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Issues on range and accuracy of RFID-radar™ system
Matching the radar to the physical situation

The following image shows the radar picture of twelve transponders placed in front of the radar, some

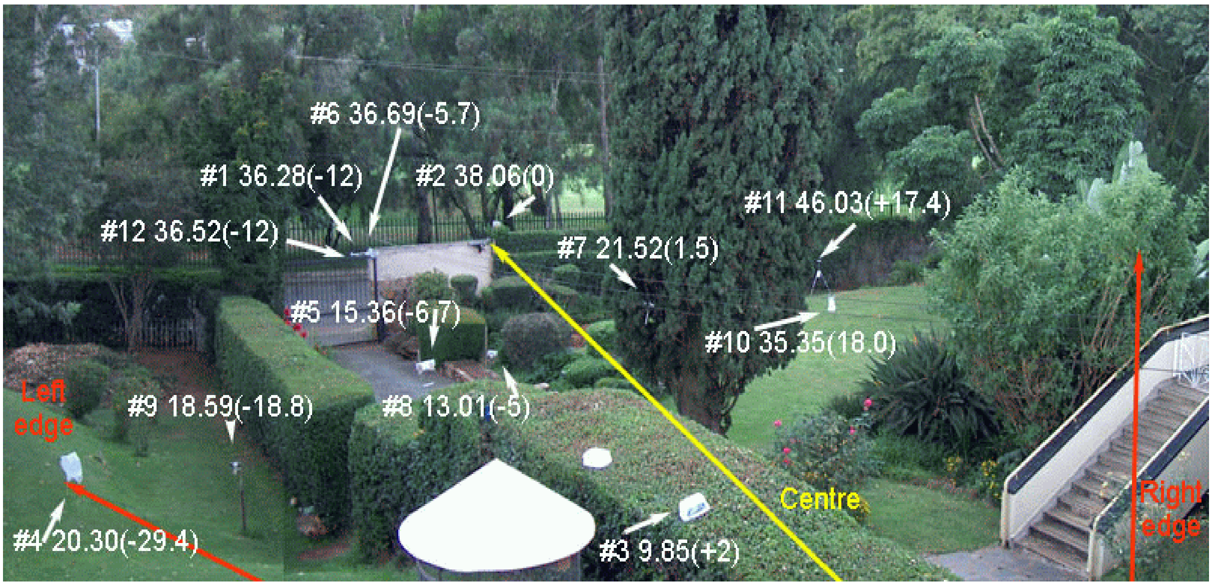


Figure 2*Placement of the transponders as viewed from the radar antennas*

out as far as 47 meters from the radar.
In the radar display image below(on the next page), the yellow zone is the field of view of the radar representing 64.4 degrees sweep. Targets outside of this 64 degrees will appear to also be within the yellow zone - this effect is called imaging.. For this reason we show targets that might be close to the edges of the zone as their location in the yellow zone and where they could be in the brown zone. Tag number 4 is just on the edge of the zone and hence appears on both sides of the yellow zone.

