Metsäteho

National perspectives on big data from forest machines: Finland

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Metsäteho Oy

NB-NORD workshop on Big data from forest machines

June 19-20 2018 Ås, Norway

Vision: Efficient Wood Supply 2025

”Efficient and precise wood supply improves the competitiveness of the forest industry and guarantees its growth and regeneration potential.”

Development goal 2025

Wood supply produces added value to the value chain while being 30% more cost-efficient than today.

Focus areas of R&D 2018 - 2025

Forest data ecosystems and decision support tools

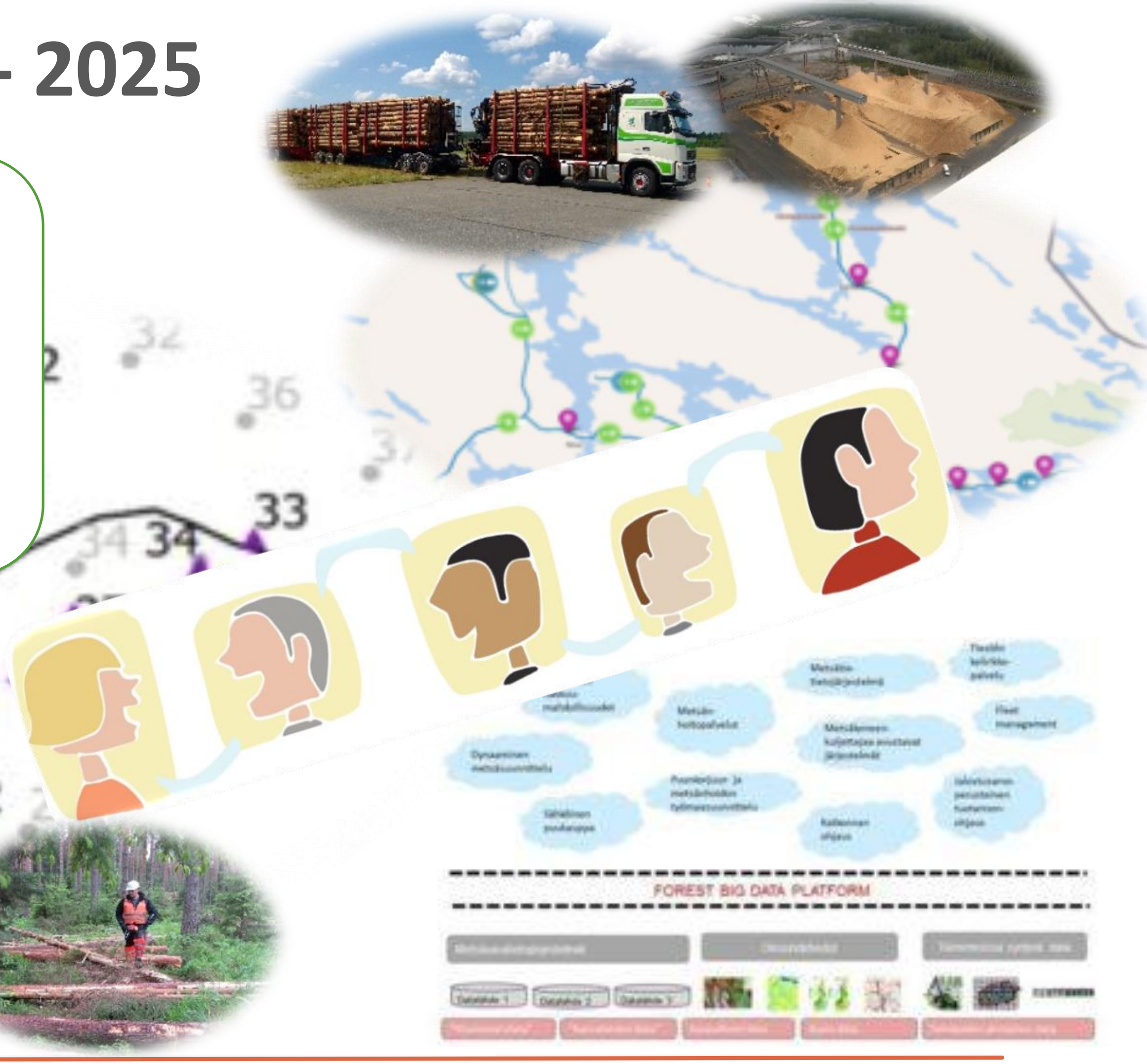
Management of sustainability

Work safety, well-being and working skills

Resource and energy efficiency

