RFID PRELIMINARY STUDY

VEHICLE MONITORING
RFID LAB FINLAND AND
RESULT SERVICE FINLAND OY

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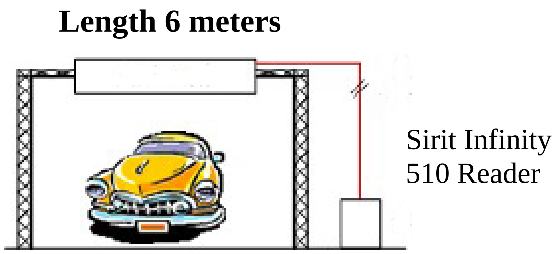
1. BACKGROUND

Public discussion has brought forth through us the possibility of the use of road tolls (congestion tax) in the capital city. “Climate change and the continually growing amount of vehicles have begun generally to make people consider these options. The idea of this preliminary study was to test the suitability of passive RFID technology for identifying vehicles, and, for example, for use in road tolls/congestion tax.” The purpose was also to compare the suitability and costs of RFID technology operating on a passive UHF frequency to other possible technology solutions. We endeavored to also take into consideration the challenging weather conditions in Finland as well as their effect on the functioning of the systems.

2. RFID LAB FINLAND, TOGETHER WITH RESULT SERVICE FINLAND OY, TESTED THE SUITABILITY OF RFID TECHNOLOGY FOR VEHICLE IDENTIFICATION AND ROAD TOLL USE.

The test was performed on 7 February 2008 on the Vihti test driving track, which was closed for the purpose of the test. We installed the portal (an iron support frame) at a height of approximately 3,1 meters and we attached an antenna developed by VTT Technical Research Centre of Finland with a width of 2,6 meters to the highest point. A patented, overflow microstrip type of waveguide, which can achieve an accurate and narrow reading beam (= reading range), was used as an antenna. Seven units of RFID tags operating on a passive UHF frequency were attached to the test car. In this case, the test system load is seven-fold compared to the so-called "normal" identification system in which the vehicle to be identified has only one tag. Of the tags, four were Rafsec Dogbone Wet Inlay tags, which were attached to the windshield of the car, and three were tags for metallic surfaces (Confidex Survivor, Confidex Ironside and Omni-ID minitag) and were attached to the car's hood and bumper (Photograph 3). The objective was to see how successful identification was when the car was driven through the identification point at the highest possible speed. During the test we also took into consideration the height of the antenna, which in normal conditions would be 3,3 meters instead of 6 meters, by reducing the reading power of the reader by 6 dB (to correspond to the duplication of the distance).



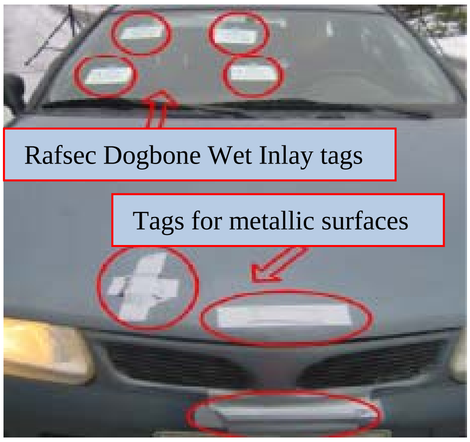
Photograph 1: Test set-up

Photograph 2: Test set-up in situ

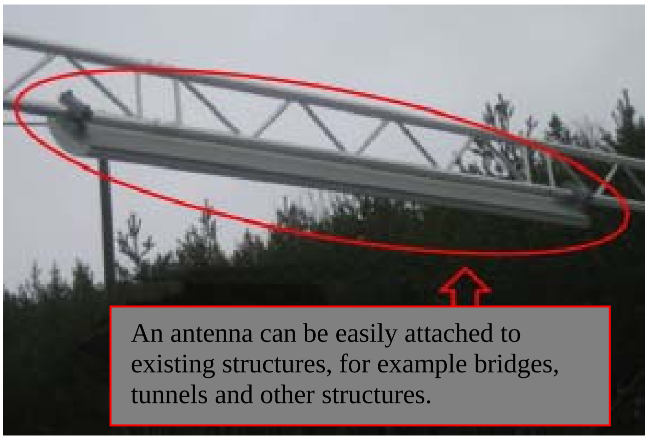
Conducting the test

Sirit's Infinity 510 UHF reader was used as the reader in the test. Before the test, the reader was parameterized for the test meaning the speed of the reader was ensured using a ten-second test, in which an average of 300-350 readings per second was achieved. During the test itself, the speed of the car and the repetition of the reading of the tags / tag, among other things, were checked dozens of times. The repetitions varied between 50 and 70 when all seven tags were on the same car at the same time. In addition, the test was done with only one tag which resulted in repetitions of approximately 150 readings. So, identification of the car went extremely well, and the tags on the test car were reliably identified at least once each time. One successful reading of an tag is sufficient for reliable identification of a car.

