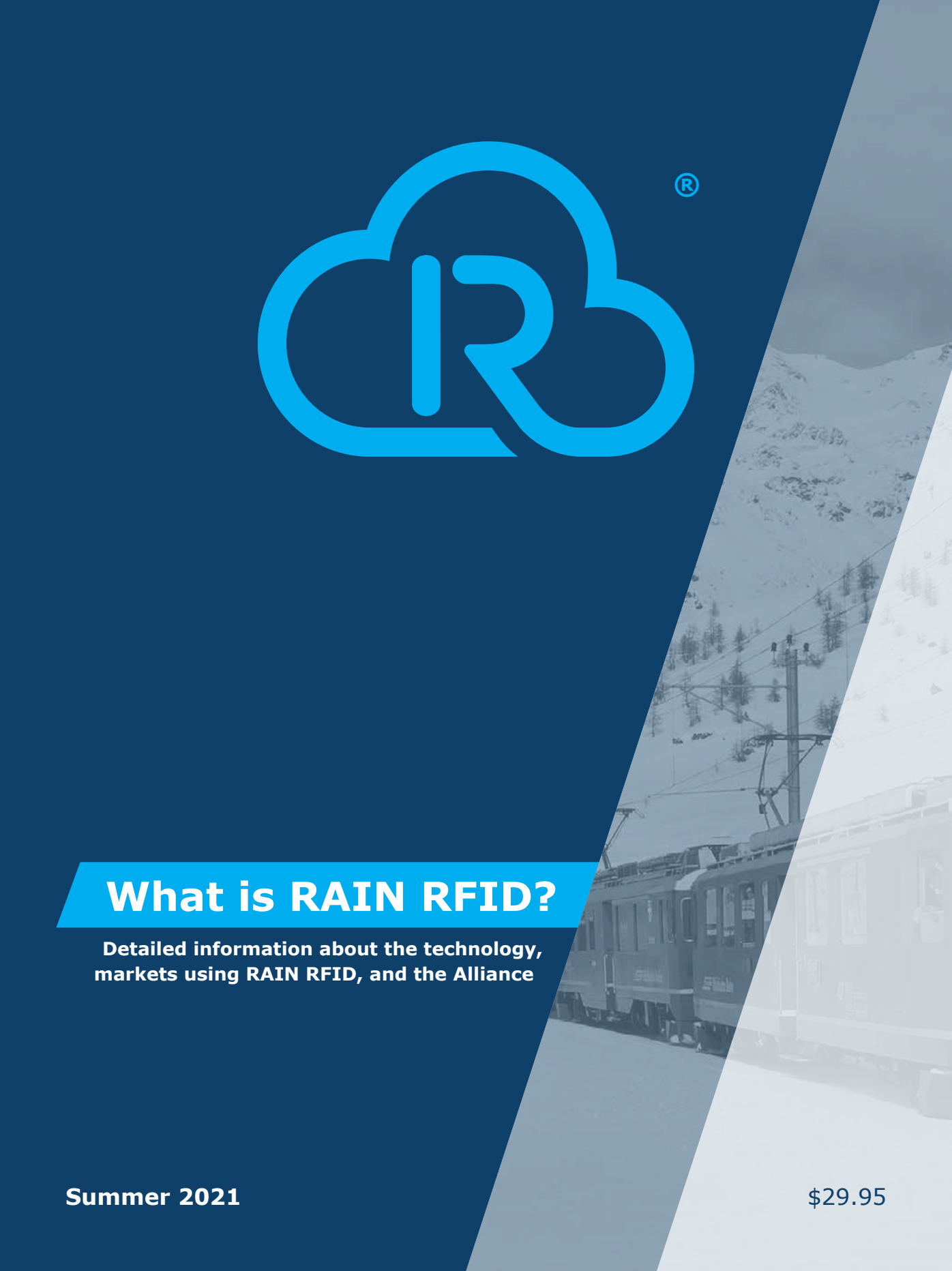

What is RAIN RFID?

Detailed information about the technology, markets using RAIN RFID, and the Alliance

Summer 2021

$29.95

ItemAware

Do you know where your IT Assets are?

DESKTOPS · LAPTOPS · SERVERS · PRINTERS · AV EQUIP

AND MORE

IT Assets are critical to every organization.

But manually inventorying and tracking them is time-consuming and prone to human error.

ItemAware is intuitive software that automatically tracks asset location, stores asset data and history, and sends you updates.

Why does it matter?

The US Patent and Trademark Office is now saving $1.2M dollars every year by tracking their IT assets with ItemAware.

Theft has been virtually eliminated and money is saved by making sure usage of current assets is at 100% before buying more.

130,000
Items Tracked

98%
Reduction in Loss Prevention Costs

54%
Reduction in Error Costs

$1.2M
Saved Annually

How does it work?

ItemAware

- Collects data from tagged assets
- Tracks location, status, history, parent/child relationships and more
- Analyzes asset data
- Sends alerts based on user rules
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- Is easy to use and learn

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INTRODUCTION

JUHO PARTANEN

Chairman of the Board of Directors
RAIN Alliance

I want to warmly thank you for taking the time and interest to click this e-book open, and start familiarizing yourself with the RAIN RFID technology. You are about to set out into a journey, that truly has the potential of transforming the supply chains and processes around you!

Building on that: Working in the RAIN industry for almost 20 years now, I actually find that most end users are not that excited to purchasing RAIN readers and tags, which are the fundamental building blocks of RAIN systems. End users typically get more excited as they understand the prospect of increasing transparency to their core operational processes, inventory changes, lower capital expenditure and increased customer satisfaction.

Fine goals. *How does one get there?*

Much of the needed guidance and links are in this e-book. Our numerous vendors and end users in China can also find a translated version on the RAIN website. And yes - you will need some of those tags and readers to reach the new money-saving efficiencies. Those investments are worth it.

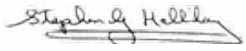
To stay up-to-date with the latest advances in the RAIN industry, I recommend two easy steps: subscribe to the RAIN Alliance newsletter, and bravely attend the RAIN events, both virtual and face-to-face. We have pencil sharp experts and great visionaries in this industry! As you become more intrigued, the third logical step is to sign up to become a member. As a member, you are eligible to join the workgroups that work on topics dear to you.

This ebook would have not been possible without the numerous talented and diligent volunteers from the RAIN member companies. I want to express my gratitude towards you all for taking the time from your busy days, and for getting this e-book completed and wrapped up for this 4th edition.

In Espoo, Finland, 7th May 2021

STEPHEN G HALLIDAY

President
RAIN Alliance



Welcome to the RAIN Alliance's E-Book that helps explain how to use RAIN RFID to solve problems for your business!

This is the fourth edition of this book and it contains new information. By getting this RAIN book, from our website (RAINRFID.org), at industry tradeshows, and at our meetings, you can learn about RAIN RFID technology, what end-users are doing with RAIN around the world, and meet all types of companies and organizations – our members and partners.

During the last year, we have seen many changes to business, with people working from home and many companies being forced to close. As we see the end in sight to these issues, now is the time to start implementing RAIN technology and reaping the benefits that it brings.

I recommend that you subscribe to our newsletter (link on the bottom of our homepage) and send us with a Request for Help if you want to contact our members to help you solve a problem.

The book is now available in Chinese for those people that would prefer to read in Chinese. You can download it from our website.

Let me know if you have any questions or suggestions for this book!

WHAT IS RAIN?

RAIN is a brand name for passive Ultra High Frequency Radio Frequency IDentification (UHF RFID) wireless technology. It was adopted in 2014 when several companies working with passive UHF RFID technology began to see that the term "RFID" was being used very broadly – to represent multiple types of sensor technologies – many of which did not have the same cost-effective, transformational capabilities of passive UHF RFID. This created a concern that the expanding use and meaning of the term "RFID" might confuse the market for passive UHF RFID solutions.

At the same time, these companies saw the growing importance of passive UHF RFID technology in enabling the Internet of Things. Powered devices like mobile phones, TVs, or fitness watches can connect to and exchange information via the internet to improve existing processes and drive new opportunities for businesses and consumers. But what about the billions of unpowered "things" in the world that make up the majority of the Internet of Things? Everything has a story to tell – whether it be a shoe in a department store, a box on a warehouse shelf, or a surgical tool in hospital.

UHF passive RFID technology gives voice to the many billions of assets that are unpowered, enabling each to have its own individual identity and send vital information – anywhere at any time - to systems and users who would benefit: name, description, status, location, etc. Given the increasingly important role of passive UHF RFID to expanding the value of the IoT – as well as the increasing importance of RFID to businesses and the consumers they serve, it became even more clear that passive UHF RFID needed to be easily differentiated from other wireless technologies with a simple, business friendly term.

Much like the term "WiFi" has simplified the way we talk about technology used for unplugged internet access, and the term "Bluetooth" has simplified the way we talk about exchanging data with a mobile device, the goal is that the term RAIN can simplify the way we talk about passive UHF RFID and how it enables visibility into the billions of unpowered assets that make up the bulk of our world.

The technology conforms to the GS1 EPC UHF Gen2 air interface protocol or to ISO/IEC 18000-63 standard "Parameters for air interface communications at 860 MHz to 960 MHz Type C" and connects billions of everyday items to the internet. RAIN RFID is used in many markets and industries worldwide to identify, locate, authenticate, and engage these items. RAIN RFID provides benefits for the end-users, depending on the applications.
RAIN RFID solutions use tags, readers, and software for a variety of applications. The tags have a unique identification number, some memory for additional information, and are attached to or embedded in the items. Readers can read and write the tags, initiate activity, and can be connected to a server (local or in the cloud).

WHAT IS THE RAIN ALLIANCE?

The RAIN Alliance is an industry organization that was formed in 2014 – in parallel with the establishment of the RAIN brand – in order to represent its many global member companies (160 and growing) who have an interest in growing and expanding the use and value of RAIN RFID technology.

You can find more information about the technology and the RAIN RFID Alliance later in this book.

WIRELESS TECHNOLOGIES

We live in a world where wireless technologies surround us. We take them for granted and we are unaware of the impact they are having on us. Whether it is Wi-Fi or 4G our lives revolve around the connectivity that they bring. And unless we are in the IoT industry, we are probably unaware of the many other wireless technologies that are all around us. Bluetooth, Zigbee, 5G, NFC, LoRa, SigFox, UWB and many others are all fighting for space in the frequency bands, looking for their place in our lives.

RAIN is another of these wireless technologies, using the airwaves to communicate the data that enables our everyday lives and makes business more efficient.

The term wireless is not new. We have all enjoyed the transmission of signals to a radio or television for a long time. But now we are finding ways to use "wireless" to connect everything in our lives. Many of us are dependent on the connectivity that our mobile phones give us, from news, to maps, to email and beyond. The IoT is also dependent on wireless technologies and they will all have a place in the future.

RAIN RFID is the leading wireless technology providing input data into the IoT. In 2020, over 21 billion tag ICs were sold. That's over 80 billion things identified in 2015-2020 time period. Other technologies bring other values, but none can match RAIN RFID for cost, simplicity, and availability.

RAIN RFID

Wi Fi™

Bluetooth®

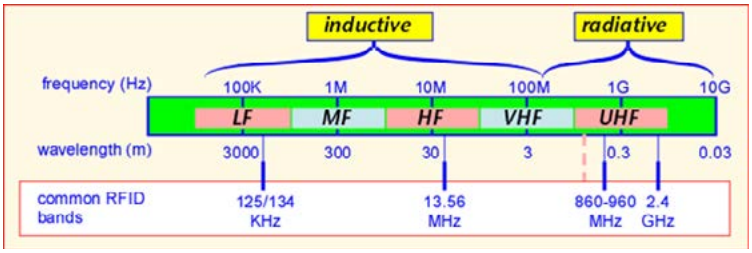
NFC

DIFFERENT TYPES OF RFID

RFID comes in many different forms. It works at different frequencies, in different applications, and with different characteristics. It is always important to select an RFID system (and frequency) that gives the best performance for the application. In many cases this will be RAIN RFID, but not always.

LF	HF (NFC, ETC.)	UHF (RAIN, ETC.)

RFID SYSTEM FREQUENCY RANGES



From The RF in RFID, Dobkin, 2012, used with permission

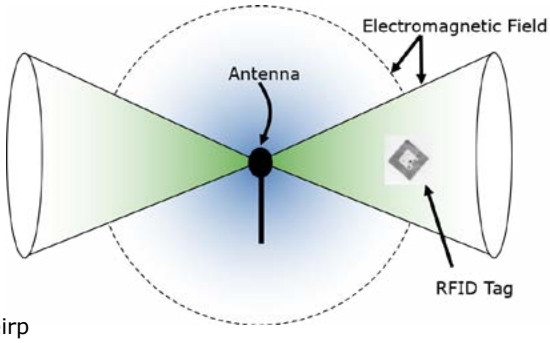
There are five major frequency ranges that RFID systems operate at. As a rule of thumb, low-frequency systems are distinguished by short reading ranges, slow read speeds, and lower cost. Higher-frequency RFID systems are used where longer read ranges and fast reading speeds are required, such as for vehicle tracking and automated toll collection.

This table gives examples of the use of the various frequencies of RFID. It is meant as a guide and is not comprehensive, nor are the applications listed specifically and solely at that frequency.

FREQUENCY	RANGE	APPLICATIONS
Low-frequency 125 - 148 KHz	up to 80mm	Pet and ranch animal identification; car keylocks; factory data collection
High-frequency 13.56 MHz	up to 1 metre	Library book identification; smart cards; NFC; transit tickets
Ultra-high frequency (UHF) 433 MHz	up to 100 metres (with active tags)	Container identification with active tags
Ultra-high frequency (UHF) 860 - 930 MHz	up to 15 metres	Supply chain tracking: item identification; apparel; healthcare;
Microwave: 2.45 - 5.8 GHz	Up to 2 metres (with passive tags) Up to 100 metres (with active tags)	Highway toll collection; vehicle fleet identification

In the UHF band, RFID systems operate in the 860 – 930 MHz range. This is a very wide band and it is because the frequency available to any application is controlled by the Radio regulations in the part of the world that the system is operating in. For example, in the USA, the frequency and power are controlled by the FCC and are defined as 902-928 MHz at 4W EIRP power (ERP and EIRP are defined below and are different methods of measuring power). Traditionally in Europe this has been 865.6 – 867.6 MHz at 2W ERP. The performance from these two systems is very different with the European regulations controlled by ETSI only allowing a much smaller band and less power. Recently RAIN and others have been working with the European Community to get more bandwidth and power for RFID. This has resulted in space in the 915 – 921 MHz band becoming available in 2019. (See more information below)

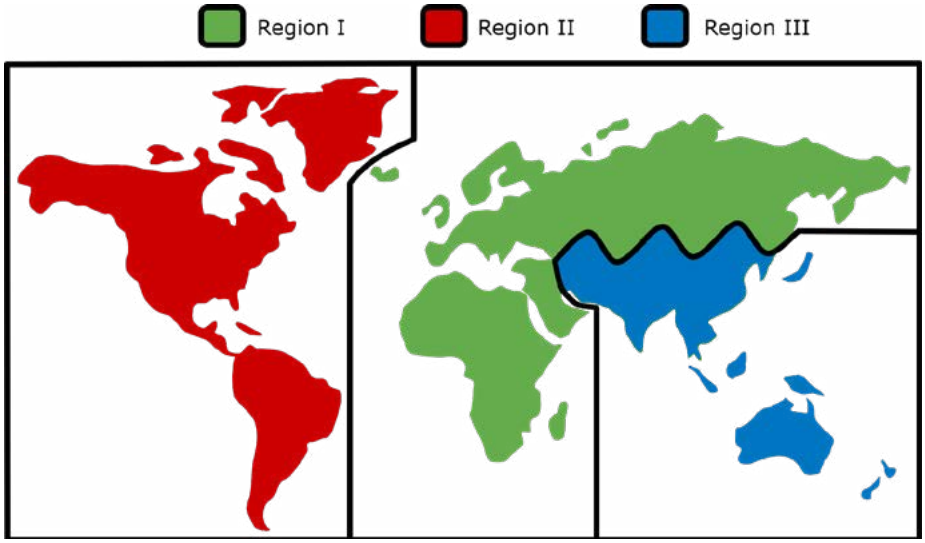
UHF RADIATED POWER – EIRP VS. ERP



- **Terminology:**
  - o EIRP: equivalent isotropic radiated power
  - o ERP: equivalent radiated power
- **Allowed power:**
  - o EN 302 208: 2W erp
  - o US (FCC): 4W eirp
- **Relationship eirp-erp:**
  - o Peirp = Perp x 1,64 => 2 Watt erp = 3,28 Watt eirp

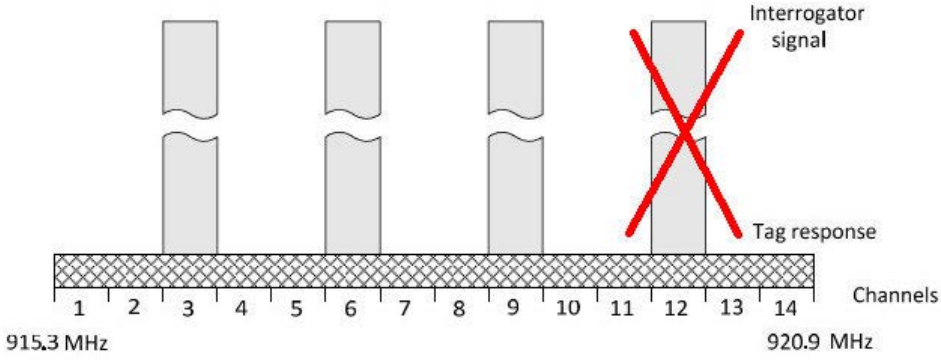
ITU RADIO REGULATION REGIONS

There are three regions defined by the ITU Radio regulations. In broad terms they are the Americas, Europe and Asia (see map below). Other countries have also changed their original allocations for RFID which brings the original bandwidth that the systems used down from 860 – 960 MHz to 860 – 930 MHz. GS1 published a document that lists all of the frequencies and power availability around the world. This can be downloaded from here (https://www.gs1.org/sites/default/files/docs/epc/uhf_regulations.pdf).



EU FREQUENCY REGULATION UPDATE

As many of you are aware, we have been working in Europe with GS1, AIM, and ConnectWave to get approval of a compromise new frequency plan for UHF. The original 915 – 921 MHz was not approved in many countries and this was causing some delay in implementation in Europe. RAIN representatives along with others have met with the regulatory representatives of the member states of Europe in an effort to get the compromise between the railways, RAIN and other IoT users of the band. The vote took place on 11 July and the compromise plan passed. The compromise allows for three channels of 4 W e.r.p. transmission at 916.3, 917.5 and 918.7 MHz.



