長野モデルとドローンレーザによる間伐支援

現地検討会（平成29年10月10日：北信州森林組合）97名参加

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【協力機関】 長野県、中部森林管理局、長野県森林組合連合会、コマツ

Outline

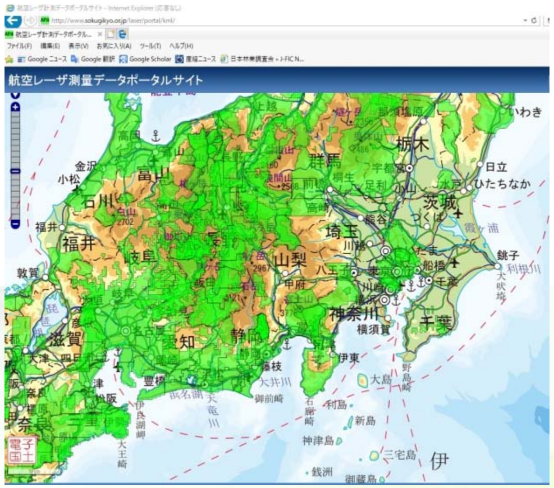
- ✧ Aim
- ✧ LS technology in Japan
- ✧ Smart precision forestry project
- ✧ Accurate forest resource survey with UAV-LS
- ✧ Efforts of 2017
- ✧ Good news

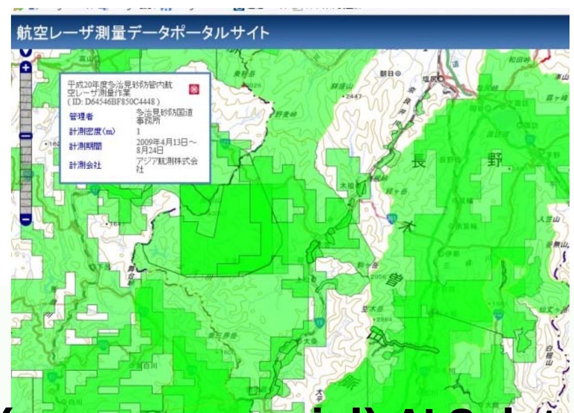
AIM

- ✧ The purpose of the research is to develop smart precision forestry through regionally innovative at the production site.
- ✧ Precise 3D forest information using ALS, UAV-LS & PLS to develop a thinning or harvest plan and practice.
- ✧ Timber production by advanced harvester with IoT function, timber information can be used in cloud services on the Internet to timber factories.
- ✧ A few years later, the goal is to build timber supply chain ‘Nagano model’ from forest stands to timber processing and building.

LS technology in Japan
ALS

1. ALS of 1 point /m^2 was undertaken for each watershed in Japan, by Ministry of Land, Infrastructure and Transport's Department (LIT). Last year it was disclosed that archival ALS data from a portal site for nationwide.
2. Area based approach (ABA) is an effective approach for efficiently understanding forest resources, ABA has not been executed yet.
3. Forestry Agency (FA) is not interested in terrain data information and LIT data could not use until last year. ABA will increase.

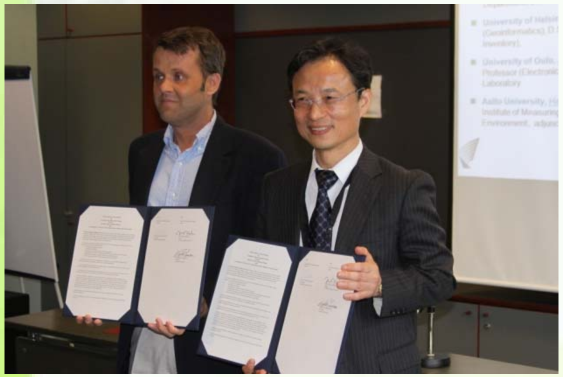




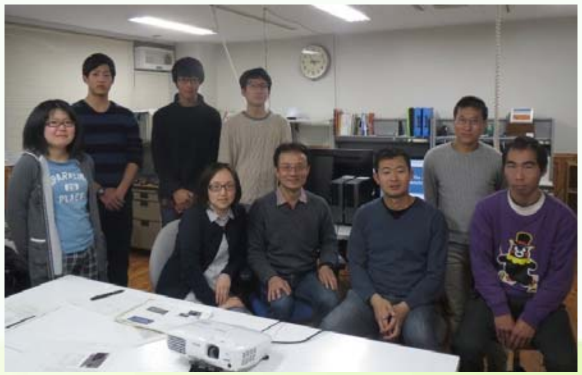
Free (non-commercial) ALS data can be obtained from the LTA web server

LS technology in Japan ITD

1. FA is promoting high-density ALS with 4-5 point /m^2, but it has only covered 20% of the forest area yet. Fortunately, Nagano Prefecture, where our university is located, has covered for the entire privately owned forest.
2. TLS, UAV-LS, MLS and PLS have been initiated experimentally in various places, but these have not been organized.
3. In 2014, we signed an academic agreement MoU with FGI and has been continuing scientific co-research of ITD for forestry.



MoU in FGI in May 2014



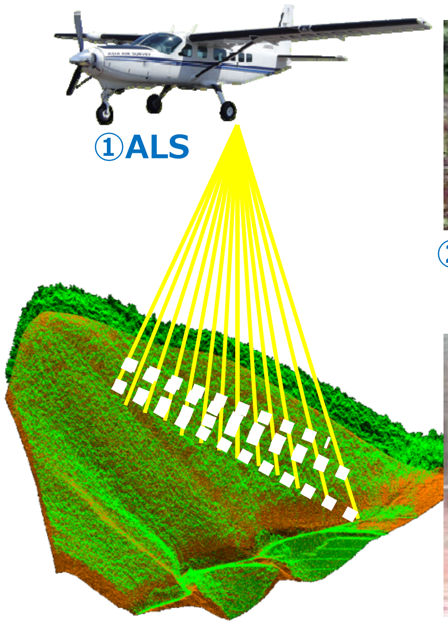
Visiting Prof. in SU from 2015

TLS in Matsumoto in 2017

Smart precision forestry project
Nagano model

- We have developed integrated information technology for obtaining useful forest information, including ALS, UAV-LS, PLS for forest monitoring and timber productivity.
- "Nagano model" of smart precision forestry, which has improved timber supply chain management by industry and academia and facilitated government collaboration.

