2010 Reader Benchmark for Apparel

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Executive Summary

RFID Global Solution, Inc. recently completed comprehensive testing of 3 of the leading UHF passive RFID readers. The readers that were tested were the Motorola FX7400, Impinj Speedway Revolution, and the Alien 9900+. The following document provides detailed analysis of the testing that was conducted and the results that we found. This testing was a follow-up of testing that we completed in October of 2009. When we did the original tests in October 2009 testing we were working with initial release firmware versions for all three vendors. While overall we were impressed with the results from all three vendors, we did see some issues/ limitations of the first release units and we elected to hold off on publishing until follow-up firmware was released.

Our test use cases were designed to model the accuracy of the RFID readers in the fast growing application of item level retail apparel. We used this application since its use cases are very well defined, the application is heavily dependent on reader performance given the volumes of items tagged, and the products being tagged are RF friendly which eliminates other interferences. We felt these factors would best test the reader's performance and the ability to solve this application. Unlike some product benchmarks, we wanted to simulate the real world application, as a customer would experience it rather than lab testing the hardware from an engineering perspective.

The results were very impressive for all three vendors and it's our conclusion that near 100% accuracy is achievable by all three readers. In our original test plan we model the use cases up to 100 items which all readers achieved 100%. As a result we expand our use case testing to increase the volume up to 200 items and still experienced near 100% accuracy. In comparison with our test from 2009, the Motorola FX7400 1.1 firmware release had marked improvement in performance over its initial 1.0 release.

In our retail item level apparel testing we covered the following use cases & their respective results:

- Point of Sale - 100% accurate with all readers
- Impact Door - 100% accurate with all readers
- Fitting Room - 100% accurate with all readers
- Front Door (Entry /Exit doors) - 100% accurate with all readers
- Shipping/Receiving Doors - 100% accurate with all readers with Gen 2 optimization & making sure no metal interference of the tag performance
- Tagging and Commissioning Station - 100% accurate with all readers

We did identify a number of points that customers should consider when deploying RFID for the item level retail application:

1. Most, if not all missed tags were attributed to either the tag being in close proximity to metal object (thereby shorting their performance) or by using the wrong Gen 2 protocol settings.

2. Selection of proper RFID antennas for your application made a noticeable difference in the results. For example we tested the Motorola FX7400 in an early release of the Jamison Strip Portal and found those to perform much less than the FX7400

using standard circular polarized, 6 dBi gain antennas. [Note: We understand that Jamison is replacing its antennas to improve the strip performance].

In fact we tested other all-in-one portal solutions (Impinj & Jamison) and saw no improvement over a standard portal with 6 dBi gain antennas. In some use cases we saw slight less performance. Our advice on this would be to look at prepackaged portals if your seeking convenience of install versus expecting any better performance of the application.

3. At 150 items all readers performed slightly less than 100% with their default reader configurations. However we saw noticeable improvements in performance after optimizing the Gen 2 mode of operation.

In summary we found that all three readers performed near 100% accurate and it is our belief that this application is primed to benefit greatly from RFID over the next 12 months. With that said selecting the right integration partner is still important to guide you to selecting the right RFID tags, designing a proper portals with the right antennas, and optimizing the readers to meet the use case requirements for this application.

1. Use-Case Definition

The following 6 use-cases define the "typical" application of RFID in item level retail apparel in-store implementations using *new* fixed RFID readers. These use-cases will serve as the test scenarios for benchmarking each of the vendors supplied fixed readers.

Common across all use-case testing will be the following:

- **RFID Tag:** Avery 826 Inlay using Monza 3 IC
- **Product:** A mix of soft apparel items, such as T-Shirts, shorts, pants, jeans, etc.
- **Fixed reader configuration settings:** As supplied by each reader vendor and optimized for each use-case to provide the best performance for each use-case.
- **Fixed reader antenna(s):** As supplied by each reader vendor for each use-case to provide optimized coverage for each use-case. In addition to the vendor supplied antennas, some use-cases may also test other third party antenna solutions.
- **Software:** The software supplied with each vendor's reader will be used to configure the reader and test each reader for each use case. Any configuration parameters, filtering algorithms, reader operational modes, etc. should be accessible and configurable through the vendor supplied software application.

1.1. Receiving (Shipping) Door

Business Value:
In Bound Goods Receipt – confirming the receipt of expected items, reducing costs associated with labor and shortages/overages, and providing an electronic proof of delivery. Validate received goods against an electronic Advanced Shipping Notice (ASN) and speed the collection and movement of goods from receipt to the floor. (Though not planned for testing under this use-case, also serves as Out Bound Goods confirmation – for return of product to manufacture, store transfer or recall, again with ASN validation, and identifying/reducing employee shrink.)

