



Arlinger John
Anders Rowell

7 May 2025

Minutes StanForD

2025-05-07

Place:	Vantaa/Teams, 2025-05-06--07, 12:00-14:00 EET
Participants:	John Arlinger, Secretary Tapio Räsänen, Chairman Anders Rowell, Skogforsk Antti Korkiakoski, JohnDeere Lovisa Engberg Sundström, Skogforsk Henrik Persson, Logmax Jonas Gustafsson, Sveaskog Jonas Thorsson, Dasa Heikki Komulainen, Ponsse Timo Melkas, Metsäteho Nicklas Nygård, Logset Kirsi Riekkö, Metsäteho (day 1) Heikki Ovaskainen, Metsäteho (day 1) <u>Attending through Teams:</u> Jeremy Gibson, PHD Forest Asko Leivonmäki, Exertus/Logset Bobby Szwajkowski, Tigercat Daniel Nilsson, Otmeka Erik Kindlund, JohnDeere Etienne Pilon, Logmax Canada Fredrik Tjernberg, Komatsu Hans-Ulrich Dietz, Univ. of Freiburg Ian Wilson, PHD Forest Janne Pursiainen, Ponsse Jean-Philippe Gaudreau, FP Innovation John Tönnesen, JohnDeere Juha Korhonen, Technion Liviu Ene, Skogforsk Mathias Håkansson, Dasa

	Mike O'Shea, Coillte Philip Ridderheim, SCA Sorsa Juha-Antti (External)
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Decision summary

Decided to do the following schema updates:

- **IndividualShortDownTime.** Description of Object/SubObjectKey under IndividualShortDownTime updated with version 4.2 in order to point out that they are to be deprecated. Also to be deleted with version 5.
- **barkFunctionCategory.** Description with version 4.2 updated according to the following text as the value "None" is not allowed any more:
Allowed values: ~~"None"~~, "Consolidated", "MatrixDiameter", "MatrixDistanceDBH", "NonLinearLatitude" and "Logistic"

Other decisions:

- **Multi-leader stems.** Rule 4.18 to be updated to allow for increasing diameters when comparing different logs.
- **Use of ObjectUserIDs.** New rule added:

R3.18	The same ObjectUserID and SubObjectUserIDs MUST be used in all types of instructions if data from different machines is to be merged for a specific object. The same ObjectUserID and SubObjectUserIDs MUST NOT be re-used for what is different objects or sub-objects.	Two data entities with the same UserId are always the same data entity. Two data entities with different UserId are never the same data entity. It will thus not be possible to merge e.g. hpr and fpr data in a third party application (e.g. in a forwarder controller) if this rule is not followed.
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Conclusions from discussions:

- **Next standard version.** Version 4.2 probably published in 2026 or 2027.
- **Priority order of instructions.** New recommendations:
Always assume that all instructions (e.g. oin/foi/ogi) have the same identity information.
The instruction file with the latest ObjectModificationDate is to have the highest priority. This means that the latest ObjectDefinition always should replace earlier versions.
- **Geo-fencing.** To be further discussed.
- **Additional coordinate reference systems.** To be further discussed.
- **RelativeLimitationMatrix.** Postponed until practical test has been completed.
- **Stem count.** To be further discussed.
- **DBHHeight.** To be further discussed.
- **HprVerifier.** To be further discussed.

Action list:

- Implement ButtLogMAXStartHeight.
- Recommend that unclassified products are reported per SpeciesGroup.
- Recommend that the diameter vector and DBH is adjusted if a short log (butt-off) is completely excluded from the hpr.
- Recommend that by default all butt-offs from single tree processed stems should be registered independently of length.

§1 Opening of meeting and agenda

The meeting accepted the proposal to appoint Tapio Räsänen as chairman for the meeting, as Johan J Möller is not participating. Johan has started working for the forest company Kopparfors but will continue to work part time for Skogforsk at least during the remainder of 2025. Johan will attend the meeting in December.

Chairman Tapio Räsänen opened the meeting.
The agenda was accepted.

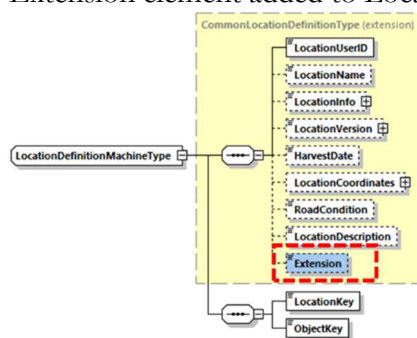
§2 Presentation of participants

Presentation of meeting participants.

§3 Information about decisions and discussions at previous meeting

Main decisions and conclusions at last meeting (2024-02-07) were presented:

- Version 4.1 to be published!
- Extension element added to LocationDefinition.



- Value “ControllerDefault” can be registered in OtherMachineDownTimeStandardCode. New description:
Enumeration list with reason for other machine down times. According to code list in mcl file.
Observe that the value “ControllerDefault” can be used in cases where operators have not registered any reason at all. “ControllerDefault” not to be available in GUI and

only generated by control system. "ControllerDefault" to be used in system where down time reasons are disabled or there is a "time-out".
The value "ControllerDefault" should therefore not be used in the mcl-file.

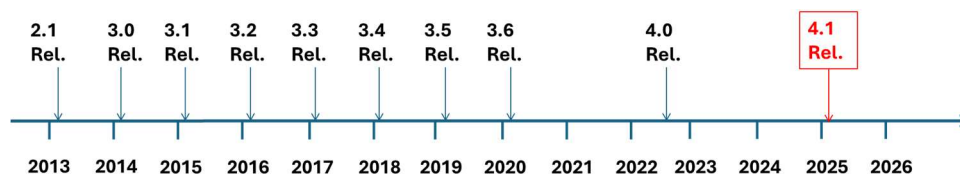
- New PileDefinition added to bpr. PileKey added to Stems in bpr.

Name	Data type	Unit	Description
PileDefinition	Boolean		A list of piles of felled stems created by a feller-buncher. Can be used for estimating number and position of piles. Only the first stem could have a reference to a pile in cases when only the first stem is registered manually simultaneously with placing the first stem in the pile.
PileKey	Unsigned Long	No	Machine specific identity per pile. Must be totally unique for a certain MachineKey. Reset only when MachineKey is changed. It does not have to be a sequential number always incremented with one for each pile.
PileNumber	Positive-Integer	Sequential no	Pile number. A running / sequential number only to be reset when starting on a new harvesting object.
CreationDate	DateTime	yyyy-mm-dd Thh:mm:ss [+ -]]hh:mm	Time and date for creating a new pile. Time stamp must have the following times registered: local time $\pm$ offset from UTC.
PileCoordinates	Coordinates-Type		Pile coordinates, describes the location of the stem pile.
Extension	Extension-Type		Extension element can include whatever data the users want. The only requirement is that it is well-formed XML i.e. it is tagged

- The description of LoadChange is kept as it is:
Structure for storing positions where logs have been loaded or unloaded.
This means that the following sentence is not to be added (discussed 2023-11-23):
~~*Deprecated structure, is replaced by LogTransport with version 4.1*~~

§4 Future frequency of StanForD updates

The figure below illustrates the timeline for publishing all versions since 2.1.



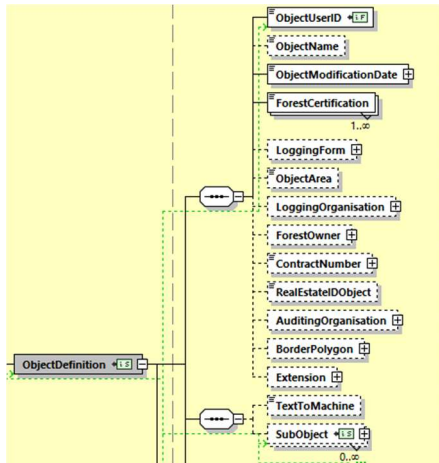
The secretary today estimates that a new version 4.2 will be finalized during the autumn of 2026 or spring of 2027. The harvester test to be carried out in the autumn this year will most certainly mean that we find errors, mistakes and improvements that needs at least two meetings in order to be finalized.

§5 Reporting of issues related to major version 4

OGI VS OIN - DUPLICATE ADMINISTRATION INFO

Issue raised by Fredrik Tjernberg, Komatsu.

The identity elements (e.g. ObjectName and ContractNumber) in ObjectDefinition are identical in ogi and oin.



What if ObjectName and ContractNumber are different in the oin and the ogi but they have the same ObjectUserID?

It was first suggested that the oin and foi takes precedent over ogi in applications where both file types are in use. However, there are a number of other instruction files as well which means that setting priority orders between different files is complex.

It was decided to have the following recommendations:

- Always assume that all instructions have the same identity information
- The instruction file with the latest ObjectModificationDate is to have the highest priority. This means that the latest ObjectDefinition always should replace earlier versions.

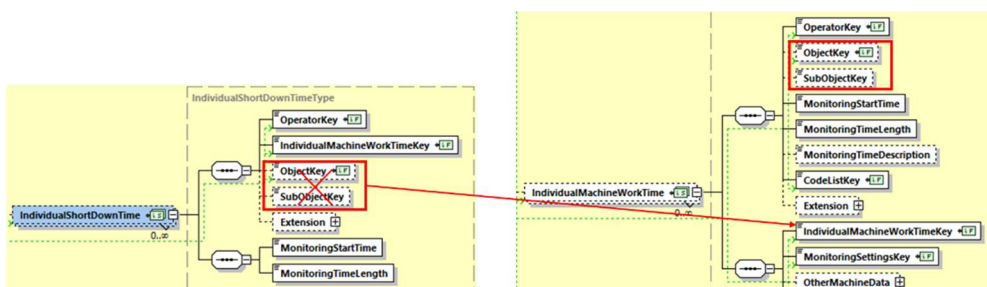
INDIVIDUALSHORTDOWNTIME HAVE REDUNDANT OBJECTKEY/SUBOBJECTKEY

Issue raised by Fredrik Tjernberg, Komatsu.

IndividualShortDownTime has a redundant ObjectKey/SubObjectKey.

This is due to IndividualMachineWorkTime having a reference to Object and SubObject.

It was suggested that the ObjectKey and SubObjectKey are to be viewed as deprecated. This is to be added to the element description with version 4.2.



Decided to update the description of ObjectKey under IndividualShortDownTime with version 4.2:

Deprecated (not to be used) as there is a reference to the Object under IndividualMachineWorkTime. Machine specific identity per harvesting object. Set when new harvesting object is started. Running no recommended, reset only when MachineKey is changed.

Decided to update the description of SubObjectKey under IndividualShortDownTime with version 4.2:

Deprecated (not to be used) as there is a reference to the SubObject under IndividualMachineWorkTime. Machine specific identity per harvesting sub object, set by machine. Set when new harvesting sub object is started. Running no recommended, reset when ObjectKey is updated.

It was also suggested that these elements are to be deleted with version 5.0. The secretary is to add this to his “version 5” notes.

BARK FUNCTION ISSUES

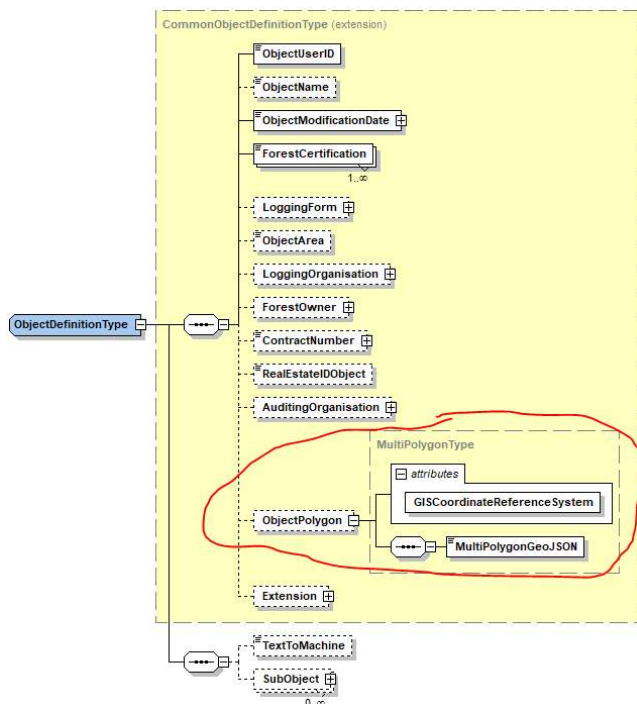
It has been noted by Jonas Thorsson, Dasa, that an update to description of barkFunctionCategory is to be carried out. Decided to update the description with version 4.2 according to the following text as the value “None” is not allowed any more:

Allowed values: ~~"None"~~, "Consolidated", "MatrixDiameter", "MatrixDistanceDBH", "NonLinearLatitude" and "Logistic"

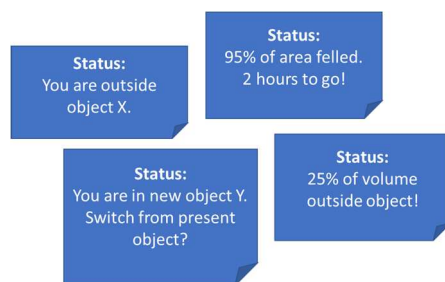
§6 New proposals

GEOFENCING AND NEW BORDERPOLYGONS ADD EXTENSION TO LOCATIONDEFINITION

The element BorderPolygon was added to the ObjectDefinition 2021-09-15 according to the illustration below:



The objective was to make it possible to implement different types of geo-fencing functions as illustrated below:



It was noted by Janne Pursiainen, Ponsse (2025-01-27), that the BorderPolygon has only been included only in ObjectDefinition and not in the SubObjectDefinition.

The possibility of reporting also a multi-polygon per SubObject and per Location was discussed at the previous meeting. It would be possible to re-use the element BorderPolygon also for Locations. However, it was noted that no extension element exists for the LocationDefinition. This would be needed in order to test this idea.

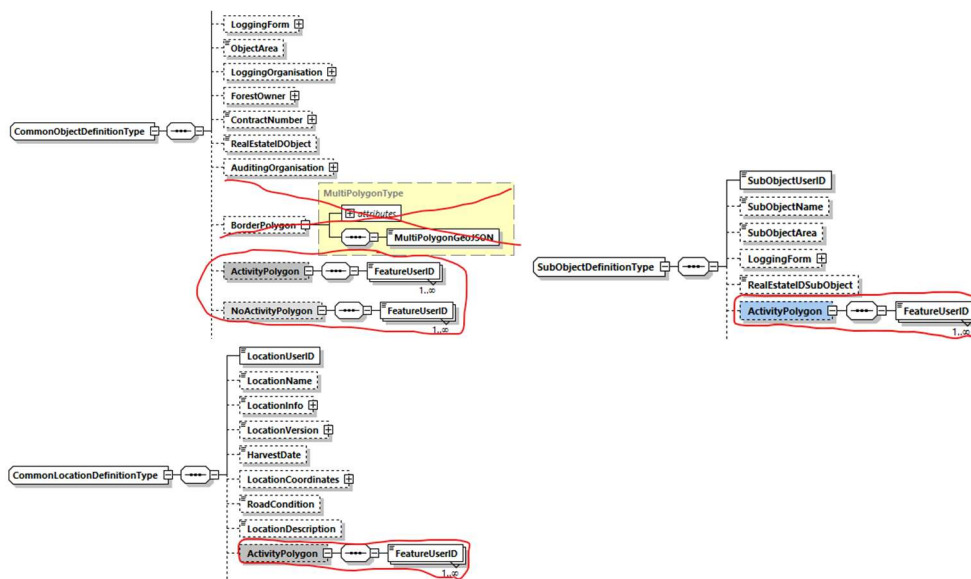
It was therefore decided at the previous meeting to add a new Extension element to CommonLocationDefinitionType with version 4.1.

