The potential of terrestrial laser scanning technology in pre-harvest timber measurement operations

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- *Terrestrial laser-scanning technology has evolved rapidly in recent years, with improvements in speed of data capture and ease of deployment.*
- *As a result, laser scanning is becoming more feasible as a data collection method for mensuration and other applications in forest management.*
- *Terrestrial laser scanners capture and store three-dimensional (3D) measurement information at a higher resolution and more detailed level than conventional standing timber measurement and can therefore improve the accuracy and precision of tree stem measurements.*
- *Scan data also provide the basis for classifying stems in terms of sweep, straightness, taper and other quality-related attributes.*
- *Once collected, scan data can be easily stored and used to monitor, verify and evaluate future forest operations.*
- *A fully automatic software system has been developed to derive stem information in the same format as that measured by forest harvesters. This can be used by timber growers and buyers to assist in optimal harvest scheduling and cross cutting operations.*

Terrestrial laser scanning technology

Laser scanning (Figure 1) has been developed to capture detailed and highly accurate information relating to an object's dimensions, spatial positioning, texture and colour in both two and three dimensions. It is now a widely used technology in architectural, engineering and industrial measurement applications.

The basic principle of laser scan measurement involves the emission of laser light pulses towards an object. A pulse hits the object and is reflected back to a sensor. The angle of laser pulse emission and reflection, together with the time between laser pulse emission and return are used to record highly accurate X, Y and Z co-ordinates for each point of reflection. About 40 million reflection points can be collected per scan, collectively referred to as a point cloud (Figure 2).

A simple analogy to how data are collected by a laser scanner is provided by imaging a wide-angled torch shining and rotating from the centre of a plot in darkness: what the torch illuminates is very similar to what is recorded by the laser scanner.

Figure 1: 3D laser scanner hardware.

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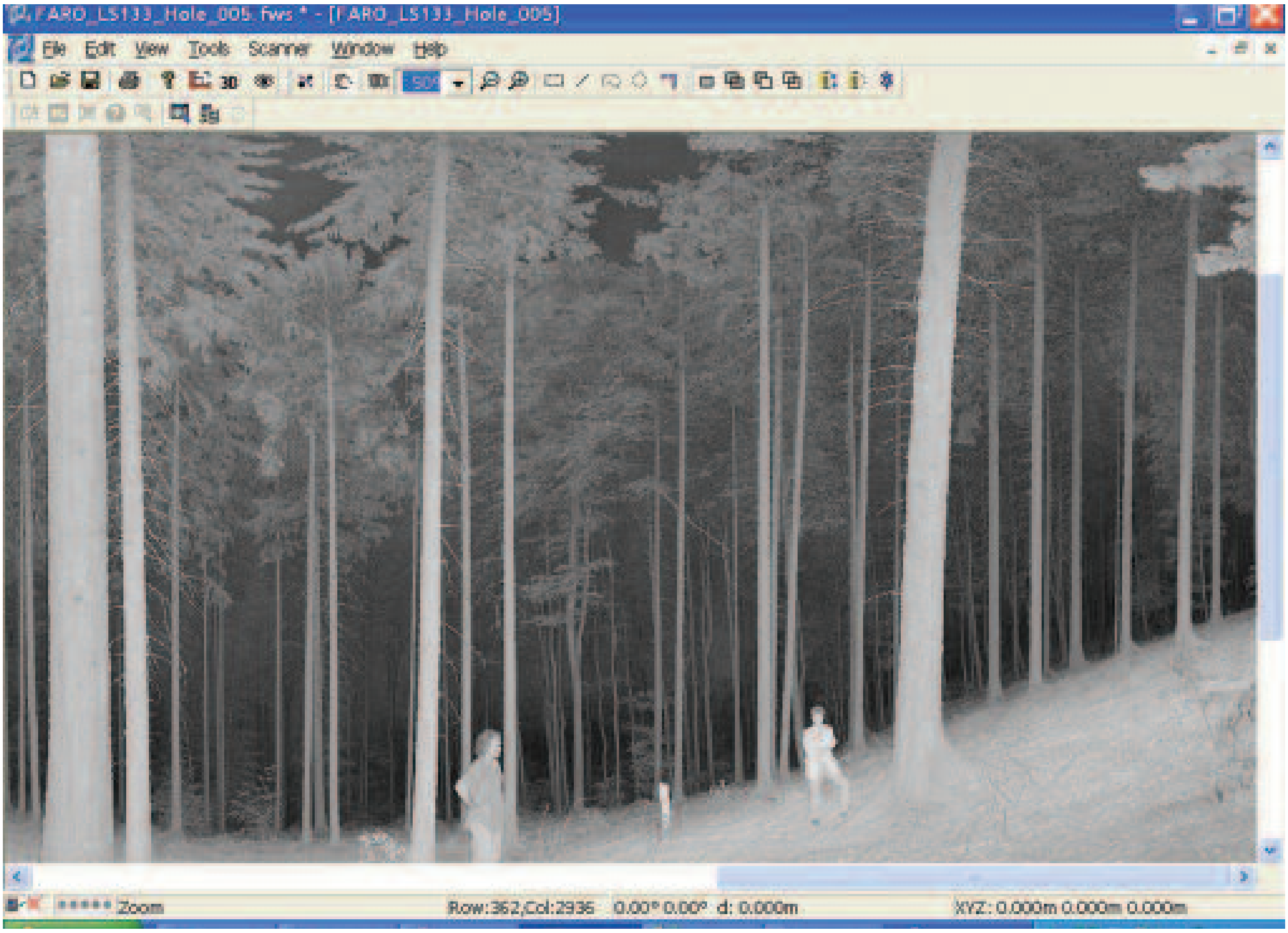