Channel plan for upper band

This compromise was reached because some countries have already allocated some of the band to other applications. In particular several countries have allocated 915 - 918 MHz for the military and/or 918 – 921 MHz for GSM-R (GSM for Railways). By limiting RAIN to three channels, most countries should be able to make some (or all) of the frequency band to RAIN use.

The compromise has now been approved and included in ETSI EN 302-208 and ERC 70-03. The decision went into effect 2019-02-01, however, not all European countries have adopted the new regulations yet. As of 1 August 2019, 10 countries have implemented the decision, 12 more are in the process of implementing, two member states have it under investigation, two are implementing special arrangements, and two countries where it is currently disallowed. There are a further nine CEPT countries that are non-member states that have implemented in some way and we are following 11 non-member states to determine their status.

RAIN members can download a presentation given at the Florence meeting from the RAIN member forum which gives a listing of the countries that have accepted the new plan and those that have issues still. RAIN is currently working to meet with the countries that have not accepted the new rules to give them the chance to learn about RAIN and its importance in the global business world.

IF YOU ARE LOOKING FOR DOCUMENTS, THE FOLLOWING LINKS MAY HELP:

The official decision document (Commission Implementing Decision (EU) 2018/1538) can be found at
https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1539694292299&uri=CELEX:32018D1538

ERC Recommendation. **70-03**. Relating to the use of Short Range Devices (SRD). Tromsø 1997. Subsequent amendments. 7 June 2019 - Edition of June 2019.
https://docdb.cept.org/download/25c41779-cd6e/Rec7003e.pdf

ETSI EN 302 208 V3.2.0 (2018-02) - Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W and in the band 915 MHz to 921 MHz with power levels up to 4 W; Harmonised Standard for access to radio spectrum.
https://www.etsi.org/deliver/etsi_en/302200_302299/302208/03.03.01_60/en_302208v030301p.pdf

NOTE this is the latest published version, but it does not include the changes from above. The new version is in final review before publication.

PASSIVE VS ACTIVE

Passive tags work by backscattering the signal from a reader, modulating it to give the data that is expected. The tags require no power supply, all of the power is harvested from the transmitted signal from the reader.

With no power supply, the life of a passive tag is virtually unlimited, and they require no maintenance. The tag uses the reader signal to power up and respond to a request for data. The tag modulates the carrier signal from the reader and reflects (backscatters) the signal. This very low amplitude signal is detected and decoded by the reader. Another advantage of passive tags is that with no transmitter they can be carried on aircraft with no issues.

Some tags have a battery associated with them but still backscatter the signal back to the reader. These tags are called Battery Assisted Passive (BAP) tags. Some companies also refer to these tags as Semi-Active or Semi-Passive. The battery is used to provide power to the tag and/or any sensors attached to the tags.

BAP tags are still passive tags, in that they backscatter the signal to the reader. The extra power supply means that they typically have greater range as they do not need as much power from the reader. They can also collect and store data from sensors that attach to them.

Active tags are often described as tags with a power supply. While this is true, the real definition of an active tag is that it has an independent transmitter. This transmitter requires more power than a reader can supply and so it needs a power source, usually a battery. As these tags have a transmitter it may mean that transporting them on aircraft cam be a problem. Not all tags have a power off switch, and even then, there is always a risk that a problem may cause them to transmit. If the power can be completely turned off (remove the batteries) there is no problem.

Active tags usually have very long range (maybe more than 100 meters) and because of the extra power, they have less problems with close proximity to metal.

Both BAP tags and active tags need maintenance or have limited life. The replacement of the battery in these tags may or may not be possible.

RAIN READER COMMUNICATION INTERFACE (RCI)

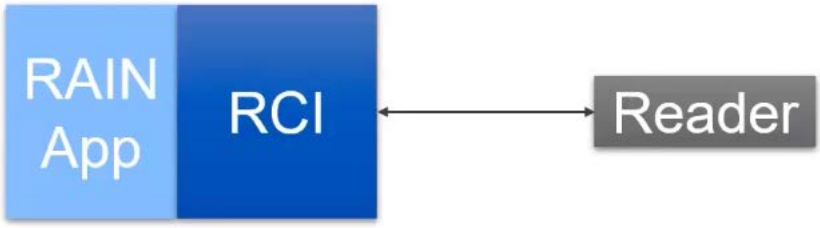
The RAIN Reader Communication Interface (RCI) guideline provides a way for UHF RFID solution providers to build systems that can communicate with any make or model of reader and operate in multiple applications with different reader types, thus eliminating the need for APIs.

The RCI guideline allows technology providers to offer systems that could operate with any reader, thereby enabling deployments with multiple reader types, as well as offering a solution that could be used at many customer sites. As billions of tags are deployed on products and assets that might move through multiple RFID reader infrastructures, the guideline will make it easier for each application to identify tags of interest, and to automatically disregard those the system does not recognize.

The guideline was created by members of the RAIN RFID Alliance's Developers Workgroup after systems integrators asked for an easier way to control readers. RCI's profile command replaces the need for a reader to send a series of commands to identify a tag and then process that tag's response. Instead, the series of commands can be built into the single profile command. That function also eliminates the requirement for application programming interfaces (APIs) for each reader.

RAIN RCI BASICS

- The "HTML" of RFID – Increases interoperability of systems and solutions.
- Compatible with existing RFID standards – RAIN inherently builds on the global standards from GS1 and ISO.
- Connecting with the IoT world – Easier to create connections with MQTT, OPC UA, and more.



FEATURES OF THE RAIN RCI

- Simple to use, and simple to implement
- Use any interface that can stream serial data (USB, TCP/IP, Bluetooth, RS-232, etc.)
- Allows for implementation on low-resource or high-resource platforms (CPU, memory, communication bandwidth)
- Extendable to allow vendors to add their own features

The current version of the guideline has all the basic commands to allow full interrogation of the reader. The Developers Workgroup is currently working to add additional features to the RCI from the GS1 and ISO/IEC protocol standards, such as support for the cryptographic techniques and sensors connected to RAIN RFID tags.

Version 4 of the document has recently been published with crypto and sensor support along with the ability to detect multiple tags with the same data. Work on version 5 has already started.The RAIN Alliance has released the RCI Guideline under the Apache License, version 2.0, and encourages all reader manufacturers to download the guideline and use it for their RAIN RFID reader development.

The RAIN Alliance has released the RCI Guideline under the Apache License, version 2.0, and encourages all reader manufacturers to download the guideline and use it for their RAIN RFID reader development.

LINK TO MORE INFORMATION ON THE RAIN WEBSITE!

https://rainrfid.org/technology/rain-communication-interface-rci/

RAIN RFID STARTER KIT

The RAIN Alliance Developers workgroup created a starter kit for potential RAIN RFID technology customers to learn about RAIN and experience the capabilities of RAIN.

The RAIN RFID Starter Kit supports the RAIN Communication Interface (RCI) and serves as an important tool to increase exposure and access to RAIN RFID. The starter kit provides an easily accessible and affordable platform for students and hobbyists to use when learning to apply this technology, while also promoting best practices for using RAIN RFID.

The kit consists of the RAIN reader, and sample RAIN tags from RAIN RFID Alliance members. The starter kit delivers out-of-box item connectivity utilizing RAIN RFID at an accessible price point.

RAIN RFID STARTER KIT FORMATS

The starter kit will be available in several different formats as they are made available by the various manufacturers. As of the publication of this E-Book, the first starter kit has been developed by ThingMagic, a JADAK brand. This reader is a standalone reader. When starter kits from other manufacturers are announced, information will be added to the RAIN RFID website.

RAIN RFID STARTER KIT SUPPORT AND SUPPLY

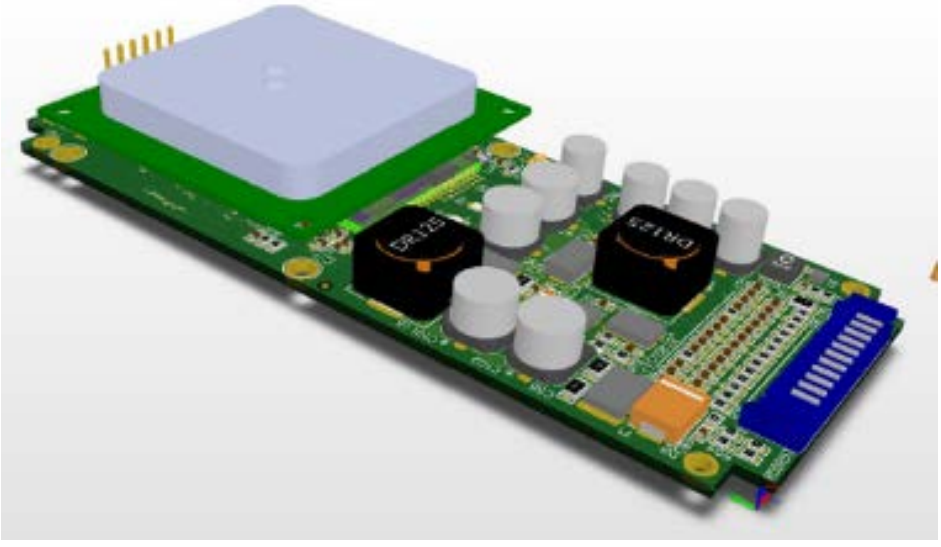
- Each RAIN Starter Kit Reader has an RCI performance sheet available electronically. This sheet describes the level of RCI support provided.
- The RAIN Alliance Developers workgroup is responsible for the RAIN RFID Starter kit. They can be contacted through the RAIN Alliance at RCI@rainrfid.org.
- ThingMagic, a JADAK brand, has launched the first Starter Kit and others will follow.
- Firmware support for the device is provided by each individual vendor.

MORE DETAILS AND LINKS TO ORDER STARTER KITS ARE ON THE RAIN WEBSITE!

RAINRFID.ORG/TECHNOLOGY/RAIN-RFID-STARTER-KIT/

RAIN RFID STARTER KIT BENEFITS

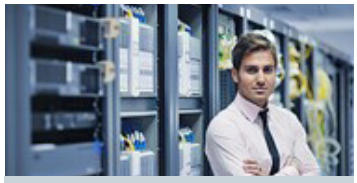
- RAIN Starter Kit and RCI support RAIN RFID technology standards and a new developer friendly interface between applications and RAIN readers.
- Ideally suited for students and hobbyist looking to learn RAIN RFID technology and best practices for implementation.
- Not intended for professional use.
- Speed and ease of integration due to all-in-one embedded solution that includes reader module, antenna, and processor to RAIN-enabled applications.



INDUSTRIES INCLUDE

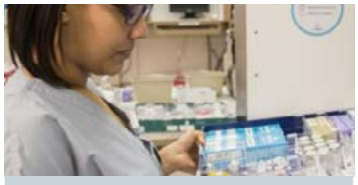
AVIATION

ELECTRONIC VEHICLE IDENTIFICATION [EVI]



ELECTRONICS

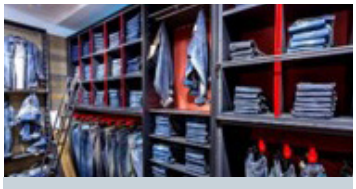
FOOD



HEALTHCARE

MANUFACTURING

PACKAGING AND LOGISTICS



RETAIL

MORE INFORMATION

HTTPS://RAINRFID.ORG/

RAIN ALLIANCE

MARKETS / INDUSTRIES / APPLICATIONS

Why do more enterprises all around the world choose Zebra for RFID?

WE'VE GOT IT ALL.

With the broadest RFID product portfolio, no matter what you need to implement your RFID solution, we have it — from handheld, sled and fixed readers to RFID printers, antennas, passive and active tags, hubs and exciters and more, with a global partner channel offering industry-best apps to wrap around it all.

EXPERIENCE.

We've installed more successful fixed, handheld and portal RFID systems than any other RFID provider. And our expertise encompasses passive ultra-high, high-frequency, low frequency and active RFID, as well as Ultra-wide Band, ISO 24730-2, Bluetooth and more.

INNOVATION.

Over 25 years of RFID innovation and 579 RFID technology patents and counting bring you unsurpassed performance you can count on — the greatest speed, highest read rates and maximum unique reads.

DEDICATION.

Over 200 Zebra engineers are focused full-time on RFID, from designing products to architecting the best solution for your facility. And no matter where you are in the world, our support team of 2,000 people in 150 offices across 50 countries is ready to help create your ideal RFID solution and provide crucial day-to-day support.

SINGLE SOURCE SIMPLICITY.

With all of your hardware from one manufacturer, troubleshooting and support are greatly simplified. No more coordination between vendors — and no more fingerpointing.

For more information, please visit www.zebra.com/rfid

ZEBRA

ANIMAL IDENTIFICATION

Animal identification has been used for many years for the purpose of identifying and tracking specific animals as a part of a certain farm. The original reason was for branding the animal for verification of ownership. Later, animal identification was developed and used for the purpose of feeding, weighing, tracking and tracing, disease management and breeding practices.

Traditional animal tags typically use either visual tags (barcode or numbers) or low-frequency (LF) RFID technology, which limits the range at which data can be read and is also vulnerable to signal interference from outside sources.

RAIN RFID tags offer superior readability at distances of up to 15 metres. RAIN RFID is also less susceptible to radio interference from farm machinery like tractors and other signal-producing equipment.

Each unique RAIN RFID tag can be linked to a database including animal-specific information history such as birth date, inoculation history, and breeding details.

Animal management practices, including feeding, weighing and disease traceability, are automated and streamlined.

RAIN BENEFITS FOR ANIMAL IDENTIFICATION

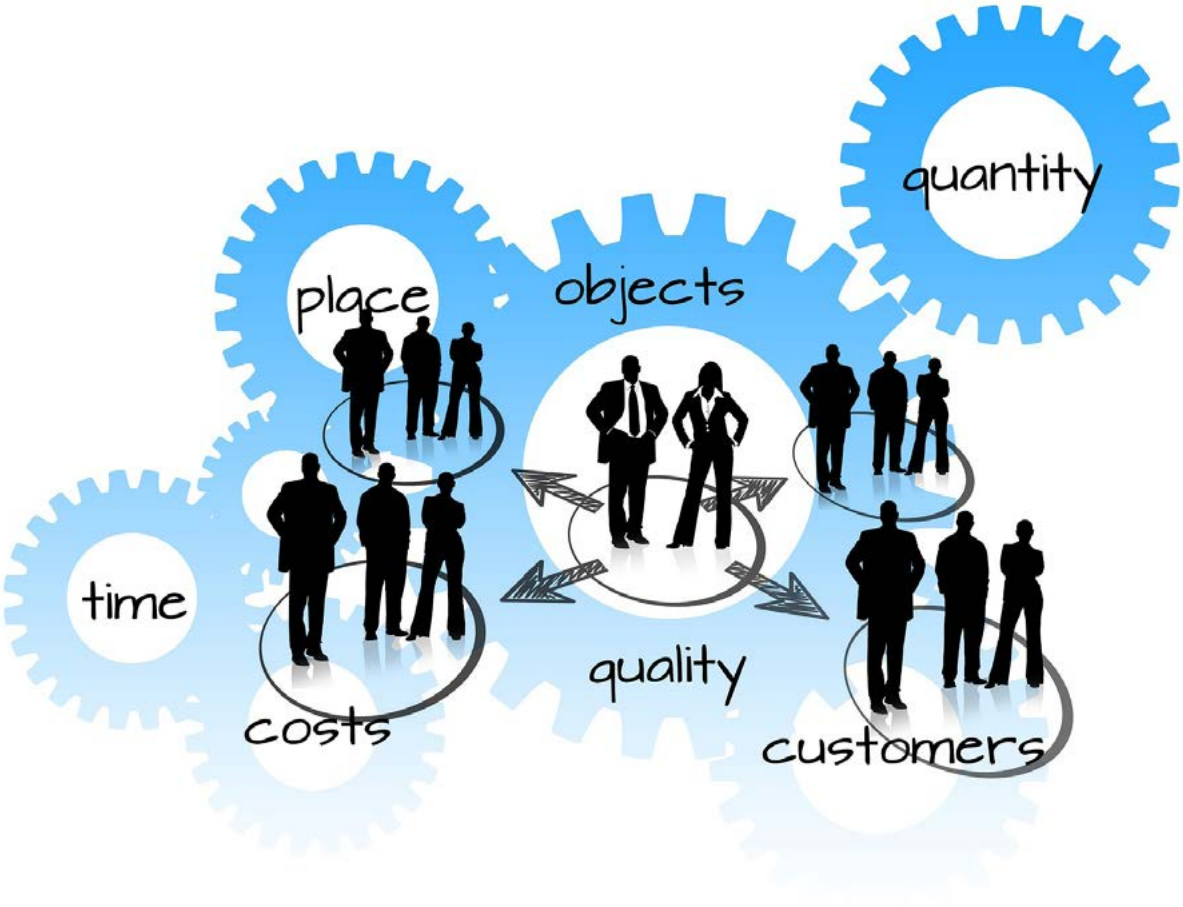
- Full "farm-to-fork" animal identification
- Longer read range, less stress to the animal
- More robust signal, less interference

Learn more about ANIMAL IDENTIFICATION - https://rainrfid.org/resources/videos/

ASSET TRACKING

Asset tracking - Track and Trace" (abbreviated to "T&T"). The process of tracking and tracing things has caught on and evolved as companies find that it improves their bottom line through improved efficiency and control of shrinkage. Regulators have begun requiring certain industries to implement extensive track and trace systems for the protection of consumers and the environment. For example, regulators have adopted variations on the basic T&T system to deter counterfeiting, identify the origin and/or destination of a product with a recall involved, and protect consumers and the environment. In the case of medical device manufacturers in the USA, there are legal requirements to use automatic identification and data capture (AIDC) technology along with appropriate systemization to provide for T&T and unique device identification (UDI) requirements. In the case of food producers, the Food Safety Modernization Act (FSMA) requires T&T from providers. Although AIDC is not legally required by FSMA, it is the only practical method of compliance. For many businesses which must meet various other compliance requirements or consider the potential cost of recalls and product liability, T&T just makes good business sense.

