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# PAMAP LiDAR PROGRAM



Department of Conservation & Natural Resources

## LiDAR Acquisition Report

For

**Program Years 2006, 2007 & 2008**

Produced By:



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Lexington, KY 40503

Under Contract to:

**BAE SYSTEMS**

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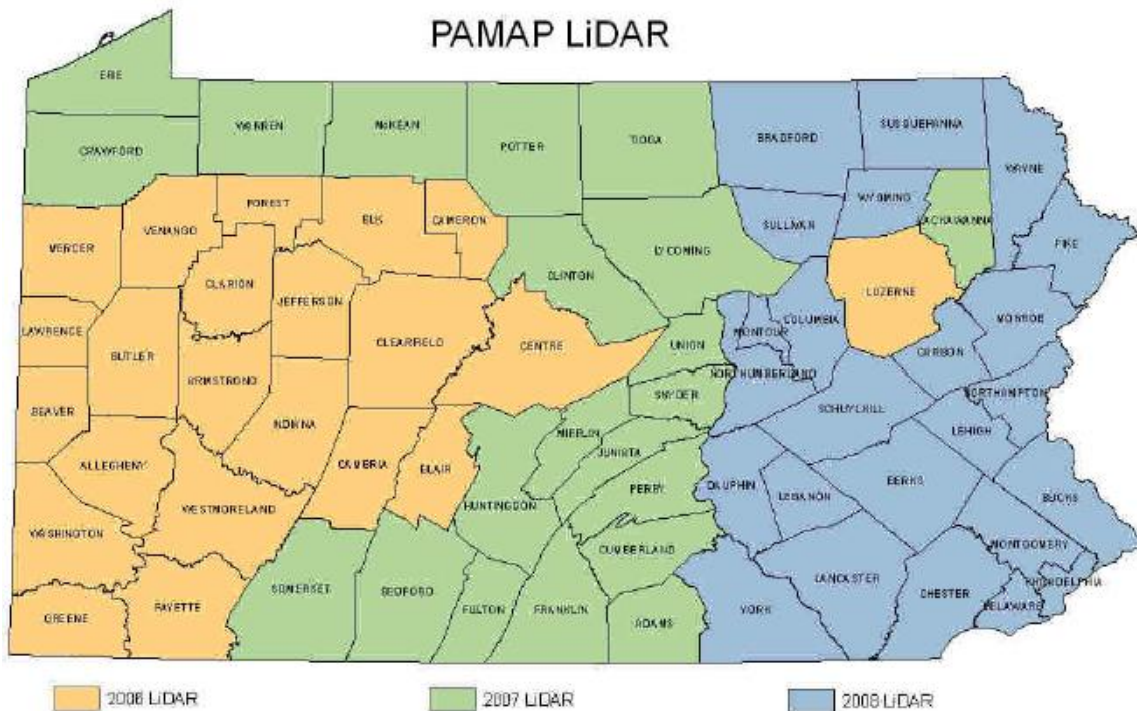
# **SECTION 1**

## **OVERVIEW**

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## SECTION 1: OVERVIEW

The PAMAP Program conducted 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 winter/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 the winter/spring of 2007. Acquisition of LiDAR in the spring of 2008 covered 25 additional counties in the eastern third of Pennsylvania. The collection progress over the three year period is shown below.



Working as a subcontractor to the PAMAP Prime Consultant, BAE Systems, Mount Laurel, NJ, Photo Science has been the lead PAMAP data acquisition firm supporting both the imagery and LiDAR program since 2005.

The LiDAR data acquired by Photo Science in support of the Program is primarily being used 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 collected and processed to generally meet specifications called for in FEMA's Guidelines and Specifications for Flood Hazard Mapping Partners. The data is collected with a 1.4-meter average point spacing (2-meter maximum) with a bare earth surface vertical accuracy of 18.5-centimeters RMSE. Data is in tile form using the PAMAP 10,000-foot tile index. All products are in the public domain.

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The data products include:

- LiDAR Point Cloud – the LiDAR points are distributed in the binary LAS format. Each point is attributed for intensity, classification, etc. according to the LAS standard and PAMAP specifications.
- Digital Elevation Model – a 3.2-foot pixel (1-meter equivalent) raster GeoTIFF Digital Elevation Model (DEM).
- Contours – a 3D shape file of 2-foot contours is provided for each tile.
- Break lines – a 3D shape file of break lines is provided for each tile.

