PICUS

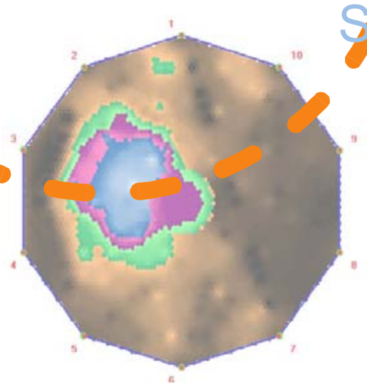
Sonic Tomograph

Schalltomograph

Tomogramma sonico

Geluidstomograaf

Scanner sonore



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PICUS© Sonic Tomograph

Manual

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1. Introduction

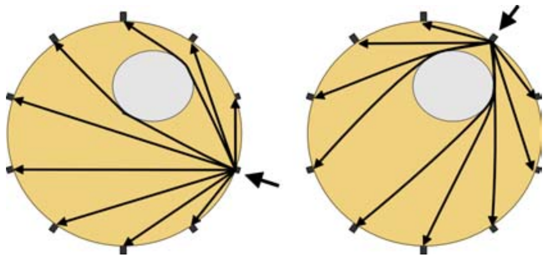
1.1. How sonic tomography works

The PICUS® Sonic Tomograph uses the fact that the velocity of sound in wood depends on the modulus of elasticity and the density of the measured wood. Most damages, which impair the safety against fracture of trees, in particular cavities, white rots, and brown rots reduce elasticity and density in wood. However, since these wood characteristics vary both within a tree species, and between the tree species, only large damages can be found by a comparison of individual sound velocities, which were measured on a specific tree, with tabulated standard values.
The PICUS® Sonic Tomograph therefore uses relative sound velocities so that the system calibrates itself automatically at each measured cross-section.

PICUS® Sonic Tomograph installed on a tree.

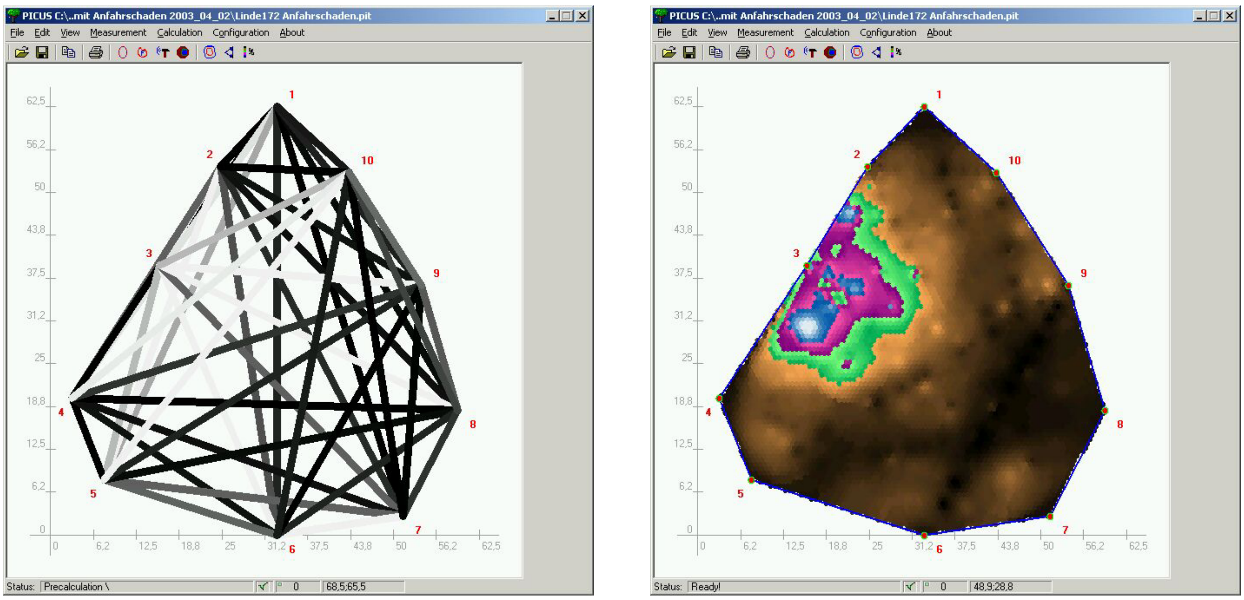
The PICUS® Sonic Tomograph consists of a set of sensors (typically 8 to 12), which are strategically placed around the tree.
Each sensor is connected to a pin or nail (0.8 - 2 mm in diameter), which is tapped into contact with the wood - onto the latest tree ring - by a pin hammer at each inspection point.