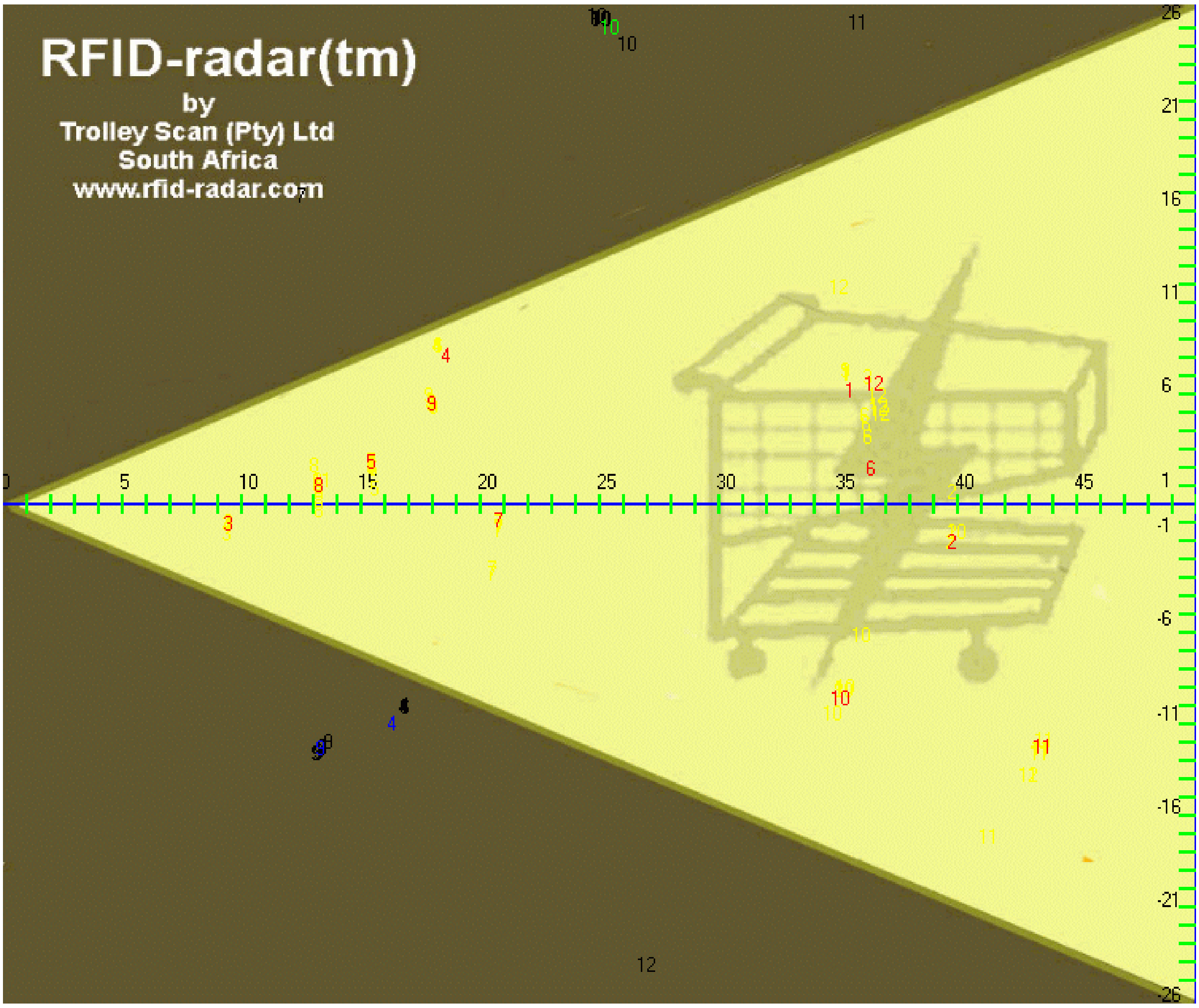


Figure 3 Twelve *transponders are plotted. Distances are in meters.*True positions and images are shown for transponders that might be outside the field of view.

In this diagram of the Physical placement of the transponders, the numbers after the hash(#) represent the numbers shown on the radar display below. Distances are shown in meters and angles in brackets in degrees. Three tags are placed on the gate, namely #12,#1 and #6 with another tag (#2) off on the left. The yellow line represents the centre line, and the red lines mark the edge of the display, after which tags outside this zone will appear as imaged tags.

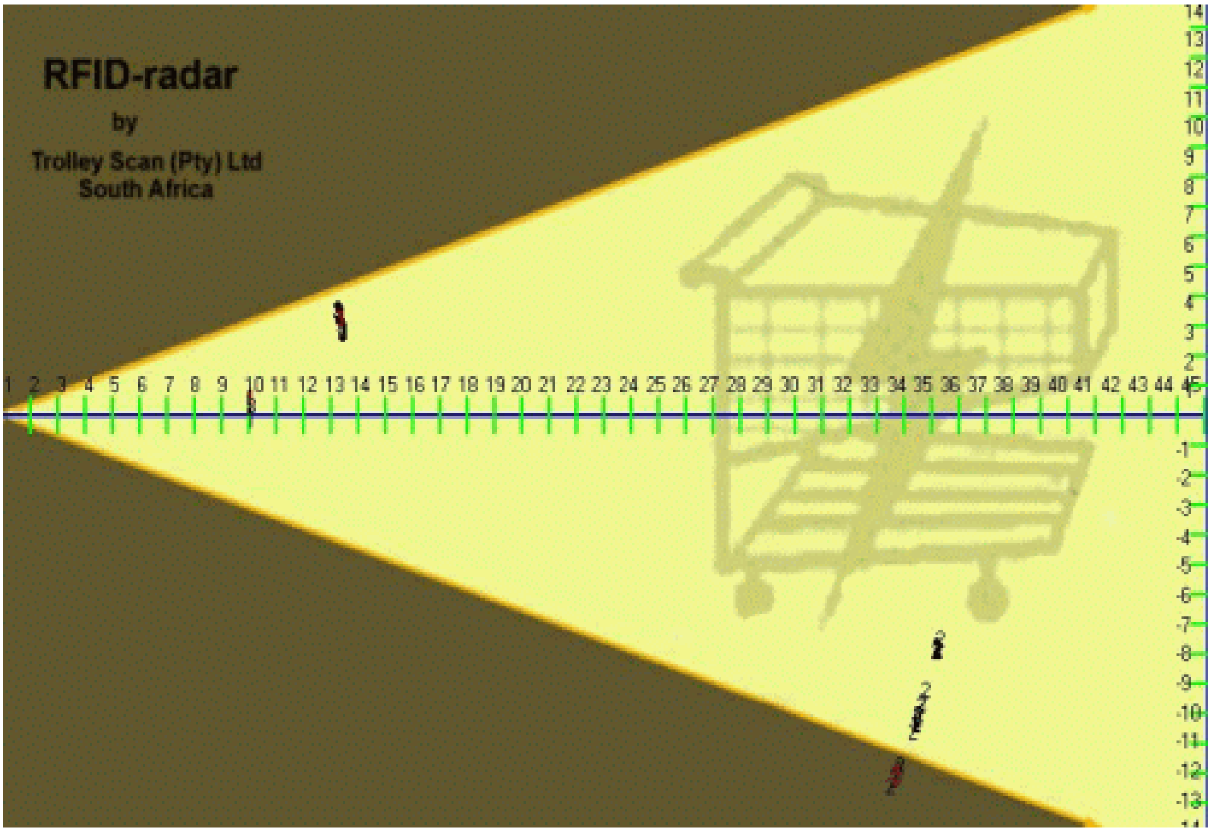
On the next page we show repeatability performance .

