NSW GOVERNMENT | Board of Surveying & Spatial Information

Guideline – Terrestrial Laser Scanning (TLS) for Cadastral Surveys

July 2020

Edition 0.1

Title:

Guideline – Terrestrial Laser Scanning (TLS) for Cadastral Surveys

Published by:

Board of Surveying and Spatial Information

346 Panorama Avenue
Bathurst NSW 2795

T: (02) 6332 8238

www.bossi.nsw.gov.au

Copyright:

Disclaimer:

This information is correct at the date of publication; changes after the time of publication may impact upon the accuracy of the material. Any enquiries relating to this publication may be addressed to the BOSSI Secretariat bossi@customerservice.nsw.gov.au

Document summary

Document control

Document Details	
Status	Draft
Edition	0.1
Date	15 July 2020
Author	Land and Mining Committee
Owner	Board of Surveying and Spatial Information

Change history and approval

Edition	Date	Authorised by	Change details
1	15 July 2020	BOSSI	Initial draft for consultation

Contents

1. Introduction

This guideline outlines the recommended procedures for use of Terrestrial Laser Scanning (TLS) methods to undertake cadastral surveys in accordance with the *Surveying and Spatial Information Regulation 2017* (S&SIR 2017) under the *Surveying and Spatial Information Act 2002* (S&SIA 2002).

As TLS is an evolving technology, this guideline will be subject to regular review and update.

It is the responsibility of the surveyor to ensure that their TLS equipment and the methods they employ in measurement and processing will achieve the required accuracy.

1.1. Scope

These guidelines are specific to the use of TLS as a means of measurement for cadastral surveys. All existing regulations, specifications, procedures and practices still apply.

TLS equipment may be used for the following type of surveys in a cadastral environment:

- Strata
- Stratum
- Small subdivision surveys where boundaries are defined by physical structures. e.g. Subdivision along Party Walls or face of walls
- Riparian Boundaries

Other applications will evolve with time.

2. TLS General Requirements for Cadastral Surveys

TLS observations produce three-dimensional position measurements in the form of a point cloud relative to the instrument location. The point cloud must be converted to absolute positions through connection to the State Survey Control Network. These measurements must be converted to either two or three-dimensional measurements (grid bearing, horizontal ground distance and vertical distance) for inclusion on survey plans.

All TLS measurement will be deemed as a derived measurement, as it is determined indirectly by calculations on the point cloud data.

The results from using TLS methods are dependent upon factors such as:

- the TLS method used,
- distance from the scanned object,
- object dimensions,
- redundancy,
- proximity to existing control,
- atmospheric conditions,
- software,
- obstructions.

It should be noted that every surface will provide a different reflectance value and the result may be affected by the surface type. The surveyor must be aware of this when using TLS observations and refer to manufacturer recommendations for guidance.

TLS observations must be made to clean / dry surfaces only.

All bearings and distances shown on the plan must satisfy all angular, length and misclose requirements stated in the S&SIR 2017. All lengths quoted on a Deposited Plan must attain a minimum accuracy of 10 mm + 50 parts per million (ppm) at a confidence interval of 95% (as per Clause 25(2) S&SIR 2017 or as amended in any subsequent revision).

In the case of Stratum surveys vertical distances and reduced levels will also be deemed as derived from the observed point cloud.

The Surveyor must validate the accuracy of TLS measurements by independent means such as:

- Conventional traversing using a total station
- Comparing distances determined against calibrated EDM distances or calibrated tape measurements

This will also ensure the survey's reliability, scale and orientation. The correct use of TLS allows these connections to be made effectively and efficiently.

To ensure both the spatial integrity and accuracy, all cadastral surveys utilising TLS must be connected to established survey marks or marks established by an approved GNSS method (Clause 12 S&SIR 2017).

The legal traceability of TLS measurements is a complex and as yet unresolved issue at a State, Federal and International level. This should NOT deter surveyors from using this technology for legal boundary definition.

2.1. Accepted TLS Methods

The accepted TLS methods for cadastral surveys include:

- Single Station Observation Set – This involves a single static scanning location to obtain TLS measurements. Derived measurements are to be independently checked. Surveyors are to appreciate that each individual TLS measurement can be considered effectively an unchecked radiation.
- Multiple Station Observation Set – This involves multiple static occupations are used to obtain TLS measurements identifying the position of a monument. A surveyor is then required to determine the final derived measurement for locating the cadastral monument.

3. TLS Annual Verification

Verification and validation are NOT the same as calibration. Unlike EDM equipment, TLS instruments cannot be calibrated for scale as the definition of scale is inherent in the TLS measured dataset (similar to GNSS methods).

Annual verification must occur for each TLS method that is used to determine survey accurate observations for inclusion on a survey plan.

Verification should also be undertaken after each service or repair of TLS equipment.