Because the northern climate in Finland is challenging for any identification technology, we also tested how successful identification is when there is approximately ten centimeters of snow or slush between the tag and the antenna of the reader. We filled a plastic bag with wet slush and attached it with duct tape to the windshield of the test car. After this, we installed the tag to the inside of the windshield (underneath the plastic bag) and drove the test car at 95 km/hour through the identification point. The test car was recognized 114 times. That is to say those ten centimeters of wet snow between the antenna of the reader and the tag did not affect the identification of the test car in any significant way, and the identification in this test was also quite reliable.



Photograph 3: Tags on the test car and their location



Photograph 4: The system is partly so cost-effective because existing structures can be utilized.

Photograph 5: Camera identification is indeed difficult in Finnish weather conditions.

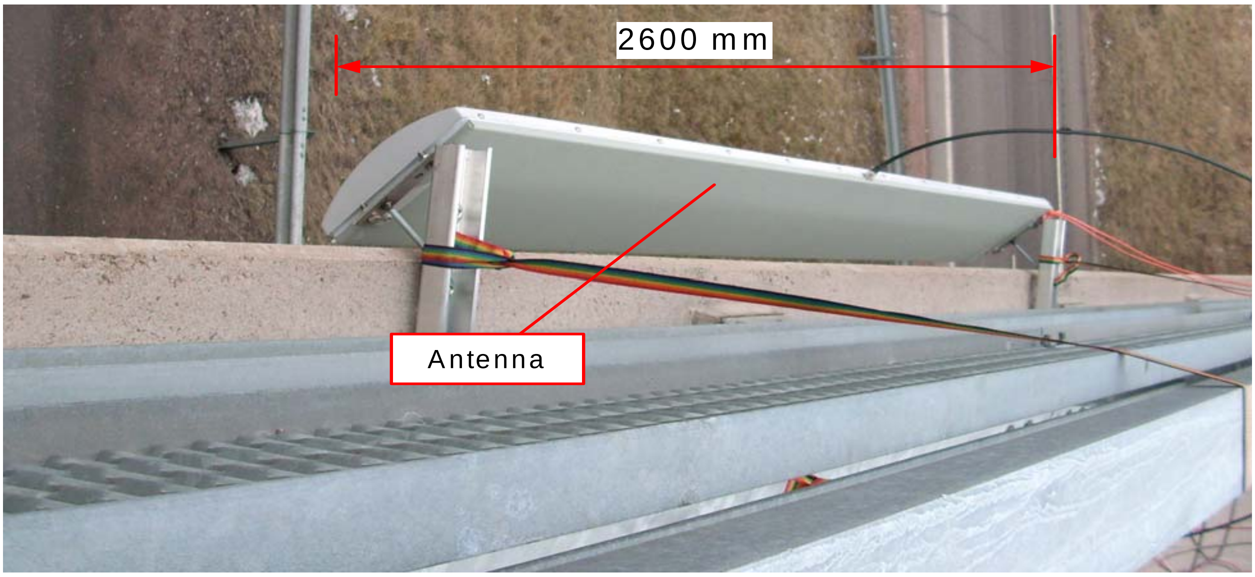
Test results and conclusions

Identification of the test car succeeded well each time, and the identification result was extremely good, especially when taking into consideration the reading performance, which was reduced to correspond to the normal installation height of an antenna, which in normal conditions is approximately 6 meters. The speed of 95 km/hour could not be exceeded with the test car due to the length of the track (which was frozen), but the conclusion made about the amount of the repetition of the readings of the tags supports our information that, in the United States, information has been successfully recorded on a tag at a speed of 140 km/hour and a tag read at a speed of over 200 km/hour. Taking into consideration the speed limits in Finland, speed should not be a problem for an RFID identification system. Monitoring cars by traffic lanes (driving in the bus lane) could be easily managed because the edges of the beam pattern are still extremely accurate even at a distance of 15 meters (discrimination in the 20 centimeter range). If there are, for example, three lanes on the road and an antenna above each lane, each lane can be monitored extremely reliably. In addition, the antennas can be located in a place where lane changes are prohibited.

The system could be introduced very easily and at a small cost. Passive RFID tags are inexpensive and public transportation vehicles, for example, could be equipped for test use in the first stage of the testing. RFID is widely utilized in industry, and the price of passive UHF frequency band tags in industry is from 8 cents on up and the price of readers from 1000 euros on up. It is also possible to utilize the solution in several other applications such as in automatic monitoring on public transportation, car wash payment systems, parking, access control, official supervision, refueling, vehicle inspection and location of vehicles with unpaid vehicle tax (laid-up vehicles).

3. A SECOND TESTING SYSTEM. RESULT SERVICE FINLAND OY TESTED THE SYSTEM AT A HIGHER SPEED AND AT A HEIGHT OF SIX METERS FROM THE ROAD.