Transport systems

Efficiency of wood production



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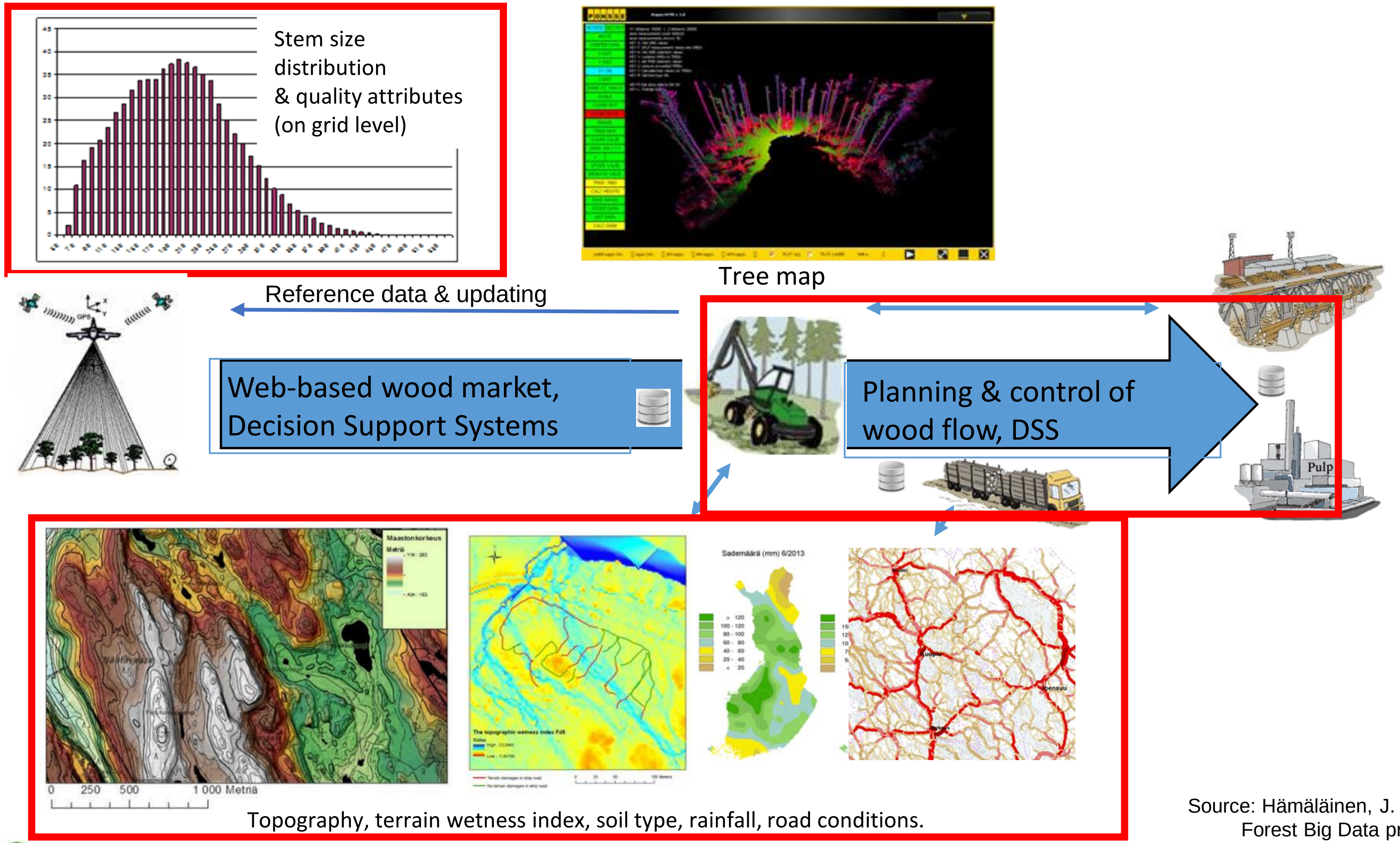
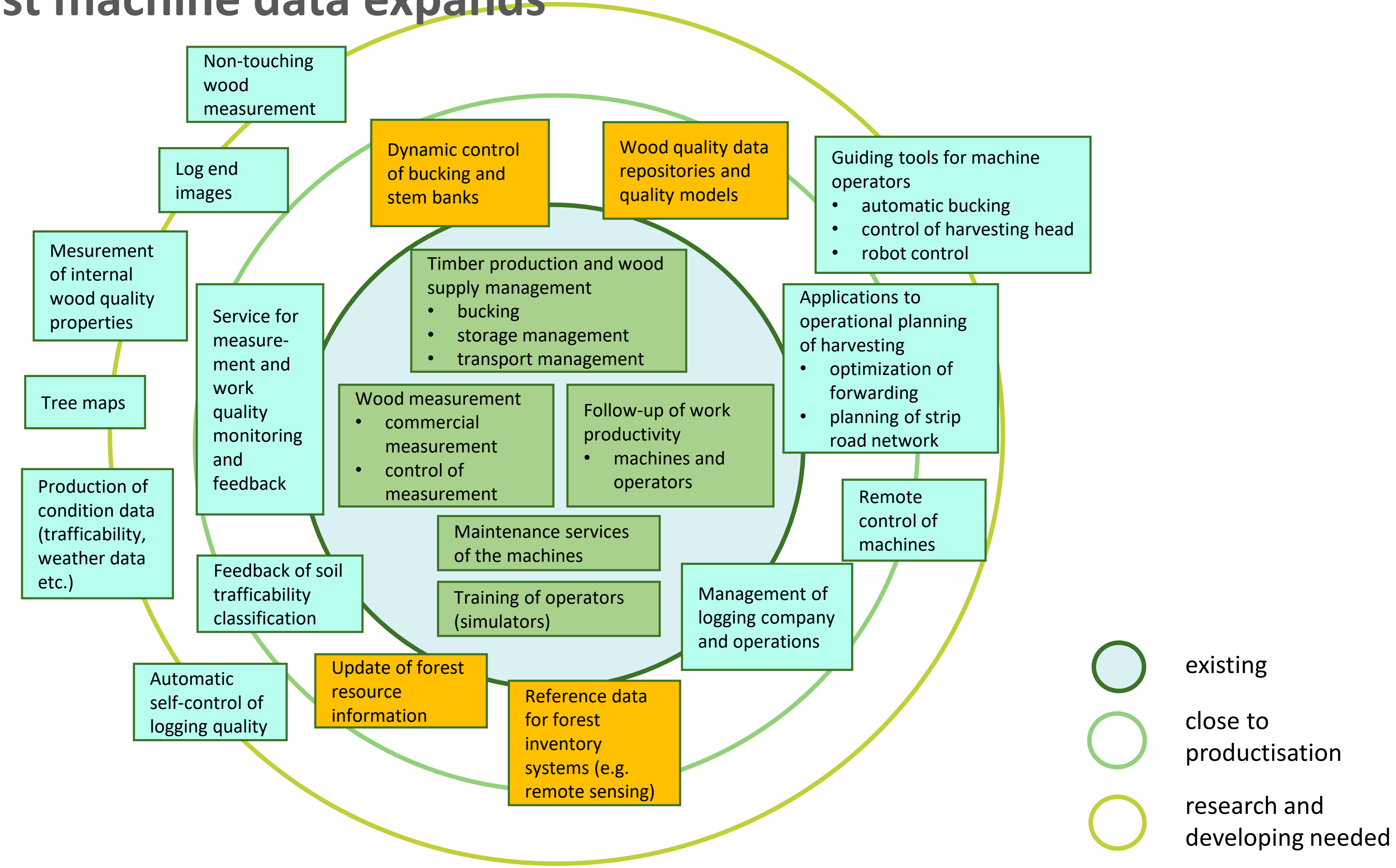
Forest Big Data vision – more precise and cost-effective wood supply through improved data and advanced decision support systems



Source: Hämäläinen, J. 2014.
Forest Big Data project.