Figure 2: 3D image generated by the laser scanner.

Basis for application in forest inventory and operations

Terrestrial laser scanning technology is in the early stages of adoption by the forest industry, with applications in standing timber measurement and optimal harvest decision-making.

Terrestrial laser scanners can capture and store highly accurate three-dimensional (3D) measurement information for any object within their field of view, including forest crops and their surrounding environment, and can provide accurate tree stem measurement in a non-destructive manner.

In 2005, COFORD funded the TreeScan project[2], which assessed the feasibility of using terrestrial laser scanning technology in pre-harvest timber measurement operations. Since the project's successful completion, TreeMetrics Ltd has researched and developed a fully automatic measurement system called AutoStem™. During development, the company has validated and further enhanced the system to enable it to operate under different forest conditions in Europe. This additional research and development included work in Sweden with Skogforsk, SCA (Swedish forest products company) and SLU (Swedish University of Agricultural Sciences), and in Austria with the Austrian Federal Forest Company (ÖBf AG). The work in Austria included the evaluation of the system to measure a range of pure broadleaf and mixed broadleaf/conifer stands.

Overall, the main objectives of work to date have been to:

- evaluate the ability of selected terrestrial laser scanning hardware and AutoStem™ software to operate under

[2] *TreeScan was a collaborative project between TreeMetrics Ltd., the Institute of Forest Growth (Freiburg University, Germany) and the Telecommunications Software Systems Group (Waterford Institute of Technology). Purser Tarleton Russell Ltd provided timber measurement expertise. The project was funded by COFORD and TreeMetrics Ltd.*

different forest conditions to accurately capture pre-harvest timber measurement data.

- evaluate the suitability of a laser scanning system to assess individual stem profiles, with a view to accurately computing stem volumes and potential log yields.

Following the completion of the work outlined, TreeMetrics launched the AutoStem™ product in November 2006 in Vienna.

Potential benefits of terrestrial laser scanning for forest planning and pre-harvest timber measurement

At the moment, most log yield forecasting is based on inputting manually captured diameter and height data into assortment models. These provide the basis for quantifying overall volume, and breaking it down into different top-diameter product assortments, usually based on the mean stand diameter at breast height. However, depending on the level and nature of the variation in diameter classes found in stands, this can lead to varying levels of accuracy in predicting assortment volumes.

