Merging LiDAR Data with Softcopy Photogrammetry Data

Cindy McCallum
WisDOT\Bureau of Technical Services
Surveying & Mapping Section Photogrammetry Unit
Overview

• Terms and processes
• Why use data from LiDAR and Photogrammetry?
• Projects using data from LiDAR and Photogrammetry (and lessons learned)
LiDAR (Light Detection and Ranging)

- A LiDAR sensor sends out pulses which hit objects and return to the sensor
- A dataset of returns are collectively called a point cloud
- LiDAR sensors can be mounted on a tripod, in the belly of an airplane, helicopter or UAV or on top of a vehicle (truck, van or boat)
LiDAR Sensor Systems

Mobile Mapping System

Helicopter

Static

Fixed Wing

UAS/UAV
Main Components of a LiDAR System

- Laser Scanner – generates the laser pulses necessary to create the LiDAR point cloud
- GPS – Mobile and Aerial LiDAR systems - use this technology to derive the precise X, Y, and Z position of the sensor in 3D space
- Inertial Navigation (IMU) – Mobile and Aerial systems - an electronic device that measures and reports velocity, orientation, and gravitational forces
- Camera(s)
- High end workstation with various software
Typical LiDAR Workflow

1) Project Planning – determine area of interest, amount of ground control and scans needed, how long will collection take
2) Data Acquisition – collection of LiDAR data and images
3) Geo-referencing – registering point cloud to ground control and specific coordinate system
4) Post-Processing – includes filtering of data and classifying data
5) Computation and Analysis – high level information extracted from lower level point cloud data
6) Package and Deliver – delivery can include LAS files, bare earth models, DTM, planimetric features
Factors affecting Collection of LiDAR Data

**Time of year:** LiDAR data can be collected at any time of the year, but seasons with no snow and few leaves are best (spring in Wisconsin)

**Vegetation:** May not find true ground if vegetation is tall or dense

**Precipitation:** LiDAR data cannot be collected during precipitation events

**Clouds:** LiDAR will be reflected off clouds (aerial) and fog

**Angle of scanner:** Areas such as ditches and in-slopes along the roadway may be missed by mobile LiDAR scanner due to angle

**Obstacles such as parked cars:** LiDAR cannot see through dense objects; however, moving cars (referred to as artifacts) can be removed from the point cloud with subsequent passes of the scanner

**Back side of buildings:** LiDAR cannot see through dense objects so mobile mapping will only include the side of buildings next to the roadway
Softcopy Photogrammetry Workflow

• Design flight for 60% overlap and ground control
• Place targets
• Images taken with large format BW film or digital camera
• Scan film with a high resolution scanner - softcopy
• Field survey the targets which were captured on the imagery
• Analytical Triangulation
• Compilation specialists draw lines and points representing the features such as trees, buildings, roads, etc., to create planimetric mapping and draw lines and points of elevations to create digital terrain models
Flight Design & Target Document

5mcoule13
1641-03-02

- Plot scale: 1/11760
- Altitude: 1506 feet
- Photo scale: 1/3000
- Strip width: 690m
- Lateral overlap: 30%
- Run spacing: 483m
- Forward overlap: 60%
- Total length: 3km
- Total lines: 1
- Total models: 11

Total photos: 12
County: La Crosse
Product: dtm
Targets: 16 new
Field work (survey staff)

- Field targeting
  - Painted or plastic “X”
- Ground control survey
  - Latitude, longitude, & height of targets
Zeiss RMK TOP 15
Optical Film Camera

Cessna Turbo 210
Aircraft
Vertical Aerial Imagery

- Photograph taken looking straight down
- Controlled
- Black & White (film)
- Color (digital camera)
- 1:3000 typical
- 1:2000 for higher accuracy
- 1:6000 for planning studies
Softcopy Analytical Triangulation (AT)

Bill Tredinnick

Joan Betz
Softcopy Analytical Triangulation

- Ties aerial imagery to the ground control
- Supplement survey ground control by measuring ground control and 14 points in each stereo model
- Allows compilation staff to accurately read the ground from the stereo model
Softcopy and Analytical Compilation

Mike Humke  
Jason Vande Hey

Karen Gehri, Ralph Kennedy
Compile discrete and relative planimetric features
DTM: Break lines, Computed Break lines, Mass Points, Weak, Obscure and Building Polygons
DTM TIN – triangulated irregular network
Editing

Edit in-house mapping and DTM data

• Clear line work out of buildings and map limits

• Label roads, rivers and railroads

• Create contours, look for waterfalls and spikes
Quality Assurance

• Review consultant AT results and mapping and DTM data

• Review map check results for in-house and consultant mapping and DTM data Translate MicroStation design files for the Region staff

• Provide standards and specifications to consultants
Factors Affecting Photogrammetry

- Missed deadlines for project requests
- Delays in targeting due to snow, large number of projects
- Delays in flights due to unsuitable weather
- Equipment problems
- Requests for additional information after initial request is made (extensions, DTM)
Why use data from LiDAR and Photogrammetry?

