2023 Update

A Smarter, Technology-Driven Supply Chain with Reusable Packaging Systems

Reusable Packaging ASSOCIATION

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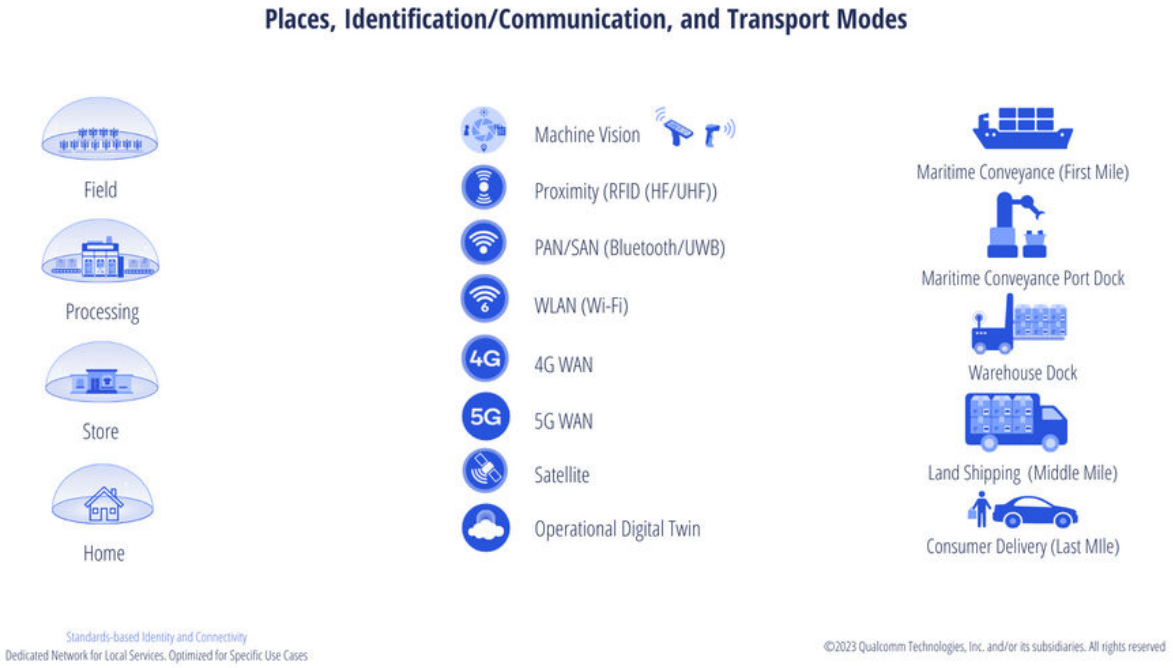
Executive Summary

The widespread adoption and deployment of Reusable Transport Packaging (RTP) assets such as pallets, bins, and containers continue to drive more extensive uses for the commercial distribution of goods. The ongoing advancements of tracking-based technologies enable these reusable assets to ensure long-term, recurring use within a system that structures their recovery and returns for the intended purpose. As reusable transport packaging assets travel through the supply chain, they can be identified and communicated through various technologies. This can include the places, asset identification, and transportation mode(s) across the supply chain.



Courtesy of Qualcomm Technologies, Inc

This white paper explores the following five areas:

"**HOW**" the necessity for visibility in reusable packaging and supply chains continues to address operational efficiencies and performance.

"**WHY**" consistent implementation and deployment of identification and communication capabilities in the logistics supply chain is growing in importance given the digital transformation trend motivating operational efficiencies, customer experience, and new business operating models.

"**WHAT**" technology and related solutions are available, and when to deploy them?

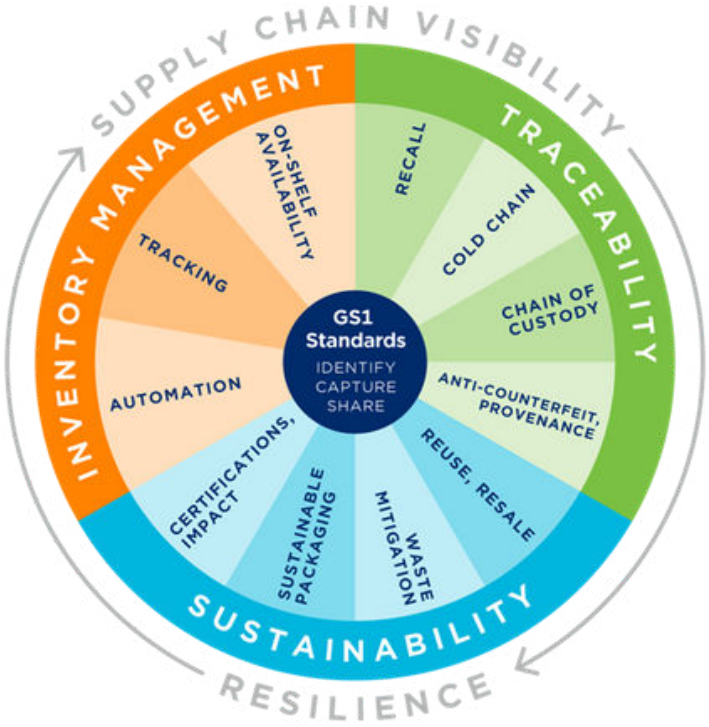
"**HOW**" identity and communication capabilities provide data trustworthiness and integrity for operational insights, adding value to your business.

"**HOW**" to begin accessing the available identification and communication technology capabilities.

This 2023 updated Technology-Driven Supply Chain with Reusable Packaging Systems white paper aims to provide an improved understanding today of using connected and data transmitting reusable assets to track and monitor the supply chain. It is essential today as more business leaders turn their attention and focus on a more effective, resilient, and transparent supply chain.

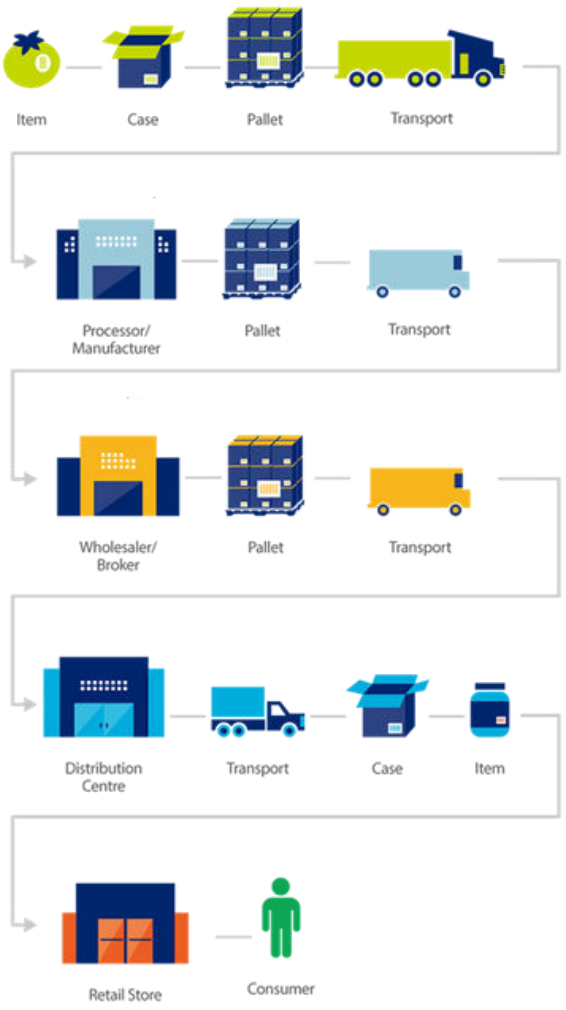
Introduction

Since the release of the industry report titled "A Smarter, Technology-Driven Supply Chain with Reusable Packaging Systems" in 2019, there has been a remarkable acceleration in developing and adopting technologies aimed at automatic identification, monitoring, and tracking of Reusable Transport Packaging (RTP) assets throughout the supply chain, as well as providing a means for demonstrating provenance for RTP assets and goods moving through the supply chain. Fundamentally, the objective of these new technologies and systems is to drive a virtuous cycle for Supply Chain Visibility and Resilience across Inventory Management, Traceability, and Sustainability providing additional functional elements as depicted in the GS1 Identify, Capture, Share model shown below:



Supply Chain Visibility and Resilience Virtuous Cycle
Source: GS1 Global

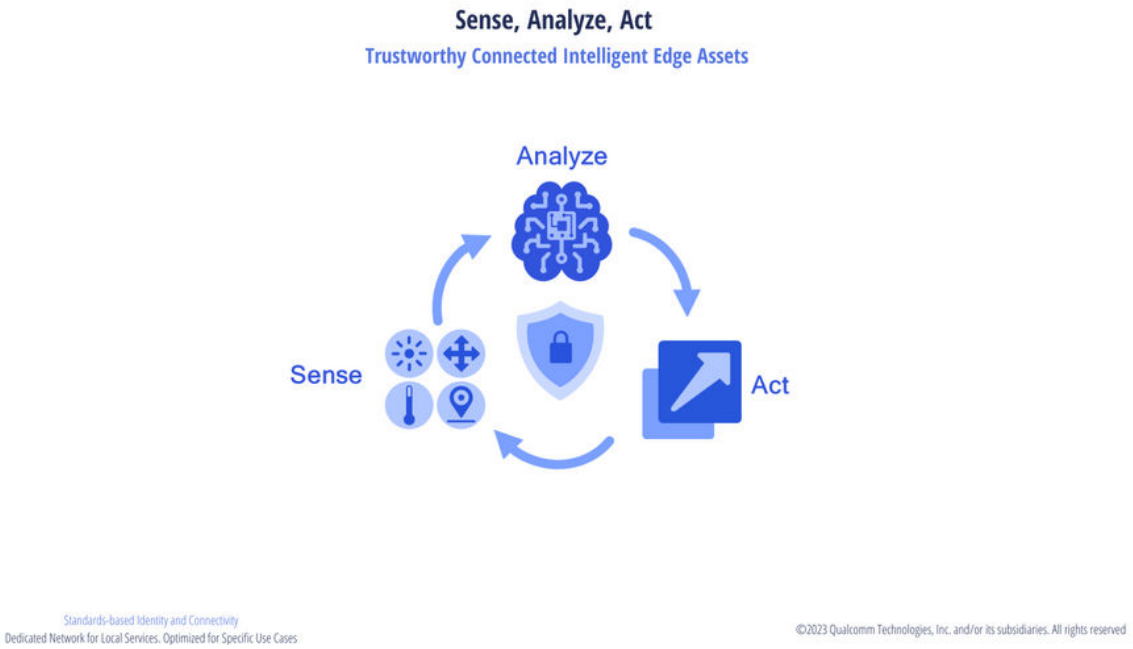
As products move through the supply chain from manufacturer to consumer, they move through various partners where RTP assets are commonly utilized to minimize loss, reduce product damage, and ultimately increase efficiency and sustainability performance. Utilizing these technologies can gain valuable insights into reusable assets' location, condition, and availability as they move through the supply chain from manufacturer to consumer.



Supply Chain Example
Source: GS1 Global

Location, Condition, and Availability
Courtesy of Qualcomm Technologies, Inc.

When machine learning is incorporated into the mix it becomes possible to obtain critical information about raw materials and goods by way of sensing, analyzing, and acting, as illustrated in the following diagram:



Location, Condition, and Availability
Courtesy of Qualcomm Technologies, Inc.

This updated guide for 2023 offers valuable insights to businesses and supply chain executives, as well as key decision-makers from suppliers, manufacturers, transportation companies, retailers, and OEMs. It focuses on the available and emerging technologies used to identify, monitor, and track reusable transport packaging. After reading this guide, management should have a better understanding of the following:

- The importance of tracking and monitoring your supply chain today
- The solutions that exist and why you should use them
- How to use the data to develop and deliver insights and value to your business
- How to get started with implementing these solutions

This updated white paper is available in the Library on the Reusable Packaging Association's website.

Acknowledgment of Contributors

This white paper is a cumulation of work performed by the Reusable Packaging Association's (RPA) Technology Working Group (TWG) members and invited industry experts. The committee's objective is to raise awareness of asset management and develop standards for common processes promoting the efficient movement, handling, visibility, and return of reusable packaging products.

RPA would like to recognize and thank the following individuals and companies for their participation on the committee and support of this project:

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3. Why Tracking and Monitoring Your Supply Chain is Important Today

In today's fast-paced global economy, supply chain management has become essential for businesses of all sizes. With the rise of e-commerce and globalization, companies are dealing with more complex and interconnected supply chains than ever before. To effectively manage these multifaceted supply chains, companies must prioritize tracking and monitoring their assets to ensure they are utilized efficiently and effectively. This is particularly important for companies that operate in industries with large volume requirements, where the failure of even a single asset could result in substantial financial losses.

The global manufacturing community has recognized the importance of tracking and monitoring products in the supply chain and is investing heavily in these technologies. The global supply chain technology market is estimated to top $6 trillion by 2025. Failure of assets in service could offer a significant loss of revenue.

"Companies are dealing with more complex and interconnected supply chains than ever before."

Here are a few important reasons why investing in technology-enabled returnable assets is a smart investment in your company's success today and in the future.

Financial Investment

Organizations that invest in modernizing their supply chain through asset tracking and monitoring technologies can improve their operations, reduce the risk of lost or damaged assets, and increase customer satisfaction, leading to improved financial performance and a positive return on investment (ROI).