Repeatability

In August 2005, Trolley Scan announced that they had developed a technique for accurately measuring the distance a signal travelled from a lowcost transponder to a reader over long distances, and hence were able to measure the identity and location of many transponders in a zone at a time.
The method of making these measurements is complex and the question arises as to how accurate and repeatable can such a new technique be?

A further impact of such a discovery is that it provides an incentive to develop a new range of very low power transponders to allow the radar to operate over much longer ranges than were needed with the existing RFID reader technology.

Accuracy
The two graphs show measurements made on transponders at far ranges on 23rd January 2006. The first shows 180 repeat measurements made on three targets, one set per



second over three minutes. The second shows the scatter from 14000 (fourteen thousand) independent successive measurements made on two transponders.

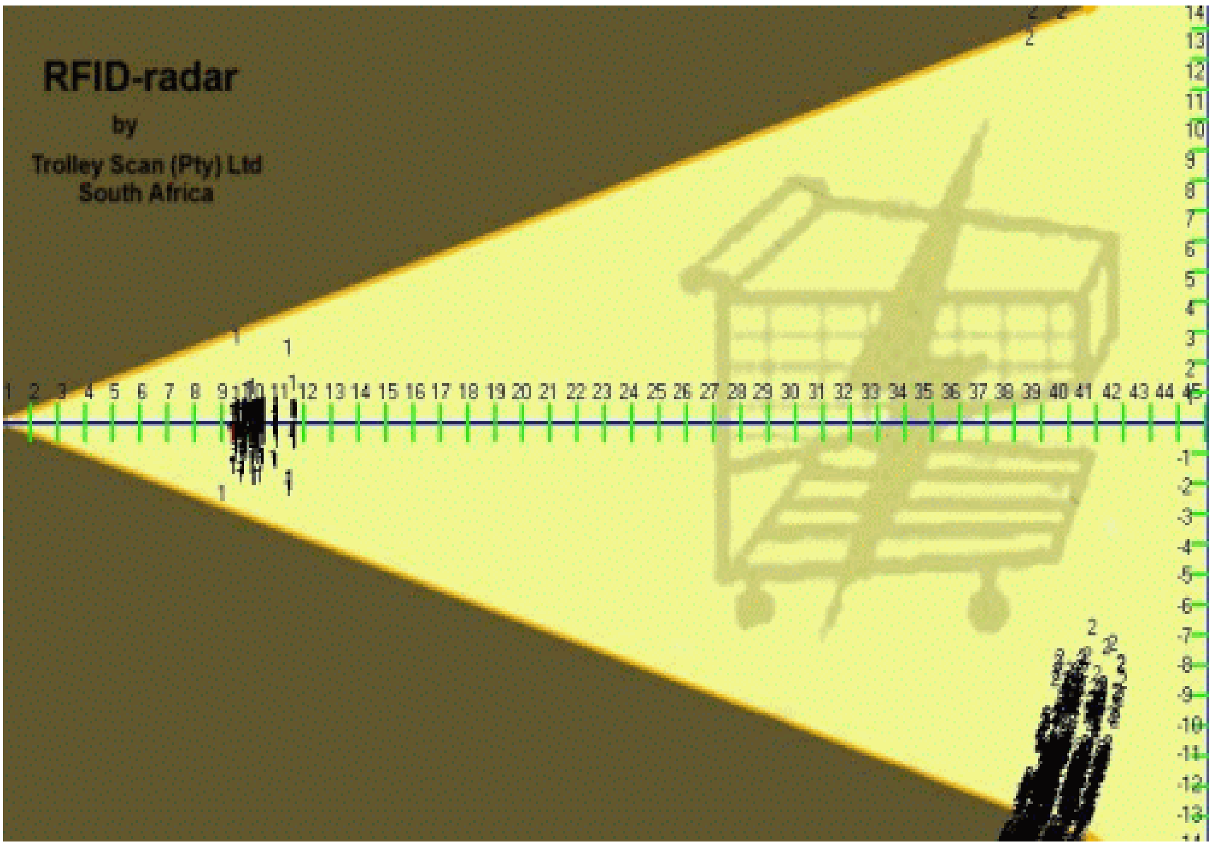
In the graphs the axis are in meters.