Laser scan data, on the other hand, can provide not only accurate tree level data but readily accessible information on stand level diameter distribution. This additional information can be used to improve harvest scheduling and its cost effectiveness.

Information derived from scanning can augment or indeed replace traditional pre-sale measurement data, to aid in marketing and optimising returns to both the buyer and seller.

A further potential application is in forest research and inventory where continually updated information is used to determine impacts of treatments on forest growth and in determining overall growth patterns. The GPS location of the centrepoint of the scan can be imported into AutoStem™. This allows for the possibility to re-measure the same plot in the future and to create a permanent record over time.

AutoStem™

AutoStem™ Forest was launched in November at the Forest Inventory and Harvest Planning conference at the headquarters of ÖBf AG in Purkersdorf, Vienna. The AutoStem™ software imports scan files collected by the laser scanner and automatically processes each scan in a matter of 3 to 5 minutes. Figure 3 shows the user interface with the different functionalities provided by AutoStem™.

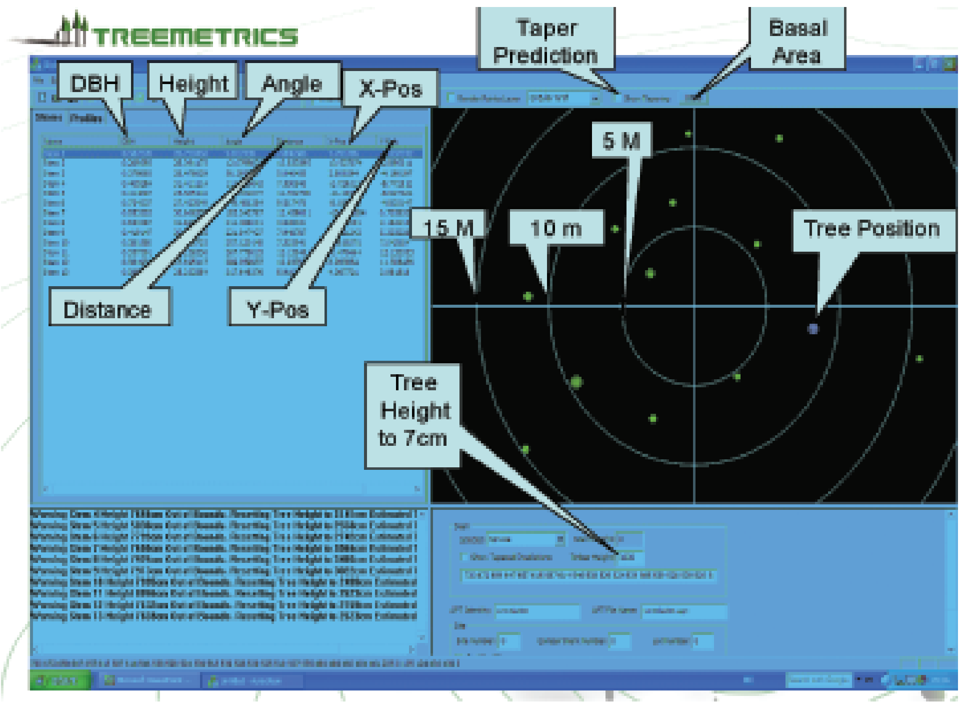

Figure 3: AutoStem™ user interface in plot view.

Along with traditional forest measurement parameters AutoStem™ describes each sample tree in the same file format – commonly known as StanForD stem files - as measured by harvesting machines.

The file format records stem diameter at decimetre intervals along the stem (this enables stem taper to be derived). Stem files from AutoStem™ have been successfully exported to existing harvester optimisation software packages, to simulate cross-cutting options and different product mixes based on length and top diameter constraints. Such applications are very useful for harvesting managers and wood procurement personnel in supporting cost effective wood supply. By providing StanForD stem files in advance for each stand, the harvest manager can now decide pre-harvest the optimal product mix, based on end-product demand and other factors.