Use of forest machine data expands



Recommendation for common forest machine data use principles (1)

- A joint recommendation for common forest machine data use principles has been prepared and published in Finland in 2017
- The purpose of the recommendation is
  - to clarify the rules of ownership and use of data
  - to promote the construction of applications and services based on forest machine information for the purposes of sector parties.
- Use of forest machine information most often calls for agreements between the owner and the user of the information, agreeing in detail on the production and use of data.
- The recommendation has been drawn up taking into account the requirements of competition legislation, and the purpose is not to harmonise agreement practices.
- Along with data ownership and use rights it takes into account the new requirements of the EU data protection regulation (GDPR).
  - separate training material of GDPR has been prepared and published 05/2018

Recommendation for common forest machine data use principles (2)

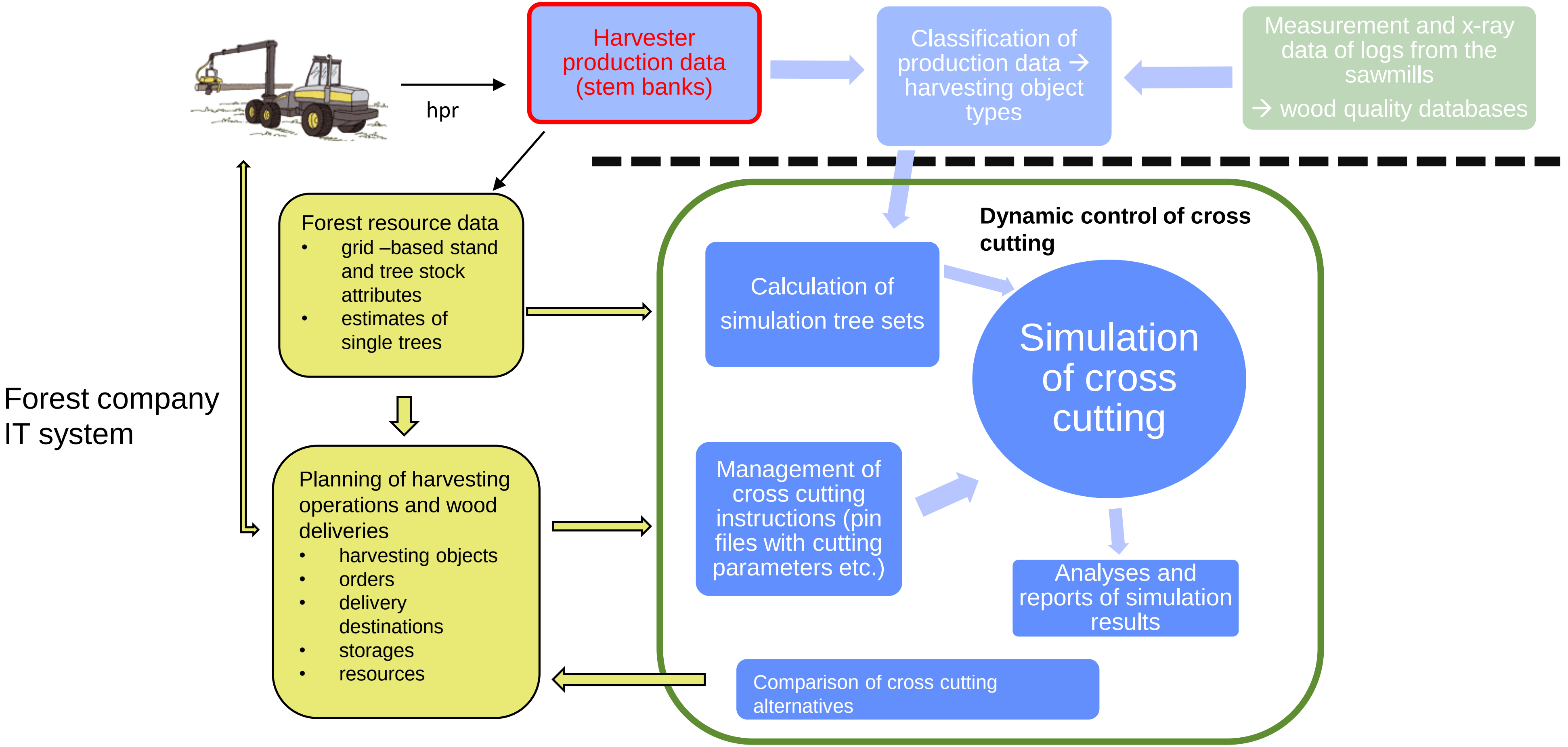
- Forest machine data ownerships and use rights
  A. Full ownership of data
     - shared ownership is possible only in some cases
  B. Free right to use the data, but no right to deliver it to third parties
  C. Restricted right to use the data for specified purposes
     - may require removal of part of the data, anonymization or processing of the data into a new format

