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DRDC Ottawa
3701 Carling Avenue
Ottawa, ON K1A 0Z4

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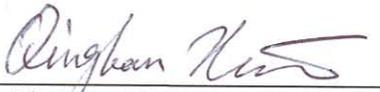
April 16, 2010

Youri Rousseau
Chef de service | Section Head
Administration des ressources | Resources Management
Recherche et développement pour la Défense Canada - Valcartier
Defence Research and Development Canada – Valcartier
2459 Boul. Pie XI Nord
Québec, QC, Canada G3J 1X5

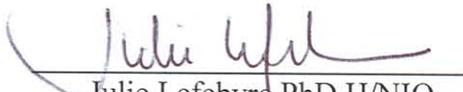
Dear Youri,

Thank you very much for inviting me to participate in your RFID initiative. To address your questions and concerns, I have prepared a Letter Report to provide you an RFID-enabled warehouse solution. Please see the attached document for details.

Prepared by


Qinghan Xiao PhD

Approved by


Julie Lefebvre PhD H/NIO

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Letter Report: An RFID-enabled Warehouse at DRDC Valcartier

Prepared for: Resources Management, DRDC Valcartier

From: Qinghan Xiao, Network Information Operations Section, DRDC Ottawa

Date: April 16, 2010

1. Background

DRDC Valcartier currently uses a barcode-based inventory system (10 digits), called SIDEC, to manage and control inventory. Since RFID technologies offer increased efficiencies in supply chain management, DRDC Valcartier would like to deploy an RFID solution in their new warehouse to enable inventory tracking, warehouse management, and asset location.

Dr. Qinghan Xiao was invited to DRDC Valcartier in February, 2010 to provide advice regarding the use of RFID technologies. They visited several stores operated by different sections to understand their warehouse operations and to identify the challenges in the current manual processes. The objective is to help ensure that an RFID deployment can satisfy both business and user requirements.

2. Benefits

The benefits of deploying RFID for warehouse and inventory management are:

- Total asset visibility;
- Full inventory history;
- Optimal and accurate inventory levels;
- Localization of misplaced items;
- Real-time security;
- Shortened cross store time;
- Speed up of sort/pick rate;
- Reduction of errors by minimizing human intervention;
- Reduction of cost of operations;
- Enhanced quality processes — satisfied suppliers and end-users;
- Reduction of external and internal theft; and
- Efficiently track incoming and outgoing deliveries.

3. Proposed Solution

As shown in Figure 1, an RFID system consists of three components:

- RFID tag or transponder made up of a microchip with an antenna
- RFID reader or interrogator with an antenna
- Backend system with data processing software

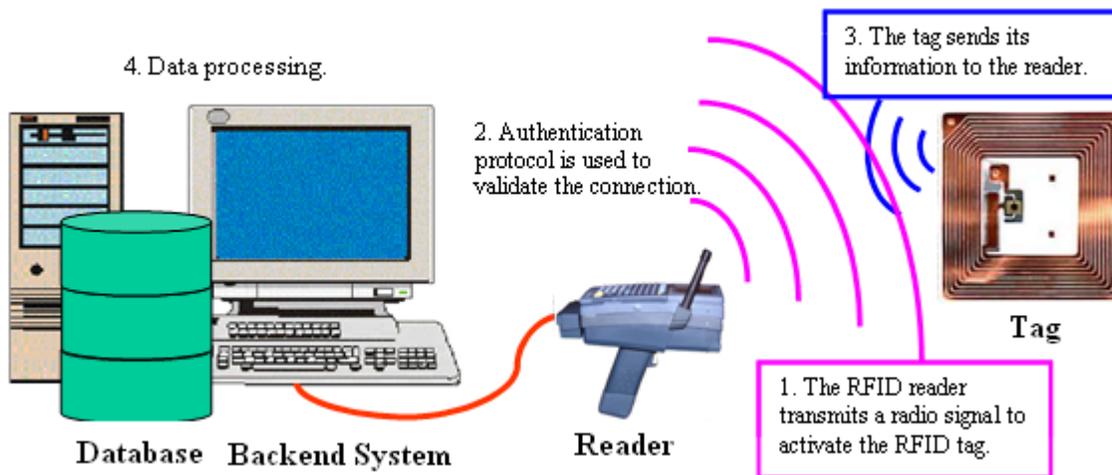


Figure 1: A passive RFID system

The proposed RFID solution (Figure 2) requires the following type of equipment:

