

Erigate's eTattoo® UHF Cattle Tag System: Evaluation of tag performance and optimal reader configuration

The information reported here represents the first known critical evaluation of a commercially available UHF RFID cattle management tag and reader system. These findings were gathered over a 6 month period from December, 2009 to June, 2010 in a dairy facility located just north of Mankato, MN. Several reader configurations were evaluated and over 58,000 tag presentations were collected through the reader portal (reading zone). Our findings further support the use and utility of the eTattoo® UHF RFID cattle tag technology for capturing animal identifications rapidly and efficiently without animal restraint or funneling through pinch points.

Background

The identification of new electronic technologies, that address the needs for accurate and rapid cattle identification at the speed of commerce, is needed. The most common electronic systems in use today utilize low frequency radiofrequency identification or LF RFID, and are restricted to fairly short read ranges – from several inches to three feet in ideal situations. LF also tends to be better suited for capturing the IDs of single animals, as opposed to groups of moving animals due to the occurrence of collision. Therefore, systems which allow more flexibility in read distances and are able to capture groups of animals during normal daily movements or management activities, would be beneficial in the industry.



Ultrahigh radiofrequency identification or UHF RFID, is a worldwide RFID technology used commonly for asset management. It is compliant with ISO 18000-6C regulations and meets the standards as set by the EPC for UHF Gen 2. This standard defines the physical and logical requirements for a passive-backscatter, Interrogator-talks-first (ITF), radio-frequency identification (RFID) system operating in the 860 MHz - 960 MHz frequency range. Erigate's eTattoo® cattle tags meet these ISO and EPC compliance standards.

When evaluating the performance of new electronic identification tags and readers, it is necessary to collect data from many tagged animals in the same reading zone over a period of time to provide repeated measurements. Ideally, these data should be collected under conditions that mimic the field to fully understand the impact of the physical environment on tag and reader performance. However, feedlot owners are reluctant to process beef cattle outside of their normal management routine due to the adverse impact of stress and handling on the performance of the animals. These animals tend not to be processed on a very frequent schedule. Furthermore, in some geographic regions, the cattle have been on the range, and passing these cattle through alleyways and headlocks is potentially dangerous to the workers. In all cases, the evaluation of tag performance involves onsite labor and the collection of several repeated measurements in identical set-ups to obtain meaningful results.

A dairy facility provides an opportunity to obtain repeated measurements daily on the same set of animals and tags, as cows move normally to the milking parlor. This type of environment provides an ideal opportunity to test the performance of a set of tags during a wide range of temperatures and humidity levels in an unchanging physical surrounding over time and in a fully automated fashion. In addition, a dairy facility allows the reader placements and equipment to be optimized to maximize the ability to capture the animal IDs from groups of moving animals in an alleyway at a distance that does not impede their normal behavior. This type of information collection is essential for providing customers useful recommendations for placement and set-up of the new technology in differing external surroundings.

Dairy Barn Layout and Dimensions



Figure 1. Dairy barn 19 foot alleyway with one fixed reader/antenna attached to a 12 foot beam overhead.

The alleyway chosen for this pilot was 19 feet wide at the portal (reading zone) and was used by the cows for both entry and exit to the milking parlor. The alleyway led to a smaller holding pen just outside of the milking parlor and at the front end of the alleyway. On each side of the alleyway were milking parlor exit lanes. Fixed readers and antennas were attached to a wooden beam / header 12 feet above the concrete alleyway floor (**Figure 1**).

A cellular modem and power strip were attached on a nearby supporting structure on



Figure 2. Cellular modem and power strip.

the right side of the alley (**Figure 2**).

Groups of 150 – 200 Jersey cows were processed through a 40-stall milking parlor. eTattoo tags were attached to the animal's right ear using a universal tagger (**Figure 3**). Control cattle management tags were applied to the left ear. Not all cattle in each milking group carried eTattoo tags.

Cows moved briskly and tended to bunch together through the portal area when released from their pens for milking. The cows near the end of the milking group would often loiter under the portal antennas while the first group of cows were milked and released.

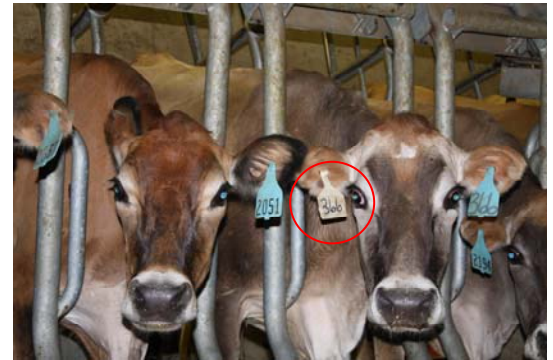


Figure 3. Photo showing white eTattoo tag and blue control management tags.

