FlexWood

Flexible Wood Supply Chain

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# Allocation procedures for existing harvesting and logistic concepts


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SEVENTH FRAMEWOR PROGRAMME

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# Abbreviations

| | |
|---|---|
| 2D | 2-Dimensional |
| ALS | Airborne Laser Scanning |
| CBH | Crown base height |
| CDmax | Maximum crown diameter |
| CL | Crown length |
| cm | Centimeter |
| D | Stem diameter at breast height (1.3m) |
| D7 | Stem diameter at height 7m |
| dm | Decimeter |
| FASY | Fagus Sylvatica (European Beech) |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| H | Crown top height |
| Lidar | Light detection and ranging |
| m | Meter |
| max | Maximum |
| min | Minimum |
| mm | Millimeter |
| PNSY | Pinus Sylvestris (Scots Pine) |
| $R^2$ | Coefficient of determination |
| REF | Reference inventory measurements |
| TLS | Terrestrial Laser Scanning |
| WP | Work Package |

# Figures



# Tables

# 1. The Approach

## 1.1 The rationale

The main objective of this Deliverable 5.2 is the description of procedures and processes for the allocation of forest raw material to the industry. It builds the link between industry and forestry. Basis is, on the one hand, the data on the industrial requirements towards forest raw material; this has been elaborated in WP3000 “Meeting of industrial requirements” and WP5300 “Interface and methods to meet market based quality and quantity requirements”. On the other hand, it is the data on the forest resource from novel inventory technology - the outcome of WP5300 and WP4000 “Integrated forest inventory design for optimized quality and quantity assessment of wood resources”.
The rationale of this Deliverable 5.2 is the conceptual development and description of how to match these points.
Following the principle of demand-driven wood procurement, the industrial requirements are used as a starting point. These are converted and condensed into an appropriate format, common across the participating European countries, (cf. chapter 2.2), which contains both dimension and quality information (“List of requirements”).
Secondly, the results of the inventory based assessment of the existing forest resources are converted into a format compatible with the list of requirements. Inventory concepts with varying technical methods have been alternatively developed in the Flexwood project and are applied in the different use cases. Therefore, the matching procedure may differ (technically) from case to case. In this Deliverable, the “Central European Case” is described in detail as an example (model case) (cf. Fig. 1) to describe the conceptual procedure.

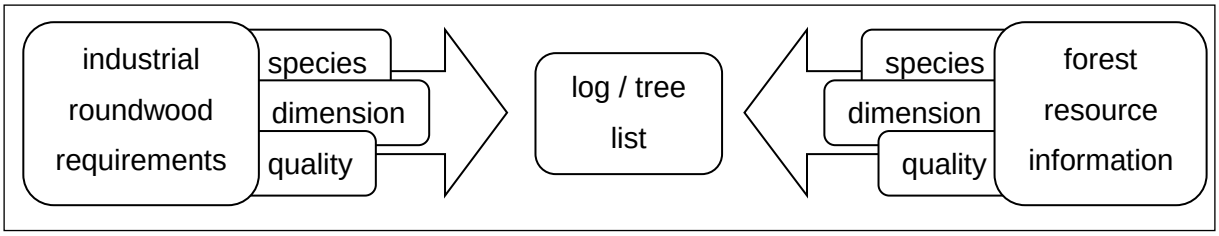


**Fig. 1 Central European Case: example for the matching procedure**

# 2. Industrial requirements

## 2.1 Establishment of requirement tables

Industry information regarding requirements towards the procurement of raw material (logs) has been collected in cooperation with WP3000. Enquiries and expert interviews have been conducted and the results thereof have been compiled separately for sawmilling, pulp and paper and wood energy industries. Specific requirements tables have been created based on standards, as well as numerous interviews and roundwood procurement specifications from several companies in Germany, Poland, Finland, Sweden and France.

Summarizing the results, it is important to state that the industrial requirements are based on and expressed towards the intake product (being either individual logs or a population of logs with an average or specified distribution of requirements). This makes the matching procedure complicated since forest resource information is typically on stand (= population of trees with average or specified distribution of attributes) or sample tree level (cf. chapter 0)

Regarding the parameters, the requirements of the wood-consuming industry are quite similar within each industrial sector, be it sawmilling, pulp, paper and fiber or bioenergy industry. This can be explained by the fact that the applied conversion technology is similar in each of these.

In contrast, the specific values of the parameters are different. This is a consequence of the markets that the different mills currently supply or - in the case of the bioenergy industry - the size of the mills. This translates into individual differences in the threshold values for each parameter. As these may change quickly over time, following the market pattern of supply and demand, it seems appropriate to stay on the category level and describe the procedure of how to extract the values for the specific parameters of the categories from the available resource inventory data.

## 2.2 The structure of industrial requirements

From the enquiries in collaboration with WP3000 and WP6000 it was obvious that the sawmilling industry has the most specific demands, so it serves as an example to describe the industrial requirements in the following chapters. The pulp paper and fibre industry as well as the energy industry follow the same concept, but with a lower grade of complexity and with less detailed parameters. Three main requirement categories can be differentiated: Species, dimension and quality.

### 2.2.1 Species

Defined tree species is one of the major requirements of the industry (cf. Flexwood Deliverable D 3.1). Different tree species show different properties regarding processing and use and thus industrial requirements may differ between species. In some cases, industry forms species groups with similar raw material characteristics regarding their product. These are e.g. white softwood (Spruce/ White Fir) versus colored softwood (Pine/ Douglas Fir / Larch).

### 2.2.2 Dimensional requirements related to logs

The log dimension requirements of sawmills depend on the sawing technology and the product to be produced from the roundwood. However, sawmills usually specify their requirements regarding accepted log dimensions either by indicating a defined value, a value range or minimum or maximum values for the following dimensional parameters:

- log length (fixed or range of values)
- diameter (range of accepted top end diameter, large end diameter or mid diameter values – this mostly depends on the region and the related customs or standards)
- taper (maximum values)

The parameter taper is derived from both categories: the dimensional and the quality requirements.

All dimensional requirements have in common that they are quantifiable and measurable. In addition, they can be assessed on the exterior both on standing timber before harvest and on logs after harvest.

**Table 1 Example of saw log dimension requirements (PNSY Germany)**

| parameter (e.g. diameter, knottiness, taper, moisture content,…) | description of parameter | reference unit | specific values (min, mean, max,…) | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) |
|---|---|---|---|---|---|---|
| | | | type | type | | |
| | | | min | max | | |
| diameter | top diameter | centimeters [cm] over bark | 13 | 55 | measured | log level |
| diameter | butt diameter | centimeters [cm] over bark | | 55 | measured | log level |
| length | log length | decimeters [dm] including cross cut allowance | 31 | 44 | measured | log level |
| taper | | millimetres per linear meter [mm/m] | 0 | 20 | measured | log level |

Table 1 is extracted from the requirements tables described in chapter 0 and gives an example of German saw log dimension requirements for Pine (PNSY), specifying an accepted range of top diameters by indicating both minimum and maximum top diameter, the maximum butt diameter, the accepted log lengths and the maximum taper.

### 2.2.3 Quality requirements

Ultimately, the quality of the product (sawn timber) to be processed depends on the interior quality of the log. As this interior quality of the wood can only be determined in the mill after sawing, exterior parameters are assessed to derive it at an earlier stage. Therefore the third category of industrial roundwood requirements are those related to the quality of the roundwood (logs). This refers to the knottiness, sweep, shakes, damages and so forth. An example of a set of quality related parameters is given in Table 2 for German Pine (PNSY) saw log quality requirements, again extracted from the requirement tables as described above.

**Table 2 Example of saw log quality requirements (PNSY Germany)**

| parameter (e.g. diameter, knottiness, taper, moisture content,…) | description of parameter | reference unit | specific values (min, mean, max,…) | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) |
|---|---|---|---|---|---|---|
| | | | type | type | | |
| | | | min | max | | |
| sweep | smooth sweep of log | millimetres per linear meter [mm/m] | | 30 | visually estimated | log level |
| sound knot | size of knot | millimetres [mm] | | 80 | visually estimated | log level |
| dead knot | size of knot | millimetres [mm] | | 70 | visually estimated | log level |
| rotten knot | size of knot | millimetres [mm] | | 40 | visually estimated | log level |
| rot | | allowed / not allowed | | 0 | visually estimated | log level |
| ring shake | | % of log top diameter | | 25 | visually estimated | log level |
| star shake | size of shake | % of log top diameter | | 50 | visually estimated | log level |
| crook | | allowed / not allowed | | 0 | visually estimated | log level |
| insect damages | | allowed / not allowed | | 0 | visually estimated | log level |
| discoloration | | allowed / not allowed | | 0 | visually estimated | log level |

It can be seen that, unlike the dimensional parameters where all parameters can be assessed on the exterior of the logs or trees, quality requirements include parameters assessable on either the exterior of the logs or trees (e.g. sweep, knots, damages) or only on the cross-cut face of logs (e.g. rot, shakes discoloration). As a consequence, only those parameters assessable on the exterior can be used to assess the quality of standing timber.

Knots are among the most important quality parameters of the sawmill requirements and together with sweep, taper and scars they are the only ones measurable and quantifiable on the exterior of the roundwood. Enquiries showed that most mills' requirements are based on and very much in line with the EU Standard EN 1927 allowing e.g. for knottiness certain maximum values of knot diameters in different roundwood quality classes.

What is given above represents the kind of information the sawmilling industry needs to receive from the forest prior to delivery at mill gate in order to be able to allocate the right stand to the right product. This allows selecting or calculating the respective parameters from the forest resource inventory data.

It should be mentioned that detection/ measuring systems are under development, which aim to measure features of these quality parameters by optical, laser-optical or x-ray technology prior to processing on saw mill log yards. To calibrate these technologies, threshold values must be established, which will lead to a more objective assessment of these quality requirements in the near future. At this moment, these thresholds are in most cases technology- and mill-specific, but efforts are underway to establish sector-specific quality measuring and sorting rules.

# 3. Forest resource information

To support the matching of the forest resource information with industry requirements it is necessary to express it according to the requirement categories species, dimension and quality. Forest resource information from the uneven-aged forests of the Central European use case with a species mix of dominantly Scots Pine (PNSY) and European Beech (FASY) serves as example (cf. Report on WP8000). For a region of 840ha located in southwestern Germany (Karlsruhe) the following forest resource information from different data sources was made available: ALS data was available from ALU-FR Felis for the full area as described in detail in chapter 4.1 in Flexwood Deliverable 4.1. Extended data (reference data) from terrestrial inventory was available for 26 rectangular plots of 30x30m out of the 477 management inventory plots evenly distributed across the region. TLS data was available from Treemetrics for these 26 plots and an additional 17 plots, but due to the scanning procedure – one circular recording from plot center with the radius r=15m - only a subset of the full inventory plot area was covered. In addition, only a subset of all trees within the scanned area were detected due to 'hidden' trees (cf. Fig. 2 for an example of a sample plot and Del. no. 4.1 chapter 7.2 regarding TLS detection rate).

As a consequence of these different types of data sources, the information derived from these sources represented different levels of detail ranging from sample plot levels of different sizes in the case of terrestrial inventory and terrestrial lidar to full coverage in the case of aerial lidar.

A comprehensive table listing numerous parameters for the description of a forest has been created in order to investigate together with WP 4000 which inventory based information is available or could potentially be made available from which data source in the use cases (cf. 0 for detailed list). From this list it is possible to identify those parameters which are useful or required for a matching with industry (i.e. sawmill) requirements (cf. 2.2). Table 3 shows the (potentially) available information and their origin from different data sources.

**Table 3 Source of origin and availability of information on forest resource**

| Category | Parameter | Terrestrial inventory (sample plot level) | ALS (full area) | TLS (sample plot level) |
|---|---|---|---|---|
| Species | Species | **X** | - | - |
| | Species group (Coniferous/Deciduous) | X | **X** | - |
| Dimension | Tree height | P | **X** | - |
| | Crown base height | P | **X** | P |
| | Crown radius/ diameter | P | **X** | - |
| | Diameter at breast height (dbh) | X | - | **X** |
| | Diameter at height 7m (D7) | P | - | **X** |
| | Taper | C | - | C |
| Quality | Taper | C | - | C |
| | Sweep | C | - | C |
| | Branch height | P | - | P |
| | Branch base diameter | P | - | P |
| | Knots | C | - | C |
| | Defects | P | - | P |

(X = available; P = potentially available but not assessed here; C = calculated; - = not available)

Several conclusions can be drawn from this overview. Firstly, it becomes obvious that species identification still requires assessment on the ground, either through terrestrial inventory methods or during TLS data collection. Consequently, this information remains available on sample plot level rather than for the full stand or relevant area. However, differentiation between species groups, more precisely between coniferous and deciduous trees, can also be achieved from ALS data analysis. Further detail is given in Flexwood Deliverable 4.1.

Regarding dimensional information, ALS data delivers information on tree height (=crown top height) crown base height and the maximum crown diameter, which make it a valuable data source for volume information. Even more so in combination with TLS data as it lacks this information but provides complementary information on tree diameter, e.g. the traditionally used breast height (dbh) and at 7m (D7).

Furthermore, the combination of ALS and TLS is also important to calculate some of the required quality parameters, such as taper and sweep, from the measured dimensional data. Information on other quality relevant tree parameters as branches, knots and defects are potentially available, but not yet automatically detected, as shown in chapter 3.4.3 and chapter 6 of Flexwood Deliverable 4.1.

It is important to state that all ALS information is available for the full area; however, it also represents a sample since predominantly larger trees are detected. TLS data is solely on sample plot level.

## 3.1 Fusion of tree data from different data sources

The objective of the fusion procedure is to generate tree lists representing the forest resource and including the parameters that are relevant to the industry (cf. 2.2). The extraction of this resource information from the different sources of existing inventory data requires substantial pre-processing.

## 3.2 Resource information extraction

When the work on this task started there was no established method for an automated fusion of TLS and ALS tree data on sample plot level. Therefore, it was decided that several TLS sample plots be chosen for a manual tree by tree fusion in order to verify and refine allocation procedures during the course of the duration of the Task (cf. also 3.3).

### 3.2.1 Tree lists from manual tree by tree fusion of TLS and ALS data on sample plot level

The following 8 plots (=19%) out of the total of 43 scanned plots in the German Use Case Area were selected based on the criteria ‘existence of both species PNSY and FASY’: 1175, 1210, 2056, 2083, 2194, 2309, 2310, and 2356.

In a GIS (ArcMap10 by ESRI) the data of the ALS trees within a radius of r=15m from the inventory plot center were selected from the full number of ALS trees in the Use Case. Fig. 2 shows as an example a 2-D view of each a TLS (circle) and a Reference sample plot (square).

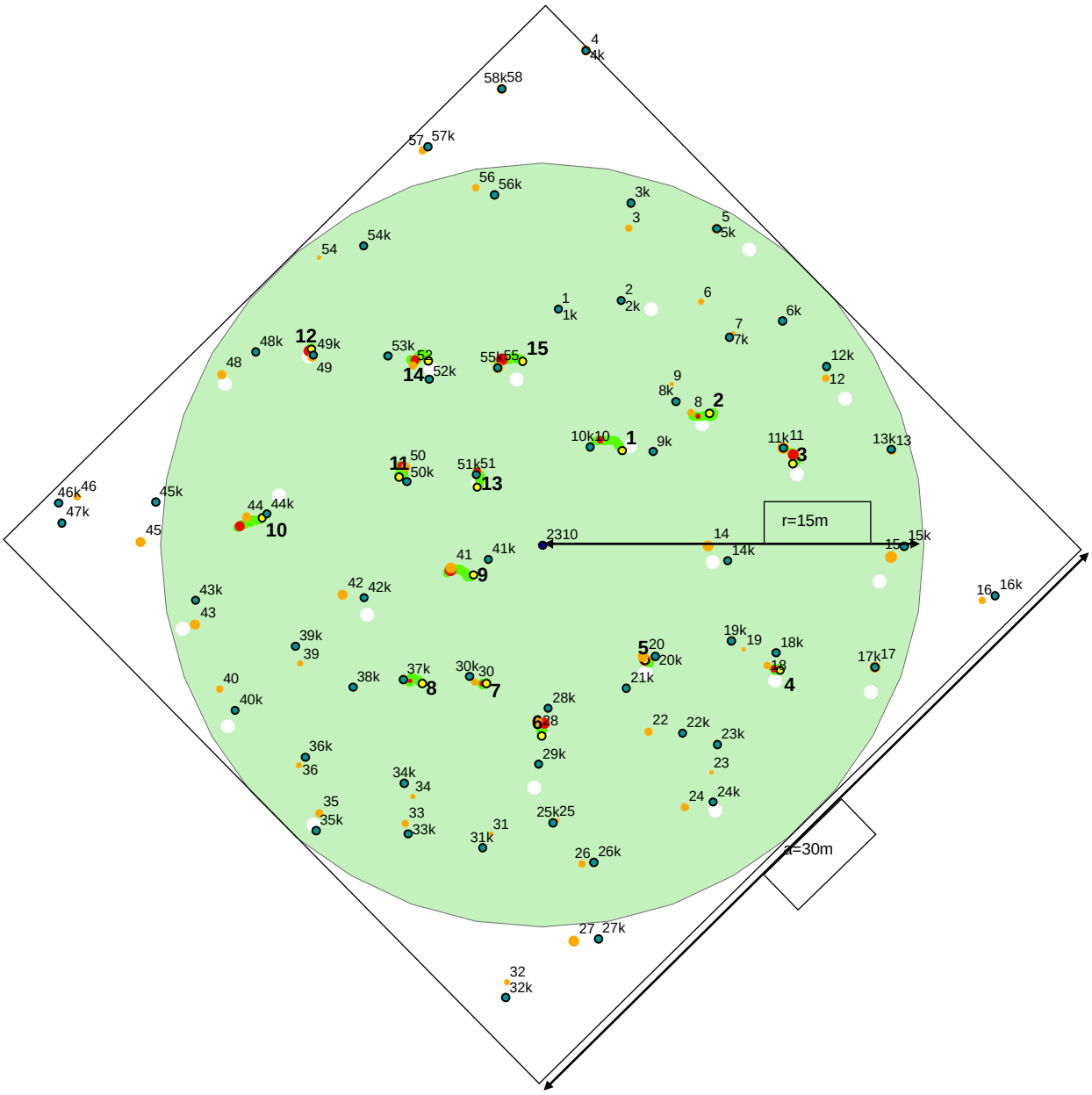


**Fig. 2 View (2D) of example sample plot (circle with r=15m) within Reference sample plot (square with a=30m)**

**Description of elements in Fig. 2:**

**Position of plot center (BI = blue center point, with plot number 2310), positions of crown tops (ALS=white points), stems (TLS=light green points), stem disk at breast height (TLS=red points, point size relative to D), stem disk at upper diameter (TLS=yellow points, with TLS tree number (bold) in the sample plot) as well as the positions of the Reference trees at breast height (REF= orange points, point size relative to D, with Reference tree number in the sample plot) and of the Reference trees' crown tops (REF= light blue points, with Reference tree number in the sample plot followed by denominator "k").**

These tree data from ALS were subsequently merged with the TLS tree data from the same plot on a tree by tree basis. Terrestrial inventory data was used additionally as a reference (REF), for verification of Lidar measurements and also to clearly identify tree species (FASY or PNSY).

