A New Framework for Accuracy Assessment of Lidar Data and Derived Elevation Models

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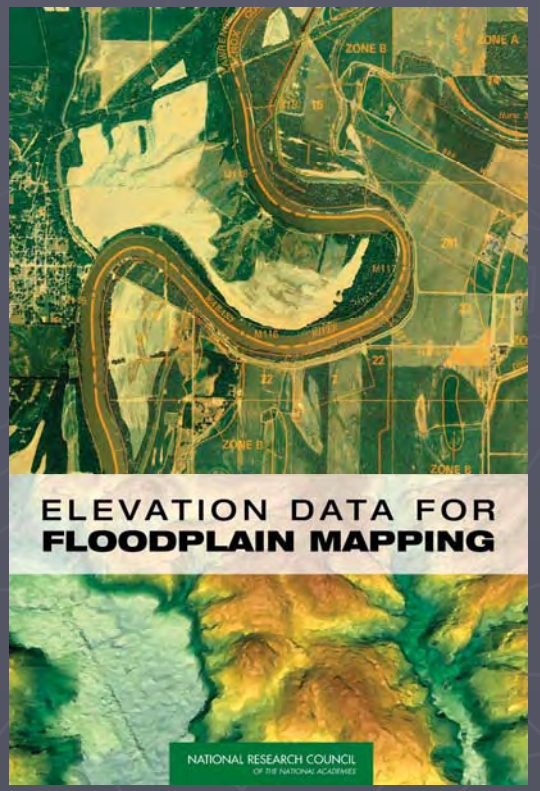
Why a New Framework?

- Committee on Floodplain Mapping Technologies National Academies of Science

- Elevation Data for Floodplain Mapping report published January 2007

- www.nap.edu/catalog/11829.html



Why a New Framework?

- The report proposes a concept called "*Elevation for the Nation*".
- "The program should employ lidar as the primary technology for digital elevation data acquisition."
- "Data collected in *Elevation for the Nation* should be disseminated to the public as part of an updated National Elevation Dataset."

Why a New Framework?

- “The current guidelines and standards of accuracy testing and reporting do not address all of the questions that could be asked about the quality of lidar-derived mapping products.”
- “Attempts by NDEP, ASPRS, and FEMA to establish guidelines and specifications are a step in the right direction, but they do not go far enough.”
- “Better ways of measuring and reporting quality and accuracy are needed to account for the appropriate sources and the spatial variability of error.”

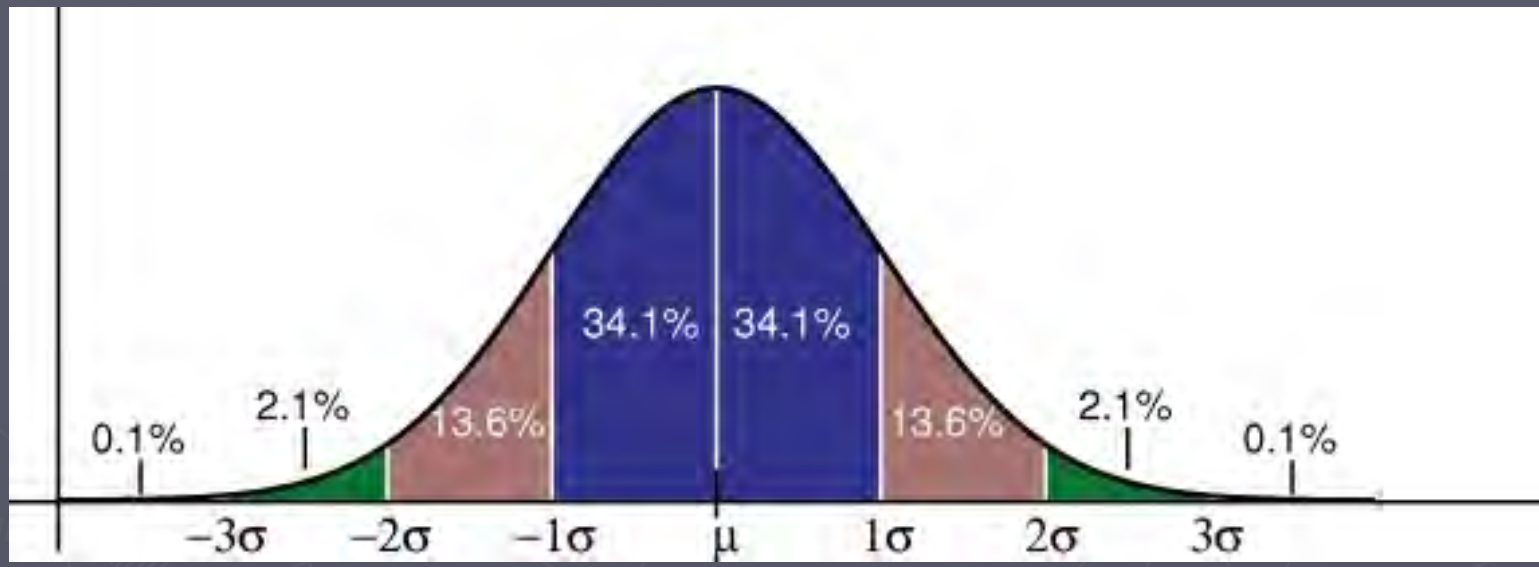
Why a New Framework?

