LiDAR and Digital Imagery for High Precision Projects

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Presentation

• Quality Assurance Process
  - System Calibration
  - Planning
  - Aerial Survey
  - Primary Processing
  - Secondary Processing
  - Delivery

• Case Study : A14, Cambridgeshire, England
Quality Assurance

- **System calibration**
  - Camera calibration
  - Laser Range Finder (LRF)
  - Scanner
  - GPS Lever Arm
  - Time synchronization
  - LRF/Camera offset
  - LRF/Camera rotation - Boresight calibration

- **Project realization**
  - Planning
  - Data capture
  - Data processing
  - Delivery

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Quality Assurance

**From planning to delivery**

- **Planning**
  - Accuracy demands
  - Flight plan: Altitude, speed, overlap, etc..
  - GPS reference stations
  - Ground control for QC/QA

- **Aerial survey**
  - Secure good GPS constellation
  - INS initialisation and drift control
  - Supporting flight lines for QC/QA

- **Primary processing**
  - GPS/INS processing
  - Point cloud calculation
  - Strip adjustment, TerraMatch
  - TASQ – quality statistics of strip overlap

- **Secondary processing**
  - Filtering – ground classification, manual editing
  - Classification of buildings, trees, etc..
  - Modelling, e.g. DEM

- **Delivery**
LiDAR versus Photogrammetry

Photogrammetry

LiDAR

\[ 2 \sigma_{XY} > \sigma_Z > 5 \sigma_{XY} \]

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LiDAR versus Photogrammetry

Photogrammetry

LiDAR

High planimetric resolution - 5 cm

Low planimetric resolution - 25 cm

15 points / m²

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RGB

nIR
LiDAR and Photogrammetry

High elevation accuracy
High planimetric accuracy and resolution
Good conditions for image interpretation

The combination gives best result

Case study – A14, Cambridgeshire

- 100 m (330 feet) AAG (Altitude Above Ground)
- > 30 points / m² LiDAR point cloud
- 2 cm digital image resolution, Rollei AIC P20 (4000x4000 pixels)
- < 5 km to GPS reference stations, logging 1 Hz dual frequency phase data
- 140 flightlines
- 34 survey stations established along A14 – 1190 control
A14 – Primary Processing

- LiDAR point cloud calculated with Topeye TEPP SW
- Topeye elliptic scan pattern – Forward and Backward scan – adjustment of Heading and Pitch errors using TerraMatch
- Strip adjustment correcting Easting, Northing, Z and Roll errors per flightline
- Adjustment towards ground control
- Statistical analysis of deviations between flightlines using Blom SW TASQ
- Digital Images developed in Capture One SW

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TASQ – Report

TASQ (TopEye Area Statistics and Quality) output report

Statistics for elevation differences between flightlines

Global statistics

- Total RMS(dZ) : 0.024 m
- Number of observations: 891501
- Maximum deviation : 0.430 m

Flightline statistics

- Flightline number 329
  - RMS(dZ) : 0.023 m
  - Number of observations: 192813
  - Mean deviation : -0.008 m
  - Maximum deviation : 0.240 m

![Graph showing distribution of RMS(dZ)](image)
A14 – Secondary Processing

- Isolate data representing A14 asphalt area. Resulting in only hits on the asphalt road.
- Smooth the data on asphalt. This reduces the noise in the data and gives a smoother dataset.
- Compare point cloud to survey detail (20 – 40 points / km) and shift accordingly. The corrections varied within +/− 4cm.
- GPS/INS orientation of Digital Images refined by tie point measurements and triangulation. Adjustment to ground control.

A14 – Final Result

- 25 check points
- RMSE Z – 0.013 m
- RMSE Easting – 0.020 m
- RMSE Northing – 0.017 m
Summary and conclusions

- High precision reachable only with careful planning and processing in all stages: calibration, planning, data collection, processing and delivery

- LiDAR length precision dependent on high S/N ration – don’t fly too high

- High precision reachable only with data enhancement procedures, such as strip adjustment and smoothing

- Smoothing only applicable on surfaces with lower noise level than LiDAR point cloud, such as asphalt

- Combine LiDAR and photogrammetry for best result