Before investing financially in these technologies, companies should conduct a cost-benefit analysis to assess the feasibility of incorporating asset tracking and monitoring technologies into their supply chain. This analysis should consider factors such as the cost of the technology, the potential benefits, and the return on investment. Once the feasibility of incorporating asset tracking and monitoring technologies is complete, companies can explore various financing options to fund the implementation of these technologies. For instance, they can apply for government grants or subsidies for businesses that invest in sustainable technologies. Additionally, companies can explore financing options such as loans or leasing agreements that can help spread the cost of implementation over a long period.

Additionally, companies can explore financing options such as loans or leasing agreements that can help spread the cost of implementation over a long period. Overall, companies that invest in modernizing their supply chain technologies can improve their operations, reduce the risk of lost or damaged assets, and increase customer satisfaction, leading to improved financial performance.

Supply Chain Visibility in Uncertain Times

As supply chain leaders strive to enhance their supply chains' resiliency, sustainability, collaboration, and transparency, tracking-based technologies have become indispensable. The global pandemic not only exacerbated the existing challenges in the supply chain but also accelerated them. These challenges included labor issues, raw material availability, difficulties ensuring visibility related to products, and the rising trend of consumers opting for remote and online fulfillment.

Given the ongoing challenges exposed by the global pandemic and the increasing complexity of global supply chains, leaders must continue to invest in innovative tracking-based technologies to ensure long-term business resiliency and success. A recent article estimated that even during the economic downturn of the pandemic, more than 92% of businesses did not stop investing in technology. Further driving that with the help of such technologies, companies can better manage their inventory, optimize their logistics, and respond quickly to disruptions. By embracing supply chain transparency and collaboration, organizations can build stronger relationships with their suppliers and customers, promote ethical and sustainable practices, and enhance their brand reputation. By leveraging cutting-edge tracking-based technologies, supply chain leaders can build resilient and agile supply chains better equipped to navigate future disruptions and capitalize on emerging opportunities.

Sustainability Metrics

With the development and increased use of data-based insights from various supply chains, leading companies can connect data insights into their sustainability metrics and objectives and better understand their business.

Understanding how raw materials and products travel in RTP throughout the supply chain drives visibility of reducing waste and empty miles, water savings, and resulting CO2 savings. Supply chains impact the environmental footprint of a company's sustainability goals. The WEF states eight supply chains account for more than 50 percent of global emissions.

Through harnessing data from goods movements across the supply chains, companies can reduce their greenhouse gas emissions, optimize their transportation CO2 impact, develop resilient and efficient supply chains, improve worker safety, and mitigate risks to their business.

Food Safety and Emerging Regulations

The food industry has been improving food safety recently due to the rise of foodborne illness outbreaks and public health concerns. As a result, many countries have implemented strict regulations to ensure safety standards throughout the supply chain. The emergence of these regulations has led to a more comprehensive approach to food safety, with an emphasis on preventative measures, traceability, and transparency.

Traceability allows for identifying the origin and history of a product, making it easier to track food safety incidents.

Many countries have implemented regulations requiring food companies to have robust traceability systems. These systems provide a supply chain history

With the ability to trace the origin of a product, incidents are quickly identified, and measures are taken to prevent the spread of illness. Overall, the emergence of these regulations has improved food safety in the supply chain, leading to a safer and healthier food system for consumers.

The recent United States Food and Drug Administration (US FDA) Food Safety Modernization Act (FSMA) Final Rule, "Requirements for Additional Traceability Records for Certain Foods," is a 597-page regulation that can be summarized in a few bullets:

Food Safety data requirements are extensive:

- The Food Traceability List (FTL) includes fresh produce, cheeses, eggs, nut butter, seafood, and deli salads
- All covered foods must maintain records for all Critical Tracking Events (CTEs) that keep track of the required Key Data Elements (KDEs) and a Traceability Lot Code (TLC)
- The TLC cannot change from when it is first assigned across supply chain partners
- Records must be digital for all but the smallest companies
- Overseas companies exporting to the US must comply with FSMA Regulation for Food Traceability List (FTL) foods
- 3 year compliance implementation timeline (2026)

Food Safety Modernization Act (FSMA) defined the Food Traceability List (FTL)
Source: US Food & Drug Administration

The FDA estimates the cost to comply over the next 20 years to be:

- Range $0.8 billion to $33.7 billion with a preliminary estimate of $8.2 billion at a 3 percent discount rate
- In their introductory remarks, the FDA indicated there might be federal funding to help companies comply

GS1 has established an FSMA 204 workgroup to address the requirements:

- Tech-enabled traceability through supply chain partners
- Smarter Tools and Approaches for the prevention and outbreak response
- New business models and retail modernization
- Improved Food safety culture

$8.2 billion

FDA estimated the cost to comply with traceability requirements over the next 20 years.

4. What Solutions Exist and Why You Would Use Them

4.1 Decision Process

4.1.1 What is the right solution for the problem to be solved?

A wide range of technologies is available to track, identify, or count goods or assets, as described in the white paper on Asset Technologies published by RPA in 2019. These include Barcode, RFID, Cellular or LPWAN, Bluetooth Low-Energy (BLE) or Wi-Fi, and recently introduced technologies such as Self-Organizing Sensor Area Networks, Low Power Mesh, or Ultra-Wide Band (UWB) for RTLS (Real-Time Location System). Each technology has specific characteristics which make them suitable for targeted use cases, as identified by a company. Combining some of the technologies can be pertinent in many applications.

"Each technology has specific characteristics which make them suitable for targeted use cases, as identified by a company."

Differences in Product Identification, Sensing, and Tracking Solutions

There are various technologies incorporated into reusable assets. The table below simplifies the technologies aligned by "Proof of Value" use cases across the supply chain. There are exceptions to each of the examples in the table below, so use this table only as a starting point in discussions with technology providers.

Technology Options for Reusable Assets

	Targeted Use Cases	Barcode/ Label	RFID	BLE	UWB	Low Power Mesh (LPM)	Cellular w/ GNSS
Inventory / Infrastructure	**Goods-in/ Goods-out/ Fixed-Point Inventory**	Cost: Labels < RFID Labor: Manual Scan Accuracy: Human Errors Scale: Difficult	Cost: RFID Infra. ($) Cost: $ RFID < BLE Accuracy: >98% Scale: Easier	Cost: BLE Infra. ($) Cost: $ BLE < Cellular Accuracy: >98% Scale: Easier	Cost: UWB Infra. ($$) Cost: $$ < Cellular Accuracy: >98% Scale: Unlimited	Cost: LPM Infra. ($) Cost: $ BLE ~ LPM Accuracy: >98% Scale: Unlimited	Cost: $$$ (Cellular w/GNSS) Cost: $ (Cellular LPWAN) Accuracy: >98% Scale: Unlimited
	Room/Zone Visibility Within a Facility	Manual scans in each area	Requires RFID readers. Hard-wired install	Requires BLE readers. Hard-wired install	Requires UWB anchors. Hard-wired install.	Requires LPM readers. Battery powered.	No indoor positioning unless cellular GNSS access points, or LPWAN gateways.
Transportation Supply Chain Visibility	**Possible to Install a Gateway**	N/A	N/A	Limited # BLE devices Long Battery Life	Unlimited # UWB devices Long Battery Life	Unlimited # LPM devices Longer Battery Life	LP-WAN gateways can be combined with BLE Beacons, …
	NOT Possible to Install a Gateway	N/A	N/A	Used in conjunction with Cellular/GPS	Visibility anywhere. Combine w/ other location technologies.	Used in conjunction with Cellular/GPS	Visibility through cellular or cellular LPWAN networks. Can be combined w/ BLE, UWB, …
	Condition Monitoring	N/A	N/A	BLE tags can incorporate temp, shock sensors Report@ regular intervals	UWB infra can collect data from any sensor Report real-time	LPM tags can incorporate temp, shock sensors and Report at regular intervals	Trackers can incorporate temp, and shock sensors and report conditions at regular intervals
	Supply Chain End User Visibility	N/A	N/A	Manual association required at mfg.	UWB tags support real-time data collection. Possible to automatically link goods to reusable assets based on geo- fences	LPM tags support bi-directional data. Possible to automatically goods to reusable assets.	Trackers support bi-directional data. Possible to automatically link goods to reusable assets.

Proof of Value – Does it Add Value to Your Business?

The level of asset visibility in a supply chain can impact the efficiency and cost-effectiveness of operations. Having the knowledge of what assets are returned and when can provide valuable insights for reducing inefficiencies and directly associated costs.

What is the actual value generated by this information? Is it worth investing in systems and processes to track returnable assets? Can this visibility provide early warnings of missing reusable assets?

These questions highlight the importance of understanding the value proposition of asset visibility in a supply chain and any potential benefits gained from it.

Use Case: Inventory / Infrastructure

What is the value of inventory and infrastructure such as RFID gates, BLE scanners, or Mesh anchors that can be deployed within the service center or storage areas?

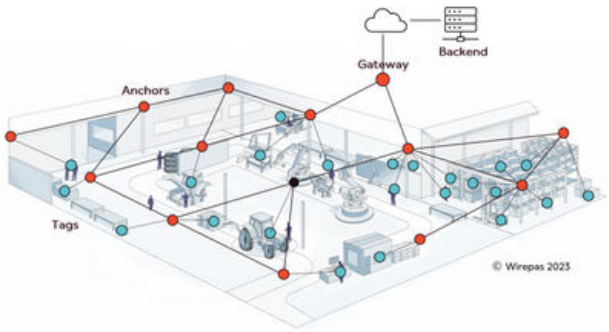
- Goods-in / Goods-out / Fixed Point Inventory

The lowest cost and best technology options in this basic use case include various solutions, ranging from barcoded label tags to passive RFID tags. In this example, readers are used to scanning a barcode or RFID tag and may require equipping employees with handheld scanners. Installing RFID infrastructure in the inventory area and placing an RFID tag on each asset to collect regular automatic inventory is also a consideration.

- Room/Zone Visibility Within a Facility

Zone visibility can help provide a detailed understanding of the internal asset handling process and WIP status. It can be easily implemented using BLE tags on the asset. From an infrastructure standpoint, the simplest and cheapest solution is to choose a system with battery-operated locators (or anchors) enabled by some last-generation, Low Power Mesh networks. These systems can be rapidly installed and are suitable for any facility.

The position accuracy is in the range of 5m or room accuracy. These solutions are available from a large panel of system integrators and can connect to the pooling company's IT systems. Note that in the case of Low Power Mesh, the inventory detection rate, density, and speed are very high, thanks to the interaction between the tags and the anchors (routers).



Zone accurate location system, based on Low Power Mesh
Courtesy of Wirepas

Use Case: Transportation / Supply Chain Visibility

Is visibility required during transportation at the producer or the retailer distribution center?

An internet connection is the main technical challenge to tracking returnable assets during transportation or at premises not controlled by the asset owner.

Depending on whether the premises (trucks, trailers, producer, or retailer premises) can be equipped with an internet gateway or not will lead to different types of systems.

Possible to Install a Gateway on Premise

In cases where there is a close business relationship between the asset owner and the transporter, the producer, and the retailer, it may be possible for the asset owner to install a gateway (fixed or mobile) that can scan BLE beacons (or collect Low Power Mesh messages).

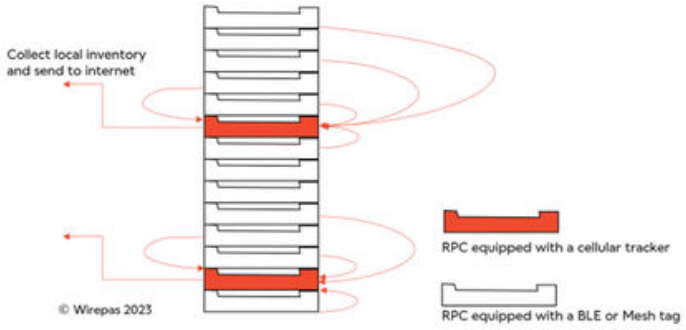
NOT Possible to Install a Gateway on Premise

This scenario is most likely. The asset owner may use several transporters, and convincing each to carry a gateway in their trailers is challenging. The producer or retailer often uses several asset vendors or simply needs the incentive to install specific infrastructure. This makes it difficult for the asset owner to get approvals to install dedicated gateways at their customer premises.

In this case, the internet connectivity needs to be embedded in assets. Mobile trackers now embed cellular communication (LTE-M or NB-IOT) and sometimes BLE scanning or Low Power Mesh connectivity-based solutions.

If each asset has a cellular tracker, it can be individually tracked anywhere (with cellular coverage), providing maximum supply chain visibility.

Companies are working to address the limitations of a cellular tracking-based solution, including cost, battery life, and density required for the desired use case.



A system combining BLE or Mesh with cellular trackers.
Courtesy of Wirepas

Companies often develop a multi-modality system using some portion of cellular trackers combined with lower-cost technologies, resulting in a system using various technologies.

Use Case: Condition Monitoring

Knowing whether goods have maintained the right temperature range or have received any shocks during the various stages of the supply chain can deliver valuable insight to improve specific parts of the supply chain or handling conditions. For example,

"A fresh food company has managed to extend the shelf time of their fruits by ~15% by combining supply chain optimizations and corrections to the transport conditions and handling."
Source: RPA Member Company

Various low-cost sensors can be added to tags or cellular trackers to monitor the conditions of goods during the supply chain.

Considering the reasonable cost of sensors and the potential value of the information they provide; it is recommended that tags and trackers are equipped with at least a temperature sensor and an accelerometer (to detect shocks).

Additional discussion on Product Monitoring and the use of sensors is included in a later section of this white paper.