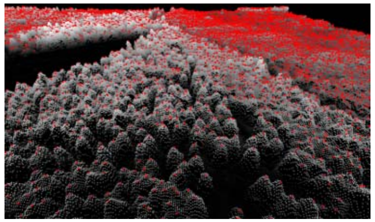
3D Precision ITD Information using LS

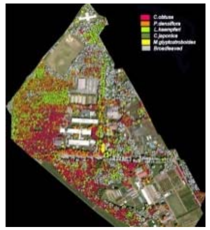


①ALS

②UAV-LS SU

③PLS SU&FGI



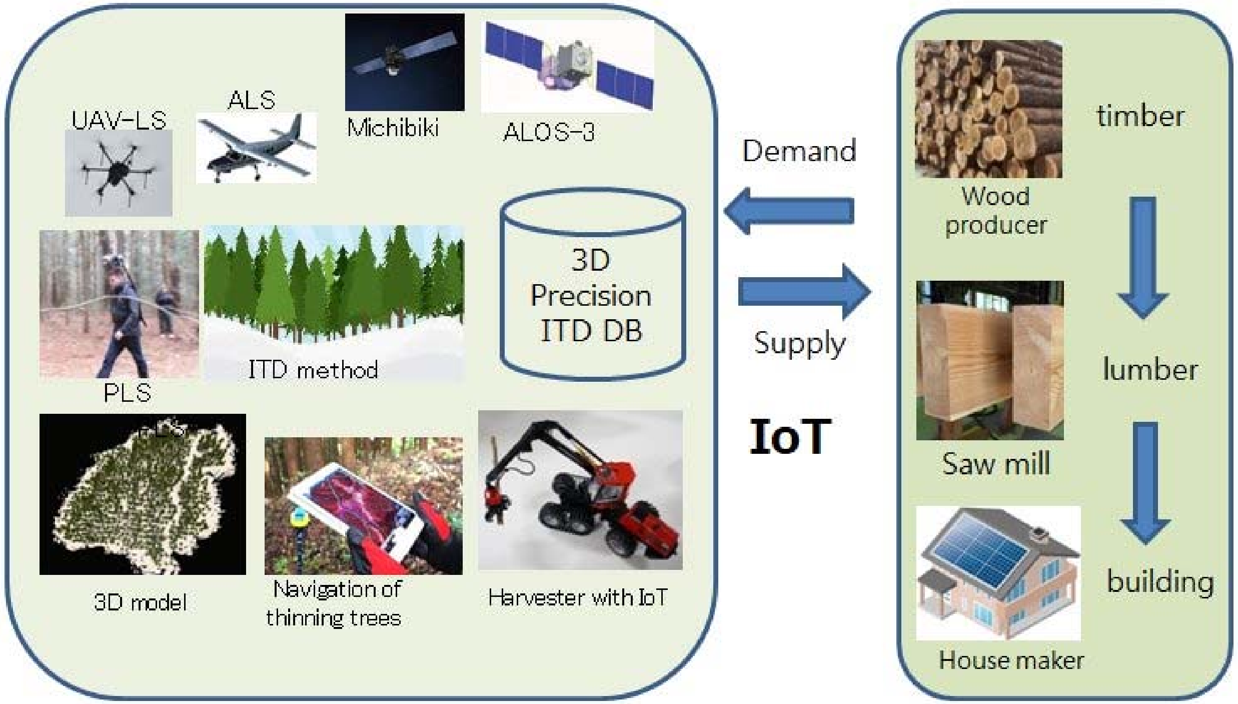


Establishment of 3D precision DB
Selection of cutting trees

Harvest and timber production
- **Navigation system on tablet PC**
- **Visualization of harvest information**

Smart precision forestry project
Timber supply chain

- Select harvest trees with the program using the 3D precision ITD DB .
- Navigate to harvest trees on tablet PC
- Use high-performance harvester (MaxiXplorer) with IoT functionality
- The timber supply chain can be built by linking timber information from the harvester operator to offices and sawmill companies on cloud service.
- This research is a large-scale project FA for 2016–2020. The budget is 800K EUR.

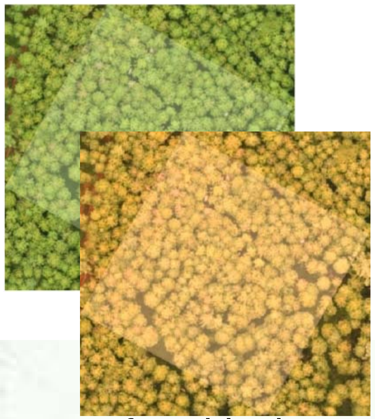


Smart precision forestry project

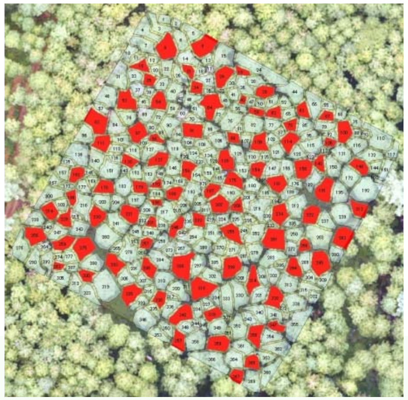
Shinshu University's Approach

- SU is the representative body of the project and Prof. Katoh is the project leader.
- SU works on 3D precision forest survey using UAV-LS and a ground-based harvest survey using PLS.
- We first perform scanning before thinning the conifer plantations, and then extract precise single-tree resources by the ITD method.
- We overlay the two different time-before & after LS images and automatically extract and verify the thinned trees.

