



PAMAP LiDAR Data FAQ (Frequently Asked Questions)

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What is the PAMAP Program Elevation Data Project?

The Program is conducting an unprecedented project to collect and process high-resolution LiDAR elevation data for the entire state. Pennsylvania is one of the first states in the nation to complete collection of this level of elevation data for the entire state. In spring 2006, the PAMAP Program began the project with the capture of LiDAR for 21 counties in the western part of the state, along with Luzerne County. LiDAR was acquired for an additional 21 counties in 2007. Acquisition of data for the remaining 24 counties was completed in the spring of 2008. LiDAR is acquired and processed by a contractor team led by BAE Systems, with Photo Science as acquisition lead, and including Woolpert, LandAir, and Kucera.

What is the definition of LiDAR?

LiDAR, an acronym for **l**ight **d**etection **a**nd **r**anging, is a process used to produce various data products including point-based digital terrain models (DTM), grid-based digital elevation models (DEM), digital surface models (DSM), and contours. In addition to these end-user products, LiDAR processing generates other data resources, including the raw point cloud, processed points, and break lines. These products require more technical knowledge and computing horsepower to use effectively.

What is the organization of the PAMAP tile structure in Pennsylvania?

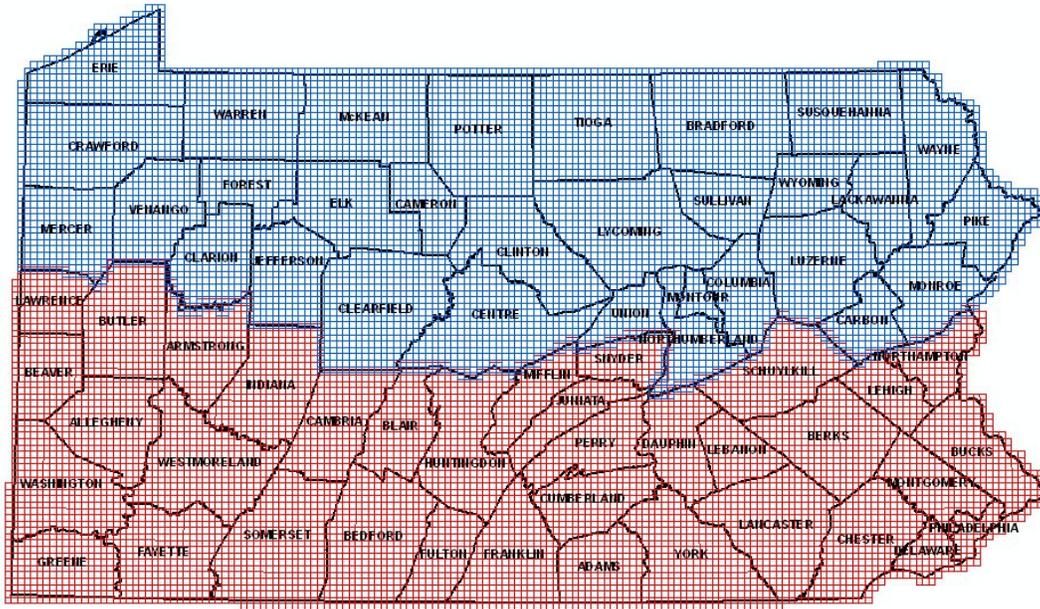
PAMAP data are organized into tiles, which do not have gaps or overlaps. Each tile represents 10,000 feet by 10,000 feet on the ground. The coordinate system for tiles in the northern half of the state (6679 tiles) is Pennsylvania State Plane North (datum: NAD83, units: feet); tiles in the southern half of the state (6736 tiles) are in Pennsylvania State Plane South. A tile name is formed by concatenating the first four digits of the State Plane northing and easting defining the block's northwest corner, the State identifier "PA", and the State Plane zone designator "N" or "S" (e.g. 45001210PAS).