This resulted in a table of 61 trees described by the following parameters:

- Inventory plot number
- TLS tree number
- Geographic coordinates [x;y] of tree breast height (BH) position from TLS
- Geographic coordinates [x;y] of tree top position from ALS
- Geographic coordinates [x;y] of tree breast height (BH) position from REF
- Diameter at breast height (D) [cm] from TLS
- Diameter at breast height (D) [cm] from REF
- Diameter at height 7m (D7) [cm] from TLS
- Crown Top height (H) [m] from ALS
- Crown length (CL) [m] from ALS
- Crown base height (CBH) [m] from ALS
- Maximum crown diameter (CDmax) [m] from ALS
- Reference tree number
- Species from REF

Table 4 shows an excerpt of this table for illustration, the full table is included in 6.3.

**Table 4 Tree list resulting from manual fusion (excerpt)**

| PLOT | TLS_TREE# | X_TLS_BH | Y_TLS_BH | D_TLS (cm) | D7 (cm) | X_ALS_top | Y_ALS_top | H_ALS (m) | CL (m) | CBH (m) | Cdmax_ALS (m) | REF# | X_REF_BH | Y_REF_BH | D_REF | REF_SPEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2310 | 1 | 3458005,55 | 5435405,39 | 23,3 | 20,5 | 3458006,755435405,16 | | 19,20 | 6,67 | 12,53 | 5,59 | 10 | 3458005,55 | 5435405,39 | 24 | PNSY |
| 2310 | 2 | 3458009,40 | 5435406,33 | 20,7 | 15,9 | 3458009,585435406,01 | | 19,62 | 12,39 | 7,23 | 6,32 | 8 | 3458009,40 | 5435406,33 | 24 | PNSY |
| 2310 | 3 | 3458013,16 | 5435404,82 | 29,0 | 24,6 | 3458013,315435404,05 | | 22,39 | 4,90 | 17,49 | 5,92 | 11 | 3458013,16 | 5435404,82 | 34 | PNSY |
| 2310 | 4 | 3458012,39 | 5435396,40 | 23,0 | 20,7 | 3458012,455435395,95 | | 21,69 | 10,56 | 11,13 | 4,79 | 18 | 3458012,39 | 5435396,40 | 23 | PNSY |
| 2310 | 5 | 3458007,32 | 5435396,73 | 29,0 | 24,6 | 3458007,345435396,25 | | 21,82 | 4,20 | 17,62 | 5,77 | 20 | 3458007,32 | 5435396,73 | 32 | PNSY |
| 2310 | 6 | 3458003,37 | 5435394,24 | 28,5 | 23,1 | 3458003,295435393,92 | | 20,55 | 9,69 | 10,86 | 6,44 | 28 | 3458003,37 | 5435394,24 | 28 | PNSY |
| 2310 | 10 | 3457991,42 | 5435402,00 | 26,3 | 21,0 | 3457992,955435403,21 | | 19,34 | 10,87 | 8,47 | 5,96 | 44 | 3457991,42 | 5435402,00 | 27 | PNSY |
| 2310 | 12 | 3457994,14 | 5435408,88 | 27,2 | 23,4 | 3457994,125435408,69 | | 19,73 | 5,77 | 13,96 | 5,21 | 49 | 3457994,14 | 5435408,88 | 27 | PNSY |
| 2310 | 13 | 3458000,73 | 5435404,15 | 22,9 | 19,6 | 3458000,785435403,71 | | 19,64 | 9,04 | 10,60 | 6,42 | 51 | 3458000,73 | 5435404,15 | 23 | PNSY |
| 2310 | 14 | 3457998,28 | 5435408,52 | 26,2 | 19,6 | 3457998,915435408,19 | | 19,40 | 4,02 | 15,38 | 5,62 | 52 | 3457998,28 | 5435408,52 | 26 | PNSY |
| 2310 | 15 | 3458001,73 | 5435408,53 | 31,5 | 25,0 | 3458002,295435407,77 | | 20,59 | 10,47 | 10,12 | 6,13 | 55 | 3458001,73 | 5435408,53 | 31 | PNSY |

### 3.2.2 Comparison of Diameter (D) values

In order to verify the fusion procedure, the values for the diameter at breast height (D) from the reference measurements have been compared to those resulting from terrestrial laser scanning.

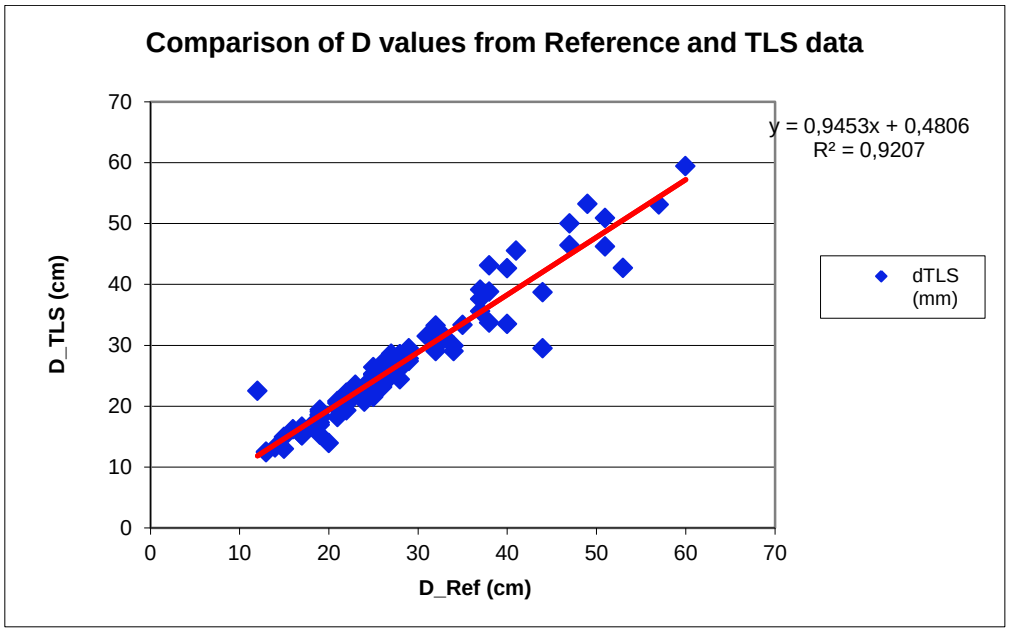


**Fig. 3 Comparison of D values from Reference and TLS data**

The comparison shows a good correlation between these two measurements with a slight underestimation of D by TLS measurements and a coefficient of determination $R^2$=0,92 as shown in Fig. 3. Consequently terrestrial lidar measurements of D could be qualified as sufficiently accurate values for the detected trees.

### 3.2.3 Tree species specific calculations

From the Reference data it can be seen that 18% (n=52) of all trees within the circles of all the sample plots are Beech (FASY), 82% (n=230) are Pine (PNSY). Tree species could not be identified automatically by TLS. However, a tree by tree identification of species is possible after visualization of the TLS data (cf. 3.5).
When applied to the 61 trees with merged ALS/TLS data this results is 11 FASY and 50 PNSY. Fig. 4 shows the species-specific diameter distribution for PNSY in the selected sample plots and Fig. 5 for FASY.

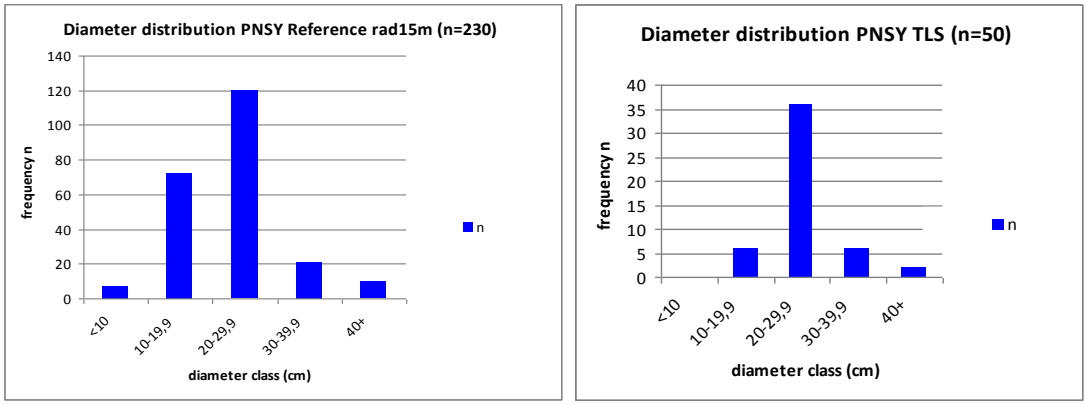


**Fig. 4 Diameter distribution (number of trees per class) of Pine (PNSY) in the selected plots. (Left: Reference data assessed on the ground, right: the subset of trees from merged ALS/TLS data, D detected by TLS)**

Assuming that the Reference data is representative for the full area, it can be concluded that PNSY are overall comparatively well represented by the merged ALS/TLS data, although the smaller diameters are underrepresented. This may be due to difficulties to detect smaller trees both by ALS and TLS if these are occluded by larger, more dominant ones.
The same effect is most likely to apply also for FASY. But contrary to the above the merged trees do not represent the stand situation very well in terms of diameter distribution.

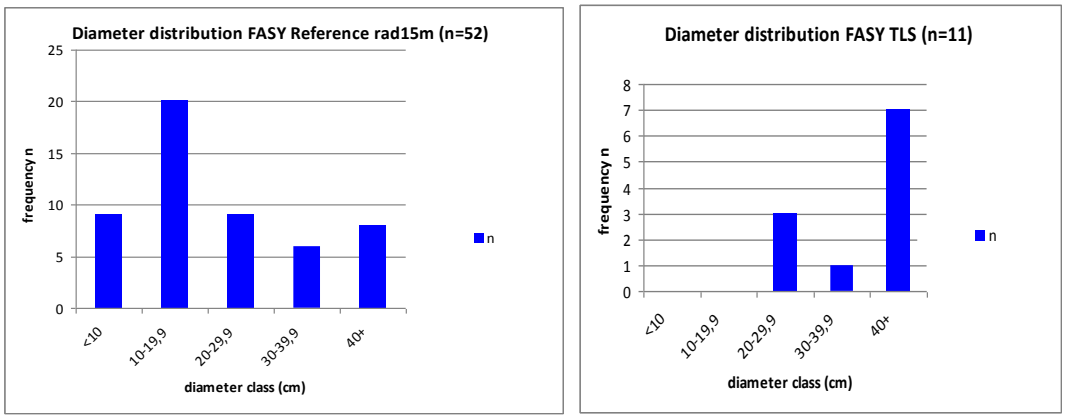


**Fig. 5 Diameter distribution (number of trees per class) of Beech (FASY) in the eight selected sample plots. (Left: Reference data assessed on the ground, right: the subset of trees from merged ALS/TLS data, D detected by TLS)**

Especially the trees of larger diameters are overrepresented whereas the smaller diameter trees are not represented at all (e.g. seven out of eight trees with a diameter of 40cm or larger could be merged; in contrast to this no trees of diameters < 20cm were merged although they account for more than 50% of the number of FASY trees in the Reference data.

Very likely the most important reason for the big difference between the species is the total number of stems per species. With four times as many PNSY than FASY, these data are more reliable. Therefore the following procedure description is based on PNSY.

### 3.2.4 Height-Diameter curves

The data resulting from the merging procedure could then be analyzed for statistical relationships between the parameters.
In traditional inventory procedures *diameter-height curves* (cf. Fig. 6 left) – constructed from measured sample tree heights - serve as a tool to predict tree height for all trees based on their measured tree diameters. Here the situation is inverse: Tree heights are measured by ALS and therefore available for the majority of the trees in a stand, but the diameters are available only for some sample trees based on TLS measurements. Consequently the reverse calculation is applied, resulting in so-called *height-diameter curves* (cf. Fig. 6 right) based on the merged trees. They allow the prediction of D for the given height values derived from ALS.

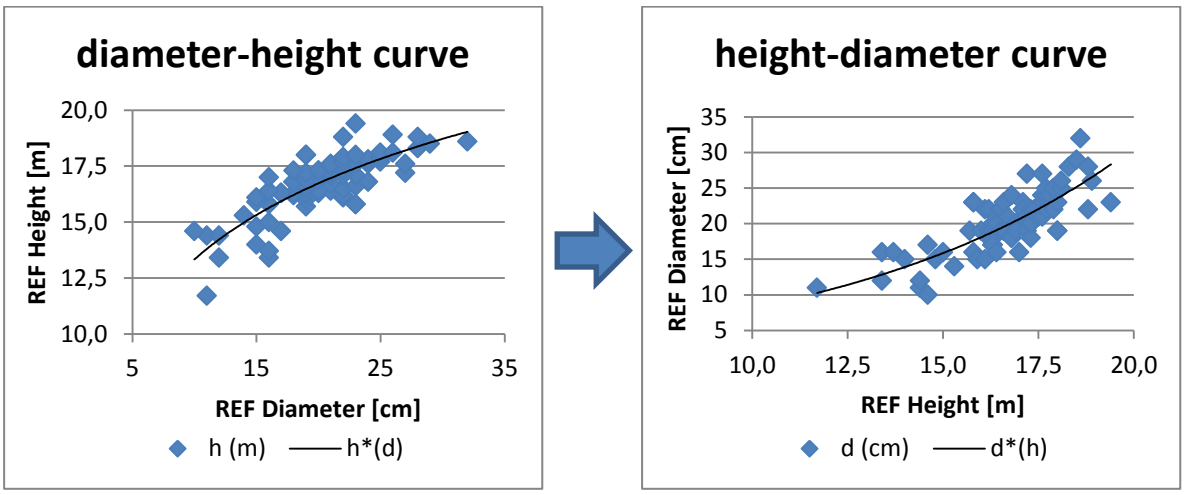


**Fig. 6 Diameter-height curve (left) vs. height-diameter curve (right). Example of a reference plot**

Fig. 7 shows a species-specific height-diameter curve for Pine (PNSY) (n=50) for the selected sample plots.

