Tag Guidance

# SHIPMENT VERIFICATION

## RAIN RFID TAG SELECTION GUIDANCE

Version 1.0

www.impinj.com

**This document provides Solutions Engineers in the Logistics Industry with information to enable their decisions when selecting RAIN RFID tags.** The document focuses on the management of Logistics and key capabilities of various tag designs that incorporate Impinj Monza chips, so that Solutions Engineers can select the best tag for their needs.

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# INTRODUCTION

Every day, shipments travel over long distances to ensure that right products are delivered at the right quantity, to the right location, and at the right time. Mis-shipments are extremely costly in both shipping expense, time spent, supply chain disruption and customer satisfaction. Logistics organizations need a cost-effective solution to ensure that packages are delivered in an efficient, timely and correct manner.

With RAIN RFID, logistics organizations can automate the tracking and management of important goods to improve efficiency and minimize the risk of mis-shipments.

Leveraging RAIN RFID with the full Impinj platform, from Impinj Monza chips and Impinj gateways to our ItemSense software, logistics operations can simply and reliably manage a wide variety of important and valuable assets.

This document introduces key information about tagging pallets, including importance of tag placement, and provides guidance for selecting tags. This document is not an exhaustive guide to available tags but rather an enabling document to help systems implementation teams and decision makers have a foundation for tag selection.

# BACKGROUND

Incorrect Shipments may occur even in the best supply chain, whether it's sending the incorrect items or quantity on the order, shipping product using the wrong shipping service level, or even shipping product to the wrong location. With the high volume of daily shipments occurring in typical logistics operations, mistakes are more common than expected.

Every erroneous pallet loaded in a trailer adds significant cost and time to the warehouse operation. In addition, every erroneous loading/unloading increases the chance of product damage with new material handling. The attempt to remedy mis-shipments adds customer service costs in arranging new shipments and incentive programs to offer compensation – not to mention the damage to customer satisfaction, which may either lead to lost revenue or corporate level involvement that takes away from the logistics core responsibilities.

Current barcode systems require manual intervention, costing time and money. Data delays and errors also occur with barcoding due to the human dependency. A fully automated shipment verification at the dock can drastically improve the speed of operation, potentially reducing all the mis-shipments caused by manual error. However, current solutions developed to address this challenge, relying on motion sensors or vision-based direction, lack the scalability and performance requirement for a large-scale deployment.

Shipment Verification with ItemSense Threshold Detection delivers the consistency and confidence that is required to realize the value of RAIN RFID in your business case. Shipment Verification not only takes out all manual elements of this tracking but eliminates the need for external triggers such as motion sensors to determine the direction of item movement through the dock door.

The core of Shipment Verification with ItemSense Threshold Detection is a proprietary event processing algorithm which looks at every individual RAIN RFID tag reads along with RF parameters to accurately determine the transition & direction of item(s) through the dock-door.

RAIN RFID tag choice is critical to a successful deployment. Impinj offers a range of endpoint ICs (sometimes called "tag chips") for many applications, and works with partners who manufacture a variety of tags to suit the endpoint and use case. This guide is an introduction to the tag selection process for Solutions Engineers working in the Logistics industry. Impinj, Inc. will work closely with all parties to assist in providing the best tag recommendation for a successful deployment.

# TAGGED ITEM CONSIDERATIONS

To ensure the proper RAIN RFID tag selected, it is important to identify a few key requirements for each item and how to use that information to find tag recommendations. These requirements consider both the actual tagged item system read performance and the environmental factors under which the tag will be used and include the following:

1. **Digital Identity:** The data requirements for the item, including product number, serial number, company information and, if needed, user memory. This digital identity is typically defined by standards such as GS1's Tag Data Standard and is stored in the Endpoint IC's Electronic Product Code (EPC) memory bank. It is used to uniquely identify the item. Common encoding standards in logistics include SSCC-96 for one-time shipments, SGTIN-96 for single item shipments, GIAI-96 for tracking individual assets and GRAI-96 for Returnable Transport Items (RTIs).
2. **RAIN RFID Features:** Use case specific feature requirements. For logistics, it is assumed that the EPC of the tags must be permanently lockable. For more information on perma-locking, consult the support article about Locking Memory on EPC RFID Tags[A].
3. **Item Read Performance:** This is the tagged item performance consideration, based on where the tagged item needs to be tracked and from how far away it should be read (e.g., wide coverage in hallway, moving through a portal/doorway; or close-range reading of product information with handheld reader). This will vary with the use case reader setup.
4. **Item Materials:** The materials the tagged item is made from, including the item surface where the tag is attached and surrounding materials such as internal circuitry; certain materials, like metal and liquid, will alter the RF environment.
5. **Region:** The geographic region(s) the tagged item will be used in; political geography determines the UHF band the tag will need to be tuned for. The frequency band used depends on the regulations for that region; for example, the FCC band (e.g. United States) versus the ETSI band (e.g. Europe).
6. **Labeling Requirements and Placement:** How the tag will be attached to the item; does it need a bar code; will it need to run through a printer; size and thickness
7. **Durability Considerations:** Environmental and durability considerations, such as a need to be treated with chemical disinfectants or be waterproof.

The first five requirements above pertain to the performance of the tag itself – the Monza IC, and its attached antenna. After the optimal base tag type (typically a bare aluminum antenna on PET with attached Monza IC known as an inlay) has been selected for performance, the tag can be 'finished' to meet durability needs, printing requirements and other form factor considerations. Finishing may include using industrial grade label adhesives or adding protective coating on to the tag. These durability considerations are industry specific – this is an important finished tag consideration which we mention in this document but do not attempt to specify.

## Performance and RFID Link Budget

The RFID system relies on exchange of power and information between the reader and the tag. The reader provides power and communicates with the tag over the RF link, and then the tag communicates back with its data by backscattering a signal back to the reader. All aspects of the communication must succeed for the RFID link to work.

The link budget is a calculation of all losses and gains of RF power level at each point in the system. It's useful to know how a link budget works, so you may select a tag with optimized performance. If a tag can use the RF power more efficiently when it receives a signal, then it will perform better once the system is deployed. For more information, you may read our white paper about RFID Link Budget[B].

### Material Detuning and AutoTune

The material construction of the tagged item will impact the read performance. Tags are tuned (or detuned) by the items on which they are placed – meaning they perform better or worse because of the physical characteristics of the item to which they are attached. Some tags are heavily optimized for specific types of items, which will give them *low* detuning tolerance. Other tags are designed for a wider range of materials and have better detuning tolerance – sometimes at the cost of peak performance.

Tags with a chip from the Monza 6 family can be optimized for a wider range of materials without compromising peak performance, due to Impinj's unique AutoTune™ feature which gives tags better detuning tolerance.

## Data Integrity and Integra

RAIN RFID uses the GS1 UHF Gen2 protocol, which defines the requirements for reliable communications over the RAIN radio link. While the protocol is inherently reliable, industries such as logistics demand consistently high data integrity.

Impinj's tag ICs include multiple layered data-integrity features ranging from excellent to exceptional, depending on the IC and feature implemented. All Monza ICs ensure excellent data integrity, including two-for-one redundancy built-in to the memory. Monza 6 family ICs have additional data integrity features as well. The brand name for this additional suite of data-integrity features is Integra™.

Monza ICs with Integra use hardware-based diagnostics, where the IC self-checks its memory at power up, and allows a RAIN RFID reader to perform additional data-integrity checks. That way, if a tag has compromised data, such as from physical damage, Integra allows the user to identify if the EPC is corrupted.