Track and Trace in, and of, itself does not do anything of great value. It is a protocol for developing and collecting data. It is the use of that data that is the benefit of track and trace and it can be of great value. Once collected the data can be used for many purposes. The best-known example is the "where is my package" application. This started because small package carriers needed to be able to roughly locate every package they were handling. T&T enabled the efficiency needed to meet their goal of 100% next-day delivery. Once they started collecting this data, they found that allowing



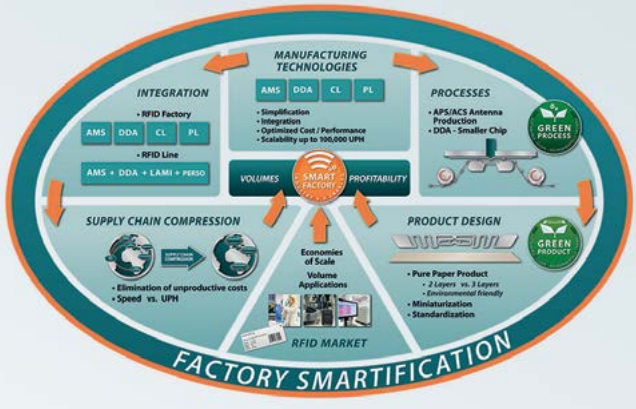
customers to view this data was a great advertising benefit. Analysis of the customer requests show that most people check on a package once and do not check again. Just the knowledge that they could check on the package status sends the message that the carrier knows where the package is, and they do not have to worry about the package delivery. The reality is that most of the inquiries are made when packages are lost. At this point the T&T data provides exceptionally good information for claims resolution.

The above examples are only a small part of what T&T systems are capable of accomplishing. The scope of what a T&T system can do is limited mostly by your own imagination. T&T systems have been around for much longer than the "where is my package" application noted earlier. Manual record-keeping was used to record locations, quantities and identity for decades before automation was available. These manual processes have, for the most part, been automated using bar codes or radio frequency identification tags. What is important is that Automatic Identification and Data Capture (AIDC) technologies allow business owners to collect more data, more accurately and faster than ever before. Data specifically configured for automated collection is often referred to as machine readable data, as it is collected and interpreted often without any human intervention.

Mühlbauer
High Tech International

CONCEPT 2023 *THE FUTURE OF RFID LABEL MANUFACTURING*

Mühlbauer, well-established turnkey production equipment and software provider for the RFID industry, has proclaimed 2023 the year where the vision of a Smart RFID Factory will become reality. In its "Concept 2023", Mühlbauer combines its revolutionary advancements in antenna manufacturing technology with its unmatched know-how in chip bonding and RFID label converting, as well as personalization by the means of MB MES®, a state-of-the-art production control software.



Key Factors for a successful Smart Label production:

- Eco-friendly and streamlined technology integration
- Newest advancements in automation technology
- Digitalization of production processes

SMART FACTORY INDUSTRY 4.0 ENABLED

RFID

Feel free to contact our experts to receive more information and find a fitting concept for your production: **info-srp@muehlbauer.de**

T&T requires three pieces of data. Identity, location, and purpose. Add an automated information storage and retrieval capability, some software, and a communications link, and you have a T&T system. Obviously full-blown T&T systems can become much more complicated, but they all contain these basic elements, plus the bells and whistles added to support business processes. Since a T&T system is going to deal with a lot more than one thing, we must have a way to know exactly which of the "things" we are dealing with at any moment in time. We refer to this as identity. The only requirement for identity is that it be unique. If there is even a small chance that two things could have the same identity, then our system integrity is in serious jeopardy.

The purpose of T&T is often just assumed. Things (e.g., packages) tendered to a transport carrier are either in motion from one place to another or awaiting onward movement. Likewise, things (e.g. chips and video cards) at a computer assembly facility are being assembled into higher level things (e.g. computers or servers). The purpose is important because the nature of the thing being monitored may change while at a particular location. The video card installed in a laptop computer is no longer discreetly tracked. Rather we now track the finished laptop while the assembly company maintains record of which parts went into each laptop. Thus, if a certain batch of video cards is found to have a fault, the assembly company can identify which laptops were affected and notify the retail stores or purchasers to return the laptop for repair. This same relationship is true for virtually any commodity such as pharmaceuticals, food, or even automobiles.

T&T enables identification of "things", their location and purpose. When you design a T&T system, think about who will need to use the recorded data and what their requirements are in terms of frequency and granularity of that data.

This article was excerpted from an AIM whitepaper: https://web.aimglobal.org/external/wcpages/wcecommerce/eComItemDetailsPage.aspx?ItemID=9

RFID READY. ARE YOU?

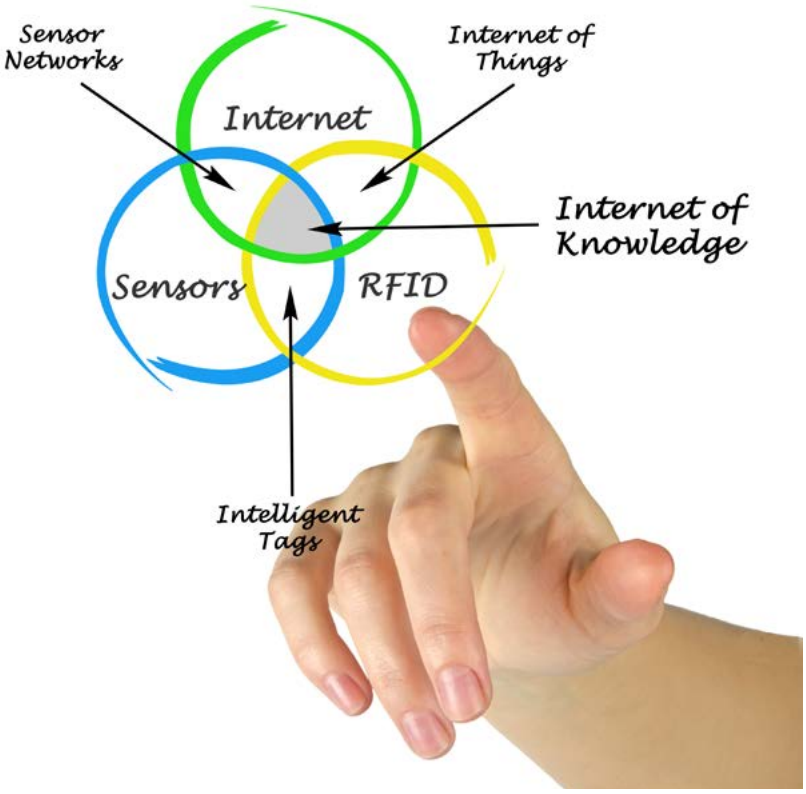
TSC PRINTRONIX AUTO ID

TSC Auto ID tscprinters.com
Printronix Auto ID printronixautoid.com

- 203, 300, 600 dpi
- 4" and 6" models available
- Standard smart labels and on-metals with a single printer
- Proven reliability and robustness in the field
- RFID auto-calibration for easy, fast, accurate setup
- Fast print speed
- Multiple competitor print languages for seamless integration
- Support for high-memory applications such as ATA Spec 2000
- SOTI Connect remote printer management

T6000e
RFID Journal's Top 10 Products of 2020

RAIN RFID



AVIATION

RAIN RFID connects billions of everyday items to the internet, enabling the aviation industry around the world to identify, locate, authenticate, and engage with each item—no batteries required. In an increasingly globalized world, enterprises need accurate, real-time data to provide accurate and timely information on location of the passenger's bags, tracking vital components on the airplane, running accurate maintenance checks within the worldwide network of RAIN enabled airlines, airports, and other vendors of the aviation industry.

RAIN BENEFITS FOR AVIATION

From the moment the bag is presented to the airlines and enabled with the RAIN technology, the bag now has a unique identification and can be tracked through its whole journey. With RAIN RFID in baggage tags, the aviation industry will face the following benefits:

- Increased read rate up to nearly 100%
- Allows passengers to track baggage in real-time by getting notifications on their mobile
- Lower the number of mishandled baggage by 25-50%, which has a potential savings of at least $100/bag
- Decrease manual operations which helps free-up staff for other value-adding tasks
- Full compliance of IATA R753 done in the most cost-effective way
- Improve operational transparency
- Reduce fraud

AVIATION SUCCESS WITH RAIN

DELTA AIRLINES

Millions of people benefit from worry-free traveling thanks to RAIN-supported baggage tracking.

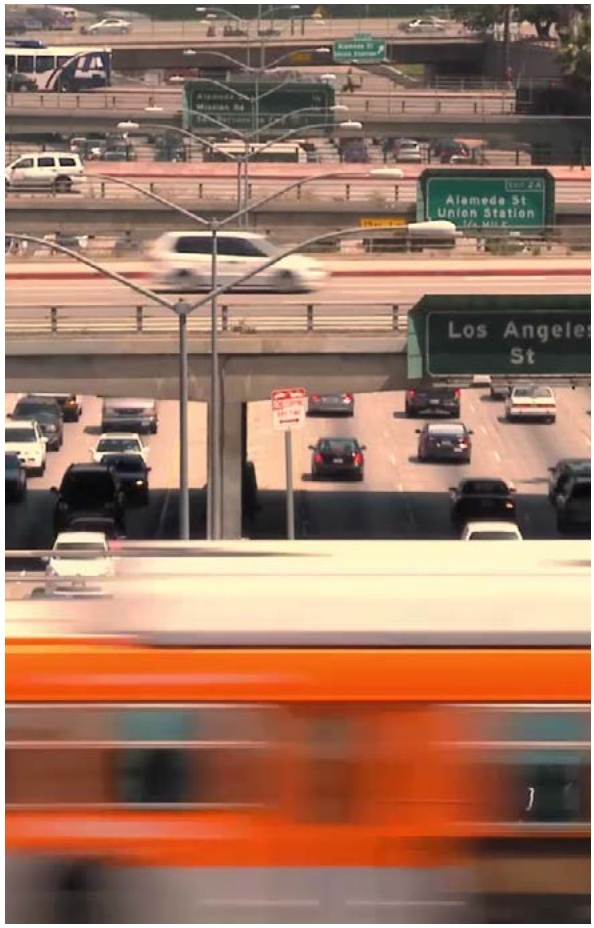
"RAIN RFID IS A COST EFFICIENT AND HIGHLY EFFECTIVE METHOD OF DATA CAPTURE FOR RESOLUTION 753, AS IT ALLOWS A HIGH DEGREE OF AUTOMATION AND THEREFORE CONSISTENCY OF DATA PROVISION FOR THE OPERATION. THIS IS ESSENTIAL AS BAGGAGE TRACKING IS ONLY EFFECTIVE IF YOU CAPTURE DATA ON ALL THE BAGS AND CAN USE THIS EFFECTIVELY." – *IATA*

IATA

INTERNATIONAL ASSOCIATION OF IABSC BAGGAGE SYSTEM COMPANIES

ELECTRONIC VEHICLE IDENTIFICATION (EVI)

RAIN RFID connects billions of items to the internet, enabling various stakeholders in a number of eco-systems to **identify, locate, authenticate**, and **engage** with each item. RAIN RFID provides worldwide, robust electronic vehicle identification for various applications including vehicle licensing, tolling and congestion management, vehicle access control, parking, fleet management, fuel management and car-wash loyalty programs.

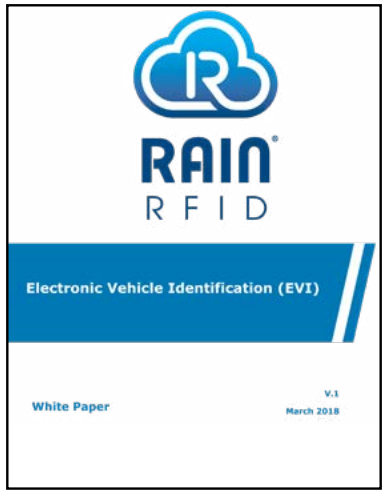


EVI BENEFITS OF RAIN

RAIN RFID has proven itself in many applications, providing automation, supply chain visibility, stock management, anticounterfeit, chain of custody and more. RAIN RFID is the ideal technology to provide electronic vehicle identification in smart cities, including automated logistics and various localised vehicle-related applications ranging from vehicle access control to loyalty programs.

- Excellent read range
- Fast read speed
- Carries additional data
- Secure – authentic, private, and untraceable

More information in the EVI white paper.
https://rainrfid.org/resource-type/documents/?c=rain-alliance&t=documents&s=evi



A Thing of Beauty: Helping EY Capture the Advantages of RFID for Grupo Boticário

Avery Dennison's beauty-specific RAIN RFID inlays helped the largest beauty franchise network in the world to almost eliminate stockouts and increase its revenue in the industry's first RFID deployment in Brazil.

Grupo Boticàrio is the second-largest cosmetics company in Brazil and the largest beauty franchise network in the world, selling makeup, fragrances, skincare products and more. The company operates a complex supply chain including branded retail stores, online channels, direct sales, and partnerships with other retailers. Founded in 1977, Grupo Boticário is present in 12 countries and growing fast. It produces some 335 million items annually and ships 100,000 items daily, supplying inventory to about 9,000 points of sale in Brazil and abroad.

Avery Dennison? The obvious choice!

These figures explain pretty well why the time was right to move to an RFID-based supply-chain management system that provides item-level traceability from end to end.

Selecting Avery Dennison to supply the RFID tags was an easy choice for Grupo Boticário and global consultants EY as, according to Fabiano Negrao, executive director with EY Brazil, "they … understood beauty and had designed products specifically for beauty packaging." Due to their superior quality, EY and Grupo Boticário chose AD-456u8 tags for metallic products, AD-301r6 tags for general-purpose tagging, and AD-160u7 tags for liquids and typical cosmetics packaging.

For the pilot testing in-store visibility, RFID tags were attached to individual items, with tagging being done at one of Grupo Boticário's distribution centers. Cartons with tagged items were shipped to two retail stores, and two wholesale stores selling products to the company's direct-sales representatives. At the stores, the RFID system was applied to improve

shipment receipt, shelf replenishment, inventory counting, checkout, and demand planning.

Instant improvements

Store employees saw improvements right away: Received shipments could check-in all items in a carton with a click of a scanner outside the box, rather than opening the carton and checking in each item one by one. Inventory could be counted in a fraction of time compared to the legacy barcode system, and with greater accuracy. As a result, demand planners received better information that enabled them to order the right products for replenishment and better forecast sales.

Convincing overall results

The pilot's outcomes exceeded expectations. Stockouts were reduced by up to 97 percent at participating stores. Identification of "hidden stockouts"—stockouts identified that were missed with the legacy system—increased by more than half. Inventory-related labor hours came down by 14 percent, thanks to faster processes. And probably best of all, revenue at stores equipped with RFID was noticeably higher than at stores without it. For Bob Pernice, Avery Dennison's Global Director of Market Development, these results were a confirmation — and less than a surprise: "The beauty industry is discovering what the apparel industry already knows—that item-level RFID tagging dramatically increases inventory accuracy and subsequent turnover. Further, it can help make beauty supply chains more efficient, secure and sustainable."

Encouraged by the pilot's results, Grupo Boticário has begun to roll out RFID across one of its store brands and will further explore RFID for other supply chain and retail use cases.

CONTACT
http://rfid.averydennison.com/en/home.html
michael.baucke@eu.averydennison.com

AVERY DENNISON

HEALTHCARE

RAIN RFID connects healthcare items to the internet, enabling caregivers, administrators and patients to **identify, locate, authenticate,** and **engage** with each item. Batteries not required. Healthcare and life sciences enterprises are challenged to deliver the best possible patient care while reducing costs and improving outcomes.

RAIN RFID provides an automated and reliable data capture system that helps enable hundreds of healthcare applications to improve patient safety, manage surgical instruments, support staff and patient workflow, automate replenishment and billing, authenticate quality and sterilization processes, manage medical equipment location and automate supply chain management.

HEALTHCARE BENEFITS OF RAIN

RAIN RFID is revolutionizing the healthcare industry and transforming how hospitals and healthcare professionals manage their inventory, people, assets and supply chain to reduce costs and provide high-quality patient care.

- Higher inventory visibility and accuracy
- Effective recall management
- Improve patient safety and care
- Automate payments and increase profitability
- Reduce product expiration, shrinkage and waste
- Decrease supply chain and equipment costs
- Reduce hospital-acquired infections
- Prevent medical errors due to misidentification

"RAIN RFID IS AN ENABLING TECHNOLOGY THAT SAVES LIVES, PREVENTS ERRORS, SAVES COSTS AND INCREASES EFFICIENCIES. MANY PARTS OF THE HEALTHCARE INDUSTRY HAVE ALREADY EXPERIENCED THESE BENEFITS AS SHOWN BY THE MARKET GROWTH RATE OF 35% EACH YEAR THROUGH 2020." *-IDTECHEX*

HEALTHCARE SUCCESS WITH RAIN

Healthcare companies around the world are achieving compelling results and ROI from RAIN RFID deployments

EMS ORGANIZATIONS

Automated inventory management using RAIN RFID resulting in an average 40% gain in efficiency.

RADY CHILDREN'S HOSPITAL

Decreased staff time by 15 minutes/tray for daily medication tray restocking of 200 trays.

HANMI PHARMACEUTICAL

Improved inventory management by tracking 60 million items annually.

RESTON HOSPITAL

Completed UDI requirements, and streamlined tissue and implant management using smart freezers.

More HEALTHCARE information – Success Stories, Presentations, News - https://rainrfid.org/markets/healthcare/

Over 40 healthcare providers are using RAIN RFID - https://rainrfid.org/markets/healthcare/rain-in-healthcare/

How CAEN RFID utilized CISC RAIN Xplorer in their Reader Development

CAEN RFID, a leading RAIN RFID reader and reader modules manufacturer, used CISC´s Xplorer to better understand how surrounding electronics have an effect on the sensitivity performance of their reader. As a result, CAEN RFID achieved optimized reader performance while saving development time.

Optimize Reader Sensitivity

CAEN RFID´s goal was to decide on architecture and configurations in reader design for optimized reader sensitivity to even better accommodate the latest generation of low-operating-power and low-backscatter-power RAIN tag chip generations.

Phase-Shifter for Reader Behavior Understanding

When CAEN RFID started to evaluate how to optimize their reader sensitivity, CISC provided the measurement solution matching the overall requirements. CISC´s huge expertise in the testing market plus the phase shifter feature for verifying problems in the RF-chain, have been the main reasons why CAEN RFID decided to purchase Xplorer.

"After receiving Xplorer, we used it intensively and discovered interrelations that we could not quantify in the past", says Gabriele Isola, RF R&D Manager of CAEN RFID s.r.l.. "The new insights helped us to advance our products in terms of quality and performance while shorten our development time. We can now use the time gained for our customer support."

CAEN RFID used the Xplorer performance test, that supports variation of backscatter strength and BLF, to understand which parameters and other impacts are essential to get the best reader sensitivity. A very interesting add-on came with the phase-shifter feature. It helped to understand how the reader changes its performance in dependence of various tag signal parameters additionally to BLF variation. This fine control was key to success. Additional evaluations have been done by the sniffer for reader to tag communication with focus on protocol and timing, supporting software verification.