- FEMA's floodplain mapping program drove the development of current accuracy specifications.
- "Our current methods of testing do not adequately characterize the data." says FEMA representative, Paul Rooney, at ASPRS-MAPPS Specialty Conference, November 10, 2006.

Why a New Framework?

- “The community of experts in remote sensing and mapping, with representation from government, private industry, and academia, has the ability to fill this gap if provided with clear direction and the mandate to do so.”

Normal Distribution



- Assumes all systematic and correlated errors are removed
- Appropriate for surveys comprised of redundant observations computed by LSQ
- Foundation for NSSDA

Current Framework

- Vertical accuracy is reported as a single measure for entire dataset at the 95% confidence limit
  - Fundamental accuracy reported in flat, open terrain as RMSE*1.96
  - Supplemental accuracy reported as 95th percentile in designated land cover types

Current Framework

- No recognition of other effects on terrain model accuracy, such as:
  - Point density
  - Slope and roughness
  - Surface reflectivity
- No horizontal accuracy component
- Current reporting standards do not reflect spatial variability of error

Cornerstones of a New Framework

DATA CHARACTERIZATION AND
ACCURACY REPORTING STANDARDS

ERROR MODELING

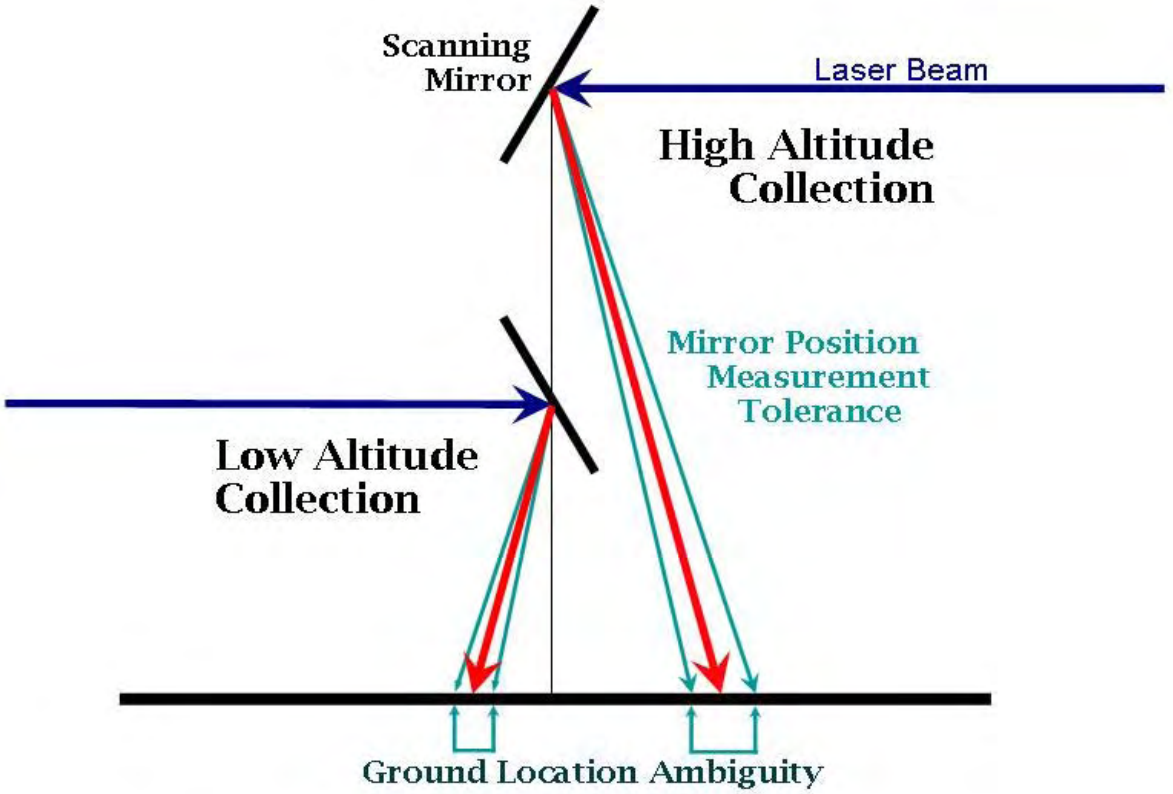
INDUSTRY LEADERSHIP

SOURCES OF ERROR

Sensor and Support Systems

- Tolerance in moving parts
  - e.g. Mirror "slop"
- Sensor calibration
- IMU calibration and errors
- GPS errors
  - Poor GPS environment
  - Poor base station configurations
- Physics – beam divergence, etc.
- Intensity normalization