Use-Case Description:
This use-case scenario will represent a typical portal application reading item level tags and testing two common door sizes: a standard exterior door (approx. 80" H x 36" W) and a standard dock door (approx. 8ft. H x 8ft. W). The items will be in corrugated cardboard boxes and/or shipping pouches with the items and RFID tags in a random orientation. The items will pass through the portals in two configurations:

- The items will be hand carried, at a normal walking pace, through the portal and will contain from 3 to 50 items in both shipping pouches and boxes with the items and RFID tags in a random orientation,
- The items will be in up to 3 boxes on a hand truck and will contain from 20 to 100 tagged items.
- Note: Later we added more items and test at 150 & 200 items respectively for this use case.

The indication of tag direction by the reader is preferable, but not required.

RFID Tagged Apparel Items: See notes above.

Read Zone: Portal, approx. 80" H x 36" W and 8 ft. H x 8 ft. W

1.2. Transition/Impact Door (Stockroom to Sales Floor)

Business Value:
Provides increased visibility into inventory location; segregating the inventory into backroom inventory and sales floor inventory. This read point tracks inventory moving from backroom to sales floor (or conversely from sales floor to backroom) providing this visibility. This read point also ensures a 100% correct fill process during replenishment and aids in identifying sources of shrink (front of store or backroom).

Use-Case Description:
This use-case scenario will represent a typical portal application using an opening approximately the width of a standard interior door (approx. 80" H x 36" W) and reading RFID tagged apparel items and shoes. The items will pass through the portal in two configurations:

- The items will be hand carried, at a normal walking pace, through the portal and will contain from 5 to 20 items loosely stacked with the items and RFID tags in a random orientation,
- The items will be on plastic hangers and hung on a metal clothing rack that is pushed through the portal at a normal walking pace. The clothing rack will contain 50 to 100 items.
- 150~200 apparel items will be in a bakers rack (pre-folded) moving through the portal

There will be RFID tagged apparel items immediately outside the marked read zone area at a distance of 3 feet (in close proximity), which should not be read to ensure an equivalence of sales floor merchandise not being read from the transition door reader

The indication of tag direction by the reader is preferable, but not required.

RFID Tagged Apparel Items: See notes above.

Read Zone: Portal, approx. 80" H x 36" W

1.3. Point of Sale (POS)

Business Value: The RFID enabled POS read point enables faster and more efficient checkout, changing inventory from sales floor inventory status to sold status. It serves to verify each sale and initiate auto-replenishment or auto-order activities. By using the POS read point to decrement the sold items from inventory, the retailer can reconcile remaining on-hand inventory with expected inventory for determining shrink and aiding in loss prevention. There is also loss prevention value in handling returns with an RFID enabled POS.

Use-Case Description: This use-case scenario will represent a typical retailer POS counter. With counter space typically limited, the read zone will be a 1 cubic foot area (1' L x 1' W x 1' H) marked on the counter. Item(s) will be placed on or passed through the read zone using several different methods:

- Passing items through the read zone on the counter, 1 item at a time, with a random tag orientation.
- Stacking items one at a time onto the read zone, 5 to 20 items, stacked loosely, with a random tag orientation.
- Optional: Placing items on the read zone on the counter all at once, 5 to 20 items, stacked loosely, with a random tag orientation.

Ideally all the tagged items will be read on the first pass or placement on the table, however, the user will be able to move or rotate the items if needed.

The reader antenna can be mounted below the table, above the table or if a pad, directly on the designated read zone. The antenna must provide a tightly defined and accurate RF read zone. There will be RFID tagged apparel items immediately outside the marked read zone area, which should not be read, or if they are read should be clearly identified by the reader as undesired

tag reads allowing an application to easily filter them out. The primary purpose of this use-case is to read only the desired tags without reading any undesired tags with 100% accuracy.

RFID Tagged Apparel Items: See notes above.

Read Zone: 1 cubic foot area (1' L x 1' W x 1' H) marked on the counter.

1.4. Fitting Rooms

Business Value: Tracks product in and out of the fitting room identifying trends and conversion rates: Fitting Room to POS, Fitting Room to Exit, and Fitting Room to Sales Floor (non-sale). Provides historical data for merchandisers and sales team and offers cross/up sell opportunities.

Use-Case Description: This use-case scenario will represent a typical retailer fitting room area; an enclosed area with a portal at the doorway the width of a standard door (approx. 80" H x 36" W). RFID tagged apparel items (5 to 10 items) will be hand carried (at a normal walking pace) through the door opening into the fitting room. The goal is to read the tagged items as they pass into and out of the fitting room, the tagged items do not need to be read continuously while in the fitting room. The indication of tag direction by the reader is preferable, but not required.