"CISC´s test equipment was fundamental for developing the architecture of our new products according to ISO/IEC 18046-2 and with improved reader sensitivity." says Gabriele Isola, RF R&D Manager of CAEN RFID s.r.l.. "The test results showed us how surrounding electronics have an effect on the performance of the reader e.g. the effect of the switching mode power supply on the sensitivity."

Advanced Reader Performance

As a result, CAEN RFID achieved advanced performance of their readers while saving development time.

- Gained instant feedback on reader performance on different reader architecture and settings
- Strengthened its reader product offering with best-in-class performance

- Enhanced understanding on reader characteristic based on the surrounding electronics
- Saved time to better spend on technical support for their customers

About CISC

CISC Semiconductor is adding trust in a connected world by providing hardware and software solutions that enhance quality and performance for wireless communication in the Automotive and Identification market.

CISC is a leading standardization consultant and an active member of the AIM Germany, emi3, ETSI, IEC, ISO, NFC Forum, and RAIN Alliance. CISC is headquartered in Klagenfurt, Austria, with subsidiaries in Graz and Mountain View (CA), USA.

CONTACT
www.cisc.at
office@cisc.at

CISC semiconductor

INTERNET OF THINGS (IoT)

RAIN RFID connects billions of everyday items to the Internet of Things (IoT), enabling consumers and businesses to **identify, locate, authenticate,** and **engage** each item. IoT applications require a data connection between the physical and digital world, and RAIN RFID is the ideal technology to bridge these realms with the ability to bring low cost, unique identification to everyday items.

- **AIRLINES**
- **AUTOMOTIVE**
- **FOOD**
- **HEALTHCARE**
- **LOGISTICS**
- **MANUFACTURING**
- **RETAIL**
- **SMART HOMES & CITIES**
- **SPORTS**
- **TRANSPORTATION**

RAIN BENEFITS FOR IOT

RAIN RFID adds intelligence to the IoT value chain and facilitates new applications for connected things. RAIN RFID is the only technology capable of providing a cost-effective and unique digital ID to everyday items.

- RAIN delivers IoT item-level value
- RAIN offers a wide variety of IoT applications
- RAIN brings additional sensor connectivity
- RAIN can be embedded in things
- RAIN complements other IoT technologies

IOT SUCCESS WITH RAIN

Over 80 billion items in industry and consumer applications have been successfully connected with RAIN RFID.

RAIN CONNECTS THINGS

Millions of people benefit from worry-free traveling thanks to RAIN-supported baggage tracking by Delta Airlines.

RAIN CONNECTS PEOPLE

Millions of runners benefit from accurate RAIN performance measurement, including the New York City Marathon and Wings for Life.

RAIN CONNECTS SUPPLY CHAINS

RAIN can help supermarkets reduce in-store waste by 20%, improve efficiency and track goods from farm to store.

RAIN CONNECTS SENSORS

Mercedes and VW use RAIN sensors to measure environmental conditions including temperature and moisture during production.

Link to more IOT information – Success Stories, Presentations, News - https://rainrfid.org/markets/iot-market/

WHAT HAPPENED TO THE "THINGS"

Steve Halliday

We are all very caught up in the "Internet of Things" phenomenon. There isn't a day goes by when we don't see an article (or sixteen) on the topic. We see statistics quoted here, there and everywhere about how this is going to/already is affecting our lives, yet almost none of these articles seems to see the big picture.

In "How to Fly a Horse" by Kevin Ashton (http://www.amazon.com/How-Fly-Horse-Invention-Discovery/dp/0385538596) we learn that Kevin coined the phrase "Internet of Things" (IoT) in 1999 when he was trying to present a solution to the problem of tracking the sales of lipsticks. Kevin worked at Procter & Gamble and the misplacement of lipsticks in the display case was causing a sales issue when the required colour was in stock, on the display, but in the wrong place and not easily found. Kevin put an RFID tag in the lipstick and an antenna under each location, monitored the display unit, uploaded the information to the internet and used it to make decisions about the actual sales stock position.

Since then the term has been broadened to include almost anything that is in some way connected to the Internet and is providing information that can be used. The term has almost become a part of everyday use, though it seems the understanding of the term has morphed. In 2013 the Oxford English Dictionary included a definition for the IoT – "The interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data" (http://www.oxforddictionaries.com/us/definition/american_english/Internet-of-things). While this definition is fine, it does not capture the real essence of the concept.

In 2013-4, Special Workgroup 5 under ISO/IEC JTC 1 (International Standards Organization/International Electrotechnical Committee Joint Working Group 1) spent a lot of time looking at the definition of the IoT and found over 30 definitions in common use. The group reviewed all of these and created a new definition that is currently being used in ISO – "The Internet of Things (IoT) is a global network infrastructure, linking physical and virtual objects through the use of interoperable data capture and networking methods. Standards-based object identification, sensors, controls, actuators, and connection capability provide for the development of independent cooperative services and applications supported by data analytics and characterized by a user-defined degree of autonomy." The work of this group can be found in a report and annexes to be found at http://www.iso.org/iso/jtc1_home.html.

So, when did we become enamoured with the thermostats and fitness bands that the public seems to think is the IoT and how is this leading us astray? The idea of wearing a band that tells us how "healthy" we are being or monitoring the temperature of the house from our smartphones are things that we view as "cool and sexy", so naturally we want to be involved and the manufacturers are keen to oblige. The possibility that we can somehow control our lives in a new way is something that is driving us forward, and with all the talk of the Internet of Things it makes us feel that we are a part of the modern world.

Obviously, this is only a very small part of the IoT and yet the market for the devices is very large, hence the interest to provide us with the technology. My fitness band talks to my phone and if I have the correct brand of fitness band it will even talk to the app that connects me with my medical records and my doctor would be able to see how good (or bad) I am at making sure I walk my 10,000 steps every day. So, I am connected, and I have a chance that the information can be used to better my life.

Now we need to think about all of the other things that can be connected, and we see that it is not always as simple as the fitness band. After all, I have to be an active part of the system, making sure the band is near the phone, maybe I have to force a sync occasionally,

make sure the band is charged, etc.. If this IoT thing is going to work, then we need to look at ways to make it less invasive in our lives

If we go back to Kevin's problem, we can see that he was interested in locating something that does not have electronics embedded, that does not have an IP (Internet Protocol) address, that does not have an electrical connection to anything, AND may only cost a few dollars. The problem of identifying, locating, authenticating and engaging with these "things" is very real and needs to be addressed.

The answer to many of these problems lies in a technology that has grown massively over the past few years. Passive UHF radio frequency identification technology (now called RAIN RFID) is small, inexpensive, does not need batteries, and can communicate with a host portal over a distance of many meters. The technology is standardized by ISO and there are many companies providing the various parts of the technology. The group is represented by an industry alliance (RAIN RFID Alliance) in the same way that Wi-Fi and Bluetooth are represented by their industry groups.

The concept behind RAIN is that the individual items are "tagged" with a small RAIN tag that has a unique number associated with it. This number describes the identification of the items that it is attached to, maybe a shoe, a pair of jeans, a clock, a manufacturing part or maybe even a person. The tag is interrogated by a reader, interrogator and the identity and location of the thing is logged into the system. This information (or possibly lack of information) is then used to make decisions about the thing.

CASE STUDY

Unlock the potential of "industry 4.0" by embedding Primo1D's unique tagging solution inside physical assets

New business models and services can be triggered by leveraging RAIN RFID technology.

Primo1D offers a miniaturized RAIN RFID tag, intended to be integrated at manufacturing and designed to endure large temperature ranges and mechanical stresses. This tagging solution is durable, providing high and reliable RF performances. A wide variety of packaging possibilities are available and make Primo1D's solution easy to use in most production processes.

Tie a native digital ID to a cable, connect it to the IoT and a smart cable is born!

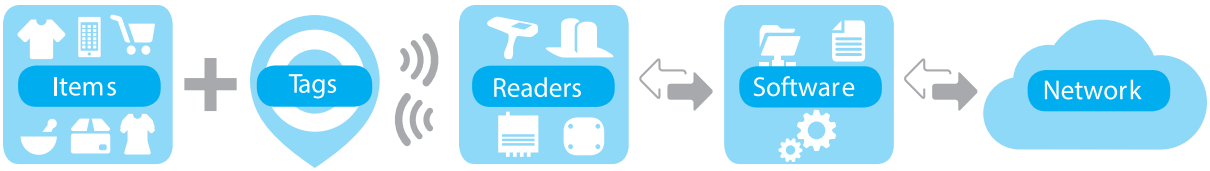
The information inside the smart cable can now be captured from product production to end of life. And this is essential since optimizing the uptime of assets is becoming critical.

The benefits are multiple with regards to product traceability, fleet management, downtime reduction and safety improvement. Operation efficiency is boosted and the supply chain is secured thanks to Primo1D's embedded tag. This is a first step to create value, not only for internal purposes but also for the end-user. Primo1D's tag is paving the way for new applications beyond the conventional-use cases mentioned above. Thanks to Primo1D's outstanding resistance to harsh environments, the cable's DNA is accessible all along the value chain and different cable usages can be addressed: rail, aircraft, renewables, utilities…

Primo1D's RAIN RFID tag empowers physical assets for industry's end-to-end product digitization.

CONTACT
7 Parvis Louis Néel – BHT Minatec
38000 Grenoble, France
contact@primo1d.com
+33 (0)456 141 249

Primo1D
The E-Thread™ Company



For example, let's suppose the thing is a pair of jeans. When I buy jeans, I know what I want, what brand, what size etc. I go to my favourite store and I look for "my" jeans. I don't find them! What do I do? The chances are that I leave, and the store just lost a sale. But what if the pair I want was actually two shelves over because someone had misplaced them? What if my size had been sold but there were three more pairs in the back room?

By using RAIN RFID, the store can have an instant notification of the jeans being removed from the shelf, being placed on the wrong shelf, or being sold. The jeans could be replaced within minutes of the event and they might have been sold me the pair I was looking for. This is exactly the premise that some retailers have been using with shoes in some of their stores. There has been a report of uptick in sales of 7% based on the fact that the store was able to keep the shoes on the floor in sight of the person who might want to buy them.

Now take this to the next level. Let's think about a manufacturing plant. Think of the value to the plant to have instant sight into all their stock, whether it is in their warehouse, on a truck, or sitting at the suppliers waiting for delivery. Most companies operate in what I will call silos. Visibility into the status of the manufacturing process is limited specifically to those who "need to know", but in many cases the need to know philosophy does not work.

I was recently made aware of a large manufacturing company that uses a very well-known enterprise management product, but they only use it to generate pieces of paper to process the receipt, inventory, and shipping of items. The purchasing folk have no sight into the status of the items that are ordered after they make the purchase. This causes many headaches with frequent calls from receiving to the purchasing agents to identify badly labelled products and recently the misplacing of several very expensive parts. These parts became the critical point in the manufacturing process and had to be reordered and shipped express at many times the original cost because they were lost. RAIN RFID is an example of how using the right technology can eliminate these kinds of issues.

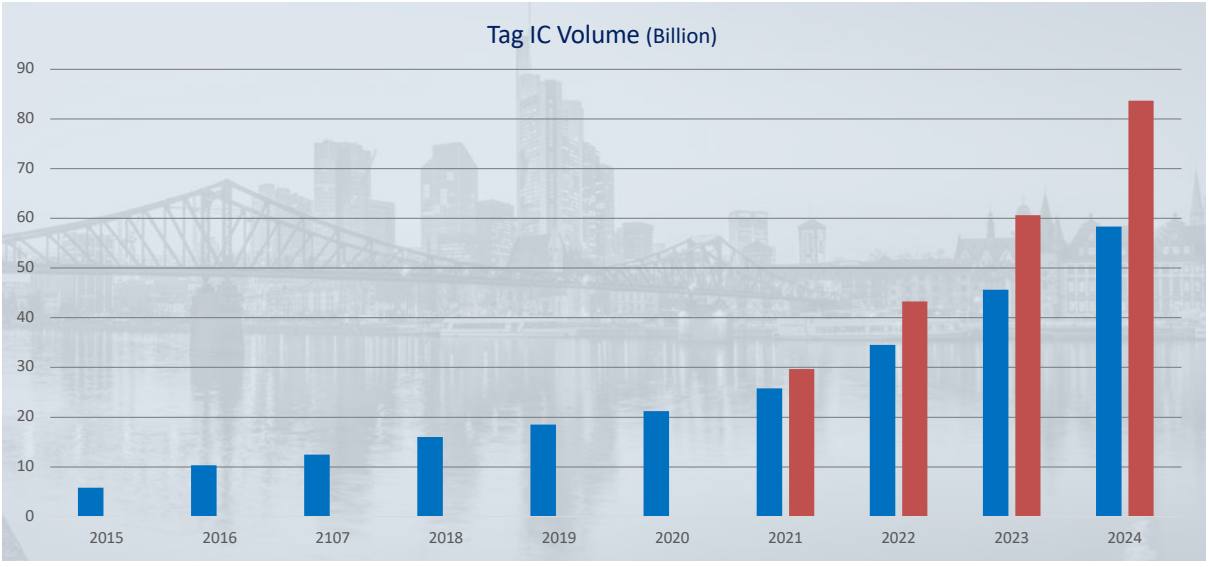
The key to the success of the Internet of Things will be the ability to identify, locate, authenticate and engage with "Things", not just expensive, IP-based devices. RAIN RFID exists today and is already starting to provide this "thing" based information. Research companies like IDTechEx (https://www.idtechex.com/en/research-report/rfid-forecasts-players-and-opportunities-2019-2029/700)have published that by 2020 we will have over 100 billion RAIN tags in use. This is about five times the numbers being quoted related to IP-connected devices. See the Gartner report – "Forecast: The Internet of Things, Worldwide, 2013"; Gartner, Inc. Research Report; Dec. 12, 2013: https://www.gartner.com/en/documents/2625419

Completely compatible with existing technologies that provide IP-connectivity to devices, RAIN allows us to identify, locate, authenticate and engage with everyday things. RAIN has the capability to interface with sensors on the things and can provide the information we need.

The Internet of Things is here to stay, it is not a university research project, and the data shows that we are engaged in the concept. The next time someone talks about connected devices, remind them that IP-connected devices are a small part of the system and that we must not forget the "Things".

Originally posted to the CISCO IoT Blog, June 2015 http://blogs.cisco.com/perspectives/what-happened-to-the-things and updated for this document.

The RAIN Alliance publishes data that shows growth in Tag IC sales each year *(see below)*



DATA COLLECTED BY RAIN RFID ALLIANCE 2015-2020, FORECAST 2021-2024 – RAIN MARKET RESEARCH REPORT 2020 BASE LINE AND BEST CASE SCENARIOS

THIS GRAPHIC SHOWS HOW RAIN TECHNOLOGY ACTS AS THE LOWEST LEVEL PROVIDING THE CONNECTIVITY TO THE "THINGS" IN OUR LIVES.

RAIN® RFID

Egypt: Electronic Vehicle Identification Powered By Secure RAIN RFID Technology

To address the growing number of unauthorized vehicles operating on Egyptian roadways, Egypt's Ministry of Interior (MOI) is deploying an electronic vehicle identification system that will securely identify vehicles and confirm their authorization to be on the road.

The new system, powered by secure, passive RAIN RFID (UHF) technology from NXP, will cover a total of approximately 10 million vehicles. Each vehicle is equipped with a windshield or headlamp label that includes an NXP UCODE DNA tag IC. The IC helps ensure label authenticity and makes it easy for reader machines, mounted on overhead gantries, to detect vehicles that are not authorized to be on the road. The solution works at high speeds – supporting readings up to 220 kilometers per hour – and even in harsh weather conditions.

The UCODE DNA chip combines high read ranges of several meters, without use of a battery, with innovative cryptographic features for AES authentication. To ensure data integrity and confidentiality, the crypto keys can be used for tag authentication as well as privacy protection.

The complete system solution, involving companies such as Kathrein Solutions, Go+, and Wireless Dynamics, provides the MOI with accurate, real-time data that can help manage and improve traffic flows while minimizing unauthorized road activities.

Beyond Egypt, governments in Peru, Kenya, Honduras, the Philippines, and other countries already rely on secure, UCODE DNA-powered electronic vehicle identification solutions.

CONTACT

NXP Semiconductors Austria GmbH Mikron-Weg 1
8101 Gratkorn
Austria
rfid.info@nxp.com

RETAIL

RAIN RFID that connects billions of retail items to the internet, enabling brand owners, retailers and consumers to identify, locate, authenticate, and engage with each item. A consumer-led revolution for omni-channel commerce has placed huge demands on retailers, but RAIN RFID is helping to make it easier, faster and more secure for brand owners and retailers to improve inventory management from manufacturing and supply chain to point-of-sale online and in the stores.

- 98% inventory accuracy results
- Up to 20% sales boost with item availability
- 96% improvement in labour productivity
- 9% decrease in shrinkage
- 50% reduction in out-of-stocks
- 96% time reduction with smart inventory

RETAIL BENEFITS OF RAIN

For omni-channel retailing, inventory visibility and returns processing is more important than ever. RAIN technology provides the best inventory management to increase sales, reduce out-of-stock and overstock, and improve employee and customer satisfaction.