Use Case: Goods (Supply Chain) End User Visibility

As referenced above, knowing where perishable goods are in a supply chain can be extremely valuable. In the fresh produce industry, there needs to be a pairing between the Reusable Plastics Crate (RPC) and the type of goods they carry when the RPC is filled to identify which goods are in which RPC.

This pairing can be done manually by scanning the bar code attached to the RPC and associating it with the barcode of the goods carried. There are also means to implement the pairing automatically if the tags on the RPC can interact with the infrastructure and receive messages helping them to identify the ID of the goods they carry automatically. Once this pairing is done, the system can directly track the goods and provide more valuable insights to the end customer.

Considerations of Mixed Deployments

Companies are now using multi-modality technology-based identification strategies across their pool or fleet of reusable assets in their network.

This allows them to build the most cost-effective solution and still gain the data-based insights to reduce product damage, reduce asset loss, improve supply chain efficiencies, and ensure the sustainability impact of their network.

For example, by combining various technologies, a company can find the optimal solution to the primary use case they are focused on. While applying cellular communications with GPS location support across a large reusable asset fleet provides the required data, it can be cost-prohibitive. Similarly, using barcodes or RFID tags does not provide enough visibility for a company and its supply chain partners to act. Companies are now combining technologies and using data analytics to generate insights from various data sources. This may include 5% of the assets using GPS/GNSS with WAN connectivity, 20% to 40% using BLE/LPM sensors, and 100% using bar codes/data labels with embedded RFID.

This is a critical consideration for companies looking for the best combinations of technology-based solutions for reusable assets.

4.1.2 Value vs. Cost (Initial and Ongoing) Considerations

While developing the business case, companies must review the value delivered and the upfront and recurring costs associated with implementing technology solutions to their reusable assets.

While developing a technology-enabled business case is discussed later in the white paper, here is a list of considerations to include:

Value-based Considerations	Cost-based Considerations

• Is the primary use case well-defined?
• What value is expected?
  ◦ Reduced product damage
  ◦ Reduction of asset loss, fewer replacement assets being purchased each year
  ◦ Optimized logistics and transportation costs
  ◦ Optimized efficiency
  ◦ Reduction of labor
  ◦ Quantification of both hard savings and softer savings
  ◦ Understanding of sustainability metrics of supply chain decisions
  ◦ Extended shelf life for fresh products (produce, dairy, etc.)
• Who benefits from the value delivered?
  ◦ Do they recognize the value?
  ◦ Consider both functional and supply chain partner value delivered
• How will this technology investment enable your company's future success?
	• What is the upfront investment?
	• What CAPEX hardware investments are required to reach the project's targeted use case?
	• What OPEX expenses will be incurred in year one, and what are the annual costs?
	• Have you accounted for the resources required to implement the project?
	• What labor savings are expected from the project?

4. What Solutions Exist and Why You Would Use Them

4.2 Product Identification Technologies

Introduction

The history of product identification traces back to when a craftsman put their name on a custom product. Even today, when an individual or a company puts their name or logo on an item, with it comes the reputation of the company making it. Eli Whitney is often called the United States Father of Interchangeability.

In 1798, Whitney obtained a government contract to produce 10,000 muskets in two years. To do that, he had to standardize parts, resulting in the identification of components by part number. This development led to engraving or stamping numbers onto the part. Eventually, serializing individual parts became normal for those with traceability requirements.

"The advent of Automatic Identification Technologies (AIT) changed everything."

If product identification had stopped there, we would have been satisfied with writing down the item identification information and typing it into a computer. However, the advent of Automatic Identification Technologies (AIT) changed everything. Whether read optically, by transmitting radio waves, or by others, these technologies do not require human interpretation, translation, or typing.

There are internal and external drivers to dictate which identification technology should be used. For example, industry sector standards or common practice will drive a primary consumer products manufacturer/supplier to a GS1-centric solution using Universal Product Code (UPC) barcodes for the items delivered.

Many automatic identification technology-based product identification methodologies, characteristics, typical applications, and reading methodologies are used on reusable packaging today.

They include:

Technology	Visibility	Reading Technology	Direct or Additive	Optimal Usage	Graphics /Logo	1D Barcode	2D Barcode	Human Readable	Multi-Color	Permanence
Paper Label	Overt	Optical/ Visual	Additive	Optimized for HSE. Use on LSE dependent on use case.	Y	Y	Y	Y	Y	Poor. Durability dependent on use case, substrate, and resistance to UV, chemicals, and pressure washing.
Polyester Label	Overt	Optical/ Visual	Additive	Durable. Optimized for HSE. Use on LSE dependent on use case.	Y	Y	Y	Y	Y	Good. Durability dependent on use case, substrate, and resistance to UV, chemicals, and pressure washing.
Photo Anodized Labels/Tags	Overt	Optical/ Visual	Additive	Durable. Adhesive optimized for HSE. Mechanical affixing suits HSE/LSE, varies with use.	X	Y	Y	Y	Limited	Very Good. Resistant to UV, heat, chemicals. Durability dependent on bond to substrate based on use case.
Metal or Plastic Tags	Overt	Optical/ Visual	Additive	Durable. Adhesive optimized for HSE. Mechanical affixing suits HSE/LSE, varies with use.	Y	Y	Y	Y	Limited	Good, limited primarily by the attachment method.
Heat Transfer / Hot Stamping	Overt	Visual	Additive	Suitable for HSE and LSE. Use on LSE dependent on use case. Human readable alphanumeric only.	Limited	N	N	Y	N	OK indoors. Outdoor durability tied to use, substrate, and resistance to UV, chemicals, pressure washing.
Polymer Fusion	Overt/ Covert	Optical/ Visual	Direct	Optimized for Low Surface Energy olefinic substrates and related.	Y	Y	Y	Y	Y	Excellent, becomes compatibly fused at molecular level.
In Mold Labeling	Overt	Optical/ Visual	Additive	Adapts to various materials. LSE bonding and durability varies with use case.	Y	Y	Y	Y	Y	Very Good. Durability tied to use, substrate, and resistance to UV, chemicals, pressure washing.

Technology		Visibility	Reading Technology	Direct or Additive	Optimal Usage	Graphics /Logo	1D Barcode	2D Barcode	Human Readable	Multi-Color	Permanence
Laser Bonding or Markable Inks/Paints for material fusion to substrates.		Overt	Optical/ Visual	Direct	Dependent upon added material and substrate.	Y	Y	Y	Y	Limited	Very Good
Laser Engraving or Etching		Overt	Optical/ Visual	Direct	Dependent upon substrate and effect of surface deformation	Minimal	Y	Y	Y	N	Very Good
Ink jet		Overt	Optical/ Visual	Additive	Optimized for HSE. LSE dependent upon use case and durability need.	Y	Y	Y	Y		Good. Durability tied to use, substrate, and resistance to UV, chemicals, pressure washing.
Dot Peen		Overt	Optical/ Visual	Direct	Surfaces where deformation is possible and stable.	Minimal	Y	Y	Y	N	Very Good
RFID – Passive											
	Labels	Overt	Radio Waves (reader activated)	Additive	Optimized for HSE. LSE dependent upon use case and durability need.	Y	Y	Y	Y	Y	Durability tied to use case, substrate, and resistance to UV, chemicals, pressure washing. Prone to intentional / unintentional tag separation
	Hard Tags	Overt	Radio Waves (reader activated)	Additive/ Direct	Adhesive optimized for HSE. Mechanical attachment for HSE/LSE dependent on use case.	Y	Y	Y	Y	N/A	Very durable. Prone to intentional / unintentional tag separation.
	Polymer Fusion	Overt/ Covert	Radio Waves (reader activated)	Direct	Optimized for durability on LSE polyolefin thermoplastics.	Y	Y	Y	Y	Y	Very durable. Fuses to and imitates LSE durable characteristics. Not susceptible to tag separation.
RFID – Active											
	Labels		Radio Waves (battery activated at intervals)		Optimized for HSE. LSE dependent upon use case and durability need.	Y	Y	Y	Y	Y	Very durable. Prone to intentional / unintentional tag separation.
	Hard Tags	Overt	Radio Waves (battery activated at intervals)	Additive/ Direct	Adhesive optimized for HSE. Mechanical attachment for HSE/LSE dependent on use case.	N/A	N/A	N/A	N/A	N/A	Very durable. Prone to intentional / unintentional tag separation.
Taggants – unique encoded materials for authentication / verification		Overt	Optical	Additive. Surface or sub-surface	Applied as a coating or mixed in, if compatible with material and process (like additive manufacturing).	N/A	N/A	N/A	N/A	N/A	Good but may be susceptible to elements dependent on bond to substrate in paint or topical applications. Very durable in polymer fusion or subsurface co-mixture applications.
Sensors – Attached		Overt	Electronic – Radio Waves, Ultrasound …	Additive	Surface must accept attachment typically adhesive or screws	N/A	N/A	N/A	M/A	N/A	Good – Due to being encased

Table: Product Identification Technologies
Courtesy of Trace it, LLC

4.2.1 Reasons and Benefits for Asset Marking

Ownership / Branding of the Reusable Asset

Brand identification on a reusable packaging asset communicates the owner's company and brand differentiation. Various forms of ownership markings, in some cases along with associated colors, have been central to maintaining control of reusable packaging for decades.

The presence of ownership information can help alert supply chain participants to the identity of the packaging owner and increase the likelihood of recovery and return of the reusable asset. Such data can ensure that trading partners know to whom the reusable packaging belongs, raising the possibility that the asset is not returned to the wrong trading partner or used for unauthorized purposes.

Another reason to brand or mark a reusable asset is the multimillion-dollar business of reusable asset theft as a source of recycled plastic resin. This illegal activity occurs across various industries, including food and bakery, where reusable pallets, crates, and trays are quickly rushed to illegal recycling operations and ground/shredded to remove evidence of ownership. To minimize this unlawful activity, the importance of color and using tags/barcodes with reusable assets must be inseparable.

For example, color-marked pallets are easily identifiable, thus aiding asset managers or auditors in determining ownership and whether a location is authorized to have reusable assets.

Additional brand markings, including logos or text stating the asset's owner, can improve the ease of identification and ownership claims.

Pallets using color for brand identification

Manufacturer or Manufacturing Information

Companies can monitor the performance and durability of reusable packaging with product manufacturer information, which can also be used to distinguish between different reusable packaging items supplied by other manufacturers.

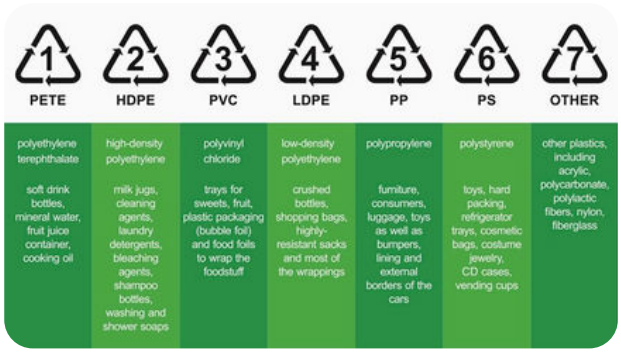
Products for reusable packaging may be date-stamped or, in some situations, color-coded to make it simple for the user to identify the date or provider.

In the case of solid wood packaging, the International Standards For Phytosanitary Measures (ISPM 15) stamp signifies that any solid wood components have been treated to prevent the international spread of wood-borne pests. Such an easily identifiable mark indicates that treated wood packaging should pass international ports of entry without incident.

Heat treat mark on wood packaging/pallet

Information about product composition can inform reusable packaging users about the type of material used and related recyclability at the end of the packaging item's life or how to repair a reusable packaging unit. Most reusable packaging items typically include a numeric recycle code.

Regarding repairing a reusable asset, the type of plastic used to make the container can be an essential quality consideration for operations such as plastic welding.



Plastic Recycling Codes
Courtesy of WCP Solutions

Special Instructions

Special instructions can help improve the efficient usage and return of reusable packaging. Information such as telephone numbers for retrieval, weight capacity, assembly or stacking instructions, label location, and other information can assist in increasing the value proposition reusables to offer.

Ownership Statement and Phone Number
for Reusable Asset Retrieval
Courtesy of CHEP

4.2.2 Identification Methods

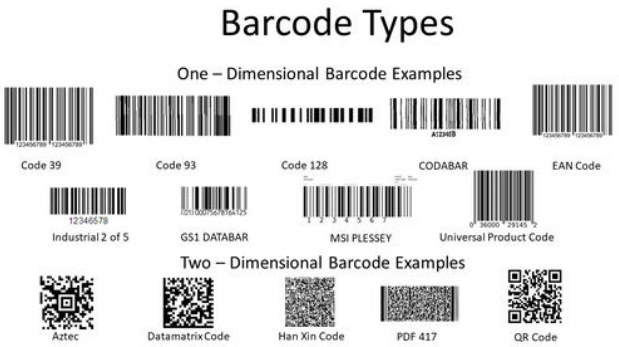
During the Manufacture of the Reusable Asset

A variety of product identification technologies can be applied to a reusable asset during manufacturing. This list is not exhaustive but includes the most common identification technologies applied during the manufacturing of reusable assets.

- Label-based Barcodes

The primary AIT (Automatic Identification Technologies) in use today for supply chain purposes are one-dimensional (1D) and two-dimensional (2D) barcodes and passive Radio Frequency Identification (RFID). While some barcodes are used primarily for retail applications such as the Universal Product Code (UPC), others are used for product identification in non-retail applications.

A device captures the barcode data by identifying its type and uses a decoding algorithm to interpret the content. Barcodes require a "line of sight" to successfully decode the barcode. There are dozens of 1D and 2D barcodes in use, with many unique to a specific application, but the primary barcodes broadly used are below.