The portal antenna(s) must provide a relatively tightly defined and accurate RF read zone. There will be RFID tagged apparel items in adjacent fitting rooms and passing through adjacent fitting room doorways, which should not be read, or if they are read should be clearly identified by the reader as undesired tag reads allowing an application to easily filter them out.

RFID Tagged Apparel Items: 5 to 10 items, with a random tag orientation.

Read Zone: Portal, approx. 80" H x 36" W

1.5. Front of Store Exits/Entries

Business Value: Capture the unique identifier (EPC number) of the tags that pass through the doorway to ensure complete inventory visibility, updating the database to reflect the items are no longer in the store and mark them for sales floor replenishment. This read point may also be used as a receiving location depending upon the retailer's store operations and location (mall vs. standalone). (Though not planned for testing under this use-case, also serves to extend EAS capability by identifying the exact item(s) moving through the read point for Loss Prevention and identification of shrink.)

Use-Case Description: This use-case scenario will represent a typical portal application using an opening approximately the width of two standard interior doors (approx. 80" H x 72" W) and reading RFID tagged apparel items. In evaluating the ability to capture items as they leave the store, the items will first pass through the portal in the following configuration:

- The items will be loosely stacked with the items and RFID tags in a random orientation. The items will be hand carried (at normal walking pace) in a typical shopping bag / gift box through the opening and will contain from 5 to 20 items.

To validate the in-bound receiving functions, the items will next pass through the portal as follows. The items will be in corrugated cardboard boxes and/or shipping pouches with the items and RFID tags in a random orientation. The items will pass through the portal in two configurations:

- The items will be hand carried, at a normal walking pace, through the portal and will contain from 3 to 50 items in both shipping pouches and boxes with the items and RFID tags in a random orientation,
- The items will be in up to 3 boxes on a hand truck and will contain from 20 to 100 tagged items.

The indication of tag direction by the reader is preferable, but not required.

RFID Tagged Apparel Items: See notes above.

Read Zone: Portal, approx. 80" H x 72 W"

1.6. Tagging/Commissioning Station, Receiving Station, Prep Station

Business Value: Several use-cases are covered in this test, each using a similar read point configuration, an RFID enabled table. In the Tagging/Commissioning use-case, an RFID tag is encoded with a unique identifier and this identifier is associated with the item's Price Lookup Label (SKU) in a database. This is normally done at manufacturing, but is required in-store for exception handling cases, like re-ticketing of returned items or items with damaged tags. In place of the Receiving Door use-case defined above, some retailers receive inbound items using a Receiving Station. This provides similar business benefits described in the Receiving Door use-case, however the Receiving Station provides the added benefit of allowing the store employee to perform the unpacking, item inspection and inventory prep during the receiving process, correcting any exceptions (shortages, overages, miss-shipments, etc.) immediately. However, a drawback to the Receiving Station approach is the inability to detect theft through the back door (unless, of course, a separate RFID portal is installed at the door exclusively for this purpose). Another use-case employing an RFID enabled table is the Prep Station. This station is used to identify items required for replenishment, prepare the items for display on the store floor and ensure the correct fill/replenishment process.

Use-Case Description:
As described in the Business Value section above, this test will cover several use-cases – all sharing similar requirements. A table with a 1 cubic foot read zone (1' L x 1' W x 1' H and identified by a 1 ft. square area on the table) will serve as the test setup. Item(s) will be passed through the read zone using several different methods:

- Placing items on the read zone on the table all at once, 3 to 50 items, stacked loosely or in cardboard box or shipping pouch, with a random tag orientation.
- Stacking items one at a time onto the read zone, totaling 3 to 20 items, stacked loosely, with a random tag orientation.

Ideally all the tagged items will be read on the first pass or placement on the table, however, the user will be able to move or rotate the items if needed.

The reader antenna can be mounted below the table, above the table or if a pad, directly on the designated read zone. A distance of 6 inches on each side of the read zone will be marked as a clear area that will not contain any RFID tagged apparel items. There will be RFID tagged apparel items outside of this clear area, which should not be read, or if they are read, should be clearly identified by the reader as undesired tag reads allowing an application to easily filter them out.

RFID Tagged Apparel Items: See notes above.

Read Zone: 1 cubic foot area (1' L x 1' W x 1' H) marked on the table.

2. Test Plan

Based on the use-cases defined above, the following test plan will benchmark each vendor's reader in each use-case using the metrics below:

Benchmark Metrics

Metric	Ranked By
Out-Of-Box Experience	Rated 0 to 5, 5 being best
Aesthetics	Rated 0 to 5, 5 being best
Feature Set	Rated 0 to 5, 5 being best
Service & Support	Rated 0 to 5, 5 being best
Hardware Cost (List Price)	Total Cost $
Use-Case Performance*	Unique Tag Read %

* Performance metric will be evaluated for each specific use-case.