The sensors record the times of flight of sound waves manually induced by knocking with a small hammer. From the times of flight of the sound wave and the distances between the sensors, apparent sound velocities are calculated.



Measuring principle of PICUS® Sonic Tomograph

Since every sensor records time of flight from every impact, a dense network of sound velocities across the cross-section collected. From these data, a Pocket PC instantly calculates a full coloured tomogram of the trees cross-section right at the tree.



The “network” of sound velocities and a Tomogramm of a Linden tree several years after car impact damage

This tomogram gives information about the presence of decay and cavities in the tree. In this tomogram many features, e.g. remaining wall thickness and opening angles of cavities can be measured with the computer mouse.

2. Components of the PICUS® Sonic Tomograph

The measurement case of the PICUS® contains the following equipment:

1 measuring tape
1 strap with buckle
1 hammer
1 Y - cable, (Y - shaped cable with magnetic poles)
1 pliers
1 box of roofing felt nails (different lengths) for trees with different barks
1 Pocket - PC (if ordered)
1 PICUS® power supply
1 PocketPC RS232 cable (optional), connection between PICUS® and Pocket - PC (beige)
1 PICUS® data cable, connection PICUS® module chain to PICUS® power supply

Contents of the measuring suitcase

3. Sonic measurements

A PICUS sonic measurement consists of five main steps:

1. Determination of the measuring level on the tree and of the number of measuring points
2. Determination which geometry fits best: Is the cross section of the measuring level of the tree "elliptical" shaped or is it very irregular?
3. Mounting of the equipment on the tree
4. Carrying out the sonic measurement
5. Calculation of the tomogram

The most important decisions at the tree are where to measure, how many measurements are to be made, and which geometry fits the trunk best.
If the cross-section is shaped circular or elliptical, please read chapter

"Measuring geometry of elliptical trees".

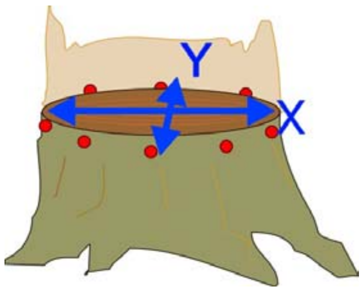
If the cross-section has an irregular form, then proceed as described in section

"Measuring free geometry".

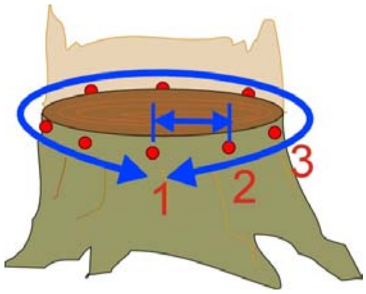
In order to achieve the maximum precision, we recommend using the "free shapes" geometry.

