



## Deliverable D.4.07

### Estimation of log/biomass quality by external tree shape analysis.

#### WP 4 – Multi-sensor model-based quality control of mountain forest production

Task 4.1- Data mining and model integration of stand quality indicators from on-field survey for the determination of the tree "3D quality index".

Revision: Final

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## REVISION HISTORY AND STATEMENT OF ORIGINALITY

### Revision History

Revision	Date	Author	Organisation	Description
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V.1.3	18/12/2015	Alex Poveda Darren Morrell	Treemetrics Ltd.	Update partners comments

### Statement of originality

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.



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# 1 Introduction

## 1.1 Purpose of the document

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The objective of this deliverable is the development of a system for estimating timber volume, timber products and timber quality for trees in a standing forest using external tree shape analysis. The system is based on field measurements from a Terrestrial Laser Scanner (TLS) and the analysis of the associated point cloud data. Tree models and crosscut simulations are generated from the recorded data and are employed to estimate timber products according to user defined specifications.

This deliverable is classified as a prototype and is provided as a service to the SLOPE consortium and is based on an existing Treemetrics engine that has been adapted to specific SLOPE requirements. This document describes the different elements and interfaces of the system and how the various user interfaces are integrated with other SLOPE elements. This document is related to D4.02 which describes the technical process and the modification of the existing Treemetrics system for SLOPE.

## 2 System Architecture Overview

Treemetrics' SLOPE service comprises a range of devices and software packages that measure, record and analyse timber products. The different elements involved in the process are:

1. Field application – to record the field data required for the analysis.
2. Terrestrial Laser Scanner (TLS) - to record each individual tree shape within the sample plots.
3. Autostem (software package) – to analyse TLS data in order to identify tree stems from the TLS point cloud.
4. Cutting simulator – to simulate an optimal forest harvest on the basis of maximising the yield of the highest value log products.

Figure 1 outlines the various interfaces between the many elements of the Treemetrics system. After the data are sent to Treemetrics Service centre, the analysis of the data start automatically. After analysing the data, the Treemetrics system returns the results of the analysis to the SLOPE database using the database API provided.

After the data are updated in the database the Slope Forest Information System (FIS) will make them available to the user. The user can update the information of the data using the FIS, as result of the virtual tree marking or cutting instructions settings. These changes will be updated in the Slope database and FIS will notify Treemetrics system that an update and/or re-process of the data is required using a specific API based on a URL.

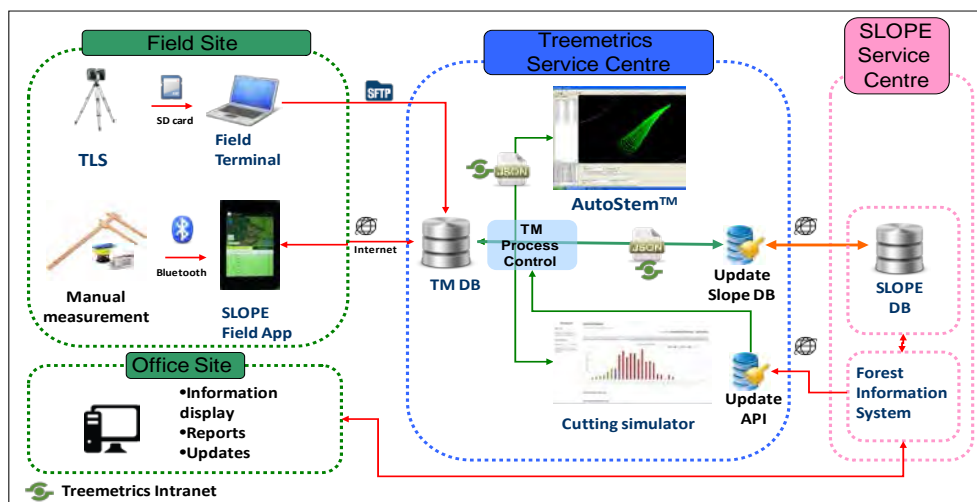


Figure 1: Treemetrics System Architecture

### 2.1.1 SLOPE field app

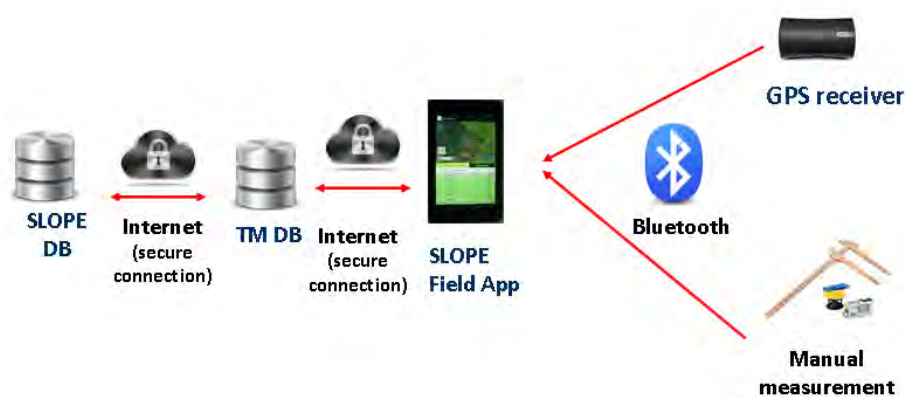
The Treemetrics field app is compatible with Android devices and has been optimised for the Nexus7 tablet device. The app is installed on the tablet as an APK (Android Application Package) file.

Installing an APK file on the Android device does not require additional software or hacks. By simply enabling the “Unknown Sources” option, the Android device will be ready to install the APK.

The app stores data in XML format and records both manually inputted data and data sent directly to the app from field instruments over a Bluetooth network.