Several participants had comments and some objections to the idea of adding element BorderPolygon to Location and SubObject at the previous meeting:

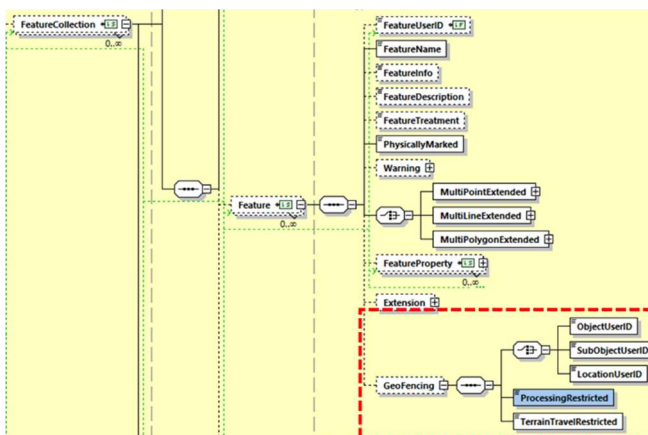
- How should overlapping polygons be handled (Jeremy Gibson)?

- The BorderPolygon is included in both ogi- and oin-schemas. Which one takes precedent if both formats are communicated with the machine (Fredrik Tjernberg)?
- Can no-go areas be handled (Tapio Räsänen)?
- Maybe better to use a reference from the oin to a specific feature in the ogi using FeatureUserID (Henrik Persson)?

The secretary has analyzed the possibility of using element FeatureUserID according to the following illustrations:



Another possible solution could be to add references from the ogi to the oin,foi, soi or yoi according to the following illustration:



There are some major questions that need to be discussed further:

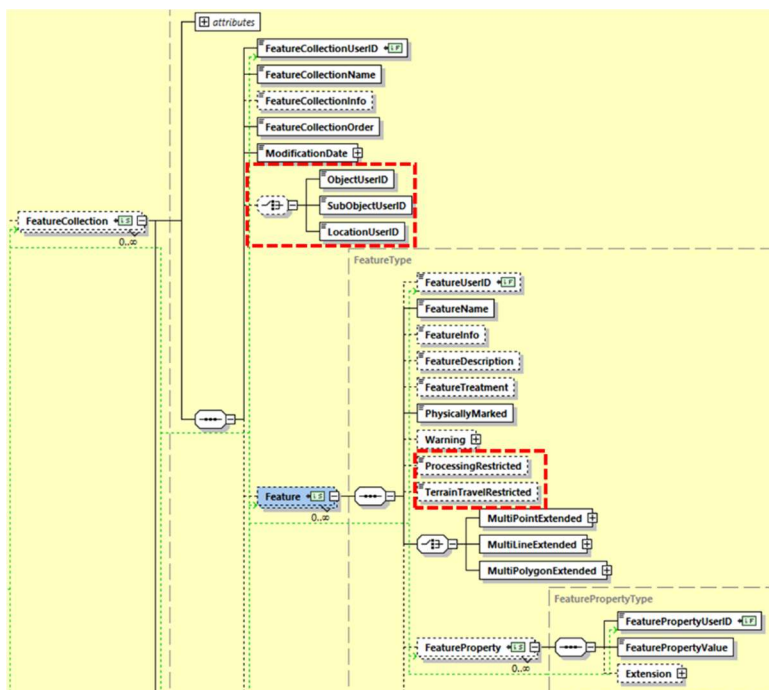
- What types/categories of geo-fencing polygons are needed? It must be a simple solution!
 1. ActivityPolygon vs NoActivityPolygon (“No-go”).

2. ProcessingRestricted vs. TerrainTravelRestricted.
Preferred by secretary as we use the “mom terminology”

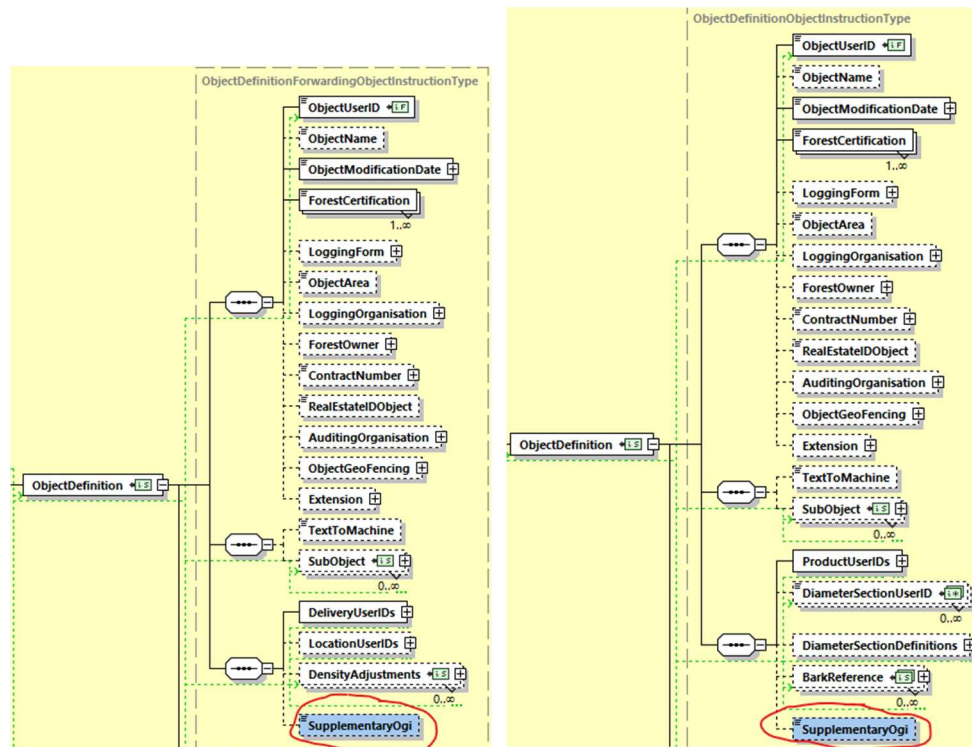
- Priority order of these types of polygons in case of overlapping?
 - Restrictions = true (“No-go”) has highest priority
- How to use Object and SubObject polygons if they are both included?
 - Recommendation is to use one of them?
- How are updates to the ogi handled if the oin is not updated or vice versa?
 - Similar problem might occur when dealing with oin and pin
 - Only use geo-fencing function for UserIDs in ogi that match oin, foi, soi or yoi.

A number of different problems with the proposal was discussed.

It was also decided to let the secretary further develop the last proposal whereby the references to the Object/SubObject/Location is located under the FeatureCollection and the elements ProcessingRestricted and TerrainTravelRestricted are to be located directly under the Feature as illustrated below.



It was decided to let the secretary further develop the proposal in order to include an element in the oin/foi/soi/yoi that indicates that there is a supplementary ogi available.

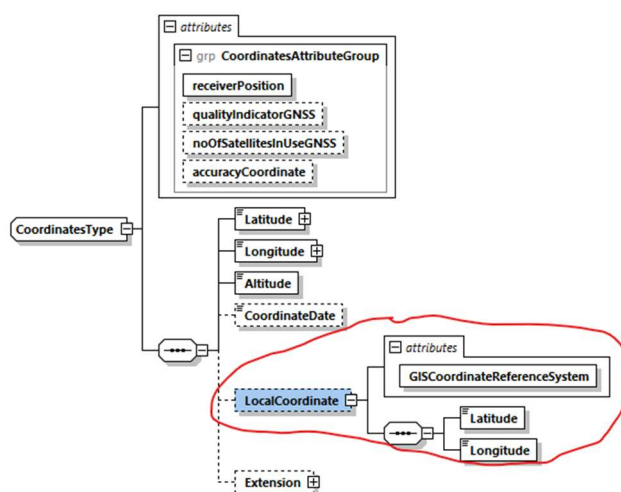


It was decided to discuss this further at the next meeting.

REFERENCE SYSTEMS FOR COORDINATES

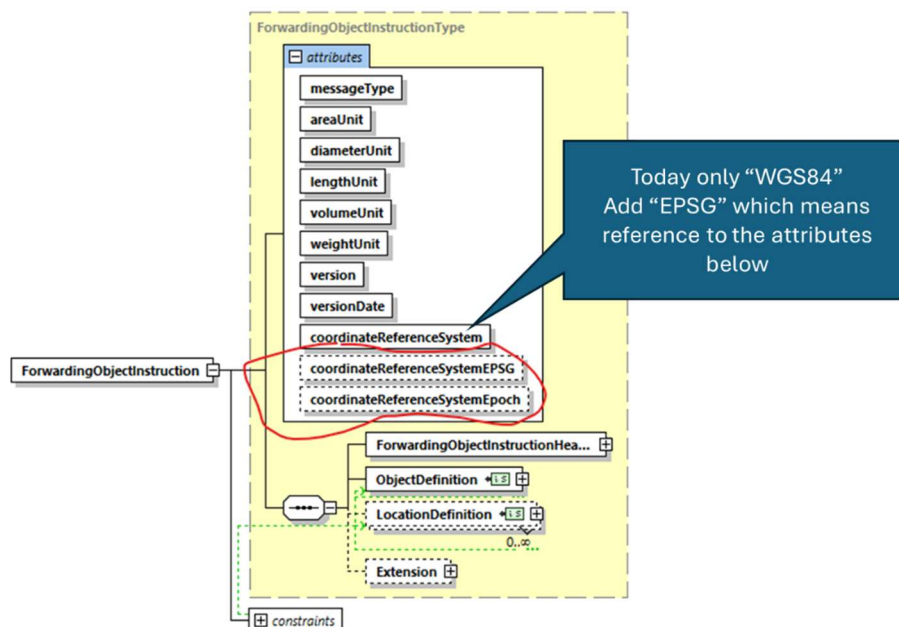
The possibility of using local reference systems in StanForD coordinate elements has been discussed. In part due to modern GNSS receivers with corrections being able to generate the coordinates based on local reference systems and in part due to problems caused by different epochs (drift of continental plates).

A possibility could be to extend the coordinate structure according to the following figure:



Another solution could be to update the header attribute of all schemas to make it possible to replace the WGS84 with any other EPSG codes and to define which epoch that was used in order to adjust for the movement of the continental plates. This solution is illustrated below:

- Add “EPSG” to coordinateReferenceSystem
 - coordinateReferenceSystemEPSG/Epoch used in case value is “EPSG”
- Add coordinateReferenceSystemEPSG
 - EPSG code for reference system used in file (EPSG.org)
- Add coordinateReferenceSystemEpoch
 - Decimal year used in transformation



= areaUnit	ha
= diameterUnit	mm
= lengthUnit	cm
= volumeUnit	m3
= weightUnit	kg
= version	4.1
= versionDate	2025-02-07
= coordinateReferenceSystem	EPSG
= coordinateReferenceSystemEPSG	9001
= coordinateReferenceSystemEpoch	2020.0

Some comments at the meeting:

- Do not add a new enumeration to coordinateReferenceSystem as it creates problems when parsing in controller based on older standard version (Jonas Thorsson).

- Present attributes and data type for Longitude and Latitude may cause problems when allowing for more coordinate reference systems (Henrik Persson).

This is due to the fact that the data type only allows for decimal degrees and the CategoryType has one of the following enumeration values North/South and East/West.

Is it possible to state that only EPSG codes that expresses position in decimal degrees are allowed?

It was decided to discuss this further at the next meeting.

MULTI-LEADER STEMS

Several cases that might result in “incomplete” stems has been discussed at some previous meetings:

- A. Stem forks
- B. Breakage (e.g. tree length operations or snow damage)
- C. Separate felling and processing by harvester (e.g. in steep terrain).
- D. Manual felling and cutting of first log before processing of the remaining stem.

Two possible standard adjustments/clarifications have been discussed:

1. Allowing increasing diameters when comparing separate logs. This is already done by at least one manufacturer.
2. Open up the possibility of registering a 0-value (zero) for DBH in cases where the butt-part of the stem is not included. This case would also mean that the ButtEndExtrapolation function is not to be used. This solution has some basic similarities with the suggestion for an element UncompleteStemTop.

The examples and suggestions below are focused only on stem forks (multi-leaders).



Example stems from harvester test 2016 where this type of registration was generated in a Ponsse Opti when the head is not tilted up between the different “sub stems”.



It would be simple to extract “multi-leaders” if we allow increasing diameters when comparing separate logs!

A questionnaire distributed to all manufacturers showed that it is possible to register “multi-leaders” as one stem in approximately half of the control systems.

It was decided to update to the rules document to allow increasing diameters when comparing separate logs as illustrated below.

R4.18	All registered diameters incl top diameters MUST be based on filtered values (no increasing values allowed) at the position. No average values based on several different height positions allowed.	Observe that this rule does not forbid increasing diameters when comparing different logs. This means that a “multi-leader” stem can be registered as a single stem where e.g. a top log can have a butt diameter larger than the top diameter of the previous log.	hpr hqc
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RELATIVELIMITATIONMATRIX

Ponsse has prepared a new test version that has not yet been tested in Finland by Metsä Group and Trimble.

This issue is postponed until tests have been carried out.

§7 Items for discussion

USING OBJECTUSERID FOR CONNECTING HPR AND FPR

At least one Swedish forest company sometimes create different ObjectUserIDs for the harvester vs the forwarder working on the same object. There are also sometimes different ObjectUserIDs for different operators on the same object and harvester.

<> ObjectDefinition		<> ObjectDefinition	
Hpr	<> ObjectUserID agency="Other" 40421-101	Fpr	<> ObjectUserID agency="Other" 40421-002
	<> ObjectName 40421-101 Aldersjön Norr		<> ObjectName 40421-002 Aldersjön Norr
	<> ObjectModification 2024-10-31T05:12:11.293+01:00		<> ObjectModification 2024-09-27T08:28:51+02:00
	<> ForestCertificate None		<> ForestCertificate FSC
	<> LoggingForm <LoggingFormCode>3		<> LoggingForm <LoggingFormCode>3
	<> LoggingOrganisation		<> LoggingOrganisation
	<> ForestOwner <Address> <BusinessID>		<> ForestOwner <Address> <BusinessID>
	<> ContractNumber 04042107		<> ContractNumber 04042107
	<> RealEstateID 04042107		<> RealEstateID 04042107

Most Swedish forest companies can identify the object using the ContractNumber as it is typically the same for all types of machines and activities on the same object. However, it is not possible to assume that this is the case on all markets. There has in fact been at least one Swedish forest company that is not using the ContractNumber at all but only the ObjectUserID.

It is not deemed possible to use anything but the ObjectUserID if a machine manufacturer or some other third party is to build an application where data from hpr and fpr is to be merged for a single object. This is at least true if you are building functionalities that are to be used on any market.

It was thus decided to add a new rule:

R3.18	The same ObjectUserID and SubObjectUserIDs MUST be used in all types of instructions if data from different machines is to be merged for a specific object. The same ObjectUserID and SubObjectUserID MUST NOT be re-used for what is different objects or sub-objects.	Two data entities with the same UserId are always the same data entity. Two data entities with different UserId are never the same data entity. It will thus not be possible to merge e.g. hpr and fpr data in a third party application (e.g. in a forwarder controller) if this rule is not followed.	All
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It was pointed out by Fredrik Tjernberg that there is some text describing how to use UserIDs in the document “Introduction to StanForD 2010”
(<https://www.skogforsk.se/contentassets/1a68cdce4af1462ead048b7a5ef1cc06/sanford-2010-introduction-200820.pdf>):

Forest companies or other users of data use UserId for identification purposes. UserIds may be used for harvesting objects, products, tree species, deliveries and machines. The main objective of UserIds is to use them for referencing between different definition when distributing instructions.

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The basic idea is that only one instance of a specific UserId should be available to use in a machine at a time.