### **Photo Science's Role**

Coordinating other leading LiDAR data collection firms, Photo Science has provided airborne topographic LiDAR collection and post processing services to BAE Systems in support of PAMAP Program years in 2006, 2007 and 2008. This LiDAR data has been used to develop the terrain surface and derivative datasets identified above as well to support the orthophoto rectification of PAMAP imagery collected in each of the same years.

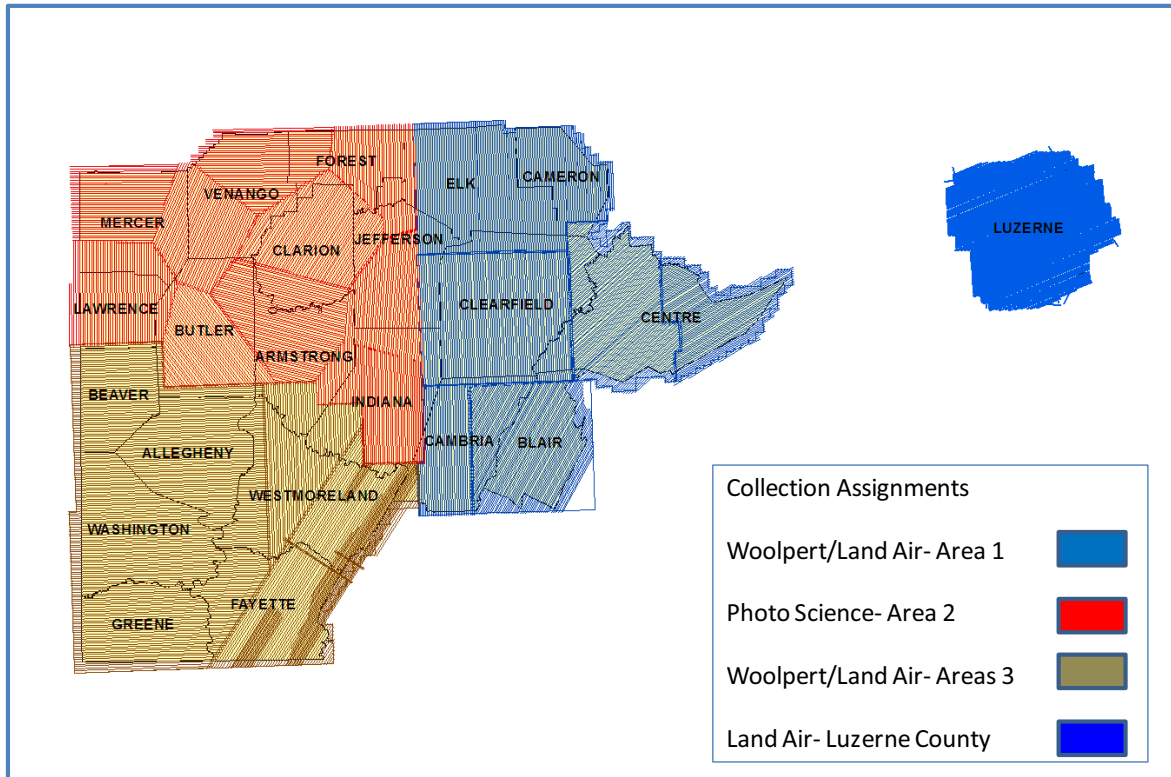
The following LiDAR providers directly supported the acquisition and processing activities in each of the three program years. Collection assignments are shown for each year in the provided diagrams.