The PAMAP tile structure can be viewed and queried using PASDA's Pennsylvania Imagery Navigator application

(http://maps.pasda.psu.edu/website/Imagery_Viewier/viewer2.asp?tools=Index2), and the tile shapefiles can be downloaded from PASDA

(<http://www.pasda.psu.edu/uci/SearchResults.aspx?originator=DCNR%20PAMAP%20Program>)

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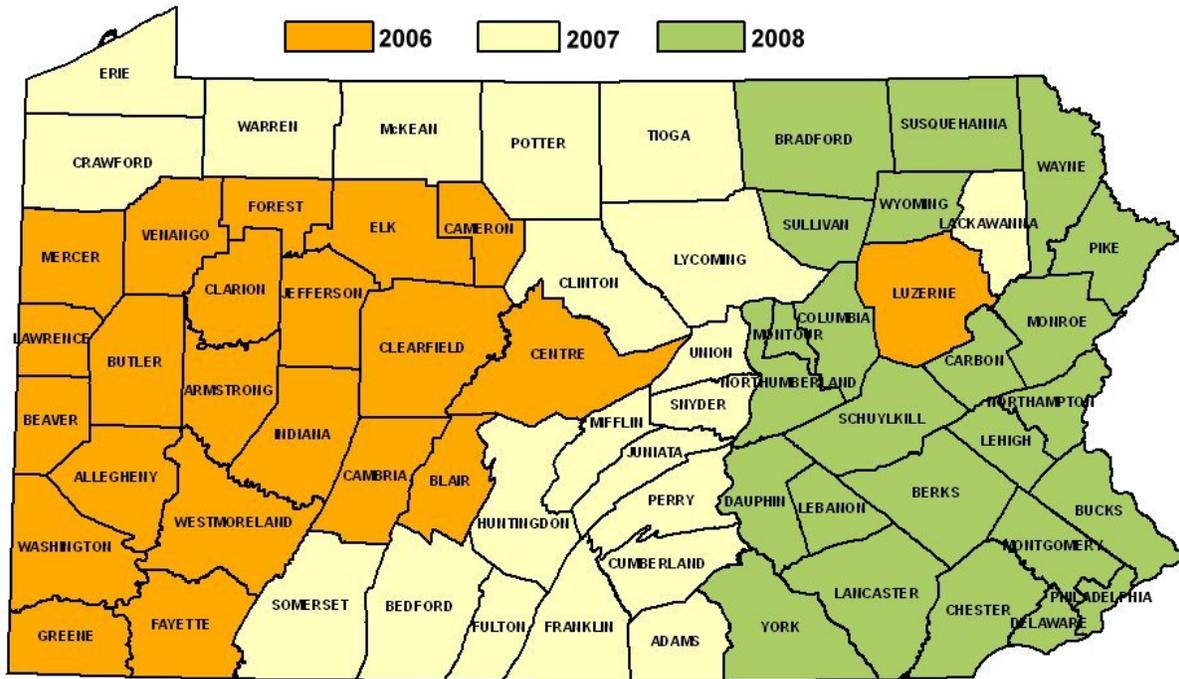


What are the standard projections and datums for the PAMAP LiDAR data?

The State Of Pennsylvania has 2 state plane zones, one for the southern half of the state, and one for the northern half. The PAMAP tile structure is based on the state plane zones, with a set of tiles for the state plane north zone, and a set of tiles for the state plane south zone. All data is provided in the appropriate state plane zone for the tile.

All data is in units of feet, NAD83 horizontal datum, Ellipsoid GRS80, NAVD88 vertical datum, and Geoid03.

What is the current coverage and status of LiDAR data collection effort?



Collected in 2006 (22 counties): Allegheny, Armstrong, Beaver, Blair, Butler, Cambria, Cameron, Centre, Clarion, Clearfield, Elk, Fayette, Forest, Greene, Indiana, Jefferson, Lawrence, Luzerne, Mercer, Venango, Washington, Westmoreland
Status: Complete.

Collected in 2007 (21 counties): Adams, Bedford, Clinton, Crawford, Cumberland, Erie, Franklin, Fulton, Huntingdon, Juniata, Lackawanna, Lycoming, McKean, Mifflin, Perry, Potter, Snyder, Somerset, Tioga, Union, Warren
Status: Complete.