STEM COUNT ISSUE

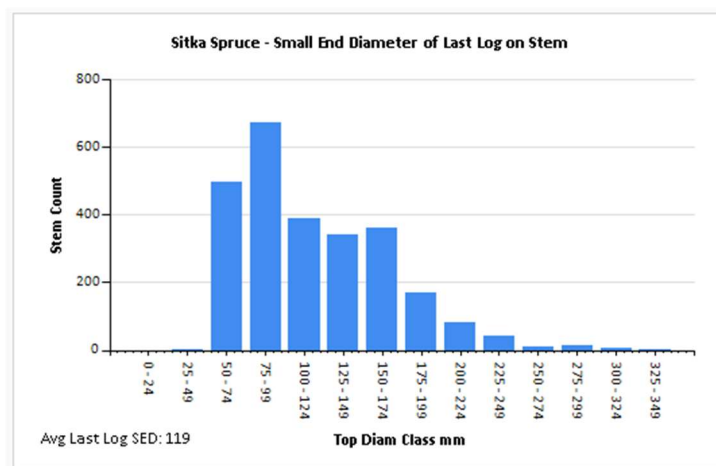
This issue was raised by Mike O'Shea, Coillte.

Harvester operators on Ireland appear to be frequently utilizing controller functionality in a way that “artificially” increases the stem count within the StanForD production file (pri and hpr files) i.e. erroneous stem count. This has a significant impact as the stem count directly affects the average tree size calculated from the StanForD production files, which is then used in contractor payments.

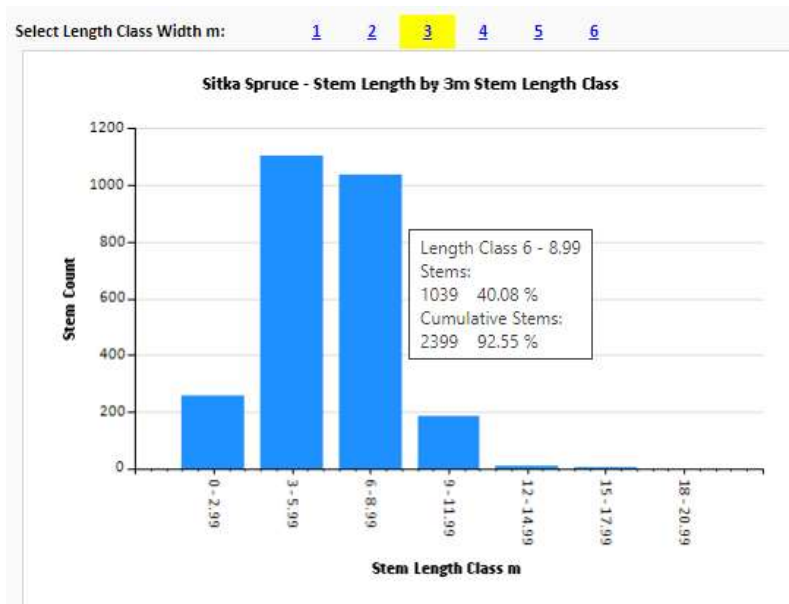
Following a detailed analysis including direct observation, recording and analysis of videos and discussion with operators, it has been concluded that, in the majority of cases, the machine operators are deliberately “flicking” the “Head Open” function to register multiple stems on the same tree.

It appears this is a deeply entrenched cultural and behavioral problem that cannot be solved through supervision alone.

This following graph is for normal clearfell/final fell (not windblow), yet there is a high frequency of stems where the small end diameter (top diameter) of the last log (product) on a stem is quite large e.g. greater than 150mm



This data shows that there are a lot of “short” or small trees, in this clearfell/final fell scenario – this does not appear correct.



There are several genuine “multiple” stems per tree:

1. Broken tops can occur during tree felling; These tops are normally out of reach from the harvester so must be picked up and processed separately, resulting in an increased stem count.
2. Windblown Trees can be difficult to harvest, especially if the trees have fallen in different directions. Usually, the machine operator would have to pick up the trees multiple times and this can result in an increased stem count.
3. Forks occur where two diverging stems remain attached to the crutch zone; the machine operator will have to press the “Head Open” function to process each fork resulting in an increase in the stem count.

Mike did a comparison where stems were considered as “faulty” using the top diameters of the last log on a stem with the large diameters of the first log of the next stem – but the “butt extrapolation” function complicated this analysis. Also, this analysis will not work in a windblow scenario.

Possible solution by using time stamps:

- Could this problem be eliminated at source by filtering out the registration of stems within a few seconds of each other in real time, i.e as the tree is being processed?
- Which brands register the stem time stamp when the tree is felled vs when the first log is cross cut?
- Is it possible to register a time stamp on each log within the hpr file?

Perhaps a technological solution could be that if the head doesn’t open a certain way (diameter change?) – i.e. it doesn’t open enough to drop the held stem, or if the open pulse is not long enough to drop the stem (is this possible?), then a new stem is not created.

Should this problem be dealt with retrospectively by analysing the time stamp that each stem and logs are registered within the hpr file? If so is there any actions required by the OEM's to standardise this requirement in the StanForD schema?

The secretary presented a Skogforsk algorithm used to “merge” stems with broken top parts where the following conditions are to be met in order to merge two subsequent stems

1. StemNumber for next stem is +1
2. Same SpeciesGroupKey for next stem
3. Same ObjectKey for next stem
4. LastDiameter of present stem > 150 mm
5. DBH of next stem < LastDiameter of present stem
6. Total length of both stems < 3800 cm

This algorithm could probably be fine-tuned by also considering positions and timing. It was originally developed based on pri-data, which is probably the reason why DBH rather than reference diameter was used. Observe that the algorithm will not work very well in case the butt diameter of the next stem is used rather than the DBH due to the butt-end extrapolation function.

It was suggested by Heikki Komulainen that we analyze the possibility of a new element describing how the stem was initialized to next meeting. That could mean adding an element to the stem level whereby it is indicated if the stem was “initiated” by a “fell cut with head in upright position” or not. This type of element may also be used in cases where “multi-leader” stems are harvested and registered as two separate stems. Observe that this element will be registered frequently in cases of a windthrow or when processing at a landing.

Comments from Jeremy Gibson after the meeting:

1. If hpr and mom are being used within the same reporting system that adjusts the stem count from a hpr, then the productivity numbers become different e.g. total stems becomes different and all derived metrics are now “incorrect” e.g. trees per hour
2. If contractors and operators are using unadjusted (*.pdf) reports in the harvester then the numbers won't match an adjusted reporting system – this will cause conflict between parties and probably the manufacturers would get dragged into it also
3. If actors are primarily using different reporting systems e.g. the forest owner uses the forest owner system and the contractor primarily uses a manufacturer fleet system then the reported numbers will be different – again this will cause conflict

For these reasons Jeremy is generally against adjusting results (e.g. stem count) in a reporting system. He would prefer to fix them at source so that everyone works with the same interpretation – e.g. if the head didn't open far enough to drop the stem (diameter sensors?) then a new stem should not be register by that operation. In this case, not registering a new stem on “flicking the head open” is probably not going to hamper an operator experience, but it might hamper their ability to fiddle the stem numbers.

The conclusions drawn by the meeting are that there are some different issues that could be further analyzed and discussed at upcoming meetings:

- Skogforsk diameter algorithm
- Filtering based on distance between stems
- Filtering based on time of stem processing
- Filtering based on time of log processing (possible in version 4 or Komatsu extensions)
- Update controllers so that a quick “flicking the head open” does not generate a new stem unless the operator does a “not too simple” manual action.
- Adding new element “StemFelledInitialization”

Observe that a filtering algorithm may be used primarily to calculate a key figure that indicates a potential problem rather than adjusting the total number of stems. It is also noted by the secretary that different types of algorithms could be tested in case we have hpr-data from a Komatsu where both time stamps and coordinates are registered in combination with having a registration of which stems are truly “false”.

It was decided to discuss this further at the next meeting.

DBHHEIGHT VALUES

Tapio Räsänen raised the issue of what DBHHeight to use in the spi-file as the stump height varies with tree size, terrain, snow depth, species etc. On almost all markets globally DBH is defined as the diameter at 130 cm from the ground. Historically, both Sweden and Finland have used the DBHHeight 120 cm which means that the stump height is assumed to be 10 cm. This is probably in most cases a systematic underestimation of the stump height. The modern Swedish spi-files created by Skogforsk therefore is using DBHHeight 110 cm. This is based on the fact that this is, on an average, more in line with the traditional assumption that the stump height is equal to 1% of the tree height.

No one at the meeting knew of any analysis done on the effect of stump height on the DBH measured in harvesters.

Henrik Persson mentioned that the stump height in many cases depend also on what type of harvester head is used as there is often a minimum stump height that is physical possible to the design of the head.

It was also pointed out during the meeting that very short unclassified logs (butt-offs) may cause distortions regarding the height of the DBH. An update regarding to butt-offs was decided 2024-04-17—18.

Conclusions at the meeting:

- It would be a good idea to analyze the stump height variation and what effect it has on DBH. Perhaps in the form of a study carried out by forestry students. Such a study should probably also analyze the effect on the volume of the butt log.

Anders Rowell discussed this issue with Björn Hannrup after the meeting. The Swedish national forest survey measures stump heights in their sampling plots. Earlier data indicates the following average stump heights in Sweden (2003-2005) according to “Behöver omvandlingstalen mellan m3f ub och m3sk revideras?, Report 7, Skogsstyrelsen 2010” (<https://shop.skogsstyrelsen.se/sv/publikationer/rapporter/behover-omvandlingstalen-mellan-m3f-ub-och-m3sk-revideras-en-for.html>).

DBH-class	0-9 cm	10-19 cm	20-29 cm	30-39 cm	40- cm
Mean stump height, all species	3.4 cm	15.1 cm	16.5 cm	20.3 cm	25.0 cm

It seems like more recent data indicates that the stump height in Sweden is today slightly higher than presented in the table above.

Anders Rowell will look at the possibility of having a forestry student doing a study on this issue.

It was decided to discuss this issue further at upcoming meetings.

§8 StanForD2010 projects / implementations

ACCURACY OF HARVESTER POSITIONING AND USE OF STRIP ROAD TREE DATA FOR ESTIMATING INITIAL STAND PROPERTIES

Heikki Ovaskainen, Metsäteho, presented results from a research project where the accuracy of tree positioning was analyzed and the use of this data in order to determine whether trees represent the strip road or not.

In the entire data set the average difference in location between the harvester head and the field measurement (stump) was 0.54 meters and the standard deviation was 0.41 meters.

The main conclusions were:

- The study provides a good understanding of what can currently be achieved in determining the location of felled trees through the location of the harvester head, when RTK correction is used in the positioning of the harvester and the crane is sensed up to the tip of the crane.
- Strip road trees can be used to identify the initial stock, but the accuracy of the method varies depending on the trees, terrain, strip road network and the shape of the stand. The width of the strip road has a significant impact on the number of trees to be removed, and the results show that there is a turning point in the volume of the removal between 3–4 meters in the picking width of the strip road trees.
- In determining the width of the strip road, a location accuracy of about half a meter from the trees gives good results.
- The direction information of the harvester head rotator could be used to obtain the last missing tree distance information. The current method of determining the location of the tree to be felled, which is based on crane sensors and the location of the base machine, is functional.

Heikkis complete presentation is distributed with the minutes.

AUTOMATED METHOD FOR MONITORING QUALITY OF THE STRIP ROADS (AATU)*

Kirsi Riekkilä, Metsätöiden tutkimuskeskus, presented results from a research project where an automated method for monitoring quality of the strip roads (AATU) was analyzed. The primary focus being on the average distance between strip roads.

It is highly recommended in Finland to have an average strip road spacing of at least 19 meters.

The project analyzed 165 sites where 116 deviated from the recommended strip road distance. The reason for deviation was to a large extent explained by openly available data sets such as:

- Aerial ortho images (density variations of growing stock, re-opening of ditch lines)
- Base map (elevation, cliffs, ditches)
- Forest estate boundaries
- Hill shade (detailed variations of elevation)

Main conclusions:

- Overall, the strip road variables can be used to identify the deviations
- HPR files are a good data source for computing the strip road networks for quality monitoring
- AATU works very well to both identify and explain the deviations of the strip road networks
- The factors causing strip road deviations can be largely identified based on open geographic data
 - AATU reduces the need to inspect the quality of the thinning sites in field after harvesting
- In the future, the examination of factors causing deviations to strip road networks can be automated by using the open geographic data
- AATU is very potential method to automate forest companies' self-monitoring of the harvesting quality at first thinnings

Heikki Komulainen pointed out that he sees an advantage in registering the position of the tree top when released by the harvester head, since this gives an indication of whether the operator has tried to decrease the risk of damage to the ground/soil. In other words, another quality parameter related to strip roads.

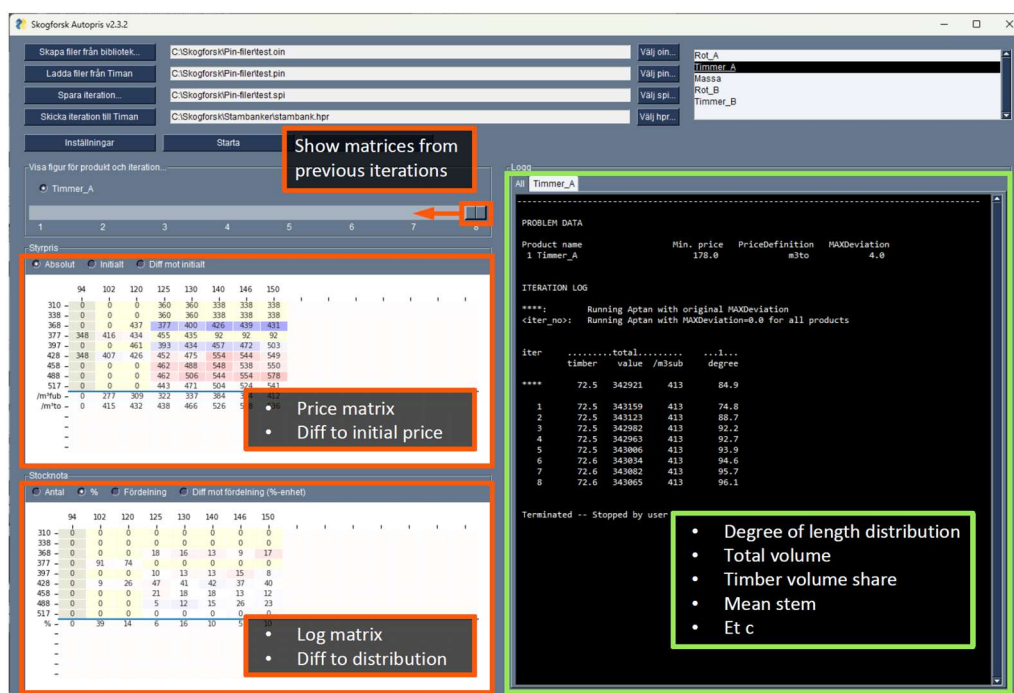
The complete presentation is distributed separately with the minutes.

AUTOPRICE – INTELLIGENT APPLICATION FOR CREATING PRICE MATRIXES

Lovisa Engberg Sundström presented a recently developed application for automatic creation of price matrixes in order to fulfill a length distribution

demand. The application is built on using pin-files as the basic input and output format.

Figure below illustrates the basic user interface by which a user defines the input data (oin/spi/pin/hpr-stembank) and then runs a number of iterations.



The complete presentation is distributed separately with the minutes.

A work report describing the algorithms has been published by Skogforsk (Automatgenererade styrprislister för skördare, Arbetsrapport nr 1234, 2025).

VIOL 3 – NEW BIOMETRIA SYSTEM SOON IN A SVEASKOG MACHINE

Jonas Gustafsson, Sveaskog

VIOL is the core system for Swedish Forestry when it comes to administration of volumes, measurement, accounting and a lot of other things connected to wood products and production. The system is developed and run by Biometria.

The current VIOL2 will be phased out and replaced by a next generation system called VIOL3. Go Live for VIOL3 is May 2nd, 2025. VIOL3 is not an upgrade of VIOL2. It is a completely new business system where interfaces and the way of working in the system involve major changes.

Sveaskog will be working with two parallel groups of products when moving over from VIOL2 to VIOL3 during the summer of 2025. Below is an example illustrating the fact that this means slightly different identities and names:

	VIOL3	VIOL2
ProductName	V3 SIKFORS 18+ GALLR	SIKFORS 18+ GALLR
ProductUserID	SVEASKOG001278V3	SVEASKOG001278
ProductInfo	011-SIK	: 0110

Another difference is also in how ContractNumber is created.

