FORMEC 2010
Forest Engineering: Meeting the Needs of the Society and the Environment
July 11 – 14, 2010, Padova – Italy

AUTO-ID IN THE TIMBER SUPPLY CHAIN - IDENTIFYING SINGLE LOGS USING RFID TAGS

Christian Kaul

Chair of Forest Work Science and Applied Computer Science,
Technische Universität München
Hans-Carl-von-Carlowitz-Platz 2
85414 Freising, Germany
e-mail: kaul@wzw.tum.de

Keywords: timber supply chain, RFID, UHF, field test, read rate

Abstract: *The paper deals with the use of Radio Frequency Identification (RFID) in the timber supply chain. Round wood can be marked with RFID tags to support the information management in timber procurement. The main focus lies on the control of incoming logs at the sawmill. The high read range of UHF-systems provides bulk reading over long distances. This allows detecting every single log on a truck passing a RFID-gate. The performances of various tag types attached to hardwood were first tested under laboratory conditions. The 4 most promising tag types were used in a field test with overall 1000 tags. The tags were attached to the logs at the forest road and read out automatically on the trucks at the entrance of the sawmill. In this trial tag read rates up to 92 % were possible. At the beginning of the sawing process the logs should be identified again for production analysis. At the chop cutting station the read rate of the used UHF tags reached 100 %.*
The use of RFID seems to be promising to support the information management in timber procurement.
An automatic control of incoming goods would be a huge improvement compared to the current methods.

1. Introduction

This paper deals with the use of RFID in round wood logistics. The logistic processes of the timber supply chain have been a major focus at the chair of forest work science and applied computer science. The current problems in the timber supply chain are asking for solutions. Long lead times have negative effects on timber quality and delay final payment. Furthermore, they contribute to timber losses due to uncompleted deliveries, mix up of banks or logs and forgotten residual banks or logs. Currently, timber industry is controlling the completeness of incoming timber using random sampling. Therefore, the numbers on plastic number plates are checked manually and then compared to the bill of lading by the gatekeeper. This procedure is time and cost intensive without being failsafe. Auto-ID systems are being used by other logistic areas to solve similar problems. The basic idea for RFID in forestry and timber industry is to use automatic identification to detect single logs and support the information management in timber procurement. Therefore, every single log is marked with a RFID tag. A unique number on every tag individualizes the log in transit. The high read rate of UHF-systems allows bulk reading over long distances. This makes it possible to detect single logs on a truck by passing a RFID-gate at the entrance of the sawmill.

2. The research project

The scope of a recently finished research project (Kaul and Schneider, 2009) was to show that ultra high frequency technology (UHF) can be a feasible alternative to other RFID-spectrums like high frequency (HF), which had already been tested for these applications (Korten and Schneider, 2006).
The first step was to identify suitable RFID tags in various laboratory tests. The second step was to show the practicability under realistic conditions in the framework of a field test.

2.1 Laboratory tests

The laboratory tests started checking the performance of various tags by using the measuring system Voyantic "Tagformance". The system enables tag sensitivity measurements including orientation sensitivity and tag backscatter signal analysis. The tested tags were attached to a timber disc. The measuring antenna is installed in front of the disc in a constant distance (Figure 1).