3.1. Measuring geometry of elliptical trees

1. Determine the smallest and largest diameter of the trunk at the height where the measurement is to be made.

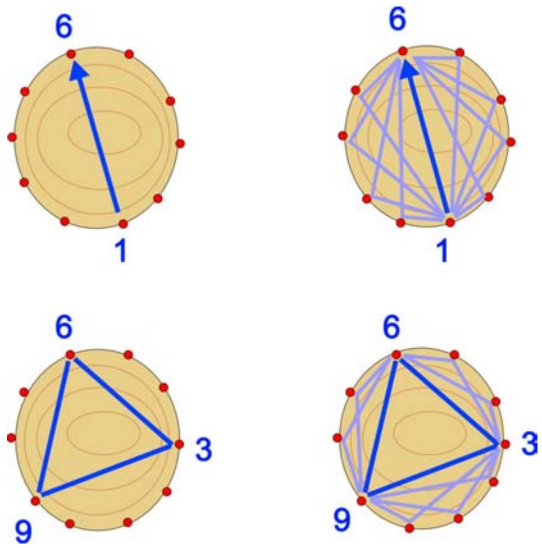


2. Fix the tape around the tree at the height of measurement. The zero point (and sensor 1) coincides with the largest diameter! Read off the circumference.
3. Input of geometry of the tree into the PICUS program: "measurement" → "change geometry" → "ellipse". Enter the X and Y diameters. The distance between sensors is calculated.

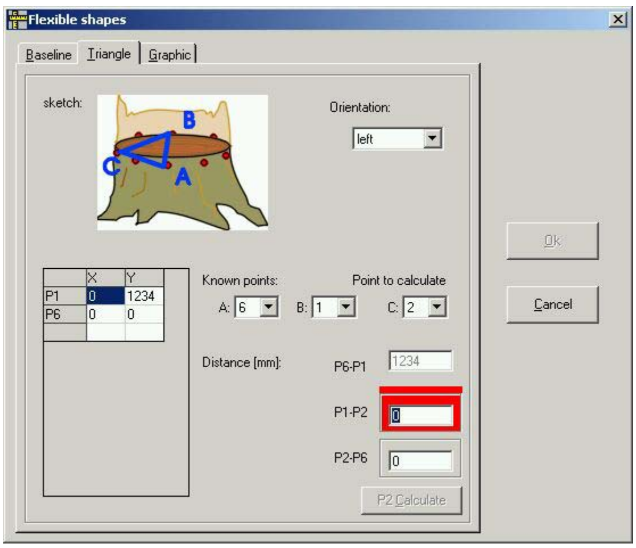


3.2. Measuring free geometry

To record the geometry of irregular shaped trees the "Free shapes" feature of the program can be used. The working principle of this toll is the following: If all three sites of a triangle are known, the exact shape can be calculated.
Depending on the size of the tree and on the size of the calliper you can either use the "One - Baseline System" or "Three - Baselines - System".
The following sketches show what distances have to be measured in both cases.



Enter the distances into the program. The accurate shape of the tree is calculated.



3.3. Sonic measurement

After having entered the geometry sensors and pins can be mounted.

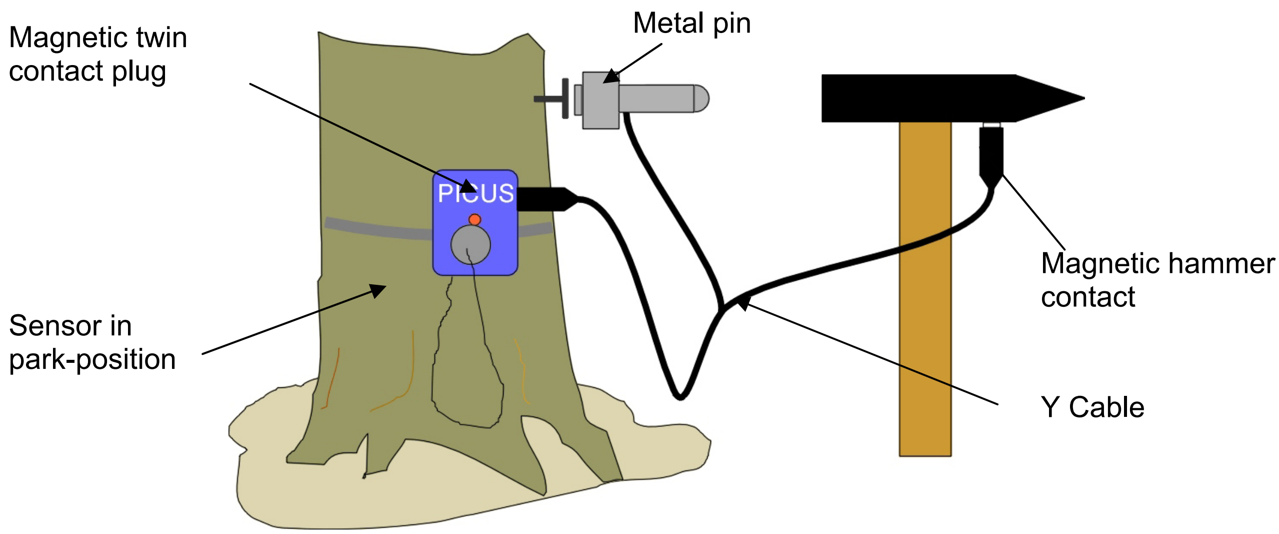
4. With the hammer provided, bring the sensor pins onto the wood at the distances calculated before. **Sensors** must be mounted **anti clockwise**: Sensor 2 is to be mounted right from Sensor 1 and so on.
5. Fix the black belt to the tree approx. 10 cm underneath the tape. If you plan to measure on two different levels on the tree, attach the belt between the measuring levels to save time (sensor cable length = 60 cm).