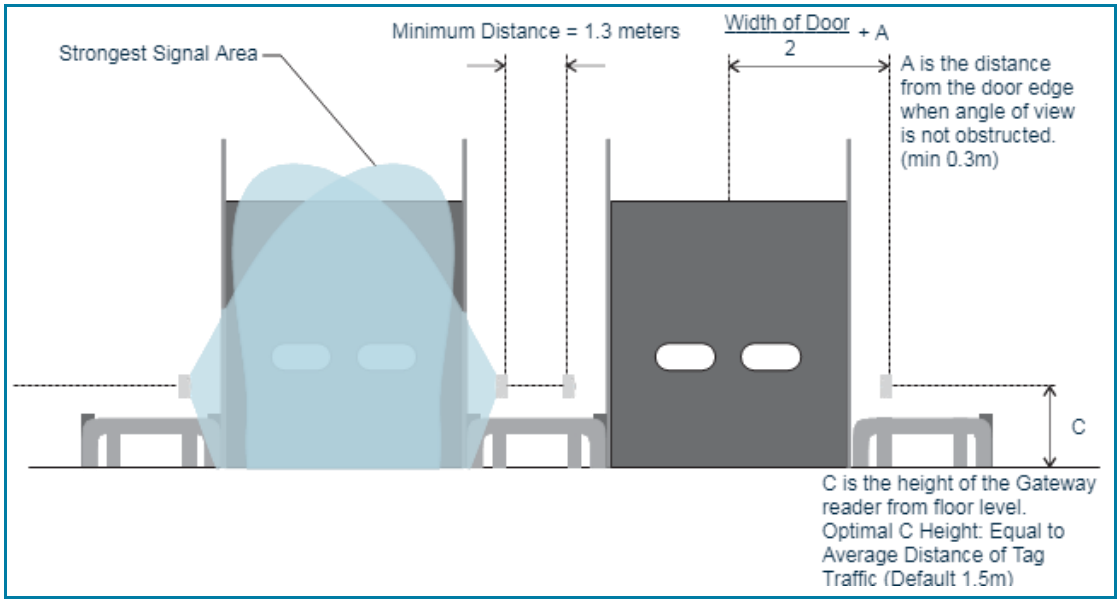
Relying on Integra, logistics professionals can build advanced business processes knowing that their RFID tags will deliver accurate, highly reliable data. For more information, you may read our Integra Overview[C].

# USE CASE SCENARIO

## Reader Setup: Side-By-Side

For this scenario, two Impinj Gateways are placed side-by-side at a dock door gate. Tagged pallets are read as they move between the readers, which can authenticate the pallet using the attached pallet tags and determine the direction of the pallets. For this scenario to be successful, the tags must be high performing to read at a long distance away. We have found success using Impinj Monza based tags optimized for the external item material, preferring Monza 6 family of tags or Monza 4 family utilizing True3D technology and with tag antennas measuring >60mm on at least one dimension. This enables a solid starting point for feasible tag options based on tagged item performance.

**Figure 1: Side-By-Side Setup**




*A typical dock door side-by-side reader setup, with recommended dimensions.*

## Endpoint: Wooden Pallet and Corrugated Boxes

One-time shipments generally contain trade items shipped in corrugated boxes attached to wooden pallets. For this item category, we will treat pallets loaded with multiple boxes and wrapped the same as ones containing only a single corrugated Gaylord box. Pallet load would be identified with Serial Shipping Container Code using the SSCC-96 encoding scheme identified in the GS1 EPCglobal Tag Data Standards. The following table details the item requirements for this endpoint to work well with a side-by-side reader setup.