Before thinning



After thinning



Harvest tree (red)

收穫木 No

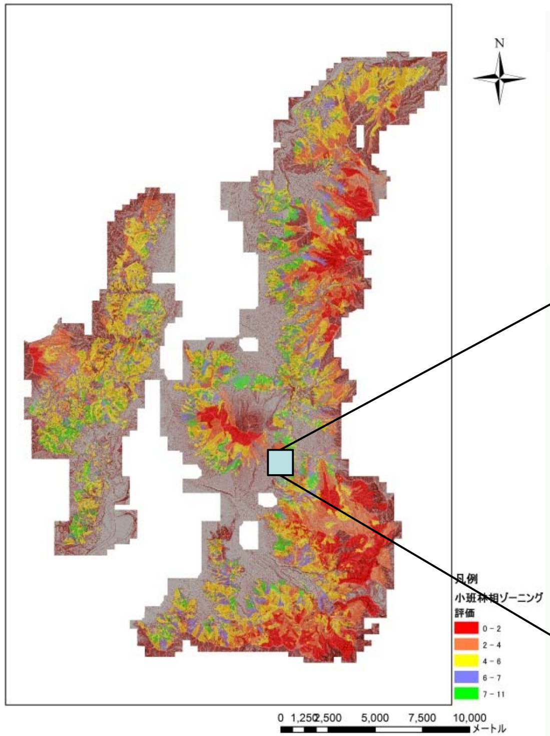
收穫木 No	樹冠面積	胸高直径	樹高	材積	X	Y
1	7.7	29.3	23.1	0.8	−5861.35	79827.09
2	5.1	27.5	24.4	0.7	−5858.05	79826.04
3	16.1	35.2	24.8	1.1	−5863.03	79825.41
4	22.6	39.7	24.0	1.3	−5866.48	79824.16
5	15.9	35.0	25.1	1.1	−5853.76	79823.55
6	16.1	35.1	25.0	1.1	−5856.82	79821.31
7	20.7	38.4	23.8	1.2	−5867.19	79819.98
8	28.1	43.5	24.6	1.6	−5850.37	79819.62

	樹冠面積	胸高直径	樹高	材積
平均	13.2	33.1	25.3	1.1
最小	0.9	24.6	15.1	0.3
最大	45.7	55.7	32.7	2.9
合計				392.3

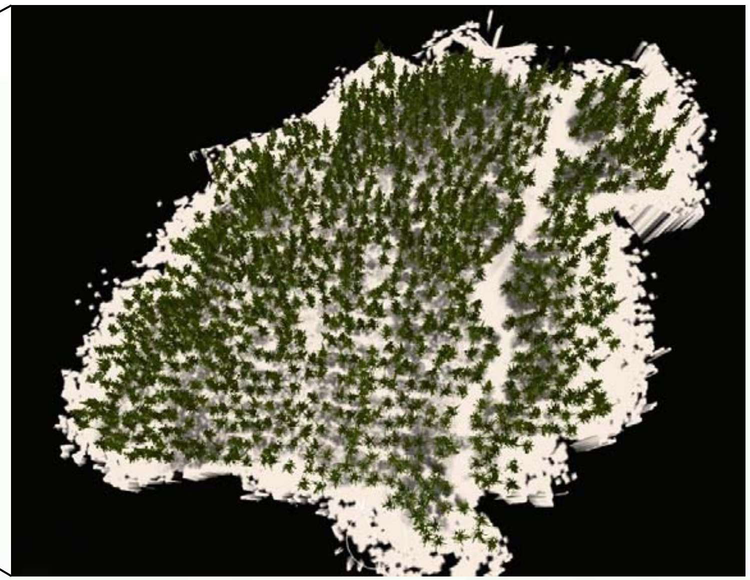
harvested timber Information

Accurate forest resource survey with UAV-LS

- ✧ Proposal for problem solving
  The current forest resource survey method uses a sample survey based on standard sites(1plot per ha), and human error may affect the survey's accuracy.
- ✧ Using ALS, zoning logging forests for wide area municipalities.



- ✧ Using UAV-LS, 3D precise Information on the logging site (5–20 ha) is acquired by ITD method.



Accurate forest resource survey with UAV-LS
ex. Study area in 2016

- ✧ The tree species was Japanese larch, 63 years old.
- ✧ The logging method was 50% band clear-cutting at 20-m intervals. The red area showed harvested area was 2.37 ha of 4.44 ha.

Narai, Shiojiri City
Nagano Prefecture

Japanese larch

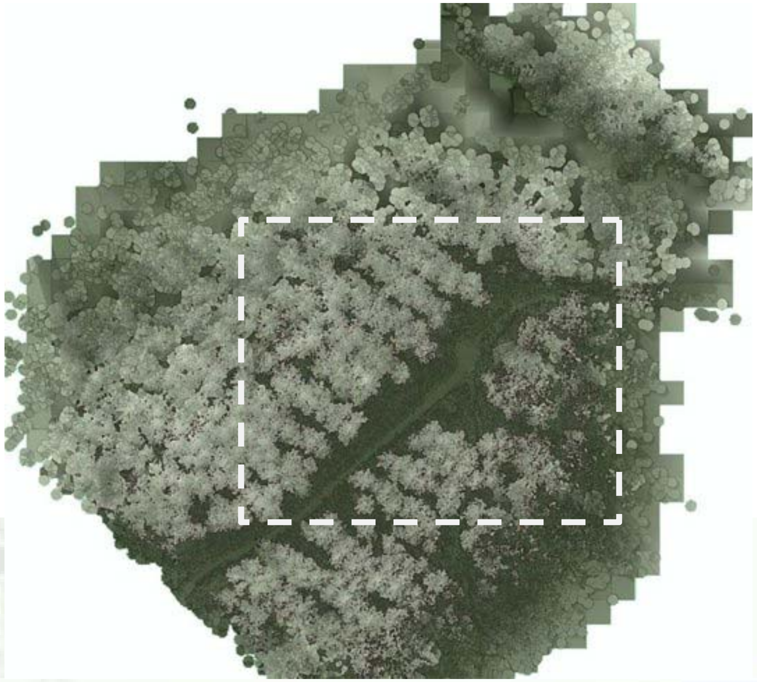
Accurate forest resource survey with UAV-LS

UAV-LS

- ✧ UAV used was an enRouteM's M940 industrial domestic drone, which was a hexacopter with six propellers, suitable for aerial shooting with cameras and sensors.
- ✧ The laser used was the YellowScan (France) Surveyor.

