Investigation on Laser Scanners

Brian Fuss, Catherine Le Cocq, Robert Ruland
Stanford Linear Accelerator Center

Rudolf Staiger
Essen University
Overview

- SLAC’s Metrology Department will expand its scope by purchasing a laser scanner
- Department needs are defined
- Vendors invited to SLAC to demonstrate their scanner and perform three field tests:
  - Tunnel Test
  - Building Test
  - Accuracy and Resolution Test
The Vendors

HDS4500
Leica Geosystems HDS

Phase USA

iQsun880
iQvolution

Phase Germany

GS200
Trimble / Mensi

TOF France

Imager 5003
Zoller+Fröhlich

Phase Germany
Applications

• Geometrical record of a tunnel or similar area for retro-fitting work
  – Full 3D “map” of area
  – Rapid survey (e.g., radiation or other time-limits)
  – Easily converted into CAD drawings

• As-built surveys of SLAC buildings for Geographic Information System (GIS)
“Wish We Had a Laser Scanner!”

- New LCLS (Linac Coherent Light Source) injector
- Existing tunnel
- As-built survey with total station was slow and had very limited coverage
Scanner Requirements

- The scanner should have an **optimal range** of up to 50 m for large structures including buildings or long tunnel sections.
- The **minimum range** of 1 m or less to capture regions that are close to the laser scanner such as accelerator magnets in a narrow tunnel.
- User selectable scan density so that only regions of special interest need the highest resolution, saving time and disk space.
- The **resolution** < 350 µrad.
- Minimum **accuracy** of better than 5 mm at a 50 m range.
- Measure minimum of 5000 **points every second**; significantly larger rate desired.
- The **field of view** of 360° horizontal and at least 60° vertical; full panoramic view desired.
Test 1: Tunnel Test

- Laser scan of shut down SLC tunnel including 1.5 inch (3.81 cm) spherical SLAC monuments
Test 1: Sample Results

Imager 5003
- Image is clear and noise is minimal

iQsun880
- note noise in image
Test 2: Building Test

- Testing ability of laser scanner to capture building floor plan
Test 3a: Accuracy

- Testing for distance and angle accuracy
  - Horizontal and vertical measurements of standard SLAC monuments
  - Distance between points checked against laser tracker
Test 3b: Resolution

- Use Boehler’s Box to test resolution
  - Narrow slits cause false points between the planes
  - Less noise between the plates means higher resolution
Test 3b: Results

HDS 4500

iQsun 880

GS 200

Imager 5003
Leica’s HDS 4500

Intermediate points eliminated due to manual clipping filter
Z+F’s Imager 5003

Very few intermediate points with automatic filtering
The Selection

- Zoller+Fröhlich’s Imager 5003
  - Meets SLAC’s specifications
  - Open to future hardware upgrades

- Decision weighting:
  - Accuracy (15%)
  - Data acquisition speed (15%)
  - Price (15%)
    - Initial Acquisition
    - Hardware Upgrades
  - Customer References (15%)
  - Field evaluation results (40%)
    - Software
    - Test 1: Tunnel Test
    - Test 2: Building Test
    - Test 3: Accuracy Test
Imager 5003 Ranging Errors

Calibration
10,000 point samples

Linearity Errors
- Non-gaussian
- Constant over range
- Empirical testing: ± 5 mm

Random Errors

Range Noise
- Object distance and reflectivity
- Can not be “averaged out”
- 1 to 6 mm for dark and far objects

Mechanical Deflection Errors

Distance (m)  50  30  20  10  Practical (registered)  SLAC Testing
Abs. Error (mm rms)  25.2  15.7  11.1  7.0  ~ 3 mm (Z+F)  ~ 0.6 to 1.3 mm
“I Scan, You Scan”

- Should receive the scanner in a few months
- Training for field personnel in January
- Another practical instrument in our toolbox
- For further details see our lovely IWAA2004 poster “Laser Scanner Demonstration”