2.1. Non Use-Case Evaluations

The following five metrics are evaluated on an overall basis and are not use-case specific.

2.1.1. Out-Of-Box Experience

For evaluating the Out-Of-Box Experience, it is assumed the user has a general knowledge of RFID, some RFID installation experience and a working knowledge of PCs and Windows based software installation and operation. The criteria used for evaluating the Out-Of-Box Experience are listed below.

Out-Of-Box Experience

Reader Criteria	Alien 9900+	Impinj Speedway Revolution	Motorola FX7400	Comments
All required components in box(s).	5	5	5	Yes, professional delivery on all vendors
Documentation included	5	5	5	CD and/ or web site for all vendors
Reader setup	5	5	5	Easy instructions & setup for all
Reader configuration	5	3	5	We found that Impinj Reader Configuration is not web based and is difficult to configure for the normal user.
Software installation	5	5	5	Easy & without issues for all vendors
Software operation	5	4	3	Motorola Showcase II demo software crashed and was not very well liked by our engineering team
Overall	5	4	4	

* Rating: 0 to 5, 5 being best.

2.1.2. Aesthetics

When implementing technology within retail store environments, aesthetics are an important factor, ideally the technology becomes invisible to the consumer. Many of the use cases required for item level RFID, require the RFID technology to be in the front of the store and

therefore require special attention to the overall solution aesthetics. The criteria used for evaluating the Aesthetics are listed below.

Aesthetics				
Criteria	**Alien**	**Impinj**	**Motorola**	**Comments**
Reader	9900+	Speedway Revolution	FX7400	While all readers have a small form factor, the FX7400 aesthetics was most suited for retail in store floor environment. The Alien and Impinj readers were well suited for back of store.
Front of store install	3	3	5	
Back of store install	5	5	4	
Overall	4	4	4.5	

* Rating: 0 to 5, 5 being best.

2.1.3. Feature Set

In addition to the basic function of reading RFID tags, today's readers offer a variety of additional features. The chart below lists the features for each vendor's reader, providing a side-by-side comparison.

Feature Set				
Feature	**Alien 9900+**	**Impinj Speedway Revolution**	**Motorola FX7400**	**Comments**
Web based interface	x		x	
Gen 2 Protocol Control	x	x	x	All readers have mature gen 2 protocol optimization. Impinj had more advanced auto configure for the novice.
Power over Ethernet		x	x	We view this as a key feature to keep install costs down.
Port Options		x	x	2 & 4 port configurations help to keep costs down for the overall deployment.
Data Output options	x			Alien has the most robust options for outputting data that simplifies collection.
Overall	3	3	4	

* Rating: x = has it while blank does not; 0 to 5, 5 being best.

Motorola FX7400 and Impinj Speedway Revolution readers support Power over Ethernet (POE) connectivity that is important as it simplifies deployment, eliminating the need for AC outlet installation at read points, and saving substantial cost up to $1000 in potential deployments. Motorola FX7400 reader is also plenum rated which can further simplify and reduce the deployment complexity for many installations when operating the reader in airtight spaces such as above a false ceiling.

2.1.4. Service & Support

An important factor in deploying RFID technology in hundreds to thousands of store locations is the Service and Support offered by each reader vendor when things go wrong. Each vendor's service and support options are evaluated and rated below.

Service & Support				
Reader Criteria	Alien 9900+	Impinj Speedway Revolution	Motorola FX7400	Comments
Service Offerings	5	N/A	5	The Alien RMA process is sufficient; the repair turnaround time is the worst in the industry.
Support Options	5	N/A	5	The Impinj reader has never had to be serviced.
Overall	3	N/A	5	Motorola has one of the best RMA processes with a best turnaround time.

* Rating: 0 to 5, 5 being best.

2.1.5. List Price of Readers

The table below lists manufacturer's suggested retail price (MSRP). You can often get better pricing through your distributor or systems integrator; especially if you have significant unit volume.

List Price, MSRP				
Reader Criteria	Alien 9900+	Impinj Speedway Revolution	Motorola FX7400	Comments
List Price	$2199	$1585	$1285	Price is for 4 antenna port readers. Alien reader includes power supply while Impinj and Motorola sell power supplies separately because they use power over Ethernet.

The Motorola FX7400 falls in the lowest MSRP price range at $1,285. If you were deploying a large number of fixed readers, this difference could be material. From our test results, you will also note that there is not a clear correlation between price and performance as all readers excelled on multiple performance tests. While price and performance should not be the only considerations, the Motorola FX7400 leads with an excellent price/performance to enable the Apparel application, as well as other similar applications.

2.2. Preliminary Test Setup:

Prior to performing any use-case testing, the following will be done in preparation and for consistency for all following use-case specific testing.