- An RFID dock door portal to record inbound and outbound shipments;
- A fixed reader to record check out and return of RFID-tagged items;
- Handheld RFID-PDA readers;
- A forklift RFID reader to move objects and read RFID tags from storage shelves;
- WORM RFID tags for general inventory;
- On-Metal RFID capability for gas cylinders;
- Recommended antennae type; and
- A label printer for on-the-spot printing of barcodes on RFID tags.

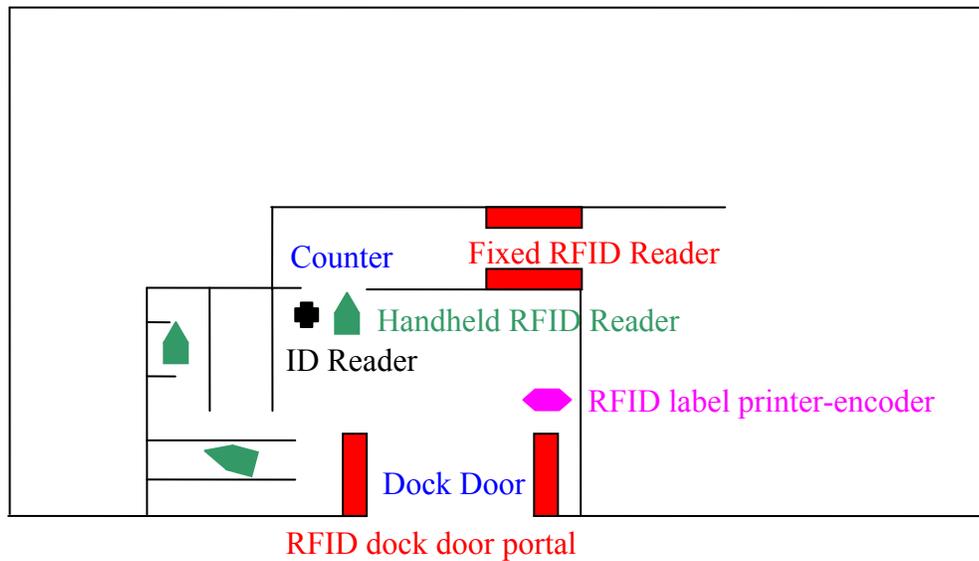


Figure 2: Proposed RFID-enabled warehouse solution

A. Backend system

The RFID implementation should be integrated with the SIDEC inventory management system in order to maintain current inventories and remain backward compatible. One potential integration strategy would be to develop an RFID server application that would communicate inventory transactions to the SIDEC backend database. This RFID server application could be developed by the DRDC Valcartier IT and Resources Management team¹.

B. Tags

1) WORM tag

There are a number of tag design constraints including:

- size;
- cost; and
- compatibility with the various objects to which the tag may be attached.

There may exist policy restrictions to utilize active RFID technology on the DRDC Valcartier campus. Therefore, passive, Ultra-High Frequency (UHF) RFID technology that ranges from 860–960 MHz are recommended. This technology allows tags to be read by a typical fixed reader from as far as 3 meters away. Among different tags, WORM- tags (write-once-read-many) are best suited to satisfy DRDC Valcartier's operational requirements.

Antenna designs often contain elaborate features, but many fall into one of three categories: single dipole, dual dipole antennas, and bent dipole/meander. A single dipole tag (Figure 3) only has one dipole antenna, which typically has good read range when oriented along the polarization of the radiation from the reader, but the tag is sensitive to the direction of the antenna's radiation field.