### **PAMAP 2006**

- Photo Science, Lexington, KY
- Woolpert Inc., Dayton, OH - sub consultant to Photo Science
- Land Air, Peach Tree, GA (now part of Northrop Grumman/3001) – sub consultant to both Photo Science for the Luzerne County Area and Woolpert

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## PAMAP 2006 LIDAR Collection Area

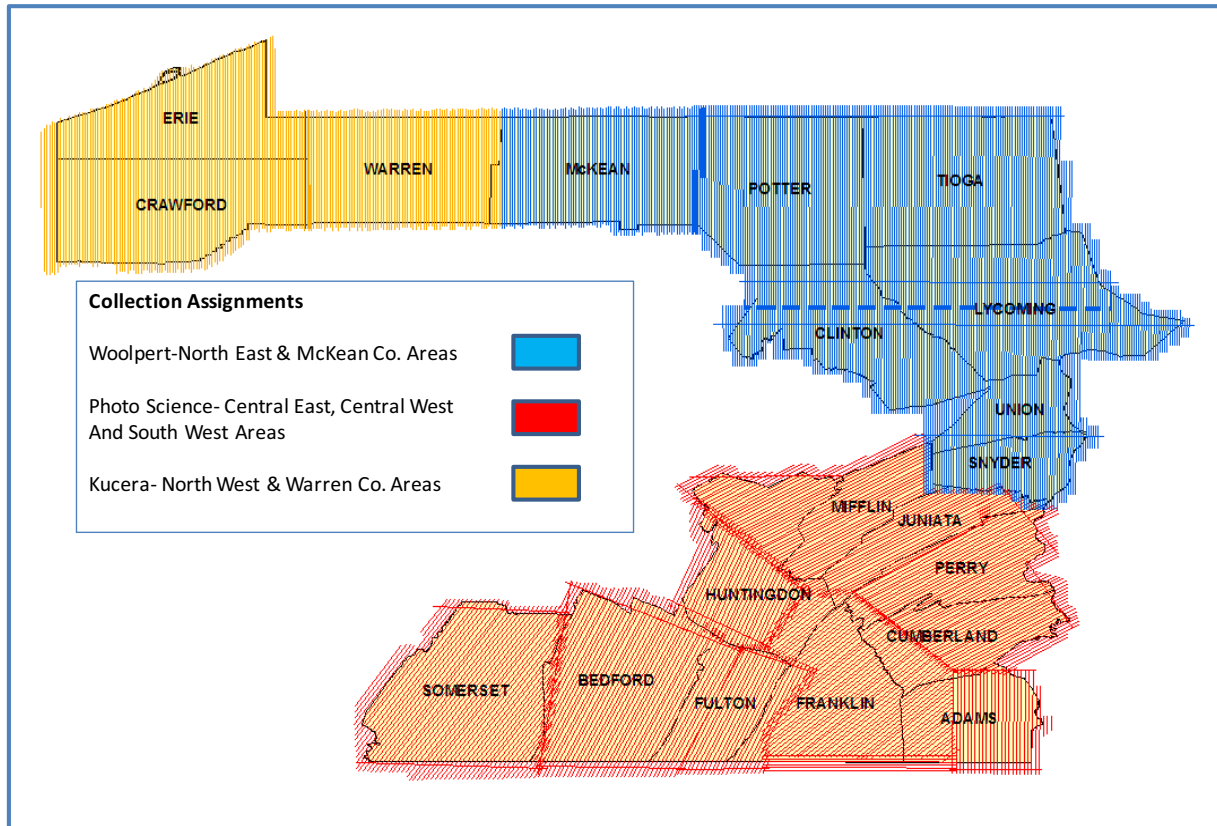


### PAMAP 2007

- Photo Science, Lexington, KY
- Woolpert Inc., Dayton, OH - sub consultant to Photo Science
- Kucera International, Willoughby, OH – sub consultant to Photo Science