All machines working on VIOL3 sites will receive a set of “VIOL3-products”

A normal start of work area is when OIN-FOI are being used. All sites are specified for one work area with it’s planned Products.

However, if there are some short notice changes and operator “have to” get new PIN or FDI from library it’s of great importance to pick the right product or delivery. This is the reason why ProductName and DeliveryName always includes “V3”.

VIOL3 will not tolerate errors in ProductUserID and DeliveryUserID.

What happens when we have passed VIOL2 in the autumn? Product and delivery libraries need to be cleaned from all the VIOL2 products/deliveries. Meaning all machines have to be fixed manually.

There are probably a number of other Swedish forest companies that handles the transition in the same way as Sveaskog. It is known that e.g. SCA and Mellanskog handles the transition in a similar way, meaning that there will be both Viol2 and Viol3 products in the pin-libraries of the harvesters.

However, there are also companies that will move individual machines from VIOL2 to VIOL3 and avoid having “copies” of the products such as e.g. Derome.

The secretary concluded that it is probably a good idea to implement a simple controller function for deleting all products in a pin-library (also true for Deliveries and SpeciesGroups).

MASEN – SVEASKOG’S NEW COMMUNICATION APPLICATION

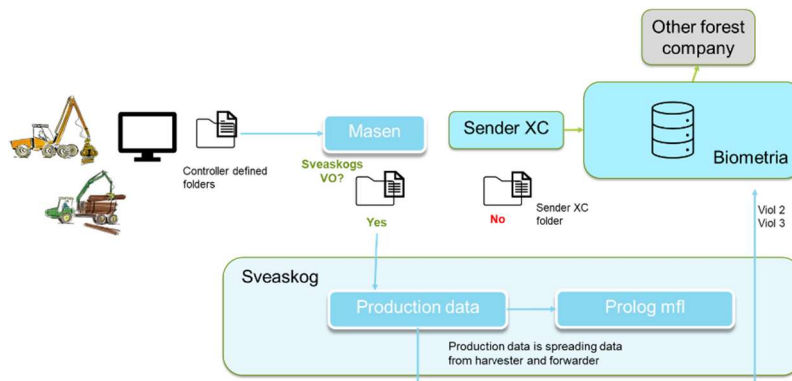
Jonas Gustafsson, Sveaskog.

Sveaskog has developed their own communication application called MASEN.

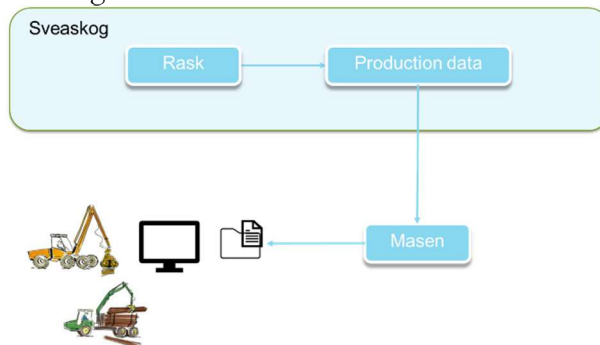
The main reasons being:

- Because we would like to fully have the ability to send out and collect information from machines working for us.
- Sveaskog will be able to add more functionality connected to other Sveaskog applications in the area of production.
- It all started with a strategic decision in ”The Digitalisation Council” 2023

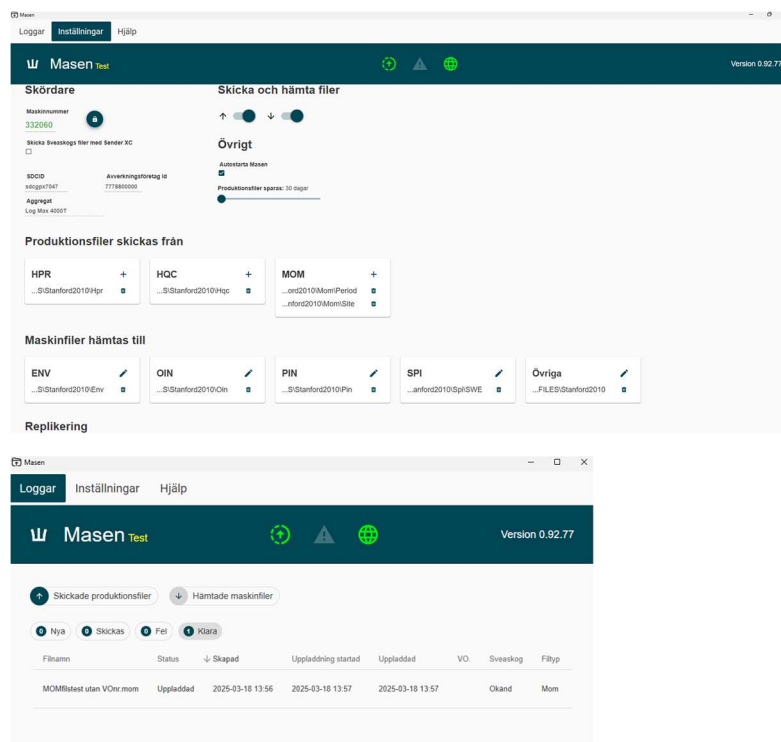
Reporting from a machine:



Sending instructions to machine:



Example GUI:



Almost 300 machines installed today. Except for MASEN we have to install MW Desktop Runtime 6.X.X. Every file going out from machine is validated (StanFord Schema and Location Coordinates)

NEW MONITORING METHOD FOR CONTROLLING HARVESTER LOG MEASUREMENT

The secretary presented the on-going work to develop new methods for controlling log measurements.

A pilot test was run during the spring of 2024. A more permanent three-year project was started in February this year.

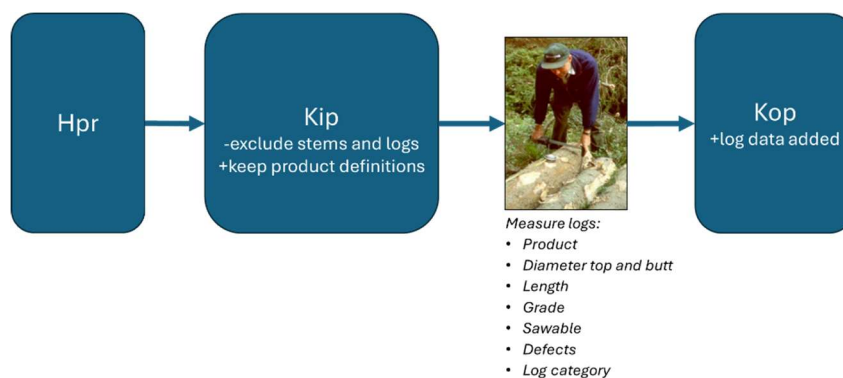
As individual log measuring at sawmills is becoming increasingly uncommon new methods to give relevant feedback to harvester operators is needed. Historically the most important key figures calculated based on mill measurements are related to the “extra lengths” (physical length minus length class).

Main objective is to make it possible to give quick feedback on length measuring and production quality.

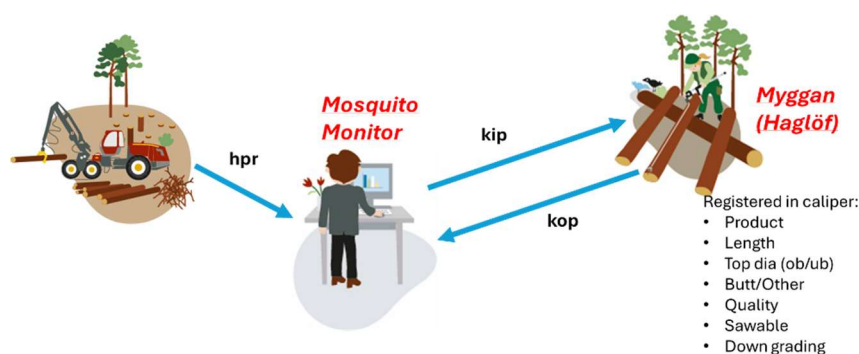
The new methods should be possible to use by e.g. Biometrias ”quality technicians”, operators, logging managers, quality specialist and the method should be applicable if the logs are located in the forest, at roadside or some type of terminal.

However, there is a pre-requisite in the form of length and diameter classes used in harvester must be known. This is the reason why the method is based on having a correct hpr-file as the input. The messages communicated with a caliper is according to two separate test schemas (kip=caliper input, kop=caliper output).

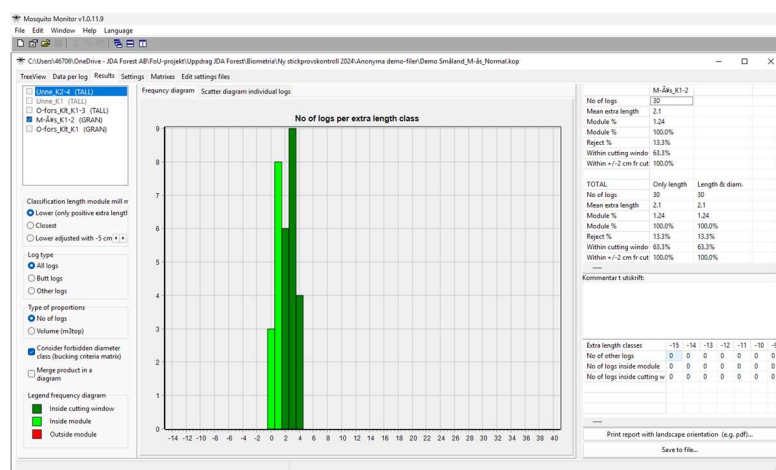
The data flow is illustrated below:



The beta softwares developed within the project are illustrated below:



Example results when analyzing a kop-file in MosquitoMonitor:

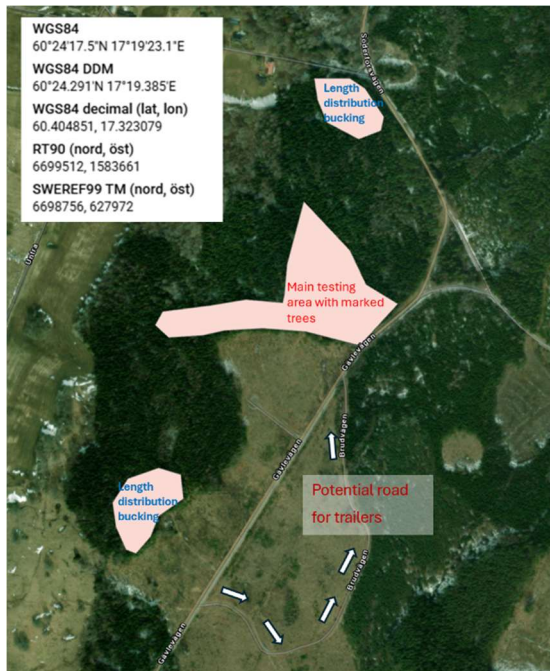


It may soon be possible to combine the data from the kop with the hpr when having high precision positioning per log in both harvester (hpr) and caliper (kop). Combining data would rely on position, log diameter, log length, species, log category and harvesting time.

HARVESTER TEST 2025

The secretary gave a general presentation of the harvester test that will be carried out in October-November 2025.

The harvesting object is located approximately 75 km north of Uppsala.



The following areas will be analysed/described during the test:

- Accuracy of harvester length and diameter measurements
- Functions for calibration of the measurement system
- Cutting times and damages (bucking splits, damages caused by studs, unwanted debarking)
- Functions for production control and bucking to value, including length distribution bucking
- Other functions and map handling (ogi/ogr)
- Accuracy of the positioning of harvested trees and logs

Chronological schedule for harvester test:

1. Chain speed measured with camera
2. Importing of oin/pin/spi (new object)
3. Harvest 3 stems and send hqc to caliper communication to study calibration interface
4. Importing of oin (new object) and ogi
5. Single tree harvesting of 45 stems for evaluation of measuring, damages and bucking optimization
 - Reporting production data (hpr)
 - Reporting operational monitoring data (mom)
6. Update of oin and pin (updated object and products)
7. Multi/single tree felling and multi tree processing of approximately 10 stems and new species
 - Reporting production data (hpr)

- Reporting of operational monitoring data (mom)
- 8. Import oin, pin and ogi(new object and products)
- 9. Harvesting of 500-600 saw logs and random selection of control stems (hqc) for evaluation of length distribution bucking.
 - Importing of updated ogi
 - Frequent automatic reporting of production data (hpr)
 - Reporting of harvesting quality control (hqc) and operational monitoring data (mom)
 - Reporting of ogr with manually added polygon and “point-of-interest”

There is a separate detailed test protocol available.

§9 Other issues

BUTTLOGMAXSTARHEIGHT

Since version 3.6, spi file has included the ButtLogMAXStartHeight element, which can be used to define the maximum start height for butt log identification, e.g. 100 or 150 cm from the felling cut.

The parameter has an effect on which assortments are allowed to be bucked, taking into account the BuckingCondition values of the product: “Buck butt-log only” or “Do not buck butt log”. All logs with a butt end cut below e.g. 100 or 150 cm are to be classified as butt logs.

The determination of the butt log has been implemented in different ways in different machines and controllers hardcoded as the maximum allowed length of an unclassified piece or in the settings of the controller

Until now, ButtLogMAXStartHeight has not been implemented in any measuring systems and it has not been included in the Finnish default spi files.

ButtLogMAXStartHeight will be implemented in Ponsse 5G version soon. It is included in the latest Swedish spi files with the value 100 cm (same for all tree species?)

Decision in the Finnish StanForD group meeting 2025-03-25 was that ButtLogMAXStartHeight will be included also in the Finnish default spi files (to be updated). The forest companies did not have any strict opinion of the exact value – 100 cm for all species could be acceptable.

Today only Ponsse has a plan for implementation of this recent element. The Finnish forest companies would like to see ButtLogMAXStartHeight being implemented by the other manufacturers as well.

VERIFICIATION TOOL - HPRVERIFIER

Fredrik Tjernberg, Komatsu, commented that we should discuss the possibility of developing a common application for verifying hpr-files. This issue was last discussed 2023-04-25—26.

§10 Next meetings

StanForD meeting 2025-12-11, Uppsala/Teams (10:00-15:00 CET)

By default, all financially contributing members will receive an Outlook invitation to all meetings in advance.

§11 End of meeting

The chairman Tapio Räsänen thanked everyone for attending the meeting.

