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Total Station Instrumentation Improves Accuracy and Efficiency of Coordinate Measurements in Forestry

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Significance to Forestry

There is a growing requirement to improve the accuracy of spatial measurements in both operational forestry and forest research. The Pacific Forestry Centre undertook a review of coordinate measuring instruments on the market to determine their advantages and disadvantages. A total station instrument incorporating advances in lasers, miniaturization, and electronics was found to significantly improve forest measurement accuracy and efficiency.

For many years, foresters and researchers have used a hand-held compass, inclinometer and chain to measure growth and yield plots and forest research installations and to carry out forest health surveys. The level of accuracy has varied greatly. More recently, hand-held electronic and laser-based survey instruments such as the Criterion 400 (pioneered by the USDA) have been developed for stem mapping of trees in forest plantations. However, the problems associated with compounded errors introduced by either human or instrument inaccuracies have persisted.

A total station is a survey instrument capable of measuring three fundamental spatial variables – the slant distance, azimuth and vertical angle of a target object – within one self-contained unit. The x, y, and z coordinates of the object are computed from these variables within the instrument. The unit contains a laser source and detector for measuring the slant distance and precision encoders for measuring the horizontal and vertical angles.

Total station is accurate and easy to use.

Total Station Use

A total station instrument can be used for most conventional forestry measurements such as stem mapping, tree heights, boundary traverses, permanent sample plots, and growth and yield plots. Its accuracy level is ideal for acquiring data needed for modelling work. It can also be used to provide accurate locations of other stationary field instruments such as dataloggers and weather instruments.

The key to using the total station is its ability to measure coordinates and determine reference points quickly and accurately. Particular applications of the total station include:

a) Coordinate measurement: The total station can store hundreds of target points (for example seedlings) which are visible from the instrument without moving from the initial set-up.

b) Coordinate re-establishment: Where the coordinates of reference points and target

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objects are known from paper or computer records but the actual field locations need to be re-established, the total station will direct the field person to the actual location from the set-up point. Consequently, plot information can be re-established or verified.

c) Hidden targets: Secondary reference points, or stations, may be required in situations where not all of the targets or trees can be seen from the original set-up point. The operator can shoot intermediate reference points and have their coordinates recorded (Figure 1). The operator can then set-up over an intermediate point and backsight to any known point; the instrument will calculate its new position and subsequent measurements of targets or trees will be recorded relative to the original coordinate system.

Alternatively, the operator can set-up anywhere within the plot and shoot to any two known points (Figure 2). Again, the instrument will calculate its new position and subsequent measurements of targets or trees will be recorded relative to the original coordinate system. Users will find either method of triangulation very straightforward with a total station.

Accuracy

Total stations are very accurate instruments. For example, the instrument purchased by the Pacific Forestry Centre is accurate to millimetres in distance and its angle encoders are accurate to 5 seconds of arc.

A first impression is that this level of accuracy may appear to exceed the requirements for most forest operational and research work. This is a correct impression if one is able to shoot all the targets from a single point. However, if it is necessary to establish intermediate stations or reference points then this accuracy is not excessive. There is a tendency for errors to accumulate or compound with many techniques and instruments. Because the total station is so accurate, any compound errors are still well within the accuracy required for forestry.

In any case, most total stations come with a high degree of accuracy. Although it is possible to obtain instruments with a lower order of accuracy, the compound errors associated with their use can exceed the error levels acceptable for forestry work.

Coordinate measurement using total station reference points.