- Data ownerships and use rights are specified by
  - type of data
    - StanForD 2010 file type groups
    - unstandardized / machine-specific files
    - potential new data types
  - machine type
    - harvesters
    - forwarders
    - machines for silvicultural operations
  - parties involved
    - business parties: service buyers (forest companies and others) and service providers (logging companies, contractors)
    - machine manufacturers
    - third parties: IT providers, Finnish Forest Centre, research organizations, forestry schools etc.

Some examples of R&D projects

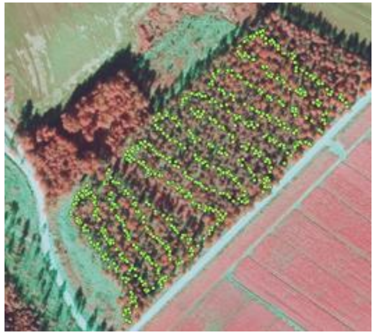
Advanced and dynamic bucking

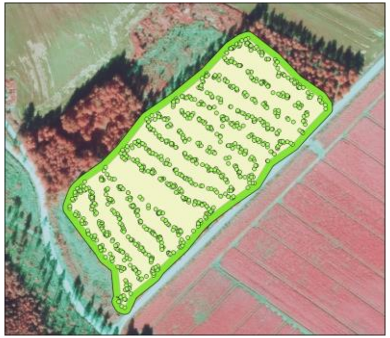
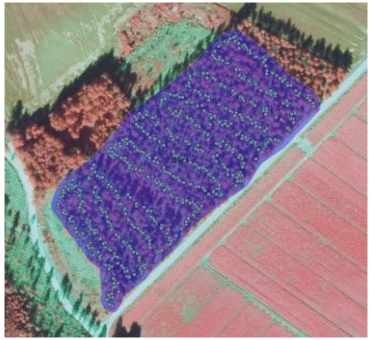
- is developed in ValueForce service by Trimble Forestry



Method to Generate Stand Delineation Based on Harvester Locations

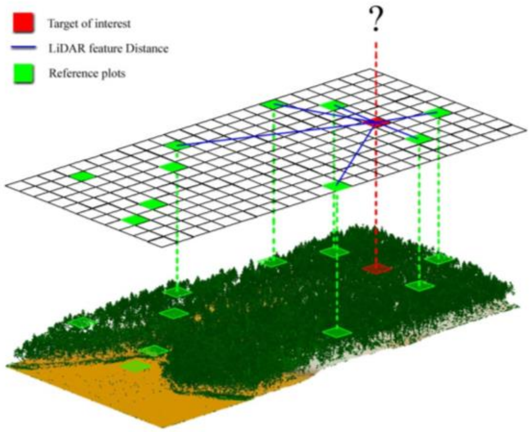
Data collection by harvester and pre-processing of stm / hpr -files → Importing data to GIS - software and performing coordinate transfor-mations → Separation of strip roads, which lead to the stand. → Creating basic patterns based on Delanay triangulation and buffering → Creating final stands delineations and calculating the area of the stand.