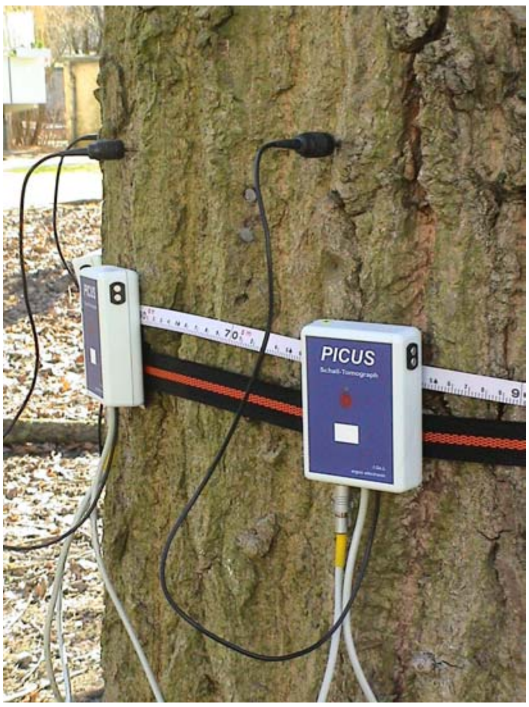
6. Attach modules to the belt and sensors by means of the magnet to the sensor pins
7. Start the measurement of sound velocities: “measurement” → “measure sonic”.
8. Tap hammer on the knocking pin. Repeat twice.
9. Continue this process on each module until the last sensor has been measured. Calculate the tomogram.

3.4. How to generate sound waves

In order to generate sound waves please use the “Y - Cable” provided. The use of the Y - cable causes best signal quality.

The sketch shows the “Y - cable”.





Modules on the tree

Taping on the pin

4. Calculating the tomogram

4.1. General

The tomogram of the sonic measurement can be calculated on the PocketPC or in more detail on the PC in the PICUS analysis software.

Note: Due to the limited calculation speed of the PocketPC the tomogram of the PocketPC is different from the tomogram of the PC program.

To calculate the tomogram simply click on “Calculation” Button of the PICUS analysis software. On the PocketPC the calculation takes several minutes.

4.2. Reading the tomogram

The PICUS® Sonic Tomograph detects and shows differences in the ability of the wood to transmit sound waves.

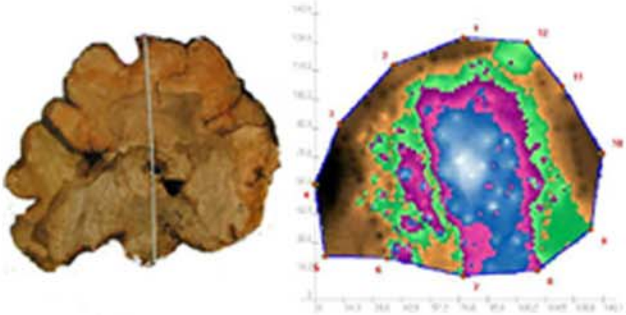
It does not differentiate between decay or cavities, both are shown as pale blue or white.

