd4b

Nabesna	Tanacross
nabd1	tnxa2
nabd2	tnxa3
	tnxb3

Fairbanks	Big Delta	Big Delta
faic1a	xbda4a	xbdb6b
faic1b	xbda5	xbdb6c
	xbdb5a	xbdc6a
	xbdb5b	xbdc6b
	xbdb6a	xbdc6c

Bettles	Tyonek	Talkeetna
beta1	tycb1a	tala1
betb1	tycb1b	talb1
betb2	tycb2	talc1
betc2	tycc1a	tald1
betd1	tycc1b	
betd2	tycc2	
	tycd1	

Tanana	Wiseman	Anchorage
tand1	wisa1	ancc8
	wisb1	

Delivery 6

Fairbanks	Livengood	Livengood
faid1a	liva2	livc4b
faid1b	liva3	livc5
faid1c	livb3	livd5
faid1d	livb4a	livd6a
faid2a	livc4a	livd6b

Delivery 7

Fairbanks	Healy
faia5	heaa5
faib4	heaa6
faib5	heab4
faic4	heab5a
faic5	heab5b
faid2b	heac4
faid3a	heac5
faid3b	heac6
faid4a	head4
faid4b	head5

Livengood	Talkeetna Mts.
liva4	timd6
livb4b	

Delivery 8

Nabesna	Tanacross
nabc1	tnxb4
nabd1	tnxb5a
	tnxb5b
	tnxb6a
	tnxb6b

Delivery 9

Gulkana	Mt. Hayes	Big Delta
gulc3a	xmha3	xbda4b
gulc4a	xmha4	
gulc4b	xmhb4	
guld3	xmhc4	
guld4a	xmhd4a	
guld4b		

Delivery 10

Gulkana	Valdez
gula3	vala4
gula4a	vala5
gula4b	vala6
gulb3a	vala7
gulb3b	valb3
gulb4	valb4
gulc3b	valc4
gulc4c	vald4

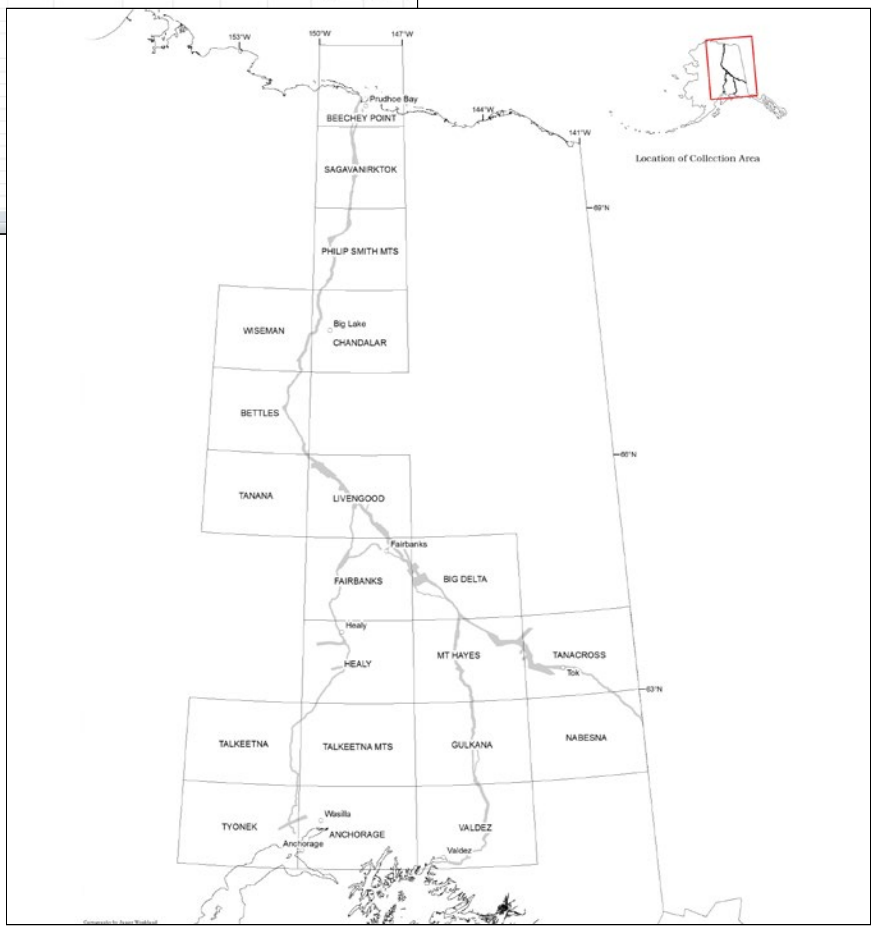
Delivery 11

Chandalar	Philip Smith Mts.	Sagavanirktok	Wiseman	Beechey Point
chnb6	psma4	saga3a	wisb1	xbpa3
chnc6	psma5	saga3b		xbpa4
chnd6	psmb4	saga3c		xbpb3
	psmb5a	saga4		
	psmb5b	sagb3		
	psmc4	sagc3		

table 1 table 2

Left: DGGS delivered LiDAR data for 11 areas and is making this data available to the public through its website.

Bottom: The coverage area for LiDAR data will be available for analysis of permit applications and construction plans for proposed natural gas pipelines in Alaska.



this delivery report contains information about the first delivery received by DGGS; Section 2 contains information about the second delivery received, and so on. A similarly organized quality control report contains information provided by DOGAMI. Both reports are available via the DGGS website.

The DGGS data release includes bare-earth digital elevation models (DEMs), LiDAR intensity images, bare-earth DEM hillshade images, water-body polygons, canopy cover digital surface models (DSMs), normalized DSMs, vegetation DSMs, mean vegetation elevations, highest-hit DSMs, coefficient of variation DSMs, and point-cloud data.

Processing three-dimensional data such as LiDAR requires software that can accurately manage, represent, and analyze its feature information. Alaska DGGS found that ArcGIS provided the platform needed to ensure the data are ready for analyzing proposed pipeline routes by providing a base layer of data for the GIS database that will be used by both the state and federal governments for evaluating permit applications and construction plans.

For more information on LiDAR and 3D mapping with ArcGIS visit esri.com/lidar.

James Weakland, GISP, has been with DGGS since 2011 and serves as a GIS analyst in the Geologic Communications Section, updating legacy geologic mapping techniques including instituting division standards for GIS data, and creating web mapping applications for customers without access to GIS software. Weakland holds a degree in Geography from Excelsior College and is currently studying at The Pennsylvania State University for his Post Baccalaureate Certification in GIS. He can be reached at james.weakland@alaska.gov or (907) 451-5029.