#### SLOPE field app interface

The interface between the field app, the field measuring equipment (electronic callipers, laser range finder), the RFID unit and the GPS is a bluetooth network. The various devices transmit data to the field app over the bluetooth network. The returned data is stored in XML format by the application before being sent to Treemetrics’ database via a secure internet connection.



### 2.1.2 Terrestrial Laser Scanner (TLS)

The Terrestrial Laser Scanner used for the SLOPE project is a Treemetrics owned FARO Focus 3D. This scanner was chosen by Treemetrics as it is extremely practical for forestry applications due to the fact that it is light weight and small in size. Some of the key features of this scanner include:

- Weight: 5,2kg
- Size: 240 x 200 x 100mm
- Range Focus3D X 130: 0.6 – 130m
- Measurement speed: up to 976,000 points/second
- Ranging error:  $\pm 2$ mm
- Integr. colour camera: Up to 70 mio. pixel
- Laser class: Laser class 1
- Multi-Sensor: GPS, Compass, Height Sensor, Dual Axis Compensator
- Scanner control: via touchscreen display and WLAN
- Distance accuracy up to  $\pm 2$ mm
- Range from 0.6m up to 130m
- Noise reduction 50%
- Focus3D X 330 offers extra long range - 330m, Focus3D X 130 is a mid-range device offering precise scanning up to 130m.

Before conducting a TLS scan, the operator is required to set the scan resolution, provide an SD card and set the project and scan names. The user then starts the scan which usually takes between 1.5 to 3 minutes (depending on the resolution) for each sample plot. While the scan is progress, the operator can take additional manual field measurements (tree DBH and height) for a selection of trees.

#### **TLS interface**

The interface between the TLS and the field terminal is an SD card which stores all of the scan data. The data stored on the SD card can be sent to Treemetrics' database via SFTP (Secure File Transfer Protocol).



### 2.1.3 *Autostem*

Autostem is Treemetrics' proprietary software for analysing TLS scans. The software identifies tree stems from a point cloud and subsequently generates 3D stem profiles for the identified trees. The raw TLS scans (SD card) must first be filtered before being imported into Autostem.

Treemetrics uses Faro Scene 3D laser scanner software for filtering the raw point cloud data. SCENE 3D laser scanner software is specifically designed for the FARO Focus3D Laser Scanner. SCENE processes and manages scanned data efficiently and easily by using automatic object recognition and scan registration and positioning. SCENE can also colourise scans.

The required information for AutoStem is a filtered set of TLS scans in .dat format. The "cleaned" data is filtered once again by AutoStem to remove branches from the identified tree stems before the tree profile is created.

#### **Autostem Interface**

The point cloud is transferred by the field user via SFTP to Treemetrics' server. This data is pre-processed by SCENE 3D software in a desktop application. The data is then transferred to Autostem by the personnel performing the analysis within the Treemetrics network. Finally, the output of Autostem is loaded to Treemetrics' database in JSON (JavaScript Object Notation) format.

### 2.1.4 *Cutting simulator*

Treemetrics' Cutting Simulator simulates an optimal forest harvest on the basis of maximising the yield of the highest value log products for a given forest site. The simulation is based on a pattern of log products and their relative monetary values. Stem profiles can be generated by Treemetrics from either TLS data or taper models. A definition of the desired log products and a weighting of product importance, which reflects their perceived values for a given harvest operation, are also required as input to the simulator.

The type of defects and the severity of such defects can be customized for each user in the current system. In addition, the "rules" for each severity level need to be defined in the harvesting processor as explained in D4.02.

#### **Cutting Simulator Interface**

The JSON output from Autostem is sent to the Cutting Simulator. If no TLS data has been recorded for a forest site, the tree DBH and height manually recorded in the field are used to generate stem profiles based on taper models and are sent directly to the Cutting Simulator.



## 3 Functional Solution Overview

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The purpose of this section is to review the functional capabilities of the different system elements.

### 3.1 Field app

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#### 3.1.1 Graphical User Interface

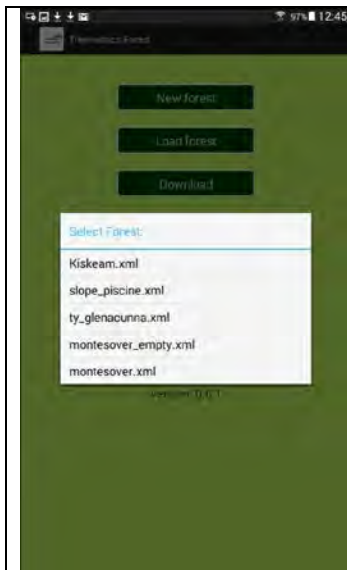
The Treemetrics field app is used for recording field data - both manually and remotely using a wireless bluetooth network. The app has a touch-screen GUI for foresters recording field data. Using the app, foresters can record data for:

- tree DBH/height pairs
- tree DBH for transects
- Angle & distance to dead/forked trees within a TLS plot
- GPS location
- Tree defects observed in the field

Data entered manually into the app includes data relating to tree defects and stocking levels. Ultimately, the data recorded on the app is later incorporated into the cutting simulation.