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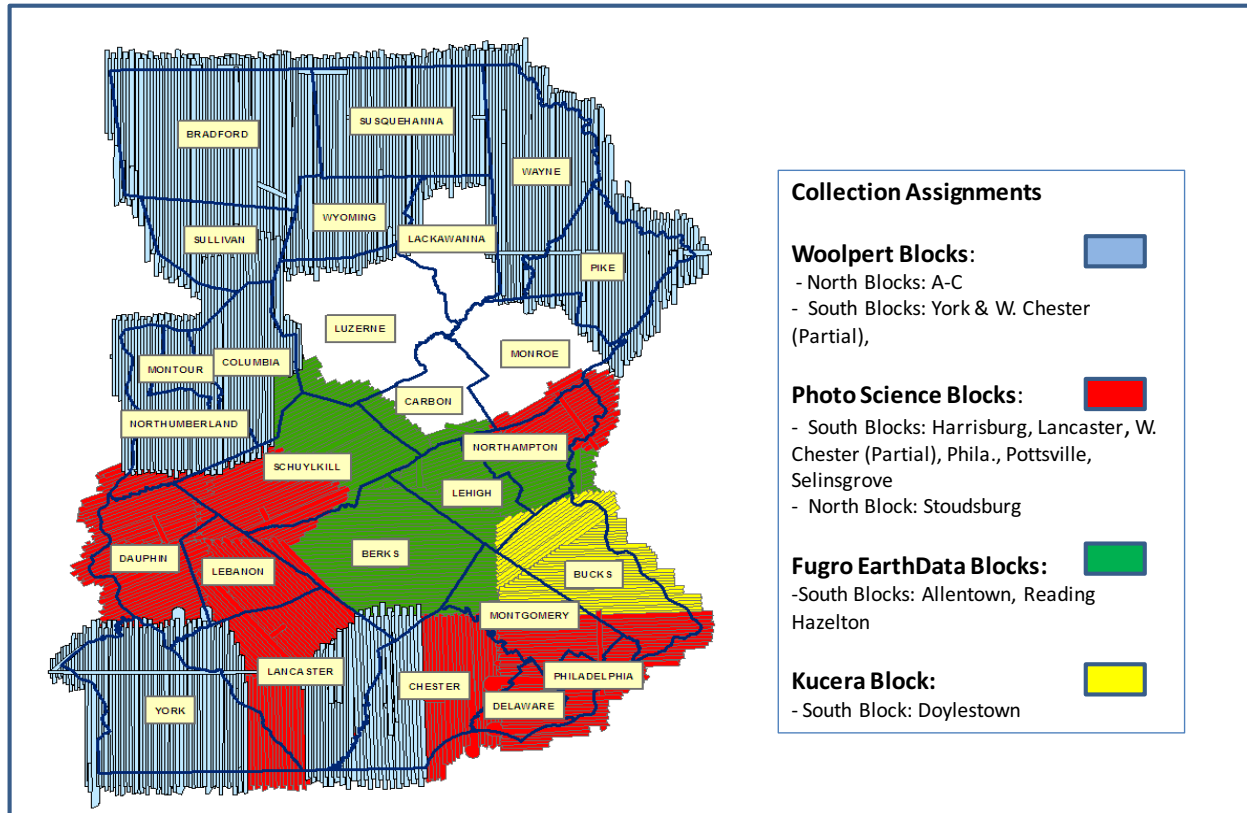
## PAMAP 2007 LIDAR Collection Area



### PAMAP 2008

- Photo Science, Lexington, KY
- Woolpert Inc., Dayton, OH - sub consultant to Photo Science
- Kucera International, Willoughby, OH – sub consultant to Photo Science
- Fugro EarthData, Fredrick, MD- sub consultant to Photo Science

## PAMAP 2008 LIDAR Collection Area



### Report Contents

This report contains a review of the project requirements and detailed information for LiDAR data acquisition, processing and quality control performed by Photo Science (and its sub consultants) including:

- Documentation specifying altitude, airspeed, scan angle, scan rate, LiDAR pulse rates, and other flight and equipment information deemed appropriate
- A LiDAR Data Acquisition Report
- A LiDAR Data Processing Report
- A System Calibration Report (Sample)
- Flight & Base Station Logs



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Please note that Photo Science primary LiDAR sub consultant, Woolpert Inc., submitted separate (but similar) reports directly to BAE Systems for LiDAR acquisition and post processing work assignments covering each of the three program years (2006-2008).

## **Project Requirements**

General standards for the LiDAR mission include:

- High density LiDAR data acquisition within the project limits at a sufficient altitude and density to support digital terrain model (DTM) development for 2-foot contours with a vertical accuracy of 18.5 cm RMSE for the bare earth surface & a vertical accuracy in vegetated areas of 37 cm RMSE.
- Avoidance of inclement weather for all flight missions as well as ground conditions that do not allow adequate and/or accurate laser returns (Snow, extremely high water etc.).
- Planned flight paths which provide satisfactory coverage of the study area, including both parallel and enough cross flight lines to allow for proper quality control.
- Documentation of flight mission date, time, flight altitude, airspeed, scan angle, scan rate, laser pulse rates and other information deemed pertinent.