Source: AIM, Inc.

Araditional linear/1D barcodes have limited capacity, typically only contain a single piece of data per barcode, require more than one per item, and are highly susceptible to damage. In contrast, Stacked 1D and 2D barcodes can carry thousands of characters. In addition, 2D barcodes often contain "unprintable" characters that separate and allow the imaging device to unambiguously identify individual data elements and parse the data into fields in the software supporting the business process for which the product identification is being used. A single data capture event can provide dozens of pieces of data.

Unlike most other AIT, telephone Apps have made barcodes accessible to users, from individual consumers to professionals, greatly extending data capture and access to automated data capture.

Dedicated imagers are required for most industrial applications and extensive use of barcodes or direct data entry via a tethered handheld imaging device in combination with a computer.

- Heat Stamp / Hot Stamping

Hot stamping or foil stamping is a common product marking or branding approach that uses pressure and heat to release foil pigments or pre-printed labels from a carrier to a part creating a permanent, graphic image post-mold. Hot stamping plastic components can give them a particular color, texture, or metallic sheen. The method can be carried out with a press (hot stamping) or without one (tipping).

High temperatures are used in hot stamping to fuse the ink to the plastic, which produces a solid bond and long-lasting finish. In contrast to a label-based technology using adhesive, the ink effectively melts into the plastic, making the decal, logo, or other finish a part of the plastic piece.

Information hot stamped onto a pallet. Source: ORBIS

- Polymer Fusion

Polymer fusion is the method of merging two different polyolefin thermoplastics (polyolefin label + polyolefin

product, part, or component) utilizing melting point temperature, time, and pressure, to seamlessly produce a singular piece of polymer without the use of adhesives, tie-layers, bonding agents, or secondary surface treatments.

Once the fusion process is complete, the two polyolefin materials have combined to form one piece of seamless and flush polyolefin plastic with no change in durability or structural integrity. This can eliminate issues with incompatible substrates, unsuitable adhesives, and unreliable protective coatings.

Most reusable plastic assets are manufactured using polyolefin thermoplastics, and when combined, this process results in a durable, permanent solution to label reusable assets for branding, warning/safety, track/traceability (sequential serialization, RFusionID®, 2D, QR, and more), authentication/anti-theft, and antimicrobial in a sustainable solution.

Polymer fusion labeling
Courtesy of Polyfuze Graphics

The result is a customized polymer "tattoo for plastic" designed to fuse permanently with durable polyolefin thermoplastic products, parts, and components for life use.

For reusable assets used in applications where sanitation is a vital requirement (such as food or medical contact), this process also eliminates the adhesives, construction layers, and coatings where microbes typically harbor and thrive even after sterilization efforts.

- Laser Engraving / Laser Etching / Laser Marking

Laser etching or laser marking etches the material's surface. Etching can be utilized for various materials, including plastic, metal, and wood. Using a laser to mark an asset's surface is permanent and removes the need for consumables such as ink, labels, or foil stampings. Laser markings on plastic or wood surfaces can be smudge and abrasion resistant.

It is essential to consider the plastic used to manufacture the reusable asset to ensure it is compatible with the laser marker system. Sometimes, a resin additive must be added to the plastic molding process to optimize the laser engraving.

Laser-printed identification
Source: Trotec Laser

Inkjet / Printing UV LED-curable inks are used today for printing on wood and plastic pallets and containers, allowing for customizable images, bar codes, and labeling to be printed directly onto the asset. Adhesion is critical to the asset when using inkjet printing technologies for product identification.

Some variables include the materials used to manufacture the asset (wood, type of plastic), the molding conditions and surface, and the ink optimized for adhesion.

- Label-based Radio Frequency Identification (RFID)

Like barcodes, RFID tags contain data coded onto them. Still, instead of a physical code, they use digital code programmed into memory, typically limited by the onboard chip/memory capacity. Unlike barcodes, RFID tags do not require "line of sight," however they do have a maximum read range which is affected by the:

- Material of the item to which the tag is applied
- Type and size of the tag, including its antenna
- Placement/location on the item
- Surrounding environment (e.g., metal, competing frequencies, water, fluorescent lighting)
- Type and antenna of the reader
- Number of tags in the vicinity of the reader

Individual product identification is common; however, RFID tags are generally associated with transportation, packaging, and movement. Handheld or fixed readers read them and are often associated with a directional read to show the direction of travel for gating, alerts, or security.

Product-level RFID tag use has increased as the cost, durability, and reader infrastructure have expanded.

An RFID system includes the physical tag containing an antenna and a chip sandwiched between a carrier layer and an overlay that hosts and protects, to some extent, the antenna and chip.

Encased tags work well where more protection is required. Like barcode imagers are read externally using an "interrogator" to retrieve the data from the RFID tag. An RFID "sled" or attachment is sometimes used with a barcode imager to form an all-in-one data capture device.

There are Low Frequency (LF), High Frequency (HF), and Ultra High Frequency (UHF) tags with read ranges of 10cm to 100 meters depending upon the frequency band used to transmit the data. In addition, RFID tags are either powered internally, called an "active" tag which typically transmits data on a cyclical basis, or energized by the interrogator to transmit the data, called a "passive" tag.

- Sensors

While sensors are not product identifiers, they can tell you about the surrounding environment or activity surrounding a product. Some examples are shock, temperature, and light exposure. Sensing these activities is critical for products that can be adversely impacted. Combined with other product identification technologies, they allow users to understand which assets had exposure to a sensor read condition, such as temperature, shock, or vibration.

Sensors are discussed in more detail in the following section, "Product Sensing and Monitoring Solutions."

During "In Use" of the Reusable Asset

- Labels / Labeling

The use of "In-use" temporary labels is designed to meet the challenges of an application.

They must be easy to apply and survive the usage cycle until they are no longer needed. At that point, they must be easy to remove.

"Using an experimental environment, fresh produce containers showed a tag/barcode separation loss of up to 70% after assets were randomly distributed and cleaned through several rounds."
Source: RPA member company

In the case of reusable plastic containers (RPCs, or Intermediate Bulk Containers) for perishable foods, for example, labels must survive exposure to coolers and the rigors of supply chain handling yet be released and removed cleanly with no adhesive residue when they go through an automated wash line.

A common challenge that occurs is the ease of removing labels after use. Companies that provide pooling services for reusable assets often struggle to remove the label from reusable assets after use by a customer. This increases costs for the pooling services company and, ultimately, the companies that use that service offering. Selecting a temporary and removable label solution that will not leave paper or adhesive residue on the reusable asset is important.

Label Types and Materials

There are many label options available. Popular approaches include direct thermal paper, thermal transfer paper, direct thermal film, and thermal transfer film.

Label material selection is an economic (label cost) and a functional choice. Typically, paper labels are lower cost than film. However, paper labels will not survive in any wet applications, such as the hydro cooling of fresh produce. They may be suspect in any moisture-rich environment, such as high humidity or condensation. The most common film labels are BOPP (bi-axially oriented polypropylene) with emulsion acrylic adhesives.

The adhesive must comply with FDA 21 CFR 175.125 for "indirect" food contact. The selection of a film label typically starts with how it will be printed; thermal transfer, which uses a ribbon, or direct thermal, which uses heat from the print head to "burn" the variable content onto the label surface.

"In Use" Label Best Practices

- Use Case-based Selection

When switching to reusable packaging from single-use corrugated boxes, it is key to recognize that labels previously used may not be the best solution for reusables.

The most vital attribute of any label (whether permanent or removable) is how it interacts with the substrate to which it is attached. The composition and surface energy of the substrate is just as important a factor as the label method and construction. When working with a label provider to validate labeling for reusable packaging applications, it is important to review these requirements with them and that they provide accurate performance data supporting the best industry practice stated below:

- Compatibility with the reusable asset plastic material and surface texture
- Performance at temperature range and handling environment
- Method for removal of temporary labels
- Other requirements unique to a company's supply chains

- Traceability Requirements

Any traceability requirements for labeling should also be considered when using "In Use" labels across the supply chain.

Different traceability standards are used across various industries to support industry practices and compliance with regulatory requirements.

As an example, the US Produce Industry follows best practices outlined in the following guide: "Produce Traceability Initiative Best Practices for Formatting Case Labels Revision 1.4", updated June 12, 2019 Source: www.producetraceability.org

Example Produce Traceability Initiative (PTI) compliant label

4.2.3 Industry Standards and Solutions

- GS1 1D and 2D Symbology

1D barcodes have traditionally been used to physically mark the Global Trade Item Number (GTIN) on the product label or the packaging material. The traditionally used symbols, EAN/UPC and ITF-14 can only carry the GTIN. There is a shift towards using GS1-128 barcodes since these allow additional attributes to be encoded. This is driven by the need for more precise product information in distribution processes, for example, to address product and consumer safety requirements.

With the emergence of two-dimensional (2D) symbologies, more compact representations of the Global Trade Item Number and attributes have become possible and are also becoming increasingly popular in logistics and supply chain applications.

In retail supply chain applications, GS1 has completed various projects to address the questions and requirements of adopting 2D symbologies.

These initiatives focus primarily on the impact on the identification of consumer products at the retail POS, including the transition to image-based scanning and the mobile scanning requirements of consumers.

- One-dimensional (1D) Barcode Symbols

One-dimensional barcode symbols consist of a pattern of bars and spaces. GS1 standards include four (4)types of 1D symbologies:

- Two symbologies, EAN/UPC and ITF-14, can only carry the Global Trade Item Number (GTIN) and no additional data attributes.
- The other symbologies, GS1-128 and GS1 Data Bar, can represent the GTIN plus additional data attributes.

- 2D barcodes (2) Barcode Symbols

Two-dimensional barcodes are composed of patterns such as square modules arranged in a matrix. GS1 offers two (2) types of 2D symbologies:

GS1 QR Code and GS1 Data Matrix

Depending on the length of the additional attributes to be included, the 1D symbols can become large, making them more difficult to produce, fit on the label, and scan. For GS1-128, it is allowed to include multiple separate symbols to alleviate size concerns.

Example GS1 1D and 2D bar codes

The 2D symbologies are more space efficient. Usually, the data required for a trade item grouping will fit into one 2D symbol without significantly impacting the area of the label needed. This results in more data transmitted via the 2D symbologies on reusable transport assets, unit load license plates, individual cases and layers, and consumer packaged goods.

Learn more - Source: GS1 2D Symbols in Distribution & Logistics

- Radio Frequency IDentification (RFID)

Like the many types of barcodes, all RFID tags are not the same.

The use of active and passive RFID tags, including NFC, UHF, HF, and LF variations, each offers a function to meet the needs of particular use cases. GS1 standards have been developed for UHF and HF RFID tags and are the tags most commonly used in the logistics and transportation sectors that move goods through the supply chain. The most broadly implemented tags in our industries are UHF passive tags, also known as RAIN RFID tags.

When unique EPCs (Electronic Product Code™) are encoded onto individual RAIN RFID tags, radio waves can capture the unique identifiers at high rates and distances greater than 10 meters, without line-of-sight contact.

These characteristics of RAIN RFID are leveraged to boost supply chain visibility and increase inventory accuracy of reusable assets and goods transported through the supply chain.

Source: GSI RFID Standards

UHF RAIN RFID vs. Proprietary

RFID technologies are often categorized by their operating frequency bands and refer to the size of the radio waves used to communicate between system components.

"RAIN" and "UHF" are often used interchangeably when describing RFID solutions, but they can operate differently. Labeling a system as RAIN RFID lets the user know that the system or technology adheres to a specific standard and protocol. The RAIN Alliance is the industry organization supporting the universal adoption of RAIN RFID.

Today, the majority of new RFID projects are using RAIN RFID. As the fastest-growing segment of the RFID market, with more than 80 billion tag chips sold to date, RAIN RFID is used in many markets and industries worldwide.

While RAIN RFID operates in the UHF radio frequency band, other proprietary RFID solutions may be employed for different purposes.

There are advantages and disadvantages to using each of these technologies, including operating at various frequency bands. Examples include:

- Low-Frequency (LF) RFID, which can only read one tag at a time and has a low range. Due to its slower data-read rates, it is frequently used for access control and individual product microchips.
- High-frequency (HF) RFID is commonly used for data transfer, ticketing, and payment-based systems.

Source: Rain Alliance

4.2.4 Emerging Technologies

Innovation in product identification technologies continues as companies explore new methods to identify and store additional information about a product or goods shipped through the supply chain. With new regulations emerging, the additional data of a product may need to be stored in new methods.

Here are some examples of emerging technologies in product identification.

Taggants and Additive Materials/Manufacturing

Adding product identifiers like taggants and additives can be used to identify a change in the state of the product, authenticate an item from a supplier, or may provide a digital fingerprint at the item level.

These are generally added to a designed product solely to disclose unwanted behavior.

Examples may include:

- Paints or other coatings applied to items that, when hit with a particular light frequency, react to a detector in a specific way for a manufacturer or product type
- Thermochromics that changes color when threshold temperatures are exceeded
- Submicron particles embedded within an object (e.g., added to the feed for a 3D-printed object)

Product identification (including identifiers unique to the maker, part numbers, or individual instance of an item) is critical to managing items through the supply chain, customer support, maintenance, and authentication when items are susceptible to counterfeit or negatively impacted by environmental factors.

- Digital Watermarks / Product Digitization

The use of digital watermarks has been expanding in use through the consumer-packaged goods industry over the past years. Through product digitization using digital watermarks, companies have improved customer experiences through faster scanning, more efficient handling, and simplifying the brand packaging experience.