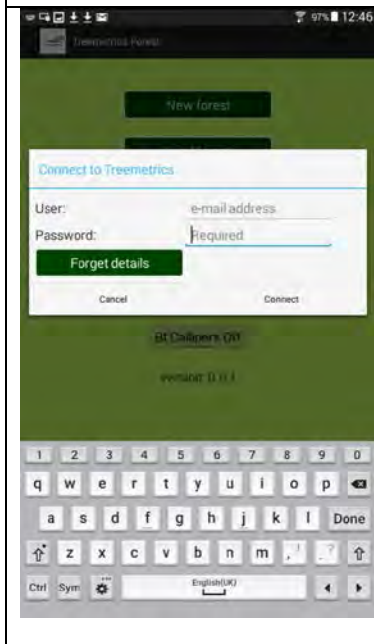
### 3.1.2 Functionalities

	<p><b>Home screen:</b></p> <p>The Treemetrics app home screen presents the user with four options that allow the user to either create a new forest, load an existing forest site, download a new forest from Treemetrics’ database, or continue with the forest site presently downloaded on the app (in this case ty_glenacunna).</p> <p>In addition to the above four options, the home screen has two status bars indicating whether or not the app has been paired with an electronic callipers and/or a range finder device.</p>
	<p><b>New forest:</b></p> <p>Clicking on the <b>new forest</b> option loads a pop-up window requesting the user to provide details for the forest operation they wish to create. Clicking the <b>enter forest</b> button will create the new site and subsequently load the site in the app. This functionality is rarely used by Treemetrics as all new forest sites are created on Treemetrics’ website and subsequently downloaded onto the app before entering the field.</p>



#### Load forest:

The **load forest** option permits the user to open a previously downloaded forest site. The user simply selects the required forest from the list presented.



#### Download:

The **download** option enables the user to download a forest site from Treemetrics' database provided the user has been given permission to this functionality and has been provided with log-in credentials.



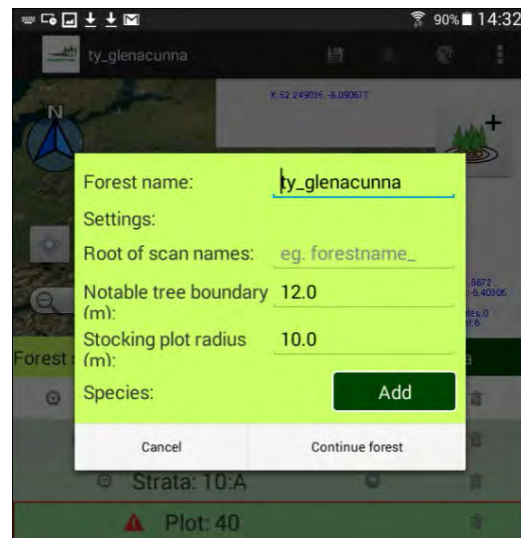
Clicking on the forest name will bring up the site details.

The red warning signs indicate the there are no data associated with the plots.

### Forest site landing page:


Once the selected forest site has loaded, the landing page displays a map viewer highlighting the geographic location of the forest site. The zoom-in/zoom-out functionality allows the user to alter the level of map detail as required.

Below the map viewer, the blocks, strata and plots associated with the forest site are listed. Clicking on any of the plots will load a new page highlighting the details of the TLS scan associated with that plot (note this page will remain blank until scan data is uploaded to the app). Blocks, strata and plots can be deleted and added by the user as required.




	<p><b>Species Tab:</b></p> <p>After selecting a plot, the species tab will allow the user to group the trees in that plot by species, and will also enable the user to set Height pairs and Tree Diameters.</p> <p>After selecting a species type for your forest, you can enter your data by tapping the relevant box (for Height pairs you would click on the box with “0 pairs”). The values for the Height pairs and Tree Diameters will remain red until the user has entered enough values so as to create a valid sample size.</p>
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**New Plot:**

The **create new plot** button  allows the user to create a new plot using the app's current GPS location. Alternatively, a plot can be created for a different GPS location by clicking on the desired location on the map viewer and then clicking on the **create new plot** button.

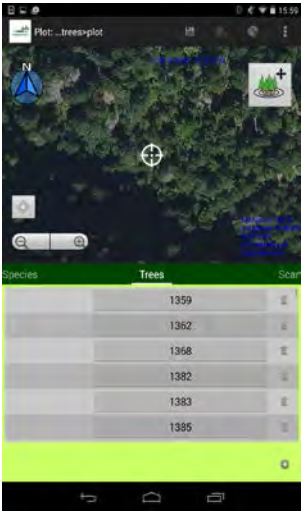


**Default Location:**


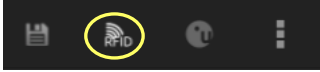

After panning the map viewer, the user can jump back to the apps current GPS location using the centre map button .

**Trees Tab:**

The trees tab will allow you to view each of the trees within that block, as identified by their ID. You can add a new tree to the block by clicking the plus icon in the bottom right corner of the tab.

After tapping on one of the tree ID's from the Trees tab, you are brought to a data entry page. Here you can enter tree specific data such as; DBH, height and quality grading.






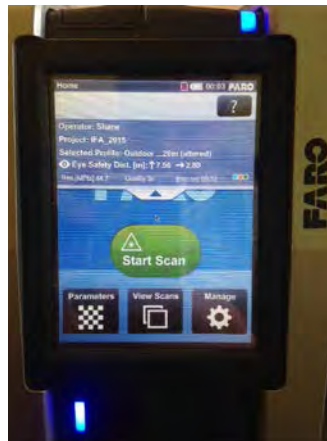
	<p><b>Scan tab</b></p> <p>The Scan tab is used to enter metadata for the scanning device. The Scan number is the unique identifier used to identify specific scan files.</p>
	<p><b>Settings:</b></p> <p>The <b>settings</b> option allows the user to toggle the internal GPS device on or off (used when external GPS has lost reception), to toggle on shapefiles and labels, to save the current forest (typically after uploading the TLS data for each plot), and to send the collected data to Treemetrics where it will be analysed using Autostem and the cutting simulator.</p>
<p><b>Toggle U-Blox (GPS):</b> Used to connect the app to the U-Blox GPS device (external GPS).</p>  <p><b>Toggle RFID:</b> Pairs the app with the RFID reader. If an RFID tag has been assigned to a tree, the forester can scan that tag with the RFID reader and will be presented with the information associated with that individual tree.</p>  <p><b>Save Icon:</b> An alternative method of saving the current forest site.</p>  <p><b>Toggle North:</b> Toggles the map to face north.</p>	

## 3.2 TLS

### 3.2.1 Graphical User Interface

Treemetrics employ a FARO Focus 3D when undertaking terrestrial laser scanning operations. This active remote sensing system is used to create 3D stem profiles. The 3D stem profiles enable better estimations to be made regarding timber values compared to traditional forestry measuring techniques.