- Tag Normalization
- Apply tags to all items in a consistent manner across all apparel types.
- RF Site Survey for test lab to validate no RF interference. Additional RF interference monitoring will occur during all testing as well to insure no RF interference is introduced during testing.

2.3. Use-Case Testing

Each use-case will have its own set of test procedures as defined below. To maintain consistency in testing and to minimize the time required to prepare the tagged items for each test, recommend testing each use-case with all readers and performing the use-case testing in the order listed in the table below.

		Apparel Item Test Configurations										
		Boxes			Pouches			Loosely Stacked/Hung/Bagged			Clothing Rack	
		A	B	C	A	B	C	A	B	C	A	B
#	Use-Case Items	20	30	50	3	5	10	5	10	20	50	100
1	Receiving Door	x	x	x	x	x	x					
2	Exit/Entry Door	x	x	x	x	x	x	x	x	x		
3	Tag Comm, Receiving, Prep Station	x	x	x	x	x	x	x	x	x		
4	POS							x	x	x		
5	Fitting Rooms							x	x			
6	Impact/Transition							x	x	x	x	x

2.3.1. Receiving (Shipping) Door

Item Tagging Preparation
Prepare tagged items for both of the following test scenarios.

- Prepare 3 boxes of tagged items (20, 30 and 50 items respectively),
- Prepare 3 shipping pouches of tagged items (3, 5 and 10 items respectively).

Test Scenario #1: Standard Exterior Door Portal

Test Setup:

- Configure a portal covering a doorway 36” wide x 80” high using the vendor’s recommended antenna(s) and reader. Insure the antenna(s) do not interfere with the flow of traffic through the doorway and represents a realistic implementation for a retail store. Designate a direction for the portal indicating the “Entry” direction, vs. the “Exit” direction.
- Configure the reader per the vendor’s recommended configuration for this use-case.
- Perform several test passes to establish a baseline.

Test Procedure:
Following each step below, record the percentage of unique tag reads in the chart below under Test Data:

- Hand-carry, at a normal walking pace, Pouch A through the portal in the “Entry” direction, repeat 10 times, recording the results after each pass.
- Repeat the above using Pouches B and C.
- Hand-carry, at a normal walking pace, Pouches A, B & C through the portal in the “Entry” direction, repeat 10 times, recording the results after each pass.
- Hand-carry, at a normal walking pace, Pouches A, B, C & Box A through the portal in the “Entry” direction, repeat 10 times, recording the results after each pass.
- Repeat the above substituting Boxes B and C for Box A.
- Using a hand truck, at a normal walking pace, carry Box A through the portal in the “Entry” direction, repeat 10 times, recording the results after each pass.
- Repeat the above using Boxes B and C.
- Using a hand truck, at a normal walking pace, carry Box A, B & C through the portal in the “Entry” direction, repeat 10 times, recording the results after each pass.

Test Data – Test Scenario #1:

Recorded test data on separate spreadsheet.

Receiving (Shipping) Door 36"Wx80"L Test Scenario #1: Pouches	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

Receiving (Shipping) Door Test Scenario #1: Pouches & Boxes	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

Receiving (Shipping) Door Test Scenario #1: Boxes on Hand-Truck	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

Receiving (Shipping) Door Test Scenario #2: Pouches	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

Receiving (Shipping) Door Test Scenario #2: Pouches & Boxes	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

Receiving (Shipping) Door Test Scenario #2: Boxes on Hand-Truck

Reader	Comments
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

Test Scenario #2: Standard Dock Door Portal

Test Setup:

- Configure a portal covering a doorway 96” wide x 96” high using the vendor’s recommended antenna(s) and reader. Insure the antenna(s) do not interfere with the flow of traffic through the dock door and represents a realistic implementation for a retail store receiving dock door. Designate a direction for the portal indicating the “Entry” direction, vs. the “Exit” direction.
- Configure the reader per the vendor’s recommended configuration for this use-case.
- Perform several test passes to establish a baseline.

Test Procedure:

Following each step below, record the percentage of unique tag reads in the chart below under Test Data:

- Hand-carry, at a normal walking pace, Pouch A through the portal in the “Entry” direction, repeat 10 times, recording the results after each pass.
- Repeat the above using Pouches B and C.
- Hand-carry, at a normal walking pace, Pouches A, B & C through the portal in the “Entry” direction, repeat 10 times, recording the results after each pass.
- Hand-carry, at a normal walking pace, Pouches A, B, C & Box A through the portal in the “Entry” direction, repeat 10 times, recording the results after each pass.
- Repeat the above substituting Boxes B and C for Box A.
- Using a hand truck, at a normal walking pace, carry Box A through the portal in the “Entry” direction, repeat 10 times, recording the results after each pass.
- Repeat the above using Boxes B and C.
- Using a hand truck, at a normal walking pace, carry Box A, B & C through the portal in the “Entry” direction, repeat 10 times, recording the results after each pass.