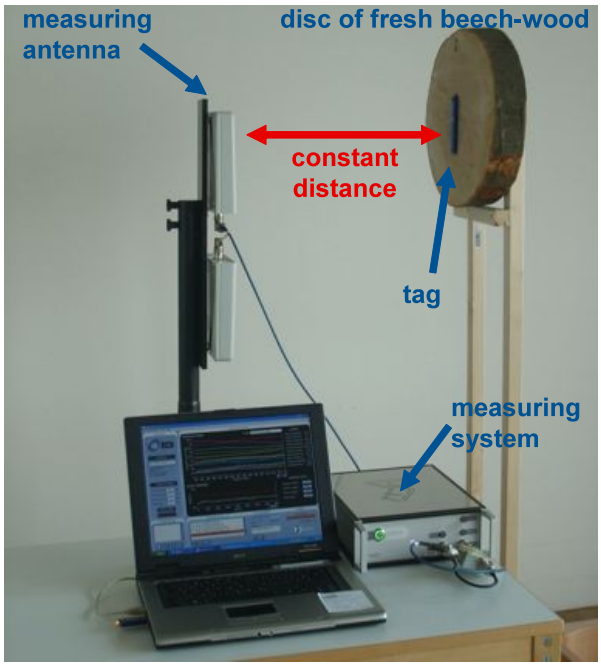

Figure 1. Set up of the measuring system Voyantic "Tagformance"

The system analyses the performance by comparing the input and output power at the measuring antenna. The most important measured parameters are *transmitted power, backscattered power* and the *theoretical read range*. *Transmitted power* is the power that is needed to activate the tag and to receive an answer from the tag. *Backscattered power* is defined as the power with which the tag responds. The *theoretical read range* is calculated by the measuring system using the measured values. Table 1 shows a list of the tested tags. To give an example of the measured values, Figure 2 shows the results for the transmitted power measure of the tested tags.

Table 1. List of tested tags

Manufacturer	Model	Short form	Dimensions LxWxH [mm]
smartTEC	smart-Dome MOM 868	Dome	130 x 41 x 19
Schreiner	rfid Dura Tag	Dura	86 x 54 x 0,69
Schreiner	rfid - onmetal - case	onmetal-case	180 x 43 x 15
Elatec	UHF On Metal Tag	Elatec	158 x 23 x 18
Confidex	ULC 4652 G2P	Confidex	46 x 52 x 10
Sokymat	InLine 55	InLine	104 x 55 x 7,5
Intermec	Kleines Rigid Tag	Rigid_s	79 x 31 x 11
Intermec	Großes Rigid Tag	Rigid_l	142 x 32 x 11
Wisteq	Typ 132	Wisteq132	133 x 30 x 8
Assion	Assion.001 (Prototyp)	Assion1	133 x 42 x 2,8
Assion	Assion.002 (Prototyp)	Assion2	89 x 44 x 2,8
Wisteq	Typ 127	Wisteq127	126 x 24 x 8
Euro-ID	laminated Tag (Prototyp)	laminated	105 x 55 x 0,6
Schreiner	Flag-on-Metal Label	FlagTag	102 x 30 x 0,1 (Flag)