**Table 1: Mapping Item Requirements to Tag Features – Wooden Pallet and Corrugated Boxes**

| CATEGORY | ITEM DETAILS | | TAG FEATURE DETAILS |
|---|---|---|---|
| | Need | Requirement | Capability |
| **Digital Identity** | Is there an existing encoding scheme? | GS1 EPC encoding scheme: SSCC-96 | 96-bit EPC (All Monza tag chips) |
| **RAIN RFID Features** | What RAIN RFID capabilities are needed? | EPC must be permanently locked after encoding | Gen2 permalock support (All Monza tag chips) |
| **Item Read Performance** | How does the item need to be tracked? | Side-by-side gateway system | >60mm tag antennas<br>Monza 6 dipole or Monza 4 with True3D |
| **Item Materials** | What material is the tagged item composed of? | External casing: corrugated board<br>Internal casing: varies with pallet load | Inlay design for use on corrugated board |
| **Region (Geographic)** | Optimized to Specific Region? | Tag used for a global supply chain | 860 – 960 MHz |
| **Labeling Requirements** | Does the use case need a printed label? Will the tag be pre-printed or printed as needed? | Printing and encoding done with RFID printer | Printable with RFID printer<br>A6 (101 mm x 25.4 mm) or 6 in x 4 in<br>Low profile label (<0.008 in thick or <0.2 mm) |
| | How will the tag be attached? | Self-adhesive label | |
| | Where will it be attached? | Label placement: one tag on each side; four tags total. See further details below. | |
| | How much space is available? | Finished label dimensions:<br>A6 (101 mm x 25.4 mm) or 6 in x 4 in<br>Low profile label (<0.008 in thick or <0.2 mm) | |
| **Durability Considerations** | What factors will the tagged item need to endure in this use case? | Industry specific durability requirements | Finished label must meet durability requirements. |

*[1]GS1 General Specifications outline labeling dimensions for this scenario with the SSCC barcode printed on the label. There is an additional larger size available; the same inlay may be used in either size label.*

From the requirements outlined above, we need a Monza 6 dipole or Monza 4 True3D tag antenna optimized for cardboard that is greater than 60mm on at least one side. The tag antenna must work globally (860 – 960 MHz). The finished label must be a self-adhesive, printable label capable of printing a barcode.

The industry specific durability requirements, after matching all other requirements above, must also be met by the tag supplier.

## Tag Options for Evaluation

Based on the item consideration above, the following list contains tag options for this scenario. These list is the name of the *inlay* (or tag antenna) that would be used in a finished label. The inlay will be smaller than the finished label size. Note that the tag options below are listed with the recommended tag chip but the inlays are available with other IC types for the given family of Monza tags (e.g., Monza 6 family includes Monza R6 and Monza R6-P).

**Table 2: Tag Options for Wooden Pallet and Corrugated Boxes**

| TAG DESCRIPTION | IMPINJ TAG IC | ENCODING SCHEME | ANTENNA DIMENSIONS (MM) | RAIN RFID FEATURES | | |
|---|---|---|---|---|---|---|
| | | | | LOCKABLE DATA | AUTOTUNE | INTEGRA |
| **SMARTRAC Belt R6** | Monza 6 family | SSCC-96 | 70 x 10 | ✓ | ✓ | ✓ |
| **SMARTRAC ShortDipole R6** | Monza 6 family | SSCC-96 | 93 x 11 | ✓ | ✓ | ✓ |
| **SMARTRAC DogBone R6** | Monza 6 family | SSCC-96 | 94 x 24 | ✓ | ✓ | ✓ |
| **SMARTRAC Frog 3D 76mm Monza 4 family** | Monza 4 family | SSCC-96 | 68 x 68 | ✓ | | |
| **Avery Dennison AD-237r6** | Monza 6 family | SSCC-96 | 70 x 14.5 | ✓ | ✓ | ✓ |
| **Avery Dennison AD-229r6** | Monza 6 family | SSCC-96 | 95 x 8.2 | ✓ | ✓ | ✓ |
| **Confidex Crosswave Monza 4E** | Monza 4 family | SSCC-96 | 91 x 35 | ✓ | | |
| **Tageos EOS400 MR6** | Monza 6 family | SSCC-96 | 70 x 17 | ✓ | ✓ | ✓ |
| **Tageos EOS500 MR6** | Monza 6 family | SSCC-96 | 93 x 23 | ✓ | ✓ | ✓ |
| **LAB ID UH106 MR6** | Monza 6 family | SSCC-96 | 95 x 8 | ✓ | ✓ | ✓ |
| **trace ID TER16** | Monza 6 family | SSCC-96 | 95 x 8 | ✓ | ✓ | ✓ |
| **trace ID TE26** | Monza 6 family | SSCC-96 | 70 x 14 | ✓ | ✓ | ✓ |

