AUTO-ID CENTER

WHITE PAPER
Towards RFID Peformance Benchmark Tests
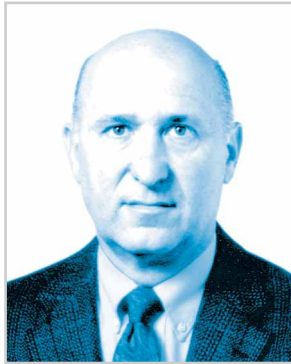
Noel Eberhardt

ABSTRACT

Benchmark performance tests for radio frequency identification tags and readers as applied to supply chain management applications are needed to provide a uniform means for End Users to assess and compare performances of different product offerings. Conversely, these tests also establish sets of mininmal performance expectations for equipment suppliers. This paper sets out to describe [1] the common RFID tag and reader applications and [2] the methodology in establishing the test criteria.

WHITE PAPER

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Biography

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Noel comes to the Auto-ID Center after a long and distinguished career. He recently retired from Motorola WSSD (Worldwide Smartcard Systems Division), where he was serving as the VP of Advanced Technology of Indala Corporation. Noel has also been an integral part of the Mechanical Engineering teams at Hytek Microsystems, Timex Corporation, Intel Corporation and Litton Guidance & Controls Systems and is the founder and President of Solectrol Corporation. Noel's professional career has focused on the design, development, process development, and manufacturing of electronic packages, i.e., the transformation of electronic circuit designs into physical, manufactured products. The scope of products has included airborne and satellite borne computers, industrial computers, computer memories and power supplies, digital watches, and very low cost disposable radio frequency electronics.

WHITE PAPER

Towards RFID Peformance Benchmark Tests

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PROGRAM OBJECTIVE

The objective of RFID performance Benchmark Performance Test development is to establish sets of minimal performance criteria for targeted supply chain and retail applications.

1. INTRODUCTION

Benchmark Tests for RFID (radio frequency identification) tags and readers are essential in establishing performance expectations for common supply chain management applications. Historically speaking, industrial applications of RFID technology evolved from pursuit of niche applications in the absence of industry standards or guidelines. The advent of the Auto-ID Center has created a forum for End Users and Technology Suppliers to blend application expectations with the physical capabilities of RFID into defined performances, or Benchmark Performance descriptions.

The Field Tests incorporate RFID reading situations typically encountered within industry wide supply chain applications. These trial situations provide the opportunity for End Users and Technology Suppliers to learn, understand, and appreciate each other's conditions. Although the primary purpose of the Field Tests is to prove out the system architecture for data communication within and through the entire supply chain (from product sources through distribution to transportation, retailers, and finally to retail customers), the Technology Suppliers can experience the End Users real applications in near real world conditions. The End Users also get an early experience at the capabilities and/or limitations of RFID technologies.

Now that End Users and Technology Suppliers have experienced some Field Testing and acquired cross familiarity between applications and technology capability, it is appropriate to obtain inputs from all consortium members so that sets of minimal performance conditions and expectations can be defined and documented. End users can use the criteria for performance comparison while the technology suppliers can use this same information to determine completeness of product development, when a product is "good enough", or, conversely, "not good enough". There is reason to believe future technology changes could bring performance improvements and suggest re-establish benchmark performance conditions. However, the time has come to focus and apply the status of today's technologies to the applications at hand.

The primary purposes of this paper are to [1] outline the envisioned fundamental, industry wide common RFID reader applications and [2] make all consortium members aware they will have the opportunity to participate with inputs. Questionnaires will be circulated in the near future. The importance of feedback from **all consortium members** cannot be understated. It is imperative that all members participate so that meaningful and useful criteria are established. As a side note, it is anticipated other applications and reader types will evolve in the future as a result of implementation experiences and continuing developments. The challenge today is to establish sets of conditions useful for near term application and being a base for implementing improvements.

2. THE APPROACH TO DEVELOPING BENCHMARK PERFORMANCE TESTS

Use the Field Test
The three phases of the Field Test are viewed as a microcosm of the world of supply chain management from which conditions for RFID application can be extracted.

Extract users' applications conditions

One of the most difficult issues facing RFID developers is determining the user's requirements and application(s). The Field Test is ideal in that it's close to the real world.