Timo Melkas & Kirsi Riekki, Metsäteho 2017

Harvester data as reference data in forest inventories

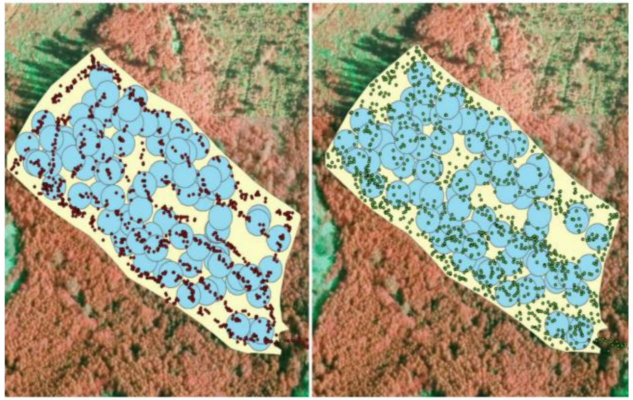


- Utilization of tree data measured by the harvesters in the forest inventory systems based on laser scanning and satellite images has been developed and studied in the project
  - Arbonaut Oy
  - VTT (Technical Research Centre of Finland)

- Aim is to make the forest resource inventories more cost-efficient and to improve their quality

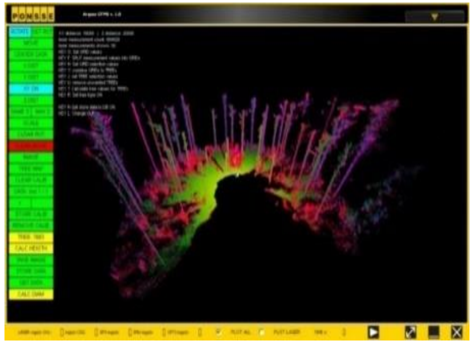
- Harvester sample plots could be used
  - to complete regular field measurements
  - to add varied wood quality parameters in the reference data

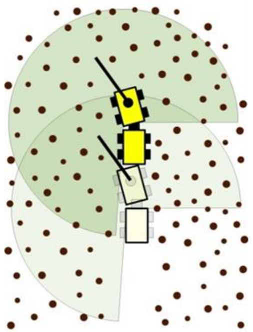
- Results have shown so far that
  - use of the harvester sample plots improves the estimates of all stock attributes slightly at least with the main tree species
  - however, location accuracy of the plots is critical

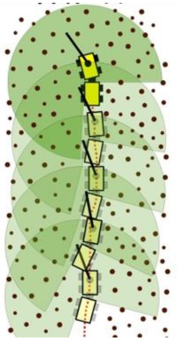


Source: Hakkuukoneen paikannetulla hakkuulaitteella kerätyn puutiedon hyödyntäminen lentolaserkeilaukseen perustuvan puustotulkinnan aputietona. Atte Saukkola, Pro gradu thesis, University of Helsinki

Harvester tree maps







Goals

- Tool for the harvester operator to follow thinning density
  - partly automated selection of trees
  - semi-automated boom movements
  - control and report of thinning density
- To produce a map of remaining trees after the thinning
  - to be used in GIS systems

Technology

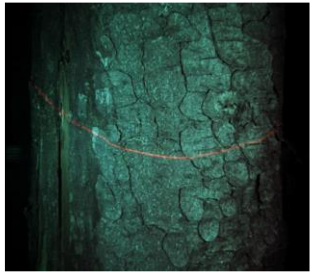
- Laser scanners or digital camera
  + GNSS + measuring system

Challenges

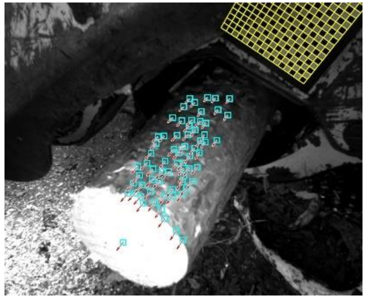
- Precise location of the trees
- Detection of trees
- Image processing time
- Costs vs. benefits