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## **SECTION 2**

# **LIDAR DATA ACQUISITION**

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## SECTION 2: LIDAR DATA ACQUISITION

This section provides an overview of the general LiDAR acquisition methodology employed by Photo Science and its subcontractors on the LiDAR portion of the PAMAP Program.

The following table provides the planned LiDAR system collection parameters that were utilized by Photo Science and its sub contractors for the PAMAP Project across all three project years. Actual parameter values fluctuate depending on sensor/aircraft configuration, terrain, ground conditions/cover, weather conditions and air space access. Please refer to the flight logs in Appendix A for actual parameters for each mission. Woolpert's parameters are detailed in their LiDAR Acquisition Reports that were separately delivered to BAE Systems for each of the three project years.

### 2006 Project

LiDAR Collection Parameter	Photo Science	Woolpert*	Land Air
Flying Altitude, Feet (AMSL)	6000	5500	5400
Airspeed (Knots)	128	130	130
Scan Angle, Degrees (FOV)	42	42	42
Scan Rate (Hz)	29	26	26
Pulse Rate (Hz)	54	41	41
Pulse Mode (Returns)	4	2/4	4
Ave Point Spacing (meters <sup>2</sup> )	1.5	1.4	1.4

\* Two different ALS sensor models utilized

### 2007 Project

LiDAR Collection Parameter	Photo Science	Woolpert*	Kucera
Flying Altitude, Feet (AMSL)	6000	5500/7000	6000
Airspeed (Knots)	128	130	140
Scan Angle, Degrees (FOV)	42	42	44
Scan Rate (Hz)	31	26/27	31
Pulse Rate (Hz)	57	41/54	56
Pulse Mode (Returns)	4	2/4	4
Ave Point Spacing (meters <sup>2</sup> )	1.5	1.4	1.3