Collected in 2008 (24 counties): Berks, Bradford, Bucks, Carbon, Chester, Columbia, Dauphin, Delaware, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Montour, Northampton, Northumberland, Philadelphia, Pike, Schuylkill, Sullivan, Susquehanna, Wayne, Wyoming, York
Status: Partially complete. Production and QA work is dependent on available funding.

How often will the PAMAP data be updated (reflown)?

The PAMAP Orthoimagery completed an entire cycle of the state from the 2003 through the 2006 data collection years. Starting with the 2007 data collection year, and continuing into Spring 2008, the PAMAP Program adopted a 3-year re-flight cycle. The eastern portion of the state was collected in 2008. Economic conditions have delayed production of the 2008 orthoimagery, and no collection was performed in 2009. The Program will resume the imagery cycle in 2010, pending funding.

The PAMAP elevation data effort is not cyclical in nature, and will conclude a 3-year data LiDAR collection effort in 2008.

What are some of the key uses for PAMAP's LiDAR data?

- Updating state flood insurance rate maps (FEMA)
- Flood risk analysis and flood control projects
- Natural gas exploration, extraction, and transmission
- Wind farm siting
- Other uses include water and flow management, mapping habitat, subsidence evaluation, riparian studies, forestry, emergency response, recreation, transportation planning, telecommunications planning, land development.

What programs can I use to view the PAMAP LiDAR data?

This can vary with the type of PAMAP LiDAR data used. The shapefile contours and breaklines, as well as the GeoTIFF DEMs can readily be utilized in ESRI's ArcGIS. Extensions such as 3D Analyst, Lidar Explorer 2.0 from ProLogic (http://lidar.prologic-inc.com/lidar/MainPages/LE_Main_Index.html), and LP360 from QCoherent Software (<http://www.qcoherent.com/product.htm>), can extend ArcGIS's capabilities with utilizing LAS file data.

A number of free software choices are available. GeoCue (www.geocue.com) offers free downloads of both PointVue LE software, a 3D LiDAR visualization tool which can be used to view LiDAR data in ASPRS LAS Version 1.1 format, and their LAS Reader for ArcGIS 9 extension, which adds LAS Version 1.0 File read capability to the ArcGIS 9 family of products. Merrick & Company (www.merrick.com) offers a free LiDAR viewer called the Mars Viewer (<http://www.merrick.com/servicelines/gis/mars.aspx>). ESRI offers ArcGIS Explorer software (<http://www.esri.com/software/arcgis/explorer/index.html>) that provides a 3D viewing environment where you can combine PAMAP imagery and elevation from the LiDAR DEMs. And the US Forest Service makes available FUSION, a robust LiDAR viewing and analysis software suite (<http://forsys.cfr.washington.edu/fusion/fusionlatest.html>).

Basically, any program that can read a USGS DEM file should work with PAMAP LiDAR DEMs. This would include Bentley Inroads, ERDAS Imagine, ESRI ArcInfo, ESRI ArcView (with the 3D Analyst extension), KeiganSystems MFWorks, and Intergraph MGE Terrain Analyst. CAD programs such as AutoDesk AutoCAD and Bentley MicroStation cannot read DEM files directly, but there are extensions that allow a CAD user to use DEM files with these CAD programs. Examples are Bentley's Inroads and Intergraph MTA.

The following table summarizes LiDAR software choices from several vendors:

Company	Product
Applied Imagery	Quick Terrain Modeler
Merrick	MARS Explorer Pro MARS Viewer (free)
GeoCue	GeoCue, LASEQC, Lidar Cue Pack, DEM Cue Pack, PointVue LE (free), Arc LASReader (free)
PCI Geomatics	Lidar Engine
Prologic	Lidar Explorer
QCoherent	LP360
Watershed Concepts	WISE Terrain Analyst
VLS	Lidar Analyst

How do I feedback any questions, concerns, other comments to the PAMAP Program?

Information about the PAMAP Program can be found at www.dcnr.state.pa.us/topogeo/pamap. Program staff can be contacted at 717-702-2017.