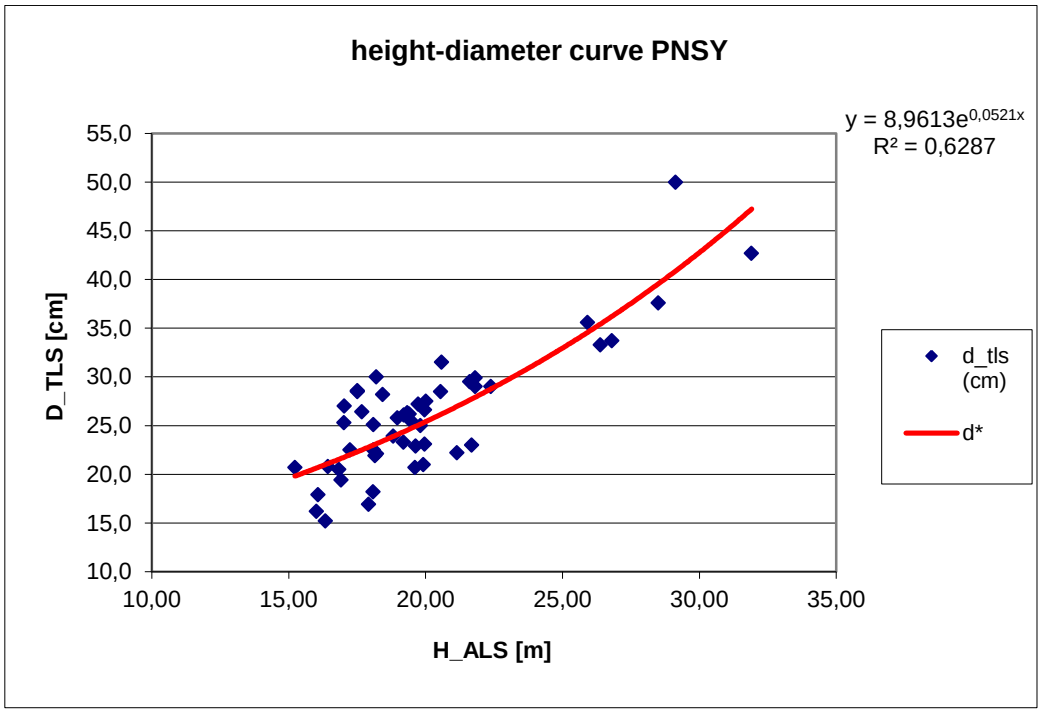


**Fig. 7 Height-diameter curve Pine (PNSY) for merged trees in the selected sample plots**

Here d* represents the best-fit curve for D_TLS = f (H_ALS) with a coefficient of determination $r^2 = 0.63$; it can be expressed as shown in Equation 1.

$$d^*(h) = 8.9613 * \exp(0.0521 * h)$$ **Equation 1**

### 3.2.5 Diameter (D) calculation for all ALS-trees (PNSY)

The diameter d* has been calculated based on Equation 1 and the tree heights of all trees detected by ALS in the eight selected sample plots (n=122).

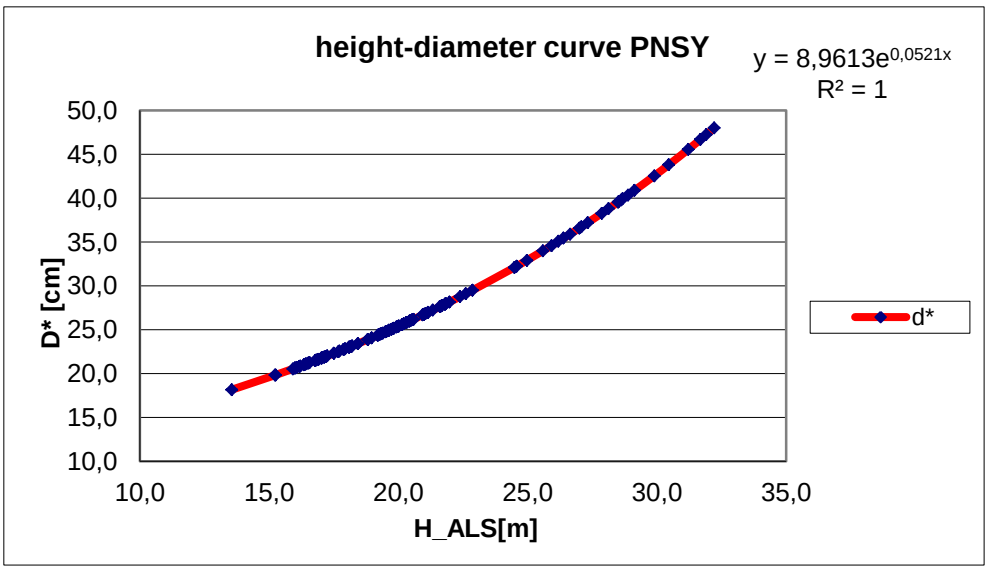


**Fig. 8 Height-diameter curve PNSY for ALS trees in the selected sample plots**

### 3.2.6 D/D7m ratio based on TLS Data to create specific taper functions

Based on the fact that there are strong correlations between different diameters along the stem, specific taper functions can be created from TLS data that allow the prediction of diameters at different heights and are a prerequisite for correct volume determination and for bucking simulations and decisions. The D/D7m ratio also allows the assessment of the quality requirement “taper” (cf. 3.4.2).

Diameter measurements are available from TLS for a subset of trees within the sample plot. This is the case for those trees where stem data is available up to the desired height. Wherever this is not the case, taper functions are required.

Therefore the ratio between D and the diameter at tree height 7m (D7) has been calculated for the Pine trees (n=74) in the sample plots where a diameter measurement was available from TLS at height 7m. Out of the results the following Equation 2 could be established in order to predict the D7* from D with a coefficient of correlation $r^2 = 0.94$.

$$d7(d) = 0.863 - 11.732 * d \quad r^2=0,94 \qquad \textbf{Equation 2}$$

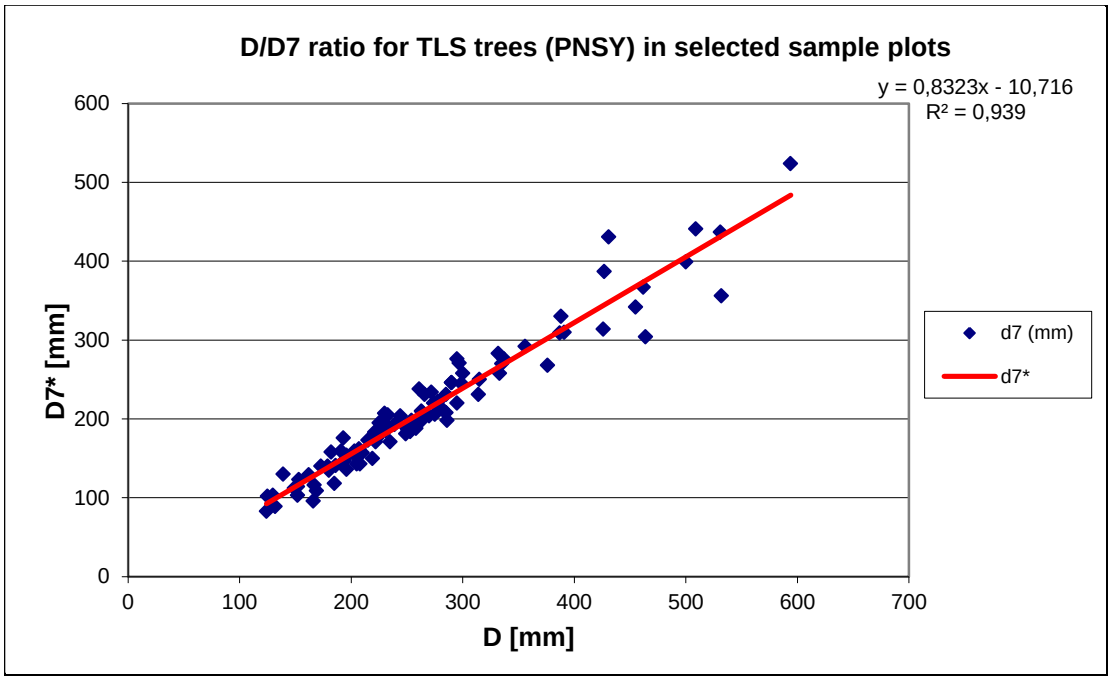


**Fig. 9 D/D7-ratio for TLS trees (PNSY) in the selected sample plots**

## 3.3 Automated fusion of TLS and ALS tree data on sample plot level

As work in the project continued a method for the automated fusion of TLS and ALS trees on sample plot level became available, which has been developed by the coordinating partner Felis (Department of Remote Sensing and Landscape Information Systems at the University of Freiburg) and which is described in Flexwood Deliverable 4.1 chapter 7.1.1: Integration of tree data from ALS and TLS. This represents a leap forward in the use of Laser Scanning for the applicability of harvest prediction and allocation procedures in advanced harvesting and logistics concepts.
In the following the results from this automated merging procedure are shown as comparison to the results from the above presented method of manual tree by tree fusion (3.2.1) in GIS.

With the new method in total 68 trees could be merged in the eight selected sample plots, compared to 61 trees by manual fusion. For 52% of the trees the match was identical in both fusion procedures, which means that exactly the same crown data (from ALS) was merged with the same stem data (from TLS) in both methods.

Fig. 10 shows the three different height-diameter curves resulting from different fusion procedures for the same ALS tree height data (d* and d**) and for a larger data set (d***) for comparison. d*(h) has been calculated from the above presented tree by tree fusion based on the eight selected sample plots, d**(h) has been calculated from the automated fusion again for the eight selected sample plots and d***(h) has been calculated from the automated fusion for all plots in the Use Case.

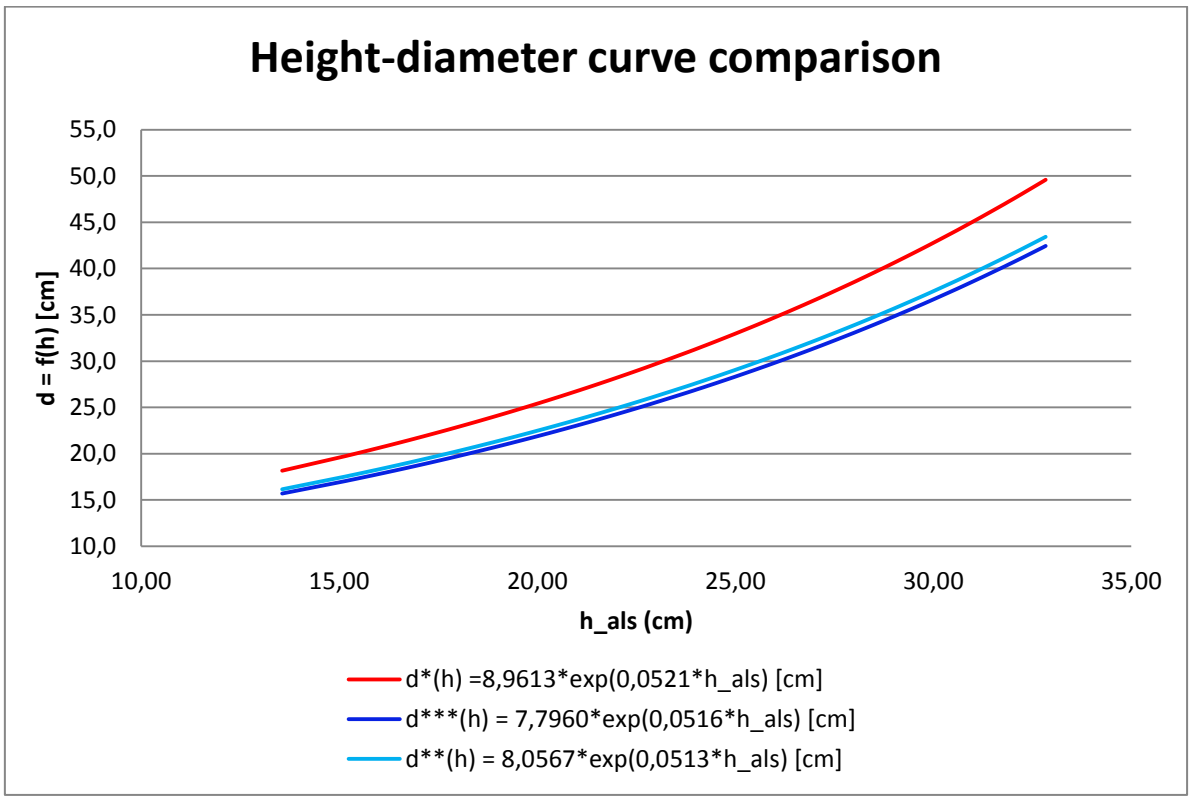


**Fig. 10 Comparison of the height-diameter curves resulting from the different fusion procedures**

Although there is an obvious difference between these three curves, it is still of an acceptable range, depending on the application. E.g. for a tree of 20m height the different height-diameter functions will return the following different values for the tree's dbh:

| | | |
|---|---|---|
| d* (h=20m) | = | 25,4 cm |
| d*** (h=20m) | = | 22,5 cm |
| d** (h=20m) | = | 21,9 cm |

In the light of chapter 3.2.2 and the good accordance of Diameter from the comparison between the Reference and the TLS tree data it can be concluded that the height-diameter curve resulting from the manual fusion procedure is the best match for the selected sample plots. However it can be assumed that the actual height-diameter curve is somewhere in between d*(h) and d**(h).

With the help of these tools, it becomes possible to retrieve from combined ALS and TLS measurements the basic parameters to create individual tree lists for a stand in order to obtain the dimensional information. From an industrial roundwood procurement point of view, the above presented concept is already of high value as it gives an overview on the expectable tree dimensions, which are otherwise (by traditional means) time-consuming and costly to assess.

However, the extraction of the quality information parameters, needed by the industry for an efficient raw material use and by the forest management for an efficient product allocation, requires additional procedures, which are presented in the following.

## 3.4 Information on quality

As mentioned above, information on the two categories species and dimension are very important for an efficient roundwood allocation to the industry, but they offer only little possibility for improvement if not accompanied by information on quality. As aforementioned, sweep, taper and most importantly branchiness/knottiness are the most important quality parameters accounting for a big proportion of the reasons for log downgrading. In addition they are assessable from the outside, on standing timber as well as on logs.

### 3.4.1 Sweep

Sweep refers to the shape of the stem, and is defined as the deviation from the straight vertical axis. Measurement unit is cm (deviation) per m (linear axis). These dimensional data can be extracted from the ALS/TLS data (cf. Fig. 11) and visualized.

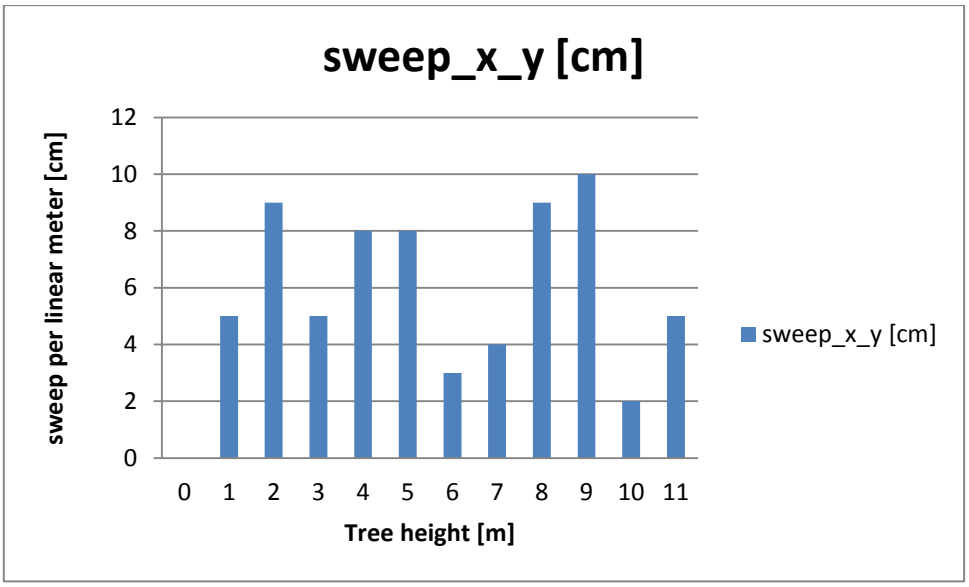


**Fig. 11 Example of sweep per linear meter from TLS measurements (Plot 1175 tree 2), cf Fig. 15 for an image of the same tree.**