\* Two different ALS sensor models utilized

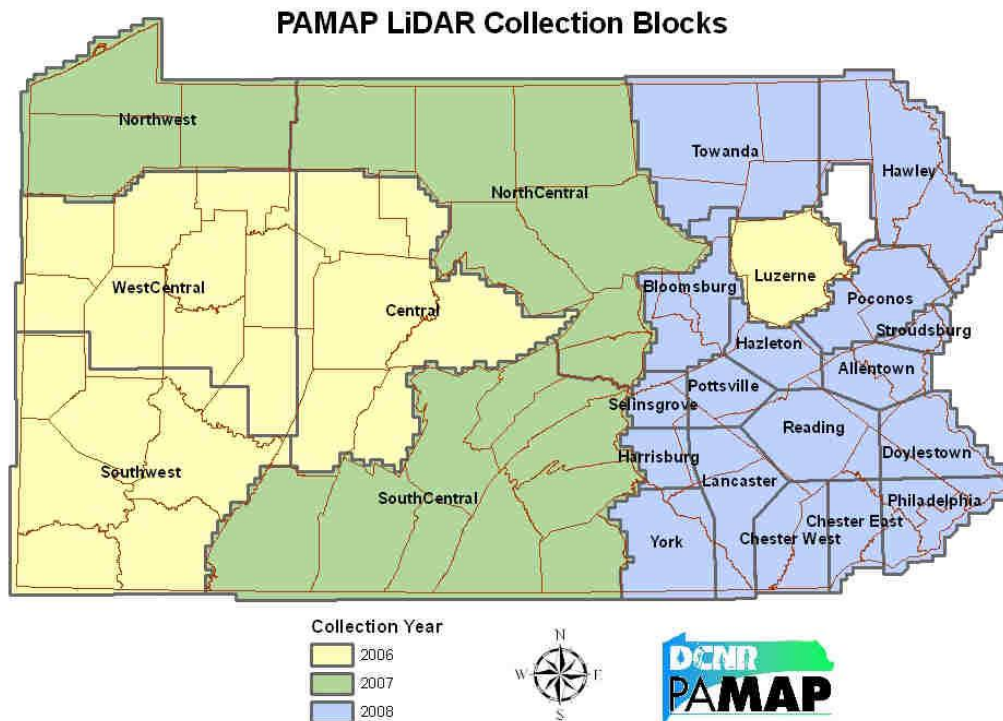
## 2008 Project

LiDAR Collection Parameter	Photo Science	Woolpert*	Kucera	Fugro Earthdata
Flying Altitude, Feet (AMSL)	7500	5500/7000	6000	8000
Airspeed (Knots)	120	130/125	130	160
Scan Angle, Degrees (FOV)	42	40/42	45	42
Scan Rate (Hz)	26	25/27	28	35
Pulse Rate (Hz)	53	41/53	52	93
Pulse Mode (Returns)	4	2/3/4	4	4
Ave Point Spacing (meters^2)	1.4	1.4	1.4	1.3

\* Two different ALS sensor models utilized

## LiDAR Overview

Photo Science conducted airborne topographic LiDAR surveys to support the production of a DEM for orthophoto rectification as well as 2-foot contour intervals. The LiDAR data was acquired for the entire State of Pennsylvania over a three year period (2006-2008) based on the collection blocks shown below.



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## **LiDAR Mission**

All LiDAR acquisition utilized Leica LiDAR ALS Systems with maximum pulse rates ranging from 40kHz to 150kHz. Leica Aeroplans detailing each LiDAR Provider's proposed collection parameters were previously submitted to BAE Systems for each project year along with flight line shape files and base stationing as part of the preflight planning deliverables. Additionally, specific details about the ALS systems are included in Section 5 of this report.

The airborne GPS (ABGPS) base stations supporting the LiDAR acquisition consisted of the Pennsylvania CORS system as well as supplemental bases set up by the flight and survey crews at various airports and control points in Pennsylvania. Dual Frequency data was logged continuously for the duration of each LiDAR flight mission at a one-second sampling rate or better. LiDAR collection was planned to try to remain within approximately 25 miles of base stations wherever possible.

The 2006-2008 flight line plans (shown below) for LiDAR acquisition consisted of parallel flights in north-south directions or as dictated by the terrain for maximum efficiency across the project site. The following is a breakdown of the number of approximate flight lines and flight line miles per project year.

### **PAMAP 2006**

#### **Areas 1, 2 & 3**

- 1,132 flight lines
- 32,956 flight line miles

#### **Luzerne County**

- 84 flight lines
- 2,064 flight line miles

### **PAMAP 2007- All Areas**

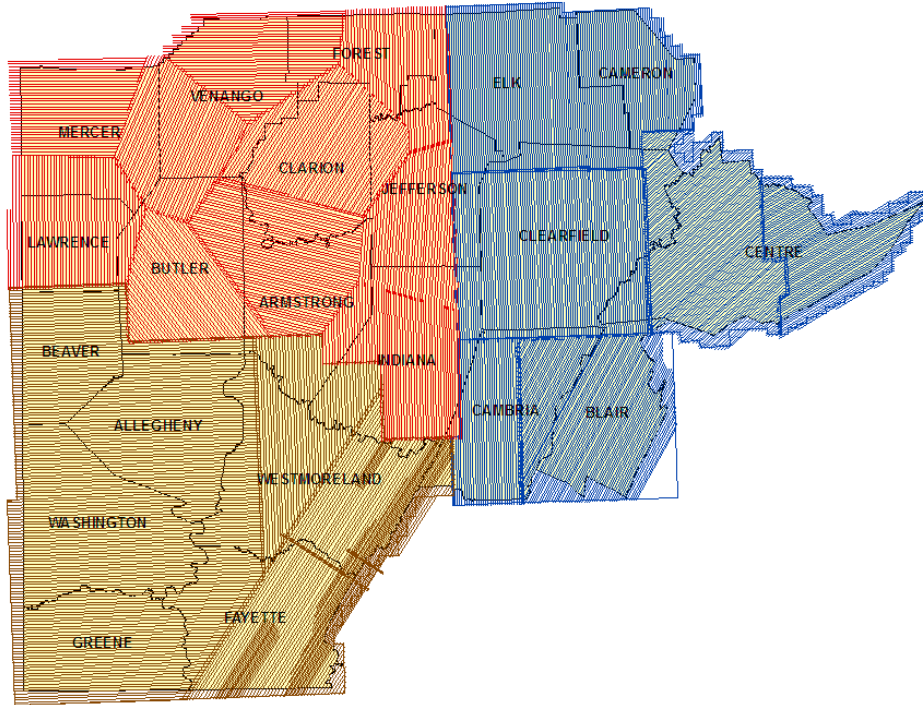
- 1,275 flight lines
- 34,216 flight line miles