Test Data – Test Scenario #2:
Recorded test data on separate spreadsheet.

Receiving (Shipping) Door Test Scenario #1: Pouches	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

Receiving (Shipping) Door Test Scenario #1: Pouches & Boxes	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

Receiving (Shipping) Door Test Scenario #1: Boxes on Hand-Truck	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

Receiving (Shipping) Dock Door 96"x96" Test Scenario #2: Pouches	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

Receiving (Shipping) Door Test Scenario #2: Pouches & Boxes	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

Receiving (Shipping) Door Test Scenario #2: Boxes on Hand-Truck	
Reader	**Comments**
Alien 9900+	No Missed Tags

Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

Due to all readers performing virtually the same, RFID Global Solution administered more testing with 150-tagged items in 3 corrugated boxes containing 50 items each and 200 items in 4 corrugated boxes. Below are the summary results with 200 tags run 10 times through the dock door:

- Alien 9900+: 100% accuracy (Never missed a tag)
- Impinj Speedway Revolution: 99.55% accuracy (missed 1 or 2 on several runs)
- Motorola FX7400: 99.95% accuracy (missed one tag and it was against the metal cart)

2.3.2. Front of Store Exits / Entries

Item Tagging Preparation
Prepare tagged items for the following test scenario.

- Use the prepared boxes of tagged items from the previous test.
- Use the prepared shipping pouches of tagged items from the previous test.
- Prepare 3 Bags of loosely stacked apparel items (5, 10 and 20 items respectively).

Test Scenario: Front of Store Exit / Entry Portal

Test Setup:

- Configure a portal covering a doorway 72" wide x 80" high using the vendor's recommended antenna(s) and reader. Insure the antenna(s) do not interfere with the flow of traffic through the doorway and represents a realistic implementation for a retail front of store entry. Designate a direction for the portal indicating the "Entry" direction, vs. the "Exit" direction.
- Configure the reader per the vendor's recommended configuration for this use-case.
- Perform several test passes to establish a baseline.

Test Procedure:
Following each step below, record the percentage of unique tag reads in the chart below under Test Data:

Front of Store Receiving (Inbound / Entry):

- Hand-carry, at a normal walking pace, Pouch A through the portal in the "Entry" direction, repeat 10 times, recording the results after each pass.
- Repeat the above using Pouches B and C.
- Hand-carry, at a normal walking pace, Pouches A, B & C through the portal in the "Entry" direction, repeat 10 times, recording the results after each pass.
- Hand-carry, at a normal walking pace, Pouches A, B, C & Box A through the portal in the "Entry" direction, repeat 10 times, recording the results after each pass.
- Repeat the above substituting Boxes B and C for Box A.
- Using a hand truck, at a normal walking pace, carry Box A through the portal in the "Entry" direction, repeat 10 times, recording the results after each pass.
- Repeat the above using Boxes B and C.
- Using a hand truck, at a normal walking pace, carry Box A, B & C through the portal in the "Entry" direction, repeat 10 times, recording the results after each pass.

Front of Store Inventory Visibility, Capturing Exiting Items (Outbound / Exit):

- Hand-carry, at a normal walking pace, Bag A through the portal in the "Exit" direction, repeat 10 times, recording the results after each pass.
- Repeat the above using Bags B and C.
- Hand-carry, at a normal walking pace, Bags A, B & C through the portal in the "Exit" direction, repeat 10 times, recording the results after each pass.

Test Data – Test Scenario: Front of Store Exit / Entry Portal

Recorded test data on separate spreadsheet.

Front of Store Exit / Entry Test Scenario: Receiving Pouches	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags
Front of Store Exit / Entry Test Scenario: Receiving Pouches & Boxes	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags
Front of Store Exit / Entry Test Scenario: Receiving Boxes on Hand-Truck	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags
Front of Store Exit / Entry Test Scenario: Inventory Visibility, Capturing Exiting Items	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

No further tests were needed.

2.3.3. Commissioning, Receiving and Prep Station

Item Tagging Preparation
Prepare tagged items for the following test scenario.

- Use the prepared boxes of tagged items from the previous test.
- Use the prepared shipping pouches of tagged items from the previous test.
- Remove the loosely stacked apparel items from the bags used in the previous test for use in this test.

Test Scenario: Commissioning, Receiving, Prep Station

Test Setup:

- Configure a table with a 1 cubic foot read zone, 1' L x 1' W x 1' H and identified by a 1 ft. square area on the table, using the vendor's recommended antenna(s) and reader. The reader antenna can be mounted below the table, above the table or if a pad, directly on the designated read zone. A distance of 6 inches on each side of the read zone should be marked as a clear area that will not contain any RFID tagged apparel items. Place RFID tagged apparel items immediately outside of this clear area. These tags should not be read, or if they are read, should be clearly identified by the reader as undesired tag reads allowing the vendor's supplied software application to easily filter them out. Insure the setup represents a realistic implementation for a retail backroom.
- Configure the reader per the vendor's recommended configuration for this use-case.
- Perform several test passes to establish a baseline.