Dark colours (black to brown) in the tomogram indicate areas of the trunks cross section where the sound travels relatively fast - compared to violet and blue areas. In violet and blue areas the sound travels relatively slow.
Green indicates the area between fast and slow sound transmission.

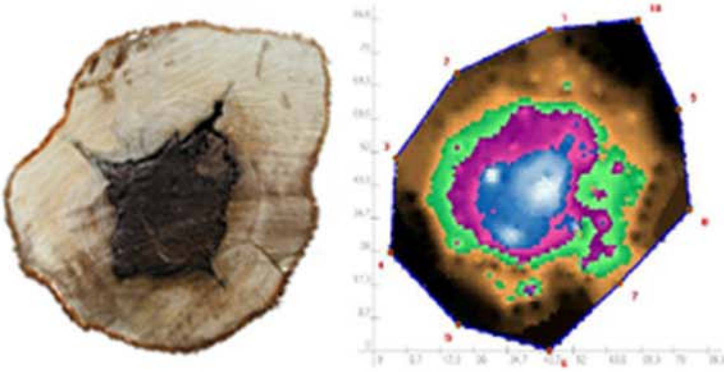
1. Axis scale: At the left and at the lower edge of the tomograms there are scales, which represent the extent of the examined cross-section.
2. Sensor positions points: red points with numbers denote the sensor positions. Sensor 1 is always at the top of the tomogram. The sensors are arranged anti clockwise.
3. Cross-section: a blue line, which connects the sensor positions, delineates the perimeter of the stem cross-section. Within the blue line, the wood is coloured according to the relative sound velocities measured. Brown represents solid wood. The colours green, violet, and blue indicate increasing degrades of decay.
4. Distances and angles: In the tomogram, distances (e.g. the diameter of cavities) and angles (e.g. the opening angle of an open cavity) can be measured and displayed.

The images in the following chapter show some examples of tree cross-sections and their tomograms.

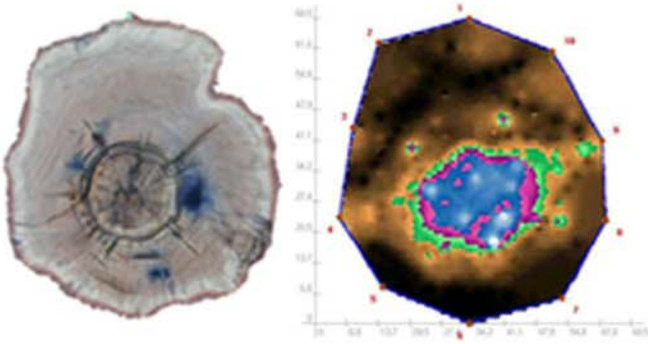
4.3. Examples for tomogramms of the PICUS© Sonic Tomograph



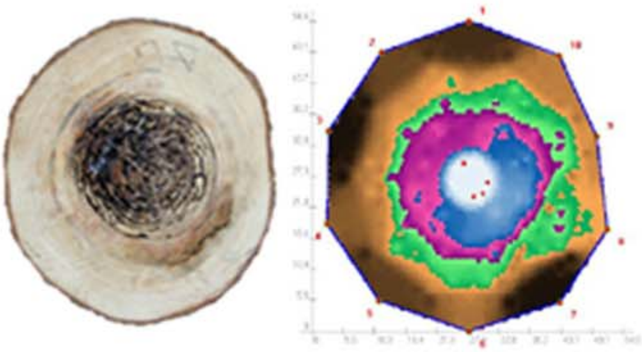
Linden tree with a severe *Ustulina deusta* infection (Germany)