Automated method for monitoring quality of the strip roads (AATU) – piloting

Maija-Stiina Arponen, **Kirsi Rieki**, Heikki Ovaskainen ja Jukka Malinen, Metsäteho Oy

6.5.2025

StanForD meeting



Euroopan unionin rahoittama –
NextGenerationEU

Introduction

- The goodness of the strip road networks plays an essential role in harvesting quality at first thinnings
- EU's recovery and resilience facility (RRF) has funded KESTOTÄSMÄ project; one of the aims was to develop automated self monitoring of harvesting
- Metsäteho has earlier developed a method for computing stand-wise strip road networks and their variables
 - based on location of the harvester
 - Ovaskainen & Riekk, *Forests* **2022**, 13(5), 782
- Automated computation methods enable nationwide and objective follow-up of thinning quality
- Presentation follows publication Metsäteho Result Series 3/2025, available at website



Background: implementing strip road network

Currently in Finland, the harvester operator plans and implements the strip road network at thinning site, taking into account background factors, such as:

- Areas of high biodiversity values that are known before
- Terrain properties
 - elevation conditions, cliffs, terrain wetness, ditches etc.
 - density variations of the growing stock
 - old strip roads at the edges of the site etc.
- Stand geometry and boundaries of forest estates
 - The aim is that the whole area is thinned



Background: strip road recommendations

- In forest management recommendations (Tapio 2025), the criterion of strip road spacing at thinnings is at least 19 m
 - Description: "The properties of the stand, such as terrain variation and stoniness may affect the aim."
- However, the spacing of at least 20 m is regarded as a good practice
 - This value was recommended earlier
- Inspection guide of Finnish Forest Center:
 - "Strip road spacing is only measured at stands over 1 ha, and stand geometry enables creating a regular strip road network."
 - Special cases in spacing measurements are e.g. narrow parts of the stands and ditched stands



AATU method – automated quality monitoring of strip roads

- Metsäteho has developed a computation method AATU, which aims
 - to automatically identify quality deviations of the strip road networks and
 - to examine the factors that have caused the deviations
- The inputs of the AATU method: computed strip road networks based on harvester location data
- Deviating strip road networks: comparison of the strip road variables vs. the values of the forest management recommendations
- For the identified deviating sites, the background factors are examined by using open geographic datasets



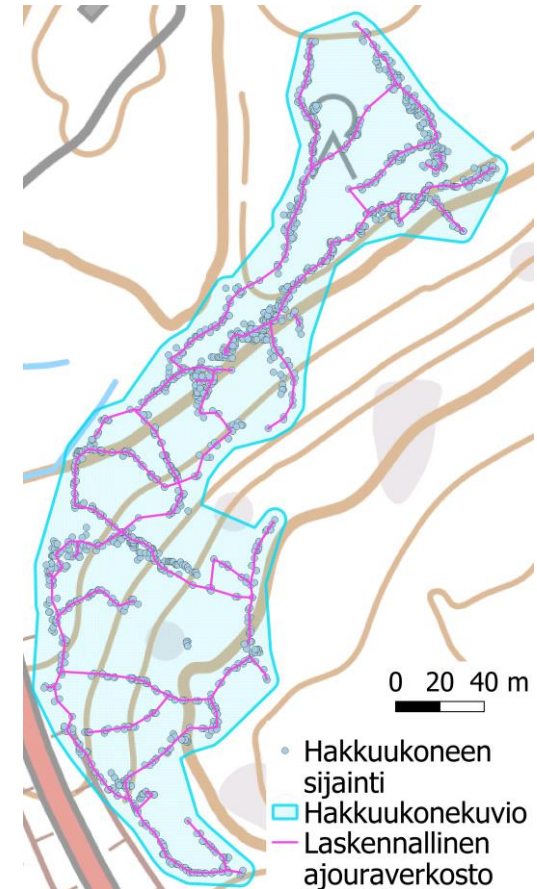
Aim of this work

1. To pilot how AATU method works using harvester data of first thinnings
 - Manual investigation: how the background factors of the site affect the properties of the computed strip road networks
 2. Comparison to reference strip road networks
 - How the background factors affect the strip road variables of references
- Maija-Stiina Arponen has made a degree work of AATU piloting (<https://www.theseus.fi/handle/10024/875700>, Häme University of Applied Sciences)

Harvester data in AATU pilot

- First thinnings of Metsäteho's owners
 - From Southern Finland to Southern Lapland
 - Thinned during years 2017 – 2021
 - HPR files available according to StanForD-standard
 - No accuracy positioning at harvesters
- HPR files and Metsäteho's methods were used to compute
 - Stand delineations (Melkas ym. *Remote Sens.* **2020**, 12(17), 2754)
 - Strip road networks and their variables: mean spacing and its mode and standard deviation (STD) (Ovaskainen & Riekkilä 2022)
- Additionally, a form number was calculated
- Piloting data included 1234 stands over 1 ha

$$\frac{p}{4\sqrt{A}}$$



At this stand (2.9 ha) spacing is 20.2 m, its STD 5.8 m and form number w.r.t. square 1.61

Using AATU method in piloting

- Deviating strip road networks were searched for using the following conditions:
 - Either mean spacing or mode > 23 m or < 17 m
 - Or STD of the strip road spacing > 6.5 m
- From the piloting data, this search resulted 370 sites (n. 30 %)
 - 165 sites were randomly selected into manual inspection in GIS program
- The strip road network was assessed both visually and quantitatively using the variables
 - 51 sites met the recommendations
 - 114 sites had deviations in strip road network
- For the deviating sites, the background factors were examined from stand geometry and using open geographic datasets from National Land Survey of Finland:
 - Aerial ortho images (density variations of growing stock, re-opening of ditch lines)
 - Base map (elevation, cliffs, ditches)
 - Forest estate boundaries
 - Hill shade (detailed variations of elevation)

Results: background factors of deviating sites

- 114 sites
- For most of the sites (110, 96 %), a logical explaining factor was found from the open datasets
- For four sites, the cause of the deviation could not be found → field inspection
 - First site: 5 m wide strip roads, thinned mainly from strip roads only
 - Second site: wet area with smaller trees and a ditch missing from basemap

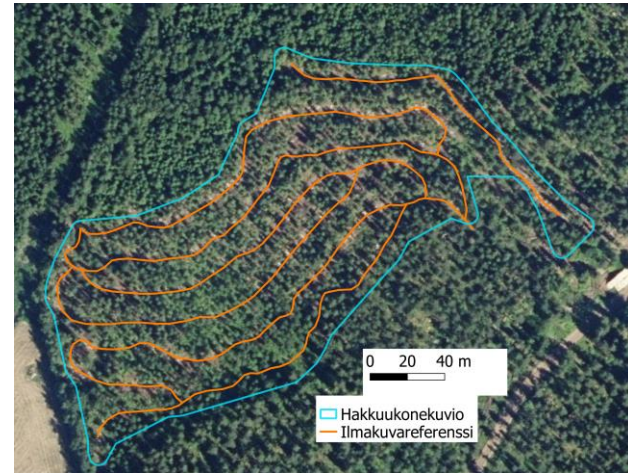
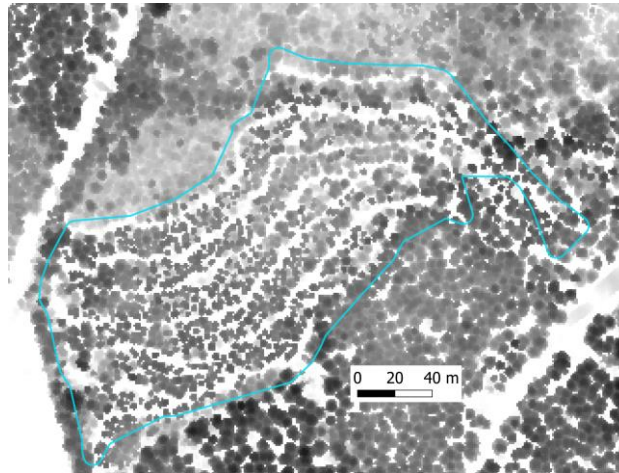
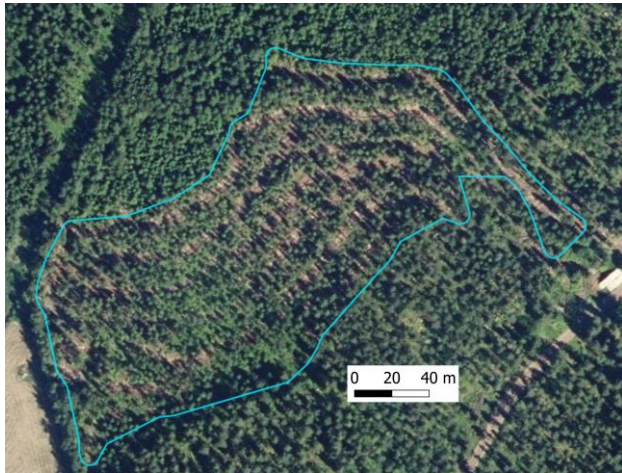
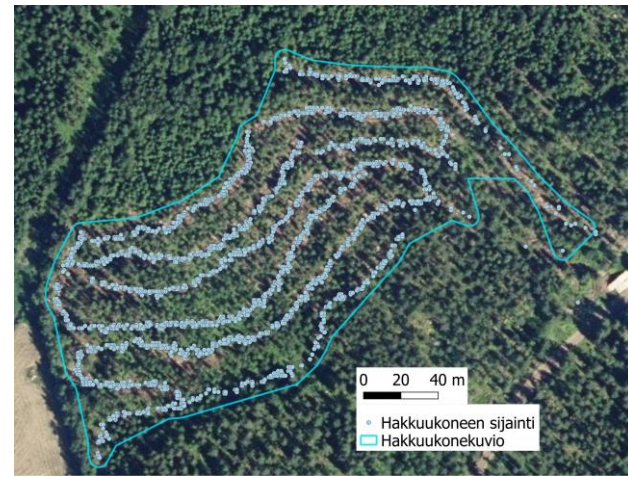
Background factors explaining deviating strip road network in the piloting harvester dataset

Background factor	Number of sites
Varying elevation	53
Ditches, wet terrain	28
Stand geometry	17
Positioning inaccuracy of the harvester	4
Other (growing stock, road)	8
No explanation	4
Sum	114

Reference strip road networks

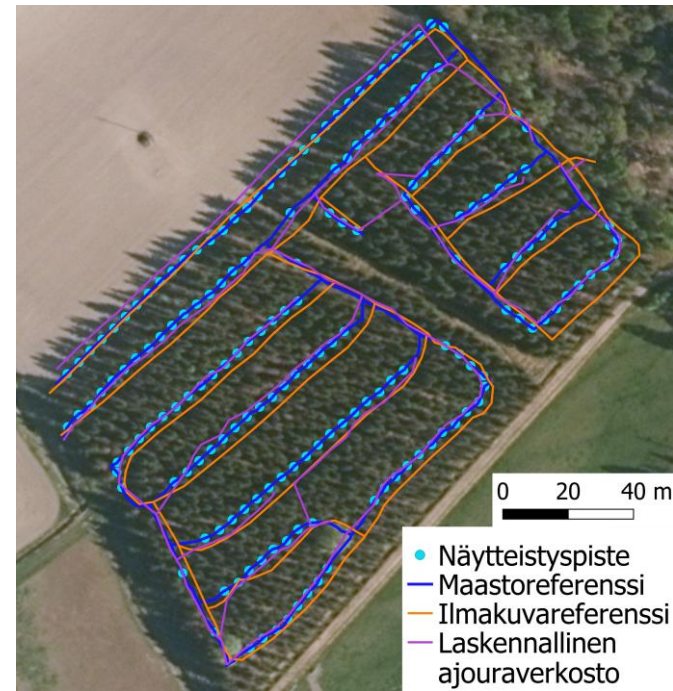
- 11 field recorded references (7 deviating, 4 recomm.)
 - 32 digitized aerial image references
- Altogether **36 reference sites**

Example: mean spacing of aerial image reference 17.2 m, mode 17 m, STD 3.1 m, density 601 m/ha.
Thinner growing stock



Results: spatial correspondence

- Examined by RMSE of perpendicular displacements
- Aerial image vs. field references: RMSE nearly 2 m
- Computed strip roads vs. both references: RMSE slightly over 2 m
- RMSE varied between 1 to 4 m
- Similar results as in Ovaskainen & Riekkilä 2022



Site-wise RMSE values and their standard deviations

Compared datasets	N	RMSE of mean displacement, m	STD, m	Sampling points /ha
Computed vs. field ref.	11	2,3	0,7	74
Aerial image vs. field ref.	7	1,9	0,8	86
Computed vs. aerial image ref.	32	2,2	0,7	82

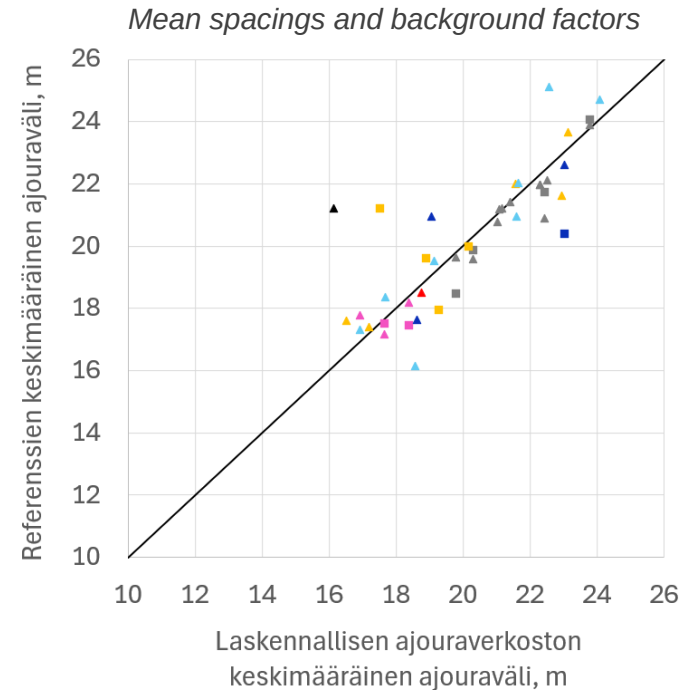
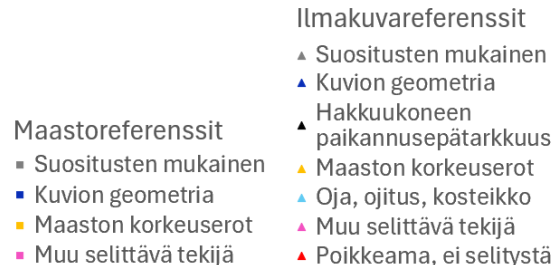
Examples of strip road networks at stand (2,0 ha) and displacement sampling points.

Aerial image © National Land Survey of Finland

Results: strip road spacings of references

Computed strip road networks vs. references:

- At most sites, mean spacings were within 1 m
 - Especially good correspondence at sites where the strip road recommendations were met
- Larger differences when
 - terrain elevation varied or
 - ditches or stand geometry affected the strip road network
- At one site, positioning inaccuracy of harvester affected notably



Summary of results: AATU method

- AATU method was able to identify possibly deviating strip road networks
 - Based on the strip road networks computed from HPR data
 - Quality of strip road network can be good also when the mean spacing is larger than the recommended value
 - In further use, the conditions of the deviations need to be adjusted
- For most of the stands (96 %), the reason for deviating strip road networks was found from open geographic datasets
 - Most common background factors: varying terrain elevation, ditches and stand geometry & dimensions
 - In some cases, the terrain affects the strip road network and then the deviation from the recommendations can be argued
- Harvester operator's lack of expertise or carelessness in implementing the strip roads was not observed in this work

Summary of results: correspondence to references

- The spatial accuracy of HPR-based computed strip road networks was adequate for determining the strip road variables
- The background factors of the sites reflected similarly to the variables of both the computed and the reference strip road networks
 - Especially at deviating strip road networks
- Only at one stand, the variables of the computed strip road network deviated notably from the references due to positioning inaccuracy of the harvester
 - Positioning is continuously improving



Conclusions

- Overall, the strip road variables can be used to identify the deviations
- HPR files are a good data source for computing the strip road networks for quality monitoring
- AATU works very well to both identify and explain the deviations of the strip road networks
- The factors causing strip road deviations can be largely identified based on open geographic data
 - AATU reduces the need to inspect the quality of the thinning sites in field after harvesting
- In the future, the examination of factors causing deviations to strip road networks can be automated by using the open geographic data
 - AATU is very potential method to automate forest companies' self-monitoring of the harvesting quality at first thinnings





KIITOS

Accuracy of harvester positioning and use of strip road tree data for estimating initial stand properties

StanForD meeting, Vantaa, Finland, 6.5.2025

Juho Ylä-Pöntinen¹, **Heikki Ovaskainen**², Riku Tarvainen², Kirsi Riekk²,

Timo Melkas², Kalle Kärhä¹, Jukka Malinen²

University of Eastern Finland¹

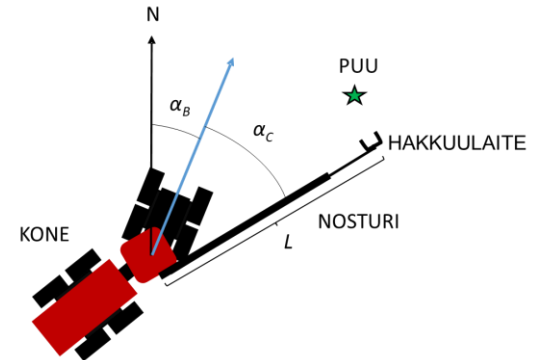
Metsäteho Oy²

Locating a forest machine

- Forest machines have had tracking devices for decades, and in the early stages, their accuracy was tens of meters.
- Today's basic GNSS receivers offer an accuracy of 3 to 10 meters.
- The recent introduction of Real Time Kinematic (RTK) correction in forest machines has increased the positioning accuracy from the metre level to the decimetre level, which significantly improves the accuracy and utilisation possibilities of the machinery's location data.