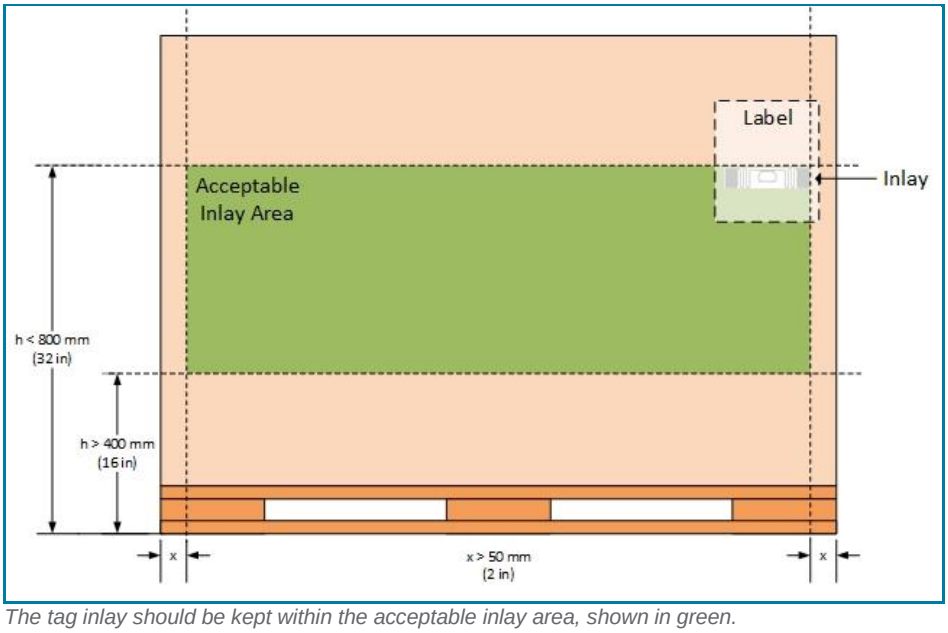
*For ordering purposes, the desired labelling options are in parentheses in the tag description next to the manufacturer and model.*

## Tag Placement

Proper tag placement is key for a RAIN RFID system to be successful. Impinj recommends placing tags following the recommendations outlined in the GS1 General Specifications. A summary of those recommendations is given below with additional inlay recommendations from Impinj. A printed label will contain a tag antenna and barcode – the placement recommendations are relative to the label unless specified.

- The tag antenna should be horizontal and the barcode should be upright (i.e., picket fence)
- Inlay height: between 400 mm (16 in) and 800 mm (32 in) from the base of the pallet.
- If the pallet height is less than 400 mm (16 in), the barcode should as high as possible.
- Keep the tag inlay at least 50 mm (2 in) from vertical edge

**Figure 2: Sample Placement on Pallets**




*The tag inlay should be kept within the acceptable inlay area, shown in green.*

Current GS1 placement recommendations are to place two or more identical labels on general distribution scanning items. To enable successful RAIN RFID deployment, Impinj recommends the RFID tags to be directly presented to the face of the Reader/ Gateway on both sides. This could mean only two tags for two-way pallets or four tags, one on each side, for four-way pallets. Each tag should be encoded with the same EPC for that pallet.

**Figure 3: Label placement on each side of pallet**

# CONCLUSION

When deploying a RAIN RFID solution for shipment verification use cases, tag selection is crucial for success. This guide has introduced the tagged item requirements that should drive tag selection, and provided instructional guidance for identifying and assessing tags that meet those requirements.

Here are the key points to remember when selecting a tag: ***digital identity, RAIN RFID features, item read performance, item materials, region, labeling requirements, and durability considerations.***

While this guide provides practical guidance for logistics asset management, it is not intended to be comprehensive or a substitute for the expertise of a RAIN RFID solutions engineer. The tags and assets selected for evaluation are only a small example of those used in healthcare asset management.

For more information about tag options and logistics asset management solutions, please visit our support portal at *support.impinj.com*, or contact Impinj, Inc.

# EXTERNAL REFERENCE

[A] Support Link: *Locking Memory on EPC RFID Tags* (https://support.impinj.com/hc/en-us/articles/202756408-Locking-Memory-on-EPC-RFID-Tags) – A article providing an overview of memory locking on RFID tags.