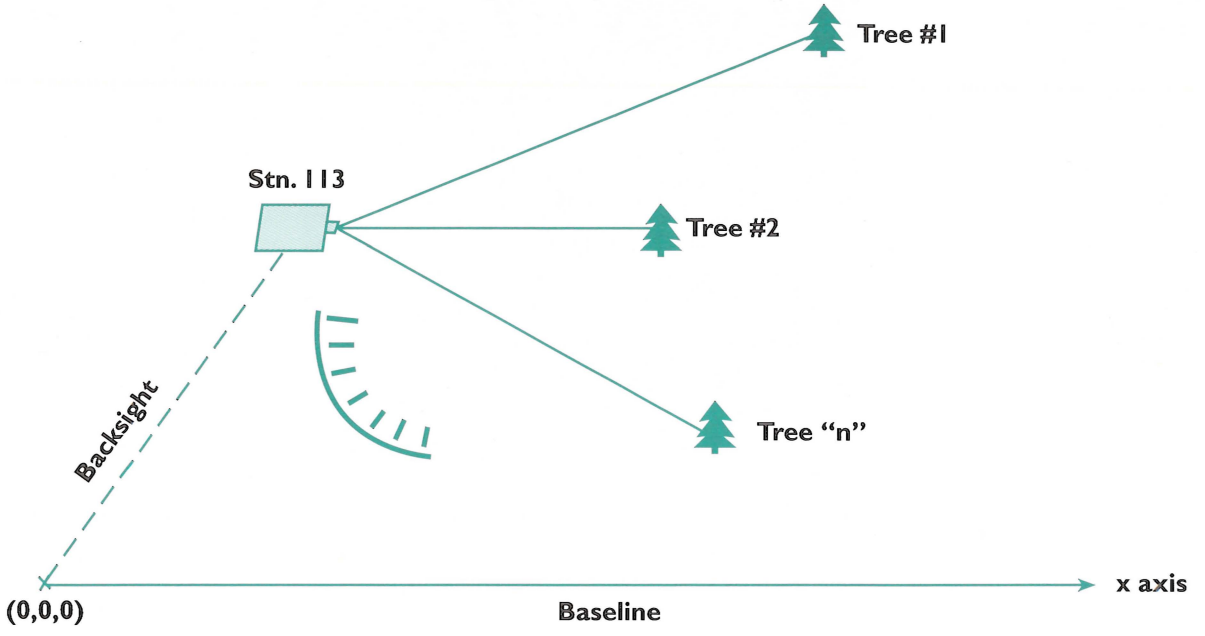

Figure 1. Set up at a known pre-measured station (for example station 113) and backsight to any other known station. This establishes the location and orientation of the instrument. All measurements will be relative to the original station (0,0,0) and the original baseline ("x" axis).

Alternative method of using reference points to locate hidden targets.

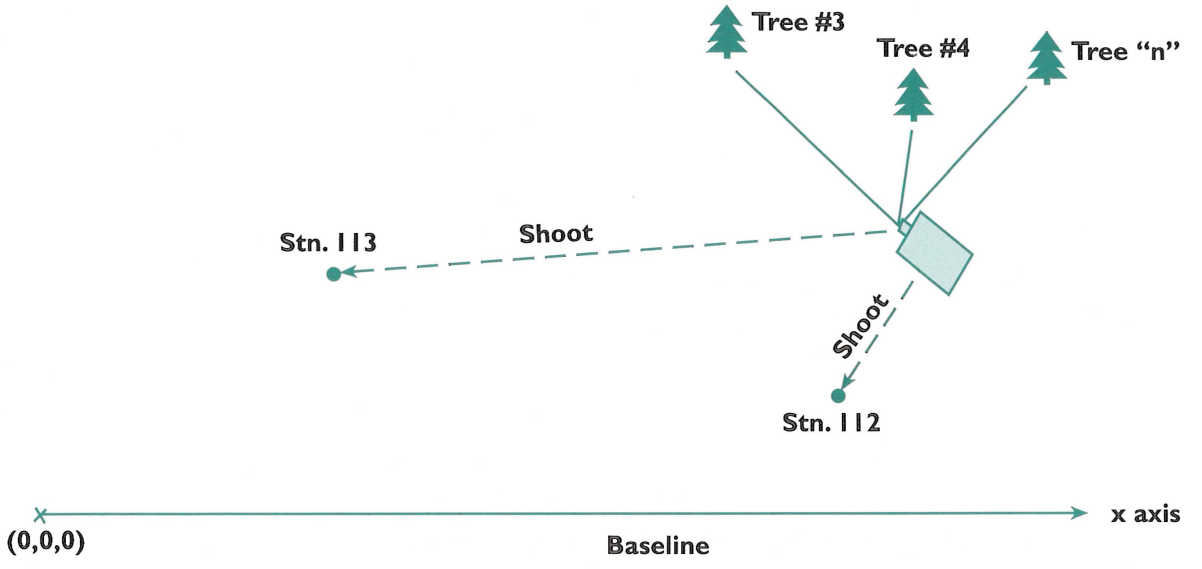

Figure 2. Set up at an unknown point and shoot two known, pre-measured stations (for example, station 112 and 113). This establishes the location and orientation of the instrument. All measurements will be relative to the original station (0,0,0) and the original baseline ("x" axis).

Mobility and Ease of Operation

Total station units weigh approximately 5.5 kg including the battery packs. While they do require a tripod and prism reflectors, some are available which do not have the batteries, calculators and associated wiring external to the instrument. Consequently, there is a reduced risk of equipment hang-up or entanglements with branches while in the field.

The total station's memory can easily hold a day's worth of measurements, which is an additional advantage. The instrument retains the tree or object identification numbers, and the corresponding x, y, and z coordinates. Field data can be easily downloaded into desk computers using the RS-232 serial port. Conversely, known coordinate point data from a desk computer can be up-loaded to the total station using the software program provided with the instrument for subsequent staking of field points. (A procedure guide, tailored for forestry applications, has been prepared by the Pacific Forestry Centre for its instrument and is additional to the manufacturer's documentation. It will take about two hours to become familiar with the total station's functions for routine operations.)

Some care is required in the transportation of a total station as would be expected with any precision instrument.

Management Implications

Measuring field targets and distances accurately and rapidly has many management advantages including reducing potential errors and avoiding the additional costs of re-measurements. The initial capital cost is higher than that associated with compass and tape measurements but this is more than off-set by the total station's increased accuracy and the field crew's increased productivity. Instruments can also be rented for one-time or periodic use.

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