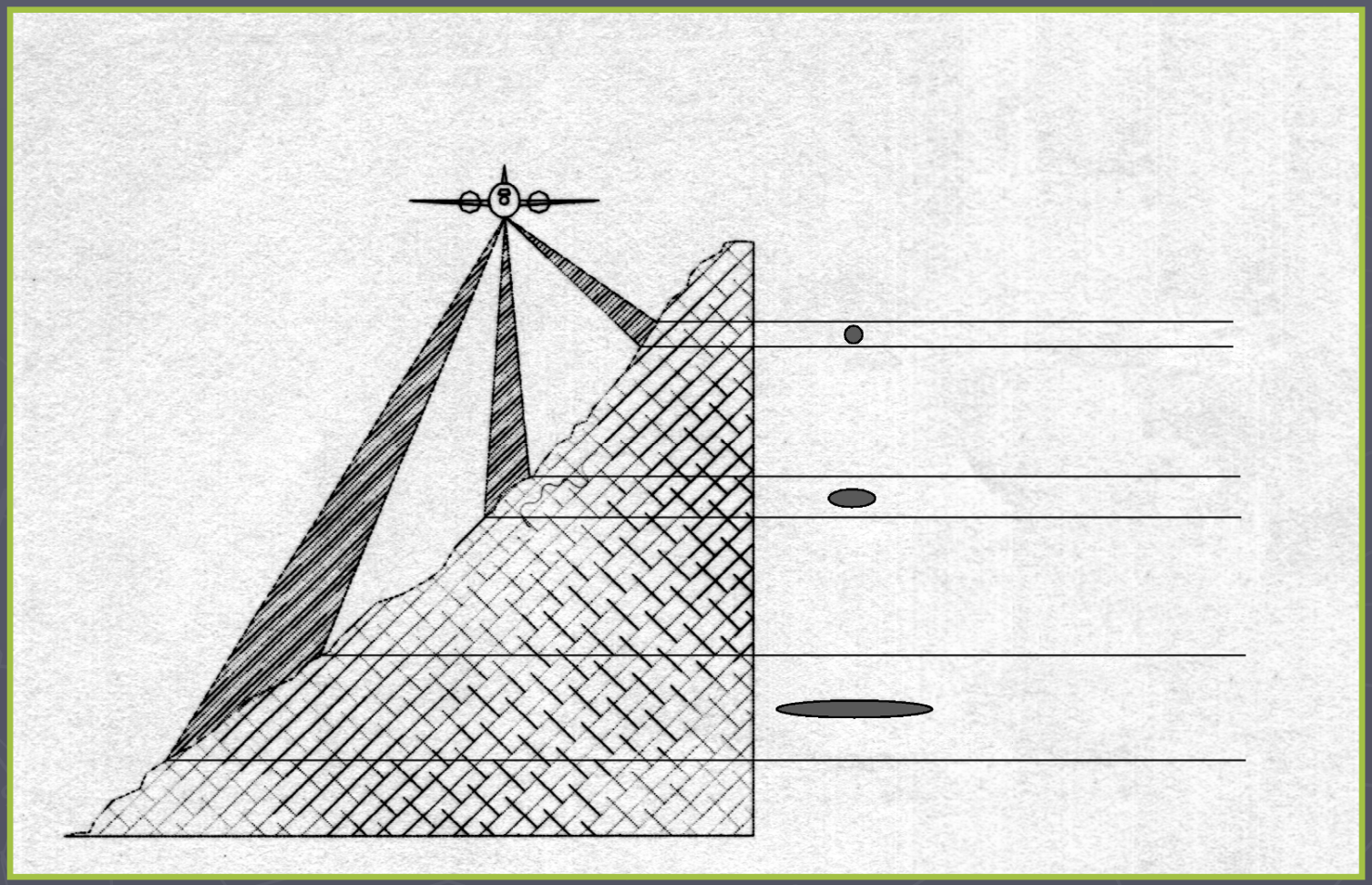
Example – Mirror Ambiguity



Geomorphology

- Surface type (hard surface, grass, trees)
- Surface reflectivity (e.g. bright vs dark leading to trigger level ambiguity, AGC errors)
- Environment (e.g. urban canyons leading to high multipath error contribution)
- Slope
  - δX, δY = f(δZ)
  - Beam divergence

Terrain Slope Effects



Processing

- Improper GPS/IMU and/or LIDAR post-processing
- Data “Calibration”
  - Changing geometry without a mathematical model (e.g. raising, lowering flight lines, tilting. Etc.)
- Data Smoothing
- Data Thinning
  - Note that thinning can be insidious such as insufficient points classified to ground
- Data Sampling
  - e.g. making a 5m grid from 1m data using a TIN
  - Making a 1m grid from 5m data using any technique