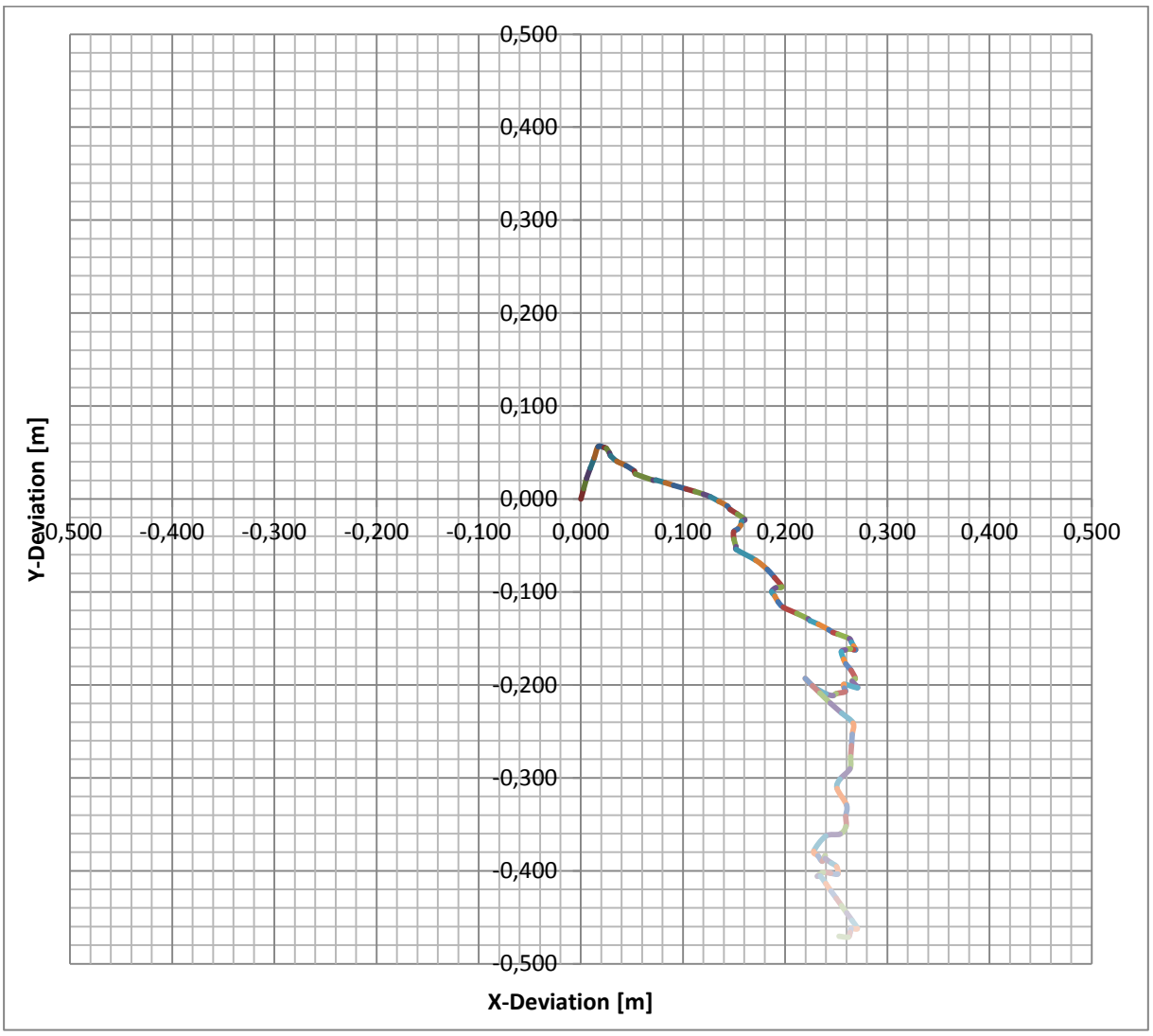


**Fig. 12 Visualization of sweep from TLS measurements. Example of FASY 1175_2**

### 3.4.2 Taper

Also taper refers to the shape of the stem, and is defined as the reduction of diameter on the stem upwards. Measurement unit is cm (decrease of diameter along the axis) per m (linear axis). Also taper can be derived from ALS/TLS data (cf. also 3.2.6)

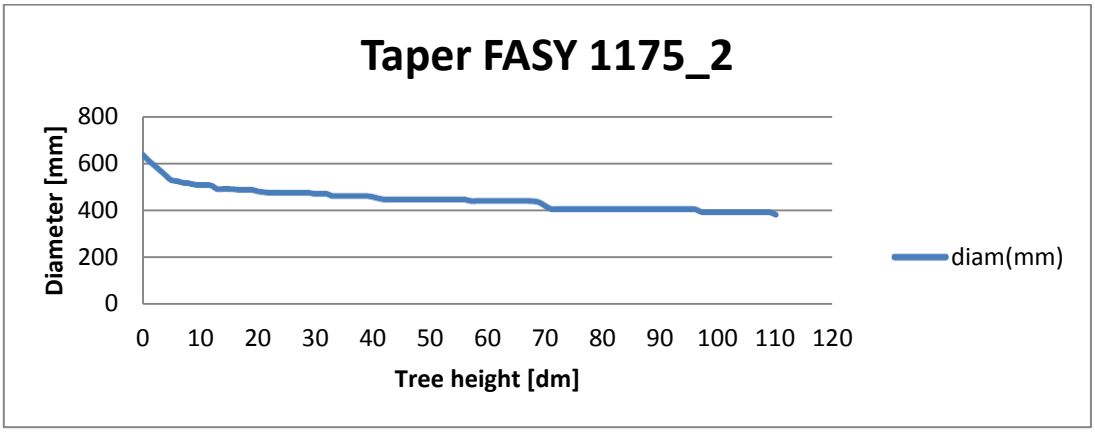


**Fig. 13 Taper visualization from TLS data. Example of FASY 1175_2**

### 3.4.3 Branchiness

In contrast to sweep and taper branchiness, which is the next most relevant tree quality parameter (cf. 2.2.3) cannot yet be assessed or derived automatically from ALS/ TLS data. However, it seems feasible to retrieve tree quality information from TLS in the near future on sample plot level. Here, the most important parameter for the quality assessment from outside is branchiness.

A first step to derive branchiness data from ALS/TLS datasets has been achieved by manual measurement on a tree by tree basis in the “point cloud” of the TLS data.

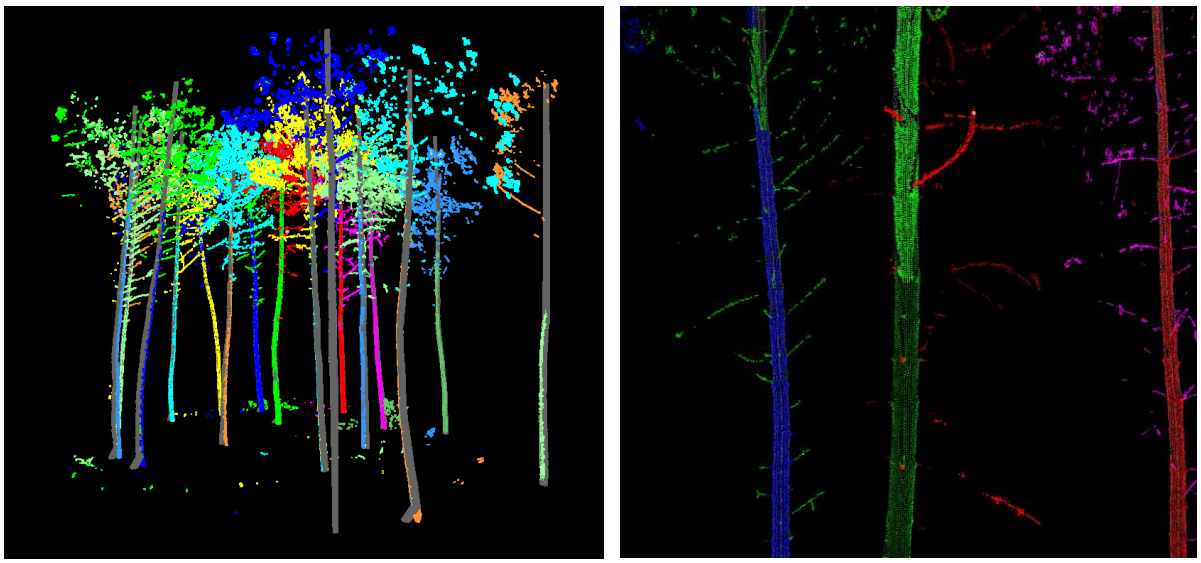

**Fig. 14 Point cloud visualization with colour marking of main stem, branches and live crown allows manual branch measurement**

The colour marking of main stem, branches and live crown, an automated procedure that the project partner Treemetrics has already in place allows manual identification and measurement of each branch diameter with recording of branch position and angle in relation to the horizontal plane. This data can then be written in a separate sheet for each tree of a sample plot.

**Table 5 Manual branch detection in TLS point cloud data. Example FASY 1175_2, cf Fig. 15 for an image of the same tree.**

| Tree | Branch | X | Y | Z | Angle [deg] | Diam [cm] | Length [m] |
|---|---|---|---|---|---|---|---|
| **238T2** | 1 | -5,81 | -9,98 | 10,34 | 30 | 1,0 | 2,92 |
| **238T2** | 2 | -5,53 | -10,1 | 11,94 | 45 | 1,2 | 4,99 |
| **238T2** | 3 | -5,76 | -9,94 | 12,72 | 85 | 1,1 | 3,49 |
| **238T2** | 4 | -5,86 | -10,09 | 12,79 | 60 | 1,6 | 2,91 |
| **238T2** | 5 | -5,03 | -11,78 | 15,08 | 45 | 0,4 | 2,23 |
| **238T2** | 6 | -5,85 | -10,3 | 15,04 | 80 | 3,7 | 8,83 |
| **238T2** | 7 | -5,61 | -11,3 | 16,03 | 50 | 2,9 | 3,55 |
| **238T2** | 8 | -6,07 | -10,43 | 18,56 | 45 | 2,1 | 2,99 |
| **238T2** | 9 | -6,23 | -10,07 | 19,82 | 60 | 1,4 | 3,61 |
| **238T2** | 10 | -6,12 | -10,24 | 20,52 | 50 | 2,2 | 5,41 |

This information is very useful for the quality assessment as it allows conclusion on the length of the knot free stem.
The next step will be the automated detection of the first dead and the first living branch and in a second step the automated recording of the above-mentioned branch parameters already measured manually on a small sample.

## 3.5 TLS point cloud visualization for standing tree quality assessment

In the Central European use case the tree quality has in addition also been assessed visually based on the procedures for standing timber quality grading of the second National Inventory, which have been developed at the Forest Research Institute of Baden-Württemberg. According to these procedures log quality is assessed on the standing tree up to a certain height depending on the tree species, which is 5m for FASY and 7m for PNSY. The trees are graded in quality classes from 1 - best quality - to 6 – very bad quality. The figures Fig. 15, Fig. 16, Fig. 17 and Fig. 18 show visualizations of TLS point clouds using the software TreesVis developed by the coordinating partner Felis (Department of Remote Sensing and Landscape Information Systems at the University of Freiburg) on the left and optical photograph pictures of the same tree on the right. The stem height which is relevant for log quality assessment according to the above is marked in the TLS visualizations by a horizontal plane (blue) and in the photographs by a red bar. While dimension is difficult to assess based on these pictures, they are of use for a support of ALS/TLS derived quality assessment in the sample plots. The shape of the tree as well as branches can be clearly identified but also scars, representing overgrown branches and therefore indicating knots can be identified. This is especially the case with FASY (cf. Fig. 15 and Fig. 16), but also for PNSY the visualization is of great use as currently not yet automatically detectable quality features (e.g. buckles) become identifiable (cf. Fig. 17 and Fig. 18).

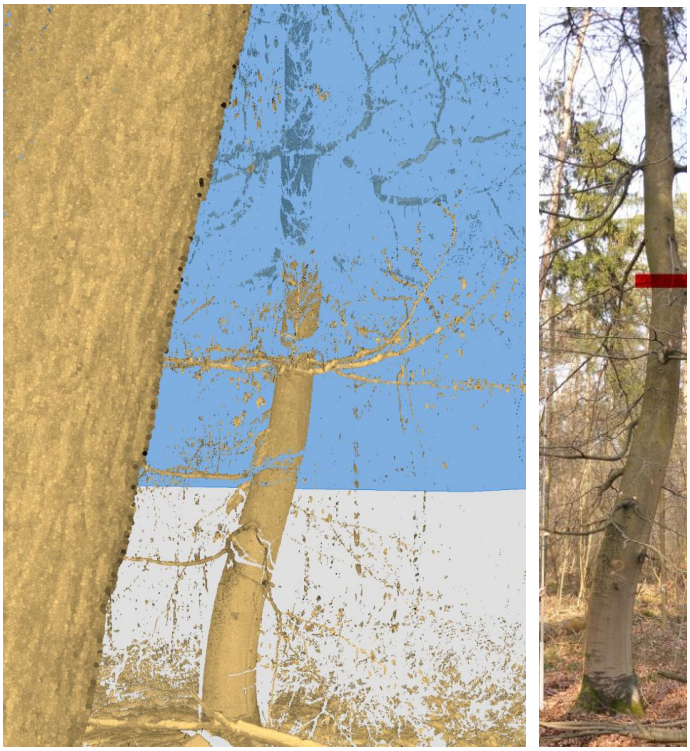

**Fig. 15 Example of a very bad quality FASY tree (quality 6) (1175_2). TLS point cloud visualization (left) and photograph (right)**

**Fig. 16 Example of a medium to good quality FASY tree (quality 3) (1175_10): TLS point cloud visualization (left) and photograph (right)**

**Fig. 17 Example of a medium to bad quality PNSY tree (quality 4) (2356_16): TLS point cloud visualization (left) and photograph (right)**

**Fig. 18 Example of a medium to good quality PNSY tree (quality 3) (2356_22): TLS point cloud visualization (left) and photograph (right)**

# 4. Matching resource information and industrial requirements - the conceptual procedure

Based on the above it is possible to classify each tree according to grade or quality classes which results in a stand data bank where trees (single trees or subpopulation of trees) are identified and described with species and both dimensional (diameter, height) and qualitative (shape, crown, branches) parameters as well as the exact geographic location.

After derivation of quality parameters and fusion of data sources the generation of tree lists is the next step. Tree lists compile and translate all relevant forest resource information into a format which corresponds to industry standards of raw material requirements. The forest resource data including those parameters, which are relevant to the industry in these lists is formally structured. Table 6 shows an example of such a tree list.

**Table 6. Example of a tree list**

| Tree # | Geo coord. X [m] | Geo coord. Y [m] | Dia bh [cm] | D 7m [cm] | Height top [m] | Length crown [m] | Height Cr.Base [m] | Species code # | Length stem [m] | Dob mid [cm] | Dub mid [cm] | Dub top [cm] | Vol sub [m³] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3458005,55 | 5435405,39 | 23,3 | 20,5 | 19,20 | 6,67 | 12,53 | PNSY | 12,67 | 20,92 | 19,74 | 14,25 | 0,36 |
| 2 | 3458009,40 | 5435406,33 | 20,7 | 15,9 | 19,62 | 12,39 | 7,23 | PNSY | 8,53 | 17,60 | 15,96 | 14,15 | 0,19 |
| 3 | 3458013,16 | 5435404,82 | 29,0 | 24,6 | 22,39 | 4,90 | 17,49 | PNSY | 16,41 | 23,77 | 22,43 | 14,25 | 0,63 |
| 4 | 3458012,39 | 5435396,40 | 23,0 | 20,7 | 21,69 | 10,56 | 11,13 | PNSY | 14,19 | 20,65 | 19,48 | 14,25 | 0,40 |
| 5 | 3458007,32 | 5435396,73 | 29,0 | 24,6 | 21,82 | 4,20 | 17,62 | PNSY | 15,69 | 23,58 | 22,25 | 14,25 | 0,76 |
| 6 | 3458003,37 | 5435394,24 | 28,5 | 23,1 | 20,55 | 9,69 | 10,86 | PNSY | 14,61 | 22,87 | 21,58 | 14,25 | 0,53 |
| 10 | 3457991,42 | 5435402,00 | 26,3 | 21,0 | 19,34 | 10,87 | 8,47 | PNSY | 12,98 | 21,38 | 20,17 | 14,25 | 0,41 |
| 12 | 3457994,14 | 5435408,88 | 27,2 | 23,4 | 19,73 | 5,77 | 13,96 | PNSY | 14,20 | 23,33 | 22,01 | 14,25 | 0,51 |
| 13 | 3458000,73 | 5435404,15 | 22,9 | 19,6 | 19,64 | 9,04 | 10,60 | PNSY | 12,37 | 20,10 | 18,96 | 14,25 | 0,33 |
| 14 | 3457998,28 | 5435408,52 | 26,2 | 19,6 | 19,40 | 4,02 | 15,28 | PNSY | 12,21 | 20,28 | 19,14 | 14,25 | 0,37 |
| 15 | 3458001,73 | 5435408,53 | 31,5 | 25,0 | 20,59 | 10,47 | 10,12 | PNSY | 15,24 | 24,47 | 23,09 | 14,25 | 0,64 |
| 1 | 3456404,02 | 5433007,51 | 53,2 | 35,6 | 26,19 | 4,06 | 22,13 | FASY | 24,10 | 32,14 | 30,96 | 9,42 | 2,07 |
| 2 | 3456412,14 | 5432998,29 | 50,9 | 44,1 | 28,13 | 7,84 | 20,29 | FASY | 26,26 | 39,83 | 38,42 | 9,42 | 2,86 |
| 5 | 3456401,42 | 5433005,30 | 59,4 | 52,4 | 27,00 | 4,03 | 22,97 | FASY | 19,25 | 50,70 | 49,00 | 36,55 | 3,63 |

The allocation of the right harvestable stand for a given demand, where the requirements on the categories species, dimension and quality are best met, requires a matching procedure. In this procedure information on industry requirements is compared to the information on the available forest resources.

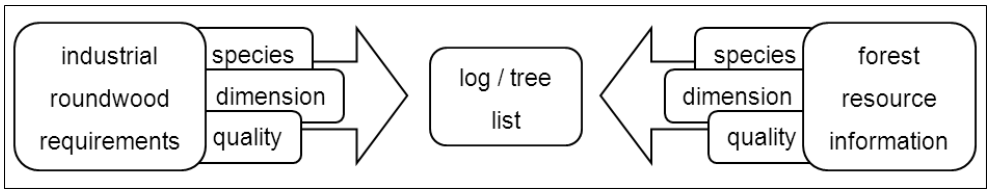


**Figure 19: Matching procedure**

Figure 19 illustrates this matching procedure: forest resource data are sorted according to the same structure as the industrial requirements, which results in tree lists for each harvestable stand. Each tree list is converted into log lists, containing the logs that comply with the roundwood requirements of the industry. This conversion can be performed by existing simulation software (bucking simulation). In the Central European Use Case, *Holzernte* software is used, as it has been developed specifically for the prevailing forest and market conditions of southwest Germany. Table 7 shows an example of such a log list with a selection of the parameters and the resulting quality grade.