Accurate forest resource survey with UAV-LS
Image interpretation of DCHM

- ✧ DSM, DTM and DCHM were created with pixel resolution of 5 cm.
- ✧ Details of branches could be obtained for each single tree.
- ✧ We found that DSM and DCHM by UAV-LS were superior for image interpretation compared with ALS.

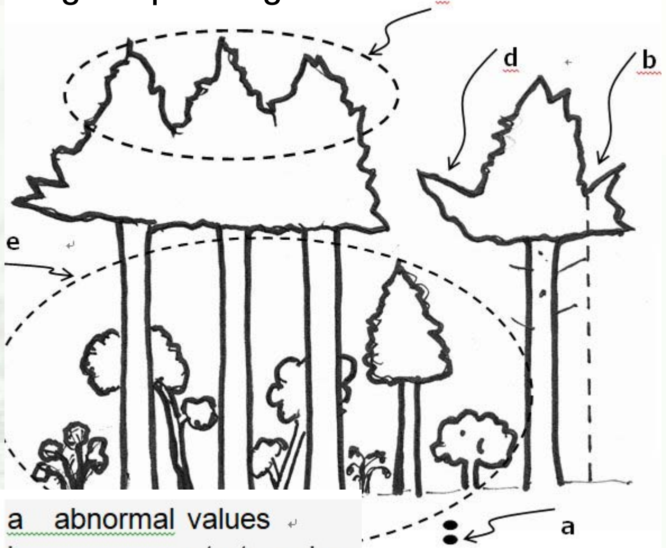


Accurate forest resource survey with UAV-LS

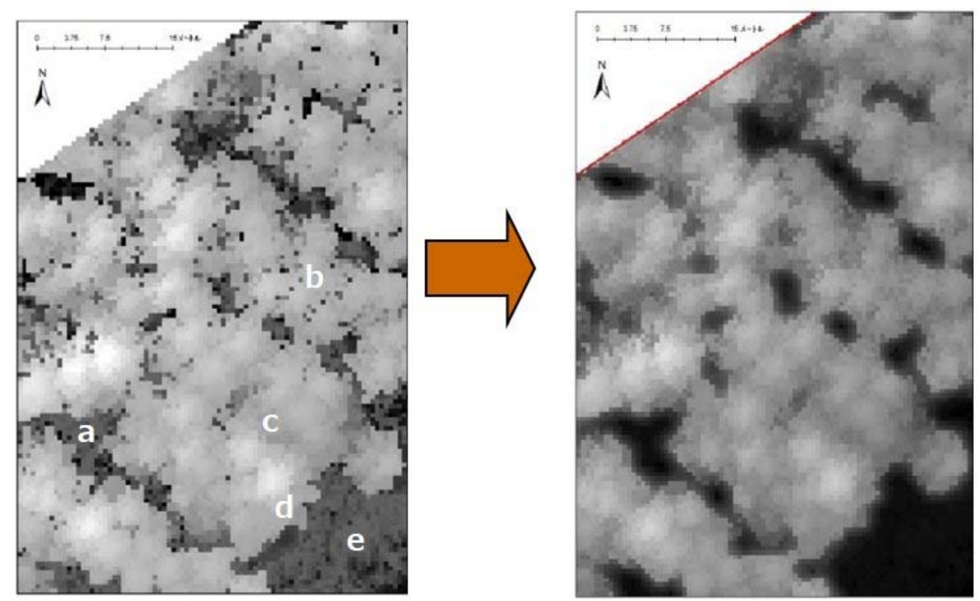
Pre-processing by noise removal

- ✧ The original UAV-LS data have a lot of abnormal values and noise.
- ✧ To automatically extract the precise crown by the ITD method, it was necessary to eliminate such noise and pre-process by logical, statistical and filtering means to clarify the outline of the canopy.

Original painting



a abnormal values
b crown penetrate pulse
c Crown unclear in group
d wild grown branches
e Underlying vegetation