Verification is a rigorous, three-dimensional measurement procedure. Field and reduction methods used for the verification must conform to those typically used by the surveyor, and in compliance with the manufacturer's guidelines.

The following is the minimum requirements for verifying TLS equipment:

- The verifying network should include a minimum of 4 targets similar to that which is outlined in ISO17123-9 (2018), the procedure which generally uses the 2/3 range of the TLS equipment used. Refer to figure 1 below;

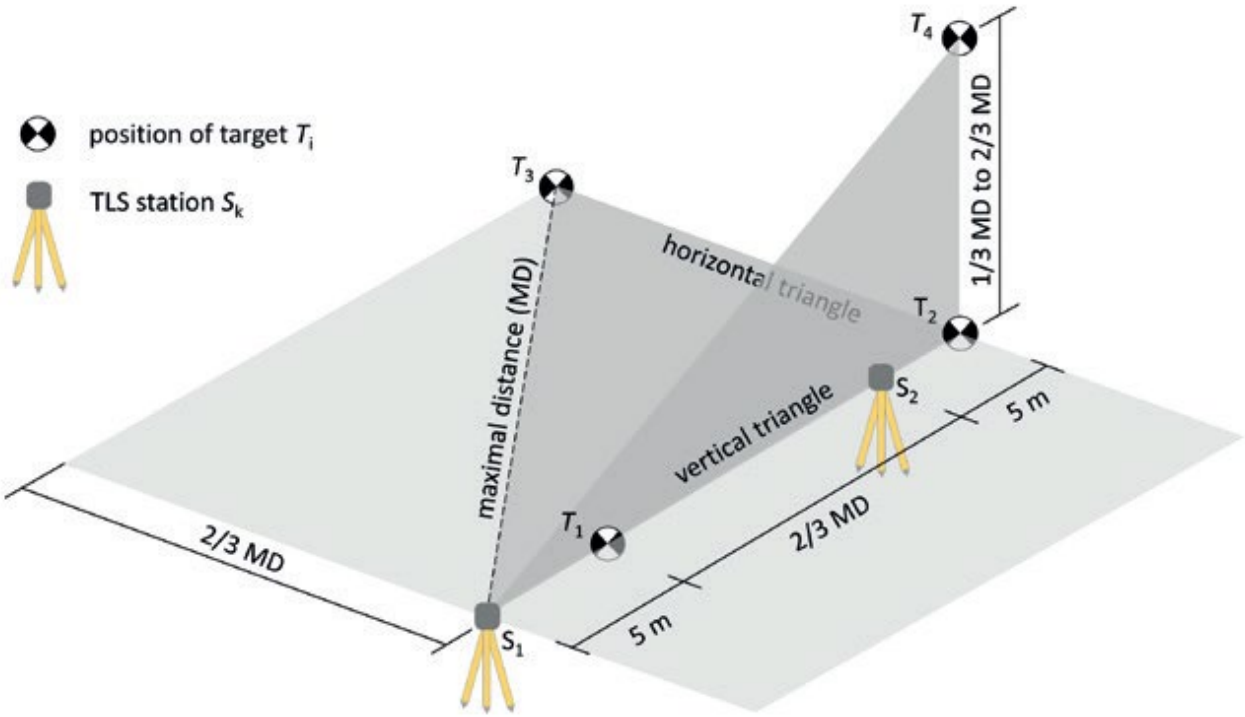

Figure 1: Measurement Configuration (Neitzel et al, 2014)

The method outlined in Figure 1 can also be used to verify an instrument for the range associated with a particular measurement task.

- The TLS is set up at locations S1 and S2 with scans completed to the targets and objects.
- Users should follow the recommendations set out in the manufacturer's handbook and manuals. All ancillary equipment must be checked and be in good adjustment and repair.
- Field observation log sheets should be completed for each session. The TLS type, serial number and firmware used must be recorded on these field sheets.
- Meteorological readings are not required, but rapidly changing weather conditions can affect all TLS results especially over longer distances.
- Use a calibrated Total Station to occupy S1 and S2 and observe bearings and distances to targets T1 – T4 to allow the determination of vectors between the fixed targets.
- The resultant determined distance from the TLS observations derived by the observations for any two target combinations must comply with a minimum accuracy of 10mm + 50 parts per million (ppm) or better at a confidence interval of 95% as per Clause 23-25 (2) S&SIR 2017.

The results of the annual verification must be forwarded to the Surveyor-General if requested.