Extract capabilities suppliers RFID equipment

Operating and demonstrating RFID equipment in "close-to-real-world" environments tends to teach performance capability. Again, the Field Test is an opportune place to determine real world performance capability.

Solicit expectations of all Auto-ID Center end user members

Ultimately, the end users are the ones using the RFID equipment with the expectation of improving overall business operation. It is imperative their needs, problems, concerns, and expectations be understood by technology suppliers. Most often, the best technology product offerings will come from the technology supplier understanding the end user's needs, issues, concerns, and expectations.

Solicit RFID performance offerings from all Auto-ID Center supplier members

With RFID equipment, it is imperative the performance capabilities be understood to establish meaningful benchmark performance criteria.

Combine all of the above into benchmark performance conditions

The challenge becomes one of establishing benchmark performance levels that will satisfy most of not all end users while enabling multiple suppliers to provide RFID tags and readers. Undoubtedly, there will be differences in performance among equipment suppliers, but over time the differences tend to level out as the physics of the technology eventually become widely understood.

3. OUTPUT AND RESULTS OBJECTIVE

The primary objective is to establish several sets of application conditions in the form of documentation that define minimal performance expectations used by (1) end users for performance comparison and (2) suppliers to develop product offerings.

4. READER SITUATIONS

The following pages describe assorted RFID reader applications. These applications are not completely quantified, at this writing. The Field Test is providing a base understanding for capability. At this juncture, it is imperative to solicit end users' expectations and technology capability to establish minimal performance "RFID Benchmark Conditions and Performance" document.

The next step towards an established set of benchmark performance conditions and criteria is to solicit responses and inputs from all Auto-ID Center consortium members to the following set of "Reader Situations". These "Reader Situations" will be distributed to all consortium members in the form of a questionnaire.

In all reader situations, FCC and CE certifications on is a governmental requirement for all commercial used RFID equipment.

5. PALLET READER

Benchmark performance objective:
Establish as set of conditions and performance criteria to read pallets passing through a doorway or portal.

Conditions, considerations, and presumptions

a) As shown in Figure 1a standard set of conditions pertaining to structure and conditions around doorway opening needs definition for benchmark test. Such elements as max/min width and height, presence of metal around door frame, presence of steel mesh embedded in concrete, metal ramp between trailer and building, overhead steel door, etc., need to be defined.

Figure 1: Portal conditions

PALLET ENTRY PORTAL
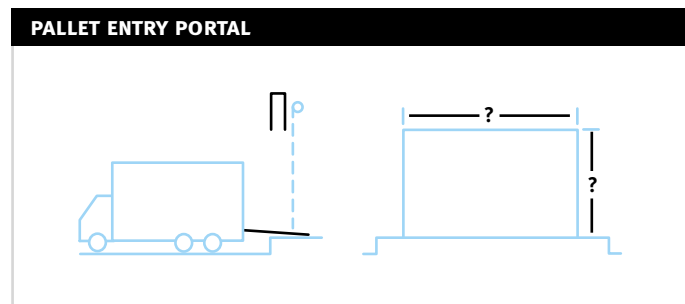
b) Pallet transport or movement by an "ordinary" forklift or pallet jack. For benchmark testing, a set of mechanical conditions describing "an ordinary" fork lift are needed in addition to a description of forklift electrical and make/break emissions.

c) Speed of forklift carrying pallet through opening. Is 4.5m/s (10mph) max appropriate?

d) Pallet stacking as shown in Figure 2 (should 2 or more be a consideration?)

Figure 2: Stacked Pallets
Figure 3: Pallet load configuration

STACKED PALLETS

CASE CONTENT VARIATIONS
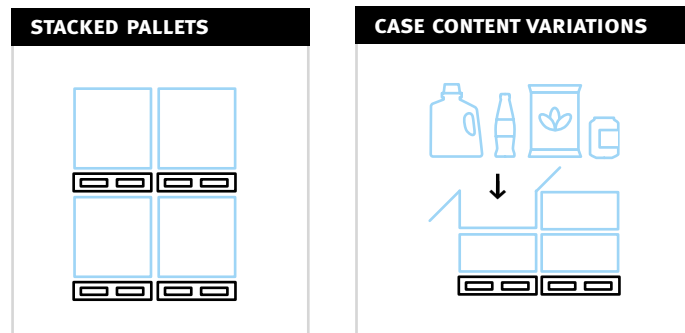
e) Types of items on pallet (Figure 3), i.e., paper or all metallic, or something "between" with gaps between metallic or liquid products

f) What are the end users expectations for reading cases and items as loaded on pallets?

g) Proximity of other equipment emitting

h) Wireless LAN transceiver on forklift?

i) End user's expectations on reading accuracy and ability to tolerate less-than-perfect reading performance.

j) Other considerations?