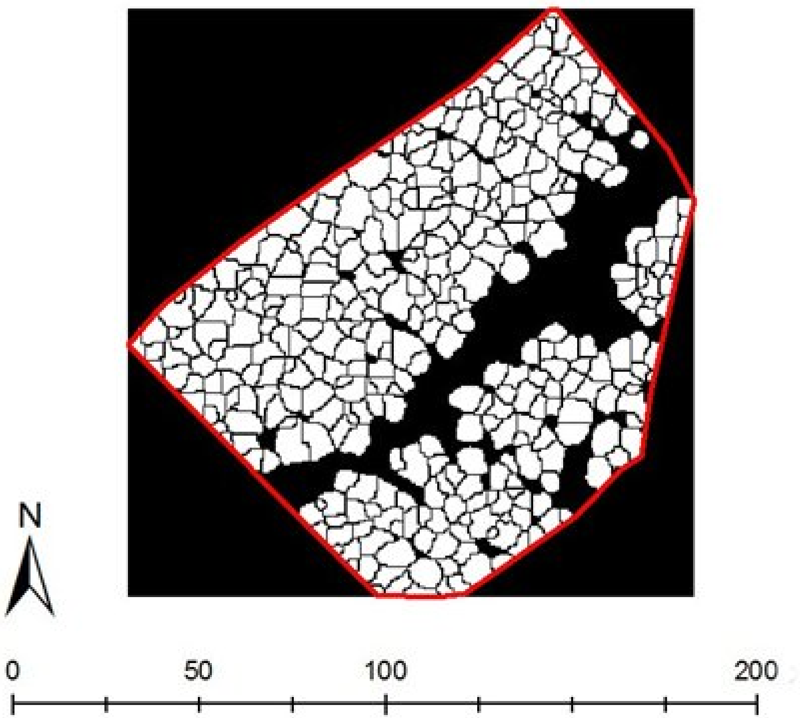


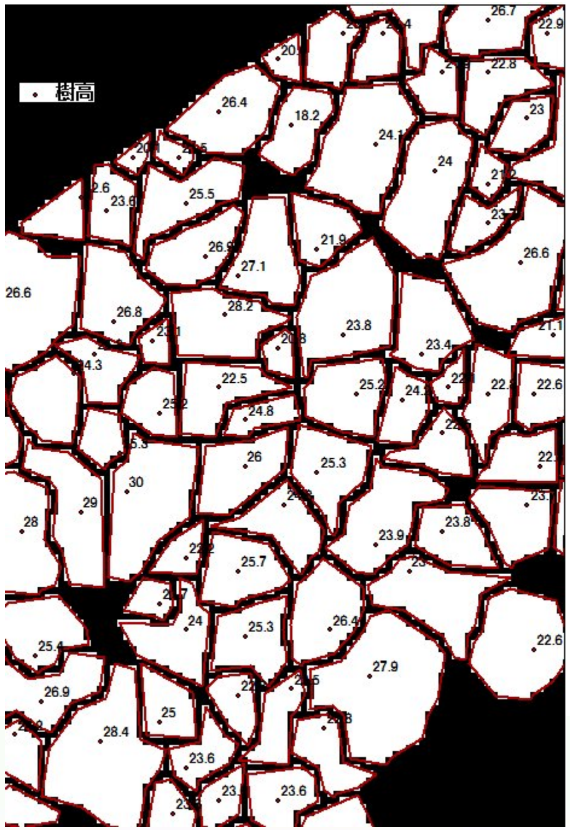
Original LS data **Eliminated noise & emphasized crown**

Accurate forest resource survey with UAV-LS

Precise crown extraction by ITD method

- ✧ Precise crowns were extracted automatically by ITD method.
- ✧ Tree height was identified by assigning the maximum DCHM to one crown





Accurate forest resource survey with UAV-LS

Calculation of tree attribute information

- Individual tree information, including tree number, position (X, Y), crown diameter, and crown area was calculated automatically.
- Diameter at breast height was estimated from multivariate analysis for every crown diameter and tree height.
- Volume was automatically calculated from DBH, tree height, and tree volume with conifer species from tree volume formula.

P34

	A	B	C	D	E	F	G	H	I
1	No	X co.	Y co.	Cr Daim	Cr. Area	DBH	Height	Volume	
2	1	-60341.7	-16167.3	3.1	7.5	30.9	23.2	0.855	
3	2	-60339	-16165.1	2.5	4.75	33.1	24.3	1.013	
4	3	-60337.7	-16168.9	5.6	24.25	35.2	25.2	1.175	
5	4	-60335.2	-16164.2	5.0	19.5	36.6	25.8	1.293	

1405

1406 Forest resource summary

1407		Count	Cr Daim (m)	Cr. Area (㎡)	DBH (cm)	Height (m)	Volume (㎥)
1408	Average		5.5	26.5	34.5	24.6	1.17
1409	Min		1.8	2.5	9.8	5.9	0.02
1410	Max		11.5	103.8	57.1	32.5	3.04
1411	Total	1403					1637.7
1412	/ha	**281**					**328.5**

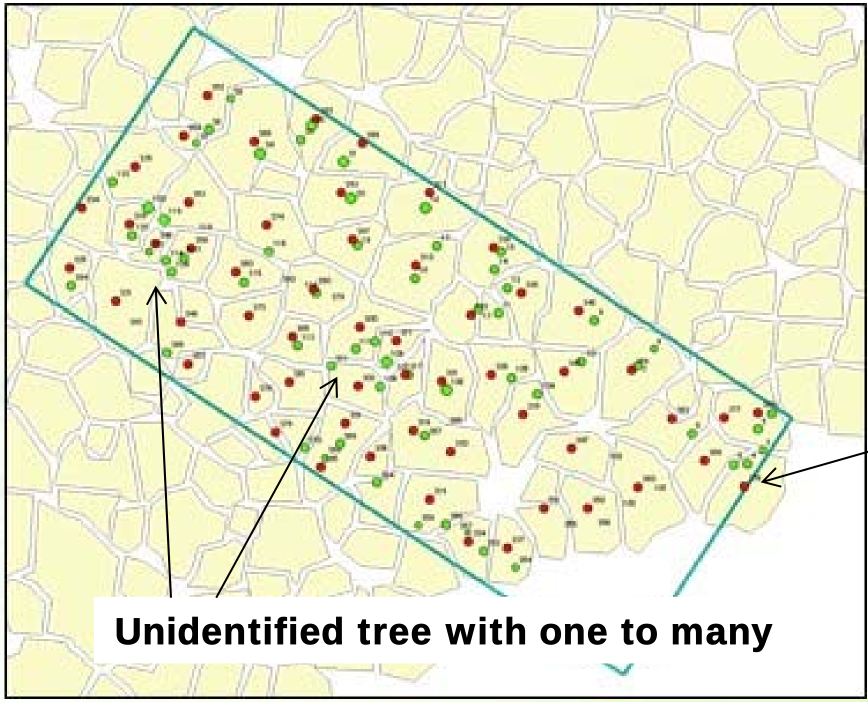
Accurate forest resource survey with UAV-LS
Accuracy verification for practice (1)

- In order to verify the accuracy of UAV-LS, a plot area (30 × 70 m) investigation of every trees with DBH greater than 8 cm was carried out in the field before harvesting. The survey items were tree position, species, DBH, and tree height. The tree heights were actually measured by measuring survey when trees were felled.
- The results of these tree investigations were then compared with the tree information analysed by UAV-LS.

