# Tower Yarder Operation in Japan and the Performance Analysis by GPS-based system

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**Abstract:**
*An operation time study system through GPS location acquisition was studied and was adapted for operation analysis in a Tower Yarder operation in Japan. GPS data are collected on a PC system and visualized, focused and analyzed. Cable setting, resetting and dismounting are also visualized and analyzed. GPS data showed clearly the operation cycle and enabled to find operation time. Even depending on site and stand conditions, operation showed productivity around 15 $m^3$/man-day in Japanese mountainous forest yarding. Frequent luck of truck roads for log transportation is also a major subject for rapid and stable uphill yarding operation. It is also expected to find to do the operation in clear cutting to have high operation efficiency.*

**Keywords**: tower yarder, GPS, productivity, FFT

## 1 Forestry and Tower Yarder Operation in Japan Today

After sixty years from eager plantation of conifer trees, many manmade forest stands are inevitable to be thinned and harvested, and have been promoted so but not had been succeeded. Domestic timber supply was politically designed to be doubled to fifty percentage from twenty three in the last year. Wood utilization was also considered for energy so far, but it is much more serious after the earthquake disaster 3.11. Forest wood biomass is anticipated as one of the major resource of new energy supply as of solar, wind and local water channel. Forest wood biomass is sparsely scattered in field, and the stable supply accumulation of timber volume are essential for make it business by promoting regional forestry activity.

Ground terrain condition is very various in Japan and harvesting operation systems are needed to suite for the conditions. The cable yardings have been major harvesting systems in Japan where mountainous steep terrains are common. Tower yarder had introduced 20 years ago but did not succeed to be utilized at fields but for small ones, due to less prevailing timber processor and poor balancing among operation processes at that time. Today in Japan, ground harvesting systems with vehicle machineries are promoted at sites with high density operation roads. But not a few fields are not easy to open by operation roads due to mountainous steep terrain. It is discussing how to find adequate adopt for suitable operation system by system productivity evaluation. Some projects are working to introduce and develop tower yarders now.

Higher the productivity of operation, larger and more efficient forestry business is required. This operation analysis study is attempting to find efficient and easy method using GPS devices.

## 2 GPS Data Acquisition for Field Operation

Yarding operation, which has two foremen and a processor operator, was observed and their movements were recorded each operation day by GPS devices put on them and a carriage of the tower yarder operating system. The carriage showed loci as on figure 1 illustrating iterating run between tower mast and log choking neighbor points. The figure showed loci were observed with error 7m at the maximum. Loci of foremen and a processor operator were scattered around skyline and spots where did carriage line extension and haul.

### 2.1 Carriage movements

Running speed of carriage is shown as figure 2. Several peaks were observed on the figure, which were from high running speed during free carriage back to loading sites and during loaded carriage hauling to landing place. A set of peaks can be found. The formers are at carriages free back and lattes are at carriages loaded yarding. Their frequency intervals with high power can be obtained by FFT processing to show figure 3. The major peak was not clearly found but noticed at around five minutes. The average time of yarding operation was estimated ten minutes by cyclic movement of carriage running. These data of figure 1 to 3 were obtained from energy wood yarding operation collecting logs which choke logs and forward carriage by frequent small steps, and this way of operation did not show clear running speed peaks.