How do I find information about data issues or corrections?

Information on data issues for PAMAP orthoimagery can be found [here](#). Information on data issues for PAMAP LiDAR and elevation products can be found [here](#).

What elevation products are being produced by the PAMAP Program?

There are four products being produced for each and every 10,000 ft by 10,000 ft tile in the state of Pennsylvania after LiDAR data collection: a filtered and classified LiDAR point cloud data set in LAS file format, 2 ft contour data in 3D shapefile format, break lines in 3D shapefile format, and a 3.2 foot (1 meter) resolution bare earth DEM in GeoTIFF format.

Contours, break lines, and DEM's are available through the PASDA state data clearinghouse. LAS (point cloud) data is available, by request, from the PA State Data Center. Products are also available through USGS.

What is a more detailed description of the PAMAP LiDAR products?

LAS file

The LAS file format is a public file format for the interchange of LIDAR data between vendors and customers. It is a binary file format that maintains information specific to the LIDAR nature of the data while not being overly complex. The American Society for Photogrammetry & Remote Sensing (ASPRS) has endorsed and strongly supports the use the .LAS standard.

The PAMAP Program's tiled LAS files contain filtered and classified LiDAR point cloud data. All points are included with noise, anomalies, and sidelap removed. Each LAS file contains the following fields for each point: Class, Northing, Easting, Elevation, Intensity, Flight Line #, Echo Number, and Echo Type.

2 ft contour shapefile

Tiled 3D shapefiles of two-foot contours with X, Y, and Z (elevation) coordinates. Each contour is attributed with its elevation value, whether it is an intermediate (2 ft interval) or index (10 ft interval) contour, and whether it is a depression contour.

Break line shapefile

Tiled 3D shapefiles of breaklines. Breaklines are interpreted from the PAMAP orthophotos and the LiDAR data is used to provide elevation (z-values) to each line. The breaklines are used in the creation of the DEM and contours only; they are not designed or created for many of the applications that typically use breakline data. Each breakline is attributed for feature type (e.g. – edge of road). The feature types are documented in the metadata.

DEM – Digital Elevation Model

A 3.2 ft (1-meter equivalent) uniformly-spaced, gridded, digital elevation model in raster GeoTIFF format. Each pixel in the DEM has an interpolated elevation value.

What are the LAS Class Field values used for the PAMAP data?

The LAS Class fields used for PAMAP are:

- Class 1 (Default) - These are the points that are a mixture of the remaining points after the ground classification. These would contain bridges, overpasses, buildings, cars, parts of vegetation, etc.
- Class 2 (Ground) - These are points on the bare earth surface. They are from the automated processing, as well as the manual surface review.
- Class 8 (Model Key) - These are the educated, thinned points to represent the final bare earth surface. This is from automated processing. These are the points that are used to generate the final contours.
- Class 9 (Water) - These are points inside of hydrographic features, as collected by photogrammetric methods. These are from automated processing, as well as the manual surface review.
- Class 12 (Non-Ground) - These are points that are identified as first of many returns or intermediate of many returns from the LIDAR pulse. These are points

that are most likely vegetation returns or points identified to be not on the ground surface.

- Class 15 (Road Edges) - These are the points that fall within +/- 1.5' of road break lines.

What are file sizes expected for each type of LiDAR data file?

- Each DEM GeoTIFF file is approximately 38 MB in size.
- The contour shapefile size will vary by tile, but averages approximately 38 MB per tile.
- The breakline shapefile size will vary by tile, but will usually be less than 1 MB per tile.
- The LAS point cloud data size will vary by tile, but averages approximately 120 MB per tile.

What determines the data specifications for the LiDAR data?

The LiDAR data is acquired to produce an accurate and high-resolution bare earth model of Pennsylvania. One of the primary uses of the bare earth model is to support floodplain mapping and flood control projects. The LiDAR data is being collected and processed to generally meet specifications called for in FEMA's Guidelines and Specifications for Flood Hazard Mapping Partners. This set of guidelines can be accessed and reviewed at FEMA's website: 'http://www.fema.gov/plan/prevent/fhm/gs_main.shtm'.