Accurate forest resource survey with UAV-LS

Accuracy verification for practice (2)

- For accuracy verification, we employed a precise crown and tree top position (red) developed by UAV-LS and a standing tree position (green) measured by the field survey, and thereby confirmed the identified and unidentified trees within a plot of 70 × 30 m using two-person teams.



Accurate forest resource survey with UAV-LS

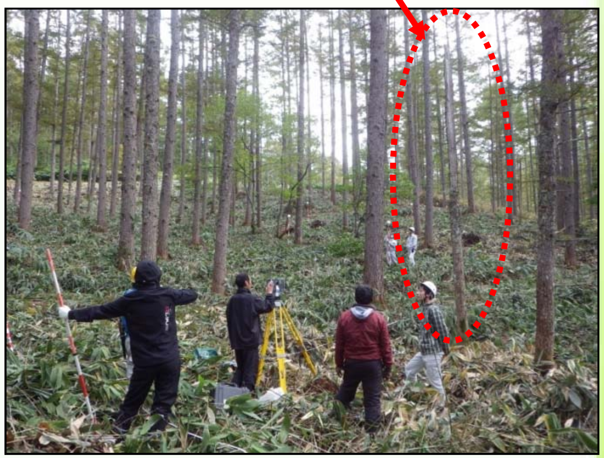
Accuracy verification for practice (3)

- The accuracy verification result is that the number of standing trees recorded by the single-tree investigation was 70, and that of trees detected by UAV-LS was 57, detection rate was 81%.
- The 13 trees undetected by UAV-LS were difficult to image from the sky. These are out of timber production

		Field Survey	Drone-LS	Drone's undetected tree	Drone's detection rate(%)
Count	total	70	57	13	**81.0**
Volume (㎥/ha)	total	392	350	42	**89.0**

		Field Survey	Drone-LS	Error between both
DBH (cm)	Average	**33.4**	**33.6**	-0.4
	Min	10.2	25.5	
	Max	54.5	45.0	
Height (m)	Average	**25.5**	**25.5**	-0.004
	Min	16.1	20.0	
	Max	30.4	31.6	
Volume (㎥)	Average	**1.2**	**1.1**	0.1
	Min	0.1	0.5	
	Max	2.7	2.3	