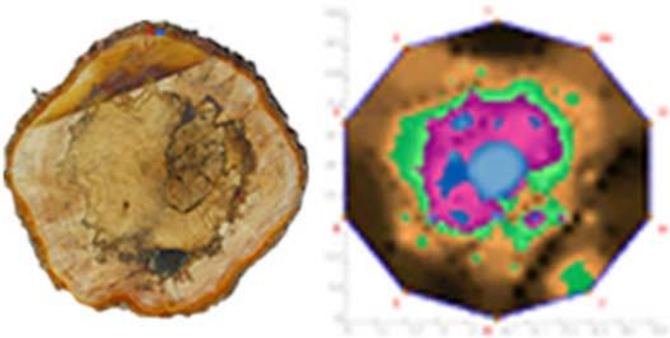
Linden tree with a large filled cavity (Germany)



Red oak with shake (circular crack) (Germany)

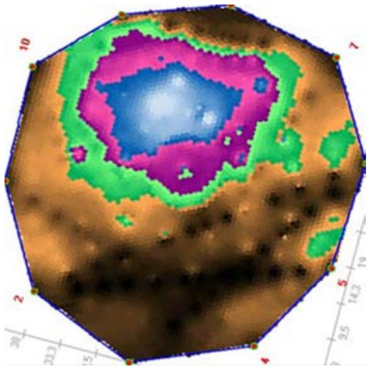


Spruce with *Heterobasidion annosum* and ant damage (Germany)

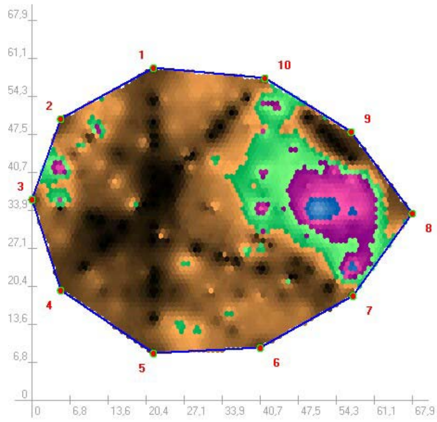


Birch with rot (Germany)

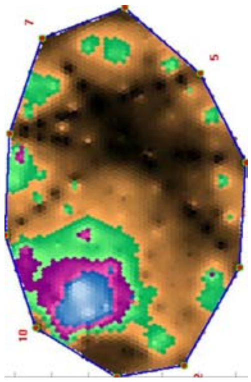
Oak (North America)



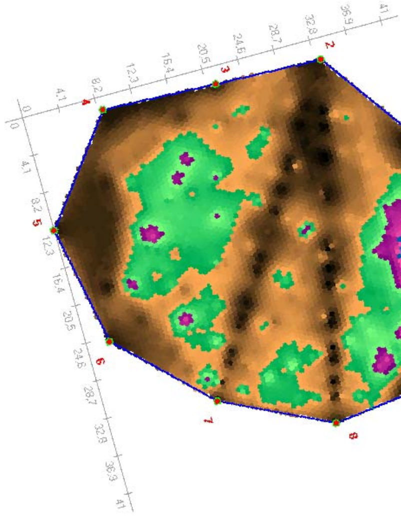
Oak (North America)



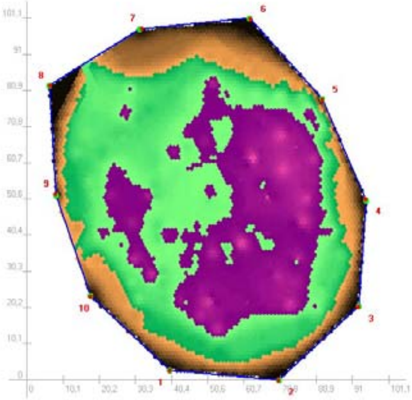
Oak (North America)



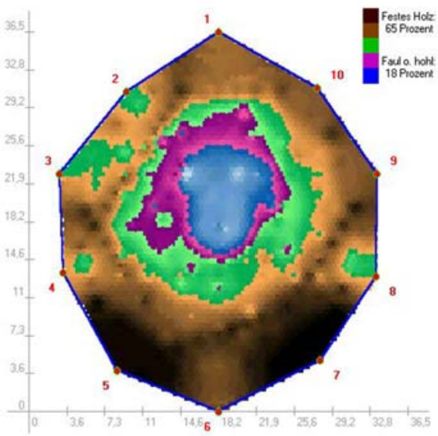
Hickory (North America)