**Figure 1: Location of tower yarder operation at clear cut for energy wood harvesting**

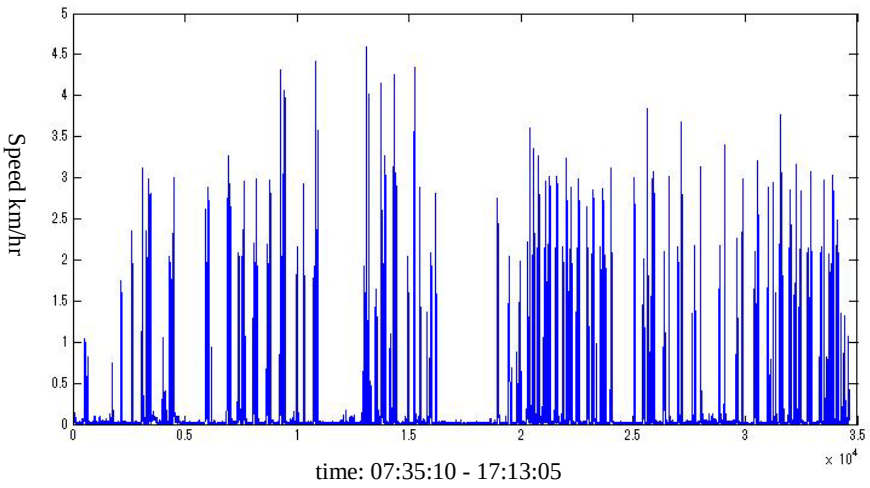



**Figure 2: Carriage speed in a day**

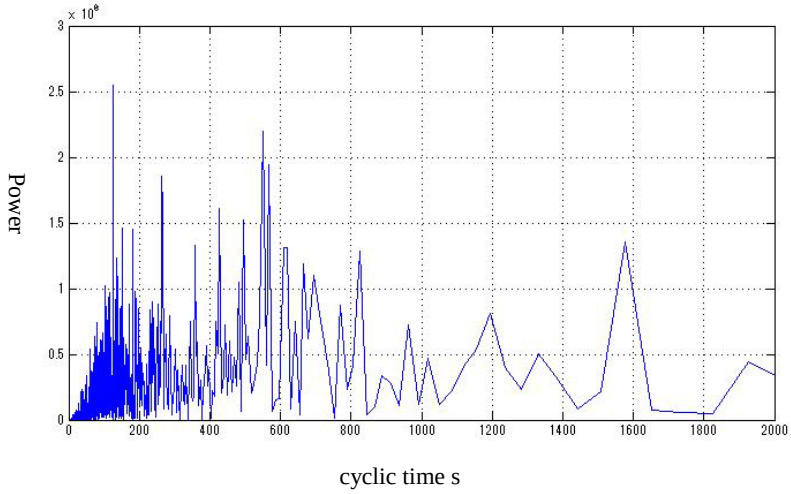



**Figure 3: Carriage speed power spectrum by cyclic time for Energy wood yarding**

A yarding operation, at clear cutting Sugi(*Cryptmeria japonica*) as on figure 4, by a middle size 2.5 pulling capacity tower yarder, showed carriage running speed record on figure 5 in a day. Loci on the map illustrates carriage in red, foreman in green and processor operator in blue, which shows two men operation on the day. No move around the noon was due to adjusting skyline/support system.

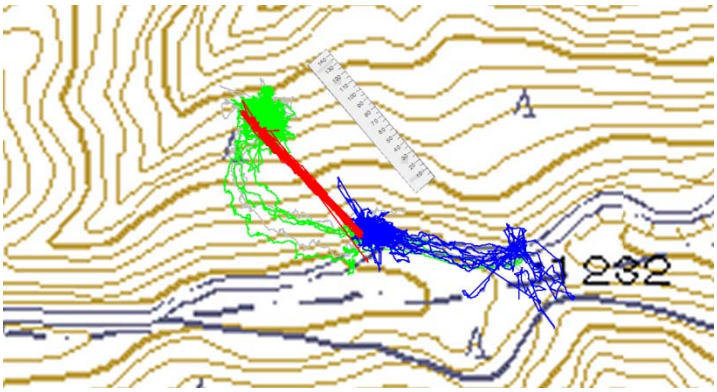
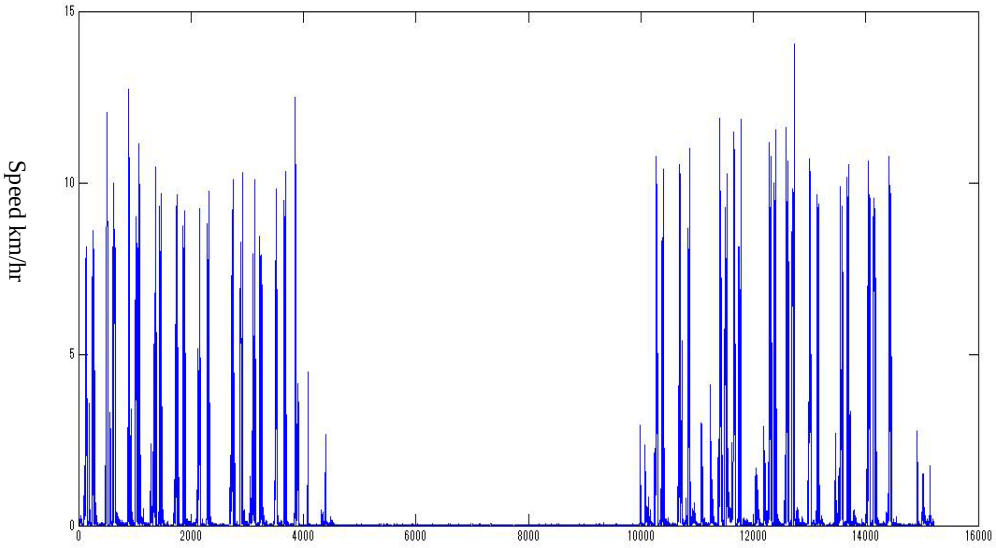