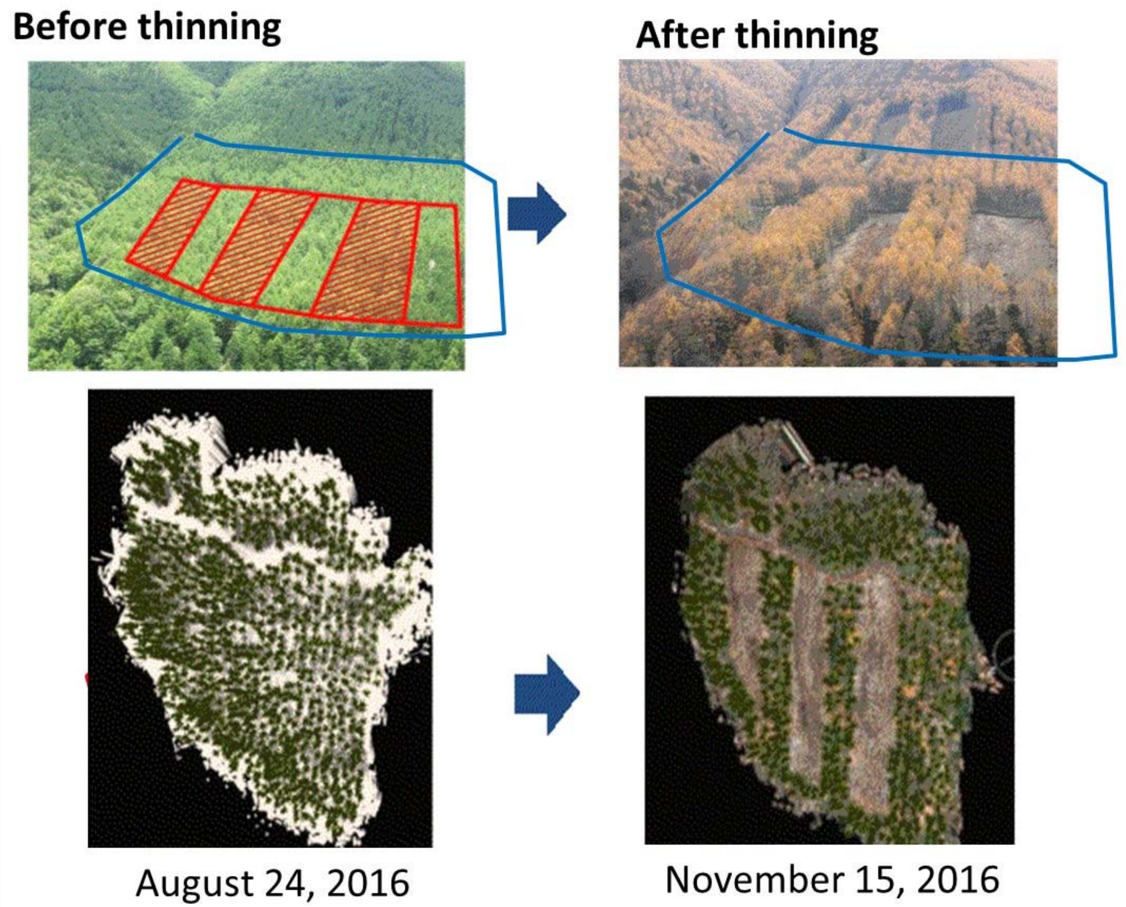
Unidentified tree with undergrowth



Accurate forest resource survey with UAV-LS

3D model of Individul tree level

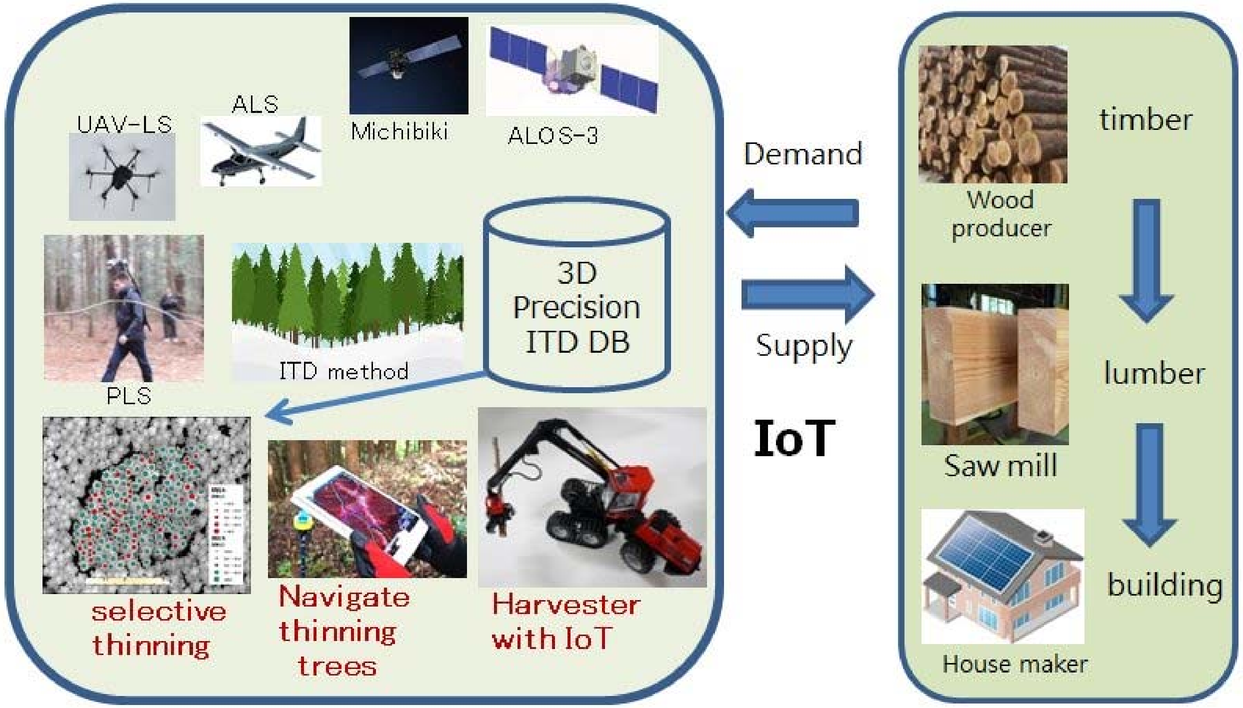
3D model of UAV-LS visualizing changes before and after thinning



Efforts of 2017 (1)

selective thinning & Harvest with IoT

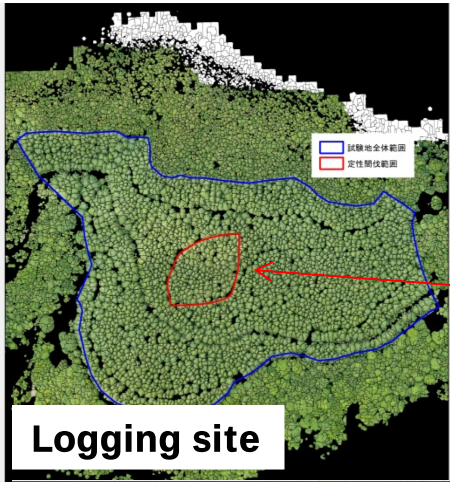
1) **developed a selective thinning program based on 3D model of UAV-LS.**
2) **Harvester(MaxiXplorer) operator navigate and cut the trees.**
3) **The harvested timber information is uploaded to the Internet for management in a cloud database to facilitate wood sales.**