Test Procedure:
Following each step below, record the percentage of unique tag reads in the chart below under Test Data:

Receiving Station:

- Place Pouch A on the table's marked read zone and initiate the read process, moving or rotating the Pouch until all items are read, but no longer than 10 seconds. Remove Pouch and repeat process 10 times, recording the results after each pass. In addition to recording the intended unique tag reads, record any undesired tag reads, as indicated by the "Stray Tags" column in the table below.
- Repeat the above using Pouches B and C.
- Place Box A on the table's marked read zone and initiate the read process, moving or rotating the Box until all items are read, but no longer than 5 seconds. Remove Box and repeat process 10 times, recording the results after each pass. In addition to recording the intended unique tag reads, record any undesired tag reads, as indicated by the "Stray Tags" column in the table below.
- Repeat the above using Boxes B and C.

Prep/Replenishment Station:

- Initiate the read process, place one item at a time from Stack A on the table's marked read zone, moving or rotating each item until read, but no longer than 2 seconds. Once all items are placed on the read zone, stop the read process and remove the Stack and repeat process 10 times, recording the results after each pass. In addition to recording the intended unique tag reads, record any undesired tag reads, as indicated by the "Stray Tags" column in the table below.
- Repeat the above using Stacks B and C.

Test Data – Test Scenario: Commissioning, Receiving, Prep Station

Recorded test data on separate spreadsheet.

Commissioning, Receiving, Prep Station Test Scenario: Receiving Pouches		
Reader	**Comments**	**Stray Tags**
Alien 9900 +	No Missed Tags	1
Impinj Speedway Revolution	No Missed Tags	None
Motorola FX7400	No Missed Tags	1
Commissioning, Receiving, Prep Station Test Scenario: Receiving Boxes		
Reader	**Comments**	**Stray Tags**
Alien 9900 +	99.80%	None
Impinj Speedway Revolution	96.40%	None
Motorola FX7400	95.80%	None
Commissioning, Receiving, Prep Station Test Scenario: Item Prep & Replenishment		
Reader	**Comments**	**Stray Tags**
Alien 9900 +	No Missed Tags	None
Impinj Speedway Revolution	No Missed Tags	None
Motorola FX7400	No Missed Tags	None

Due to all readers performing virtually the same, RFID Global Solution administered more testing with a different antenna. 50 Items in a Box

- Alien=99.60% accuracy
- Impinj=98.80% accuracy
- Motorola=98.80% accuracy

2.3.4. Point of Sale (POS)

Item Tagging Preparation
Prepare tagged items for the following test scenario.

- Use the prepared loosely stacked apparel items from the previous test.

Test Scenario: Commissioning, Receiving, Prep Station

Test Setup:

- Configure a table with a 1 cubic foot read zone, 1' L x 1' W x 1' H and identified by a 1 ft. square area on the table, using the vendor's recommended antenna(s) and reader. The reader antenna can be mounted below the table, above the table or if a pad, directly on the designated read zone. Place RFID tagged apparel items immediately outside of this marked read zone. These tags should not be read, or if they are read, should be clearly identified by the reader as undesired tag reads allowing the vendor's supplied software application to easily filter them out. Insure the setup represents a realistic implementation for a retail POS counter.
- Configure the reader per the vendor's recommended configuration for this use-case.
- Perform several test passes to establish a baseline.

Test Procedure:
Following each step below, record the percentage of unique tag reads in the chart below under Test Data:

Scanning Items

- Initiate the read process, pass one item at a time from Stack A through the read zone (as if scanning the item), placing the item down outside of the read zone. Once all items are "scanned", stop the read process and remove the Stack and repeat the process 10 times, recording the results after each pass. In addition to recording the intended unique tag reads, record any undesired tag reads, as indicated by the "x" column in the table below.
- Repeat the above using Stacks B and C.

Scanning into a Stack of items

- Initiate the read process, place one item at a time from Stack A on the table's marked read zone, moving or rotating each item until read, but no longer than 2 seconds. Once all items are placed on the read zone, stop the read process and remove the Stack and repeat process 10 times, recording the results after each pass. In addition to recording the intended unique tag reads, record any undesired tag reads, as indicated by the "Stray Tags" column in the table below.
- Repeat the above using Stacks B and C.