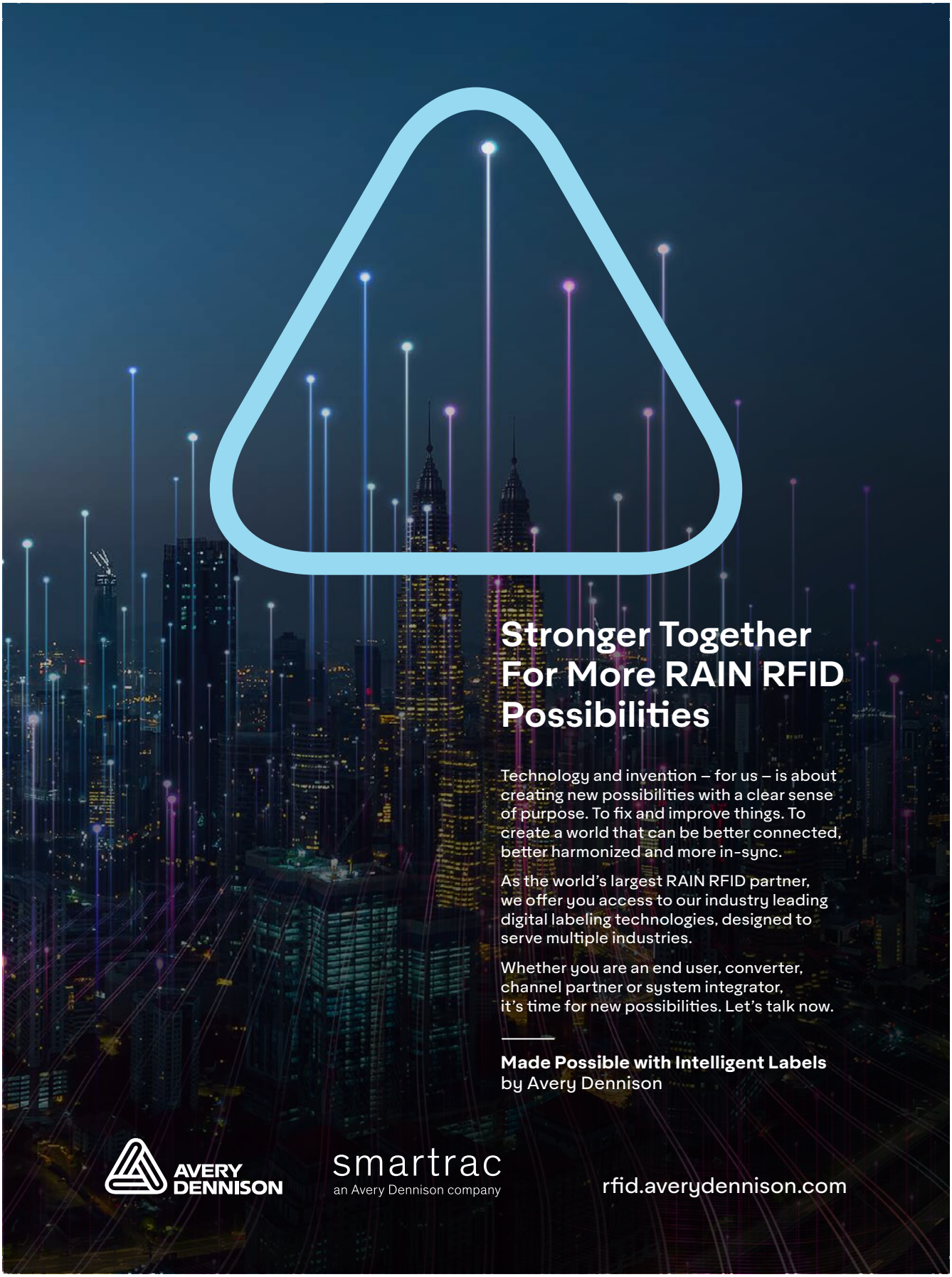
"(RAIN) RFID PROVIDES FOR NEARLY 100% ACCURATE, REAL-TIME INVENTORY INFORMATION." *-GARTNER*

RETAIL SUCCESS WITH RAIN

ZARA Improved accuracy and visibility with faster inventory counts.	**LULULEMON** Increased e-commerce sales by improving inventory accuracy to 98%.
TESCO Reduced costs by 10% with better replenishment.	**HERMAN KAY** Optimized supply chain process to 100% accuracy.

Link to more RETAIL information – Success Stories, Presentations, News - https://rainrfid.org/markets/retail/

Over 100 RETAILERS use RAIN RFID - https://rainrfid.org/markets/retail/rain-in-retail/


Stronger Together
For More RAIN RFID
Possibilities
Technology and invention – for us – is about creating new possibilities with a clear sense of purpose. To fix and improve things. To create a world that can be better connected, better harmonized and more in-sync.
As the world's largest RAIN RFID partner, we offer you access to our industry leading digital labeling technologies, designed to serve multiple industries.
Whether you are an end user, converter, channel partner or system integrator, it's time for new possibilities. Let's talk now.
Made Possible with Intelligent Labels
by Avery Dennison
AVERY DENNISON
smartrac
an Avery Dennison company
rfid.averydennison.com

SMART MANUFACTURING

SMART MANUFACTURING BENEFITS OF RAIN

From the manufacturing of goods, to ensuring the right product is in the right location, RAIN has a place at every stage of the supply chain. With RAIN, businesses gain access to the real-time data use to optimize operations, improve consumer and worker safety, and reduce costs. Benefits include:

- Higher inventory visibility and accuracy
- Effective recall management
- Improve patient safety and care
- Automate payments and increase profitability
- Reduce product expiration, shrinkage and waste
- Decrease supply chain and equipment costs
- Reduce hospital-acquired infections
- Prevent medical errors due to misidentification

"ROUGHLY 64% OF MANUFACTURERS BELIEVE THAT APPLYING IOT TO PRODUCTS WILL INCREASE PROFITABILITY OVER THE NEXT FIVE YEARS" *–MPI GROUP*

SMART MANUFACTURING SUCCESS WITH RAIN

INDUSTRY 4.0 RAIN RFID, is reshaping how manufacturers produce, deliver, and manage their products.	**MERCEDES-BENZ** Using tags with moisture sensors, RAIN RFID may be the most viable future method for leakage testing of vehicles.
DANA INCORPORATED Using RAIN RFID for 100% traceability through the manufacturing process, despite the rigors of temperature washes, painting, and handling.	**MICHELIN** RAIN RFID tags embedded in tires for unique identification, allows cradle to grave traceability.

More SMART MANUFACTURING information – Success Stories, Presentations, News - https://rainrfid.org/markets/smart-manufacturing/

INTELLIGENT PACKAGING

RAIN RFID solutions enable Intelligent Packaging for a wide range of industries and markets, from apparel and retail to manufacturing, logistics, and healthcare by adding integrated sensing, identification, and communication functionality to how things are packaged.

Packaging already serves an important role in the marketing, protection, and compliance of an item. Implementing RAIN in packaging offers the lowest application cost and greatest duration of value – the benefits of RAIN can be utilized from the point of manufacturing through shipping, distribution, sales, and end use.

Enhanced productivity, reduction of waste, heightened security, improvement of inventory accuracy, and increased engagement with consumers are advantages of RAIN. The entire supply chain can be monitored and controlled at all times.

INTELLIGENT PACKAGING BENEFITS OF RAIN RFID

PRODUCTION AND WAREHOUSING – Intelligent packaging enables real-time tracking and visibility of production. Intelligent solutions help in managing material flow, such as material coming in and out from the warehouse. Expensive warehousing is minimized. Production management gets easier, when data capture and transfer is more accurate and automatic. Errors in manual work are reduced and resources can be moved to other tasks requiring work.

LOGISTICS - Intelligent packaging solutions make it possible to track material and product deliveries. Deliveries to customers can be tailored.

Product transportation and receipt processes speed up and become more reliable through automated solutions. This reduces reclamations and increases customer satisfaction.

CONSUMERS - Intelligent packaging enables communication with products and brands, and offers useful information and content, which helps in making the buying decisions, and improves customer experience. The buying experience widens from the physical to digital, and the virtual customer service is available 24/7.

Packages, which are easily identified with mobile devices, can be attached with features that connect the consumer to benefits such as video instructions, web store, additional products, offers, and customer service.

RETAIL - Intelligent packaging can be used to differentiate the product from the competitors and gain more attention. Instead of just availability, the whole shopping experience is invested.
With intelligent shelf and storage systems, the fulfilment orders can be placed automatically. Through interactive applications connected to packages, knowledge about the buying behavior is gained directly from the consumers. And with intelligent packaging, the real-time connection is enabled between retail store, packaged goods, and different phases of the supply chain.

Customer shops unmanned convenience store in Wuhan, China

INTELLIGENT PACKAGING USES

- Frequent Inventory Updates = Less Out-of-Stocks and Higher Sales Revenue
- Shipment/Receiving Process Automation = Reduced Errors and Higher Efficiency
- Devices Authenticating Consumables and Adjusting Processes Accordingly
- Automated Real-Time Inventorying and Optimized Replenishment via Intelligent Vendor-Managed Inventory (VMI)

RAIN
RFID

RAIN RFID TECHNOLOGY

A RAIN RFID solution uses a reader to read and write a tagged item, manage the data and take action.

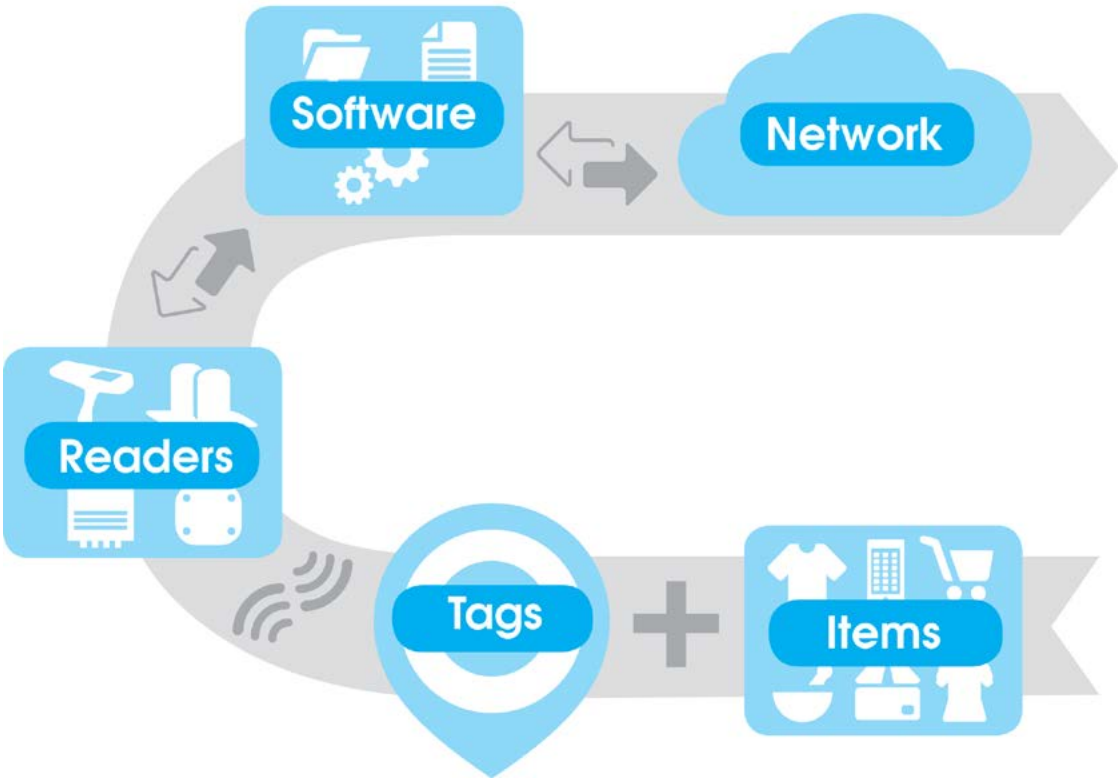
RAIN RFID is a wireless technology that connects billions of everyday items to the internet, enabling businesses and consumers to identify, locate, authenticate, and engage each item. RAIN technology is based on the UHF RFID protocol standard developed by GS1 and ISO and published as GS1 EPC Gen 2 UHF air interface and ISO/IEC 18000-63 860-960 MHz Air Interface.

ISO/IEC link - https://web.aimglobal.org/external/wcpages/wcecommerce/ecomlistpage.aspx?Keyword=18000-63

GS1 link - https://www.gs1.org/standards/epc-rfid/uhf-air-interface-protocol

RAIN tags containing an integrated circuit (chip) and an antenna are attached to or embedded in items, boxes, pallets, or other things. RAIN readers send a wireless signal to identify, locate, authenticate, and/or engage the tags. Readers can be embedded in devices, held by a person, or installed in doorways or ceilings.

RAIN software collects the tag data and can connect this information with networks or clouds to enable inventory management, asset tracking, and many other applications.



RAIN RFID TAGS

- Are either attached to or embedded in items
- Tagged items store and send information
- Thousands can be identified simultaneously and do not have to be visible to the human eye

RAIN RFID READERS

- Have antenna(s) for either short or long-range communication
- Can be small and portable, or larger and installed, or embedded in other devices

RAIN RFID SOFTWARE APPLICATIONS

- Identify – Locate – Authenticate – Engage
- Use the tags and readers to create, collect, and use the item's data – locally, or on a server, or on a cloud
- Authentication starts with determining an item is genuine
- Engage can involve sensors, or other means of interacting with the item

RAIN RFID DOCUMENTS

Here are some of the documents the RAIN Alliance has published that can help you to understand the technology and its use.

RAIN Terminology

History of RFID

RAIN Radio Protocol

The Anatomy of a RAIN RFID Solution

RAIN Communication Interface Guideline (RCI)

RAIN RFID Reader Sensitivity Testing

What RAIN Brings to the Internet of Things

RAIN Q&A with Kevin Ashton and the Internet of Things

Electronic Vehicle Identification (EVI)

New Opportunities in Usage and Challenges to Embed RAIN RFID Tags into Product & Packaging

Non transferable RAIN RFID v1.0

RAIN GS1 Guideline for tire identification

RAIN RFID Lessons learned from the field

RAIN RFID System Design Guidelines

RAIN Item Numbering and Tag Data

RAIN Item Numbering to Avoid Tag Interference

Digital Twins - a primer

RAIN RFID Relevant Standards

Link to the RAIN RFID Documents - https://rainrfid.org/resource-type/documents/?c=rain-alliance,rain-rfid&t=documents&s=

em microelectronic

A COMPANY OF THE SWATCH GROUP

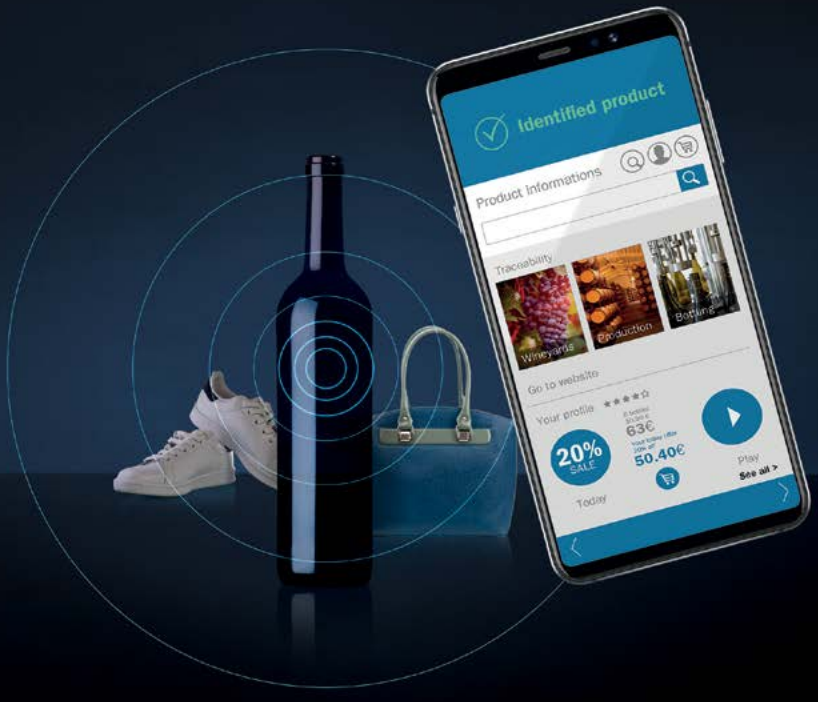
enabling a holistic omnichannel retail experience

Benefits of combining RAIN RFID and NFC into RAINFC:

em | echo
RAINFC AUTHENTICITY

To consumers
- Authenticate both the product and the channel
- Consistent consumer experience anytime, anywhere

To brands and retailers
- All-in-one tool for supply chain management, consumer engagement and product authentication
- Bring consumer behavor retail analytics to a next level
- Drive sales uplift through upselling, cross-selling, endless-aisles and tap-and-go self-checkout



NFC RAIN RFID TRUE ULTRA-LOW POWER

rainfc.com

RAIN RFID TAGS

RAIN tags are the items that are attached to the "thing" that needs to be identified. The tag is made from an integrated circuit (tag chip) and an antenna mounted on a substrate.

Tag chips are made by several companies and they offer a variety of different features. The basic feature set is common to all chips, but the standard that defines the air interface (how a tag chip talks to a reader) has many options in it that a manufacturer can choose to implement or not. Options include security, file management features, user memory, and the ability to add "battery assist".

The most common form factor for a tag is a paper label, but there are many other form factors available, as well as different configurations of the various form factors.

Tags use a technology called "passive backscatter" to talk to the reader. They use the power transmitted from the reader to energize and respond to the reader. They do not transmit the information but are able to modulate the reader signal as a response. This backscatter technique means that the tag needs to be in the "read zone", an area that receives a good signal from the reader. It also means that replies from tags are very low power and so they can easily be lost if the reader is not focused on the tags, or there is a lot of other radio noise.

Tags antennas are designed to be used in specific applications – for example, a tag may be designed to be used on a bottle of shampoo. This tag will be specially designed and tuned to consider the properties of the shampoo and the effect that it has on radio waves. Other examples might be a tag to be used on a metal object, or on a bottle of water. Size is also a factor when designing a tag. A tag that must be read at large distances will typically be larger than one that is only read close by.

OTHER FORM FACTORS MAY

- Have a hard shell around the tag chip and antenna for a more rugged application.
- Be embedded in a plastic surround such as an ID card or may include adaptions to allow the tag to be mounted on metal surfaces
- Have flexible shells to allow attachment to curved surfaces while still affording the extra protection of a shell
- Be a part of a thread used in the manufacture of garments etc.

FOCUS ON QUALITY CASTING SUCCESS

Laxcen

Laxcen Technology Limited

- **We are the inlay manufacturer, RFID hardware and solutions provider.**

With well-experienced in RFID products, Laxcen is one of the leading companies in IOT industry. Powered by industry's elite R/D team, state-of-the-art manufacturing plants and global partners, we provide end-to-end products and turn-key solutions to over 1500 customers from more than 50 countries around the world.

- **We provide Automatic Identification Technology that help people to build a smart world.**

Laxcen's product lines cover a wide spectrum of IOT applications that include NFC and RFID hardwares, Tags and solutions for libraries, apparel, aviation, retail, logistics, supply chains, etc.

RFID Inlays & Tags

Smart Equipments

Robots

Readers

Self-service Archives

For more information, please contact us: rfid@laxcen.com
www.laxcen.com

GENERAL TAG TYPES

Geek Speak

The following general tag types may be present in the read zone:

SIMPLE: Access to these tags are limited to reading the UII/EPC during inventory.

READ: Additional tags reads are required. This requires additional commands to be sent to the tag and more data to be sent by the tag. It takes longer to complete a tag interrogation. Often these actions reduce the read range of the tag.

WRITE: This requires additional commands and data to be sent to the tag. The tag needs more electric power to store the data permanently. It takes longer to complete a tag interrogation. Write actions reduce the read range of the tag.

BAP: Battery assisted tags may be in the read zone. The battery provides electric power for the tag intelligence (and sensors), so ensuring the optimal read range for all types of interrogations. Battery assisted tags have dedicated commands and modulation to optimise the use of such tags.