This technology allows for incorporating product information into the primary packaging design.

Companies are exploring using this technology in reusable assets across retail supply chains.

Other examples include applying digital watermarks to identify single-use plastic types used in consumer packaging, allowing for ease of sorting into the type of plastic and becoming a potential raw material for use in reusable packaging. AIM is leading this project - European Brands Association and powered by the Alliance to End Plastic Waste; over 130 companies and organizations from the complete packaging value chain have joined forces for the Digital Watermarks Initiative Holy Grail 2.0.

Digital Watermarks Initiative HolyGrail 2.0
Source: Digimarc

Anti-theft Solutions for Reusable Packaging Applications

Courtesy of Polyfuze USA

WHY: "The Challenge"

Across the supply chain, problems arise as "un-marked" and "un-tagged" reusable assets are stolen, illegally recycled, re-manufactured, and then sold back into the supply chain as a new product. This epidemic creates additional cost not only to reusable packaging manufacturers (who are essentially re-buying former product), but additional cost that must be passed down throughout the economy ultimately resulting in increased food and product cost to the consumer.

This plastic theft accounts for a $100M loss annually in the U.S. alone.

In addition, real-world results prove that standard adhesive-based labeling methods continuously fail their duty on polyolefin thermoplastic products typically used in reusable shipping assets that results in these stolen "un-marked" and "un-tagged" products. For example, tag/barcode had a separation loss of up to 70% in fresh produce containers after assets were randomly distributed and cleaned through several rounds.

WHAT: "A Solution"

The use of polymer fusion technology, which merges two different polyolefin thermoplastic polymers (polyolefin label + polyolefin product) and utilizes melting point, time, and pressure, results in a singular reusable asset without adhesives, tie layers, bonding agents, or secondary surface treatments. Polymer fusion technology was engineered explicitly for perfect compatibility with polyolefin thermoplastic products, parts, and components to deliver unrivaled lifelong performance.

When combined with D-TECT™ technology, fully customizable microscopic, highly tunable physical, optical, and magnetic crystals are introduced into polymer matrix fusion technology inks during production and printed as part of a logo, label, or as an imperceptible feature to be applied onto customers' products.

RESULT: “The Benefit”

During application, the polymer fusion label and the customers' polyolefin thermoplastic product, part, or component simultaneously reach the melting point, causing a fusion reaction.

Acting as a covert "proof of property" fingerprint, the result - is a permanent authenticatable adn identifiable mark on plastic that cannot be lifted, separated, or removed for the product's useful life, no matter the environment or exposure. In situations of reusable plastic theft where the plastic is ground up, shredded, or converted to recyclate; invisible luminescing pigments can also be added to polymer fusion technology inks to help investigators detect small fragments under forensic lighting for identification purposes.

Polymer Fusion Technology with D-TECT™ on a Reusable Beverage Tray
Courtesy of PolyFuze

4. What Solutions Exist and Why You Would Use Them

4.3 Product Sensing and Monitoring Solutions

Technology-enabled returnable assets can provide insights and conditions of the physical goods during movements from one location to another. As goods move from raw material suppliers to manufacturers to retailers and potentially to the consumer, many steps and opportunities exist for goods to be damaged. This damage can occur from physical, temperature, impact, environmental exposure, etc. Using product sensing and monitoring solutions can play an essential role in reducing the damage to goods while being transported.

"Technology-enabled returnable assets can provide insights and conditions of the physical goods during movements from one location to another."

4.3.1 Reasons and Benefits for Product Monitoring

When applying asset monitoring solutions across your supply chain, you must consider the users that will benefit from understanding and acting on the monitored goods. Understanding the level of value delivered to your company, suppliers, and other supply chain partners is essential.

Product sensor applied to a reusable asset
Courtesy of EPAL. The European Pallet Association

The benefits of technology-enabled reusable assets for product sensing and monitoring include the following:

- Condition: High-Value or High-Risk Products

When shipping high-value or high-risk products or perishables, it is often desirable to understand the condition of the goods while being shipped. This includes the temperature exposure of the goods or if and where the goods are exposed to high-impact events, which may cause damage to the goods, impacting the overall quality of the goods.

When considering adding technology-enabled reusable assets, it can be desirable to use product sensing and monitoring solutions to measure and validate the products' condition during the shipment of the goods to the customer. The business case for this type of use case is based on the cost of the solution versus the number of damaged goods created throughout the supply chain.

- Regulatory: Food Safety and Temperatures

Understanding the temperatures of high-risk products or perishables as they travel through the supply chain is critical to the safety of these goods. When applying sensing and monitoring technology solutions to a reusable shipping asset, all supply chain companies can understand if the product has exceeded its maximum or minimum temperature thresholds for some time and where that failure point occurred.

With the introduction of current and future food and drug safety regulations, monitoring for environmental performance plays an essential role in reporting Key Data Elements (KDEs) for certain Critical Tracking Events (CTEs) across food-based supply chains. The previous chapter (section 3) on Product and Application Tracking Solutions will further detail these regulations.

- Regulatory: Safety and Security

When shipping goods impacted by safety and security concerns in high-risk environments,

it is important to understand where a product is in the supply chain and in what condition the product(s) are currently in.

By sensing various conditions, including environmental (examples include temperature, humidity, light exposure), locations (examples include a position, image), or physical (accelerometer, shock/vibration, force/pressure), a company can ensure their goods are safely and securely moving through their supply chain. While some technologies can identify if a unit load has exceeded a targeted temperature, other technology-enabled assets identify when and where a targeted temperature was exceeded, ensuring appropriate decisions can be made. Companies can make informed decisions by understanding the product value and performance over time. Linking reusable packaging to its content allows product monitoring during the production and product journey, allowing goods to travel safely and securely through the supply chain.

4.3.2 Product Monitoring Use Patterns

Sensors attached to reusable packaging can help detect product performance or condition issues at the pallet or packaged unit level and alert stakeholders. Sensor data may also have implications for anticipated product life or identifying underlying patterns that increase the risk of loss.

Using sensors with temperature-sensitive products such as perishable foods and pharmaceuticals allows companies to understand if critical thresholds have been reached. In such applications, temperature readings can alert the supply chain professional.

Less severe temperature exposure may also have implications for anticipated shelf life. Understanding product exposure history and anticipated product life expectancy can allow decision-makers to manage the affected merchandise.

Likewise, shock/vibration sensors can be crucial in monitoring the shipment of other expensive and sensitive products, such as electronics. Such sensors can help identify the time and location of events that result in damage. Historical data can provide insights to logistics professionals regarding exposure patterns, allowing for further review and corrective action.

And while high product cost and sensitivity can help build an attractive use case for product monitoring, other applications can relate to safety. For example, safety risks associated with accidental discharge chemical industry applications
can be addressed through fill-level monitoring. Deviations in fill level can generate alerts and rapid responses to such a situation.

4.3.3 Sensor Equipment, Materials, and Hardware Solutions

A variety of IoT sensors are used in technology-enabled returnable assets. Sometimes they are standalone sensors and are often integrated into location-based tracking technologies on reusable assets.

Industry Solutions – Types

Two of the most common sensor examples on technology-enabled reusable shipping assets include

- Temperature and Humidity Sensors

Sensors that measure the ambient temperature in the container, room, or surrounding area at a defined frequency of the reusable asset are beneficial to understanding the condition of the transported. In some examples, temperature sensors are applied at a case or product level, communicating the temperature to the reusable asset.

It is important to consider that a temperature reading on a reusable asset has to be correlated to the temperature of the goods being shipped. This correlation needs to be completed and understood for the specific use case. For example, while the sensor on a reusable pallet measures the temperature at that particular location, the actual temperature of a product, in a case, on a pallet or container in a room or truck trailer, can be quite different. Consideration of the product's condition as it travels through the supply chain is key.

- Accelerometers

What levels of physical condition a good has experienced is often enabled by using accelerometer sensors, which can detect the rate of change of the reusable asset, indicating impact, shake, tilt, and drop-type events of the unit load shipment.

Accelerometer sensors can identify where potential asset damage or goods damage has occurred, allowing companies and their supply chain partners to take action to reduce these conditions resulting in minimized product damage.

These types of sensors can identify the movement of a unit load, allowing companies to understand the activity of each shipment. This can be useful in identifying and minimizing discrepancies and reducing the potential for product damage issues.

- Other Industry Solutions

Depending on a company's specific use case, more sensors can be incorporated into custom technology-enabled solutions. They may include:

  - Pressure Transducers
  - Tilt Sensors
  - Ultrasonic Sensors
  - Force Load Cells
  - LVDT Position Sensors
  - Plug and Play Accelerometers
  - Liquid Level Switches
  - Shock

Key Considerations

When considering one sensing-based technology solution over another, one should ask, "Why would you choose a specific solution?"

Based on your targeted primary use case, there may be a wide variety of considerations, which include:

- Primary Use Case Understanding

Ensure the team fully understands the targeted problem or use case before gravitating toward a particular technology-based solution. Taking the time to understand the challenge and goals of the application and sharing those with your technology partners will allow them to recommend the best path forward.

Product monitoring capabilities will impact various stakeholders in different ways. A broad dialogue within your organization and supply chain can help you better understand the costs of current inefficiencies and more accurately capture the ROI of your technology investment.

Lastly, ensure that you base your decision-making on the value of the product and/or reusable packaging and the expected cost and benefits to provide a favorable ROI calculation.

- Sensor Data Frequency

When considering the use case, configure a sensor to address the risks specific to the use case while being mindful that increased communication frequency will deplete batteries sooner. Data can be communicated at specified intervals and/or communicate exceptions. They can also be configured to sample more frequently and notify if a rate of change suggests a risk event is likely to happen.

For example, a sensor might read the temperature every 15-minutes, but if it exceeds a threshold, it may be programmed to start sampling at shorter intervals.

Adjusting the communication frequency of the sensor will also negatively impact battery life, requiring you to differentiate between nice to have and must have data.

- Monitoring as a Service

As the technologies used for product sensing and monitoring have matured, there are now multiple service-based monitoring technology solutions that companies can consider as an optional path forward versus purchase for supply chain participants making use of rented or leased reusable packaging offering this feature, or if users are concerned about purchasing a solution and then being left behind by its ongoing evolution.

Multiple reusable transport packaging companies provide this type of service-based solution for companies. These models typically incorporate a one-time setup fee, with a monthly monitoring fee based on the number of devices and reporting frequency.

- Insights and Decision Making

Sensor monitoring is not just about the device but also ensuring that the platform allows the company to assess and manage the data. Tracking solutions can quickly produce a substantial amount of data.

If the platform doesn't effectively communicate where the organization's attention should be, there is a high chance of failure.

Insights can play a critical role - to the extent it will make or break the implemented solution and the resulting ROI and payback. Predictive analytics come into play here for the different data users; on the floor, with management, with supply chain partners (suppliers and customers), and at a corporate level.

Considerations for Physical Integration

When applying a sensing technology-based solution to a reusable asset, consider where and how the solution will be used. This includes where the device is attached, the frequency of replacement considerations due to battery life, etc., and the end market performance requirements that may be experienced.

Key considerations include:

- Design and Attachment

How will a sensor be attached to the reusable asset? Ensure it is in a location that can easily be serviceable but also protected from the end user environment, which may include impact conditions and exposure to water/damp environments.

- Serviceability

How will the sensor be serviced or replaced? How should the sensor itself or the battery power source be returned when using battery-powered sensors?

Evaluate the expected replacement frequency, as some examples require them to be replaced multiple times per year based on the targeted use case.

For example, a sensing device will need replacing after four trips, and it takes 15- minutes per device on each reusable asset. More than 100,000 reusable assets in a company's network can result in more than 400 hours of operational time to replace the sensing device.

- Industry Requirements

What are the industry requirements of a sensing and monitoring technology device? For Example, industrial automation vs. oil and gas or pharma industry requirements can differ significantly from environmental or regulatory requirements perspectives.

4.3.4 Emerging Technologies

- Sensors Based on Product-specific Requirements

With Internet of Things (IoT) sensors now representing over one-third of all sensors shipped in 2022, this technology has become mainstream in various industries, including the supply chain. In 2022, the average IoT device will have four sensors, with more than 50 billion connected sensors deployed.

Source: IoT Analytics - 5 IoT Sensor Technologies to Watch

IoT sensor technologies continue to innovate around the following six key areas that may impact the transportation and logistics industry.

1. Smarter Sensors

Sensor technology continues to progress rapidly. Current innovations in sensing technologies include detecting signals from several discrete sensing units and a much higher computing capacity. Smart sensors can process signals directly (e.g., validating and interpreting the data, displaying the results, or running particular analytics applications) instead of merely transmitting them to the next level in the value chain. In this way, smart sensors transform into edge devices.

The most sophisticated smart sensors now incorporate AI in their design and operation. These sensors are designed for AI inference, including the ability to analyze and process large amounts of data without transmitting, resulting in longer-life sensors being used in more demanding applications such as transportation and logistics.

2. More Power-Efficient Sensors

An emerging development area for IoT sensors is in self-powered renewable energy sources like solar or kinetic energy, negating the need for batteries or additional power sources. This development increases the dependability and lifetime of IoT devices, especially those installed in remote or difficult-to-access areas, such as supply chain and logistics applications. These components reduce the environmental impact of the total system configuration and are self-sustaining.

3. Soft or Virtual Sensors

In some supply chain use cases, installing a physical sensor for each reusable transportation asset is impractical or costly. Innovations in IoT sensor technologies include soft and virtual sensors and focus on complex use cases where transitional sensors are not cost-effective to implement widely.