Photo: Komatsu



Studies of positioning accuracy

- In the study by Melkas and Riekki (2017), the average location accuracy of the removed tree was **4.9 meters** when the harvester had a **basic GNSS receiver** and the length of the crane extension was not taken into account.
- Taipale et al. (2022), the location accuracy of the felled tree was **3.9 meters** with a basic GNSS receiver at larger felling sites, but with a similar harvester as in Melkas and Riekki's (2017) work.
 - In good positioning conditions, a positioning accuracy of about 3 meters was achieved.
- In a study conducted in Sweden (Hannrup & Möller 2022), the average accuracy of the location of a felled tree was **0.56 metres**. The study in question had a similar precision-located harvester, hardware and software as in this study.



Komatsu 901XC-6 -harvester.

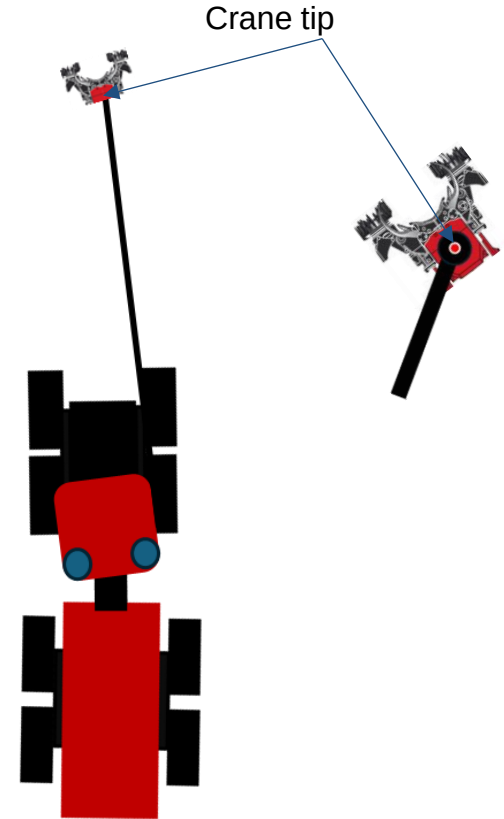
Kuva: Komatsu

Objectives of this study

1. The aim of this study was to find out how accurately the location of the felled tree can be estimated with the precision-located Komatsu 901XC-6 harvester.
 - In practice, the machine manufacturers describes the location of the harvester head (crane tip), which also describes the location of the felled tree on some accuracy level.
2. The identification of strip road trees with the help of hpr data was studied
 - What is the maximum picking width of trees in the strip road when selecting strip road trees from hpr data?
 - How does the picking width of the strip road trees affect the volume estimate per hectare of the entire growing stock calculated from the strip road trees?

This presentation is based on Metsäteho's slide serie: <https://www.metsateho.fi/wp-content/uploads/Tuloskalvosarja-6-2025-Hakkuukoneen-paikannuksen-tarkkuus-.pdf>

Juho Ylä-Pöntinen has finished his master's theses of this topic: <https://erepo.uef.fi/server/api/core/bitstreams/6638eac7-e348-416a-8559-a40ba157bcc8/content>



Study material

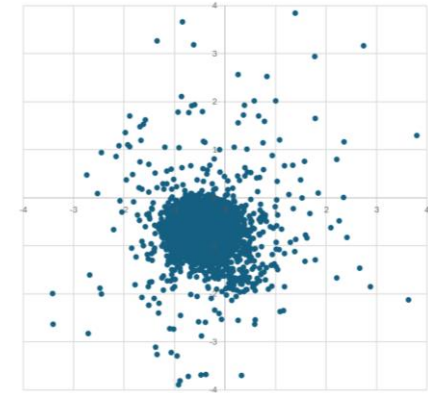
- The field measurements of the study were carried out during the period 5/2024–6/2024 in western Finland.
- The material included seven (7) measurement areas of approximately 1 hectare each.
- In the measurement areas, the diameters and locations of the stumps of thinned trees were measured and tree species were determined.
 - The Trimble R12i precision GNSS receiver was used for positioning.
- A total of **4 271 stumps** were measured.

The number of trees measured in the field by tree species in the measurement areas and the sizes of the measurement areas.

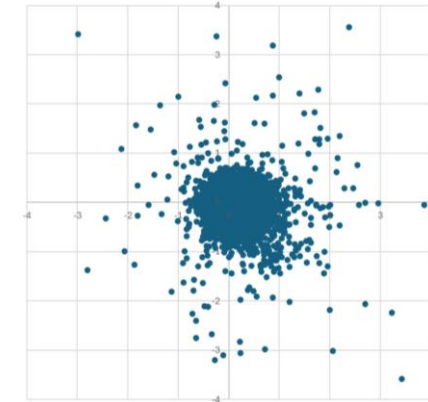
Measurement area	Pine, n	Spruce, n	Birch, n	Total tree species	Area, ha
Mittausalue 1	203	250	193	646	1,0
Mittausalue 2	520	0	2	522	1,2
Mittausalue 3	425	74	20	519	0,9
Mittausalue 4	291	146	122	559	1,2
Mittausalue 5	356	94	121	571	0,7
Mittausalue 6	607	67	39	713	0,8
Mittausalue 7	546	99	96	741	1,0
Altogether	2 948	730	593	4 271	6,8

Difference between coordinate systems

- During the processing of the data, a systematic difference was observed in the field measurements and the locations of the harvester head, which was due to the use of different coordinate systems.
- The harvester locations were recorded in accordance with the StanForD standard (Skogforsk 2025) in the global WGS84 coordinate system, while the reference data collected with a precision receiver was stored in the Finnish local EUREF-FIN (ETRS89) system. This coordinate system is tied to the WGS84 system in the 1989 situation.
 - According to the National Land Survey of Finland (2025), the Eurasian tectonic plate, to which Finland's EUREF-FIN coordinate system is attached, moves to the northeast at a rate of about 2.5 cm per year. For this reason, the positions of the reference data were corrected by moving them by 87.5 cm to correspond to the movement of the tectonic plate over a period of 35 years (1989–2024).
- After the correction, the actual positioning accuracy could be examined.



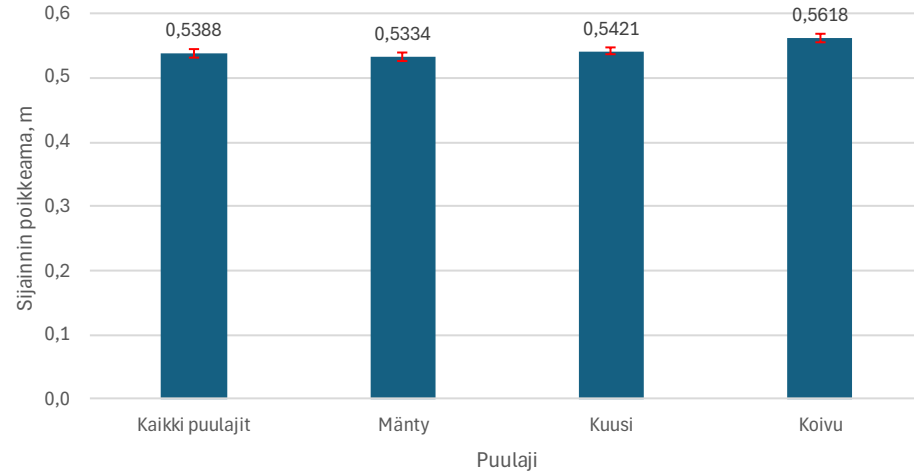
Before repair, m



After repair, m

Results – location difference

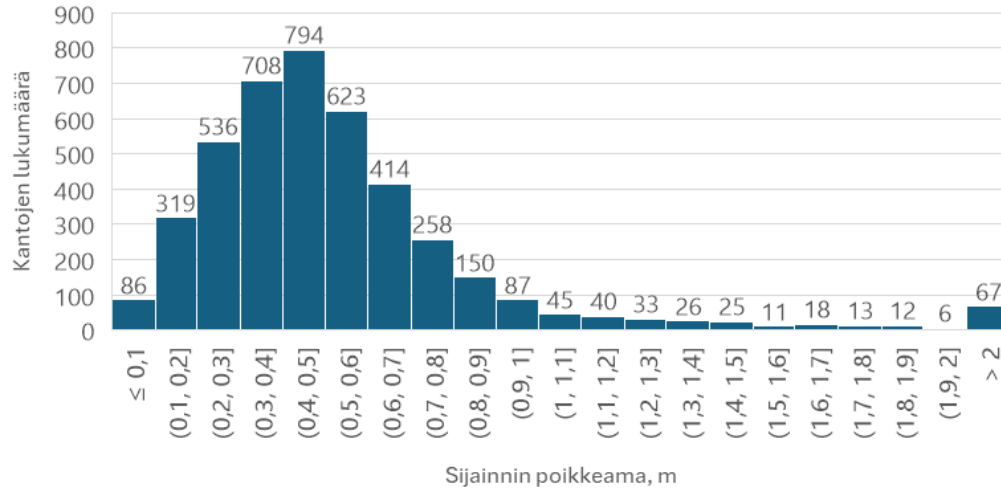
- In the entire data, the average difference in location between the harvester head and the field measurement (stump) was **0.54** metres.
- The results by tree species differed only slightly. The pines had the highest accuracy and the weakest birches. The difference between them was 2.8 centimetres.
 - The differences in location between tree species did not differ statistically significantly.



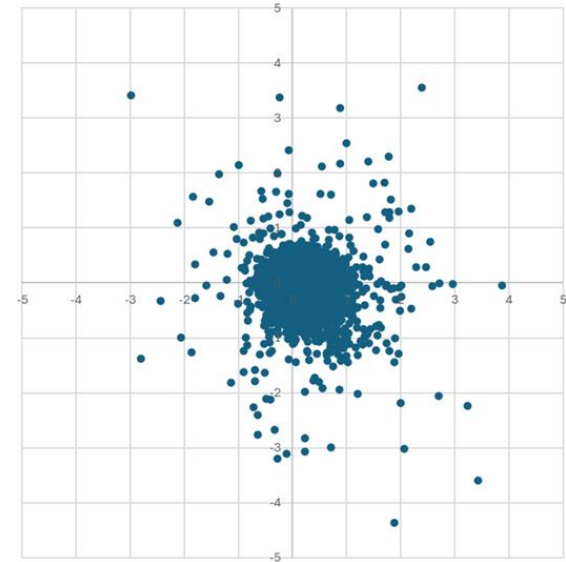
Average deviations of the location by tree species between reference data and hpr data.

Location deviation

Kantojen sijainnin poikkeamat koko aineistolle



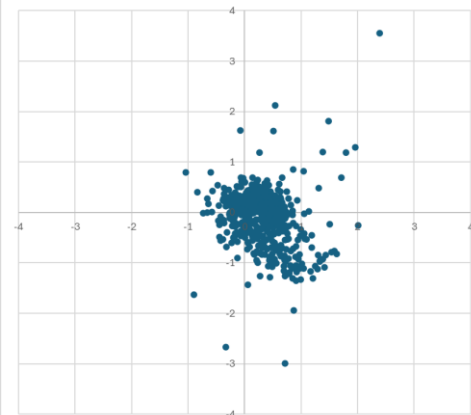
The average of the location deviation in the entire data was 0.54 m and the standard deviation 0.41 m.



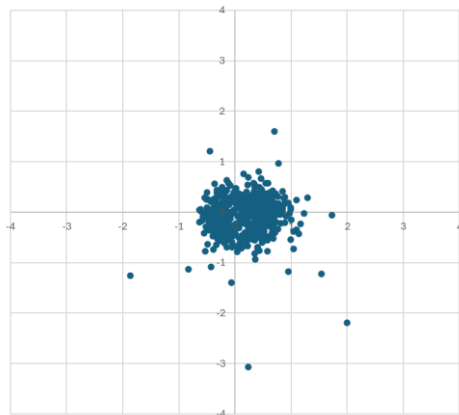
In the graph, the origo describes the location of the stump (harvester head) located by the harvester and the dots the locations of the stumps measured in the survey. The unit is a meter.

