Introduction to TLS for a geology field course – Student Exercise

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Geodetic imaging technologies (TLS, ALS, MLS, Structure from Motion, terrestrial radar) have emerged as critical tools for a range of earth science research application from hazard assessment to change detection to stratigraphic sequence analysis. Field experience utilizing geodetic and geophysical tools provides a unique opportunity for one to learn research skills applicable to a future graduate research or career path.

Introduction:

This unit introduces terrestrial laser scanning (TLS), a ground based remote sensing tool that generates 3-dimensional point clouds, with widespread research applications in geodesy, geomorphology, structural geology, paleoseismology, and other sub-fields of geology. After an introduction to the basics of TLS, you will design and conduct a TLS survey of a geologic feature. Following survey completion, you will learn the basics of TLS data exploration/visualization to answer questions about the scan resolution and findings that can be determined from the data.

Project Description:

Below is a description of the workflow path to follow when working on this project. This exercise is expected to take one full field day, including some time in the evening to learn the TLS data exploration techniques using the software RiScan.

NOTE: *These instruments are used by many scientific researchers and are on loan from a community pool maintained by UNAVCO. These instruments are in high demand, so careful and cautious handling of the equipment is essential, both for the success of the immediate project but also for others who depend on the equipment being in excellent working condition at the end of the day.*

Field Notes and Metadata Collection:

During the day, record field notes as you would on any other field day (weather, rock type(s), measurements of strike and dip or other features, a sketch of the outcrop) as well as detailed metadata related to their scans and an equipment list for a TLS survey (in the TLS Field Manual). Metadata includes a sketch of the scanner locations, target locations, and study area; justification (including the limitations) that led to the selection of these locations; file naming conventions and locations; the surface texture, color and condition and how the reflectance may affect the scan; who is present; and the object of the project (as well as anything else that seems important to recall the scan when no longer in the field). The reflectance vs. scanner range chart is in your TLS Field Manual, so refer to this when noting the impact of the reflectance of the material on the scan.

Problem Set:

In addition to the metadata, when not collecting scans, work through 3 problems: beam divergence, spot spacing, and scan resolution parameter worksheets for each of the scan locations. These are included below.

Data Exploration:

In addition to the TLS Field Methods Manual, a TLS Data Exploration and Processing Manual has been handed out. The Unit 1 section of the guide will walk-through the data exploration process necessary to answer the questions on the write-up.

Write-up:

At the end of the day, create a write-up detailed below about workflow, metadata collection, and results of data exploration.

Project Report:

Part A: Workflow

The first section of the write-up for the day should be step-by-step instructions for setting up a TLS survey. Use details like sketches of the scanner set-up from field notes to explain each step. Remember to include a list of the equipment needed, a map of the scan positions, the target locations, and the GPS locations, a summary of the necessary metadata, operational procedures for setting up a scan (like general considerations for scanner position, target location, GPS location, the scan resolution, time, registering scans and kinds of scans done) and general steps for visualizing the data.

Part B: Why TLS?

In this section, detail the societal impetus for using TLS for research including the importance of this technology for society. Many examples of the wide range of applications of TLS were given in lecture this morning. Consider the commonalities between these examples to demonstrate why TLS is useful in a general sense, not just in a sub-field of geoscience or in geoscience. Recall the object of the project at the field site and summarize why TLS was the best method of accomplishing that object.

Part C: Data Summary

Summarize the data collected by the class today. What scans were done at each scan position? File names? Are there photos associated with each scan? In addition, detail the high resolution scans from each group by creating a map of the scan partitioning. This should include scan resolution parameters worksheets from the field.

Part D: Data Exploration and Analysis

Finally, identify occluded (or shadowed) portions of the scan. How do these occluded portions affect or not affect your ability to study that feature? Demonstrate the resolution of the scan vs. reality by showing the difference between measurements of clear geologic features in RiScan and when measured in the field.

After completing these portions of the write-up, briefly answer the following question: 1.What is the societal impetus to study this feature and why is TLS a good method to use, 2. What surprised you the most about using TLS?

Riegl VZ-400 Equipment List:

Principal Investigators: ____

Project Site: ______________________________________ *Date:* ____________

Items	Quantity	Notes

Field Sketch:

Notes: atmospheric conditions, scan file names, number of scans, etc.

Problem Set:

Problem 1:

Beam Divergence Formula

Df = (BD * d) + Di

Df = Final beam diameter

BD = Beam divergence

d = distance traveled

Di = Initial beam diameter

Spot size of the beam can be calculated with a simple formula and can be helpful when determining where to locate your scanner, depending on the resolution of data your project requires. If using a Riegl VZ-400 scanner, the beam divergence is 0.35 millirads with an initial beam diameter of 0.007 m. If using another scanner, your instructor will provide the scanner specs. Calculate the final beam diameter at various distances. Use the above given formula and remember to convert millirads to radians.

Beam Divergence (radians)	Distance traveled (m)	Initial Beam Diameter (m)	Final Beam Diameter (m)
	10		
	50		
	75		
	100		
	200		
	350		
	500		
	800*		

*Beyond the range of a VZ-400

Problem 2:

Now we want to calculate the spot spacing (aka. angular resolution) of a scan with varying stepping angles to get an idea of changes in spot (aka. point) density. We will keep it simple by using a constant range, but remember that range of targets can and will change while scanning. Angular resolution will need to be figured for both the vertical and the horizontal scanning process. The formula for calculating spot spacing is as follows:

Angular Resolution Formula

$$SS = SA * R$$

SS = spot spacing

SA = stepping angle (radians)

R = range

Based on Riegl TLS specifications, we will use a minimum stepping angle of 0.0024° and a maximum of 0.288° for the vertical orientation. Given the various stepping angles, calculate the spot spacing of each scan with a target at 280 meters. You will need to convert degrees to radians for the formula to work. Similarly, the horizontal can be calculated using the Riegl specification range with the same minimum angle of 0.0024°, but with a larger maximum angle of 0.5°. Notice the effect changes in stepping angle has on resolution and think about how to approach a project with targets at varying ranges, to maximize time efficiency and quality of data collection. It is important to note that the smaller the stepping angle, the more data you'll collect, providing a higher resolution scan, but taking more time in the field, and yielding considerably more data that will need to be processed later.

Stepping Angle (Degrees)	Stepping Angle (Radians)	Range (m)	Spot Spacing (m)
0.0024°		280	
0.005°		280	
0.01°		280	
0.05°		280	
0.1°		280	
0.15°		280	
0.2°		280	
0.288° (vert. max)		280	
0.394° (horizontal)		280	
0.5° (horizontal max)		280	