Beech with White Rot (New Zealand)

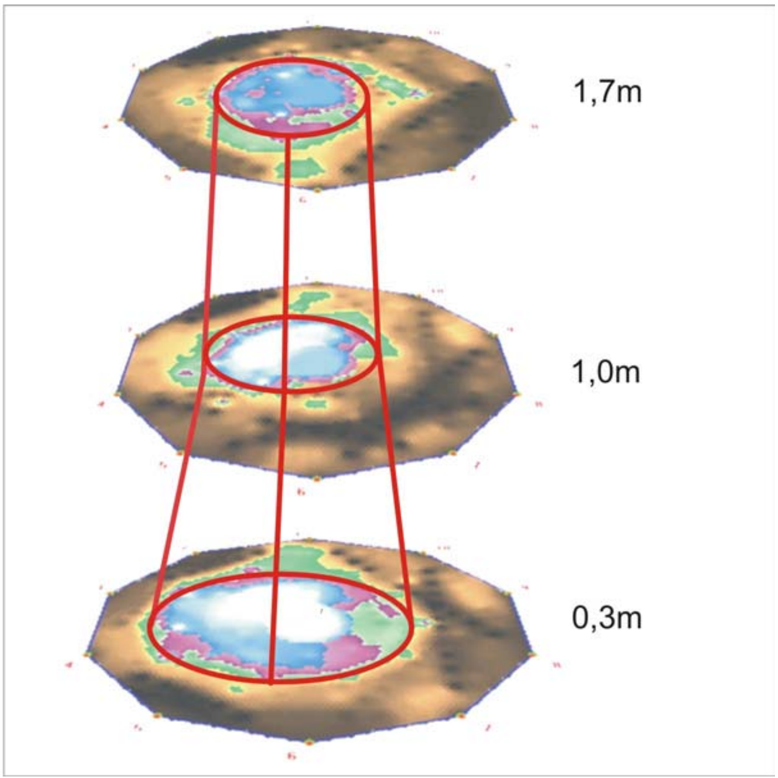


Plane tree with Ustulina deusta (Germany)



5. 3D calculations - multiple measurements

In order to find out the source of a decay, the tree should be measured ("tomographed") in several levels.
If the extension of the decayed area becomes smaller in upper tomograms the decay is probably root related.
The tomograms can be placed on top of each other to show the changes in the tomograms in detail.
The example shows an oak, measured in three levels. The red - marked structures become smaller in the upper tomograms - the decay is therefore most likely cause by damaged roots.



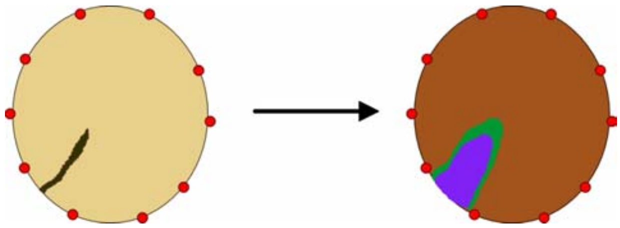
Three tomograms of an oak

6. Peculiarities in interpretation of the tomogram

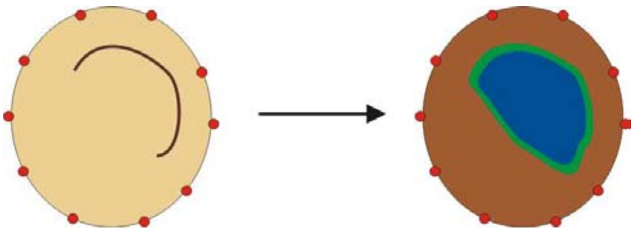
If you interpret a tomogram please mind the following peculiarities:

1. Wetwood - (Populus vs. Aesculus). If a tree suffers from wet wood, the tomogram sometimes shows the wet wood area like being hollow.
2. Cracks are show wider than they are. This is because the resolution at the edges (!) of the tree in the tomogram is limited to the distance between sensors. If necessary make smaller the distance between the adjacent sensors and repeat the sonic measurement.