Distance of stumps from the harvester head by measurement area

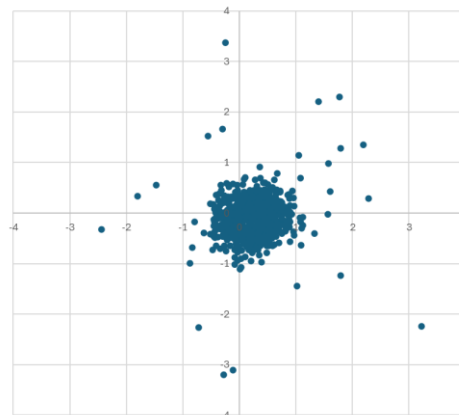
Mittausalue 1



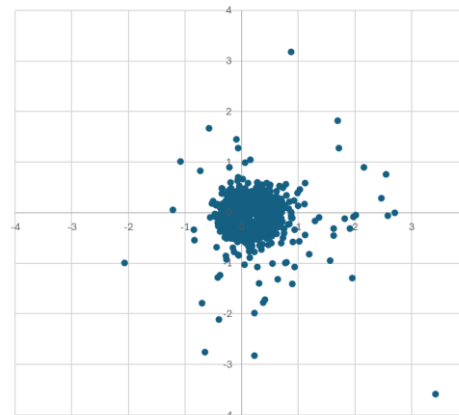
Mittausalue 2



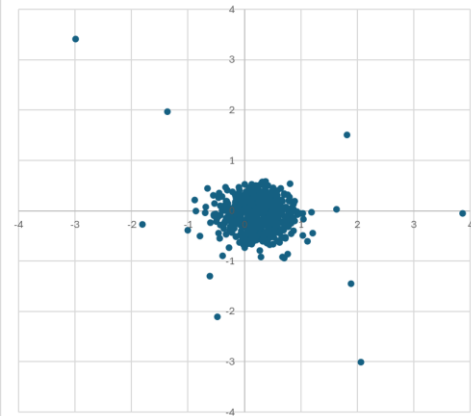
Mittausalue 3



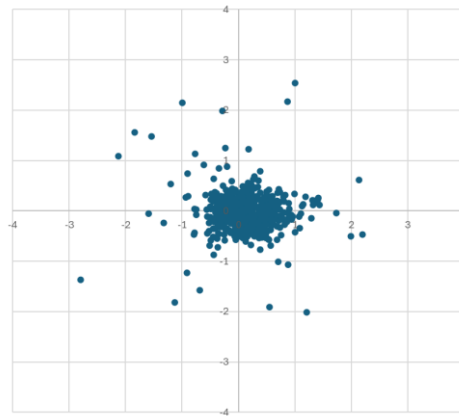
Mittausalue 4



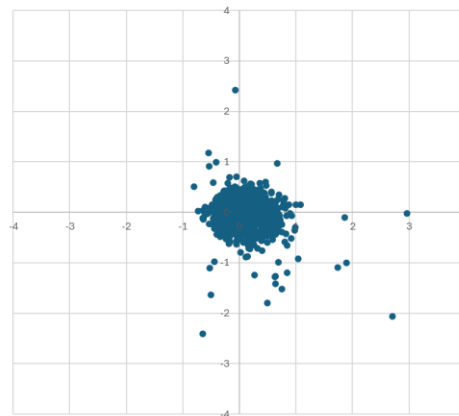
Mittausalue 5



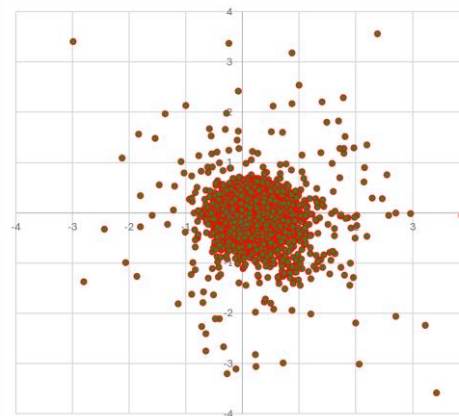
Mittausalue 6



Mittausalue 7

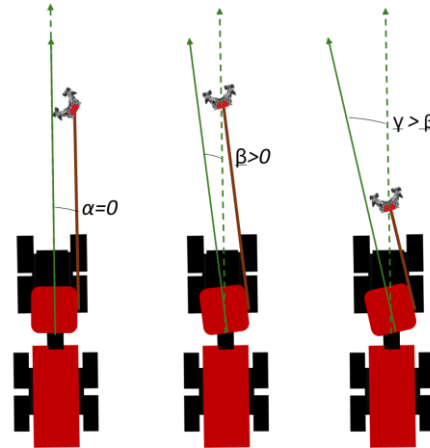


All areas

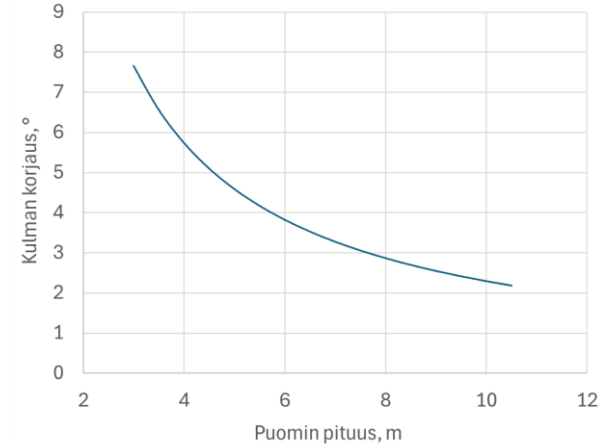


The effect of tree distance on the tree felling angle

- On a Komatsu harvester, the crane is located on the side of the cabin, which means that the angle of the tree catching changes in relation to the distance of the harvester, i.e. the length of the crane.
- The felling angle of the tree was geometrically corrected using the following formula
 - Corrected felling angle = CraneAngle + $\arcsin\left(\frac{d_t}{CraneLength}\right)$, where
 - d_t is the perpendicular distance of the crane attachment point from the centerline of the machine. In this study, 0.4 meters was used.
- After this correction, the distance of the trees from the centre line of the strip road was calculated and the strip road trees were determined.



The effect of the harvester geometry on the crane angle in relation to the tree catching distance.

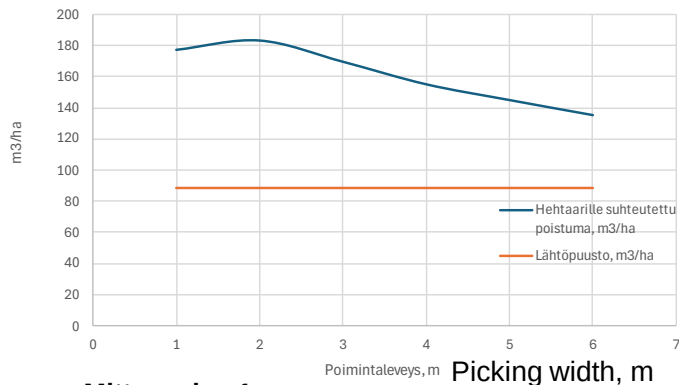


The ratio of the length of the crane to the correction of the felling angle, calculated according to the adjacent formula.

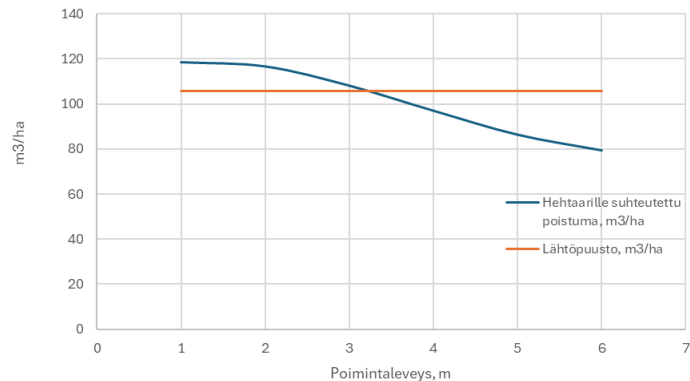
Comparability of the strip road trees and initial stock

- When examining the trees in the strip road, the idea was that the trees felled from the strip road describe the initial stock of the felling site in first thinning harvesting.
- The initial stock with the help of the strip road trees was examined by picking trees from zones of different widths around the middle line of the strip road.
- At different sampling widths the volume of removal proportional to the hectare was calculated.
- The graphs show how the removal per hectare decreases when the width of the strip road exceeds the width of the harvester/minimum strip road width.

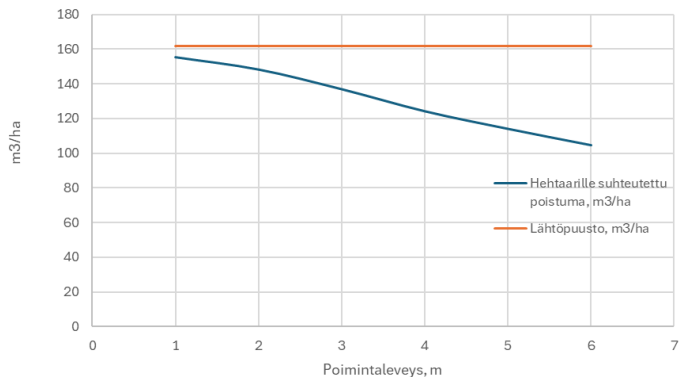
Comparison of strip road trees and initial stock, measurement areas 1 - 4



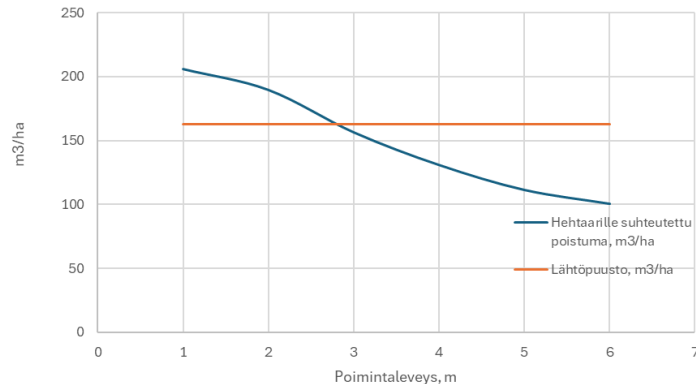
Mittausalue 1



Mittausalue 2



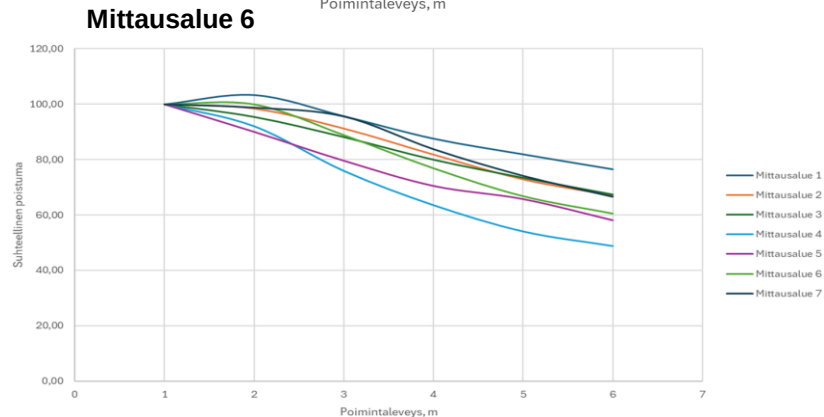
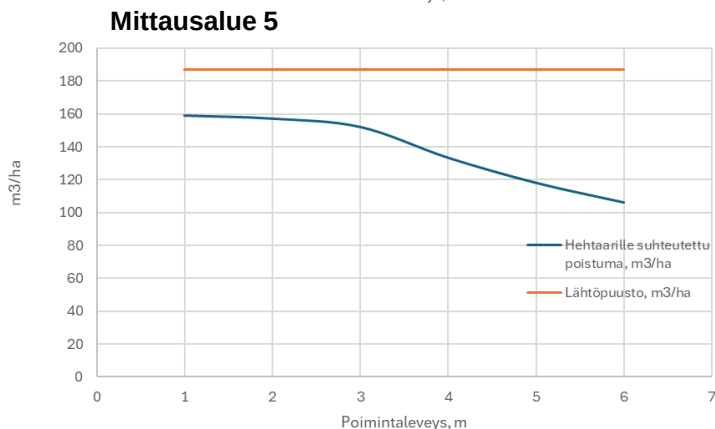
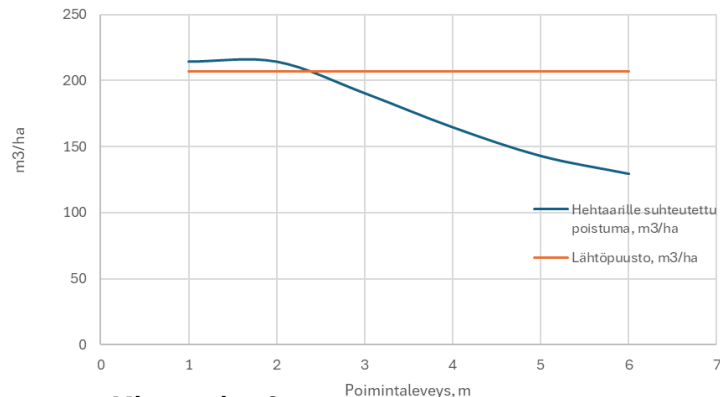
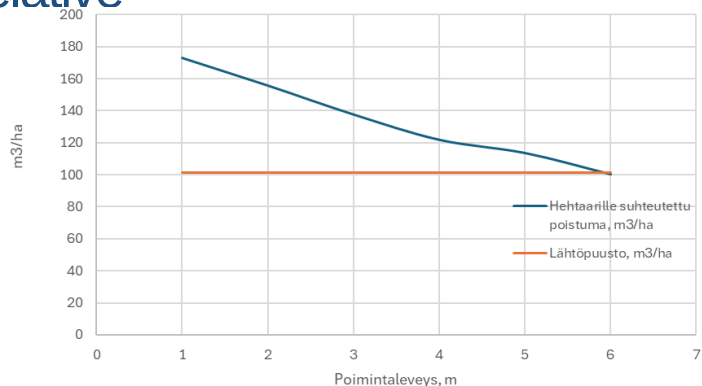
Mittausalue 3



Mittausalue 4

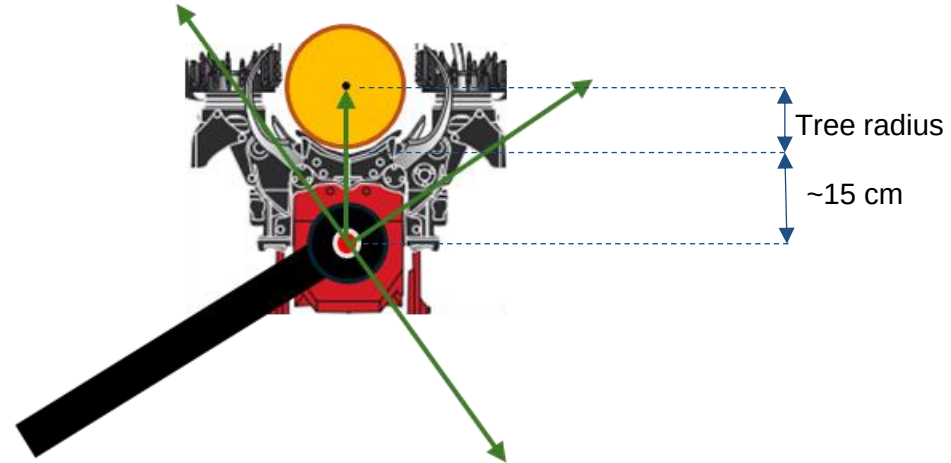


Comparison of strip road and initial stock, measurement areas 5 - 7 and all measurement areas in the same graph as relative



Discussion

- By sensing the rotator of the harvester head, it would be possible to determine the last missing part of the tree's location.
- In this case, the distance and direction of the center of the tree in relation to the tip of the crane would be known.
 - The diameter of the tree affects the position by the radius of the tree.
 - A constant distance between the crane tip and the bottom of the harvester head could be taken into account.
- When $15\text{ cm} + \text{the radius of the tree in question}$ is subtracted from the values of the position reference pairs in this study, the theoretical inaccuracy of the machine's positioning can be calculated. This way, the average difference in positioning is **0.33 m**.



Discussion

- The average difference between the location of the harvester head and reference stump was 0.54 m.
- The result is in line with the 0.56 meters obtained by SkogForsk with the same equipment for a Komatsu harvester (SkogForsk 2022).
- Compared to previous accuracy studies, the accuracy has improved by more than 3 meters.
- The main reason for the increase in accuracy is the utilization of RTK GNSS positioning technology and that the machine's crane is sensed up to the tip of the crane.
- Measurement accuracy is also known to be affected by the shade of trees and terrain, the number of satellites and the positioning receiver.
- The location of the harvester head is recorded at the time the tree is felled, but variations in satellite geometry may affect accuracy. How much positioning inaccuracy is allowed at the time of recording, and is it possible to make computational post-correction to improve accuracy?



Conclusions

- The study provides a good understanding of what can currently be achieved in determining the location of felled tree through the location of the harvester head, when RTK correction is used in the positioning of the harvester and the crane is sensed up to the tip of the crane.
- Strip road trees can be used to identify the initial stock, but the accuracy of the method varies depending on the trees, terrain, strip road network and the shape of the stand. The width of the strip road has a significant impact on the number of trees to be removed, and the results show that there is a turning point in the volume of the removal between 3–4 meters in the picking width of the strip road trees.
- In determining the width of the strip road, a location accuracy of about half a meter from the trees already gives good results.
- The direction information of the harvester head rotator could be used to obtain the last missing tree distance information. The current method of determining the location of the tree to be felled, which is based on crane sensors and the location of the base machine, is functional.



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Autoprice

Intelligent application for creating price matrices

StanForD meeting, May 6-7 2025



Lovisa Engberg Sundström
Johan J Möller
Liviu Ene
John Arlinger

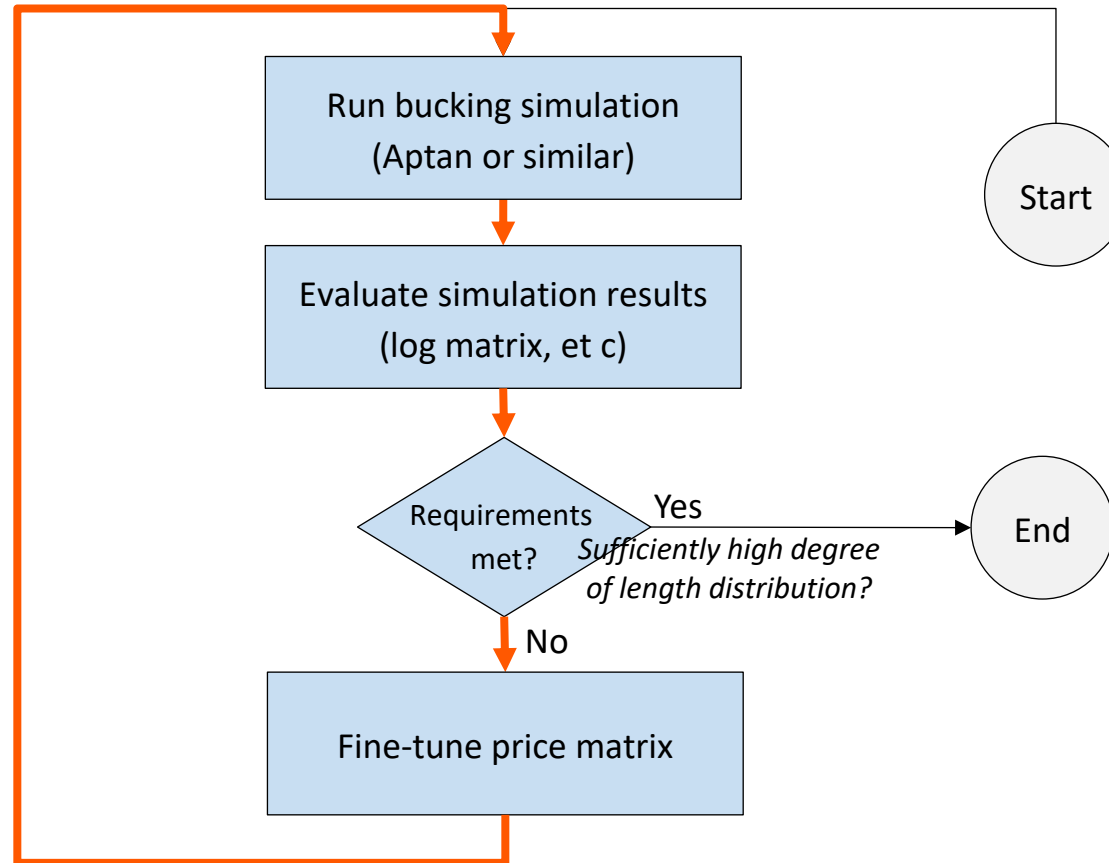
Bucking

(in general)
 $\neq$
How similar
are they?