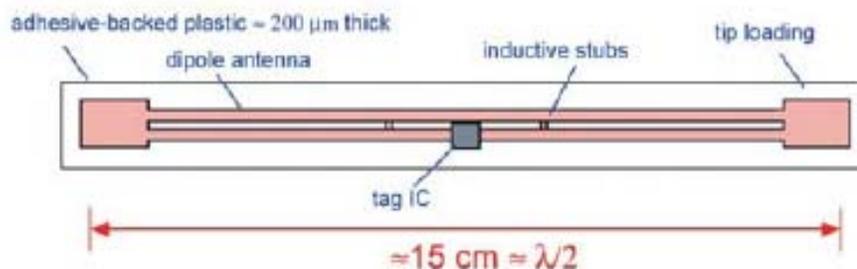


Figure 3: Schematic depiction of typical single-dipole tag

¹ Training would be helpful for the IT staff to learn the techniques necessary to develop software for RFID readers, in particular, on handheld RFID PDA reader. Dr. Miodrag Bolic, University of Ottawa (<http://www.site.uottawa.ca/~mbolic/>), could provide such training.

A dual dipole tag (Figure 4) has two dipole antennas and is less sensitive to the direction of the antenna's radiating field. It depends on the application to determine whether to use dual-dipole tags or not.



Figure 4: A dual-dipole passive RFID tag; tag size is roughly 9×9 cm.

In a bent dipole tag, the dipole is fed in the middle and the dipole arms are bent at different angles α and at different distances d (Figure 5). The conducting arms of the antenna can also be curved and fall upon or generally upon a circle, ellipse, oval, and square. The bent tags have great potential for item-level RFID applications in restaurants or libraries for tracking the items such as plates and books. However, the read range of the bent tag is reduced by a factor of 2 to 3 vs. a single dipole tag.

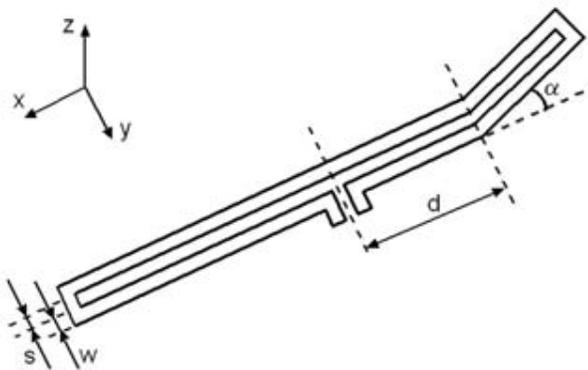


Figure 5: An example of bent dipole antenna curved towards the z-axis.