### **PAMAP 2008- All Areas**

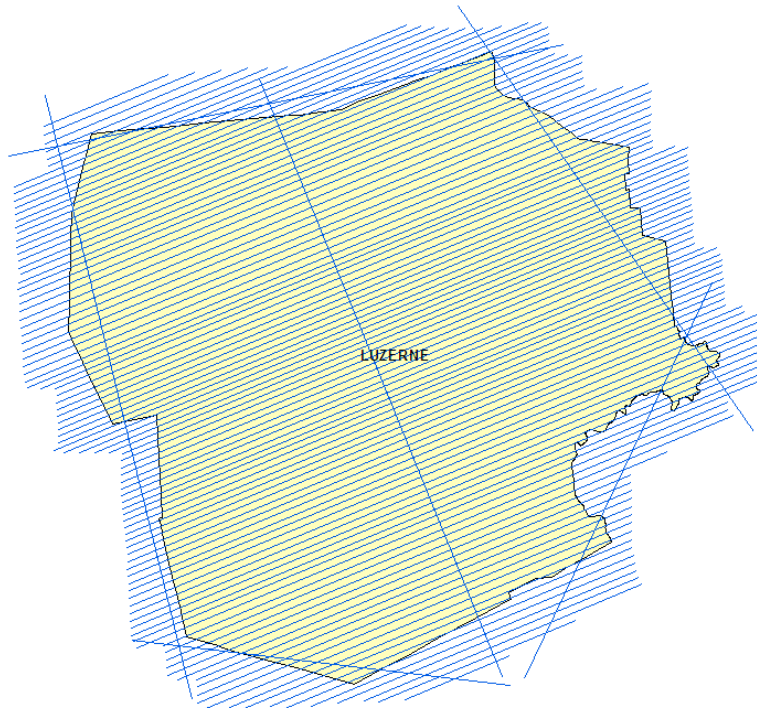
- 900 flight lines
- 22,303 flight line miles