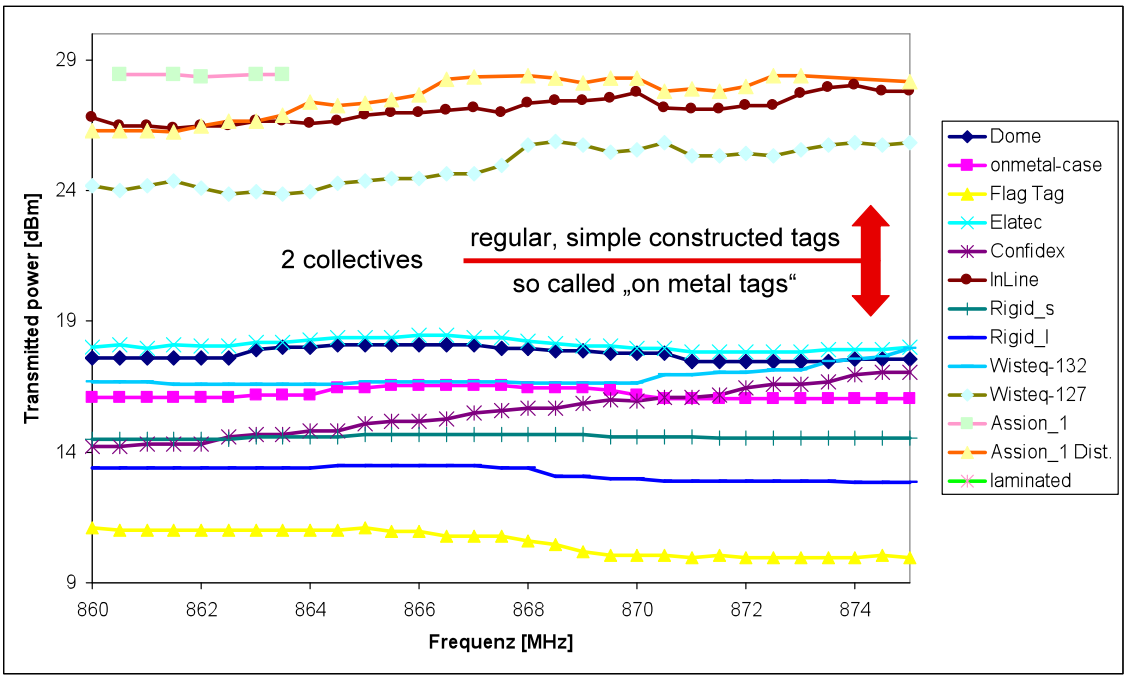

Figure 2. Transmitted power [dBm] / parallel alignment

The measured tags are divided into two collectives. The regular tags need more power than the so called on-metal tags. On-metal tags are a special tag type that is developed for difficult cases, such as the use on high reflecting surfaces.

Considering the results of all measured values, it was possible to identify 4 powerful UHF tags with outstanding performances. They are very efficient in various angles and also proved to be very useful on logs with different wood moisture. Figure 3 shows the selected tag types.

Figure 3. Selected tag types / tags used for the field test

The next step was to prove the consistent performance of the chosen tags. Therefore, a comparative measurement of 10 tags of the same tag type using the Voyantic "Tagformance" system was done. Checking the transmitted power [dBm] value three of the four tag types showed a variance of the mean that was lower then 0.2. Only the Elatec tags had an inconsistent performance. Two tags showed a deviation starting at 860 MHz. The variance of the mean was 1.76.

Overall, the consistency of the tags was satisfying. So the variance was not considered during the further tests.

In the next trial the actual read range of the four tag types was tested. For this experiment, the original field test equipment was chosen. Using a Feig Obid I-Scan Reader "ID ISC.LRU2000-A" and a Feig Obid I-Scan Antenna "ID ISC.ANT.U250/250-EU", the tests were done on the measuring track of the TUM in Garching. The tags were attached to a fresh hardwood timber disc. Then, the distance between the marked timber disc and the reader antenna was enlarged. In steps of 10 cm, the system recorded if the tag could be read or not. One tag of each tag type was measured three times. Figure 4 shows the results.

This real life scenario confirmed the results of the "Tagformance" measurement regarding the maximum reading distance. Three of the four tags could not be read at certain distances. These detection holes are related to the environmental conditions. In real life, the tags move through the reading field and the distance between the reader antenna and the tags varies. Detection holes may occur but they do not have a serious influence on the read rates.