[B] Support Link: *RFID Link Budget Overview* (https://support.impinj.com/hc/en-us/articles/212284327-RFID-Link-Budget-Whitepaper) – A whitepaper discussing RFID Link Budget and solutions for power optimization.

[C] Support Link: *Monza 6 Integra Overview* (https://support.impinj.com/hc/en-us/articles/212041177-Integra-Overview) – An overview of the Integra suite of technologies and how Impinj can provide exceptional data integrity for industries that need it.

# APPENDIX 1: GS1 STANDARDS ORGANIZATION

GS1 is a not-for-profit organization that develops and maintains global standards for business communication. Impinj RAIN RFID uses the GS1 UHF Gen2 protocol to standardize its data.

For the GS1 main website, visit http://www.gs1.org/.

For information about the GS1 EPCglobal Class 1 Gen 2 UHF Air Interface Protocol, go to https://www.gs1.org/epcrfid/epc-rfid-uhf-air-interface-protocol/2-0-1.

For information related to the GS1 EPCglobal Tag Data Standards, go to http://www.gs1.org/gsmp/kc/epcglobal/tds/.

For GS1 General Specifications, go to https://www.gs1.org/barcodes-epcrfid-id-keys/gs1-general-specifications.

For the GTIN Executive Summary, you may download it at http://www.gs1.org/sites/default/files/docs/idkeys/GS1_GTIN_Executive_Summary.pdf

For GTIN Allocation Rules, you may download it at http://www.gs1.org/docs/idkeys/GS1_GTIN_Allocation_Rules.pdf

The GS1 EPCglobal Tag Data Standard specifies various encoding standards including those encoded to tags as EPCs. Table 3 provides a quick summary of standards from that document.

### Table 3: GS1 EPCglobal EPC tag data standard

| EPC | DESCRIPTION | HEADER | HEX | STATIC | SERIAL # | NOTES |
|---|---|---|---|---|---|---|
| **SGTIN-96** | Serialized Global Trade Item Number | 0011 0000 | 30 | 58 | 38 | numeric only serial # |
| **SGTIN-198** | Serialized Global Trade Item Number | 0011 0110 | 36 | 58 | 140 | alphanumeric serial # |
| **SSCC-96** | Serial Shipping Container Code | 0011 0001 | 31 | | | |
| **SGLN-96** | Global Location Number | 0011 0010 | 32 | | | |
| **SGLN-195** | Global Location Number | 0011 1001 | 39 | | | |
| **GRAI-96** | Global Returnable Asset Identifier | 0011 0011 | 33 | 58 | 38 | numeric only serial # |
| **GRAI-170** | Global Returnable Asset Identifier | 0011 0111 | 37 | | | alphanumeric serial # |
| **GIAI-96** | Global Individual Asset Identifier | 0011 0100 | 34 | 34-54 | 62-42 | numeric only serial # |
| **GIAI-202** | Global Individual Asset Identifier | 0011 1000 | 38 | 34-54 | 168-148 | alphanumeric serial # |
| **GSRN-96** | Global Service Relation Number | 0010 1101 | 2D | | | |
| **GDTI-96** | Global Document Type Identifier | 0010 1100 | 2C | 55 | 41 | numeric only serial # |
| **GDTI-113** | Global Document Type Identifier | 0011 1010 | 3A | 55 | 58 | alphanumeric serial # |
| **GID-96** | General Identifier | 0011 0101 | 35 | 60 | 36 | numeric only serial # |
| **USDoD-96** | US Department of Defense | 0010 1111 | 2F | 60 | 36 | numeric only serial # |
| **ADI** | Aerospace and Defense Identifier | 0011 1011 | 3B | | | |
| **Unencoded** | Unencoded tag | 0000 0000 | 00 | | | |

# VERSION INFORMATION

### Table 4: Version Information

| VERSION NUMBER | PUBLICATION DATE | READER SETUP | ENDPOINT |
|---|---|---|---|
| **1.0** | TBD | • Side-by-side | Wooden Pallet and Corrugated Boxes |

# NOTICES



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