**Table 7. Example of a log list**

| Log # | Species code | length [m] | allow. [m] | mid Dub [cm] | top Dub [cm] | Vol sub [m³] | Taper [mm/m] | Quality | Grade |
|---|---|---|---|---|---|---|---|---|---|
| 1 | FASY | 25,8 | 0 | 38,44 | 10,50 | 3,00 | 21,64 | Ind | Ind |
| 4 | FASY | 9,3 | 0 | 32,22 | 10,50 | 0,76 | 34,76 | Ind | Ind |
| 3 | FASY | 18,3 | 0 | 29,63 | 10,50 | 1,26 | 12,42 | Ind | Top log |
| 1 | FASY | 5,1 | 0,2 | 54,09 | 51,83 | 1,17 | 8,87 | Saw B | Butt log |
| 2 | FASY | 5,1 | 0,2 | 50,09 | 48,27 | 1,01 | 6,98 | Saw B | Top log |
| 1 | FASY | 5,1 | 0,2 | 43,85 | 37,04 | 0,77 | 26,72 | Saw C | Butt log |
| 3 | FASY | 5,1 | 0,2 | 45,94 | 43,00 | 0,85 | 10,34 | Saw C | Top log |
| 2 | FASY | 2,5 | 0,2 | 34,72 | 33,26 | 0,24 | 15,09 | Saw C | Top log |
| 4 | PNSY | 3 | 0 | 13,30 | 11,26 | 0,04 | 12,89 | Ind | Ind |
| 4 | PNSY | 3 | 0 | 14,27 | 11,51 | 0,05 | 17,30 | Ind | Ind |
| 4 | PNSY | 2 | 0 | 13,06 | 11,45 | 0,03 | 15,84 | Ind | Ind |
| 3 | PNSY | 2 | 0 | 13,64 | 13,00 | 0,03 | 6,42 | Ind | Ind |
| 4 | PNSY | 2 | 0 | 12,28 | 11,47 | 0,02 | 7,63 | Ind | Ind |
| 4 | PNSY | 2 | 0 | 14,10 | 12,37 | 0,03 | 17,01 | Ind | Ind |
| 4 | PNSY | 2 | 0 | 12,73 | 10,79 | 0,03 | 18,94 | Ind | Ind |
| 4 | PNSY | 2 | 0 | 12,28 | 10,77 | 0,02 | 14,83 | Ind | Ind |
| 4 | PNSY | 2 | 0 | 12,63 | 11,13 | 0,03 | 14,51 | Ind | Ind |
| 4 | PNSY | 2 | 0 | 13,75 | 11,63 | 0,03 | 20,67 | Ind | Ind |
| 1 | PNSY | 5 | 0,1 | 25,41 | 23,68 | 0,25 | 6,90 | Saw B | Butt log |
| 1 | PNSY | 5 | 0,1 | 20,65 | 19,71 | 0,17 | 3,77 | Saw B | Butt log |
| 1 | PNSY | 5 | 0,1 | 25,45 | 23,70 | 0,25 | 6,98 | Saw B | Butt log |
| 1 | PNSY | 5 | 0,1 | 24,53 | 22,40 | 0,24 | 8,51 | Saw B | Butt log |
| 1 | PNSY | 5 | 0,1 | 20,18 | 18,84 | 0,16 | 5,36 | Saw B | Butt log |
| 1 | PNSY | 5 | 0,1 | 26,91 | 24,36 | 0,28 | 10,20 | Saw B | Butt log |
| 1 | PNSY | 4 | 0,1 | 21,05 | 20,20 | 0,14 | 4,24 | Saw B | Butt log |
| 1 | PNSY | 4 | 0,1 | 17,72 | 16,00 | 0,10 | 8,58 | Saw B | Butt log |
| 1 | PNSY | 4 | 0,1 | 22,40 | 20,01 | 0,16 | 11,96 | Saw B | Butt log |
| 2 | PNSY | 5 | 0,1 | 22,69 | 20,93 | 0,20 | 5,50 | Saw B | Top log |
| 2 | PNSY | 5 | 0,1 | 22,68 | 20,83 | 0,20 | 5,75 | Saw B | Top log |
| 2 | PNSY | 5 | 0,1 | 21,22 | 19,23 | 0,18 | 6,34 | Saw B | Top log |
| 2 | PNSY | 4 | 0,1 | 19,76 | 18,48 | 0,12 | 4,30 | Saw B | Top log |
| 3 | PNSY | 4 | 0,1 | 16,73 | 14,61 | 0,09 | 9,67 | Saw B | Top log |
| 2 | PNSY | 4 | 0,1 | 15,39 | 14,28 | 0,07 | 4,30 | Saw B | Top log |
| 2 | PNSY | 4 | 0,1 | 19,38 | 18,27 | 0,12 | 3,61 | Saw B | Top log |
| 3 | PNSY | 4 | 0,1 | 16,80 | 15,13 | 0,09 | 7,86 | Saw B | Top log |
| 1 | PNSY | 5 | 0,2 | 22,48 | 20,40 | 0,20 | 8,31 | Saw C | Butt log |
| 1 | PNSY | 5 | 0,1 | 24,14 | 22,58 | 0,23 | 6,22 | Saw C | Butt log |
| 3 | PNSY | 5 | 0,1 | 18,61 | 15,77 | 0,14 | 10,32 | Saw C | Top log |
| 2 | PNSY | 5 | 0,1 | 21,50 | 19,34 | 0,18 | 6,48 | Saw C | Top log |
| 2 | PNSY | 5 | 0,1 | 18,01 | 16,18 | 0,13 | 5,31 | Saw C | Top log |
| 2 | PNSY | 5 | 0,1 | 22,95 | 20,77 | 0,21 | 7,17 | Saw C | Top log |
| 2 | PNSY | 4,5 | 0,2 | 19,35 | 17,55 | 0,13 | 6,34 | Saw C | Top log |
| 3 | PNSY | 4,5 | 0,2 | 15,10 | 11,68 | 0,08 | 13,06 | Saw C | Top log |
| 3 | PNSY | 4 | 0,1 | 18,88 | 16,70 | 0,11 | 10,33 | Saw C | Top log |
| 3 | PNSY | 4 | 0,1 | 17,31 | 14,58 | 0,09 | 11,64 | Saw C | Top log |
| 2 | PNSY | 4 | 0,1 | 19,00 | 17,56 | 0,11 | 6,12 | Saw C | Top log |
| 3 | PNSY | 4 | 0,1 | 15,91 | 14,03 | 0,08 | 8,82 | Saw C | Top log |
| 3 | PNSY | 4 | 0,1 | 18,73 | 15,76 | 0,11 | 12,52 | Saw C | Top log |
| 3 | PNSY | 2,4 | 0,1 | 17,90 | 16,51 | 0,06 | 11,82 | Saw D | Top log |
| 4 | PNSY | 2,4 | 0,1 | 14,43 | 12,16 | 0,04 | 18,10 | Saw D | Top log |
| 3 | PNSY | 2,4 | 0,1 | 14,97 | 13,73 | 0,04 | 10,22 | Saw D | Top log |

The logs can subsequently be sorted according to actual demand which allows the right products to be allocated to the right mills depending on the respective requirements.

# 5. References

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# 6. Annex

## 6.1 Industrial requirement specifications

| Industrial requirements (wp3000 6000) request from task5300 | | Respondent: Antti Heikkilä | | Flexwood Partner Organisation: VTT | | Flexwood Task No: | | 22 October 2010 |
|---|---|---|---|---|---|---|---|---|
| Industrial requirements towards forest raw material | Industry type: | sawmill | Species: (code = EN13556) b) | Pine Pinus sylvestris (PNSY) | | product group: b) | saw coniferous appearance | |
| Country: (a) Finland | | choose from dropdown menu | choose from dropdown menu | | | choose from dropdown menu | | |

| rank of importance c) | requirement type d) ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,...) | category of parameter e) | description of parameter | reference unit | values (min, mean, max,...) h) | | | | | possible target value, if "category of parameter" = "accepted value" g) h) | | | | | required data type (e.g. measured, predicted, direct, indirect, ...) | required level (e.g. stand level, tree level, batch level, ...) f) | data sources (e.g. literature, expert interview, nat./intl. standard,...) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | hard demand | diameter f) | target values/ value range | top diameter | centimeters [cm] over bark | 15 | 50 | | | | | | | | | measured | log level | requirements of different companies | Max butt end diameter 55 cm |
| 3 | hard demand | diameter | accepted values/ range of acceptance | top diameter | centimeters [cm] over bark | 15 | 50 | | | | | | | | | measured | log level | requirements of different companies | |
| 1 | hard demand | length f) | target values/ value range | log length | desimeters [dm] | 43 | 55, 58 or 61 *) | | | | | | | | | measured | log level | requirements of different companies | *) depending on sawmill |
| 3 | hard demand | length | accepted values/ range of acceptance | log length | desimeters [dm] | 37 | 55, 58 or 61 *) | | | | | | | | | measured | log level | requirements of different companies | |
| 1 | hard demand | sweep | accepted values/ range of acceptance | smooth sweep of log | millimetres per linear meter [mm/m] | | 10 | | | | | | | | | visually estimated | log level | requirements of different companies | |
| 1 | hard demand | sound knot | accepted values/ range of acceptance | size of knot | millimetres [mm] | | 60 | | | | | | | | | visually estimated | log level | requirements of different companies | |
| 1 | hard demand | dead knot | accepted values/ range of acceptance | size of knot | millimetres [mm] | | 40 | | | | | | | | | visually estimated | log level | requirements of different companies | |
| 1 | hard demand | rotten knot | accepted values/ range of acceptance | size of knot | millimetres [mm] | | 30 | | | | | | | | | visually estimated | log level | requirements of different companies | |
| 1 | hard demand | steep slay knot | accepted values/ range of acceptance | size of knot | millimetres [mm] | | 40 | | | | | | | | | visually estimated | log level | requirements of different companies | only one not rotten allowed per log |
| 1 | hard demand | rot | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | requirements of different companies | |
| 1 | hard demand | ring shake | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | requirements of different companies | |
| 2 | hard demand | star shake | accepted values/ range of acceptance | size of shake | % of log top diameter | | 50 | | | | | | | | | visually estimated | log level | requirements of different companies | |
| 1 | hard demand | crook | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | requirements of different companies | crook: sweep>10mm/m at any meter |
| 1 | hard demand | insect damages | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | requirements of different companies | |
| 1 | hard demand | discoloration | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | requirements of different companies | |
| 2 | hard demand | scar | accepted values/ range of acceptance | length of scar | centimetres [cm] | | 90 | | | | | | | | | visually estimated | log level | requirements of different companies | not allowed inside top cylinder |
| 2 | hard demand | scotch pine blister rust | accepted values/ range of acceptance | width of rust | proportion of circle | | 1/2 | | | | | | | | | visually estimated | log level | requirements of different companies | not allowed if the log is cracked or deformed |

| Industrial requirements (wp3000_6000) request from task5300 | | Respondent: | Antti Heikkilä | Flexwood Partner Organisation: | VTT | Flexwood Task No: | | 22 October 2010 |
|---|---|---|---|---|---|---|---|---|
| Industrial requirements towards forest raw material | Industry type: | sawmill | Species: (code = EN13556) b) | Spruce Picea abies (PCAB) | | product group: b) | saw coniferous appearance | |
| Country: (a) Finland | | choose from dropdown menu | | choose from dropdown menu | | | choose from dropdown menu | |

| rank of importance c) | requirement type d) ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter e) | description of parameter | reference unit | values (min, mean, max,…) h) | | | | | possible target value, if "category of parameter" = "accepted value" g) h) | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) f) | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | hard demand | diameter f) | target values/ value range | top diameter | centimeters [cm] over bark | 16 | 50 | | | | | | | | | measured | log level | requirements of different sawmill companies | Max butt end diameter 55 cm |
| 3 | hard demand | diameter | accepted values/ range of acceptance | top diameter | centimeters [cm] over bark | 16 | 50 | | | | | | | | | measured | log level | requirements of different sawmill companies | |
| 1 | hard demand | length f) | target values/ value range | log length | desimeters [dm] | 43 | 55, 58 or 61 *) | | | | | | | | | measured | log level | requirements of different sawmill companies | *) depending on sawmill |
| 3 | hard demand | length | accepted values/ range of acceptance | log length | desimeters [dm] | 37 | 55, 58 or 61 *) | | | | | | | | | measured | log level | requirements of different sawmill companies | |
| 1 | hard demand | sweep | accepted values/ range of acceptance | smooth sweep of log | millimetres per linear meter [mm/m] | | 10 | | | | | | | | | visually estimated | log level | requirements of different sawmill companies | |
| 1 | hard demand | sound knot | accepted values/ range of acceptance | size of knot | millimetres [mm] | | 60 | | | | | | | | | visually estimated | log level | requirements of different sawmill companies | |
| 1 | hard demand | dead knot | accepted values/ range of acceptance | size of knot | millimetres [mm] | | 40 | | | | | | | | | visually estimated | log level | requirements of different sawmill companies | |
| 1 | hard demand | rotten knot | accepted values/ range of acceptance | size of knot | millimetres [mm] | | 30 | | | | | | | | | visually estimated | log level | requirements of different sawmill companies | |
| 1 | hard demand | steep slay knot | accepted values/ range of acceptance | size of knot | millimetres [mm] | | 40 | | | | | | | | | visually estimated | log level | requirements of different sawmill companies | only one not rotten allowed per log |
| 1 | hard demand | rot | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | requirements of different sawmill companies | |
| 1 | hard demand | ring shake | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | requirements of different sawmill companies | |
| 2 | hard demand | star shake | accepted values/ range of acceptance | size of shake | % of log top diameter | | 50 | | | | | | | | | visually estimated | log level | requirements of different sawmill companies | |
| 1 | hard demand | crook | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | requirements of different sawmill companies | crook: sweep>10mm/m at any meter |
| 1 | hard demand | insect damages | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | requirements of different sawmill companies | |
| 1 | hard demand | discoloration | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | requirements of different sawmill companies | |
| 2 | hard demand | scar | accepted values/ range of acceptance | width of scar | proportion of circle | | 1/4 | | | | | | | | | visually estimated | log level | requirements of different sawmill companies | only on one side, not inside top cylinder |

a) Please indicate the country for which the given data is applicable. If it is true for all of the studied countries, please mark "all". Please fill out one separate sheet for each country.
b) Please fill out one seperate sheet for each species and each product group covered within the industry type of your task. Additional product groups may be entered by selecting "other" and by specifying behind.
c) Please rank the parameters according to their importance for processing within the respective product group. 1 = highest importance, total number of parameters unlimited (you may add rows if needed!), if two or more parameters are considered of the same i
d) Please differentiate for each parameter between "hard" and "soft" demand to indicate whether industry considers it as absolutely necessary for processing according to the specific product group (="hard demand") or more of a "nice-to-have" but not absolute
e) Please differentiate for each parameter whether the values given are considered representing the whole possible range of acceptance ("accepted values/ range of acceptance or) or if they represent the industry's "target values/ value range" for the above g
f) Assuming -from our experience-, any industry has certain target value ranges at least for some parameters, we ask you to give at least not only the accepted but also the favored range for the parameters "diameter" and "length". In this case, and presumabl
g) If parameter description, reference unit, data type, level etc. differ between the accepted and the targeted values, please use seperate rows each for the accepted and the targeted values of the same parameter.
h) If no values are given, it is assumed there is no limitation, be it minimum or maximum

| Industrial requirements (wp3000_6000) request from task5300 | Respondent: Antti Heikkilä | Flexwood Partner Organisation: VTT | Flexwood Task No: | | 22 October 2010 |
|---|---|---|---|---|---|

| Industrial requirements towards forest raw material | Industry type: | sawmill | Species: (code = EN13556) b) | other | if species "other", please specify: | Birch Betula pendula & pubescens (BTXX) | product group: b) | saw broadleave plywood | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Country: a) Finland | | choose from dropdown menu | | choose from dropdown menu | | | | choose from dropdown menu | | |