4. Survey Validation

For all surveys where TLS techniques have been used to determine a measurement to be shown on a cadastral survey plan the following validation should be adhered too;

- Targets should be placed in suitable locations which can be surveyed by other means such as tape, total station or GNSS observations. Preference would be a minimum of 3-4 targets in multiple quadrants.
- The targets are to be located in the TLS observation set.
- The derived measurements from the TLS observations must be compared with the independent observations and accuracy noted in field notes or office reductions.
- The error vector between these measurements must comply with Clause 23, 24 and 25 of S&SIR 2017

5. Best Practice Guidelines

The TLS method used must be recognised by surveyors as good practice, and in particular, should always support good cadastral survey practice such as:

- working from the whole to the part,
- establishing a control framework that is fit for purpose,
- a minimum of 4 control targets should be used where appropriate,
- avoiding unchecked occupations or cloud to cloud registration (stitching) TLS scan stations,
- never scan objects at the extent or beyond the manufacturers recommended range of the instrument,
- TLS observations must be made to clean / dry surfaces only.

5.1. Orientation of surveys (datum line) for TLS

The datum line of any survey must be determined in accordance with Clause 12 of S&SIR 2017. TLS methods are not allowed to be used for the determination of datum line, another approved method must be used to determine the datum line, such as approved GNSS or total station direct measurement.

The position of survey marks defining the datum line of any survey must be determined specifically for each survey to ensure the survey marks' veracity and stability. All TLS Surveys must adopt an MGA orientation where the datum line is based upon permanent survey marks or reference marks unless otherwise approved by the Surveyor General.

5.2. Accuracy requirements

All cadastral surveys whether they are using TLS methods or not must ensure they have achieved a length accuracy of 10mm +50ppm or better at a 95% confidence interval for all lengths shown on a survey plan. This closely equates to the Class C category.

All TLS measurements should not exceed 50m as part of the survey.

5.3. Observational guidelines

Regardless of the method used these guidelines provide a framework for the survey.

- Work from the whole to the part. Observe a primary network to establish the datum, then in-fill other control as necessary. Where possible, connections to accurate height control should include additional marks to verify the datum.
- The overall network geometry must be “fit-for-purpose”. This implies redundancy.
- Always provide independent checks for instrument heights by taking a second measurement, for example using imperial units (inches), and ensure the two measurements agree.
- The minimum number of points observed (density) must be such that an accurate determination of the derived measurement for the monument can be achieved. This will vary subject to the distance from the object which the TLS is measuring to.

6. Field notes and data archiving

Field notes are an invaluable record of what was actually surveyed and must be kept for each TLS occupation. They should contain the following information:

- Project name, Observers’ name,
- Date and session start/stop times, Mark type and name/number,
- TLS filenames,
- Equipment details (TLS) including models, serial numbers, TLS height measurement and confirmation (check cm & inches),
- and a simple sketch.

Field notes, raw observational data and adjustment results must be suitably archived.

All practically available observations must be retained when TLS observations are used in the preparation of a survey plan.

7. Tips for TLS users

7.1. Point Spacing

TLS surveys should have a point density/spacing suitable to remove any error in positioning of the structures located, noting that point density is subject to distance from the object being measured.

In order to comply with Clause 24 of the S&SIR 2017 it is recommended that scan length and point density comply with the table below:

Scan distance v Point density	
Scan distance (m)	Maximum point density spacing to comply with Clause 24 S&SIR (mm)
50	1.5
40	1.8
30	2.2
25	2.5
20	3.0
15	3.8
10	5.5
5	10.0
2	25.0
1	50.0

Table 3: Recommended maximum point spacing for typical scan distances

Point densities are approximate only and are based on derived lengths measured from a single occupation and do not include allowance for other factors such as environment, equipment setup, multi-station scans, traversing, surface material, etc. The surveyor should always consider other factors which affect accuracy.

Scans beyond 50m are not recommended for cadastral surveys.

7.2. Know your equipment

Surveyors are encouraged to know how to operate their equipment. A thorough understanding of the instrument settings is required and how those settings affect the results.

All TLS users should regularly consult with the manufacturer or supplier of new TLS equipment or software to ensure they are using it correctly.

7.3. Traceability

Surveyors must adopt TLS best practices to ensure reliable results. TLS observations are currently NOT traceable to a recognised value standard.

7.4. Double occupations

While double occupations are not required, enough occupations to meet the accuracy required should be undertaken, with occupation stations no more than 50m apart so as to ensure suitable overlap from TLS scan stations.

7.5. Site Transformation

Adopt the coordinates of, and validate on, at least 3 established (Class D or better) State survey marks that have accurate AHD values. Four or more marks will give a better result. The marks should surround the survey project to avoid extrapolation.

8. References

Neitzel, F., Gordon, B., Wujanz, D. (2014): Verfahren zur standardisierten Uberprufung von terrestrischen Laserscannern. DVW-Merkblatt 7-2014. www.dvw.de

ISO17123-9:2018(E) Optics and optical instruments – Field procedures for testing geodetic and surveying instruments – Part 9: Terrestrial Laser Scanners