A soft sensor is a computational algorithm that estimates the value of a difficult-to-measure quantity based on other existing physical sensors and algorithms or computational models that infer the value of the measured quantity.

A virtual sensor is similar to a soft sensor, the difference being that its values are not based on existing physical sensors but purely on algorithms/computational models.

4. Sensor Fusion and Autonomous

Sensors are now becoming a major component to autonomous vehicles, material handling, and automation systems across the supply chain. While not placed on a reusable asset, these technologies are applied to autonomous fork trucks, which handle reusable assets across the supply chain. Three key sensors for autonomous material handling include LiDAR, radar, and 3D cameras (image sensors).

These sensor technologies interact with the reusable asset through vision-based systems identifying type and quantity and the safest way to move and handle it.

Reusable shipping assets work well with these sensors, which are repeatable and predictable for autonomous-based material handling systems.

5. Disposable Sensor Technologies

Disposable sensor technology has matured recently and is adopted in the healthcare industry. Current developments in biosensor and disposable sensor technology research imply this technology is also almost ready for the market in other sectors, such as the supply chain.

Disposable sensors convert the environmental response into an electrical signal. Depending on their application, these future types of sensors will detect chemical and environmental-based exposures

6. Platform System-based Solutions

Innovations across platform-based solutions can now collect and link location data and sensor data from different technologies/input sources. They can track the product and goods being transported and the reusable packaging that carries it, providing the best of all worlds with complete visibility of the supply chain and goods shipped.

Data and Insights based systems, incorporating AI and machine learning-based technologies, allow multiple sensors and corresponding data to create a learning-based insights solution. This is discussed further in this report under How to Data to Develop and Deliver Insights.

Industry Case Study
Monitoring and Sensing

Pharmaceuticals Placed in a Non-temperature Control Environment

A shipment of nine pallets of pharmaceutical goods, valued at $50 million, was being sent by air from Ireland to China. The palletized goods were outfitted with wireless IoT devices equipped with temperature sensors. The freight forwarder received an alert. It showed four pallets being out of temperature range, and the logistics service provider was instructed to investigate. The four pallets were found in a non-compliant storage area, and the situation was quickly corrected. Data history from the pallets helped expedite the quality assurance process and release of the products to the market.

Source: Controlant Webinar

The Truck Inspection Window Was Left Open by Mistake, Resulting in a Temperature Drop

A truckload of pharmaceutical goods was being transported from Italy to Lithuania. Following a temperature breach alert from sensors on unit loads, the driver was contacted. The driver checked the trailer temperature recorded and reported that the trailer temperature was within range. Following a second alert, the driver was contacted again and asked to investigate more thoroughly.

The back inspection window was discovered to have been left open from a Customs inspection, resulting in the back pallets being exposed to below-threshold temperatures. The window was closed, and the issue was resolved before the goods reached 13 degrees C, which would have made the product unsalable.

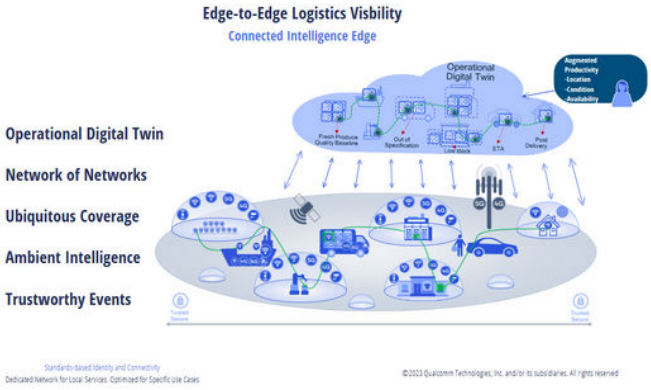
Source: Controlant Webinar

4. What Solutions Exist and Why You Would Use Them

4.4 Product Applications and Tracking Solutions

The application of tracking technologies for reusable assets across various supply chains can be necessary for minimizing disruptions, increasing resiliency, improving efficiencies, and lowering business costs. As goods move through the supply chain from the 'Field' to the 'Home,' it is becoming increasingly important to understand the location, condition, and availability of raw materials and goods moved. The use of identification and connectivity technologies assists in the visibility of technology-enabled reusable assets as they move through the supply chain.

"The application of tracking technologies for reusable assets across various supply chains can be necessary for minimizing disruptions."



Edge-to-Edge Logistics and Supply Chain Visibility
Courtesy of Qualcomm Technologies, Inc.

4.4.1 Reasons and Benefits for Asset Tracking

When considering applying asset tracking solutions to the goods movement of your supply chain, it is essential to understand the benefits to the Owner of the asset (i.e., a retailer, pooling services company, etc.) and the User of the asset (i.e., a retailer, manufacturer, worker, etc.). By understanding the value of each of these use cases, a company can determine the holistic value across its entire supply chain and maximize the value of the technology investment.

The benefits of technology-enabled reusable assets include the following:

- Location: Goods Visibility
  [Asset User]

Knowing where your goods and raw materials are in the supply chain can help eliminate potential shortages, shrinkage issues, and constraints, allowing for reduced costs and more efficient movements of goods.

Do you have a good understanding of the cycle time of goods in your supply chain? Where are goods getting 'stuck' in the supply chain, and what actions can you take? You can improve efficiencies and reduce costs by better understanding your supply chain.

- Condition: Product Damage Awareness and Reduction
  [Asset User and Asset Owner]

Understanding where and how your goods are damaged while moving through the supply chain is important in investigating and developing damage forensics. When tied to geolocation and time coordinates, it can help determine when the product damage or exposure occurred, offering the opportunity for a more targeted investigation and an earlier resolution of the claims process. Historical data can provide movement, shock/vibration insights to supply chain professionals regarding patterns of exposure, allowing for further review and corrective action by a company's supply chain partners.

- Regulatory: Food Safety Requirements
  [Asset User]

With the introduction and global implementation of food safety regulations, technology-enabled reusable assets are increasingly being utilized to meet these requirements.

For example, the US FDA recently issued the final rule on requirements for Additional Traceability Records for Certain Foods (Food Traceability Final Rule).

This regulation is the last element of the FDA's New Era of Smarter Food Safety Blueprint and implements Section 204(d) of the FDA Food Safety Modernization Act (FSMA). This rule establishes traceability recordkeeping requirements for companies that manufacture, process, or hold/provide storage of foods included in the Food Traceability List, including dairy products, vegetables, fresh-cut fruits, and types of seafood.

Companies and their supply chain partners must track specific information called Key Data Elements (KDEs) for certain Critical Tracking Events (CTEs) across food-based supply chains. This framework forms the foundation for effective and efficient food tracing and requires all entities to share information with other entities across the supply chain. The final compliance date for recordkeeping of this guideline is January 2026.

Similar food safety regulations are being instituted globally and play a big role in using technology-enabled reusable assets through food-based supply chains.

Source: FDA FMSA FInal Rule Requirements

- Availability: Loop Management of Your Reusable Assets
  [Asset Owner]

Do you have enough returnable shipping platforms for your goods? Do you have too few quantities on hand? Are they in the right location to meet your customer's needs?

Using technology-enabled returnable assets allows businesses to better plan for forecasted and un-forecasted customer supply and demand. During supply chain disruptions events, such as natural disasters, pandemics, labor shortages, etc., the need to plan and understand the necessary shipping assets plays a critical part in the efficiency of supply chains by retailers, manufacturers, and supply chain partners.

In 2023, returnable assets are experiencing shortages due to assets not being in the supply chain's required location. These shortages add costs to the relocation efforts, creating a negative impact on transportation sustainability and the creation of new assets.

- Sustainability: Environmental, Social, and Governance Impact
  [Asset User and Asset Owner]

Is your ESG reporting an annual reporting project, or is it integrated into your supply chain strategy?

"Companies are coming under regulatory, investor, and customer pressure to provide expanded ESG disclosures, including how environmental and social issues impact value chains. While there have been gains in the past year, ESG-related issues still challenge the supply chain function."

By incorporating technology-based returnable assets into the supply chain, companies can better understand reusable assets, the use of transportation and logistics of the reusable assets, and how goods generally move through the supply chain.

Source: PWC Digital Supply Chain Survey

- Governance: Financial
  [Asset Owner]

An increasingly crucial financial benefit of asset tracking is understanding the 'actual' number of reusable assets in a company's fleet or pool at a given time. This allows proper financial governance when local or national government entities are looking at capital investments in assets and appropriate depreciation and tax implications based on the actual vs. estimated size of the asset pool.

The use of technology-enabled assets provides a solution to a company's financial leadership of the actual size and reporting of reusables assets in the financial reporting processes without manual semi-annual inventory processes, which can be inaccurate and not provide a realistic view of the number of assets in a company or partner's network.

- Customer: Improved Experience
  [Asset User and Asset Owner]

Last, but perhaps the most important, is the customer's visibility of their goods shipped on a technology-enable returnable asset. How many resources (website, human, etc.) has your company invested in to help your customers or internal planning teams find a product's location in your supply chain?

By properly utilizing a holistic approach to technology-enabled assets, companies can proactively communicate with their customers or suppliers, often with less human capital working to track down lost shipments or missing orders. Enabled assets benefit the company and its supply chain partners when combined with a company's ERP system.

4.4.2 Tracking Sensors, Equipment, Materials, and Hardware Solutions

When contemplating the use of technology-enabled returnable assets, there can be multiple considerations that a company needs to incorporate into its strategy, investment, planning, and implementation.

These areas can include the following:

- Frequency of Reporting

What is required to maximize the value of data for the insights necessary? This will impact the investment required, such as battery life, etc.

- Redundancy

What is the needed redundancy of the technology applied to the reusable asset?

How is the asset tracked or visible if the tag/technology gets damaged? Are multiple tags or technologies required?

- Cost vs. Value Delivered

What is the expected cost vs. value delivered based on the goods shipped and supply chain characteristics of the company and its suppliers? i.e., Is the company sending a high-value asset into a complex supply chain?

- Sanitization or Cleaning Processes

If the returnable asset is used in a supply chain that requires cleaning or sanitizing, how will the sensor, materials, and hardware handle that exposure? And how will it operate after repeated cycles over multiple years, as reusable assets have a multi-year life expectancy?

- Others

There are other considerations that a company should consider based on their use case. Additional examples may include environmental conditions and logistics and handling of the technology-enabled reusable asset, etc.

Industry Solutions – Types

As discussed earlier in this white paper, various technology-based solutions can be applied to returnable assets.

There are varying levels of adoption based on the industry use cases and cost vs. value delivered for specific companies' use cases across their supply chains. They include:

- Barcodes for Tracking

Using barcodes as part of a system provides a low-cost, widely used approach to tracking. Simply put, the barcode, affixed to a reusable asset, offers a unique license plate. The reader scans the barcode, and that record is captured in a database. Barcodes help improve inventory, sales, and shipping accuracy and aid the efficiency of sorting and loading dock operations.

Barcode records also provide an accurate account of reusable container shipments and returns from customers. Unique barcodes can be associated with variables such as time and location, products being carried, or reusable asset maintenance history, for example, to provide tracking information to the user.

Regarding tracking the location of reusable packaging units for asset management, their whereabouts are invisible from a digital perspective between scans. However, scanning empty returning containers can help operators understand key performance indicators such as dwell time or the return rate (flow-through) associated with customers to initiate corrective action as required.

One RPC pooler uses scan data to monitor customers' return rates and assess return rates from geographic areas or distribution center service areas. For example, low return rates from a city may indicate issues with local plastic theft.

Barcode label on a reusable container. Recessed between ribs for durability.
Courtesy: Monoflo International

- Radio Frequency Identification (RFID) for Tracking

RFID offers a relatively established approach to the automated tracking of reusable packaging products. Two commonly touted benefits of RFID compared to barcode are that RFID tags do not need a direct line of sight to be scanned and that multiple RFID tags can be scanned simultaneously, making the process faster than barcode scanning. Similar to barcode systems, RFID has limitations from a tracking perspective in that tagged items are only visible at read points.

Other locations, such as in transit or trading partner locations, may only be visible from a digital tracking perspective if read/scan equipment is installed, which adds cost to the packaging owner.

Unfortunately, the loss of reusable packaging assets is often associated with empty reusable packaging whenit is in the custody of logistics providers or trading partners. As such, even though reusable packaging managers may know which ship-to locations result in poor return rates, further intervention will be required to determine the root cause and location of asset loss.

While passive RFID tags are relatively inexpensive, the cost of readers can be more substantial and must be an option from an ROI perspective. RFID works best within facilities or controlled supply chains where fixed RFID readers can be reasonably installed at shipping and receiving locations or where personnel can access handheld readers. While RFID tags are inexpensive, readers are more costly. The greater the number of readers required for a supply chain, the more challenging achieving an ROI can be.

RFID / Barcode label on a reusable container
Courtesy: IFCO

- Brand Secure System for Tracking

Using a Brand Secure System is a simple and cost-effective way to verify the authenticity of a product and make distribution channels traceable.

Using a counterfeit-proof Brand Secure Label with overt and covert code in combination with the Brand Secure Database, APP, and Dialog Platform. It offers various security services, including brand and product monitoring and identification, counterfeit protection, and customer loyalty solutions. The code is unique and can only be assigned by one single customer to one product of the manufacturer. Brand Secure Systems offer an innovative approach to tracking reusable packaging products for the manufacturer and the end consumer.

This solution enables the end consumer to independently read the product composition, ingredient properties, and handling instructions on their APP by scanning the open code on the label before buying the product. Moreover, the customer can read all the information, from warranty to return, exchange, claim, and recycling – paperless and always up to date.