Scanning an entire Stack (Optional)

- Place Stack A on the table's marked read zone, initiate the read process, wait 5 seconds, stop the read process and remove the Stack and repeat process 10 times, recording the results after each pass. In addition to recording the intended unique tag reads, record any undesired tag reads, as indicated by the "Stray Tags" column in the table below.
- Repeat the above using Stacks B and C.

Test Data – Test Scenario: Point of Sale (POS)

Recorded test data on separate spreadsheet.

POS Test Scenario: Scanning Items		
Reader	**Comments**	**Stray Tags**
Alien 9900+	No Missed Tags	None
Impinj Speedway Revolution	No Missed Tags	None
Motorola FX7400	No Missed Tags	None

POS Test Scenario: Scanning Into a Stack of Items		
Reader	**Comments**	**Stray Tags**
Alien 9900+	99.00%	None
Impinj Speedway Revolution	95.00%	None
Motorola FX7400	100.00%	None

POS Test Scenario: Scanning an Entire Stack of Items		
Reader	**Comments**	**Stray Tags**
Alien 9900+	100.00%	None
Impinj Speedway Revolution	84.50%	None
Motorola FX7400	90.00%	None

Due to all readers performing virtually the same, RFID Global Solution administered more testing with a different antenna. All readers were able to read all tags with zero stray tags.

2.3.5. Fitting Room

Item Tagging Preparation
Prepare tagged items for the following test scenario.

- Use the prepared loosely stacked apparel items from the previous test.

Test Scenario: Fitting Room

Test Setup:

- Configure a portal covering a doorway 36” wide x 80” high using the vendor’s recommended antenna(s) and reader. Insure the antenna(s) do not interfere with the flow of traffic through the doorway and represents a realistic implementation for a retail fitting room. Designate a direction for the portal indicating the “Entry” direction, vs. the “Exit” direction. Place RFID tagged apparel items immediately adjacent to the portal, replicating apparel items in other adjacent fitting room doorways. These tags should not be read, or if they are read, should be clearly identified by the reader as undesired tag reads allowing the vendor’s supplied software application to easily filter them out.
- Configure the reader per the vendor’s recommended configuration for this use-case.
- Perform several test passes to establish a baseline.

Test Procedure:
Following each step below, record the percentage of unique tag reads in the chart below under Test Data:

- Hand-carry, at a normal walking pace, Stack A through the fitting room portal in the “Entry” direction. Recorded the unique tag reads along with any undesired tag reads in the associated “Stray Tags” column. Shuffle Stack of items and hand-carry back through the portal in the “Exit” direction. Record the unique tag reads in the “Stray Tags” column in the table below along with any undesired tag reads in the associated “Stray Tags” column. Repeat this “Entry/Exit” process 10 times, recording the results after each pass.
- Repeat the above using Stacks B and C.

Test Data – Test Scenario: Fitting Room

Recorded test data on separate spreadsheet.

Fitting Rooms Test Scenario: Scanning Items		
Reader	**Comments**	**Stray Tags**
Alien 9900+	No Missed Tags	None
Impinj Speedway Revolution	No Missed Tags	None
Motorola FX7400	No Missed Tags	None

No further tests were required.

2.3.6. Impact / Transition Door

Item Tagging Preparation
Prepare tagged items for the following test scenario.

- Use the prepared loosely stacked apparel items from the previous test.
- Prepare 2 metal clothing racks with apparel items on hangers (50 and 100 items respectively).

Test Scenario: Impact / Transition Door

Test Setup:

- Configure a portal covering a doorway or hallway 36" wide x 80" high using the vendor's recommended antenna(s) and reader. Insure the antenna(s) do not interfere with the flow of traffic through the doorway and represents a realistic implementation for a retail impact / transition door. Designate a direction for the portal indicating the "Store Floor" direction, vs. the "Backroom" direction.
- Configure the reader per the vendor's recommended configuration for this use-case.
- Perform several test passes to establish a baseline.

Test Procedure:
Following each step below, record the percentage of unique tag reads in the chart below under Test Data:

- Hand-carry at a normal walking pace, Stack A through the portal in the "Store Floor" direction, repeat 10 times, recording the results after each pass.
- Repeat the above using Stacks B and C.
- Using a clothing rack, at a normal walking pace, push Rack A through the portal in the "Store Floor" direction, repeat 10 times, recording the results after each pass.
- Repeat the above using Rack B.

Test Data – Test Scenario: Impact / Transition Door

Recorded test data on separate spreadsheet.

Impact / Transition Door Test Scenario: Small Store Replenishment	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags
Impact / Transition Door Test Scenario: Department Store Replenishment	
Reader	**Comments**
Alien 9900+	No Missed Tags
Impinj Speedway Revolution	No Missed Tags
Motorola FX7400	No Missed Tags

This concludes this test, additional testing was performed due to the close compatibility to all readers. The test has a red header and is marked "Retest"