The Focus 3D graphical user interface is touch screen and easy-to-use. It presents the user with four options from the home screen: 1) Start Scan, 2) Parameters, 3) View Scans, 4) Manage. Each of these options is discussed in more detail in section 5.2.2. In addition, there is a help button  that briefly explains each of the four options as well as some of the other Focus 3D features.



FARO Focus 3D graphical user interface.

### 3.2.2 Functionalities

The Focus 3D has a touch screen interface that is easily navigable, even to first time users. The home screen presents four initial options to the user:

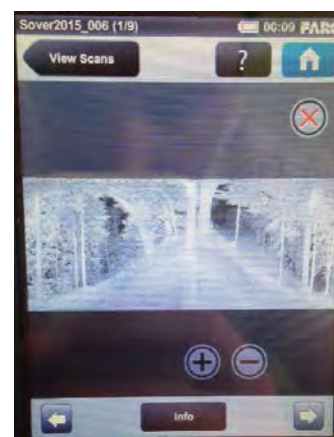
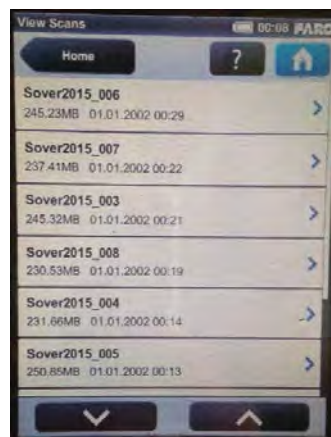
- i. **Start Scan** – initializes a terrestrial laser scan (provided there is an SD card inserted into the device).
- ii. **Parameters** - allows the user to view the system parameters and to edit them accordingly. The help button  can be used for a further explanation of any parameter. In addition, once inside the help menu, a video guide  can be viewed for an even further explanation of how to



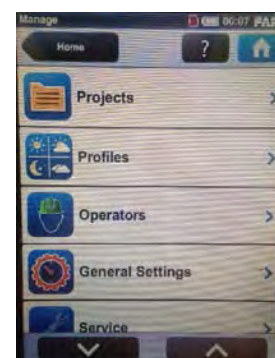


use/set any feature.

- iii. **View Scans** – allows the users to view previous scans saved to the SD card, or to preview the scans recorded during the current scanning session. In addition, the user can view the scan properties for each scan using the **Info** button.



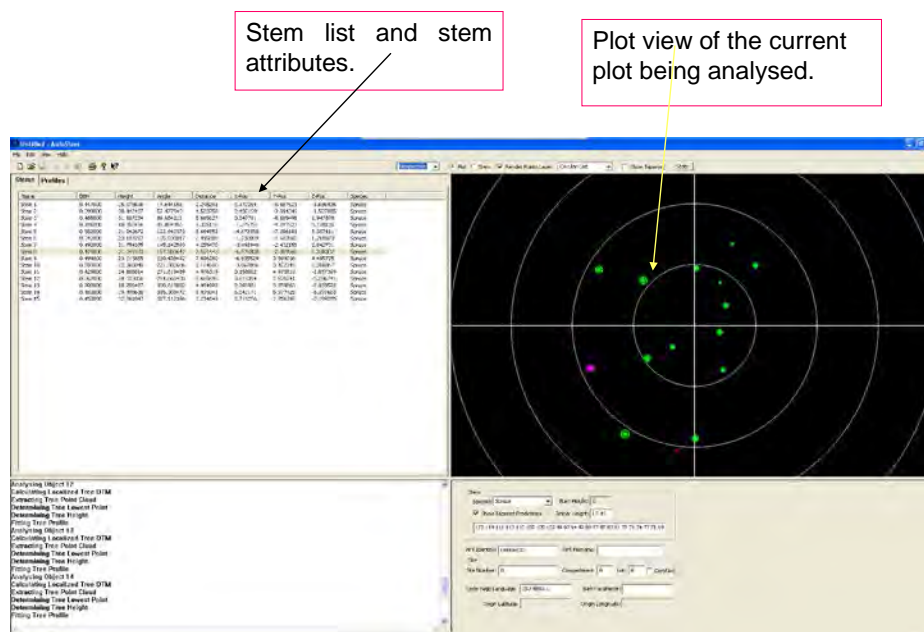
- iv. **Manage** – the manage function permits the user to manage the system settings; such as the General Properties, Operators and Service, amongst others. This functionality is rarely used by Treemetrics.