2) On-Metal Tag

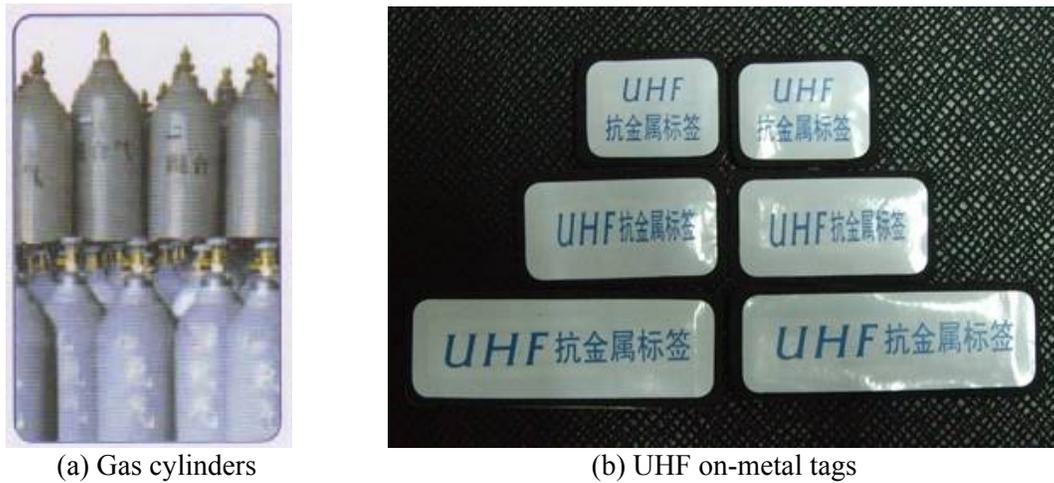


Figure 6: RFID for tracking of gas cylinders

One requirement from DRDC Valcartier was to use RFID tracking gas cylinders (Figure 6 (a)). In the literature, it is reported that IBM launched a pilot project that used passive Low-Frequency (LF) half-duplex (HDX) tags to track 500,000 cylinders. DAILY RFID, used High-Frequency (13.56MHz) RFID On-Metal Tag to identify gas cylinders either individually or in whole shipments in pallets, which showed an impressive read range up to 40-100mm on metal basing on different RFID readers. However, LF and HF tags cannot meet the read range requirement of DRDC Valcartier. Recently, DAILY RFID reported that it developed a UHF Metal Tag — UHF Metal Tag-03 (Figure 6 (b), specifications in Table I) that could possibly satisfy the requirements, but requires testing to confirm: 1) that the tag can be firmly affixed to the gas cylinders; 2) the read ranges are acceptable when the tag affixed to different parts of a gas cylinder; 3) the read ranges are acceptable when a gas cylinder is filled with different gases under various conditions (from full to empty).

Table I: UHF Metal Tag-03		
Product Details:		
1	Product Material	Special material, 3M Glue, can use direct on metal
2	Operating Frequency	860MHz to 960MHz
3	Operating Mode	FHSS or regular frequency
4	Support Protocol	ISO18000-6C (or ISO18000-6B)
5	Memory Capability	512bit or 96 bit (2K bit)
6	Compliant Rate	100 km/h
7	Operating Temperature	-40° C to +70° C
8	Data Maintenance	10years,EMS memory can be wiped or written over 100K times
9	Read and Write Range	10cm to 3m
10	Tag Size	2cm x 2.5cm, 2cm x 3.5cm, 2cm x 5.5cm; Thickness: 0.2cm

C. Printer

When shipments arrive at the dock door, RFID tags are generated and labels are printed on the spot and attached to each incoming item that has a value of more than \$1000. Because it is preferred to make a “smart label” application, one of the requirements is to combine the bar code labeling with the RFID technology. Therefore, it is necessary to buy a special label printer that can encode data on RFID tags, while simultaneously printing text, bar codes and graphics (Figure 7).



Figure 7: RFID label printer-encoder

D. Readers

RFID readers are used to capture the raw information on the RFID tag and automatically transmit the data to an RFID server that creates transactions records that are sent to the SIDEC server.

a) RFID dock door portal

The RFID dock door portal, which has a fixed reader and several antennae, is an integral part of an RFID deployment (Figure 8). It allows for inventory visibility of assets entering or leaving designated areas within a warehouse, a distribution center or a cross dock location. Additionally, inventory management can easily be streamlined through the use of the RFID dock door portals.



Figure 8: An example of RFID dock door portal

b) Fixed reader

Fixed RFID readers are used at designated read zones and connected to the backend system (Figure 9). They are easy to deploy, use, manage and install without much technical knowledge. In the proposed solution, a fixed reader will be installed in a hallway to double record the RFID tagged items after they are taken away from and before they are returned to the counter to mitigate potential human errors.



Figure 9: Fixed RFID UHF long-range reader

c) Forklift reader

RFID readers can be installed on the forklifts to read the shelf tags or pallet tags (Figure 10). Unlike fixed readers, which are deployed to specific locations, an RFID-enabled forklift can move throughout the warehouse. Because transforming an ordinary forklift into the one that incorporates RFID technology requires specialized knowledge and a considerable amount of hands-on work, it is necessary to buy an RFID-enabled forklift. Vendors such as Intermec, Motorola and LXE all offer forklift-oriented RFID systems, as well as the hardware and service support required mounting the technology.



(a) Single antenna



(b) Double antennas

Figure 10: Forklift-mounted RFID infrastructure

d) Handheld PDA RFID reader

A handheld reader (Figure 11 (a)) expands the ability to utilize the information on the RFID tagged items beyond the fixed readers at designated read zones. By adding mobility, handheld reader is able to extend the benefits of RFID to additional inventory processes. For example, a quick scan of the shelves or loads in the staging area now allows the location of a specific item. One of the requirements for inventory control is to ensure that an item is placed in the right room. If the room is tagged, the mobility also allows on-the-spot association of item and room tags.