Cows exited the milking parlor along the outside of the holding pen and eventually merged into the original alleyway near the portal (**Figure 1**). Exiting cows moved more slowly and were normally not crowded together. One full milking cycle, therefore, consisted of an entry and exit read for each eTattoo tagged animal. Cows were milked three times a day.

Configurations and Pilot Software Application

Data was captured remotely each day from all three milking cycles using a RAVEN Cellular Modem / Network Hub and a fixed IP address. The modem was networked to the fixed reader using an ethernet cable and wirelessly connected to the internet through an 'always on' cellular connection. Using the fixed IP address, the reader's web server could be accessed directly to change reader settings or control its built-in database and command language. A custom Python application was developed for the project and allowed monitoring of the reader continuously. Tag reading results were downloaded on an hourly basis to a local file and database.

The pilot application operated from the HerdStar® Business Center computers located in Omaha, NE. The application connected via the internet and used data from the reader to determine when the animal first entered the milking portal for milking and when it finally exited the milking portal area (i.e. length of time from entry to exit). The application also captured which antenna (when multiple antennas were in use) first read the tag. The tag collection data was then matched to a master database that tracked sick animals, deaths, sold animals and lost tags. Any missing cows or missed tag reads from the cycle were identified and a follow-up email to the dairy manager confirmed the status of the cow and tag to determine if the reader missed the tag in the portal, or if it was not presented during that milking cycle. This test cycle and procedure was repeated three times a day.

A typical pilot application display is shown in **Figure 4**. Four tags appear to be missing in the top four rows of the display after a mid-day milking cycle after the data was merged with the master tag list. The missing four tags in this cycle belonged to four animals that were residing in a sick pen and had not been milked in this cycle. Therefore, these tags were not counted as missed reads nor were they counted in tag totals. The "Hits" column is a counter on how many times the tag was read by the reader during this cycle.