The Technical Scope of Work for the 2006 LiDAR and imagery project is available [here](#). This scope of work also applies for the 2007 and 2008 project years.

Where can I get LiDAR data?

PAMAP LiDAR and derived products can be acquired from the following organizations. Data may be available from other sources as well.

DEMs, contours and breaklines are provided through FTP and map services at the Pennsylvania Spatial Data Access Clearinghouse ([PASDA](#)).

The LAS point cloud data as well as contours and DEMs are available for bulk and/or offline acquisition from the Pennsylvania State Data Center at http://cgis.hbg.psu.edu/pdf/PAMAP_Bulk_Order.pdf.

The LAS point cloud data is also available from the USGS Center for Lidar Information Coordination and Knowledge ([CLICK](#)).

Is there any way to batch download LiDAR data?

Similar to PAMAP imagery available through PASDA, data is available both through a FTP connection, and through the PASDA Imagery Viewer & Download Tool. The FTP connection allows the user to select several files for download at one time. The Imagery Viewer & Download Tool allow for one download at a time.

There is planning for possible enhancement to the download process through a tool used for determining what PAMAP tiles cover a user-defined geographic area.

How can I determine what tiles I need for a given area in Pennsylvania?

The PAMAP Tile Reference Access program available from PASDA and DCNR provides lists of PAMAP tiles for selected geographies such as municipalities, State Forests, and USGS quadrangle maps.

The Map Index PDF available from PASDA and DCNR shows the PAMAP tile index overlain on each of the 1:100,000 scale USGS maps.

The PASDA Imagery Viewer & Download Tool

(http://maps.pasda.psu.edu/website/Imagery_Viewer/viewer.asp?tools=PAMAP) allows the user to turn on different index layers (PAMAP, USGS quad and quarterquad), zoom directly to a selected county, or type in an address with zip code, or USGS quad name as a short cut. The tiled data can then be downloaded from the same application.

Another application to determine what tiles you need is the PAMAP Viewer (www.pamap.info). This web viewer allows you to search by GNIS (place name), county/municipality name, zip code, address, or coordinate.

If I need a large number of tiled DEMs or contours, how I can get a DVD or hard drive with the data that I need?

The PA State Data Center can provide large amounts of LiDAR data (LAS, DEMs, contours, or breaklines) or imagery on DVD or portable hard drive. Information for bulk and/or offline acquisition from the Pennsylvania State Data Center can be found at http://cgis.hbg.psu.edu/pdf/PAMAP_Bulk_Order.pdf.

How can I get the LAS data?