6. FORKLIFT READER

Benchmark performance objective:
Reliably read one and two stacked pallets on a forklift with the ability to discern which pallet(s) are on the forklift (Figure 4) for a given set of conditions and performance criteria.

Figure 4: Forklift & multiple Pallets
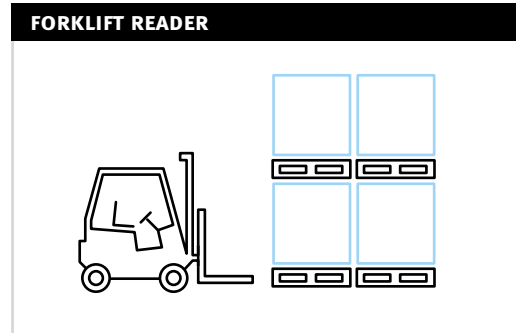
FORKLIFT READER

Conditions, considerations, and presumptions
a) Proximity of other tagged pallets nearby or could be in the forklift's reader field of reading
b) Type of items on pallet, i.e., paper or all metallic, or something "between" with gaps between metallic items
c) Forklift electrical and make/break noise
d) Wireless LAN transceiver on forklift
e) Establishment of standard pallet size or sizes
f) What are users expectations for reading cases and items as loaded on pallets?
g) End user's expectations on reading accuracy and ability to tolerate less-than-perfect reading performance.
h) Other considerations?

7. CONVEYOR READER

Benchmark performance objective:
Be able to read all cases on roller and belt convery-types for given sets of conditions and performance criteria.

Figure 5:
A) Roller-type conveyor,
B) Belt-type conveyor,
C) Item orientation on conveyor

Figure 6:
– Size envelope for items on conveyor

CONVEYOR TYPES & ITEM ORIENTATION

A)

B)

C)

READING ENVELOPE OVER CONVEYOR
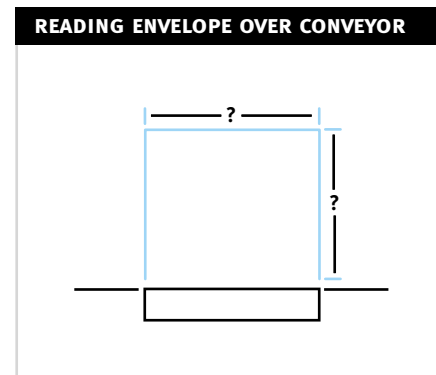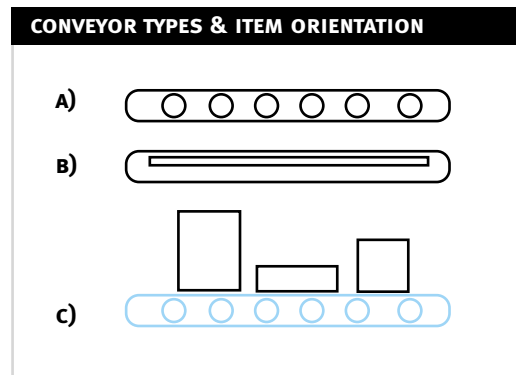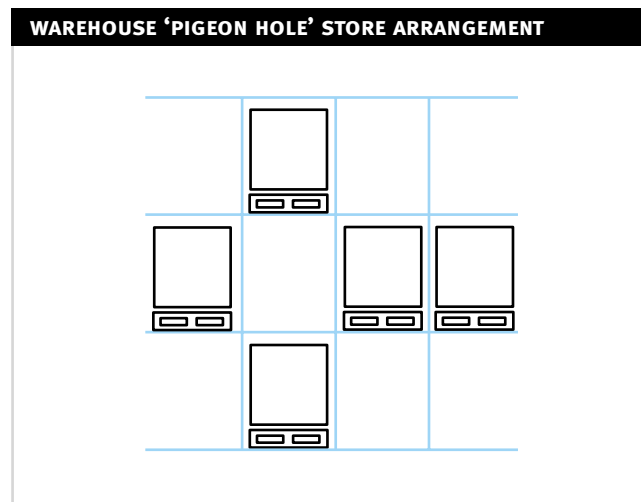
Conditions, considerations, and presumptions
a) Definition of conveyor parameters (Figures 5a & 5b), i.e., roller size and spacing, conveyor width, height reading range above conveyor, belt material, speed(s)
b) User expectations for item alignment and orientation on conveyor (uniform or zero spacing, uniform or haphazard orientation, stacking (Figures 5c & 6)
c) LAN wireless equipment and other sources of RF interference
d) Equipment electrical and make/break noise, spurious RF interference
e) End user's expectations on reading accuracy and ability to tolerate less-than-perfect reading performance.
f) Other considerations?