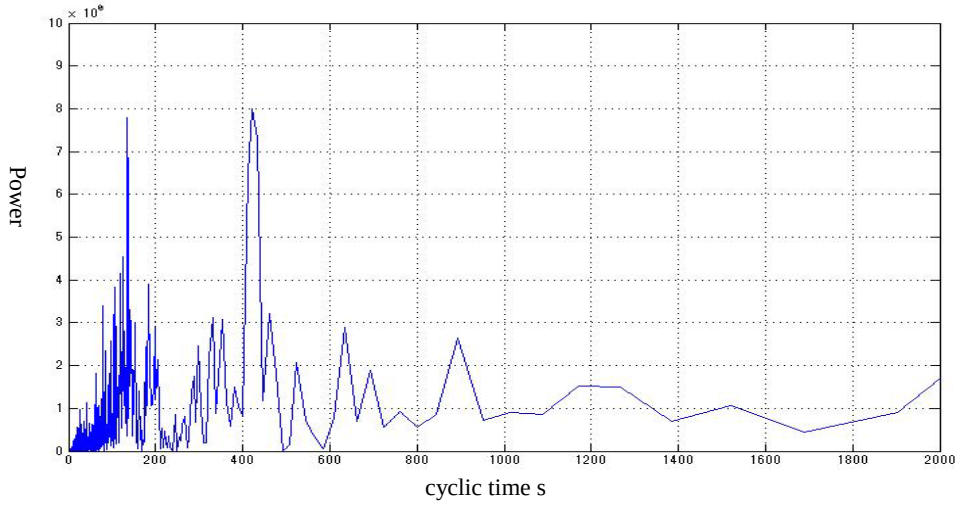
**Figure 4: Location of yarding at clear cut of manmade forest**

Figure 5 shows the operation enabled carriage move at higher speed and clearer speed peaks during their iterations than the former data obtained at energy wood yarding operation, which shows cyclic operation of average set of sequence of choke and free logs and carriage haul and back




time: 08:46:44 - 16:15:54

**Figure 5**




cyclic time s

**Figure 6: Carriage speed power spectrum by cyclic time for timber wood yarding**

This data showed distinct power peaks at three minutes and seven minutes of the cyclic occurring intervals as on figure 6 after processing by FFT. These power peaks were obviously large and noticed the carriage had run frequently at the time intervals three minutes and seven minutes.

### 2.2 Operation system

The interconnection among operation processes was analyzed, using data from manmade forest thinning operation, to see that sub-process A, B and C were connected to show act separately and act at the same time on the same spot. Sub-process A is related to carriage move, sub-process B is related to foreman and sub-process C is related to processor at landing.

Where sub-process A is as follows,

iteration of

- unloaded carriage haul back,
- extent choking wire,
- iteration of
  - log choke
  - wire haul
- haul wire hoist,
- loaded carriage haul,
- unload,

sub-process B is choking preparation of foreman,

sub-process C is,

iteration of

- unloading,
- timber move,
- timber processing,
- log assort.

Additionally, trouble managements and planning discussion occur irregularly.

## 3 Estimation for cycle time and productivity - a simple application

A productivity was discussed for the data from manmade forest thinning operation which showed distinguish peaks of carriage movements.

The most expect time interval of high running speed of carriage is seven minutes. One timber yarding needs twice carriage move and which is expected fourteen minutes. One load is four full trees, 1.8m3. Log conversion rate is 0.65. They produce 5.01m3 log per hour. And the two men six hour operation in a day lead to 15.0 m3 per man day.

The whole system of the operation can be numerically modeled by the transition probability matrix when the process of each system elements are cut out and their interconnections are extracted1). It is also possible and useful to express their mutual interconnection by three dimensional matrix.

## 4 Conclusion and prospect

System operation observation by GPS is useful and the data are valuable to analyze multi points operation. FFT analysis of moving data also useful to find cycle time of operation.

GPS data are also useful to extract operation system formation by multi acting system components. Interconnection modeling and transition among element processes illustrate numerically the operation space. This also expect to find relationship between operation field condition.

## 5 Literature

1)Toshio Nitami, Innovative double long arm vehicle system for log harvesting operation, J. JFES, 23(3), 169-174, 2008