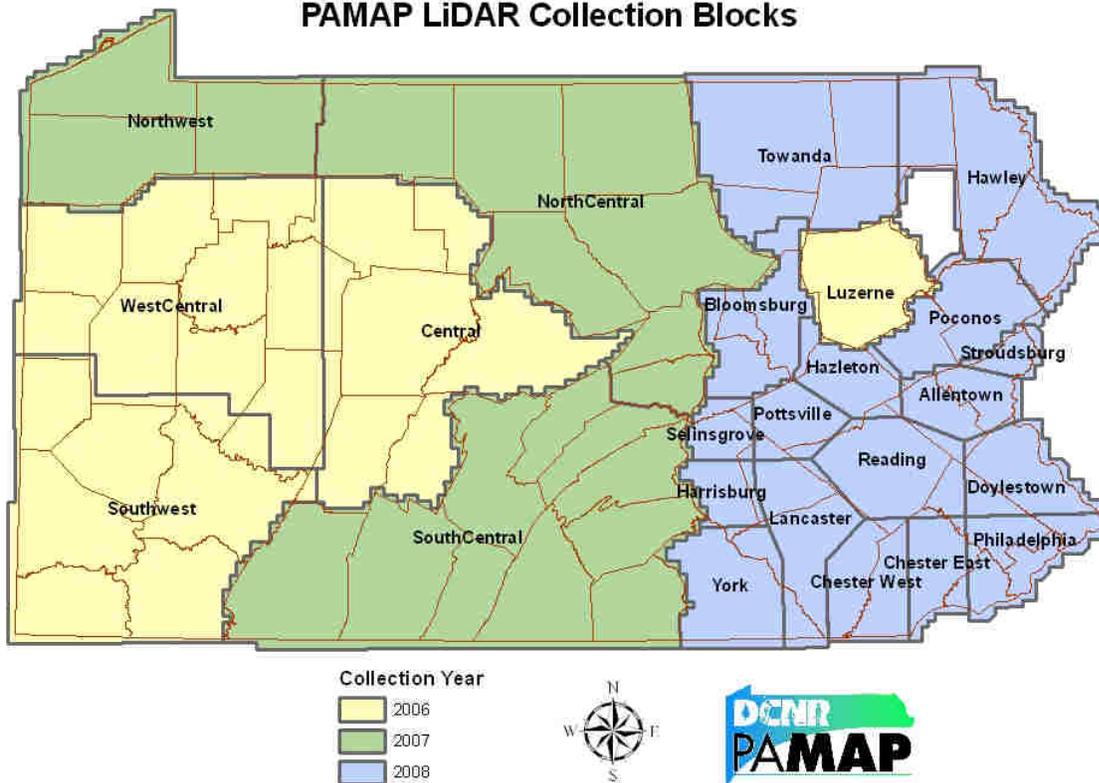
The PA State Data Center can provide the LiDAR LAS data on DVD or portable hard drive. Information can be found at http://cgis.hbg.psu.edu/pdf/PAMAP_Bulk_Order.pdf.

The LAS point cloud data is also available from the USGS Center for Lidar Information Coordination and Knowledge ([CLICK](#)).

What are the LiDAR collection areas?

Much of the information supporting the LiDAR data, such as metadata and quality assessment reports, is provided by collection block. These blocks are organized by year and geographic area, and are shown below.

PAMAP LiDAR Collection Blocks



What is the accuracy of PAMAP LiDAR data?

The LiDAR data has a vertical (z) accuracy specification of 18.5 cm in open areas, and 37 cm in forested areas.

The PAMAP imagery has a horizontal accuracy specification of 5 feet or less.

LiDAR vertical accuracy specifications:

NSSDA/FEMA, RMSEz	0.61 ft, bare earth & urban
NSSDA/FEMA, Accuracyz	1.19 ft at 95% confidence level
NDEP/ASPRS, Fundamental Vertical Accuracy	1.19 ft at 95% confidence level
NDEP/ASPRS, Consolidated Vertical Accuracy	2.38 ft at 95% confidence level

Can I get LiDAR accuracy reports?

The LiDAR data was tested using industry standards to ensure that vertical accuracy specifications were achieved. The reports are available below, by collection area.

Vertical Accuracy Assessment 2006 Luzerne
 Vertical Accuracy Assessment 2006 Southwest

Etc.

What quality assessments were performed on the elevation products?

The PAMAP Program contracted with the team of Dewberry, URS Corporation, and Herbert Rowland Grubic (HRG), Inc. to perform an independent third-party quality assessment of PAMAP elevation products. The purpose of the assessment was to verify that these products pass all acceptance criteria defined in the original acquisition contracts.

- **Horizontal and vertical accuracy check of LiDAR:** HRG, Inc. conducted a field survey of checkpoints used by Dewberry to perform quantitative accuracy assessment following American Society for Photogrammetry and Remote Sensing (ASPRS) Guidelines and 1998 NSSDA reporting standards for LiDAR data and derived products (i.e. contours and raster DEMs). Data were assessed within the following cover types: (1) bare earth and low grass; (2) high grass, weeds, and crops; (3) brush lands and low trees; (4) forest; and, (5) urban areas.
- **Qualitative review of LiDAR products:** Dewberry inspected every PAMAP tile of LiDAR and derived data for anomalies and artifacts such as data voids, discontinuities between adjacent flight lines or mission areas, over smoothing, incomplete removal of LiDAR points on water bodies, and incomplete removal of buildings, vegetation, bridges, etc. from the bare earth surface.