Tree with crack | Tomogram of this tree

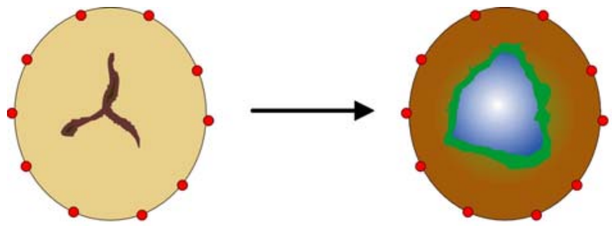


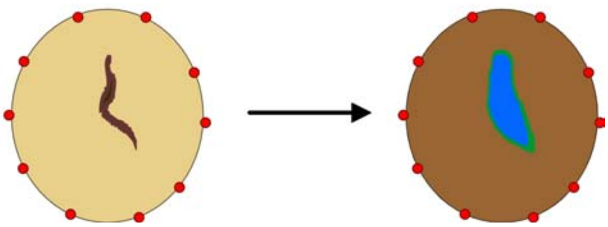
3. Ring shaped cracks - Eucalyptus trees tend to have ring shaped cracks.



4. Star shaped cracks - because the sonic waves surround the crack. Old oaks tend to have cracks like this.

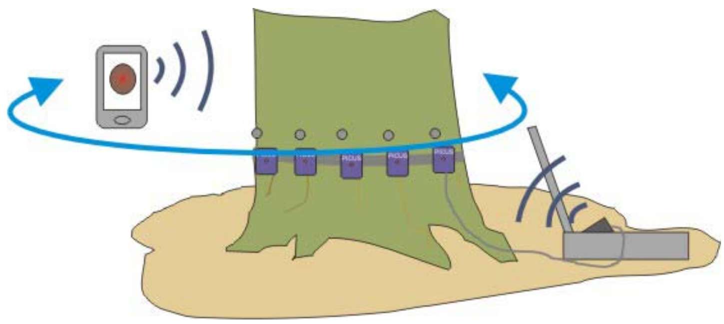
Slice of a tree with “Star shaped” crack | Tomogram of this slice





7. PICUS® with Bluetooth™ - wireless radio technology

In order to improve the handling of the PocketPC during sonic measurements PICUS® Sonic Tomograph is available with integrated Bluetooth™ module. Using this feature the tree expert can move freely around the tree during a measurement with the PocketPC in his hand without being hindered by a cable.



An iPAQ PocketPC - with the latest 'bluetooth' radio frequency, cable-free transfer technology - is recommended to be used.

8. Technical data

Dimensions of the unit:	540 x 480 x 180 (B x T x H) [mm]
Weight of the unit:	11.3 kg
Power supply:	Charging unit at 100 – 240 V~ (AC), 50 Hz
Type of Accumulator:	Lead accumulator
Accu power:	2,1 Ah. The accumulators get older. Therefore, the age and number of charging/discharging procedures reduce the capacity.
Charging time:	max. 10 hours, (no overloading because of automatic turn off)

Power consumption of one PICUS module: approx. 35 mA

Time of operation at 20°C:	
with 8 Modules:	approx 7,5 h, meets 80 trees: 5 min / tree
with 10 Modules:	approx: 6 h, meets 50 trees: 7 min / tree
with 12 Modules:	approx: 4 h, meets 24 trees: 10 min / tree
Operation temperature:	0°C to 40°C
Humidity:	Electronic devices can be damaged by humidity. The PICUS Sonic Tomograph should be protected against the direct impact of water and humidity. Nevertheless, the system is protected against light rain.
Release date of this manual:	05 May 2003

9. Address

PICUS Sonic Tomograph was developed by two German companies:

argus electronic gmbh in cooperation with the

tree experts from the ***Institut für Gehölze & Landschaft GmbH.***

argus electronic gmbh

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