PDA RFID readers (Figure 11 (b)) provide additional capabilities in that tag information can be stored locally in order to enhance the overall inventory management activity.



(a) RFID HF/UHF handheld reader



(b) PDA UHF handheld reader

Figure 11: Handheld RFID readers

E. Packing box

Using the current RFID technology, it is difficult to read tagged items inside of packing boxes, and it is almost impossible if the packing box made of metal. Figure 12 shows different packing boxes that DRDC Valcartier uses. Tests would need to be carried out in order to ascertain the usability of various RFID solutions within the context of packaged items.



Figure 12: Packing boxes

4. RFID-enabled Operations

There are several possibilities for how RFID technology can be utilized in warehouse. Many manual steps can be eliminated from the warehouse processes — for example, incoming and outgoing items no longer require the physical attention of a worker. The RFID readers automatically transmit all received data into the SIDEC in real time.

A. RFID at the outbound counter

When assigning equipment to an employee, the RFID reader captures the RFID information on the item, while an ID reader scans employee's ID. Data are instantly transferred into the warehouse management system with a time stamp. The employee's ID number is associated with the RFID number and automatically registered as the item holder.

B. RFID on the move in the Centre

An RFID Handheld Reader expands the ability to utilize the information on the RFID tagged items beyond the fixed readers at the warehouse dock door. By adding mobility, we are able to extend the benefits of RFID to additional inventory processes. For example, a quick scan of the shelves or lab rooms enables the instant location of a specific item.

C. Item-level tracking

Currently, Valcartier's SIDEC has each and every item uniquely identified, instead of generally identified with, for example, a U.P.C. symbol, which makes it easy to incorporate RFID technology into their warehouse management system. Item-level tracking provides a great insight of what is going on with the inventory. It makes it possible to keep track of items with full accountability for all three major areas of item distribution – from warehouse to lab room to testing field.

5. Approx Hardware Cost

In order to estimate the total costs, several RFID vendors and distributors have been asked to provide quotations. The result is shown in Table II for cost estimation.

Table II: RFID Equipment Pricing			
Equipment	Type	Price	Supplier
UHF Labels with Single Dipole Antenna	UHF Gen 2 Labels: 4" x 2", without perforation	\$0.18 per label Qty: 5000-25000	RFID Canada
UHF Labels with Dual Dipole Antenna	UHF Gen 2 Labels: 4" x 2", without perforation	\$0.45 per label Qty: 5000-25000	RFID Canada
On-Metal Tag	UHF Metal Tag-03		DAILY RFID
RFID Portal Kit	4 Circular Polarized Antenna	\$4,950.00	RFID Canada
Fixed UHF Reader with 2 9dBi Antennas	2 Circular Polarized Antenna	\$1,850.00	RFID Canada
Forklift Reader	RX2	USD\$5,095.00	LXE
Hand Held UHF/HF RFID Reader	Hand Held RFID Reader Kit with Bluetooth Interface	\$998.00	RFID Canada
Handheld PDA Reader	Hand Held Terminal with Barcode Scanner and RFID Reader	\$4,950.00	RFID Canada
Handheld PDA Reader	DL770	USD\$1180.00	DAILY RFID
Label Printer-encoder	RFID-UHF Printer	\$2,990	RFID Canada
Wax Ribbon	4"x1181' (Minimum order is 24)	\$6.75/Each	RFID Canada
Label Design Enterprise Software	Print RFID and Barcode on Tags	\$985.63	RFID Canada
Professional Services	Engineering, Design, Training plus Travel Expenses	\$125.00/Hour	RFID Canada
Professional Services	Engineering, Design, Training plus Travel Expenses	\$110.00/Hour	University of Ottawa

6. Summary

To design a successful RFID application, not only must we identify what we want the system to do, but we also must be very clear about what kinds of tags and readers can be used to deliver the performance we are looking for. Since it has successfully developed and operated a bar code system for inventory control, DRDC Valcartier should have no problem to build an RFID-enabled warehouse with adequate training and consolidation. Since several tag and reader technologies are new to every one, as mentioned in the report, a feasibility study is recommended as a first step.