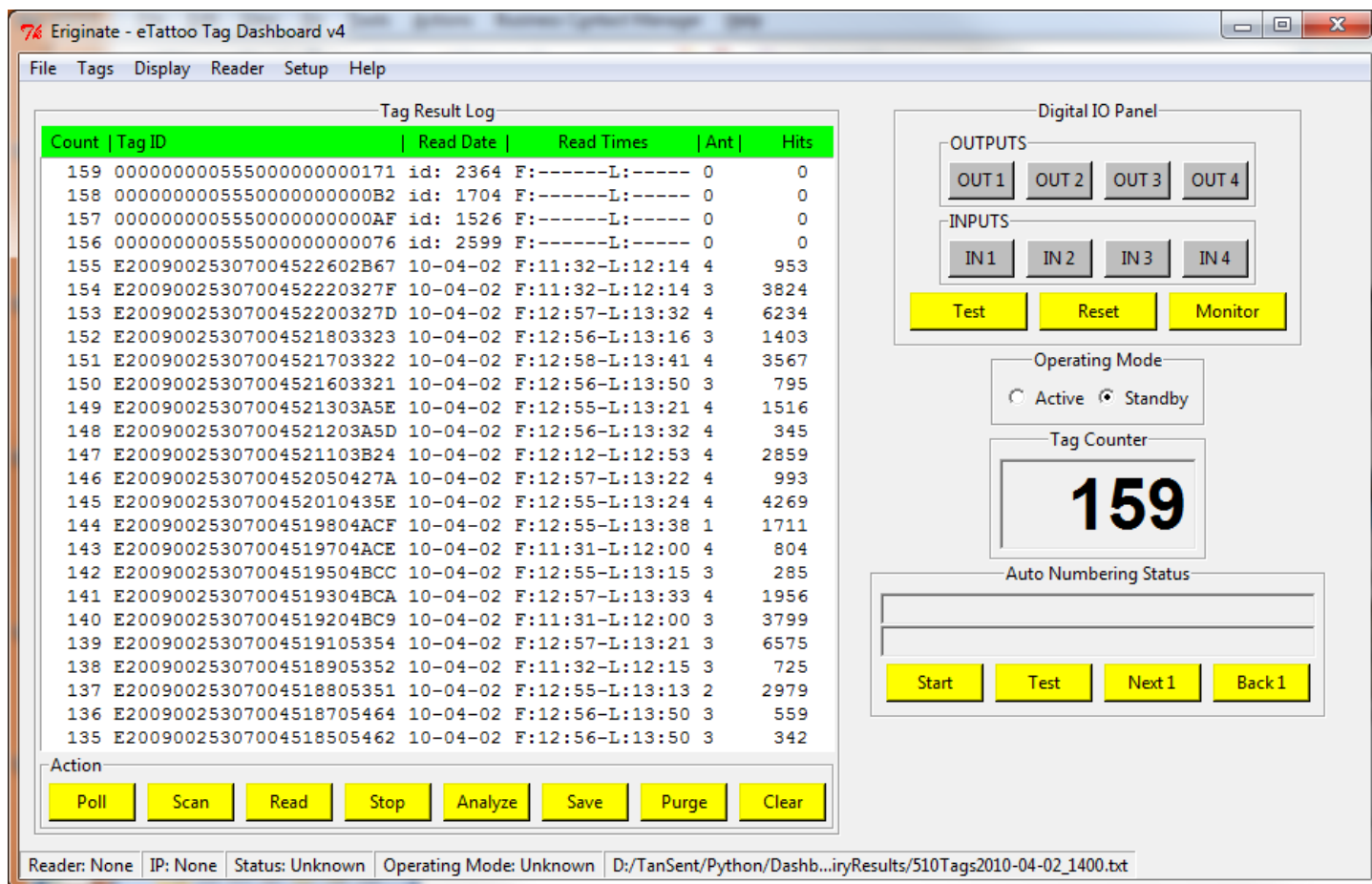


Figure 4. Pilot application display.

UHF RFID Reader Hardware and Configurations

Sirit (www.sirit.com) UHF RFID fixed readers and external antennas were used in this study due to their performance, quality, reliability and environmental ruggedness. The smart reader programming greatly simplified and streamlined the remote monitoring and modification of the data collection. In addition, Sirit had significant experience using UHF RFID technology to read high volume, high speed objects in outdoor environments. All of the Sirit Reader models tested utilized a common internal computer and command language that was easily managed with the custom pilot application developed by Eriginate. The following Sirit reader models and configurations were tested or are currently being tested:

- **Sirit ID 4100 circular polarized reader with 12” antennas (Figure 5)**
 - Tested in FCC Part 15 power setting
 - Tested with dual antennas in various positions and angles



Figure 5. Sirit ID4100 circular polarized reader – dual antennas.

- **Sirit Infinity 510 circular polarized reader with 12” antennas (Figure 6)**
 - Tested in FCC Part 15 power setting
 - Tested with four antennas in various positions and angles
 - Phase I and II ending in June 2010
- **Sirit Infinity 510 circular polarized reader with 12” antennas (Figure 7)**
 - Tested in FCC Part 15 power setting
 - New lower height (10 feet) now being tested
 - Phase III testing (no data compiled at this time)



Figure 6. Sirit Infinity 510 circular polarized reader – four antennas.



Figure 7. Sirit Infinity 510 circular polarized reader – four antennas at 10 feet.

eTattoo® Tags

eTattoo tags were applied to the right ear of the cow using a universal tagger. A management control tag was applied to the left ear. Not all cows in a milking group were tagged with eTattoo tags. Over the course of six months, three lots of eTattoo tags were used, including at least one lot of a prototype tag.

Results

Preliminary Dairy Test Results

Initial results were used to quickly identify reader configurations and angling of the antennas that were not considered optimal and to select configurations for more in-depth evaluation that were most cost effective and reliable for the livestock industry. This early screening gathered information from basic measurements while the pilot software application was being developed. “Full Cycle Reads”, “Entry” and “Exit Reads” were analyzed to compare multiple reader and antenna configurations and led to the finding that 4 antennas were required to obtain the target read percentage of 99+% (i.e. 99+% of tags presented were successfully captured by the reader). These results are shown below along with the number of full milking cycles tested on approximately 140 tags being presented during each cycle.

Definition of terms used below:

- **1 Full Cycle** (1 Cycle) is 2 presentations of the tag (Entry and Exit) and therefore equals **2 Tag Passes**
- **Full Cycle Reads** is the tag reporting at least once during a Full Cycle. (Entry or Exit or Both)

Reader & Configuration, Mode	Cycles Measured	Entry %	Exit %	Combined % Full Cycle Reads
4100 Dual, 15°, Portal	12	95.93%	99.43%	99.82%
4100 Dual, 15°, Vehicle	12	96.00%	98.41%	99.27%
4100 Dual, 15°, Portal	7	97.20%	97.70%	99.73%
4100 Dual, 0°, Portal	75	97.76%	99.27%	99.90%
510 Quad, 0°& 11°, Portal	14	98.36%	99.27%	99.95%

NOTE: The table above indicates readings taken with the ID4100 and the Infinity 510 readers. Readers were used with two (dual) or four (quad) antenna configurations at various angles to the alleyway (15, 11, or 0 degrees). Readers were set for “vehicle” or “portal” settings.