In the first there are three transponders, namely at (10,0); (13,4) and (34,-11) meters. One hundred and eighty successive range measurements were made on each transponder. The reader accurately determines the range, and calculates the angle of arrival based on the difference in distance between two adjacent readers.

These measurements were made using a 915MHz energising signal to UHF tag- talks-first protocol Trolleyponder/Ecotag transponders. The system only uses 10 kilohertz of bandwidth and measures with good precision despite the speed of travel of the radio signals being at 300 000 kilometers per second.

The second graph shows the result of fourteen thousand measurements on two targets, one set per second over four hours. Targets were at (10,0) and (41,12) meters. These measurements were made over open fields and have the occasional bird flying through the beams and people moving in the vicinity which causes some excursions on the angular measurements.
Both these graphs show the remarkable ability this new technique exhibits for measuring range of the transponder from the reader.

At present the maximum distance over which we can measure is limited by the energising requirements of the transponders. Trolley Scan expect the range measuring algorithm to



operate with similar performance at ranges up to 100 meters.

Increasing the maximum operating range of backscatter transponders

Different operating frequencies and the associated propagation of energy results in different operating ranges for transponders. The first transponders in the 1970's operated at 125/135kHz and have an operating range of a few centimeters. Moving the operating frequency to 13.56Mhz resulted in an increase in range to 50 cms with developments in the 1990s. UHF transponders were developed in the 1990s and dramatically increased the operating range up to 15 meters. Microwave transponders at 2.45Ghz suffer from reducing aperture of the antenna and offer 1 meter ranges. Superimposed on the choice of frequency is the size of the antenna structure which is large at UHF and shrinks as the frequency increases.

UHF frequencies offer the greatest operating range in terms of the laws of physics. Globally countries have allocated frequencies in the 860 to 960MHz bands which allows design of systems with frequency agility which can allow for goods labelled in any one country to be read by readers in other countries. This is achieved by making the transponders responsive to signals over a 100MHz bandwidth.

Hence the challenge for developing long range transponders becomes making UHF backscatter tags that have 100MHz of bandwidth and operate on very low powers.

The arrival of RFID-radar - where identity and exact location can be reported, results in a need for much longer operating ranges for the reader which means there is a need for transponders that can operate at distances beyond the cap of 10 meters needed for conventional readers.

The operating range of a reader comes from two elements, namely:-

< The energy radiated from the reader to energise the transponder and provide an RF signal that can be returned to the reader for backscatter transponders.

< The ability of the reader to detect very weak signals in the presence of the strong energising signal operating on the same frequency.

The energy leaves the reader from the amplifier at some power level, is focussed by the reader antenna as it launches into space and from then on dissipates as the inverse square of the distance travelled. This means that a power density at 1 meter from the reader will be four times the density at the 2 meter point, or 100 times the density at 10 meters, or 10 000 times the density at 100 meters. Hence to increase range from the energising field perspective you can :-

< Increase the power of the transmitter - this is limited by the radio regulations of the different countries so that it does not interfere with other radio users.

< Increase the focus of the transmit antenna - causes more energy to be focussed down the beam at the expense of wider coverage.

< Decrease the power requirements of the transponder

Trolley Scan have long been supplying the 200uW Ecochiptags, Ecowoodtags and laundry tags that have operating ranges as far as 13 meters.

Trolley Scan are now supplying 5uW long range tags, with an operating distance of 30 to

35 meters, where receive paths start becoming an issue. These 5uW tags now need 10000 times less RF energy than needed by that standard 5 volts circuit on a dipole.

These are the next step into supplying transponders with 100 meter ranges to meet fully the needs of RFID-radar users.

8 April 2006