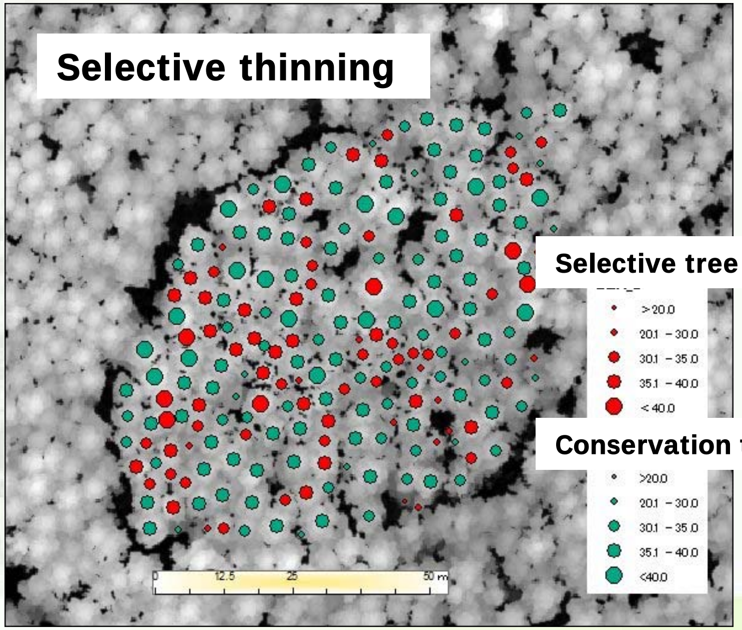


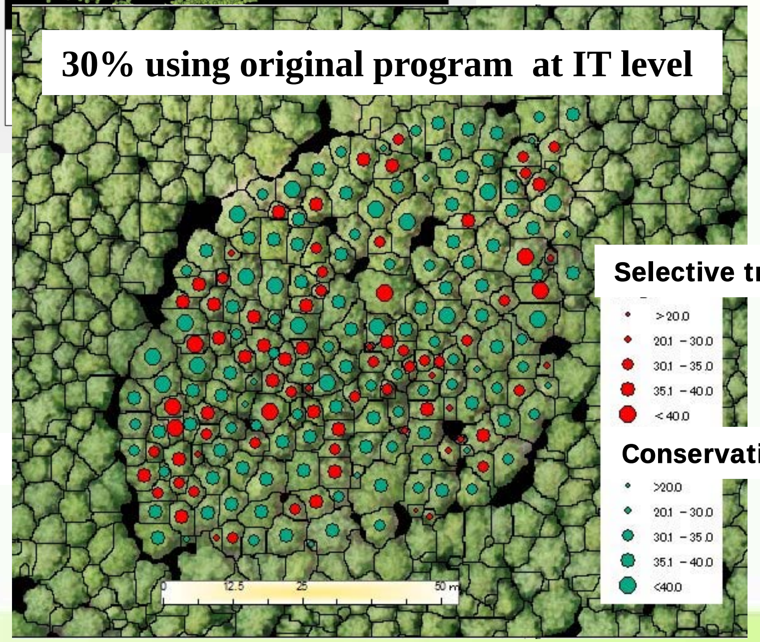
Japan's Smart Precision Forestry & Timber Supply Management Chain

Efforts of 2017 (2)

✧ Field study meeting of precision forestry on Oct 10, 2017

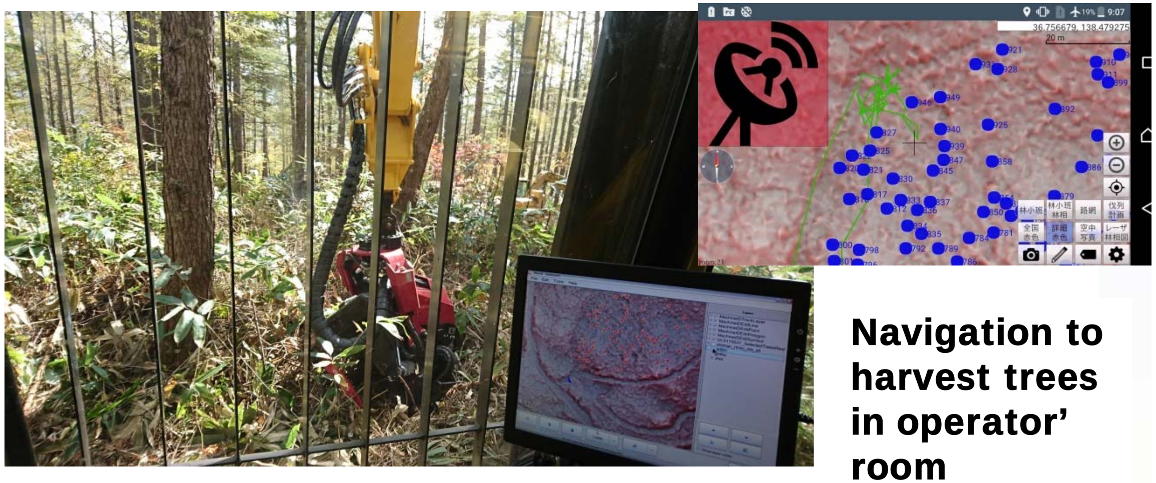






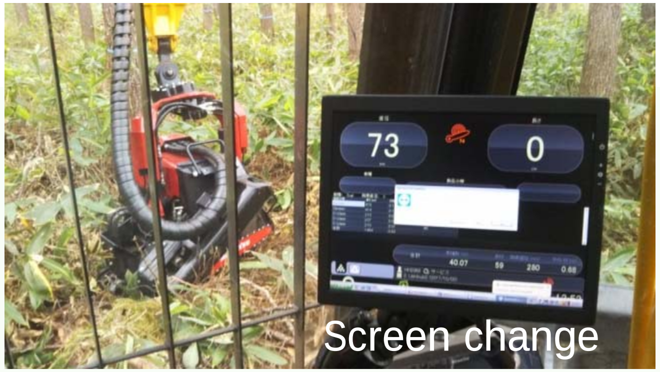
Efforts of 2017 (3)

✧ Use high-performance harvester (MaxiXplorer) with IoT function



Navigation to harvest trees in operator' room

Cut & fell down



Screen change

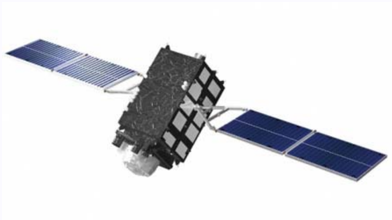
We can see the same screen as the operator

- Operator navigate and cut the trees
- The harvested timber information is uploaded to the Internet in a cloud DB

Good news

- **Field of high-accuracy position information of trees will be improved greatly by the Jpn. satellite positioning system Michibiki No. 3 and No. 4, launched on August, in the spring of 2018 will begin operation. It is expected that the position accuracy of 6 cm from10 m.**
- **The Advanced Land Observation Satellite (ALOS) No. 3 optical high-resolution satellite will be launched at the end of 2020. It has a wide observation range (70 km), high spatial resolution (80 cm), and RedEdge band addition at low cost. It is expected to be available for improved tree species classification and forest attribute data improvement.**
- **As a venture of Shinshu University, we established the Precision Forestry Measurement Co., Ltd., to develop the business of 3D forestry innovation in Japan.**

Good news



ALOS No. 3 will be launched in 2020.

J. satellite positioning system Michibiki No3 and No. 4 were launched

A venture company of Shinshu University has been challenging the business of 3D precision forestry in Japan.

Acknowledgment FGI and CoE-laSR
Thank you for your attention.

Snow Monkeys

visiting MattiVaaja

Backpack-LS for application forestry
Juha, Antero, Anttoni, Risto etc.

Sightseeing at old wooden castle Samurai era Jarkko & Juha