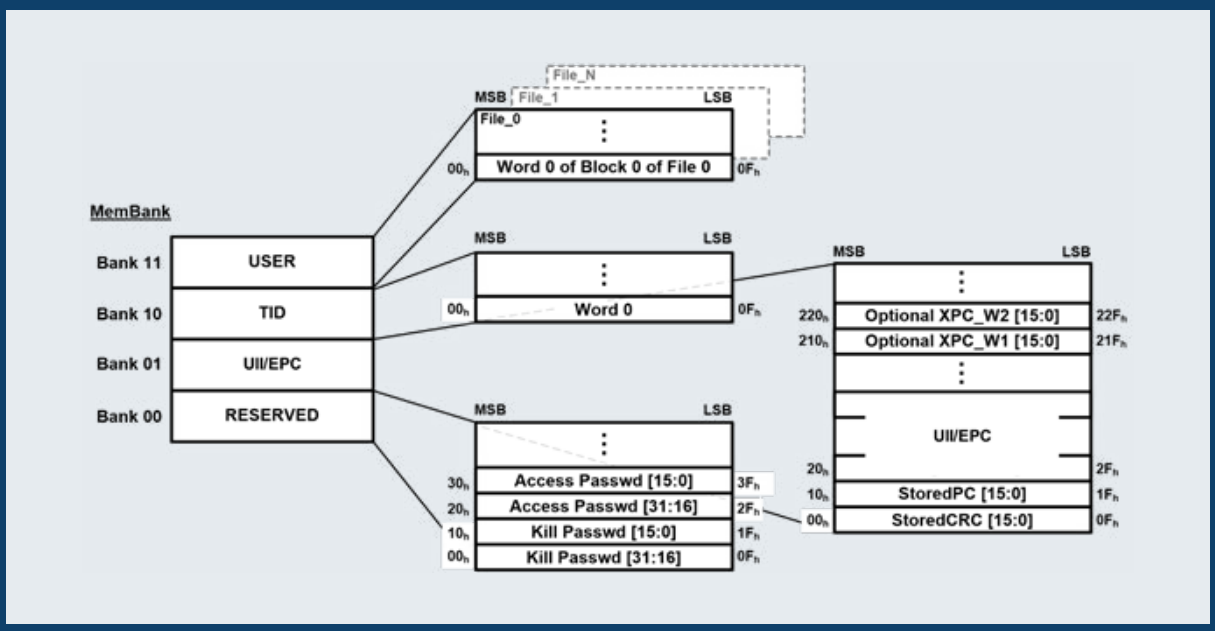
SIMPLE SENSOR: Tags may provide simple sensor data. Simple sensor data is added to the UII/EPC during inventory as indicated by the protocol.

SENSOR: Tags may provide sensor data.

CRYPTO: These tags offer extra security to the transaction and may reduce read range.

TAG MEMORY ORGANISATION

Information in the tag is stored in specific locations. RAIN tags have the following memory map:
Note: MB and MemBank is an abbreviation of memory bank.



SIMPLE ISO TAG WITH 128 BITS UII

MB-01 PC Bits					MB-01 UII
UII len	UserMem	XI	Standard	AFI	UII as specified by the AFI
01000	0	0	1 (ISO)	8 bits	128 bits as per UII len

SIMPLE GS1 TAG WITH 96 BITS EPC

MB-01 PC Bits					MB-01 UII
EPC len	UserMem	XI	Standard	RFU	EPC as specified by GS1
00110	0	0	0 (GS1)	0x00	96 bits as per EPC len

GS1 OR ISO TAG WITH ISO/IEC 15961 & 15962 DEFINED USER MEMORY DATA

MB-01 PC Bits					MB-01 UII	MB-11 User Memory	
UII/EPC len	UserMem	XI	Standard ISO|GS1	AFI/ RFU	UII/ EPC	DSFID	Data fields according to ISO/IEC 15961 & 15962
00110	1	0	1 or 0	0x00	*96 bits*	8 bits	*≥ 0 bits*

ISO TAG WITH ISO/IEC 20248 DEFINED USER MEMORY DATA

MB-01 PC Bits					MB-01 UII			MB-11 User Memory
UII Len	UserMem	XI	Standard	AFI	DAID	CID	Optional company assigned fields	signature, timestamp Optional company assigned fields
00110	1	0	1 (ISO)	0x92	32, 40 or 48 bits	16 bits	48 bits	≥ 256 bits

GS1 TAG WITH ISO/IEC 20248 DEFINED USER MEMORY DATA

MB-01 PC Bits					MB-01 UII	MB-11 User Memory			
EPC len	UserMem	XI	Standard	RFU	EPC	DSFID	DAID	CID	Signature, timestamp & optional company assigned fields
00110	1	0	0 (GS1)	0x00	*96 bits*	0x11	*32 or 40 bits*	*16 bits*	*≥ 0 bits*

ISO TAG WITH A SIMPLE SENSOR

MB-01 PC Bits					MB-01 UII	MB-01 Simple Sensor Data	XPC
UII len	UserMem	XI	Standard	AFI	UII as specified by the AFI	As specified by ISO	Simple sensor bit set
01000	0	1	1 (ISO)	8 bits	128 bits as per UII len	32 or 48 bits	16 bits

The Protocol Control (PC) word and eXtended PC (XPC) words 1 and 2 provide information on the data received and available on the tag. It also indicates the security access methods for the tag. The PC and optional XPC words are transmitted to the reader during inventory.

Memory Bank 11 (user memory) may be organised in separate data blocks called files. The default configuration is one file, called file 0. The Tag manufacturer chooses where a Tag stores its FileType and FileNum data. The Tag manufacturer also chooses the file-allocation block size (from one to 1024 words). User memory and the files in it may be encoded according to the GS1 EPC Tag Data Standard or to ISO/IEC 15961/15962 and ISO/IEC 20248.

The data stored on the tag is protected by a Cyclic Redundancy Check (CRC) digit. This means that a reader can calculate a CRC for the data received and check it against the stored value, helping to ensure that the data transmission was accurate.

GS1 tags and ISO tags have the same memory bank structure. They do differ in the content of banks 01 (EPC/UII) and 11 (User Memory). The following examples illustrate the differences.

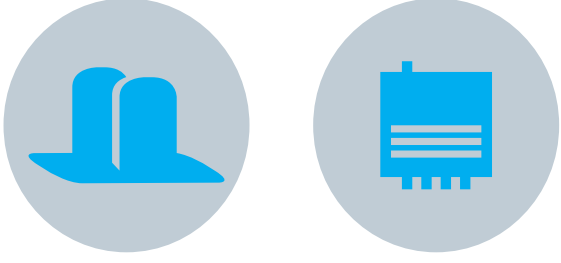
RAIN RFID READERS

RAIN Readers are available in many different configurations. All readers accomplish some basic tasks and then may have additional features. All RAIN readers can communicate with the RAIN tags and learn their identity. Most can also write to the tag. There are two basic types of reader, though these come in many different variations: fixed and portable (sometimes called hand-held).

FIXED READERS

Fixed readers typically mount to a fixed location (near a door, on a fork lift truck etc.) and can communicate with one to many antennas. They usually require a power supply and are connected to a network with an Ethernet cable, though some use power over Ethernet and some have wireless communications capabilities. Some readers have the antenna(s) built into the reader module. Some readers offer the ability to control the antenna to allow steering of the radio beam.

FIXED READERS



PORTABLE READERS

Portable readers can be dedicated devices, incorporated with barcode readers, or sleds to allow the attachment of a mobile computer or mobile phone. The form factor can range from a "gun" type device with an antenna attached to small devices not much bigger than the phone they carry.

PORTABLE READERS

READERS MAY SUPPORT MANY ADDITIONAL FEATURES SUCH AS:

- Working in dense reader mode
- Providing access to the user memory part of a tag
- Enabling file management in the tag
- Providing secure communications with the tag
- Providing commands to the tag to take other actions such as read a sensor or activate a switch or actuator

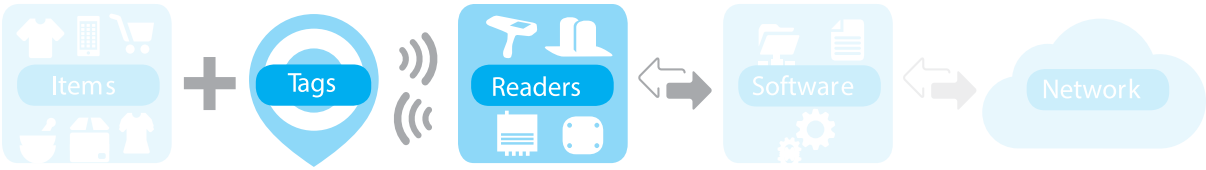
Does your RAIN RFID need:

Accurate counts, Reliability, Correct data?

Voyantic

Enabling RFID excellence

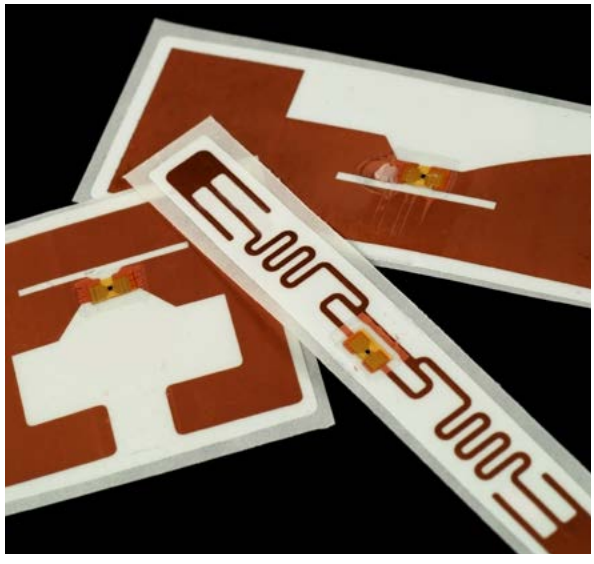
ANTENNAS



THE TAG ANTENNA

The first antenna is the one connected to the tag chip. This antenna can be of many different shapes, sizes, and capabilities. As with all wireless systems, the design and size of the antenna help to specify the performance of the system. Many tag antennas are designed specifically with the end use in mind, e.g. mounting on metal or liquids, or to provide a specific range for an application.

Tag antennas may be designed to work globally (over the full 860 – 930 MHz band) or locally in a specific country or regulation band. They are usually linearly polarized so that a reader needs to be designed to take this into account for optimum performance. Tag antennas can be near-field (operating close to the reader only), far-field (operating at a greater distance from the reader) or a combination of both antennas in one design. The far-field tags are typically linearly polarized (vertical or horizontal) although a few tags are dual-polarized. Antennas are typically made from copper or aluminium but can also be printed with conductive inks. The choice of tag and its antenna is one of the critical decisions to ensure good performance of a RAIN system.



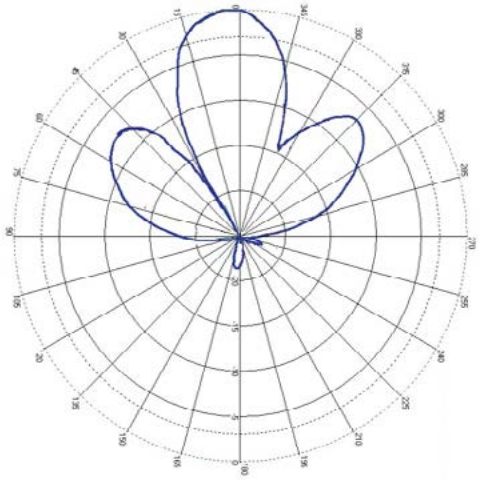
THE READER ANTENNA

The second antenna is associated with the reader and again can be of various shapes and sizes. Reader antennas can be large, in a hard case and mounted inside a doorway, or can be very thin to allow their incorporation into a shelving system. Reader antennas on handheld devices are designed to give the best performance from the compromises that require them to be portable.

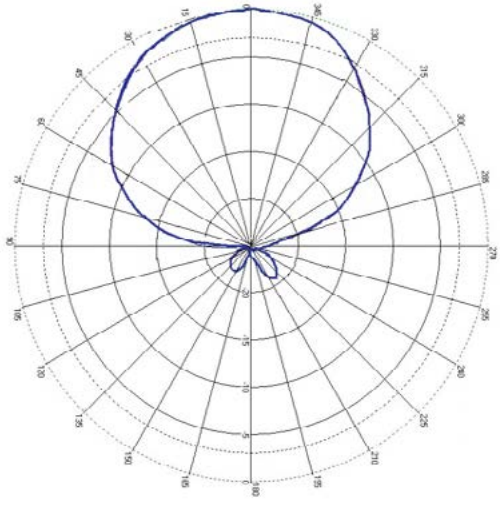
Reader antennas are classified as near-field and far-field antennas, sometimes also mid-field. Far-field antennas are typically electric field radiators and are unidirectional. They can be horizontally linearly, vertically linearly, or circularly polarized to provide the best performance for the application. Far-field antennas can detect tags in the range of up to 15 metres or more depending on the RAIN RFID reader's output power and the antenna's gain.

Near-field antennas, on the other hand, create a proximity RF magnetic field enabling RAIN RFID tag detection in challenging environments like metals and liquid. The far-field antennas' RF energy would be absorbed and reflected by the liquid and metal assets, respectively and thus near-field antennas are preferred to obtain a reliable tag read performance without having any false reads.

Each antenna has its own physical and electrical characteristics, which control the way the antenna radiates the RF energy. The 3-dimensional transmitting range of an antenna can be perceived through its radiation pattern, also known as the beam plot. The beam plot helps to identify the read range, in which tags will be detected. The reader antenna's read range can be extended or contracted by adjusting the power levels from the RAIN RFID reader.



XZ-plane



YZ-plane

Some reader antennas can operate in a wide frequency range that covers all the RAIN RFID regions – called wideband antennas - whereas others are specifically tuned for one of the two major frequency bands (ETSI and the FCC). Some may be tuned for specific regulations other than these.

Some fixed reader antennas offer steerable beams to allow better location capabilities for the system. The reader can control the positioning of the broadcast beam and so determine the location of tags that it sees.

The antenna selection should be determined by the use case or application, the choice of tag and the relative geometry of the tagged objects required to be read.

CASE STUDY

9 Steps to a Successful RFID Pilot

Access to instant information means that today's tech-savvy consumer can effectively buy whatever they want, whenever they want. To remain competitive, retailers are having to work harder to guarantee immediate product availability and richer customer experience; whether in-store or online.

Such challenges can be overcome with the use of RFID technology, which offers 98%+ inventory accuracy, great customer service, improved loss-prevention and frictionless checkout.

Deploying RFID, however, doesn't happen overnight. The technology requires new processes, ways of working and skills. In addition, because your business is unique, the way RFID works for others may not work for you. This is why implementing RFID without research, training, planning and testing may not meet your expectations. There are 4 RFID roadmap stages to ensure a successful deployment: Proof of Concept, Pilot, Phase 1 Rollout (several stores) and Phase 2 Rollout (all stores).

The Pilot stage is one of the most important stages. Failing to adequately prepare for a Pilot could result in a delayed or cancelled RFID deployment, higher costs and more time expended.

Global apparel label manufacturer, ITL Group, has released a whitepaper that defines the

9 steps to a successful RFID Pilot.

Key takeaways

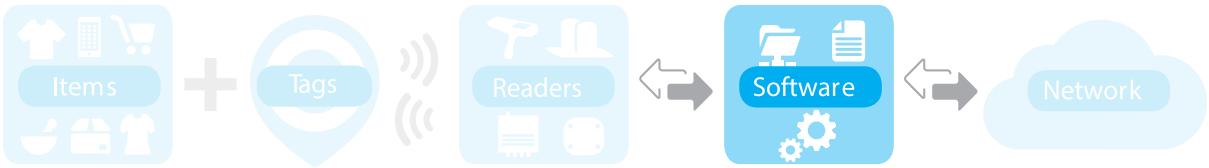
- A simple step by step guide to preparing for a perfect Pilot
- Do's and don'ts
- Key lessons learnt from previous pilots
- Critical success factors and business case analysis

To find out more, you can download the complete whitepaper here.

CONTACT
www.itl-group.com
stewart.plimsoll@itl-group.com

ITL
Intelligent
Label Solutions

RAIN RFID SOFTWARE APPLICATIONS



The software used to control a RAIN system is tailored to suit the application that it serves. It can range from small standalone programs that are simply detecting a RAIN tag and storing that information to systems that use large databases contained in the cloud to collect information and make decisions.

There is no "right way" to setup a software system for a RAIN application and the provider analyses the best way to satisfy the needs of the user and the application. Software is broken into several types; first there is the software that may reside on the reader as the interface to the user. This software may only provide the structure to talk to the reader or it may include the ability to make higher level decisions based on the data that is reported. The RAIN Communications Interface (RCI) is an example of a protocol in the software that sits in the reader and helps the user to get to the information that is needed. The RCI software accepts commands that allow the building of complicated actions including filtering the output.

https://rainrfid.org/resource-type/documents/?c=rain-alliance,rain-rfid&t=documents&s=RAIN%20Reader%20Communication

PASSIVE VS. ACTIVE REAL-TIME LOCATION SYSTEMS (RTLS)

Real-time location systems (RTLS) track assets, equipment, vehicles, people, and more in many industries. RTLS identifies where something is, and RAIN RFID identifies what something is, and while these technologies may be mutually exclusive, they can also now be combined to automatically identify and an item and track its location in "real time".

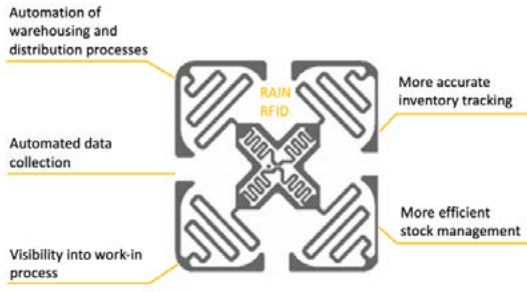
There are two categories of RTLS which are defined by the type of tag being tracked: Active vs. Passive. Passive RTLS uses RAIN RFID tags (a passive technology) typically have no internal power source, compared to an Active RTLS where each tag has a transmitter and power source (battery). Since RAIN RFID tags receive power from a tag reader up to 18 meters away these deployments tend to be indoors, while the more expensive and bulky active tags may be read at much longer distances (in some instances kilometers away or more if using GPS technology).

	Passive RTLS RAIN RFID	Active RTLS BLE Wi-Fi UWB GPS
⏻	No Internal Power Source	Powered Internally
🔋	Long Life Span	Shorter Life Span
📶	Short to Medium Range	Long Range
€$ £¥	Lower Cost Per Tag	Higher Cost Per Tag

COMPARING THE TWO TYPES OF RTLS

WHY USE RTLS?