DATA CHARACTERIZATION AND ACCURACY REPORTING STANDARDS

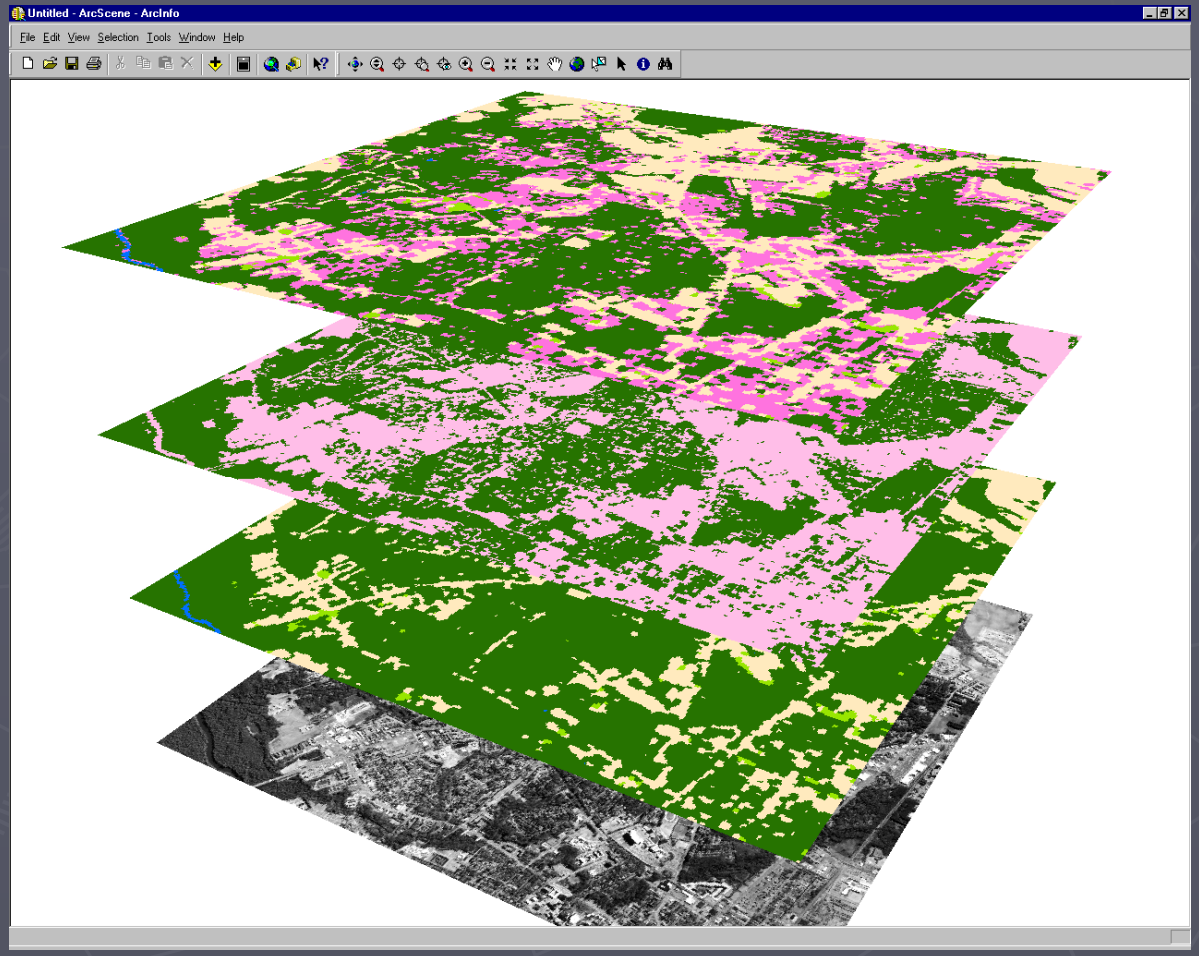
Accuracy Reporting as a Spatial Variable

- Classification from lidar dataset to produce two-dimensional maps of:
  - Land cover
  - Slope
  - Surface Roughness
  - Point Density (ground points/model key points)
  - Surface reflectivity

Accuracy Reporting as a Spatial Variable

- Design sampling for ground check points based on spatial analysis
- Assess accuracy in sample areas using appropriate statistical measures
- Extrapolate accuracy assessment results to entire dataset based on common characteristics
- Report accuracy as a two-dimensional map, not a one-dimensional table

Accuracy Reporting as a Spatial Variable



Education

- What level of terrain model accuracy is needed in different applications?
  - Floodplain mapping
  - Forestry
  - Infrastructure mapping
- How might accuracy and error reporting requirements vary by application?
- Can end user applications make use of 2D reporting?

Call to Action

- Penn State is working on:
  - Characterization of error as a function of geomorphology
  - User presentation of error
- GeoCue is working on best practices in processing from an error point of view
- Intensity normalization?
- Metadata to record processing steps?

Call to Action

- Metadata at the pixel level 

- Integrates with ArcGIS Desktop
- Could this be adapted to mass point (LAS data)?

Summary

- LIDAR has become the preferred source for digital elevation data
- Accuracy assessment and data characterization is rudimentary at best
- Further action is required to improve our understanding of uncertainty in results of analyses based on lidar data and derived products

INDUSTRY LEADERSHIP

- USGS Center for LIDAR Information Coordination and Knowledge
  - Second National Lidar Meeting, May 21-22, Reston VA http://lidar.cr.usgs.gov/registration.php
- ASPRS Photogrammetric Applications Division (PAD) — Lidar Subcommittee
  - April 29, Portland, OR http://www.asprs.org/society/committees/lidar/

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