| rank of importance c) | requirement type: d) ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter e) | description of parameter | reference unit | values (min, mean, max,…) h) | | | | | possible target value, if "category of parameter" = "accepted value" g) h) | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) f) | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | **hard demand** | diameter f) | target values/ value range | top diameter | centimeters [cm] over bark | 18 | *) | | | | | | | | | measured | log level | Tapion taskukirja ("Handbook of forestry") | maximum diameter factory-specific |
| 2 | **hard demand** | diameter | accepted values/ range of acceptance | top diameter | centimeters [cm] over bark | 16 | | | | | | | | | | measured | log level | Tapion taskukirja ("Handbook of forestry") | straigth defect free butt log |
| 1 | **hard demand** | length f) | target values/ value range | log length | desimeters [dm] | 34 | 67 | | | | | | | | | measured | log level | One company's requirements | Best: 41 and 61 dm, Good: 34,54,57,67 dm; Avoid: 46 and 49 dm |
| 2 | **hard demand** | length | accepted values/ range of acceptance | log length | desimeters [dm] | 31 | 70 | | | | | | | | | measured | log level | Tapion taskukirja ("Handbook of forestry") | **) |
| 1 | **hard demand** | sweep | accepted values/ range of acceptance | smooth sweep of log | millimetres per linear meter [mm/m] | | 30 mm/1,5 m | | | | | | | | | visually estimated | log level | Tapion taskukirja ("Handbook of forestry") | |
| 1 | **hard demand** | sound knot | accepted values/ range of acceptance | size of knot | millimetres [mm] | | 70 | | | | | | | | | visually estimated | log level | Tapion taskukirja ("Handbook of forestry") | |
| 1 | **hard demand** | dead knot | accepted values/ range of acceptance | size of knot | millimetres [mm] | | 40 | | | | | | | | | visually estimated | log level | Tapion taskukirja ("Handbook of forestry") | |
| 1 | **hard demand** | rotten knot | accepted values/ range of acceptance | size of knot | millimetres [mm] | | 40 | | | | | | | | | visually estimated | log level | Tapion taskukirja ("Handbook of forestry") | |
| 1 | **hard demand** | steep slay knot | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | Tapion taskukirja ("Handbook of forestry") | |
| 1 | **hard demand** | **soft** rot | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | Tapion taskukirja ("Handbook of forestry") | |
| 1 | **hard demand** | face shakes | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | Tapion taskukirja ("Handbook of forestry") | |
| 1 | **hard demand** | star shake | accepted values/ range of acceptance | size of shake | % of log top diameter | | 33 | | | | | | | | | visually estimated | log level | Tapion taskukirja ("Handbook of forestry") | |
| 1 | **hard demand** | crook | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | Tapion taskukirja ("Handbook of forestry") | crook: sweep>10mm/m at any meter |
| 1 | **hard demand** | rotten scar | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | Tapion taskukirja ("Handbook of forestry") | |
| 1 | **hard demand** | malformations (burls) | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | visually estimated | log level | Tapion taskukirja ("Handbook of forestry") | |
| 1 | **hard demand** | deep butt wrinkles | accepted values/ range of acceptance | | allowed / not allowed | | 0 | | | | | | | | | | log level | Tapion taskukirja ("Handbook of forestry") | |
| 1 | **hard demand** | knot cluster | accepted values/ range of acceptance | number of maximun size (or maximun size-10 mm) knots | pcs / 20 cemtimeters | | 3 | | | | | | | | | | log level | Tapion taskukirja ("Handbook of forestry") | |
| | | | | | | | **) Maximum 1,5 m length zone that do not fulfil minimun quality requirements is allowed if on both sides of the zone exists at least 1,5 m qualified log zone | | | | | | | | | | | | |
| | | | | | | | **) Plywood log price is payed only from qualified part of the log | | | | | | | | | | | | |

a) Please indicate the country for which the given data is applicable. If it is true for all of the studied countries, please mark "all". Please fill out one separate sheet for each country.

b) Please fill out one seperate sheet for each species and each product group covered within the industry type of your task. Additional product groups may be entered by selecting "other" and by specifying behind.

c) Please rank the parameters according to their importance for processing within the respective product group. 1 = highest importance, total number of parameters unlimited (you may add rows if needed!), if two or more parameters are considered of the same i

d) Please differentiate for each parameter between "hard" and "soft" demand to indicate whether industry considers it as absolutely necessary for processing according to the specific product group (="hard demand") or more of a "nice-to-have" but not absolute

e) Please differentiate for each parameter whether the values given are considered representing the whole possible range of acceptance ("accepted values/ range of acceptance or) or if they represent the industry's "target values/ value range" for the above g

f) Assuming -from our experience-, any industry has certain target value ranges at least for some parameters, we ask you to give at least not only the accepted but also the favored range for the parameters "diameter" and "length". In this case, and presumabl

g) If parameter description, reference unit, data type, level etc. differ between the accepted and the targeted values, please use seperate rows each for the accepted and the targeted values of the same parameter.

h) If no values are given, it is assumed there is no limitation, be it minimum or maximum

| Industrial requirements (wp3000_6000) request from task5300 | | Respondent: | FCBA | Flexwood Partner Organisation: | FCBA | Flexwood Task No: | | 15 October 2010 |
|---|---|---|---|---|---|---|---|---|
| **Industrial requirements towards forest raw material** | **Industry type:** | **sawmill** | **Species:** (code = EN13556) **b)** | **Beech Fagus sylvatica (FASY)** | | **product group: b)** | **saw broadleave furniture MQ** | |
| Country: **(a)** France | | choose from dropdown menu | choose from dropdown menu | | | choose from dropdown menu | | |

| rank of importance **c)** | requirement type **d)** ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter **e)** | description of parameter | reference unit | values (min, mean, max,…) **h)** | | | | | possible target value, if "category of parameter" = "accepted value" **g) h)** | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) **f)** | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | **hard demand** | diameter **f)** | target values/ value range | mid diameter | cm on bark | 33 | | | | | | | | | | measured | log level | procurement ordering forms | |
| 1 | **hard demand** | diameter | accepted values/ range of acceptance | top diameter | cm on bark | 30 | | | | | | | | | | measured | log level | procurement ordering forms | |
| 1 | **hard demand** | length **f)** | target values/ value range | minimum log length | m | 3 | | | | | | | | | | measured | log level | procurement ordering forms | |
| 2 | **hard demand** | heart wood Colouration | target values/ value range | red heartwood | not allowed if star shape | | 0 | | | | | | | | | direct detection | log level | procurement ordering forms | |
| 2 | **hard demand** | heart wood Colouration | accepted values/ range of acceptance | red heartwood | % of diameter | | 30 | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | **hard demand** | knots | accepted values/ range of acceptance | sound knot | number knots / 3 lm | | 3 | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | **hard demand** | straitness | accepted values/ range of acceptance | maximal bow accepted | cm/m | | 4 | | | | | | | | | measured | log | procurement ordering forms | |
| 2 | **hard demand** | eccentric pith | accepted values/ range of acceptance | | not allowed if more than slightly eccentric | | | | | | | | | | | measured | log | procurement ordering forms | |

**a)** Please indicate the country for which the given data is applicable. If it is true for all of the studied countries, please mark "all". Please fill out one separate sheet for each country.

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**c)** Please rank the parameters according to their importance for processing within the respective product group. 1 = highest importance, total number of parameters unlimited (you may add rows if needed!), if two or more parameters are considered of the same i

**d)** Please differentiate for each parameter between "hard" and "soft" demand to indicate whether industry considers it as absolutely necessary for processing according to the specific product group (="hard demand") or more of a "nice-to-have" but not absolute

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**f)** Assuming -from our experience-, any industry has certain target value ranges at least for some parameters, we ask you to give at least not only the accepted but also the favored range for the parameters "diameter" and "length". In this case, and presumabl

**g)** If parameter description, reference unit, data type, level etc. differ between the accepted and the targeted values, please use seperate rows each for the accepted and the targeted values of the same parameter.

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| Industrial requirements (wp3000_6000) request from task5300 | Respondent: FCBA | Flexwood Partner Organisation: FCBA | Flexwood Task No: | 15 October 2010 |
|---|---|---|---|---|

| Industrial requirements towards forest raw material | Industry type: | sawmill | Species: (code = EN13556) b) | Coniferous | product group: b) | saw coniferous construction |
|---|---|---|---|---|---|---|
| Country: a) France | | choose from dropdown menu | choose from dropdown menu | | choose from dropdown menu | |

| rank of importance c) | requirement type d) ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter e) | description of parameter | reference unit | values (min, mean, max,…) h) | | | | | possible target value, if "category of parameter" = "accepted value" g) h) | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) f) | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | hard demand | diameter f) | target values/ value range | Top diameter under bark | cm | 12 | | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | diameter | accepted values/ range of acceptance | Big diameter under bark | cm | 40 | | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | length f) | target values/ value range | log length | m | 3 | | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | Non-wood elements | accepted values/ range of acceptance | excluded | allowed/notallowed | | 0 | | | | | | | | | geolocation or visual appearance | batch | procurement ordering forms | |
| 2 | hard demand | Colouration | accepted values/ range of acceptance | excluded | allowed/notallowed | | 0 | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | Species | accepted values/ range of acceptance | requested species | species name | | Picea Abies Abies Alba | | | | | | | | | visual appaerance | batch | procurement ordering forms | |
| 1 | hard demand | knots | accepted values/ range of acceptance | knot size and number per unit | knots/lm | | too long to describe in the cell | | | | | | | | | measured | log | procurement ordering forms | |
| 2 | hard demand | shakes | accepted values/ range of acceptance | shake lenghth in comparison to log diameter | cm | | length<0,5diameter | | | | | | | | | measured | log | procurement ordering forms | |

a) Please indicate the country for which the given data is applicable. If it is true for all of the studied countries, please mark "all". Please fill out one separate sheet for each country.

b) Please fill out one seperate sheet for each species and each product group covered within the industry type of your task. Additional product groups may be entered by selecting "other" and by specifying behind.

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| Industrial requirements (wp3000_6000) request from task5300 | Respondent: FCBA | Flexwood Partner Organisation: FCBA | Flexwood Task No: | 15 October 2010 |
|---|---|---|---|---|

| Industrial requirements towards forest raw material | Industry type: | sawmill | Species: (code = EN13556) b) | Coniferous | product group: b) | saw coniferous construction |
|---|---|---|---|---|---|---|
| Country: a) France | | choose from dropdown menu | choose from dropdown menu | | choose from dropdown menu | |

| rank of importance c) | requirement type d) ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter e) | description of parameter | reference unit | values (min, mean, max,…) h) | | | | | possible target value, if "category of parameter" = "accepted value" g) h) | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) f) | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | hard demand | diameter f) | target values/ value range | under bark | cm | 25 | 100 | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | length f) | target values/ value range | minimum log length | m | 4,2 | | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | Non-wood elements | accepted values/ range of acceptance | excluded | allowed/notallowed | | 0 | | | | | | | | | geolocation or visual appearance | batch | procurement ordering forms | |
| 2 | hard demand | Colouration | accepted values/ range of acceptance | excluded | allowed/notallowed | | 0 | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | Species | accepted values/ range of acceptance | requested species | species name | | Picea Abies Abies Alba Douglas Fir | | | | | | | | | visual appearance | batch | procurement ordering forms | |
| 1 | hard demand | knots | accepted values/ range of acceptance | knot size and number per unit | knots/lm | | too long to describe in the cell | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | straitness | accepted values/ range of acceptance | maximal bow accepted on a 4m length | cm/m | | 2 | | | | | | | | | measured | log | procurement ordering forms | |
| 2 | hard demand | shakes | accepted values/ range of acceptance | shake lenghth in comparison to log diameter | cm | | length<0,5diameter | | | | | | | | | measured | log | procurement ordering forms | |
| 2 | hard demand | shakes (star shape) | accepted values/ range of acceptance | maximum length from the center | cm | | 5 | | | | | | | | | measured | log | procurement ordering forms | |

a) Please indicate the country for which the given data is applicable. If it is true for all of the studied countries, please mark "all". Please fill out one separate sheet for each country.

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g) If parameter description, reference unit, data type, level etc. differ between the accepted and the targeted values, please use seperate rows each for the accepted and the targeted values of the same parameter.

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| Industrial requirements (wp3000_6000) request from task5300 | | Respondent: | FCBA | Flexwood Partner Organisation: | FCBA | Flexwood Task No: | | 15 October 2010 |
|---|---|---|---|---|---|---|---|---|
| Industrial requirements towards forest raw material | Industry type: | sawmill | Species: (code = EN13556) | Pine Pinus pinaster b)(PNPN) | product group: b) | saw coniferous construction | | |
| Country: (a) France | | choose from dropdown menu | | choose from dropdown menu | | choose from dropdown menu | | |

| rank of importance c) | requirement type d) ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter e) | description of parameter | reference unit | values (min, mean, max,…) h) | | | | | possible target value, if "category of parameter" = "accepted value" g) h) | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) f) | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | hard demand | diameter f) | target values/ value range | Top diameter under bark | cm | 25 | | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | length f) | target values/ value range | minimum log length | m (+/- 2cm) | 2,08 | | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | Non-wood elements | accepted values/ range of acceptance | non wood elements (metall) Cristallised resin pockets | allowed/notallowed | | 0 | | | | | | | | | visual appearance | log | procurement ordering forms | |
| 1 | hard demand | Colouration | accepted values/ range of acceptance | excluded | allowed/notallowed | | 0 | | | | | | | | | visual appearance | log | procurement ordering forms | |
| 1 | hard demand | Species | accepted values/ range of acceptance | requested species | species name | | Picea Abies Abies Alba Douglas Fir | | | | | | | | | visual appaerance | batch | procurement ordering forms | |
| 1 | hard demand | knots | accepted values/ range of acceptance | knot size and number per unit | knots/lm | | too long to describe in the cell | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | straitness | accepted values/ range of acceptance | maximal bow accepted on a 2m length | cm/ 2m | | 5 | | | | | | | | | measured | log | procurement ordering forms | |
| 2 | hard demand | shakes | accepted values/ range of acceptance | shake due to logging operation | allowed/notallowed | | 0 | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | knot ring | accepted values/ range of acceptance | Number and diameter of sound knot on ring | nb and max diameter / ring | | 3 4cm | | | | | | | | | measured | log | procurement ordering forms | |
| 1 | hard demand | Freshness | target values/ value range | Freshness without blue stain | allowed/notallowed | | 0 | | | | | | | | | visual appearance | log | procurement ordering forms | |
| 1 | hard demand | Resin pockets | target values/ value range | Resin pockets | allowed/notallowed | | 0 | | | | | | | | | visual appearance | log | procurement ordering forms | |
| 1 | hard demand | Fire damage | target values/ value range | Consequences of previous forest fire | allowed/notallowed | | 0 | | | | | | | | | visual appearance | log | procurement ordering forms | |

a) Please indicate the country for which the given data is applicable. If it is true for all of the studied countries, please mark "all". Please fill out one separate sheet for each country.

b) Please fill out one seperate sheet for each species and each product group covered within the industry type of your task. Additional product groups may be entered by selecting "other" and by specifying behind.

c) Please rank the parameters according to their importance for processing within the respective product group. 1 = highest importance, total number of parameters unlimited (you may add rows if needed!), if two or more parameters are considered of the same i

d) Please differentiate for each parameter between "hard" and "soft" demand to indicate whether industry considers it as absolutely necessary for processing according to the specific product group (="hard demand") or more of a "nice-to-have" but not absolute

e) Please differentiate for each parameter whether the values given are considered representing the whole possible range of acceptance ("accepted values/ range of acceptance or) or if they represent the industry's "target values/ value range" for the above g

f) Assuming -from our experience-, any industry has certain target value ranges at least for some parameters, we ask you to give at least not only the accepted but also the favored range for the parameters "diameter" and "length". In this case, and presumabl

g) If parameter description, reference unit, data type, level etc. differ between the accepted and the targeted values, please use seperate rows each for the accepted and the targeted values of the same parameter.