Using a Brand Secure System
Courtesy: PMG Labels

The end consumer can independently convince himself of the original through a Brand Secure System. In addition, the consumer's brand experience is improved, and his loyalty to the brand increases.

The consumer simply exposes the hidden code after purchase, scans it, and has the certainty of purchasing an original product. The manufacturer can control and log access. By tracking access, companies or organizations can improve the security and protection of assets or information.

The app or web app is future-proof and creates a completely new manufacturer-consumer relationship based on double trust. This way, companies become more transparent with their customers with the digital product passport. It is already integrated into a Brand Secure System.

For a company, it is easier to introduce the Digital Product Passport (DPP), which is mandatory throughout the EU. The DPP is part of the measures the EU Commission announced under the Sustainable Product Initiative (SPI). The digital product passport serves as an essential instrument for a climate-friendly economy. For example, it can provide information on a product's origin, composition, repair possibilities, and handling at the end of its life.

A Brand Secure System is based on QR codes. This means that the technology can be used by any smartphone without restrictions. The open code can be scanned on any cell phone with a QR code reader. The hidden code can be scanned with the Brand Secure System, Webapp, or native app and with a plugin integrated into the manufacturer's app. With this direct and real-time feedback, customers have direct access to the information if the product is original.

These types of Brand Secure Systems consist of four functional areas:

1. The Label
The tamper-proof Brand Secure Label with one overt and one covert code can be customized and is designed for all common surfaces such as glass, foils, cardboard, or metal surfaces. There are no limits to the variety of shapes, and direct integration into the packaging is also possible without additional labels.

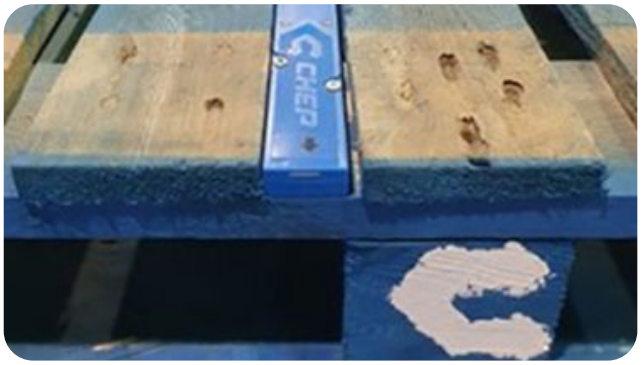
2. Smartphone with an App
After purchasing the product, consumers can uncover and scan the hidden code within a Brand Secure System app. This code is unique and can only be assigned to one product. The integration of the app into existing apps is possible. It can be a web app or a native app.

3. Database
If the batch information of a scanned code is stored in a Brand Secure System database, the consumer immediately receives feedback in the app as to whether it is an original product. The database-supported software tool contains numerous functions for product and group management and access tracking. If it is a counterfeit, this is immediately indicated to the consumer, protecting companies from inferior counterfeit products and possible recourse claims.

4. Dialogue
A Brand Secure System allows manufacturers to interact with their own customers and build trust. This increases brand reliability and is a new marketing tool. Competitions, loyalty, or birthday bonuses can all be integrated into manufacturers' CRM using an API and create an entirely new brand experience. Customer loyalty can be sustainably increased by providing customized sales offers and loyalty points.

- Machine-to-Machine (M2) and Internet of Things (IoT)

IoT or M2 refers to a network of physical objects like reusable packaging assets, each equipped with a unique identifier and internet connectivity that allows for the communication and transfer of data between objects and other internet-enabled devices. An IoT system can comprise four components: sensors/devices, connectivity method, data processing (cloud platform), and user interface.



GPS device (BXBD Ultra device) on a reusable pallet
Source: Brambles / CHEP

IoT solutions are becoming increasingly attractive for the tracking of reusable packaging. Because such approaches communicate directly with cellular or non-cellular LPWA networks, they provide tracking data even without an infrastructure of proximity readers or scanners, as is necessary for solutions such as barcode and RFID.

As such, IoT devices can provide greater visibility of reusable packaging units and related contents in transit as they make their way through the supply chain - points where they are most susceptible to loss and points where the product is carried and most vulnerable to damage.

IoT networks rely on various cloud network connectivity types, including cellular, LPWA, Bluetooth, Low Power Mesh, UWB, and Wi-Fi. These technologies are described in further detail in the Appendix and Industry Resources.

Connectivity types include:

- Cellular
- LPWA (Low Power Wide Area Network)
- Bluetooth or BLE (Bluetooth Low Energy)
- Low Power Mesh
- UWB (Ultra-wideband)
- Wi-Fi

Reusable roll containers equipped with tracking devices
Source: Heliot/Sigfox Germany

Key Considerations for Physical Integration

When considering a technology-based solution integrated into a returnable asset, it is crucial to consider where and how the technology-based solution is attached to the asset based on the use case of the returnable asset.

When a tag or technology device loses its tag, either directly or indirectly, the result is data loss, tracking loss, etc., of the asset and can result in the loss of the asset and the data it is providing to the company and partners. For example, using traditional bar code tags can cause up to 1 out of 10 asset tags to fall off or lose the ability to read the tag.

Some considerations need to include:

- Material

A critical and often overlooked piece of information to address at the front end of any tracking project is the material an asset is made with. How various types of tracking will work can highly depend on the material used to create the reusable packaging - wood, metal, composite, and polypropylene will all interact with tracking differently. Ensure your technology-based solution considers the material used in the asset's construction, ensuring it remains attached over the expected lifetime.

- Design

Evaluate where the tag or technology will be applied to the reusable asset. Is it exposed to wear, puncture, or impact? Device placement on reusable packaging must be planned so that it is not damaged or destroyed by forklifts or manufacturing processes.

Ideally, place the tag in a protected area of the asset that does not experience high levels of potential damage throughout its life.

If the technology utilizes a battery power device, how will the battery be charged or replaced? Key questions include, will it require removal and what tools will be required?

Recessed data nameplate inside Ribbed structure
Source: Kennedy Group

- Assembly

If the technology is attached mechanically to the reusable asset, how is it accessible for service? What tools will be required to remove or install the device?

- Location

Assess device placement and concealment. When a reusable packaging asset is stolen, highly visible devices may be destroyed to prevent the tracking of those assets.

Multi-modality Identification

When reviewing the various technology asset tracking solutions based upon a company's use case, often the use of various technologies should be applied to reach the desired outcome.

This may include applying multiple tags on an asset or applying combinations of technologies on an asset. For example, using a data label (visual) that is RFID enabled (proximity) is often applied to reusable assets.

Other examples include applying advanced solutions such as 5G-enabled devices on a portion of the asset fleet or pool, with the remainder using a lower-cost solution. The company combines the right data insights to achieve the expected result.

Think about interoperability (data standards) when using various technologies. Do you understand the data available by each technology? When combined on a single asset or a pool of assets, does it provide the right level of data and resulting insights?

Emerging Technologies

- **Blockchain and Distributed Ledger Technologies**

While the ROI for reusable packaging asset-tracking technologies is already compelling for many applications, the emergence of blockchain platforms is expected to provide further synergy, increasing the value of sensor data and IoT-tracking solutions for supply chain applications. Keeping track of reusable assets worldwide, throughout the entire supply chain, using a single source of truth data hub is a potential solution to break with the siloed systems.

Nowadays, transactions of reusable assets need to be registered in multiple systems and portals. Data shared with supply chain partners happens by sharing a copy of the transaction, resulting in two lines instead of a single line of data.

The result? Discrepancies about the actual data and truth. Blockchain bridges the gap between siloed systems and ensures transactions are 100% trusted, validated, and secured when sharing information.
Blockchain technology for managing reusable asset transactions enables supply chains to collaborate and provide insights into their stock and balance. To increase sustainability in the supply chain, all companies involved should take responsibility and invest in emerging technologies. To reduce waste and bring how we process reusable assets to the next level.

Many thought leaders remain enthusiastic about the potential for blockchain combined with data generated from IoT sensors, seeing it as an opportunity to provide a "single, definitive version of the truth to all trading partners." However, there are still challenges ahead to reach the vision of an open, transparent network of distributed systems throughout the supply chain.

Global Blockchain in Logistics Market 2021-2028

"PwC showed that blockchain is spurring interest in the field. Yet it has not gained much traction. Only 5% of all companies and 27% of Digital Champions have already implemented blockchain."
Source: PWC & Marketsandmarkets

As an introduction to Blockchain technologies, this technology provides supply chains with an automated process for storing the data in digital format, which is extremely difficult to tamper with. Moreover, blockchain technology synchronizes all the transaction data across networks so that each participant validates the work of other participants.

Driver:
Major challenges faced by companies operating in the supply chain industry included the demands for reduced costs, enhanced speed, and continuous tracking of product movement. Blockchain technology improves transparency and trust and reduces data manipulation. This last one is one of the biggest drivers for blockchain in the market.

Opportunity:
The supply chain includes services such as legal, insurance, settlement, transport management, route planning, compliance, fleet management, delivery, and so on. These processes often require middlemen. These middlemen can be cut out due to the nature of the technology, as stakeholders are directly linked.

Blockchain technology is a distributed and decentralized digital ledger that allows for secure and transparent record-keeping of transactions. The technology is considered suitable for managing reusable assets in the supply chain due to its ability to provide a tamper-proof and transparent record of all transactions, which can significantly improve the efficiency and accuracy of the supply chain. Here are some reasons why blockchain technology is the future in technology infrastructure to manage reusable assets in the supply chain:

1. Increased Transparency:
Blockchain technology enables the creation of a secure and transparent system for managing the movement of load carriers across the supply chain.

2. Enhanced Security:
Blockchain technology is built to provide robust security features that ensure data integrity, transactions, and identities. This makes it an ideal infrastructure for managing reusable assets in the supply chain as it helps to prevent the loss or theft of assets, reduces the risk of counterfeit products, and ensures the authenticity of all transactions.

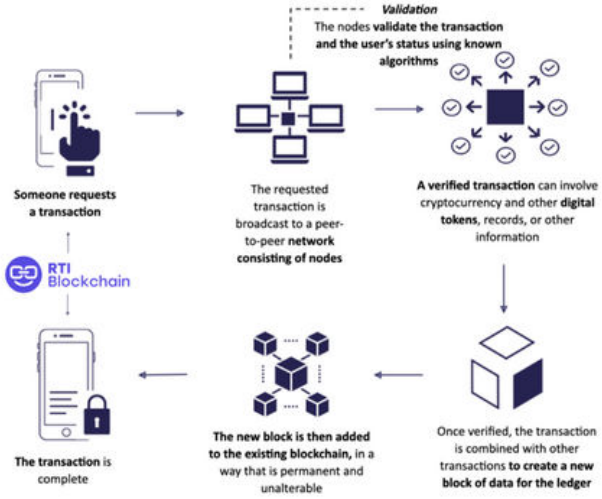
3. Improved Efficiency:
Using blockchain technology can significantly improve the efficiency of reusable asset management in the supply chain. The technology allows for creating of a shared database that can be accessed by all participants, enabling real-time tracking of reusable assets and reducing the time and resources required to manage the supply chain.

4. Cost-effective:
Blockchain technology can help to reduce the cost of managing load carriers in the supply chain by eliminating the need for intermediaries such as banks, clearinghouses, and other middlemen. This can help to reduce transaction fees and other costs associated with managing the supply chain, making it a cost-effective infrastructure for managing reusable assets.

Overall, blockchain technology can provide a robust and secure infrastructure for managing reusable assets in the supply chain. Its ability to improve transparency, security, efficiency, and cost-effectiveness makes it ideal for managing reusable assets and other supply chain processes.

Key Characteristics of a Blockchain

Blockchain can offer an automated network where records are shared. Sharing data between parties is typically a huge trust issue that makes collaboration difficult. Blockchain addresses this trust issue because data ownership is shared by all the parties involved, is traceable and unchangeable, and is secured by an advanced level of encryption.



Blockchain Overview
Courtesy of RTI Blockchain

Key Characteristics of a Blockchain

Blockchain can offer an automated network where records are shared. Sharing data between parties is typically a huge trust issue that makes collaboration difficult. Blockchain addresses this trust issue because data ownership is shared by all the parties involved, is traceable and unchangeable, and is secured by an advanced level of encryption.

- Distributed ledger

Every participant in the network has a full copy of all data, updated in real-time. This removes the need for verification by creating a single source of truth.

- Cryptography

The integrity and security of blockchain data are maintained with cryptographic functions, and all updates and changes are displayed with timestamps.

- Consensus

All updates, changes, and transactions must be validated by all participants. This eliminates the need for central control and creates trust.

- Smart contracts

A computer program that executes itself when certain terms and conditions are met. No human interference is required. It automates the repetitive and 'if else' situation in operational and commercial processes.

Blockchain Readiness Check

Follow this Blockchain readiness check for the logistics market to evaluate whether the logistics market could benefit from blockchain technology:

- Multiple participants need to be able to view common information
- Multiple participants take actions that need to be recorded and changes the data
- Participants need to trust that the actions that are recorded are valid
- Removal of intermediaries can reduce costs and complexity
- Creating more time efficient solutions, whilst reducing delay has business benefits
- Transactions created by different participants depend on each other

- **Machine Vision / Vision-based Technologies**

In addition to tags, BLE, and IoT GPS, a new generation of vision-based technology systems can identify reusable assets and products being transported when combined with machine learning. With investments being made

into automation and vision systems, the use of vision-based systems is emerging to read barcodes and identify the type and number of products being transported - enabled by AI-based tools.

This area of combining vision-based systems with existing tracking-based technologies is creating the next level of product and reusable tracking of assets.