### 3.3 Autostem

#### 3.3.1 Graphical User Interface

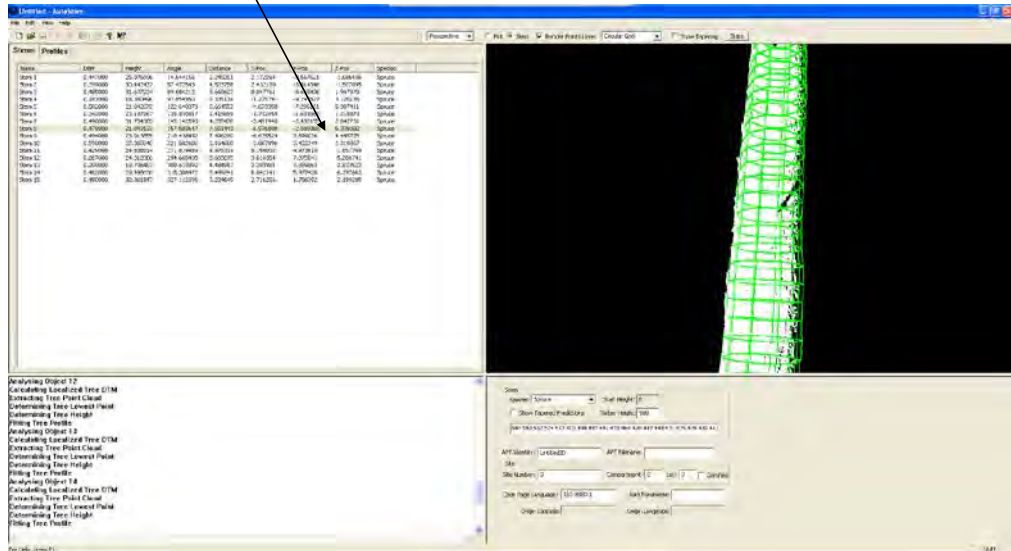
Autostem is a proprietary software package developed by Treemetrics for analysing TLS scans. The GUI design is simple and requires minimal user input. This GUI is designed for internal use by Treemetrics analysts. Other SLOPE users do/will not have direct access to Autostem.



#### 3.3.2 Functionalities

Autostem analyses filtered TLS scans at DBH level for point clusters in an attempt to identify tree stems. After detecting a cluster of points, Autostem then scans for additional points in a two meter radius around the already identified stem. Once a stem has been detected, the software fits decimetre disks to the identified stem up to the point of the tree canopy – thus creating a 3D stem profile. Autostem completes the 3D stem profile using built in height models and taper equations to estimate the top height of the stem.

Decimeter disks fitted to the stem profile identified from the point cloud.



Stem view displayed in Autostem.



## 3.4 Cutting Simulator

### 3.4.1 Graphical User Interface

The GUI for Treemetrics' cutting instruction is a web page with restricted access and is accessible only by Treemetrics personnel. The GUI is used to run harvest simulations which optimise the value of a harvest by extracting the optimal value of timber from a forest. There are five GUI tabs with various functionalities that allow the user to change the different aspects of the specifications required for the cutting simulation – log products and pricing scheme.

This GUI is designed for internal use by Treemetrics analysts. Other SLOPE users will not have direct access to the cutting simulation.



### 3.4.2 Functionalities

The cutting simulator cuts a forest to value i.e. it maximises the value of a forest by cutting the highest number of high value timber products as is feasible.

The Forest tab displays the stem and volume data that the user has uploaded to Treemetrics' Forest Warehouse. The user can click into any forest site to see the field inventory data for that specific forest site. The user analyst can also add any site to the working set and it will later be subject to the cutting simulation.

Working Set		Sales Proposal																																														
<b>Sales Proposal</b> wm_corr>3>3:A>6 <a href="#">Remove</a>		10 <table border="1"> <thead> <tr> <th>Name</th> <th>PreHarvest Date &amp; Source</th> <th>Gross Area (ha)</th> <th>Net Area (ha)</th> <th>Predicted Volume (m<sup>3</sup>)</th> <th></th> </tr> </thead> <tbody> <tr> <td>batovi</td> <td>19/12/2014 Scanner</td> <td>7.83</td> <td>7.83</td> <td>2,103.95</td> <td><a href="#">Add to Working Set</a></td> </tr> <tr> <td>ce_cloonlaheen</td> <td>09/12/2014 Scanner</td> <td>19.5</td> <td>19.5</td> <td>5,153.93</td> <td><a href="#">Add to Working Set</a></td> </tr> <tr> <td>ce_cragbrien</td> <td>15/01/2015 Scanner</td> <td>0.74</td> <td>0.74</td> <td>341.72</td> <td><a href="#">Add to Working Set</a></td> </tr> <tr> <td>ck_killaveenogue_west</td> <td>28/04/2015 Scanner</td> <td>24.72</td> <td>24.72</td> <td>5,524.02</td> <td><a href="#">Add to Working Set</a></td> </tr> <tr> <td>cn_corraleehanbeg</td> <td>16/07/2015 Scanner</td> <td>18.69</td> <td>18.69</td> <td>9,835.42</td> <td><a href="#">Add to Working Set</a></td> </tr> <tr> <td>croghan_rosccommon</td> <td>07/11/2014 Scanner</td> <td>12.94</td> <td>12.94</td> <td>3,961.36</td> <td><a href="#">Add to Working Set</a></td> </tr> </tbody> </table>					Name	PreHarvest Date & Source	Gross Area (ha)	Net Area (ha)	Predicted Volume (m <sup>3</sup> )		batovi	19/12/2014 Scanner	7.83	7.83	2,103.95	<a href="#">Add to Working Set</a>	ce_cloonlaheen	09/12/2014 Scanner	19.5	19.5	5,153.93	<a href="#">Add to Working Set</a>	ce_cragbrien	15/01/2015 Scanner	0.74	0.74	341.72	<a href="#">Add to Working Set</a>	ck_killaveenogue_west	28/04/2015 Scanner	24.72	24.72	5,524.02	<a href="#">Add to Working Set</a>	cn_corraleehanbeg	16/07/2015 Scanner	18.69	18.69	9,835.42	<a href="#">Add to Working Set</a>	croghan_rosccommon	07/11/2014 Scanner	12.94	12.94	3,961.36	<a href="#">Add to Working Set</a>
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croghan_rosccommon	07/11/2014 Scanner	12.94	12.94	3,961.36	<a href="#">Add to Working Set</a>																																											
<b>Cutting Instruction</b> Pallet(3.1... <a href="#">Remove</a> 4.9(20_7min)... <a href="#">Remove</a> At any time click on the 'Cross Cut Results' menu to inspect results of your working set																																																



The Log Products tab allows the user to view the specifications of existing log products. This tab also enables the user to create new log products as desired. When creating a new log product, the user is required to provide a log name, log length, and SED and LED information. There is also the functionality for users to configure the sweep tolerance for a log product in addition to adding species restrictions for a particular product. The user analyst will update these fields when the Slope end user provides this information.