Result Service Finland Oy performed a second test related to the same matter in conjunction with the Finnish Road Administration on the E18 Kotka-Hamina motorway on 2 March 2008. The test system was the same as in the previous test except the speed of the car was greater (approximately 120 km/hour) and the antenna generating the observations was located six meters above the road surface. The car still had seven passive UHF RFID tags (seven times the amount compared to the "normal" circumstances). A second antenna, used in an attempt to simulate the situation in which interference in identification is caused by a possible second antenna, was also connected to the reader. The connection of this antenna did not noticeably disturb the testing system, and the system worked well despite the two antennas. The test was performed three times with powers of 25, 27 and 30 dBm. The system worked well except at the lower power level the identification of the tag from the car's license plate was not successful. However, this tag was an older model.



Photograph 6: The antenna is attached to the bridge above the motorway (at a height of 6 meters above the surface of the motorway).

Photograph 7: The car coming 140 km/hour to the control point

Photograph 8: The tags on the car (ID’s 2010, 2011 and 1010)

Photograph 9: The tags on the windshield of the car (ID’s 2001-2004)

Test results on the motorway

Tag Number	Arrive	Depart	Time on the field	Repeat	Power
1010	fault	fault	**fault**	fault	25 dBm
1010	10:37:05,625	10:37:05,733	**0:00:00,108**	4	27 dBm
1010	11:05:02,993	11:05:03,234	**0:00:00,241**	9	30 dBm
2001	10:54:27,709	10:54:28,076	**0:00:00,367**	18	25 dBm
2001	10:37:05,448	10:37:05,837	**0:00:00,389**	18	27 dBm
2001	11:05:02,866	11:05:03,335	**0:00:00,469**	21	30 dBm
2002	10:54:27,672	10:54:28,052	**0:00:00,380**	18	25 dBm
2002	10:37:05,419	10:37:05,835	**0:00:00,416**	20	27 dBm
2002	11:05:02,705	11:05:03,256	**0:00:00,551**	28	30 dBm
2003	10:54:27,613	10:54:28,103	**0:00:00,490**	22	25 dBm
2003	10:37:05,142	10:37:05,910	**0:00:00,768**	47	27 dBm
2003	11:05:02,462	11:05:03,345	**0:00:00,883**	46	30 dBm
2004	10:54:27,674	10:54:28,102	**0:00:00,428**	8	25 dBm
2004	10:37:05,421	10:37:05,908	**0:00:00,487**	15	27 dBm
2004	11:05:02,527	11:05:03,370	**0:00:00,843**	27	30 dBm
2010	10:54:27,750	10:54:27,992	**0:00:00,242**	10	25 dBm
2010	10:37:05,514	10:37:05,795	**0:00:00,281**	10	27 dBm
2010	11:05:02,956	11:05:03,270	**0:00:00,314**	12	30 dBm
2011	10:54:27,785	10:54:27,987	**0:00:00,202**	5	25 dBm
2011	10:37:05,517	10:37:05,791	**0:00:00,274**	10	27 dBm
2011	11:05:02,443	11:05:03,252	**0:00:00,809**	21	30 dBm

Table 2: Comparison of the options for road toll implementation

Feature	Camera identification	Passive RFID technology on UHF frequency	Semi-passive RFID technology on microwave frequency	Satellite positioning (GPS/Galileo)
Basis for definition of location	Identification and definition of location at reading point	Identification and definition of location at reading point.	Identification and definition of location at reading point.	Vehicle location positioning is in real time and possible regardless of location.
Price	Cameras become quite expensive. No additional costs for tags.	Very inexpensive tags and reading equipment.	The second least expensive solution. Expensive tags and readers.	Very costly vehicle equipment. Costs for data transfer.
Equipment needed for car	None (License plate cleaner?)	Passive UHF frequency RFID tags.	Semi-passive microwave frequency RFID tag containing a battery.	Satellite positioning module. Data transfer modem.
Monitoring of use	Easy because no equipment is needed for the car (Validity of the license number)	Easy. Authorities can use handheld readers for monitoring. RFID mobile phones in the future?	Difficult to utilize in other applications and difficult for authorities to monitor due to the high price of the reader (practically no handheld readers or expensive ones).	Can be covered with, for example, aluminum foil to prevent reading. Difficult to check the status of satellite positioning from the vehicle.
Certainty of identification	Generally good, except that northern weather conditions affect it greatly.	Good.	Good.	Generally good.
Challenges of the technology	Finnish weather conditions: snow, slush and dirt. License number recognition is not always successful. Large amount of data to be transferred. Determination of when the car is at the correct point.	It would be good to take a photograph in case of missing tag.	Price. Limited life span of the tag due to the battery. High price of the readers and active tags. High damping of frequency. High transmission power needed.	Dead spots: indoor spaces, tall buildings, tunnels, etc. Dependence on U.S. technology for GPS. Accuracy (traffic lane monitoring).

View videos of the test from the Internet:

First test (2 Mt) Second test (8,9 Mt)

Additional information:

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