Key features of AutoStem™ include:

1. Automatic production of forest stand parameters.
2. Spatial display of tree position for use with growth models.
3. Development of stem volume and taper data at forest level.
4. The ability to catalogue the forest according to the products that can be produced from a given harvest
5. Objective assessment of quality attributes of standing trees, e.g. ovality, straightness, sweep, branching, butt swell and lean.
6. Provision of a permanent digital measurement record.

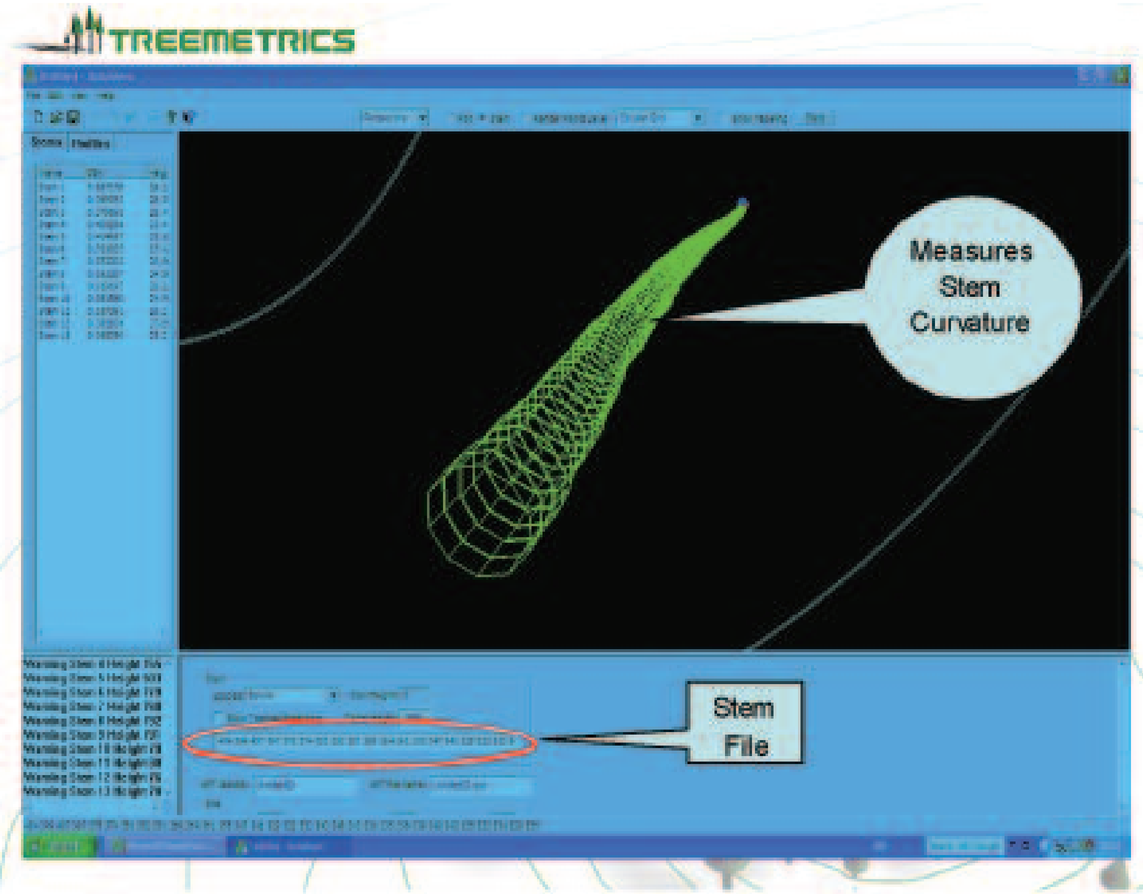

Figure 4: AutoStem™ user interface with 3D stem file data.