8. PIGEON HOLE READER

Benchmark performance objective:
Be able to determine inventory status of palletized goods stored in warehouse pigeon holes for a given set of conditions and performance criteria.

Figure 7: Pigeon hole storage

WAREHOUSE 'PIGEON HOLE' STORE ARRANGEMENT

Conditions, considerations, and presumptions
a) Proximity of other tagged pallets in adjacent pigeon holes
b) Type of items on pallet, i.e., paper or all metallic, or something "between" with gaps between metallic items
c) Forklift electrical and make/break noise
d) Wireless LAN transceiver on forklift
e) LAN wireless equipment and other sources of RF interference
f) End user's expectations on reading accuracy and ability to tolerate less-than-perfect reading performance.
g) Other operational considerations?

h) Alternative pigeon hole identification scenarios for consideration…

1. Readers in each pigeon hole to read pallet ID only…
Each pigeon hole is reader equipped to read only tagged pallets such that the pigeon holes could be remotely polled or read on demand. Inventory on pallet would likely be in the host database, i.e., in a look-up table. The readers could be hard wired or wireless.

2. Readers in each pigeon hole reading pallets & pallet contents…
Each pigeon hole reader equipped such that inventory on pallets could be read.
COMMENT: This is likely to be difficult and require costlier readers.

3. RFID tag attached to each pigeon hole to ID location (reader on forklift)…
Each pigeon hole has an RFID tag attached such that the forklift reads that location simultaneously when placing or removing a tagged pallet, thereby providing pigeon hole content, status, and activity.
COMMENT: This could be a simpler, lower cost solution for pigeon hole identification, but involves a more involved reader or readers for the forklift. The forklift needs to read pallet tags and pigeon hole location tags.

4. RFID tag attached to each pigeon hole plus RFID tags embedded in the warehouse floor…
In an extension of III above, RFID tags would also be installed in the warehouse floor such that the forklift passing over a tag would have its location identified. Thereby, a pallet location in a warehouse could be established in conjunction with the forklift's pallet drop off or pick-up activity. Again, the forklift reader or readers are more involved. The fork lift needs to read the pallet tag, pigeon hole location tag, and a floor location tag.

10. HANDHELD READER

NB. At the time of writing, this reader type is being presented as likely to be useful and needed by the retail industry.
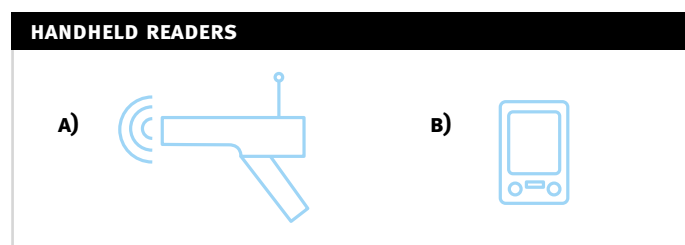
Benchmark performance objective:
Read pallets, cases, and/or unit level items using a handheld device for given sets of conditions and performance criteria.

Conditions, considerations, and presumptions
a) Wireless and/or tethered
b) Read range expectations
c) Ruggedness expectations
i) End user's expectations on reading accuracy and ability to tolerate less-than-perfect reading performance.
d) Other considerations?