h) If no values are given, it is assumed there is no limitation, be it minimum or maximum

| Industrial requirements (wp3000_6000) request from task5300 | | Respondent: | Axel Winking | | | Flexwood Partner Organisation: | FVA | | | Flexwood Task No: | 6100 | | 11.11.2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industrial requirements towards forest raw material | Industry type: | sawmill | | Species: (code = EN13556) b) | Beech Fagus sylvatica (FASY) | | | product group: b) | saw broadleaf flooring | | | | |
| Country: (a) | Germany | choose from dropdown menu | | choose from dropdown menu | | | | choose from dropdown menu | | | | | |

| rank of importance c) | requirement type d) ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter e) | description of parameter | reference unit | values (min, mean, max,…) h) | | | | | possible target value, if "category of parameter" = "accepted value" g) h) | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) f) | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | | diameter f) | target values/ value range | mid diameter | mid diameter (cm u.b.) | 30 | | 30 | | | | | | | | measured | tree level | EN 1316-1 expert interview | |
| 1 | | diameter | accepted values/ range of acceptance | top diameter | top diameter (cm u.b.) | 28 | | | | | | | | | | measured | tree level | expert interview | |
| 2 | | length f) | target values/ value range | log length | meter (m) | 2 | 5,1 | | | | | | | | | measured | tree level | expert interview | |
| 2 | | length | accepted values/ range of acceptance | | meter (m) | | | 3 | | | | | | | | measured | tree level | EN 1316-1 | |
| 3 | | yearring width | | | mm allowed | allowed | allowed | allowed | | | | | | | | measured | tree level | EN 1316-1 | |
| 4 | | knot | | occluded | N/lm | | 3/3lm | | | | | | | | | measured | tree level | EN 1316-1 | |
| 4 | | knot | | not occluded | N/lm | | ∑ of diameters ≤ 200 mm/3lm (thereof 40 mm max. unsound knots/lm) | | | | | | | | | measured | tree level | EN 1316-1 | |
| 5 | | spiral grain | | | cm/lm | | ≤ 9 | | | | | | | | | measured | tree level | EN 1316-1 | |
| 6 | | excentricity | | | % | | ≤20 | | | | | | | | | measured | tree level | EN 1316-1 | |
| 7 | | curvature | | | cm/lm | | ≤4 | | | | | | | | | measured | tree level | EN 1316-1 | |
| 8 | | ovality | | | % allowed/not allowed | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| 9 | | fluting | | | allowed/not allowed | | not allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| 10 | | heart shake | | | allowed/not allowed | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| 11 | | star shake | | | allowed/not allowed | | not allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| 12 | | damage by insects | | | allowed/not allowed | | not allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| 13 | | white rot | | % of diameter | % | | ≤15 | | | | | | | | | measured | tree level | EN 1316-1 | |
| 14 | | red heart | | % of diameter | % | | ≤30 | | | | | | | | | measured | tree level | EN 1316-1 | |
| 15 | | spray heart | | % of diameter | % | | ≤10 | | | | | | | | | measured | tree level | EN 1316-1 | |
| 16 | | stain | | | allowed/not allowed | | not allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| 17 | | T-spots | | | allowed/not allowed | | not allowed | | | | | | | | | measured | tree level | EN 1316-1 | |

| Industrial requirements (wp3000_6000) request from task5300 | | Respondent: | Axel Winking | | Flexwood Partner Organisation: | FVA | | Flexwood Task No: | 6100 | | 11.11.2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Industrial requirements towards forest raw material** | **Industry type:** | **sawmill** | **Species:** (code = EN13556) **b)** | **Beech Fagus sylvatica (FASY)** | | | **product group: b)** | **saw broadleaf furniture HQ** | | | |
| Country: **(a)** | Germany | **choose from dropdown menu** | | **choose from dropdown menu** | | | | **choose from dropdown menu** | | | |

| rank of importance **c)** | requirement type **d)** ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter **e)** | description of parameter | reference unit | values (min, mean, max,…) **h)** | | | | | possible target value, if "category of parameter" = "accepted value" **g) h)** | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) **f)** | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | **hard demand** | diameter **f)** | target values/ value range | mid diameter | mid diameter (cm u.b.) | 30 | | 30 | | | | | | | | measured | tree level | EN 1316-1 expert interview | |
| 1 | **hard demand** | diameter | accepted values/ range of acceptance | top diameter | top diameter (cm u.b.) | 28 | | | | | | | | | | measured | tree level | EN 1316-1 | |
| 2 | **hard demand** | length **f)** | target values/ value range | log length | meter (m) | 2 | 5,1 | | | | | | | | | measured | tree level | expert interview | |
| 2 | **hard demand** | length | accepted values/ range of acceptance | | meter (m) | | | 3 | | | | | | | | measured | tree level | EN 1316-1 | |
| 3 | **hard demand** | yearring width | | | mm allowed | allowed | allowed | allowed | | | | | | | | measured | tree level | EN 1316-1 | |
| 4 | **hard demand** | knot | | occluded | N/lm | | 3/3lm | | | | | | | | | measured | tree level | EN 1316-1 | |
| 4 | **hard demand** | knot | | not occluded | N/lm | | ∑ of diameters ≤ 200 mm/3lm (thereof 40 mm max. unsound knots/lm) | | | | | | | | | measured | tree level | EN 1316-1 | |
| 5 | **hard demand** | spiral grain | | | cm/lm | | ≤ 9 | | | | | | | | | measured | tree level | EN 1316-1 | |
| 6 | **hard demand** | exctentricity | | | % | | ≤20 | | | | | | | | | measured | tree level | EN 1316-1 | |
| 7 | **hard demand** | curvature | | | cm/lm | | ≤4 | | | | | | | | | measured | tree level | EN 1316-1 | |
| 8 | **hard demand** | ovality | | | % allowed/not allowed | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| 9 | **hard demand** | fluting | | | allowed/not allowed | | not allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| 10 | **hard demand** | heart shake | | | allowed/not allowed | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| 11 | **hard demand** | star shake | | | allowed/not allowed | | not allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| 12 | **hard demand** | damage by insects | | | allowed/not allowed | | not allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| 13 | **hard demand** | white rot | | % of diameter | % | | ≤15 | | | | | | | | | measured | tree level | EN 1316-1 | |
| 14 | **hard demand** | red heart | | % of diameter | % | | ≤30 | | | | | | | | | measured | tree level | EN 1316-1 | |
| 15 | **hard demand** | spray heart | | % of diameter | % | | ≤10 | | | | | | | | | measured | tree level | EN 1316-1 | |
| 16 | **hard demand** | stain | | | allowed/not allowed | | not allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| 17 | **hard demand** | T-spots | | | allowed/not allowed | | not allowed | | | | | | | | | measured | tree level | EN 1316-1 | |

| Industrial requirements (wp3000_6000) request from task5300 | Respondent: Axel Winking | Flexwood Partner Organisation: FVA | Flexwood Task No: 6100 | 11.11.2010 |
|---|---|---|---|---|

| Industrial requirements towards forest raw material | Industry type: | sawmill | Species: (code = EN13556) b) | Beech Fagus sylvatica (FASY) | product group: b) | saw broadleaf packaging |
|---|---|---|---|---|---|---|
| Country: (a) Germany | | choose from dropdown menu | | choose from dropdown menu | | choose from dropdown menu |

| rank of importance c) | requirement type d) ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter e) | description of parameter | reference unit | values (min, mean, max,…) h) | | | | | possible target value, if "category of parameter" = "accepted value" g) h) | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) f) | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| | hard demand | diameter f) | target values/ value range | mid diameter | mid diameter (cm u.b.) | 25 | | | | | | | | | | measured | tree level | EN 1316-1 expert interview | |
| | hard demand | diameter | accepted values/ range of acceptance | top diameter | top diameter (cm u.b.) | | | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | length f) | target values/ value range | log length | meter (m) | 2 | | | | | | | | | | measured | tree level | expert interview | |
| | hard demand | length | accepted values/ range of acceptance | meter | meter (m) | | | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | yearring width | target values/ value range | | mm | allowed | allowed | allowed | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | knot | | occluded | N/m | | sound knots allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | knot | | not occluded | N/m | | ∑diameters rotten and unsound knots ≤120mm/3lm | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | spiral grain | target values/ value range | | cm/lm | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | exctentricity | | | % | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | curvature | | | cm/lm | | ≤8 | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | ovality | | | % allowed/not allowed | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | fluting | | | allowed/not allowed | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | heart shake | | | allowed/not allowed | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | star shake | | | allowed/not allowed | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | damage by insects | | | allowed/not allowed | | not allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | white rot | | % of diameter | % | | ≤25 | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | red heart | | % of diameter | % | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | spray heart | | % of diameter | % | | ≤ 40 | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | stain | | | allowed/not allowed | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |
| | hard demand | T-spots | | | allowed/not allowed | | allowed | | | | | | | | | measured | tree level | EN 1316-1 | |

| Industrial requirements (wp3000_6000) request from task5300 | | Respondent: | | Flexwood Partner Organisation: | IBL | Flexwood Task No: | | 15 October 2010 |
|---|---|---|---|---|---|---|---|---|
| **Industrial requirements towards forest raw material** | **Industry type:** | **sawmill** | **Species:** (code = EN13556) | **Pine** **Pinus sylvestris** **b)(PNSY)** | | **product group: b)** | **saw coniferous appearance** | |
| Country: **(a)** Poland | | choose from dropdown menu | choose from dropdown menu | | | choose from dropdown menu | | |

| rank of importance **c)** | requirement type **d)** ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter **e)** | description of parameter | reference unit | values (min, mean, max,…) **h)** | | | | | possible target value, if "category of parameter" = "accepted value" **g) h)** | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) **f)** | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | **hard demand** | diameter | accepted values/ range of acceptance | minimal top diameter; minimal nominal diameter (1 m from bottom) | centimeters, under bark [cm] | 22<br>35 | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 1 | **hard demand** | length | accepted values/ range of acceptance | log length; length of bottom part without defects or with accepted defects | meters [m] | 2.7<br>4 | | | | | | | | | | measured | log level | technical standard of State Forests | length with minimal intervals of 0.1 m |
| 2 | **hard demand** | knottiness | accepted values/ range of acceptance | open knots<br>enclosed knots | not allowed<br>allowed / not allowed | | 0<br>h≤1cm / 0 | | | | | | | | | measured | log level | technical standard of State Forests | |
| 2 | **hard demand** | shakes | accepted values/ range of acceptance | end shakes;<br>end-side shakes, deep and passing through | % of diameter;<br>not allowed | | 20<br>0 | | | | | | | | | measured | log level | technical standard of State Forests | |
| 3 | **hard demand** | sweep | accepted values/ range of acceptance | simple sweep | cm / m | | 1 / 1 | | | | | | | | | measured | log level | technical standard of State Forests | |
| 3 | **hard demand** | spiral grain | accepted values/ range of acceptance | | cm / m | | 5 / 1 | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | flutting | accepted values/ range of acceptance | | allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | discoloration | accepted values/ range of acceptance | blue stain<br>brown stain | not allowed<br>not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | rot | accepted values/ range of acceptance | inner;<br>root rot;<br>surface rot | not allowed;<br>not allowed;<br>not allowed; | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | insect wholes | accepted values/ range of acceptance | ` | not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | foreign objects | accepted values/ range of acceptance | metals, stones etc. | not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |

| Industrial requirements (wp3000_6000) request from task5300 | | Respondent: | Krzysztof Jodlowski | Flexwood Partner Organisation: | BL | Flexwood Task No: | | | 15 October 2010 |
|---|---|---|---|---|---|---|---|---|---|
| **Industrial requirements towards forest raw material** | **Industry type:** | **sawmill** | **Species:** (code = EN13556) | **Pine** **Pinus sylvestris** **(PNSY)** | | **product group:** | **saw coniferous packaging** | | |
| Country: **(a)** | Poland | choose from dropdown menu | choose from dropdown menu | | | choose from dropdown menu | | | |

| rank of importance **c)** | requirement type **d)** ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter **e)** | description of parameter | reference unit | values (min, mean, max,…) **h)** | | | | | possible target value, if "category of parameter" = "accepted value" **g) h)** | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) **f)** | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | **hard demand** | diameter | accepted values/ range of acceptance | top diameter | centimeters, under bark [cm] | 13 | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 1 | **hard demand** | length | accepted values/ range of acceptance | log length | meters [m] | | | | | 0.8; 1.0; 1.2; 1.6; 2.4 | | | | | 1.2 | measured | log level | technical standard of State Forests | |
| 2 | **hard demand** | sweep | accepted values/ range of acceptance | simple sweep<br>multi sweep | cm / m<br>not allowed | | 1.5 / 1 | | | | | | | | | measured | log level | technical standard of State Forests | |
| 3 | **hard demand** | rot | accepted values/ range of acceptance | | not allowed (allowed upon agreament) | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 3 | **hard demand** | burnt wood | accepted values/ range of acceptance | | not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | discoloration | accepted values/ range of acceptance | blue stain -soft shade<br>brown stain | percentage of sapwood<br>not allowed | | 50<br>0 | | | | | | | | | measured | log level | technical standard of State Forests | |
| 5 | **hard demand** | insect wholes | accepted values/ range of acceptance | active<br>non active, single | not allowed<br>diameter, mm | | 0<br>3 | | | | | | | | | measured | log level | technical standard of State Forests | |
| 6 | **hard demand** | foreign objects | accepted values/ range of acceptance | metals, stones etc. | not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |

| Industrial requirements (wp3000_6000) request from task5300 | | Respondent: | | Flexwood Partner Organisation: | BL | Flexwood Task No: | | 15 October 2010 |
|---|---|---|---|---|---|---|---|---|
| **Industrial requirements towards forest raw material** | **Industry type:** | **sawmill** | **Species:** (code = EN13556) | **Pine** **Pinus sylvestris** **b)(PNSY)** | | **product group: b)** | **saw coniferous construction** | |
| Country: **(a)** Poland | | choose from dropdown menu | choose from dropdown menu | | | choose from dropdown menu | | |

| rank of importance **c)** | requirement type **d)** ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter **e)** | description of parameter | reference unit | values (min, mean, max,…) **h)** | | | | | possible target value, if "category of parameter" = "accepted value" **g) h)** | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) **f)** | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | **hard demand** | diameter **f)** | target values/ value range | top diameter, u.b.; bottom diameter, u.b.; | centimeters [cm] | 12 | 35 | | | | | | | | | | | | |
| 1 | **hard demand** | diameter | accepted values/ range of acceptance | top diameter, u.b. | centimeters [cm] | 14 | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 1 | **hard demand** | length | accepted values/ range of acceptance | log length | meters [m] | 2.7 | | | | | | | | | | measured | log level | technical standard of State Forests | length with minimal intervals of 0.1 m |
| 2 | **hard demand** | knottiness | accepted values/ range of acceptance | open knots | allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 2 | **hard demand** | knottiness | accepted values/ range of acceptance | enclosed knots (bumps) | allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 2 | **hard demand** | shakes | accepted values/ range of acceptance | end shakes | allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 2 | **hard demand** | shakes | accepted values/ range of acceptance | end-side shakes, deep and apssing through | not alowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 3 | **hard demand** | sweep | accepted values/ range of acceptance | simple sweep | cm / m | | 3 cm /1 m | | | | | | | | | measured | log level | technical standard of State Forests | |
| 3 | **hard demand** | spiral grain | accepted values/ range of acceptance | | allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | flutting | | | allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | discoloration blue stain | accepted values/ range of acceptance | | % of crossection | | 50 of sapwood | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | discoloration bown stain | accepted values/ range of acceptance | | not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | inner rot | accepted values/ range of acceptance | acceptable on one end of log | % of diameter | | 20 | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | root rot | accepted values/ range of acceptance | | not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | surface' rot | accepted values/ range of acceptance | | % of circumference / % of diameter | | 25% / 10% | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | insect wholes | accepted values/ range of acceptance | | not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | foreign objects | accepted values/ range of acceptance | | not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |

| Industrial requirements (wp3000_6000) request from task5300 | | Respondent: | Krzysztof Jodlowski | Flexwood Partner Organisation: | BL | Flexwood Task No: | | 15 October 2010 |
|---|---|---|---|---|---|---|---|---|
| **Industrial requirements towards forest raw material** | **Industry type:** | **sawmill** | **Species:** (code = EN13556) **b)** | **Pine Pinus sylvestris (PNSY)** | | **product group: b)** | **saw coniferous plywood** | |
| Country: **(a)** Poland | | choose from dropdown menu | choose from dropdown menu | | | choose from dropdown menu | | |

| rank of importance **c)** | requirement type **d)** ("hard" or "soft" demand) | parameter (e.g. diameter, knottiness, taper, moisture content,…) | category of parameter **e)** | description of parameter | reference unit | values (min, mean, max,…) **h)** | | | | | possible target value, if "category of parameter" = "accepted value" **g) h)** | | | | | required data type (e.g. measured, predicted, direct, indirect, …) | required level (e.g. stand level, tree level, batch level, …) **f)** | data sources (e.g. literature, expert interview, nat./intl. standard,…) | further description of parameter or of values (also: additional values) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | type | type | type | other | | type | type | type | other | | | | | |
| | | | | | | min | max | mean | type | value | min | max | mean | type | value | | | | |
| 1 | **hard demand** | diameter | accepted values/ range of acceptance | top diameter, u.b. | centimeters [cm] | 20 | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 1 | **hard demand** | length **f)** | target values/ value range | log length | meters, [m] | 1.3 m and multiplicity of that length | | | | | | | | | | | | | |
| 1 | **hard demand** | length | accepted values/ range of acceptance | log length | meters, [m] | 4 | | | | | | | | | | measured | log level | technical standard of State Forests | log length with minimal interval 0.1 m |
| 2 | **hard demand** | knottiness | accepted values/ range of acceptance | open knots | not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 2 | **hard demand** | knottiness | accepted values/ range of acceptance | enclosed knots (bumps) | heigh, [cm] | | | | accepted | ≤1 | | | | | | measured | log level | technical standard of State Forests | |
| 2 | **hard demand** | knottiness | accepted values/ range of acceptance | enclosed knots (bumps) | heigh, [cm] | | | | accepted with limits | >1 | | | | | | measured | log level | technical standard of State Forests | accepted: up to 4 'rims' with bumps on 1/2 of log length from the top end of log |
| 2 | **hard demand** | shakes | accepted values/ range of acceptance | shakes at log ends, end shakes | % of diameter | | | | in the pith zone | ≤30 | | | | | | measured | log level | technical standard of State Forests | |
| 2 | **hard demand** | shakes | accepted values/ range of acceptance | end and side shakes (rifts) | not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 3 | **hard demand** | sweep | accepted values/ range of acceptance | average sweep of log (simple sweep) | cm/m | | 2 cm / 1m | | | | | | | | | measured | log level | technical standard of State Forests | |
| 3 | **hard demand** | flatten | accepted values/ range of acceptance | log ovality | % of diameter | | ≤ 10 | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | fluting' | accepted values/ range of acceptance | length on log side | cm | | ≤ 10 | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | discoloration | accepted values/ range of acceptance | | not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | rot | accepted values/ range of acceptance | | accepted in heartwood (pith) zone, cm | | ≤ 8 | | | | | | | | | measured | log level | technical standard of State Forests | |
| 4 | **hard demand** | insect wholes | accepted values/ range of acceptance | | not allowed | | | | | | | | | | | measured | log level | technical standard of State Forests | |