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## 2006 Flight Plan

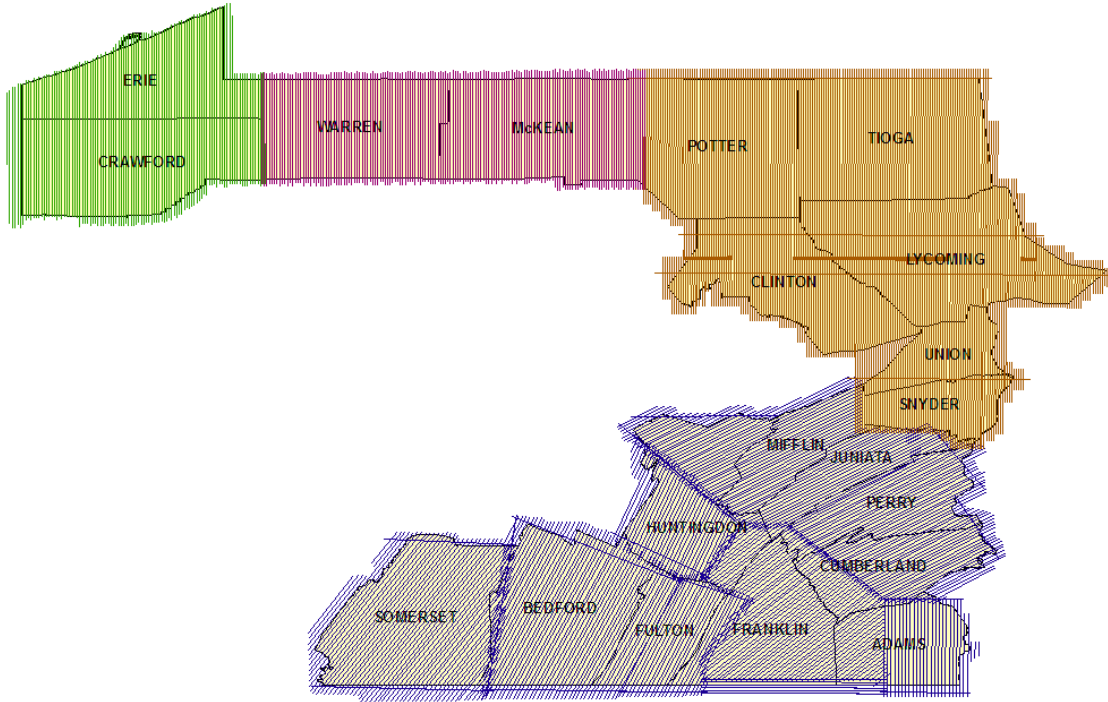


## Luzerne County-2006

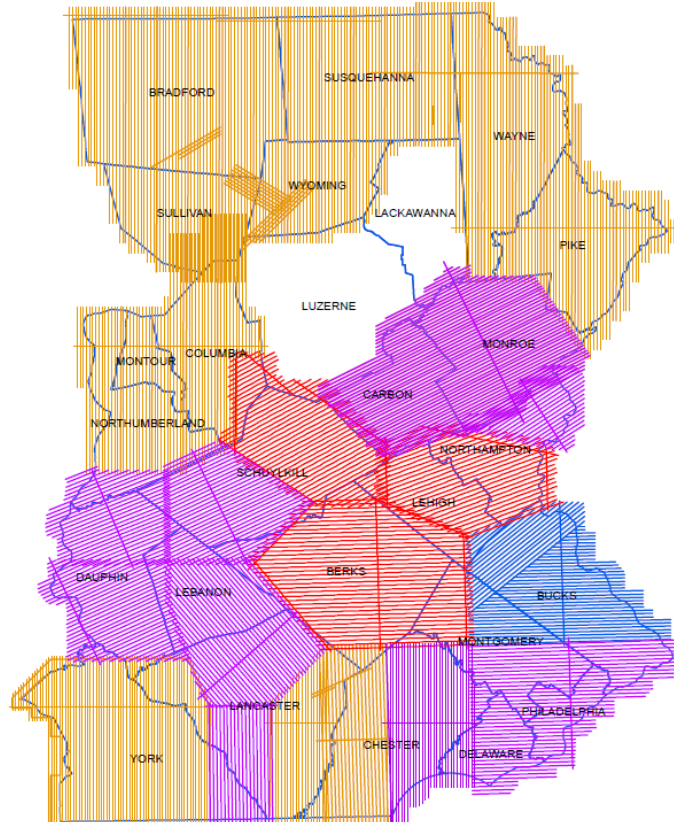


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## 2007 Flight Plan



## 2008 Flight Plan



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Data collected during the day (or night) was quality checked in the field by the collection crews to assure that there are no gaps or issues with data integrity. This is accomplished in order to develop a final data set before the equipment and crews leave the area. Generally we are able to catch 100% of the anomalies, but occasionally there may be issues that surface in the final processing that do require a return to an area. Photo Science had no data void issues for the 2006 or the 2008 collection areas. However, 2006 reflights were needed due to data voids in the Woolpert 2006 collection area. These were accomplished in the fall/winter of 2006/2007. Additionally, Photo Science did have some minor data anomalies and data void issues in 2007 that were picked up early during the 2008 season. All initial and re-collected LiDAR data was processed to the degree necessary to ensure that complete datasets were delivered in each of the three project years.

## **LiDAR Statistical Data**

The general LiDAR acquisition parameters utilized in the PAMAP program are shown below in the sample Aeroplan. . Leica Aeroplans detailing each LiDAR Provider's proposed collection parameters were previously submitted to BAE Systems for each project year along with flight line shape files as part of the preflight planning deliverables.

Specific to Photo Science, two systems were utilized; one an upgraded 150 MHz system and the other a 50 kHz System upgraded to 150 kHz Collection parameters for the two required different settings to collect the data to the PAMAP specification required. Photo Science and its sub contractors used these same general parameters for collection for all three years of collection (2006, 2007, and 2008). This helped assure that all data was collected to meet the final Specification.