After analysis of the preliminary dairy test data, readers with either two or four antennas were selected for further investigation. The antennas performed best when positioned at an angle of 0° or horizontal to the alleyway floor. The Identity 4100 (ID4100) also met the requirements for environmental ruggedness with an IP 67 rating. Since the ID4100 reader currently can accommodate a maximum of two antennas, we utilized an Infinity 510 reader (IN510) to test a four antenna portal. The IN510 is similar to the ID4100 reader, has four antenna ports, but is not suitable for outdoor environments. The IN510 was used solely to provide field performance data needed to test the 4 antenna configurations that are currently being explored in testing.

Test Results Using 2 and 4 Antenna Configurations

Using the data collected and stored after verifying each missed tag and determining whether it was available to be read or whether the tag and / or cow had missed the milking cycle, the database of information was computed and summarized in the table below.

Definition of terms used below:

- **1 Full Cycle** (1 Cycle) is 2 presentations of the tag (Entry and Exit) and therefore equals **2 Tag Passes**
- **Full Cycle Reads** is the tag reporting at least once during a Full Cycle. (Entry or Exit or Both)

- **1-Way Reads** is total tags read out of all tags presented upon entry OR exit. (**all Tag Passes = total Entry + total Exits**)
- The remaining percentage accounts for tags that were presented, but not read either on Entry or Exit

		Count	Percentage
Combined	Total Tag Passes	58574	100.00%
	Full Cycle Reads	58544	99.95%
	1-Way Reads	58019	99.05%
Reader: 4100 Dual Antennas	Total Tag Passes	12302	100.00%
	Full Cycle Reads	12288	99.89%
	1-Way Reads	12141	98.69%
Reader 510 Quad Antennas	Total Tag Passes	46272	100.00%
	Full Cycle Reads	46256	99.97%
	1-Way Reads	45878	99.15%

12,302 total tags were presented to the ID4100 in a dual antenna configuration. Of these total tag presentations, 1.31% or 161 tags were missed either on entry or exit to the milking parlor. However, when entry and exit readings were combined, only 0.11% or 14 tags were missed.

In comparison, using the Infinity 510 reader and four antennas to simulate the ID4100 with four antennas, 0.85% of the tags were missed on either entry or exit (394 tags out of a total of 46,272 presentations). This represents an improvement of approximately 0.5% in tag capture. When both entry and exit readings were combined, 0.03% of the tags were missed or an improvement of 0.08%.

These data suggest that in an alleyway of 19 feet width, with readers placed at a height of 12 feet, an ID4100 reader system using four antennas is recommended for achieving 99+% tag capture.

Summary

Our findings support the ability to efficiently capture the identification numbers of groups of animals moving through a wide alleyway with antennas placed overhead. The eTattoo tags and Sirit reader / antenna system can achieve greater than 99% tag capture in a 19 foot alleyway with 4 antennas placed 12 feet overhead. Recommended hardware configurations and results will vary dependent upon the specific application and physical surroundings, but the results presented here should serve as a basis for expected results under similar conditions.

The ability to read exit passes from the dairy parlor were almost always 100%, while most 1-Way misses occurred on the entry portion of the cycle where the cattle were moving briskly through the portal in a much more crowded arrangement. On entry, body masses may have more easily blocked a successful read of a tag as can be visualized in **Figures 8 and 9**. These findings are important and indicate that cattle behavior can also affect the ability to successfully capture the tag ID and not simply size of the reading zone. To address this, the antennas have been lowered from 12 feet to 10 feet to determine if the tag capture performance can be improved on entry (**Figure 7**). These data are currently being collected and analyzed.



Figure 8. Crowding in read zone on entry.



Figure 9. Crowding in read zone on entry.

The temperature during the study ranged from a low of -19°F in January to a high of 94°F in May. The average outdoor humidity was between 46% and 76% during this six month period, but frequently reached 100%. The humidity levels within the dairy barn were not measured, but were generally higher than the outdoor levels due to the daily washing of surfaces. Despite the temperature and humidity cycling of winter into early summer, there were no identified detrimental effects of either temperature or humidity on the performance of tags or readers during this trial.

The test results presented in this paper demonstrate the utility of using a dairy to conduct evaluations of the eTattoo UHF cattle identification system through remote data collection. The ability to obtain thousands of tag passes through the reader portal during milking was ideal for analyzing reader configurations and antenna placements in a short amount of time with limited on-farm labor and minimal animal stress.