- RTLS provides intelligence about items.
- Improve inventory management and asset tracking with real-time knowledge of item location.
- Automate tasks and remove manual outdated, error prone, less efficient solutions such as spreadsheets and clipboards.



RTLS SOLUTIONS IN MANY MARKETS

Healthcare: This rapidly growing application for RTLS in hospitals allows tracking and location of devices improving utilization. GS1 global standards protocols are increasingly being mandated for medical equipment. RAIN tags are now being applied onto all medical devices in some countries, such as the UK. This leads to the rapid expansion of Passive RTLS solutions where medical supply storage areas and cabinets are being fitted with RAIN RFID sensors.

Manufacturing/Logistics: Essential supplies, work in progress, or finished goods can be tracked and located in logistics and manufacturing facilities to improve utilization, lower costs, and increase efficiencies. Additionally, assets and spare parts can be tracked and located in storage areas around a manufacturing facility using Passive RTLS. As 2D/3D location accuracy improves, the total addressable market for Passive RTLS expands to new use-cases.

Retail: Moving to Passive RTLS automates inventory processes and can provide greater current stock data. Stores can perform continuous, always-on inventory counts using overhead antennas or steerable phased array solutions to track "last know location" in a fraction of the time it takes to use hand-held RFID solutions of other manual methods. Interim updates and item locations occurs more frequently with Passive RTLS.

Tool Tracking: The tracking and locating of maintenance and production tools is becoming more important, especially in the aviation industry, not only for improving utilization, reduction of losses, but also for important safety reasons. Tools can be tagged using special on-metal, small RAIN RFID tags, and Passive RTLS solutions read all of the tags in an industrial toolbox or tool storage area in continuously, as they are removed or returned by a defined person.

SESSIONS AND TAG TARGETS

Sessions are an expert air protocol method to add an additional layer of tag separation where readers are located close together. Other methods are RF shielding and frequency separation. Sessions may also be used to limit the number of times you read the same tag.

Targets are an expert air protocol method to silence tags already inventoried. This is very useful in helping to prevent problems due to too many tags in the portal trying to answer at the same time. It is also very useful to control battery assisted tag responses, since battery assisted tags may have substantially longer read ranges.

AIR INTERFACE PROTOCOL PARAMETERS

The air protocol parameters are used to optimize the speed and reliability of the over-the-air communication channel from the reader to the tag and from the tag to the reader. The over-the-air communications are influenced by various environmental and use factors in the read scenario. It must be noted that tags have very little power available (since they harvest electric power from the reader radiation) and have a small chip and are therefore limited in the speed and intelligence they can apply to decode reader radio messages. Readers, on the other hand can have all the electric power and intelligence they need to decode the tags radio messages.

The following air protocol parameters can be specified:

1. Q: The Q value is used to optimize the reading speed in relation to the number of tags simultaneously under the field. The higher Q values are good for large number of tags while lower values are good for small population of tags. Valid Q values are between 0 and 15 but typical values range between 3 and 7. Reader vendors typically implement an automatic Q value adjustment algorithm to adapt the reading speed dynamically to the tag population.

2. Tari: Tari is a factor used to determine the data link speed to the tag.

3. BLF: BLF is a factor used to determine the data link speed from the tag.

4. Modulation: The modulation specifies the method used to put data on the RF carrier. RF environments and use cases differ requiring different modulations methods.

5. Data encoding: Data encoding specifies the method for encoding the data onto the carrier (as specified by the modulation parameter).

6. Preamble: Long or Short; Long for noisy areas.

Parameters 2 to 6 specifies the radio modulations. These parameters influence the air link speed and robustness against radio noise. Typically, a higher speed will result in a reduced robustness. Each read scenario should be evaluated carefully for the optimal settings. This evaluation is often automated by the reader vendors.

These parameters are read only but may be very helpful in a system:

1. RSSI: Receive Signal Strength Indicator - An indicator of how well the reader has seen the tag. Should be interpreted with read count.

2. Phase: An RF indicator to assist in the optimisation of the read scenario.

AIR-INTERFACE PROTOCOL SUMMARY

Tags are energised by the reader. Once energised a tag will listen for a command from the reader. If the command is intended for the tag, the tag will respond by modulating and reflecting the signal received from the reader. The ability to recognize these commands is called the air-interface protocol and the standard defines the various commands and responses available.
The commands form part of three basic operations:

1. Select. The operation of choosing a tag population for inventory and access. A Select command may be applied successively to select a particular tag population based on user-specified criteria.

2. Inventory. The operation of identifying tags. Inventory comprises multiple commands. The result is the PC/XPC word(s), UII/EPC, and CRC from the tag. The PC/XPC bits inform the reader on the availability and access methods of additional information (e.g. sensor and crypto tags).

   Crypto tags inform the reader that they have encrypted information and which crypto suite is to be used to access the information. The application must provide the keys and use the indicated crypto access method to gain access to the protected data and/or verify the tag and/or the data.

3. Access. The operation of communicating with (reading from and/or writing to) a tag. An individual tag must be uniquely identified prior to access and a tag access handle obtained. Access comprises multiple commands (using the tag access handle) with multiple results and directed by the application.

STANDARDS

There are many standards that are relevant in the RAIN RFID world. The use of these standards is voluntary, but they mean that the system implemented can conform to well-known and agreed practices.

The main standard for RAIN RFID is the air interface standard. This standard has been published by both GS1 and ISO and the although the basic command sets are identical, there are differences between the two standards. The GS1 standard is *"EPC UHF Gen2 Air Interface Protocol"* and can be downloaded from https://www.gs1.org/standards/epc-rfid/uhf-air-interface-protocol. The ISO standard is *ISO/IEC 18000-63: Information technology — Radio frequency identification for item management — Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C* and can be downloaded from your local ISO National Body or its agent (in the USA this standard is available from AIM – https://web.aimglobal.org/external/wcpages/wcecommerce/eComItemDetailsPage.aspx?ItemID=381.

The air-interface standard is not the only relevant standards that can apply to the use of RAIN RFID technology. There are many other types of standards including numbering systems, data format, data identification, conformance and performance, cryptography, system architecture and application specific. These are all detailed in the RAIN RFID Alliance Guideline – "RAIN RFID Relevant Standards" (https://rainrfid.org/resource-type/documents/?c=rain-alliance,rain-rfid&t=documents&s=standards) and the reader is advised to be aware of these standards. Standards are available from the publisher.

The table shows how the ISO standards are used together to help create a standardised numbering scheme.

Other standards that are useful in defining and testing a RAIN RFID system include:

GS1 TIPP - specifying tagged item performance grades.

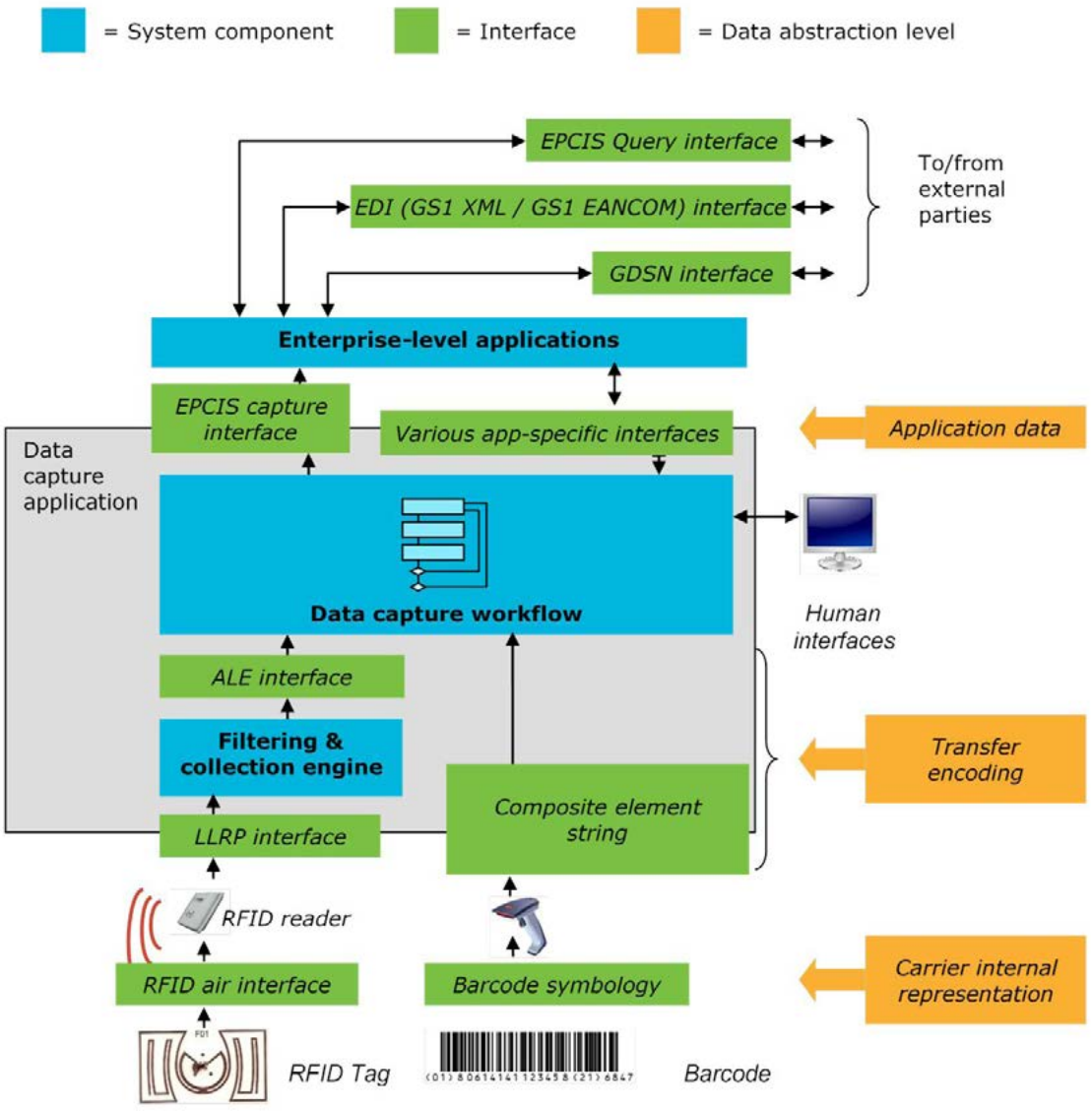
ARC Categories - practically same test methodology to TIPP, but different analysis and utilization of test results. Program run and administered by the University of Auburn in USA.

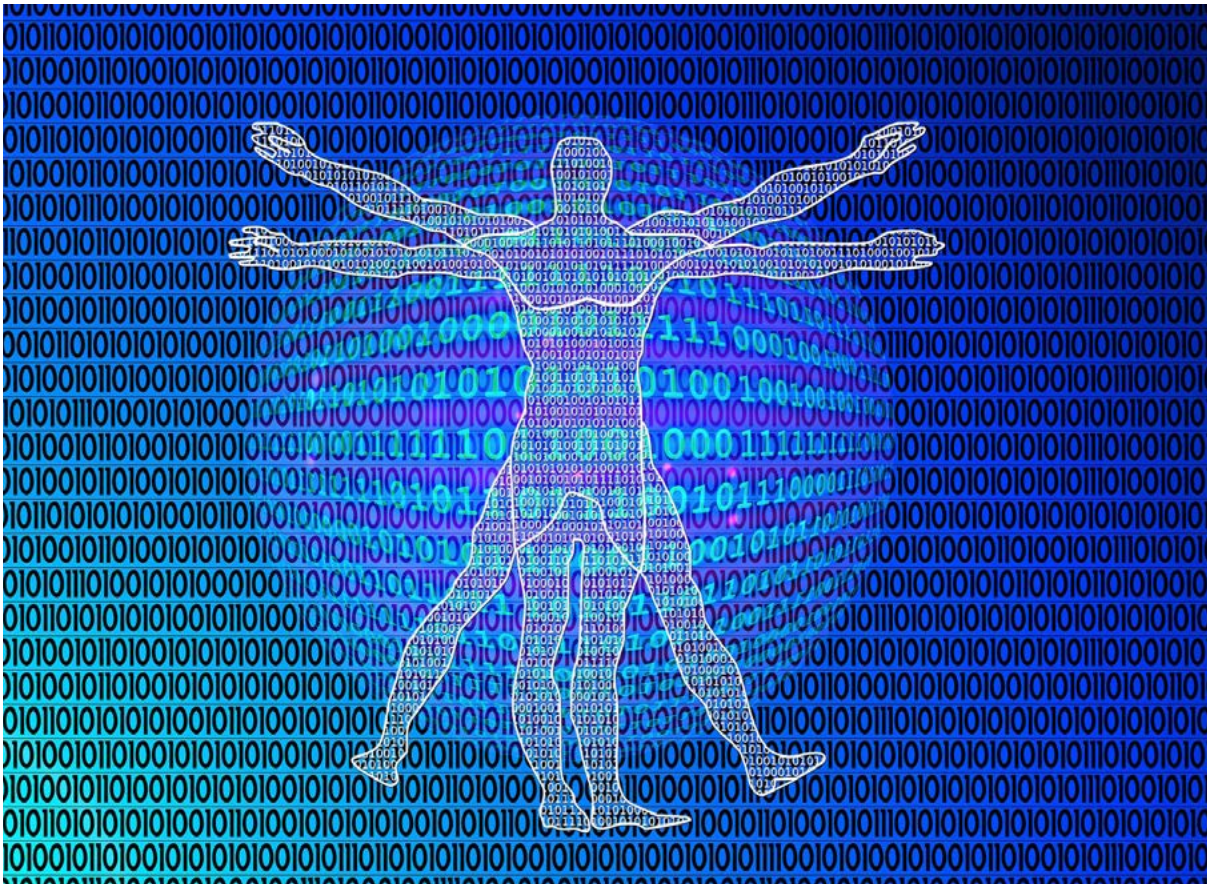
AS5678 (Spec 2000) for aerospace. A requirements specification created by SAE International for the production and test of passive only Radio Frequency Identification (RFID) tags for the Aerospace industry. This specification is also related to the Air Transportation Association SPEC2000 specification. http://www.spec2000.com/10.html

RAIN RELEVANT STANDARDS

STANDARD CODE	DESCRIPTION
ISO/IEC 15961	RFID for Item Management: Host Interrogator; Tag functional commands and other syntax features
ISO/IEC 15962	RFID for Item Management: Data Syntax
ISO/IEC 15963	Unique identification for RF tags
ISO/IEC 18000	**RFID FOR ITEM MANAGEMENT: AIR INTERFACE** -1 Generic parameters -2 below 135 kHz -3 at 13.56 MHz -4 at 2.45 GHz -5 at 5.8 GHz -6 at UHF frequency band -63 RAIN RFID
ISO/IEC 29161	Data structure — Unique identification for the Internet of Things

If the system being designed is using the GS1 system, then the following graphic shows the inter-relation between the GS1 standards.





RAIN RFID AND THE IOT – THE UNIQUENESS OF THINGS

There are many reasons why the IoT is important, but the underlying issue is that in order to identify a particular thing it has to be uniquely identified. These "things" can then be tracked, sensed, modified etc. and provide information that is used in the "system" to make the IoT work.

The underlying issue is the uniqueness of the "thing". There are several ways to help define that uniqueness.

NUMBERING SYSTEMS

There are currently two principle numbering systems being used within the RAIN RFID "world".

- The EPC numbering system. This requires you to purchase a number (company prefix) from GS1 and then gives you the ability to define a unique number. This has been widely accepted in the retail world. For more information contact the GS1 member body in your country.

- The ISO system. This uses an AFI (Application Family Identifier) to help define the uniqueness. An AFI is available at no charge from the ISO Registration Authority. The process for obtaining an AFI requires that it is being used in a global application and that the data structure that will be used is predefined. AIM acts as the Registration Authority for this standard (https://www.aimglobal.org/registration-authority.html)

IDENTIFIERS

Once a numbering system is chosen, then there are other issues within that system when trying to identify not just the thing but what the thing is doing. Many of these identifiers are defined (and standardized) by the issuing body.

In the GS1 world, the uniqueness is defined by a company prefix that defines a particular organization followed by a product code and a unique serial number. This information makes what is called the EPC number. Further data can be provided by using Application Identifiers (AIs) to identify the type of data being stored (e.g. name, address, size, date etc.). The AIs are all available in the GS1 General Specification available from the GS1 web site (https://www.gs1.org/standards/barcodes-epcrfid-id-keys/gs1-general-specifications).

The ISO world offers a similar method of ordering a unique number. The AFI allows an application to be identified and a controlling organization will define the method to guarantee uniqueness. As mentioned above, an application form for an AFI is available from the registration authority.

ISO has published a standard that talks about the needs of the Internet of Things and how we can approach unique identification. The ISO/IEC 29161 standard "Information technology — Data structure — Unique identification for the Internet of Things" gives a great introduction to the issues. The standard talks about the 'Identification of an "entity"':

"For the purpose of this International Standard, the terms "entity", "item", "object" and "thing" are considered synonymous. An entity may be a person, object, or location."

When one considers the Internet of Things (IoT), the definition of the "Thing" is most often coloured by the perspective of the person undertaking the consideration.

- If one is coming from the world of sensors, the Internet of Things (IoT) is simply an expansion of a sensor network.
- If one is coming from the world of RFID, the Internet of Things (IoT) is simply an expansion of an RFID infrastructure.
- If one is coming from the world of geospatial data the Internet of Things (IoT) is simply an expansion of a location-based network.
- If one is coming from the world of telecommunications, the Internet of Things (IoT) (IoT) is simply an expansion of a telecommunications network.

In truth, all are correct.

The "questions" below underpin the very heart of the traceability, tracking, and chain of custody.

TABLE 1 – TRANSACTIONAL IDENTIFICATION

WHO	Individual	Identification of the individual
WHAT	Product code	Identification of the product (SKU)
WHICH (ITEM)	Unique item	Globally unique item serial number
WHICH (GROUP)	Specific group	Identification of the lot or batch
WHICH (CONTAINER)	Package ID	Globally unique transport unit identifier
WHERE	Location (Storage/Postal/ Latitude, Longitude, Altitude)	Unambiguous identification of the location
WHEN	At what time	Unambiguous time stamp
HOW	Method	Unambiguous identification of the process
WHY	Authority	Purchase Order/ Work Order

A single transaction may need to capture several identities as it progresses from origin to destination (and return). For example, there may exist a need to capture, each time a transaction is recorded, the following:

- Item identification
- Sensor identification
- Node identification
- Gateway identification
- Target resource identification
- Location of data capture
- Time of data capture
- Identification of the individual

These items help us to understand the details of identifying a "thing". Not all of these will be applicable in every case, but the concepts presented above give a good starting point in the data needed to make an IoT numbering system work.