## Log Products

[New Log product](#)

Name	Length	Min Sed	Max Led	Sweep				
<a href="#">Veneer 4.1m 30cm</a>	4.1	300.0		none	<a href="#">More Details</a>	<a href="#">Copy</a>	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Veneer 4.1 45</a>	4.1	450.0		5.0 mm/m	<a href="#">More Details</a>	<a href="#">Copy</a>	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Veneer 4.1 50</a>	4.1	500.0		5.0 mm/m	<a href="#">More Details</a>	<a href="#">Copy</a>	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Sawlog 4.1m 15cm</a>	4.1	150.0		10.0 mm/m	<a href="#">More Details</a>	<a href="#">Copy</a>	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">Biomass 3.0 m 5cm</a>	3.0	50.0		99.0 mm/m	<a href="#">More Details</a>	<a href="#">Copy</a>	<a href="#">Edit</a>	<a href="#">Delete</a>
<a href="#">sawlog 4.1 22 cm</a>	4.1	220.0		10.0 mm/m	<a href="#">More Details</a>	<a href="#">Copy</a>	<a href="#">Edit</a>	<a href="#">Delete</a>

## Log Product

\* required fields

Name\*:

Length (m)\*:

Min Sed (mm)\*:

Max Sed (mm) :

Min Led (mm) :

Max Led (mm) :

Log Type :

[Show Species Restrictions](#)

[Add Sweep Config](#)

The user analyst can view the pricing scheme for different log products from the Pricing tab. Additionally, the user analyst can specify a weighting (or pricing) scheme for a new log product in addition to editing and deleting existing weighting /pricing schemes.



## Pricing Scheme Creator

\* required fields

Name\* :

Log product\* :

Sed Class (mm):	<input type="text"/> +	<a href="#">Add Sed Class</a>
Value Per Cubic Metre (€):	<input type="text"/>	

[Add Product](#)

[Back](#)

The user analyst can view existing cutting instructions from the Cutting Instructions tab or alternatively, can create a new cutting instruction. Cutting instructions are a combination of different log products and their respective weightings of importance for a particular harvesting operations. The product weightings typically reflect market demands for a particular product.

## Cutting Instruction Creator

\* required fields

Name\* :

Log product\* :

Sed Class (mm):	<input type="text"/> +	<a href="#">Add Sed Class</a>
Weighting Value:	<input type="text"/>	

[Add a Instruction Item](#)

[Back](#)

## 4 Interface with Slope modules/elements

Treemetrics' SLOPE solution communicates with the SLOPE field application and the SLOPE database in order to update the SLOPE Forest information system. The interaction with the overall SLOPE solution can be divided into 7 steps and is described as such below.

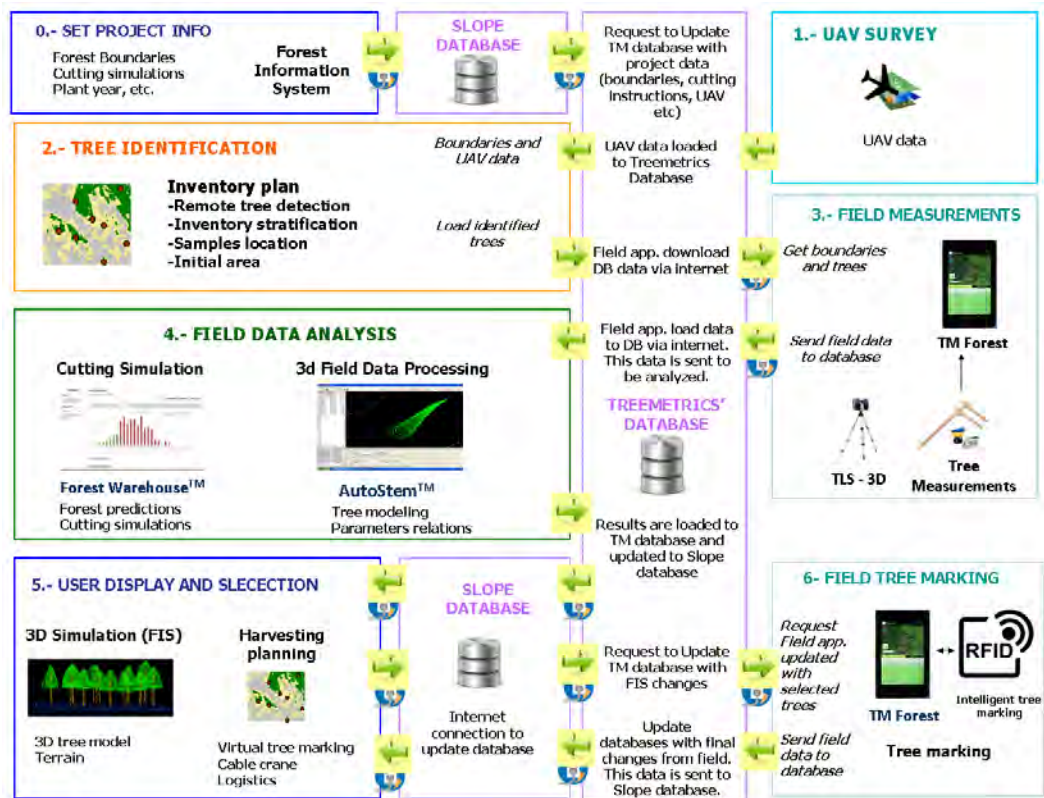


Figure 2: Treemetrics System Architecture

### 0.- SET PROJECT INFORMATION

The first step of a project is the definition of the area of interest and other relevant parameters such as project name, stand age and cutting instructions. These parameters shall be provided by the client using the SLOPE platform.