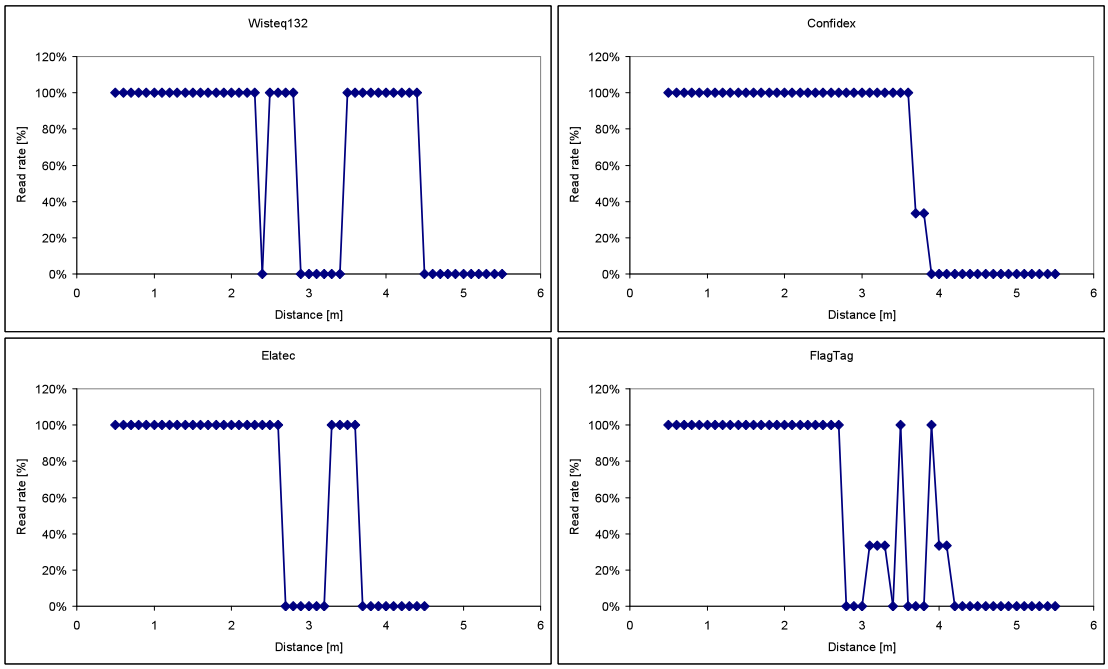

Figure 4. Read rates of the chosen tag types depending on the reading distance

2.2 Field test

The field test started by doing a first pretest with a variable RFID gate at the logyard of a sawmill. The four proven tag types were tested with various numbers of reading antennas, various truck types and various gate-widths. The tags had been attached to the logs on a truck and were to be read out while the truck passes the RFID gate. The tests started with three reading antennas (Fig. 5). But this set up did not lead to satisfying results. It was not possible to detect the logs in the upper left and right corners while the truck passed the antennas. A set up with four antennas delivered much better results (Fig. 6). The knowledge gained in these first pretests, was very helpful for the processing of the RFID gate at the entrance of the sawmill that was used in the main field test.

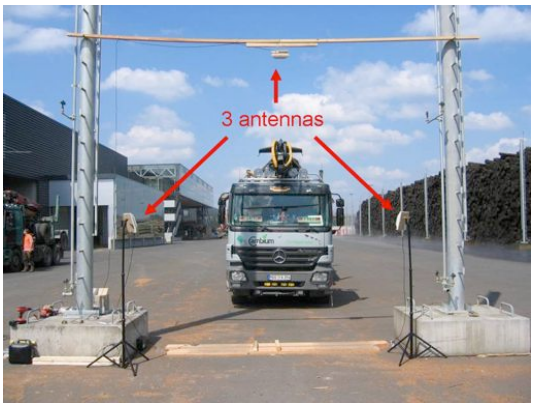

Figure 5. Pretest set up with 3 reading antenna

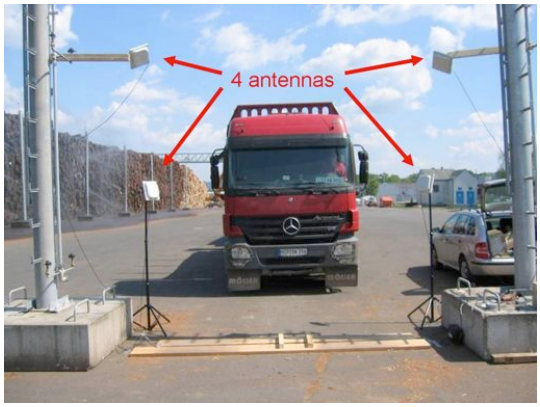

Figure 6. Pretest set up with 4 reading antennas

The intention of this test was to demonstrate the practicability under realistic conditions. The test was done with the four tag types (Fig. 3) and overall 1000 tags. It started at the forest road where the timber inventory was taken on a PDA, the tags were attached to every log and the tag number was saved to the timber data.