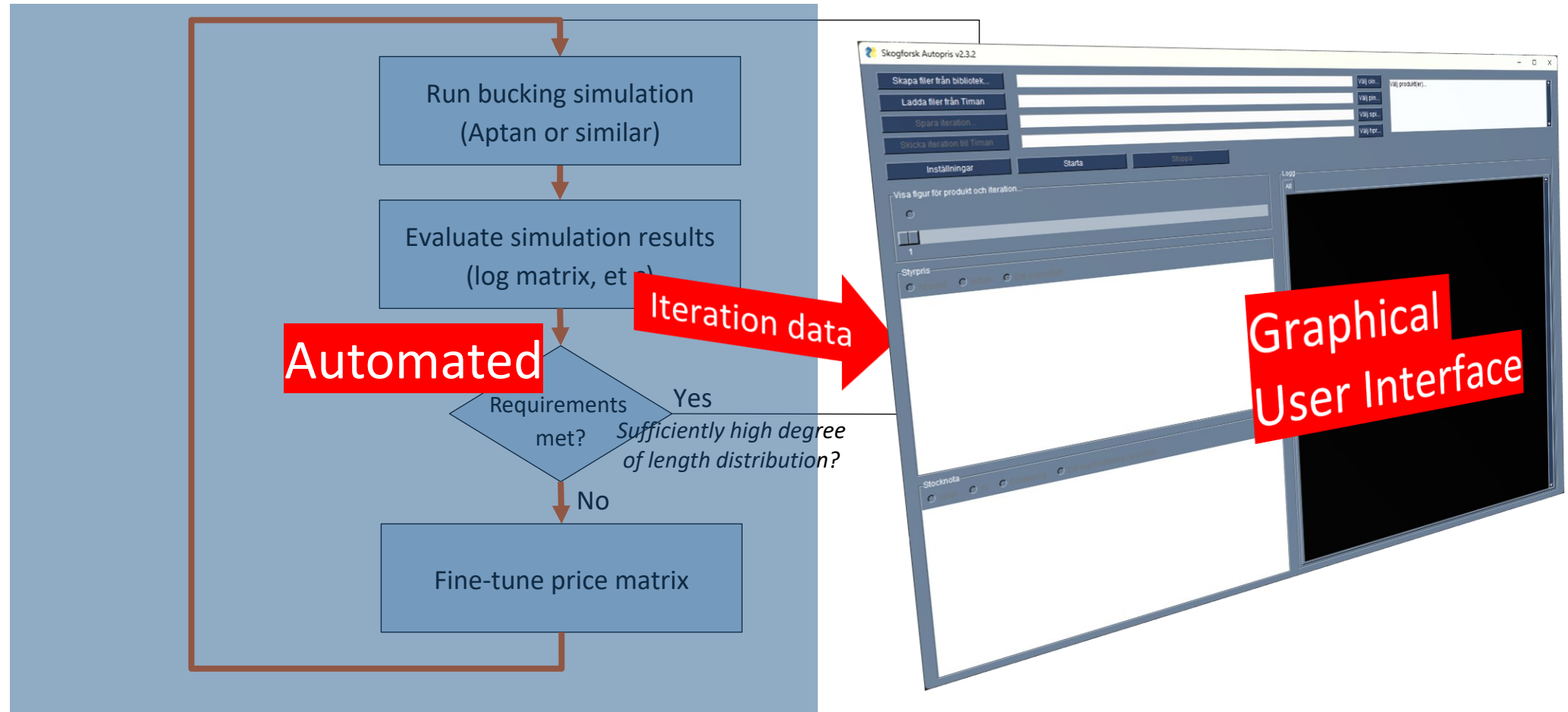
Degree of length distribution
[0-100 %]

$$= \underbrace{\sum_j \frac{S_j}{\sum_j S_j}}_{\text{weight}} \underbrace{\left(100 - \frac{1}{2} \sum_i |\hat{S}_{ij} - \hat{W}_{ij}|\right)}_{\text{degree for diameter class } j}$$

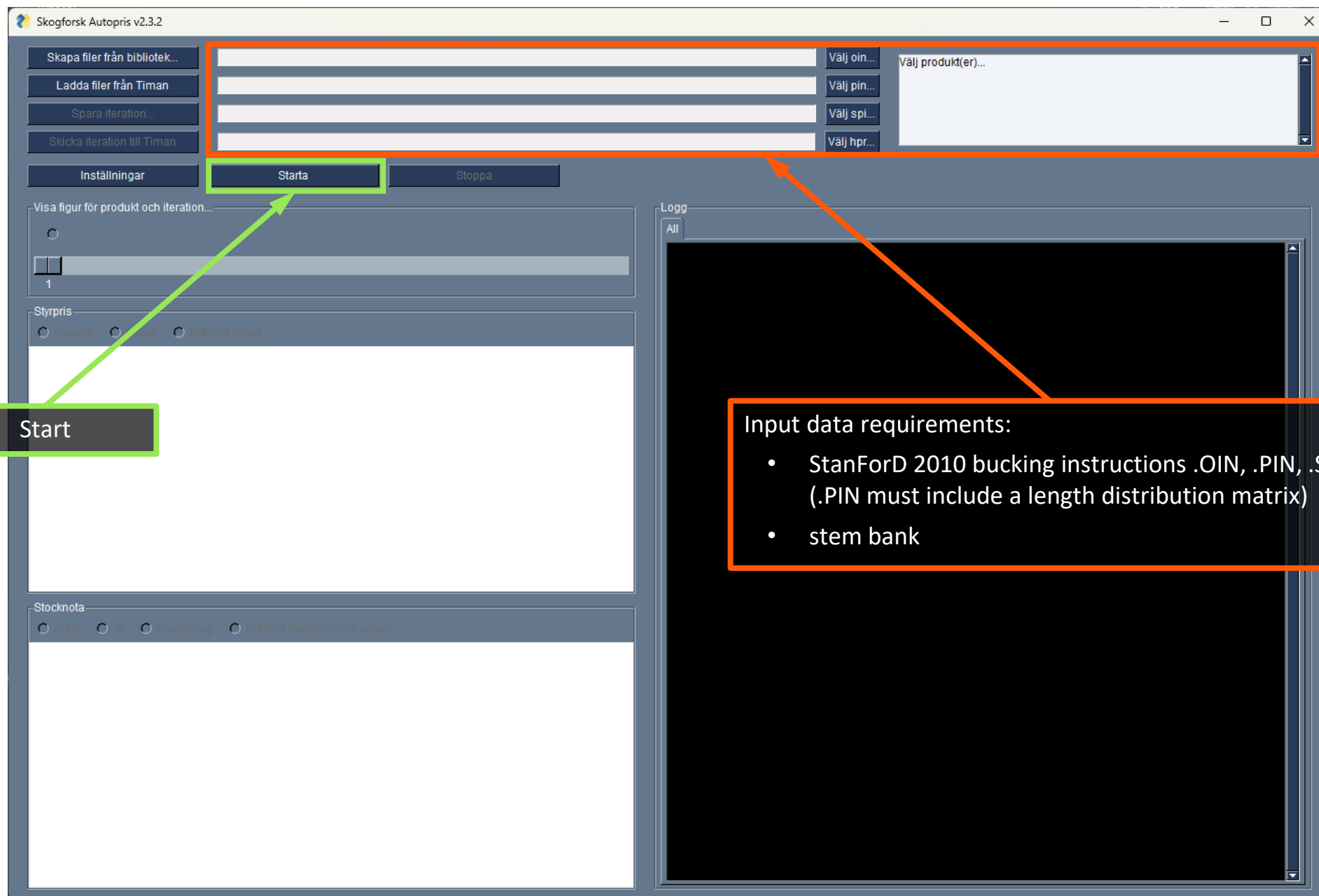
Background



Background



GUI



GUI

Skogforsk Autopris v2.3.2

Skapa filer från bibliotek... C:\Skogforsk\Pin-filer\test.oin
 Ladda filer från Timan C:\Skogforsk\Pin-filer\test.pin
 Spara iteration... C:\Skogforsk\Pin-filer\test.spi
 Skicka iteration till Timan C:\Skogforsk\Stambanker\stambank.hpr

Välj oin... Rot_A
 Välj pin... Timmer_A
 Välj spi... Massa
 Välj hpr... Rot_B
 Timmer_B

Inställningar Starta

Visa figur för produkt och iteration...
 Timmer_A

1 2 3 4 5 6 7 8

Styrpris
 Absolut Initialt Diff mot initialt

	94	102	120	125	130	140	146	150
310	0	0	0	360	360	338	338	338
338	0	0	0	360	360	338	338	338
368	0	0	437	377	400	426	439	431
377	348	416	434	455	435	92	92	92
397	0	0	461	393	434	457	472	503
428	348	407	426	452	475	554	544	549
458	0	0	0	462	488	548	538	550
488	0	0	0	462	506	544	554	578
517	0	0	0	443	471	504	524	541
/m²fub	0	277	309	322	337	384	384	412
/m³to	0	415	432	438	466	526	526	586

- Price matrix
- Diff to initial price

Stocknota
 Antal % Fördelning Diff mot fördelning (%-enhet)

	94	102	120	125	130	140	146	150
310	0	0	0	0	0	0	0	0
338	0	0	0	0	0	0	0	0
368	0	0	0	18	16	13	9	17
377	0	91	74	0	0	0	0	0
397	0	0	0	10	13	13	15	8
428	0	9	26	47	41	42	37	40
458	0	0	0	21	18	18	13	12
488	0	0	0	5	12	15	26	23
517	0	0	0	0	0	0	0	0
%	0	39	14	6	16	10	5	10

- Log matrix
- Diff to distribution

Logg
 All Timmer_A

PROBLEM DATA

Product name	Min. price	PriceDefinition	MAXDeviation
1 Timmer_A	178.0	m3to	4.0

ITERATION LOG

****: Running Aptan with original MAXDeviation
 <iter_no>: Running Aptan with MAXDeviation=0.0 for all products

iter	timber	total value	/m3sub	...1... degree
****	72.5	342921	413	84.9
1	72.5	343159	413	74.8
2	72.5	343123	413	88.7
3	72.5	342982	413	92.2
4	72.5	342963	413	92.7
5	72.5	343006	413	93.9
6	72.6	343034	413	94.6
7	72.6	343082	413	95.7
8	72.6	343065	413	96.1

Terminated -- Stopped by user

- Degree of length distribution
- Total volume
- Timber volume share
- Mean stem
- Et c

How is a new price matrix constructed?

At iteration r , we have:

C_k : Price matrices, $k = 1, \dots, r$

$\hat{S}_k$: Normalized log matrices, $k = 1, \dots, r$

$\hat{W}$: Distribution matrix

How do we construct the new price matrix C_{r+1} ?

The intuitive approach:

$C_{r+1} = C_r$ – something, where there is surplus (where $\hat{S}_r - \hat{W} > 0$)
 + something, where there is shortfall (where $\hat{S}_r - \hat{W} < 0$)

A little more systematic:

$C_{r+1} = C_r - \gamma_r (\hat{S}_r - \hat{W})$ (i.e., using the exact deviation (appropriately scaled with some factor γ_r))

The approach in Autoprice (Gåfvels, 2004):

$C_{r+1} = (C_1 x_1 + \dots + C_r x_r) - \gamma_r (\hat{S}_1 x_1 + \dots + \hat{S}_r x_r - \hat{W})$ (i.e., using a *convex combination* of all previous matrices)

with $x_1, \dots, x_r$ chosen so that the convex combination $\hat{S}_1 x_1 + \dots + \hat{S}_r x_r$ is “as close as possible” to $\hat{W}$

$\sum_{ij} s_{jr} |(\hat{S}_1 x_1 + \dots + \hat{S}_r x_r) - \hat{W}|_{ij}$ is minimal

Does it work?

Tested on various input data, including:

- Homogeneous initial price matrices
- Length-neutral distribution matrices

Consistent and stable performance:

- Almost monotone convergence
- ...to high degrees of length distribution
- ...often within 10 iterations (~2 min)
- ...irrespective of input data

Available for users in Sweden since April 2024

- Currently in use by $N > 0$

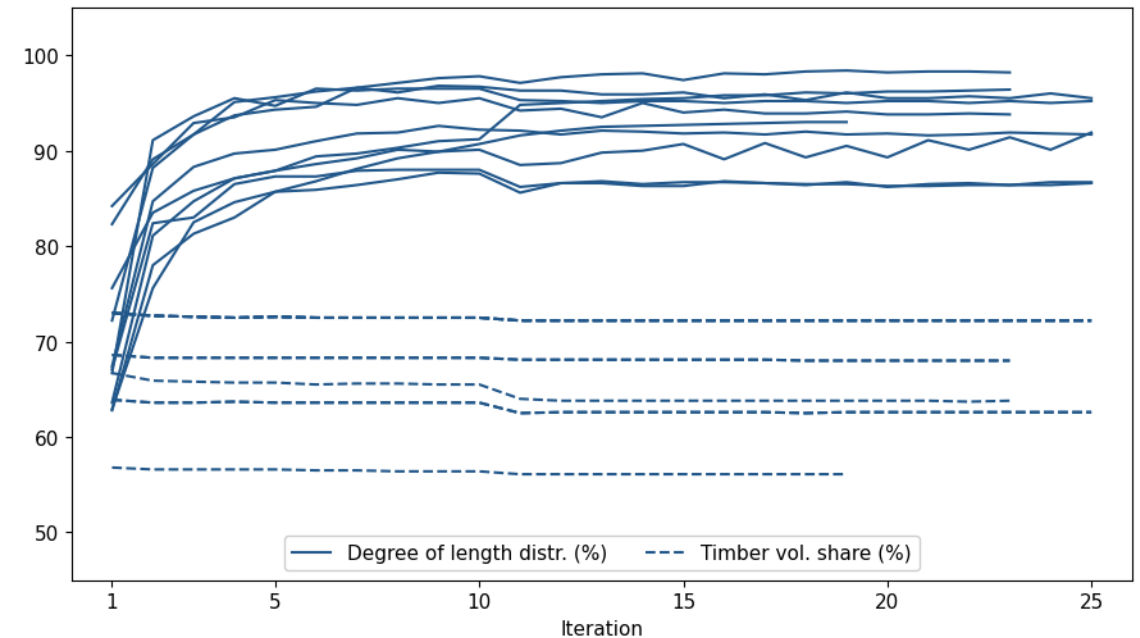


Fig: Generation of the price matrices for 10 timber products. Initial price matrices provided by project's reference group.