• Maps provide XYZ data of existing natural and man-made features from which planning, engineering, construction, and legal decisions can be made
• Economical: large and restricted areas are quickly mapped
• Legal: defines the field conditions at that point in time
• Increased safety for surveyors
• Geo-referenced and ortho imagery enhances the information

• Data uses
  • Planning studies (i.e., investigation)
  • Preliminary and final design (exhibits, plan and profile sheets)
  • Vertical profile
  • Bridge clearances, low wire for power lines, sign inventories
  • Right of way plats
  • Construction final quantities and payment
  • Public (open records) requests for aerial photos
Aerial Imagery

Georeferenced Imagery (Uncontrolled)
- 1:12000 or larger typical
- Scaled dimensions are semi-accurate
- Produced from existing or new imagery
- Good for PIM and engineering exhibits

Ortho Imagery (Controlled)
- Existing digital terrain model (DTM) is applied to the vertical aerial image
- Is as accurate as a map
- Uses
  - Plan sheets
  - PIM and engineering exhibits
  - Land use maps

Ortho imagery example with preliminary design superimposed (NW region)
LiDAR – Image Draped over Riegl Scans (WisDOT Riegl VZ400 static scanner)
WisDOT LiDAR Projects to Date

- 5 Fixed Wing LiDAR projects
- 10 Mobile LiDAR projects
- 14 Static LiDAR projects
- 0 Helicopter LiDAR projects
- 0 UAS LiDAR projects
WisDOT LiDAR Projects to Date

Fixed Wing LiDAR projects
  engineering design
  IH 39
  STH 73
  IH 43
  STH 23/130
planning studies
  Menomonee Area
WisDOT LiDAR Projects to Date

10 Mobile LiDAR projects
   engineering design
14 Static LiDAR projects:
- with mobile LiDAR - engineering design consultant and WisDOT’s Riegl static scanner:
  - Vertical clearance for 6 bridges (consultant processed)
  - Deflection monitoring for a bridge (consultant processed)
  - Borrow pit for construction quantities (consultant processed)
- Engineering design
WisDOT\Bureau of Technical Services\Surveying and Mapping Section\Photogrammetry Unit

- Jan Bennett Unit Supervisor
- Cindy McCallum Unit Coordinator
- Tiffany Novinska Aerial Imaging Specialist
- Matt Bodden Aerial Imaging Specialist
- Joan Betz Stereo Compilation and Analytical Triangulation Specialist
- Bill Tredinnick Analytical Triangulation Specialist
- Karen Gehri Stereo Compilation Specialist
- Mike Humke Stereo Compilation Specialist
- Ralph Kennedy Stereo Compilation Specialist
- Jason Vande Hey Stereo Compilation Specialist
- Pat Suess LiDAR Specialist
- Bill Schloemer (Digital Cartography Unit) Cartographer
Advantages of LiDAR Mapping

• Provides high data density so we can obtain large amounts of information
• Is very accurate relative to itself (needs ground control to be accurate to true ground)
• Can scan areas under bridges (not accessible from Photogrammetry)
• Can be used for asset management mapping (signs, etc.)
• Data collection is relatively fast
• The data can be “mined” at any time for additional information such as distances between objects (we can provide this service to designers)
• LiDAR is safer than traditional ground survey in traffic areas; however ground control is still needed to obtain accuracy
Disadvantages of LiDAR Mapping

• May be more expensive than traditional mapping techniques (costs may be coming down)
• May need more ground control than traditional mapping techniques
• Fixed Wing LiDAR alone may not be adequate; need Photogrammetry for better accuracy and imagery
• Mobile LiDAR is restricted to roadways and approximately 60’ extent of data collection
• Results in large data files which require more time and CPU memory to process, as well as much larger storage area
• Although data collection is fast, more time is dedicated to extracting and post-processing the data
• New technology requires we deal with the following:
  • Learning curves
  • Misconceptions regarding capabilities and limitations
  • Existing standards for process, accuracy, and quality need further development
Advantages of Photogrammetric Mapping

- Engineering design accuracy and large area coverage are obtained from a single flight pass
- May be less expensive than LiDAR
- Data files are much smaller so require less storage space
- Photogrammetry has been around for a long time and its mapping techniques are well established

Disadvantages of Photogrammetric Mapping

- Need ground survey to map area under bridges
- Less accurate than ground survey
- Less accurate than mobile or static LiDAR on hard surfaces when LiDAR has ground control and good satellite coverage
Evaluate each project for LiDAR

- Is the project for planning or engineering design purposes? LiDAR is better suited for design due to its high accuracy.
- What type of project is it? Urban or Rural? Resurface, reconstruct, intersection, structure rehabilitation or replacement, etc. LiDAR is best on hard surfaces.
- What accuracy is really needed? Best accuracy is needed for structure work.
- Do we need a combination of Photogrammetry, LiDAR, and ground survey?
- Would Photogrammetry or ground survey provide the information more cost-effectively? LiDAR accuracy is good on hard (paved) surfaces but no better than Photogrammetry on soft (vegetated) surfaces.
- When should data be acquired? LiDAR can be collected at any time if hard surfaces and no snow. Collect same time as Photogrammetry if used together. Consider changes due to development or other construction.