According to the SLOPE platform architecture, the user inputs are managed by the Forest Information System (FIS) graphical user interface.

The FIS web application is also the main element where the user executes simulations and is presented with the associated results. The Cutting simulation provided by Treemetrics is an example of such a simulation however, in order to



perform this simulation. The user must input the data relating to the "log products" definitions and the desired "cutting instructions".

These data will be included in the Slope database by a Database GUI provided by Graphitech (FIS). This information will be updated in the Slope database and FIS will notify Treemetrics system that an update and/or re-process of the data is required using a specific API based on a URL.

#### 1.- UAV SURVEY

High resolution imagery (lower than 0.5m) is required in order to perform the tree detection analysis and to accurately locate trees in the field . Therefore, the collection of UAV data is a key step in the planning of SLOPE harvesting operations.

Treemetrics require high resolution imagery to identify individual trees and to subsequently prepare the field inventory.

#### 2.- TREE IDENTIFICATION

Treemetrics manually carry out the tree identification analysis. This analysis is performed using GIS desktop applications as explained in D2.03. The result of this analysis is a CSV containing all the trees identified from the UAV image. The CSV is loaded to the database in the same structural format as a standard XML. The connection to the database in this case happens locally within Treemetrics' facilities.

#### 3.- FIELD MEASUREMENTS

After the tree detection has been performed and the data uploaded to the local Treemetrics database, the SLOPE field user is able to access and download the tree data (to the Field application). In addition, to the detected trees, the forest area shapefile and the UAV data are imported onto the mobile application.

The SLOPE user requires an internet connection and a username and password to be able to download the data to the field app.

The mobile field application is used for recording data during the field measuring exercise. After the field data has been collected, the recorded data is sent back to the Treemetrics database via an internet connection. The data is transferred and uploaded to the Treemetrics database automatically.



#### 4.- FIELD DATA ANALYSIS

After the data has been uploaded to the Treemetrics database, an email notification is sent to the analysis team. The analysis of the field data, which includes the TLS data and other recorded parameters, is performed by Treemetrics personnel using Autostem.

After the analysis is completed, the tree and timber log information is loaded to the common SLOPE database using the SLOPE database API.

The figure below shows the different data types sent to the SLOPE database, including, at tree level, timber products and timber logs. An example of the database API is shown in Appendix 1.

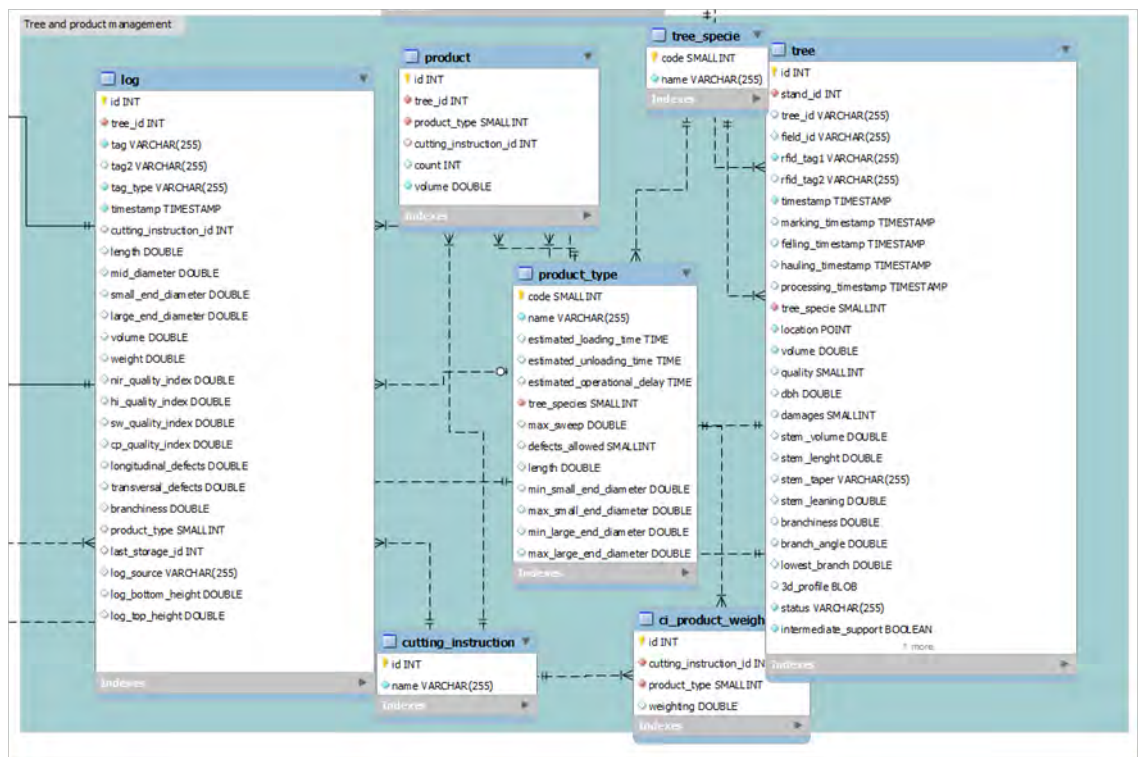


Figure 3: Database structure

#### 5.- USER DISPLAY AND TREE SELECTION

The data stored in the SLOPE database can be accessed by other SLOPE applications, such as the Forest Information System (FIS). SLOPE users can modify the database using FIS and can edit specific attributes which are displayed in the field application. An example of this is the tree marking application, whereby a user can mark a standing tree to be harvested using the FIS.