Figure 8:
A) Pistol-type reader
B) PDA-type reader

HANDHELD READERS

A)   B)

11. SHELF READER

Benchmark performance objectives:

1) Inventory control of multiple, stationary items on display
2) Sensing and detection of item removal such that item quantity could be used for inventory replenishment and/or security (for example, detect unusual, high quantity removal of high value items)

Figure 9:
A) Display box
B) Display shelf
C) Pegboard display
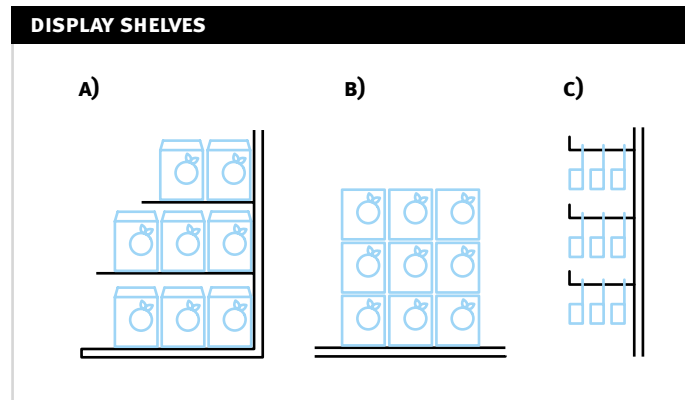
DISPLAY SHELVES

A)   B)   C)

Conditions, considerations, and presumptions
a) Determine if consortium members have a need for reader types depicted in Figures 9a, 9b & 9c.
b) If yes, determine product types, application(s), and users expectations.
c) End user's expectations on reading accuracy and ability to tolerate less-than-perfect reading performance.
d) Other considerations?

12. CHECKOUT READER

Benchmark performance objective:
Provide checkout counter reading capability for a given set of conditions and performance criteria to complete the supply chain management cycle to the consumer.

Conditions, considerations, and presumptions
a) Determine if consortium members have a need for reader types depicted in Figures 9a, 9b & 9c.
b) If yes, determine product types, application(s), and users expectations.
c) End user's expectations on reading accuracy and ability to tolerate less-than-perfect reading performance
d) Other considerations?

Legend:

- Conveyor Reader
- Pallet Reader
- Forklift Reader
- Shelf Reader
- Shopping Cart Reader
- Checkout Counter Reader

A = PHASE 1
B = PHASE 2

1. apply tag to individual products, labels, pallets, pkgng mat'l
2. conveyor reader for cases
3. aggragation of items in case lots
4. read empty pallets
5. read re-useable tray on pallet
6. read loaded pallet at exit door (stationary/portal reader)
7. read loaded pallet on forklift
8. aggragation of cases on pallets
9. conveyor read for cases
10. read cases on pallet (?)
11. read loaded pallet at exit door (stationary/portal reader)"
12. read loaded pallet on forklift
13. read pallet at receiving door
14. read case on conveyor
15. aggragation of pallet
16. read loaded pallet at exit door (stationary/portal reader)"
17. read loaded pallet on forklift
18. read loaded pallet at receiving (stationary/portal reader)"
19. read loaded pallet on forklift
20. Indoor pallet read (Silvio – explanation?)"
21. combined pallet & case reader (retailer floor)
22. Unload cases and read
23. Read cases (portal?) (move from back room to retail floor)
24. Read pallets &/or reuseable containers at exit door
25. Shelf reader
26. Shopping cart reader
27. Checkout counter reader

	MFGR'S FACTORY						MFGR'S CENTER					RETAILER'S DIST. CENTER					RETAILER									
---	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
ENDUSER																											
P&G (MFGR) Camp Girardeau, MO						A																					
GILLETTE Chicago, IL								B			A																
UNILEVER Baltimore, MD								B			A																
J&J Olive Branch, MS								B			B																
P&G (Dist. Center) Iowa City, IA																											
KRAFT FOODS Ft. Worth, TX																											
COCA COLA Little Rock, AK			B		B		B		B																		
SAM'S CLUB DC Kansas City, MO													B			B	B										
PILOT TEST FACILITY Bentonville, AK													B			B	B										
WALM MART DC Bentonville, AK															B	B											
SAM'S CLUB Tulsa, OK																		A	B	B			B	A			
WAL-MART Broken Arrow, OK																		B			B			B			
CHEP																											
INTERN. PAPER																											
WESTVACO																											
YUEN FOONG YU																											
DAI NIPPON PRINT.																											
KIMBERLY CLARK																											