## 6.2 Forest resource information

| level | parameter (to be expanded individually) | reference unit | data type (e.g. measured, | data source (e.g. ALS, TLS, Forest inventory,...) |
|---|---|---|---|---|
| standard site information | latitude | | direct | ALS |
| | altitude | | direct | ALS |
| | exposition | degrees | processed | ALS |
| | slope | degrees | processed | ALS |
| | soil | | | Forest inventory |
| | site classification | | measured and terrestrial esitmated | Site mapping |
| | height distribution | | measured | Forest inventory |
| | diameter distribution | | measured | Forest inventory |
| | number of trees | | measured | Forest inventory |
| | damage | | measured | Forest inventory |
| | stand type | | terrestrial assessed | Forest management planning |
| stand information | species / group of species | | modelled, estimated | ALS/hyperspectral data/aerial photographs/ forest management planning |
| | height distribution | m | modelled/processed, modelled | ALS, ALS/Forest Inventory |
| | diameter distribution | cm | modelled | ALS/Forest Inventory |
| | number of trees | | modelled/processed | ALS/Forest Inventory |
| | solid volume (>7cm) | m3 | modelled, extrapolated | ALS, Forest management planning |
| | total biomass volume | m3 | modelled | ALS |
| | total biomass | kg | modelled | ALS |
| | age | years | modelled, assessed | ALS, Forest management planning |
| | damage | | terrestrial assessed | Forest management planning |
| | mean height | m | modelled, measured, processed | ALS, Forest management planning |
| | mean diameter | cm | modelled, measured, processed | ALS, Forest management planning |
| | dominant height | m | measured/processed, measured, processed | ALS, Forest management planning |
| | taper curve | | measured/processed, modelled | TLS |
| | stand delineation | | modelled, measured | ALS, Forest management planning |
| | crown cover | % | measured, processed | ALS |
| | basal area | m2 | modelled, measured | ALS, Forest management planning |
| tree information | species | | modelled, direct | ALS/hyperspectral data/ aerial photographs |
| | age | years | measured, assessed | Forest inventory |
| | coordinates (XYZ) | | measured | ALS, TLS |
| | total height | m | measured | ALS, TLS |
| | height of lowest green branch | m | modelled, measured | ALS, TLS |
| | height at crown base | m | modeleld, measured | ALTLS |
| | crown diameter | m | measured, measured | ALS, TLS |
| | crown volume | m3 | modelled, measured | ALS, TLS |
| | dbh | cm | modelled/measured | ALS, TLS |
| | d7 | cm | modelled, measured | ALS, TLS |
| | defects | | | |
| | bow | | | |
| | solid volume (>7cm) | m3 | modelled | ALS |
| | total biomass volume | m3 | modelled, processed | ALS, TLS |
| | taper curve | | measured, processed | TLS |
| | crown ratio | % | modelled, processed | ALS, TLS |
| | stem ratio | | processed | TLS |
| | timber assortments | m3 | modelled, modelled | ALS, TLS |

| Legend: | green = Data existing for public forests and large area forest enterprises<br>blue = expected information<br>yellow = possible Information derived form TLS-Analyses |
|---|---|

## 6.3 Tree list from manual fusion

| PLOT# | TLS_TREE# | ALS_GPS_X | ALS_GPS_Y | REF# | REF_GPS_X | REF_GPS_Y | REF_SPEC | D_TLS (cm) | D_REF | D7_TLS (cm) | H_ALS (m) | BH_ALS (m) | CL_ALS (m) | Cdmax_ALS (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1175 | 1 | 3456407,450 | 5433010,880 | 2 | 3456404,021 | 5433007,505 | Bu | 53,2 | 49 | 35,6 | 26,19 | 22,13 | 4,06 | 9,27 |
| 1175 | 2 | 3456411,840 | 5432997,500 | 10 | 3456412,137 | 5432998,294 | Bu | 50,9 | 51 | 44,1 | 28,13 | 20,29 | 7,84 | 10,10 |
| 1175 | 5 | 3456400,180 | 5433007,640 | 1 | 3456401,420 | 5433005,303 | Bu | 59,4 | 60 | 52,4 | 27,00 | 22,97 | 4,03 | 9,95 |
| 1210 | 3 | 3457817,330 | 5433404,100 | 10 | 3457813,911 | 5433404,578 | Kie | 33,7 | 38 | 27,6 | 26,81 | 22,77 | 4,04 | 6,90 |
| 1210 | 4 | 3457814,100 | 5433394,670 | 27 | 3457813,921 | 5433395,081 | Kie | 35,6 | 37 | 29,2 | 25,92 | 21,29 | 4,63 | 7,43 |
| 1210 | 9 | 3457801,660 | 5433391,460 | 35 | 3457799,285 | 5433390,187 | Kie | 37,6 | 37 | 26,8 | 28,50 | 14,11 | 14,39 | 5,91 |
| 1210 | 10 | 3457797,550 | 5433386,850 | 40 | 3457796,669 | 5433388,332 | Kie | 33,3 | 35 | 25,8 | 26,39 | 22,27 | 4,12 | 8,47 |
| 1210 | 13 | 3457786,220 | 5433398,310 | 44 | 3457787,997 | 5433396,382 | Bu | 27,8 | 29 | 22,2 | 24,36 | 19,92 | 4,44 | 9,79 |
| 2056 | 3 | 3457005,320 | 5434212,730 | 8 | 3457004,778 | 5434212,472 | Kie | 25,1 | 25 | 18,6 | 18,10 | 14,03 | 4,07 | 6,02 |
| 2056 | 5 | 3457007,950 | 5434205,950 | 16 | 3457007,877 | 5434206,442 | Kie | 16,9 | 19 | 10,9 | 17,92 | 11,59 | 6,33 | 6,44 |
| 2056 | 7 | 3457011,930 | 5434204,510 | 22 | 3457011,421 | 5434205,210 | Kie | 18,2 | 21 | 15,8 | 18,09 | 13,85 | 4,24 | 5,92 |
| 2056 | 12 | 3457011,910 | 5434196,230 | 32 | 3457011,776 | 5434197,205 | Kie | 21,9 | 24 | 15,0 | 18,15 | 12,73 | 5,42 | 6,71 |
| 2056 | 13 | 3457006,320 | 5434197,360 | 29 | 3457006,443 | 5434197,934 | Kie | 19,4 | 19 | 14,7 | 16,91 | 11,66 | 5,25 | 6,66 |
| 2056 | 14 | 3457006,840 | 5434192,350 | 39 | 3457007,011 | 5434193,205 | Kie | 28,6 | 27 | 19,8 | 17,51 | 10,45 | 7,06 | 6,70 |
| 2056 | 15 | 3457001,570 | 5434197,040 | 37 | 3457001,645 | 5434197,220 | Kie | 26,4 | 25 | 20,8 | 17,68 | 13,64 | 4,04 | 7,18 |
| 2056 | 19 | 3456994,920 | 5434191,070 | 60 | 3456995,321 | 5434191,619 | Kie | 28,2 | 27 | 21,2 | 18,44 | 12,64 | 5,80 | 6,68 |
| 2056 | 20 | 3456990,630 | 5434189,420 | 64 | 3456990,950 | 5434189,141 | Kie | 25,8 | 26 | 18,8 | 18,97 | 11,36 | 7,61 | 6,61 |
| 2056 | 22 | 3456991,240 | 5434197,710 | 66 | 3456991,584 | 5434197,541 | Kie | 30,0 | 32 | 25,8 | 18,20 | 13,93 | 4,27 | 7,50 |
| 2056 | 25 | 3456988,370 | 5434202,700 | 78 | 3456988,035 | 5434202,994 | Kie | 26,1 | 28 | 23,8 | 19,21 | 14,43 | 4,78 | 6,15 |
| 2056 | 26 | 3456991,740 | 5434211,270 | 54 | 3456990,594 | 5434210,366 | Kie | 22,5 | 12 | 18,6 | 17,24 | 13,19 | 4,05 | 6,68 |
| 2083 | 3 | 3456908,340 | 5434407,060 | 19 | 3456905,000 | 5434410,155 | Bu | 46,4 | 47 | 30,4 | 21,97 | 17,68 | 4,29 | 8,31 |
| 2083 | 6 | 3456910,280 | 5434401,870 | 20 | 3456908,553 | 5434401,904 | Bu | 53,1 | 57 | 43,7 | 24,58 | 20,50 | 4,08 | 8,95 |
| 2083 | 8 | 3456896,010 | 5434403,060 | 13 | 3456896,845 | 5434398,874 | Bu | 45,5 | 41 | 34,2 | 20,44 | 16,37 | 4,07 | 7,68 |
| 2083 | 12 | 3456893,340 | 5434406,930 | 16 | 3456896,607 | 5434406,217 | Bu | 29,5 | 44 | 27,6 | 21,33 | 17,32 | 4,01 | 8,69 |
| 2194 | 3 | 3457103,770 | 5435000,170 | 93 | 3457104,381 | 5435000,406 | Kie | 22,1 | 23 | 18,3 | 18,21 | 14,10 | 4,11 | 6,69 |
| 2194 | 4 | 3457103,070 | 5434995,460 | 9 | 3457103,240 | 5434995,892 | Kie | 27,0 | 26 | 20,4 | 17,03 | 12,59 | 4,44 | 5,21 |
| 2194 | 6 | 3457098,200 | 5434991,440 | 19 | 3457098,661 | 5434991,518 | Kie | 20,8 | 21 | 14,3 | 16,43 | 10,09 | 6,34 | 6,14 |
| 2194 | 7 | 3457096,810 | 5434988,030 | 30 | 3457096,976 | 5434988,302 | Kie | 20,5 | 21 | 14,3 | 16,83 | 10,57 | 6,26 | 5,49 |
| 2194 | 9 | 3457094,650 | 5434991,490 | 28 | 3457094,697 | 5434991,754 | Kie | 16,2 | 16 | 12,9 | 16,01 | 11,72 | 4,29 | 6,62 |
| 2194 | 10 | 3457096,400 | 5434996,380 | 27 | 3457095,820 | 5434996,468 | Kie | 20,7 | 22 | 16,2 | 15,23 | 10,38 | 4,85 | 6,00 |
| 2194 | 11 | 3457094,260 | 5434994,960 | 29 | 3457094,242 | 5434994,847 | Kie | 17,9 | 19 | 14,0 | 16,07 | 7,17 | 8,90 | 5,50 |
| 2194 | 12 | 3457087,680 | 5434992,320 | 41 | 3457087,707 | 5434992,349 | Kie | 15,2 | 17 | 11,4 | 16,34 | 11,90 | 4,44 | 7,32 |
| 2194 | 15 | 3457086,860 | 5434997,550 | 49 | 3457086,365 | 5434997,454 | Kie | 22,5 | 23 | 19,5 | 18,10 | 9,24 | 8,86 | 5,04 |
| 2194 | 18 | 3457094,840 | 5435004,440 | 53 | 3457095,114 | 5435004,563 | Kie | 25,3 | 25 | 18,4 | 17,02 | 13,01 | 4,01 | 4,96 |
| 2194 | 19 | 3457095,380 | 5435008,740 | 70 | 3457095,639 | 5435009,330 | Kie | 28,5 | 28 | 20,8 | 17,51 | 12,32 | 5,19 | 5,62 |
| 2309 | 1 | 3457904,260 | 5435403,200 | 9 | 3457904,175 | 5435403,533 | Kie | 25,4 | 26 | 19,8 | 19,50 | 15,34 | 4,16 | 6,42 |
| 2309 | 3 | 3457913,650 | 5435399,760 | 13 | 3457913,054 | 5435400,465 | Kie | 23,1 | 26 | 18,5 | 19,97 | 15,90 | 4,07 | 5,80 |
| 2309 | 4 | 3457912,360 | 5435396,880 | 20 | 3457909,314 | 5435399,092 | Kie | 27,5 | 27 | 20,6 | 20,01 | 10,55 | 9,46 | 6,65 |
| 2309 | 5 | 3457906,020 | 5435399,250 | 16 | 3457906,196 | 5435399,207 | Kie | 21,0 | 22 | 15,7 | 19,92 | 14,05 | 5,87 | 6,37 |
| 2309 | 7 | 3457904,780 | 5435394,630 | 18 | 3457904,525 | 5435394,886 | Kie | 26,6 | 27 | 23,1 | 19,97 | 15,12 | 4,85 | 4,41 |
| 2309 | 8 | 3457897,860 | 5435399,700 | 33 | 3457897,563 | 5435399,506 | Kie | 29,9 | 34 | 24,5 | 21,81 | 17,67 | 4,14 | 5,43 |
| 2309 | 10 | 3457891,760 | 5435398,430 | 39 | 3457900,808 | 5435403,619 | Kie | 22,2 | 22 | 17,1 | 21,15 | 17,00 | 4,15 | 6,93 |
| 2309 | 11 | 3457898,210 | 5435407,030 | 44 | 3457898,290 | 5435406,549 | Kie | 25,0 | 26 | 18,8 | 19,82 | 15,78 | 4,04 | 6,08 |
| 2309 | 12 | 3457895,310 | 5435412,020 | 43 | 3457896,996 | 5435409,340 | Kie | 23,9 | 26 | 19,3 | 18,82 | 14,62 | 4,20 | 6,34 |
| 2309 | 13 | 3457903,120 | 5435407,850 | 46 | 3457902,403 | 5435407,903 | Kie | 29,5 | 29 | 22,0 | 21,61 | 17,52 | 4,09 | 6,57 |
| 2310 | 1 | 3458006,750 | 5435405,160 | 10 | 3458005,549 | 5435405,387 | Kie | 23,3 | 24 | 20,5 | 19,20 | 12,53 | 6,67 | 5,59 |
| 2310 | 2 | 3458009,580 | 5435406,010 | 8 | 3458009,404 | 5435406,325 | Kie | 20,7 | 24 | 15,9 | 19,62 | 7,23 | 12,39 | 6,32 |
| 2310 | 3 | 3458013,310 | 5435404,050 | 11 | 3458013,156 | 5435404,824 | Kie | 29,0 | 34 | 24,6 | 22,39 | 17,49 | 4,90 | 5,92 |
| 2310 | 4 | 3458012,450 | 5435395,950 | 18 | 3458012,392 | 5435396,404 | Kie | 23,0 | 23 | 20,7 | 21,69 | 11,13 | 10,56 | 4,79 |
| 2310 | 5 | 3458007,340 | 5435396,250 | 20 | 3458007,322 | 5435396,726 | Kie | 29,0 | 32 | 24,6 | 21,82 | 17,62 | 4,20 | 5,77 |
| 2310 | 6 | 3458003,290 | 5435393,920 | 28 | 3458003,368 | 5435394,240 | Kie | 28,5 | 28 | 23,1 | 20,55 | 10,86 | 9,69 | 6,44 |
| 2310 | 10 | 3457992,950 | 5435403,210 | 44 | 3457991,419 | 5435402,004 | Kie | 26,3 | 27 | 21,0 | 19,34 | 8,47 | 10,87 | 5,96 |
| 2310 | 12 | 3457994,120 | 5435408,690 | 49 | 3457994,140 | 5435408,880 | Kie | 27,2 | 27 | 23,4 | 19,73 | 13,96 | 5,77 | 5,21 |
| 2310 | 13 | 3458000,780 | 5435403,710 | 51 | 3458000,726 | 5435404,149 | Kie | 22,9 | 23 | 19,6 | 19,64 | 10,60 | 9,04 | 6,42 |
| 2310 | 14 | 3457998,910 | 5435408,190 | 52 | 3457998,276 | 5435408,520 | Kie | 26,2 | 26 | 19,6 | 19,40 | 15,38 | 4,02 | 5,62 |
| 2310 | 15 | 3458002,290 | 5435407,770 | 55 | 3458001,727 | 5435408,533 | Kie | 31,5 | 31 | 25,0 | 20,59 | 10,12 | 10,47 | 6,13 |
| 2356 | 7 | 3457009,490 | 5435803,420 | 24 | 3457009,120 | 5435803,760 | Bu | 29,7 | 32 | 27,1 | 28,53 | 24,23 | 4,30 | 11,60 |
| 2356 | 10 | 3457003,460 | 5435800,520 | 5 | 3457004,377 | 5435795,679 | Bu | 39,1 | 37 | 31,0 | 31,68 | 27,41 | 4,27 | 8,55 |
| 2356 | 12 | 3456995,670 | 5435796,900 | 8 | 3456993,597 | 5435796,490 | Kie | 42,7 | 53 | 38,7 | 31,91 | 18,83 | 13,08 | 7,73 |
| 2356 | 14 | 3456993,310 | 5435802,930 | 15 | 3456991,795 | 5435803,309 | Bu | 42,6 | 40 | 31,4 | 28,88 | 24,58 | 4,30 | 12,05 |
| 2356 | 15 | 3456998,400 | 5435806,340 | 16 | 3456996,517 | 5435805,116 | Kie | 50,0 | 47 | 39,9 | 29,13 | 24,50 | 4,63 | 10,62 |