FIS will update the SLOPE database information and notify Treemetrics of any changes that have been made to the SLOPE database via a URL execution (E.g. [slope.treemetrics.com/slope/update\\_database](http://slope.treemetrics.com/slope/update_database)). This will allow Treemetrics to update its internal database and to ultimately display the correct information in the field application.

Due to the fact that the field application loads data locally, the user needs to execute the download when there is an internet connection available in order to update the changes in the field application.

#### 6.- TREE FIELD MARKING

Finally, after the trees have been marked virtually in the FIS and uploaded to the database, the forester in the field can download the updated data in the application and will be able to see which trees have been marked for harvesting. The forester can use the field application to easily navigate to the virtually marked trees and can mark them accordingly. It is also possible for the forester to add a RFID tag to each marked tree.

Any modification that the field user makes to the tree attributes can be uploaded to the database by selecting the "Load data" button. The same approach can be used to mark trees that have been harvested within the forest area.

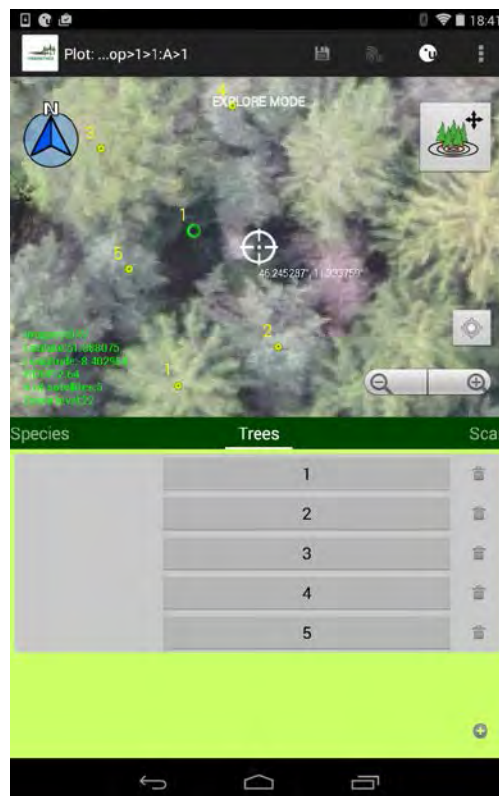


Figure 4: Find tree for field marking using the field app.



## 5 Known bugs and limitations

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The following bugs and limitations have been discovered and will be subject to fixes and improvements during the integration phase:

- The TLS is limited in that it cannot record stem data for the portion of a stem that is in the tree canopy.
- Shrubs and other vegetation can interfere with the scan data.
- GPS accuracy is problematic under the forest canopy and can lead to difficulties when navigating to the plot centres.
- WLAN reception can be problematic under a forest canopy – this is troublesome when recording field data using the app.



## 6 Conclusions

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The current document provides an overview of the main functionalities developed in the context of task 4.01 “Data mining and model integration of stand quality indicators from on field survey for the demonstration of the tree 3D quality index” and is available as a service to the SLOPE consortium. The developed tool is based on an existing Treemetrics system that has been modified to facilitate new functionalities as required by the SLOPE partners. Modifications made to the existing system include the introduction of the ability to record tree data in the field, tree quality, UAV analysis and the incorporation of cross-cut simulations that comply with SLOPE cutting instructions.

Although the presented functionalities are working, it is important to note that they are far from complete. Treemetrics aim to automate the processes of recording field data, analysing UAV imagery and integrating data with the SLOPE database. An iterative development approach has been defined in WP6 and is currently ongoing.

## 7 Appendixes

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### 7.1 Appendix 1: Example of Database API

---

```
"timestamp": ,
-----
Time stem recorded?

json:
  "timestamp": "2015-09-01 10:00:00"

"status":
-----
status of tree

json:
  "status": "standing"

tag
-----
tag of the tree

json:
  # rfid present
  "tagType": "rfid",
  "tag1": "E20020638614020119404B16",
  "tag2": "",

or

  # rfid absent
  "tagType": "none",
  "tag1": "",
  "tag2": "",

"location":
-----
location of the tree

json:
  "location": "POINT(46.23216083333333 11.3270985)",

tree measurments
-----
volume, length, dbh and age of tree
```



```
json:
  "volume": 2.4374415582392785,
  "stemVolume": 2.4374415582392785,
  "stemLength": 31.1,
  "dbh": 0.474105,
  "age": 0,
```

#### tree profile

-----

a representation of the tree. this contains data on several samples taken every 10cm up the tree. Each sample contains a xCoord, yCoord, zCoord from the center of the scan along with the diameter of the sample.

```
json:
  "dProfile": "[
  {\"diameter\":557.72,\"xCoord\":1967.0,\"yCoord\":-
  612.0,\"zCoord\":-
  2834.0},\".\".....\" ]\",
```

#### relationships to other database objects

-----

id's of the stand and species the tree belongs to

```
json:
  "stand": {
    "id": "11"
  },
  "treeSpecie": {
    "code": "6"
  }
```

#### data yet to be decided

-----

```
json:
  "quality": 0.0
  "damages": 0
```

#### timestamps

-----

timestamps not being filled in by treemetrics.....

```
json:
  "markingTimestamp": null,
  "fellingTimestamp": null,
  "haulingTimestamp": null,
```

#### other data?????

-----



other data in the database not being filled in by treemetrics.....

json:

```
"stemTaper": 0.0  
"stemLeaning": 0.0  
"branchiness": 0.0  
"branchAngle": 0.0  
"lowestBranch": 0.0  
  
"anchor": false,  
"intermediateSupport": true,
```