Source: EffFibre -project (Timo Melkas / Metsäteho, Mikko Miettinen / Argone Oy and Ponsse Oyj)

Non-touching harvester measurement



Source: MetrixPro project



Source: Heikki Hyyti, Aalto University

Goals

- Improvement in diameter and length measurement accuracy
- Automatic calibration of the measuring system
- Utilization of image data in automated bucking
  - models for predicting internal wood quality attributes (branches)

Challenges

- Camera concept and mounting to the machine
  - inside or outside the harvester head?
  - varying and uneven lightning
  - disturbing materials: bark pieces, dust, snow …
  - mechanical strain
- Image processing time and complexity
- Costs

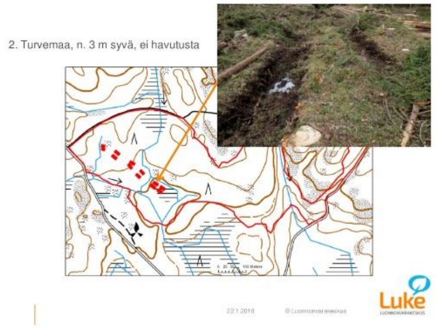
New method has been developed and studied in Aalto University (Jakke Kulovesi and Arto Visala)

- Calibrated stereo cameras
  - 3D measuring
- Modeling and estimation of cylinder surface
- Bayesian method: combination of observed and model data
- Good results with pine and birch, spruce seems to be more difficult

Harvester CAN-bus data for site trafficability mapping

- Harvester motion resistance can be measured using the data in harvester CAN-bus aiming at site trafficability map for the forwarder, which follows the harvester and is heavier, for route planning:
  - At steady speed on level ground engine power via transmission is expended on overcoming motion resistance
  - Motion resistance is mainly dependent on wheel sinkage
  - Wheel sinkage is dependent on soil strength vs. loading

- Expended power monitored from CAN-bus
  - Pressure and flow of transmission hydraulics or transmission power deduced from engine power
  - Power losses in mechanical transmission components must be estimated
  - True ground speed needed for power to force calculus
  - Further corrections:
    - Acceleration
    - Inclination



- Dimensionless output:

$$\text{coefficient of motion resistance} = \frac{\textit{motion resistance}}{\textit{vehicle weigth}}$$

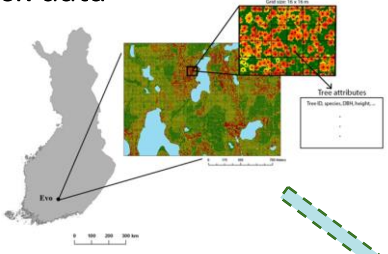
- CAN-bus mapping benefits:
  - Assessing trafficability by measuring
  - Comprehensive and continuous assessing
  - Low-cost of assessment

Source: Jari Ala-Ilomäki, Luke, Efforte project

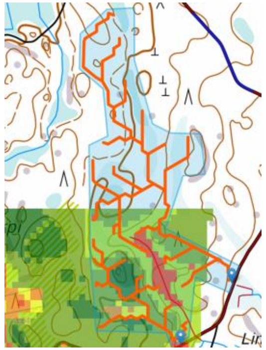
Vision for operational harvesting planning tools

- focus in soil trafficability, risk of terrain damages and productivity of forwarding

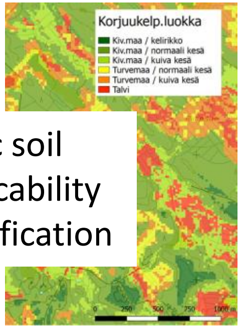
Pixel-based stock data

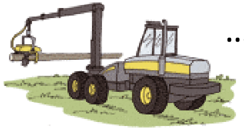


Strip road network planning service



Static soil trafficability classification





CAN-bus data
Production data (.hpr)
Tracking data
…

Forwarding optimization and guidance tools

Models of soil bearing capacity and soil damage risk & route optimization models

Topography, soil types, ditches, roads, borders

Dynamic and adaptive soil moisture index (based on weather attributes), soil frost, snow, …