Figure 7 shows, that short logs as well as long lengths were marked. Most logs were shorter than twelve meters.
Figure 8 shows the RFID gate at the sawmill. The gate had a width of 340 cm , the upper antennas were located at 330 cm, the lower ones at 220 cm.

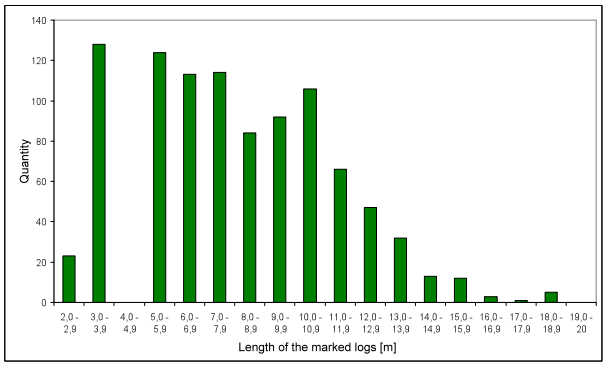

Figure 7. Length-distribution of the marked logs

Figure 8. RFID-gate at the sawmill

The gate consists of eight reading antennas. Four antennas were aligned in driving direction to detect tags at the end of the load. The other four antennas were aligned against driving direction to detect tags at the front end of the load. The antennas were aligned at an angle of 45 degrees. The removal of timber from the forest took a period of four months. The truck drivers had no special loading instructions or limitations. Table 2 shows the read rates of the tested tag-types at the entrance of the sawmill.

Table 2. Read rates of tested tag-types at the entrance of the sawmill

Tag-type	Total quantity	Quantity		Read-rate [%]
		detected	not detected	
Wisteq 132	246	227	19	92%
Confidex	241	109	132	45%
Elatec	236	142	94	60%
Flag tag	250	89	161	36%

The best tag showed a read rate of 92% while the other ones were between 36% and 60%. With the Wisteq132 it was possible to achieve read rates up to 100 % on several loads.
Afterwards, all tags were removed by the gatekeeper at the sawmill and checked for potential damages. The percentage of damaged tags, which were not reusable, but detectable, was less than 1%. Only one tag was destroyed, in the meaning that it was not reusable and not detectable.

In real life, the tags remain on the logs and need to be read out again before the sawing process for production analysis. So the readability of the tags had also to be tested at the chopping station. Therefore, the antenna was positioned above the conveyor belt in front of the chopping saw. The marked ends of the logs were cut off, the timber discs fell on another conveyor belt where the tags were removed manually. Table 3 shows the read rates at the chopping station. Read rates up to 100% were achievable.

Table 3. Read-rates at the chopping station

Tag-type	Total quantity	Quantity		Read-rate [%]
		detected	not detected	
Wisteq 132	30	30	0	100%
Confidex	30	30	0	100%
Elatec	30	30	0	100%
Flag tag	30	28	2	93%

3. Conclusions

The use of RFID seems to be promising to support the information management in timber procurement. An automatic control of incoming goods would be a huge improvement compared to the current methods. Loading instructions for the different truck types could improve the read rates at the sawmill. Further tests with an antenna on a telescopic bar showed, that a manual read out also allows a fast and reliable control of the incoming goods. This approach could be a practical alternative for trucks with difficult loads.
For a practical use of RFID technology in the timber supply chain, further development work with regard to tag design and methods for fixing and reading is needed. Therefore, a decision between an on-way tag construction and reusable tag types has to be made.

References

Kaul, C.; Schneider, J. (2009). The use of Auto-ID in the timber supply chain from roundwood to sawnwood to ensure the traceability and to control the material flow; Final report, AiF-Project Nr. 15247; Chair of Forest Work Science and Applied Computer Science, TUM; Institute for logistics, TU Dortmund; IDH / VVL e. V. 263.

Korten, S.; Schneider, J. (2006). Reorganisation of information and material flow processes in the timber supply chain using the RFID technology; Final report, AiF-Project Nr. 14186; Chair of Forest Work Science and Applied Computer Science, TUM; Institute for logistics, TU Dortmund; 161.