OTHER IDENTIFIERS

There are also other standards that contain information about "identifiers" that should also be considered.

THESE INCLUDE:

- ISO/IEC 15434 Syntax for high capacity ADC media
- ISO/IEC 15459 Unique identification (multiple parts)
- ISO/IEC 15418 GS1 Application Identifiers and ASC MH 10 Data Identifiers and maintenance
- ISO/IEC TR 29162 Information technology -- Guidelines for using data structures in AIDC media
- GS1 Identification keys (GTIN, GLN etc.)

WHAT DOES THIS MEAN?

If the Internet of Things is to flourish, then we need a numbering system that is going to work for everyone. We need a system that uniquely identifies an object but also has the flexibility to change as an object (thing) changes during its life. We need to better understand what data is required from that thing and work to create a system that has the flexibility to offer the data we need.

WHAT CAN WE DO?

RAIN has established a pre-eminent place in the Internet of Things as the identifying technology. With over 12 billion items identified in 2017, there is no other technology that has provided so much unique information about things. Members of RAIN are talking about the system that will take this information and move us forward with the information we need.

For more thoughts on the system, read
TOMORROW'S IOT FORECAST: RAIN
https://goo.gl/FwaL4N
Chris Diorio, CEO, Impinj.

REQUEST FOR HELP

If you are looking for help to implement a RAIN RFID system, use this link (https://rainrfid.org/technology/request-for-help/) and fill out the Request for Help form. The details will be sent to all RAIN Alliance members, and they will respond directly to you.

The **RAIN Alliance members** are contacted by end-users to help solve business problems!

RAIN RFID ALLIANCE

The RAIN RFID Alliance is a global organization promoting the universal adoption of RAIN technology solutions. Currently there are approximately 160 members of the Alliance worldwide. Members include vendors, organizations, academics, and end-users.

WORKGROUPS

The members of the Alliance support multiple workgroups, working together to focus on specific markets or technical topics. The workgroups have monthly conference calls and meet face-to-face at the RAIN RFID Alliance meetings.

CURRENT WORKGROUPS

Application Identity | **Aviation** | **Developers**

EU Road Charging | **Healthcare** | **Intelligent Packaging**

Smart Products | **Sustainability** | **Technical** | **Tyres**

RAIN RFID ALLIANCE MEETINGS

There are typically three face-to-face meetings each year – Americas, Asia and Europe. At these meetings, the workgroups work on projects, and non-members are invited to an Open Day for presentations and discussions. During Open Day, end-user speakers describe how they use RAIN RFID and discuss their needs with the audience.

As the world's largest RAIN RFID partner, Avery Dennison RFID solutions bridge the physical and digital world by providing physical items with a unique digital identity. Our solutions enable advanced efficiency, reliability, and accuracy across our customers' global supply chains.

http://rfid.averydennison.com/en/home.html

michael.baucke@eu.averydennison.com

Make informed decisions using ItemAware – scalable enterprise software that leverages multiple technologies to provide asset, work in process, and inventory tracking and management capabilities.

www.awareinnovations.com

info@awareinnovations.com

CISC Semiconductor is a leading RFID test equipment and solution provider with over 10 years' experience in UHF RFID testing. Additionally, CISC provides solutions for any wireless identification technology including RFID, Smart Cards and NFC.

https://www.cisc.at/

j.preishuber-pfluegl@cisc.at

CISPER

Cisper is an international distributor of Automatic Identification and Data Capture (AIDC) products and systems. At Cisper you will find the most comprehensive range of best performing RAIN RFID hardware and tags from world leading manufacturers.

www.cisper.nl

info@cisper.nl

EM's expertise, including standard and custom RFID, NFC and dual-frequency tag ICs, provides unparalleled opportunities to industries, retailers, and public sectors to connect, track, trace, and control their assets with greater security, increased productivity and cost-savings.

http://www.emmicroelectronic.com

rfidsupport@emmicroelectronic.com

Impinj is a founding member of the RAIN Alliance and pioneer of RAIN RFID solutions. Impinj provides a comprehensive platform, spanning endpoints, connectivity, and software, that connects items to business and consumer applications.

www.impinj.com

With over 40 years' experience, we are a global provider of apparel label solutions, supporting some of the best-known brands, retailers and manufacturers globally. With our comprehensive range of products and services, we can optimise your brand identity and supply chain performance.

www.itl-group.com

sabine.watson@itl-group.com

ThingMagic® — The Engine in RFID

JADAK provides engineer-to-engineer collaboration for custom ThingMagic RFID solutions utilizing a broad portfolio of embedded and finished RAIN RFID readers, supported by system and custom antenna design expertise.

www.jadaktech.com

info@jadaktech.com

LAB ID is a leading European RFID tag manufacturer and solution provider, based in Italy. LAB ID offers customized RFID products and services to give the customer the right solution.

www.lab-id.com

info@lab-id.com

Laxcen is the leading manufacturer for RFID inlays & tags, and provider for RFID solutions. With the strong R&D team, Laxcen is committed to providing high-quality and customized RFID products to global customers.

http://www.laxcen.com/

RFID@laxcen.com

Mühlbauer is a global, independent consultant and manufacturer of turnkey automation solutions for the Smart Card, RFID Smart Label, Semiconductor Backend, Flexible Solar Cell manufacturing & Vision industries. Mühlbauer's 'The RFID Factory' encompasses the complete manufacturing solution from chip attach, through converting to the finished personalized RFID label/tag/ticket.

http://www.muhlbauer.com/

info@muhlbauer.com

NXP Semiconductors N.V. (NASDAQ: NXPI) enables secure connections and infrastructure for a smarter world, advancing solutions that make lives easier, better, and safer. As the world leader in secure connectivity solutions for embedded applications, NXP is driving innovation in the secure connected vehicle, end-to-end security & privacy, and smart connected solutions markets. As a trusted RFID innovator with a rich history of over 60 years in semiconductor operations, NXP offers a broad RFID portfolio, covering UHF (RAIN RFID), HF, NFC and LF technologies.

https://www.nxp.com/

www.nxp.com/rain-rfid.

Primo1D

The E-Thread™ Company

Imagine RFID in a Yarn; this is all about E-Thread®!

This dipole offers far beyond the classic benefits that users get from UHF RFID labels solutions… this miniaturized and discreet solution is also the key for brand and theft protection.

Primo1D targets the whole textile value chain, with a focus onto laundry market, retail and luxury industry.

https://www.primo1d.com/

contact@primo1d.com

PRINTRONIX AUTO ID

Printronix Auto ID is a leading supplier of RFID-enabled thermal printers and RFID media. We are focused exclusively on designing and building reliable and easy-to-use RFID printers for the RAIN ecosystem. Printronix offers a complete suite of RFID printers to cover a broad spectrum of applications and needs. All Printronix printers are spec'ed to offer superior performance at an affordable price.

Our unique dual-antenna offering allows printing and encoding of both standard smart labels and on-metal tags with a single printer.

Printronix is committed to RAIN RFID. Our printers and media are based on RAIN standards for easy integration into any RAIN-compliant solution.

www.printronixautoid.com

RFID@PrintronixAutoID.com

Voyantic

Leading global provider of RFID testing and measurement solutions for both R&D and production. We have a proven track record with over 1000 solutions delivered to 30+ countries globally.

sales@voyantic.com

www.voyantic.com

Zebra offers a complete enterprise asset intelligence portfolio - including RAIN readers, labels, antennas, services and software - enabling businesses to quickly transform data into actionable business information.

www.zebra.com

rain@zebra.com

RAIN ALLIANCE

LIST OF MEMBERS

RAIN RFID ALLIANCE MEMBERS' CATEGORIES

CATEGORIES	DEFINITIONS
Tag Chip Manufacturer	Companies that manufacture semiconductor chips for RAIN RFID tags.
Inlay/Tag Manufacturer	Companies that use tag chips to manufacture inlays or industrial tags.
Tag/Inlay Antenna Manufacturer	Companies that manufacture antennas for tags and/or inlays
Reader Chip Manufacturer	Companies that manufacture semiconductor chips or modules used to read, write and initiate a transaction with tags.
Reader Manufacturer	Companies that manufacture readers.
Reader Antenna Manufacturer	Companies that manufacture antennas for readers.
Printer Manufacturer	Companies that manufacture printers with embedded RAIN RFID readers.
Industrial Equipment Manufacturer	Companies that manufacture industrial equipment that includes embedded RAIN RFID readers.
Independent Software Vendor (ISV)	Companies that develop and sell software separate from hardware. Software which is used for RAIN RFID solutions. Including software on readers, and/or in a network/cloud using the RAIN RFID data.
System Integrator / Solution Provider	Companies that put together a complete RAIN RFID solution, including tags, readers, antennas and software.
Consulting / Services / Technology Assistance	Individuals and companies that provide expert advice regarding RAIN RFID, and/or access to their knowledge and expertise for RAIN RFID technology.
RAIN RFID Test Equipment	Companies that manufacture test equipment used for RAIN RFID technology.
Reseller / Distributor	Companies that buy and sell RAIN RFID products.
Standards Organization	Organizations which are developing, coordinating, promulgating, revising, amending, reissuing, interpreting, or otherwise producing technical standards that are intended to address the needs of RAIN RFID adopters.
Research Facility / Academic Center	Organizations that do research and/or provide resources for RAIN RFID.
End-user	Businesses or consumers that use RAIN RFID.
Testing Laboratory	Companies that offer testing facilitires in-house.

LIST OF RAIN ALLIANCE MEMBERS

	TAGS			READERS						SOLUTIONS							
LINKS BELOW FOR MORE INFORMATION	Tag Chip Manufacturer	Tag/Inlay Manufacturer	Tag/Inlay Antenna Manufacturer	Reader Chip Manufacturer	Reader Manufacturer	Reader Antenna Manufacturer	RAIN Printer Manufacturer	Industrial Equipment Manufacturer	Independent Software Vendor	System Integrator / Solution Provider	Consulting/Services	RAIN RFID Test Equipment	Reseller/Distributor	Standards Organization	Research Facility/Academic Center	End-user	Testing Laboratory
4E Antenna AB			X														
A-1 Packaging Solutions, Inc										X							
ACURA					X	X		X			X		X				
Advanced Material Development Limited			X												X		
AdvanIDe Holdings Pte Ltd											X		X				
All4Labels Smart + Secure GmbH		X	X	X				X		X	X						
American Label Technologies, Inc.													X				
Apulsetechnology					X												
AsReader, Inc.					X												
ASYGN	X									X							
A-TEX										X							
Avery Dennison RBIS		X					X	X									
Aware Innovations									X	X	X		X				
AXEM Technology		X			X			X									
Bekaert Bekintex NV			X														
BIONIX SUPPLYCHAIN TECHNOLOGIES S.L.				X	X	X		X	X								
Bluebird Inc.					X			X			X						
BSN		X	X						X	X			X				
BW Papersystems Stuttgart GmbH								X									
C&A Services GmbH & Co. OHG																X	
CAEN RFID srl		X	X		X	X											
Cardinal Health										X							
CCRR, Inc.		X									X		X				
Cellotape Smart Products		X															
CISC Semiconductor GmbH											X	X					X
Cisper Electronics													X				
Clairvoyant Technology, Inc.					X	X									X		
Confidex		X															

LINKS BELOW FOR MORE INFORMATION	TAGS			READERS						SOLUTIONS							
	Tag Chip Manufacturer	Tag/Inlay Manufacturer	Tag/Inlay Antenna Manufacturer	Reader Chip Manufacturer	Reader Manufacturer	Reader Antenna Manufacturer	RAIN Printer Manufacturer	Industrial Equipment Manufacturer	Independent Software Vendor	System Integrator / Solution Provider	Consulting/Services	RAIN RFID Test Equipment	Reseller/Distributor	Standards Organization	Research Facility/Academic Center	End-user	Testing Laboratory
Connected Hire											X						
ConsultRFID Limited		X								X	X		X				
Convergence Systems Limited		X			X	X		X			X						
CORSO-MAGENTA								X		X	X					X	
Crocus Nano Electronics LLC	X																
Data2 Corporation, a Division of FineLine Technologies										X							
DATALOGIC USA, Inc.					X												
DECATHLON SA											X					X	
DENSO Products and Services, Inc.					X												
DeRoyal Industries, Inc.										X							
Digilogics S.A. de C.V.										X							
Dipole RFID		X								X							
Donald E. Ray LLC											X						
eAgile Inc.		X								X							
Ecartes		X			X	X			X	X	X		X				
Elcoflex Ltd.																	
EM Microelectronic	X																
Evanhoe & Associates, Inc.									X	X	X		X				
Eximia Srl										X	X		X				
Fast Value Global inc.		X															
FedEx Freight																X	
Feig Electronics, Inc.					X												
Fresenius Kabi																X	
Gillespie Manners										X							
Greenerwave						X			X	X							
GS1 Canada														X			
GS1 Global office														X			
GS1 US														X			
Hadatap Ltd.										X	X						
Hana Technologies, Inc.		X	X								X						

LINKS BELOW FOR MORE INFORMATION	TAGS			READERS						SOLUTIONS							
	Tag Chip Manufacturer	Tag/Inlay Manufacturer	Tag/Inlay Antenna Manufacturer	Reader Chip Manufacturer	Reader Manufacturer	Reader Antenna Manufacturer	RAIN Printer Manufacturer	Industrial Equipment Manufacturer	Independent Software Vendor	System Integrator / Solution Provider	Consulting/Services	RAIN RFID Test Equipment	Reseller/Distributor	Standards Organization	Research Facility/Academic Center	End-user	Testing Laboratory
HID Global Rastede GmbH		X															
Identiv, Inc.		X															
IDRO Co., Ltd		X			X												
Impinj Inc.	X			X	X	X											
Innovoi Ltd											X						
Intelligent Label Solutions		X								X	X		X				
IntelliGuard										X							
Invengo Technology Pte Ltd.		X			X	X											
ISBC Innovations Pte Ltd		X															
JADAK RFID					X												
Jiangsu HY-Link Science & Technology Co., Ltd																	
JX Instrumentation Co., Ltd.								X				X					
KAR-MIL A/S													X				
Kathrein Solutions GmbH		X			X	X				X	X						
KC Industrial Co., Ltd.					X	X				X							
Kinsetsu Ltd										X	X						
Kirk-Rudy, Inc.								X									
Korea Testing Laboratory											X				X		X
Kyubi System					X	X		X	X	X	X		X				
LAB ID srl		X								X	X						
Laxcen Technology Limited		X			X					X							
LicenSys Pty Ltd										X							
Linxens		X															
Logopak								X									
Lyngsoe Systems Ltd										X	X						
Maxim Group		X															
MaxWave Microelectronics Ltd.	X			X													
Metalcraft, Inc.		X															
Michelin																X	

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MobiZcan Technologies LLC													X				
MonsoonRF, Inc.					X			X									
Mühlbauer GmbH & Co. KG							X	X				X					
Murata Manufacturing Co.		X															
Naxis co., Ltd		X															
Nedap Retail					X				X	X	X						
newave sensorSolutions, LLC						X											
NextPoints RFID													X				
Nordic ID					X				X	X	X						
NXP Semiconductors Austria GmbH	X																
Paragon ID		X															
Perfect ID USA		X											X				
Phoenix Solution Co., Ltd.		X															
PHYCHIPS				X													
Porta Saber, Lda.		X								X	X		X				
Powercast Corporation	X		X							X	X						
Primo1D SA		X															
Printronix Auto ID							X										
race result AG																X	
RFLocus Inc.										X							
RFRain LLC					X			X		X	X						
SAG - Securitag Assembly Group Co., LTD.		X															
SAIT SRL										X	X						
Sanofi Pasteur																	
Sato Corporation		X	X				X	X	X	X	X		X		X	X	
Sensormatic by Johnson Controls, Inc.		X			X	X			X	X							
SensThys, Inc.					X	X					X						
SES RFID Solutions Asia Co . , Ltd .		X	X														
Shanghai Aviation Printing Co., Ltd		X															

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Shanghai Boing Information Technology Co., Ltd		X	X														
Shanghai HUAYUAN Electronic Co., Ltd		X			X												
Shenyang Shining Fortune Container Seal Co., Ltd.		X								X							
Shenzhen Chainway Information Technology Co., Ltd.					X	X		X									
SimplyRFiD									X	X							
SIVA Inotec Ltd		X															
Smart Label Solutions					X												
Smooth & Sharp Corporation		X															
Solos Integrity Systems										X							
SPF-Inc			X								X						
SpotSee		X															
ST Microelectronics International N.V.				X													
Star Systems International Ltd.		X				X					X						
Stora Enso Oyj																X	
Strato Innovations, Ltd.										X							
Suzhou HCTech Technology Co., LTD.	X				X												
syo.io Limited											X						
Tadbik RFID		X									X						
TAGEOS		X															
tagItron GmbH		X	X		X	X		X	X	X	X		X				
TagMaster AB					X												
Talkin' Things		X								X							
TechSigno Srl					X					X	X						
Temera Srl										X	X						
Terso Solutions, Inc.										X							
TexTrace AG											X						

	TAGS			READERS						SOLUTIONS							
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The Axia Institute, Michigan State University															X		
Times-7 Research Limited						X					X		X				
TÖNNJES ISI PATENT HOLDING GmbH											X						
Trace Tech ID		X								X	X						
Unistar Inks																	
Unitech Electronics Co., Ltd.								X									
University of New Mexico - Vizzia IoT															X		
University of Sussex															X		
Voyantic Ltd.											X	X					X
Wuxi Pinguan IOT Technology Co., Ltd.		X			X					X							
Xerafy Singapore Pte. Ltd		X															
Xiamen Xindeco IoT Technology Ltd. (Codetag RFID)		X															
Zebra Technologies		X			X	X	X	X									

ABOUT RAIN ALLIANCE

The RAIN Alliance is an organization supporting the universal adoption of RAIN RFID technology. A wireless technology that connects billions of everyday items to the internet, enabling businesses and consumers to identify, locate, authenticate and engage each item. The technology is based on the EPC Gen2 UHF RFID specification, incorporated into the ISO/IEC 18000-63 standard. For more information, visit www.RAINRFID.org. The RAIN Alliance is part of AIM, Incorporated. AIM is the trusted worldwide industry association for the automatic identification industry, providing unbiased information, educational resources and standards for nearly half a century.

RAIN ALLIANCE

401 Edgewater Place, Suite 600
Wakefield, MA, 01880, USA

Visit the RAIN RFID website – RAINRFID.org. If you are interested in learning more about the RAIN Alliance, contact us at **info@rainrfid.org**.