The PAMAP QAQC Work Plan for quality assurance and testing of LiDAR and imagery products is available [here](#).

Reports were provided for testing of the LAS point cloud data. These reports are available below, by collection area.

QAQC Report 2006 Luzerne
QAQC Report 2006 Southwest
Etc.

Where can I get metadata?

The LiDAR metadata is provided by collection area in a ZIP file [here](#). Metadata for the DEMs, contours, and breaklines is provided with those data files when downloaded or ordered offline.

Why are there more/less ground class points in a given area?

Many factors influence the density of ground points in an area. Dense vegetation, aerosols, buildings, and smoke prevent lidar pulses from reaching the ground. Dark surfaces such as fresh asphalt reflect poorly and may prevent returns to the sensor. The variable reflectivity and refractivity of standing water often results in unreliable returns. Conversely, areas may have better than average point density due to decreases in plane speed and/or overlap between flight lines. Overall, PAMAP lidar data is designed to provide an *average* point spacing of 1.4 meters.

Additional variation could have been introduced by operational characteristics associated with Leica's Auto Gain Control hardware within the LiDAR system controllers. The Auto Gain continually monitors the trend of returned pulse intensity and applies a bit of correction to the laser energy output, ramping up or down, on subsequent pulses to try to compensate for the outliers of highly reflective/absorptive surfaces. The more obvious examples of these unexpected intensity changes are usually associated with the occurrence of water or fresh paving within a swath. Moreover, haze levels in the atmosphere also impact the ability of the Auto Gain Control to assure even intensity values between different lifts on different days.

Efforts to balance/adjust intensity values across flight lines to normalize intensity data were not included in project specifications.

What data is used to produce the contours and digital elevation models (DEMs)?

The bare earth points were intelligently thinned to produce what are called model key points (Class 2 in the LAS files). This process involves an interpolation, thinning points where they do not add to the bare earth model. In this case, more points are thinned where terrain is flat or uniform in nature and less thinning occurs where terrain is more uneven. The thinning is designed to reduce the number of points processed per tile from millions to hundreds of thousands. The resulting model key points are used in conjunction with the breaklines to construct a triangulated irregular network (TIN), from which the contours and digital elevation model (DEM) data is derived. The contour generation is performed using line smoothing parameters.

Why do contours look so jagged? Why do they self-intersect?

The PAMAP Program chose the intelligent thinning interpolation numbers and line smoothing parameters to strike a balance between data-centric contours (very jagged but also very representative of the modeled ground surface) and cartographic-centric contours (smoothed to produce a more pleasing map product). The Program chose a little more on the data-centric side than the cartographic-centric side as PAMAP is first and foremost a data product. We think we chose appropriately as we have heard from people who feel the contours are not smooth enough (a little more people feel this way) and from others who feel we smoothed them too much (a little less people feel this way).

One of the other attributes of PAMAP is that we do make available the data that people can use to generate their own contours, should they wish to. Contours can be generated using the DEM data, or from the model key points in the point cloud data, or from the full bare earth point set.

Why do contours go through buildings?

The contours were not masked by building footprints, as is typically done for published maps. Users may do such masking with their own data.

How were breaklines compiled and used?

Breaklines were collected photogrammetrically along most road edges, bridges, overpasses, and shorelines of open water bodies and higher-order streams for uses given below.

Breakline feature	Purpose
road edge	maintain alignment of roads across adjacent DTM blocks; improve the appearance of contours across roads and curbs
bridge/overpass	remove bridges and overpasses from bare earth DTM
shoreline/waterbody	discount returns off water (which are highly susceptible to error); insure streams flow downhill; insure flat water surfaces on open water; maintain alignment of hydrography across adjacent DTM blocks

Additional information about the purpose, collection, and use of the breaklines is provided [here](#).

Why don't some stream channels continue under roads in the DEMs?

The DEMs are not designed specifically for large map scale hydrologic modeling. Features such as culverts are not factored into the creation of the DEM.