Key biotopes, waterside buffers, protection and sensitive areas, …

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Towards automatic work quality measurement in harvesting

Thinning intensity
- Laser

Picture: Metsäteho

Strip road density
- GNSS tracking

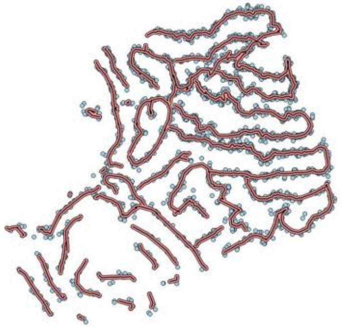
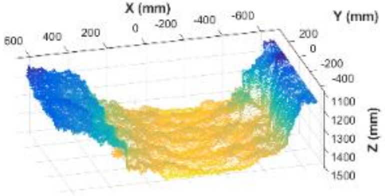


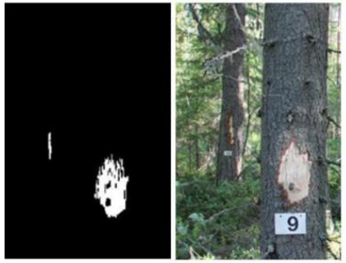
Fig. Metsäteho

Rut depth
- Time-of-flight imaging or laser



Picture: Lari Melander, Technical University of Tampere

Tree damages
- Camera



(e) Phase 9 (f) Original image

Picture: Jyry Eronen, University of Eastern Finland

Aim is to develop new methods to self control of logging quality

- Camera and laser scanning technology combined with CAN bus data of forest machines and production data

- Systems to detect automatically damages to terrain and standing trees caused by harvesters and forwarders
  - depth of tracks
  - stem bark injuries and damages to roots

Picture: Mikko Miettinen, Argone Oy

Picture: Jyry Eronen, University of Eastern Finland

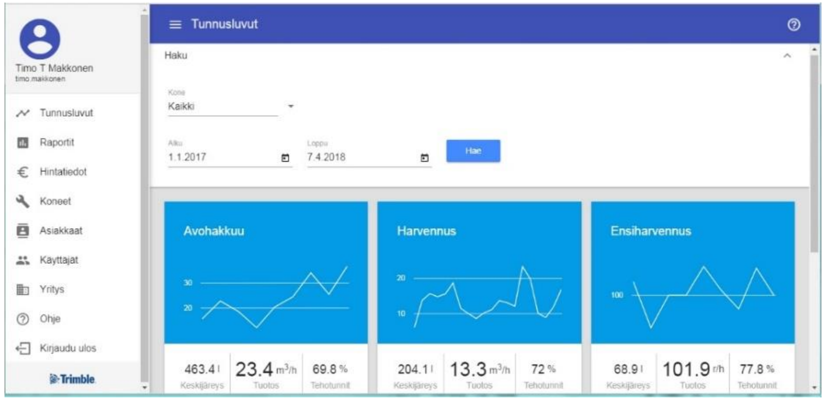
Vision: real-time application on cloud services, which
- receives the image
- detects and identifies damages
- calculates total amount of damages
- creates a report

"Contractor's Data Bank"

A service provided by Trimble Forestry in collaboration with
Trade Association of Finnish Forestry and Earthmoving Contractors

Kone	Hakkuu (m^3)	Hakkuun käyttötunnit	Rungon kk	Runkoja/h	m^3/h	Polttoaineen kulutus l/h	Polttoaineen kulutus l/m^3	Lyhyet katkot %	Tulot/tunti
Kone1	1255	63	220	83	20	12	1	1,02	103
Kone2	598	35	120	40	16	10	0,98	1,00	98
Kone3	789	42	135	42	14	11	0,92	1,08	128
Kone4	1248	65	243	86	22	13	0,88	1,09	113

Mom- and drf-files from forest machines → cloud service



Reports for the contractor through a web-based application

- key figures about productivity and profitability
  - machines and operators
- comparative figures to other logging companies in the service on average

KONEYRITTÄJÄT

Next generation's Forest Data Ecosystem

What has been done and what is still needed?