Reusable Assets for Leading German Automotive Parts and Auto Parts Suppliers

Courtesy of PMG Labels

WHY: "The Challenge"

A well-established and experienced company in the automotive industry has been supplying the automotive industry and aftermarket for more than 15 years. The company offers high-quality automotive and commercial vehicle aftermarket parts for a wide range of brands and models from its large global manufacturer network.

The company transports its products in reusable plastic crates but cannot track the returnable crates shipped worldwide.

Also, it could not be checked if the crates were opened by the wholesalers, authorized workshops & dealers, independent workshops, independent car dealers, car companies (e.g., body shops, etc.), or auto parts dealers.

The company needed to take urgent action to reduce loss and implement a Brand Secure System to ensure traceability and management of transport packaging, among other things.

It is a fact that the loss of reusable Euro containers, boxes, and pallets is very costly for companies*. Therefore, it is crucial to identify the causes of loss and take measures to reduce it.

"A 2017 Fraunhofer Institute for Material Flow and Logistics (IML) study found that the annual loss of reusable transport packaging in Germany is around 500 million euros, and includes containers, crates, and pallets."

WHAT: "Successful Solution"

The Brand Secure System was implemented and provided reliable protection against product and brand counterfeiting and a simple and cost-effective way to verify the authenticity of a product and make distribution channels traceable.

The solution implemented included:

1. The Label

The tamper-proof Brand Secure Label with one overt and one covert code can be customized and was designed and applied for the outer packaging of the reusable plastic crates as well as for the different spare parts and single parts. The tamper-proof Brand Secure Label was directly integrated into the packaging or affixed onto the product, so no additional label was necessary.

2. Smartphone with an app

Unique product and packaging codes were generated and integrated into the Brand Secure App. Additionally, the integration of the app into existing web-based or native apps is possible for future use cases.

3. Database

The product and reusable packaging information is stored in the Brand Secure Database, and when scanned the consumer immediately receives feedback on whether it is an original product. The database-supported software tool contains numerous functions for product and group management and access tracking for the company and its partners. If it is a counterfeit, this is immediately indicated to the consumer. This protects companies from inferior counterfeit products and possible recourse claims.

4. Dialogue
The automotive parts supplier now interacts and builds trust with their customers using the Brand Secure System. This has resulted in increased brand reliability and is a new marketing tool for the company. Competitions, loyalty, or birthday bonuses can be integrated into manufacturers' CRM using the Brand Secure System API and create a completely new brand experience. Customer loyalty can be sustainably increased by providing customized sales offers and loyalty points.

RESULT: "The Benefit"
The company has become more transparent to its customers with the Brand Secure System and integrates a digital product passport (DPP).

This solution provides information on a product's origin, composition, repair possibilities, and handling at the end of its life. This digital product passport is part of the measures announced by the EU Commission under the Sustainable Product Initiative (SPI).

The company now understands where the reusable plastic crates are across its partner's network. If the crates have been damaged or goods have fallen out of the package by themselves during transportation have now been identified to the partner handling the goods. Additionally, if thieves open packages, forgeries are introduced into packaging, or if reusable storage crates have remained with the customer, they can be identified. The customer has benefitted from the Brand Secure System, using the geolocation to determine where the reusable container is, and the company now knows who has it or still has it after some time. This visibility has resulted in less reusable packaging loss by the company and its partners.

The Brand Secure System is used as a new marketing tool by the automotive and aftermarket parts company. Keeping in touch with customers is now easier and more secure than ever for the company. The company can now stand out from the anonymous crowd of other interchangeable products and has turned its customers into loyal repeat customers. The insights gained from the analysis have been implemented in all areas, from marketing to the offer and the product to service.

Discussions About Missing Crates are Passe

Discussions About Missing Crates are Passe Thanks to Blockchain Technology, Van Geler Groente & Fruit

Courtesy of RTI Blockchain

WHY: "The Challenge"

No more hassle with return receipts for reusable assets at Van Gelder Groente & Fruit in Ridderkerk, the Netherlands thanks to complete and digitized packaging management. With RTI Blockchain, Van Gelder and its food service customers can see all packaging movements and balances in real-time. As the only manual process, the driver must scan the crates - with the mobile scanning application - when loading and unloading the reusable assets. This scanning application can be used as an add-on on the RTI Blockchain platform.

We used to work for the delivery of fruit and vegetables in blue EPS crates by our food service customers with return notes for the packaging," says Demis van Kouwen of Van Gelder Groente & Fruit. "A note with the number of barrels delivered or collected ended up in our tray, and the customer also had his copy. The administrative staff manually entered the data into our system, sometimes on the same day but often the following day.

This is prone to error because both the driver's warehouse manager and the customer's detriment can be both to the advantage and disadvantage of the customer," explains Demis van Kouwen.Loss of time, assets, and money with the outdated return note system. "Often, the customer has no clear insight into the balance. After months, the moment comes to make the statement. If we indicate, for example, that our balance is minus 20, the customer tells us that he has no more crates at all. The error-prone system led to discussions, which meant the loss of time, assets, and money."

WHAT: "Successful Solution"

The driver now always has the right crates with him. Fortunately, that is all over now. The customer and we know exactly who has what in the cask. No more unnecessary back-and-forth reuse. Practically speaking, it goes as follows: every crate of our swimming pool is provided with a unique barcode that the driver is scarce when loading into the van. If he scans a crate intended for a different route, the system will indicate this immediately. In cases where a crate is not scanned enough for a specific route, the driver's display displays that information. In other words, the driver cannot take alternative crates on his route, nor can he take too few.

Once at the customer, the crates are scanned. RTI Blockchain, the portal that the supplier and customer share immediately show Van Gelder and the recipient that the shipment has been delivered. The customer's return shipment is also scanned and taken back to the store. "And understanding that movement is the biggest benefit for us," says Demis. Back in the warehouse, the driver puts the crates on the washing line while they are ready for the next load from another customer. "The turnover rate of crates is high: a crate delivered today by a restaurant normally returns empty tomorrow."

Barcodes for the Crates, RFID Tags for the Pallets

"We also have a track-and-trace system in the car. The customer receives a message that they are on their way as soon as the car leaves. In the future, we will also upload photos of the crates to be delivered to the portal. For the crates, we plan to use barcodes, but for pallet loads, we are already thinking about RFID tags. We already tested this a few years ago. Still, the reliability at that time was 90%. As soon as 100% reliability is achieved, RTI Blockchain will also be the RFID system in our implementation for pallets."

RESULT: "The Benefit"

From 3 people for processing to one real-time dashboard. In addition to the real-time insight into all barrel movements and balances and the savings in time and costs in case of crate loss, is that Van Gelder does not need 3 people to manage their reusable shipping assets through the supply chain. This has additionally resulted in an improved customer experience throughout the supply chain.

5. How to Use Data to Develop and Deliver Insights and Value

When implementing technology-enabled reusable assets in your business, a crucial part in business case development is how a company expects to turn information into connected and meaningful insights that will deliver value to your business in the near and long term.

5.1 Why Data and Insights are Critical to Your Supply Chain and Business

Companies face complex challenges across their supply chains and are saturated with a large amount of data from their operations. The focus on creating meaningful insights often needs to catch up to the investments and resources in functional teams gathering and managing large amounts of data. It is essential to highlight that the creation of insights should be prioritized by business leadership.

"Companies face complex challenges across their supply chains and are saturated with a large amount of data from their operations."

When using technology-enabled assets, the benefits of understanding the insights from the data include:

- Actively managing a company's logistics and supply chain partner networks
- Locating and understanding inventory levels of your goods and shipping assets
- Achieving targeted operational efficiency levels across a company's supply chain
- Optimizing working capital and OPEX in material handling systems and assets
- Deploying labor more efficiently across the handling and movement of goods

By understanding these and other insights, companies can improve operational efficiencies and decision-making across their business operations, resulting in improved financial performance.

5.2 How to Organize the Insights Process

While technology-based investments across the supply chain continue to increase, industry executives continue to share feedback on the challenges of delivering the full expected results.

"Only 17% of executives say their company's investments in supply chain technology have fully delivered the expected results."
Source: PWC Digital Supply Chain Survey

Based on the volume of learnings and global experiences across RPA Technology Working Group membercompanies, there are a few key learnings to help address challenges when defining a strategy and implementation plan of a technology-enabled supply chain using reusable assets.

These learnings include:

- Align by Use-Case

When implementing a technology-enabled reusable asset project, focusing the team on the targeted problem and ensuring the functional ownership aligns with the expected insights is crucial. Projects that have not been successful often struggle to align functional silos of data and information across a company.

- Prioritize Primary Business Case

Define the expected outcome and how the business will measure the financial and functional results. Define the economic benefits expected from the primary use case and ensure the business case meets the financial expectations.

Build additional use cases based on customer needs after the primary use case financials are complete. Ensure the primary use case includes typical and exception-based company operations.

- Build Supply Chain Insights

To maximize the financial and operational impact of technology-enabled reusable assets, it is essential to consider insights and benefits from the owner of the reusable asset perspective and the user(s) of the asset throughout movements across the supply chain.

Often, companies build their targeted insights to measure and optimize from an internal perspective rather than from the perspective of their supply chain partners and customers.

- Develop Business Insights, NOT Software Tool-focused Insights

Ensure that the traditional disconnect of business information systems data is addressed. Provide a business-wide insights solution for the C-suite, incorporating the various data sources (ERP, etc.) across a company and its supply chain partners, starting with the primary use case. Be clear the insights are sticky and used deep into the organization for business operations.

5.3 Data and Insights Solutions

When looking at potential data and insights-based solutions for their technology-enabled reusable asset fleet, companies should consider the following areas in their strategy.

Types of Data

What type of data will be transmitted, and at what frequency? This decision will impact the shared volume data and powered devices' battery life, impacting the expected lifetime between charging.

- Sensor Event Data. Triggered at a specific event and may include when the device is read, based upon a geographic location, when a physical event occurs (i.e., shock level, temperature, etc.), and other examples.
- Streamed Data. Data is sent at a defined frequency and may include the data amount and a specified time period between transmissions..

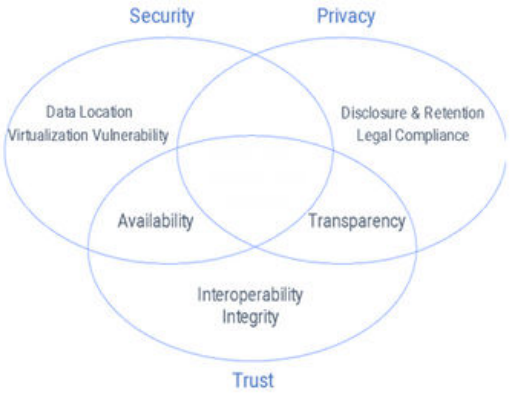
Connected Intelligent Asset Events:

What is an event, and when will a connected, intelligent asset trigger it? Are you measuring the typical operations of the asset or focused on the data during an anomaly or exception-based event? This decision also can have a significant impact on the volume of data being shared.

- Normative - Data and insights of the normal operating business
- Exceptional - Exception-based data and insights when exception-based events occur

Security | Privacy | Trust:

What security protocols are or will be followed in the company's supply chain and with partner companies? Companies need to establish a comprehensive enterprise-wide security strategy. Since IoT networks are often more extensive and complicated, merging IT and IoT security protocols can be difficult. These consist of resources, exclusive protocols, and procedures that the teams and tools used for IT security today are unfamiliar with.



It can be challenging to provide security control of individual IoT devices. In many cases, when numerous IoT devices connect to a network, it can create challenges in controlling the security of each IoT device.

When a company and its technology provider build an enabled system using numerous IoT devices, selecting IoT products and adjacent/connected products that provide the necessary security features when operating as a total system is critical.

"If users select an inappropriate product, it could be subject to cyber-attacks, preventing the system from operating as expected or enabling the system to be used as a springboard for cyber-attacks against third parties."
Source: JP Cert Security Checklist

While a company might have its own security checklists, this resource from JPCERT/CC provides a good IoT security checklist for developers and users of an IoT deployment across a pool of reusable assets. The checklist includes 39 essential security functions that allow IoT devices to be operated safely as a system.

IoT Security Checklist by JPCert/CC.
Click on the image to access the IoT Security Checklist

Security, privacy, and trust are important considerations when looking at technology-enabled solutions. There are numerous articles on this topic, including the following resources:

- JP Cert
- Science Direct
- Trend Micro

Insights and Decision-making Process and Speed:
When looking into data and insights-based learning models, you should understand and evaluate different models when acting on large amounts of data. Two primary models include the Sense-Infer-Act-Learn model and the Observe-Orient-Decide-Act model.

These models are commonly used in AI/machine learning-based applications. Learn more about these insights and decision-making processes at these links.

- Sense-Infer-Act-Learn (SIAL)

Source: SIAL (O'Reilly)

- Observe-Orient-Decide-Act (OODA Loop)

Source: OODA Loop (Wikipedia)

5.4 Emerging Technologies

- **Operational Digital Twins**

A digital model of your entire supply chain can be created using digital twin-based technologies. Once modeled, digital twin tools can allow a company to model and adapt its supply chain and identify potential weaknesses and gaps within its partner networks.

Combined with tech-enabled reusable assets, this technology enables companies to validate assumptions quickly, improve efficiencies, and reduce costs.

Learn more about the use and application of digital twins in the supply chain at these resources:

- Source: Digital Twin Consortium
- Source: McKinsey Digital Twins
- Source: EY Digital twins

- **Machine Learning**

With growing complexities across supply chains, using machine-learned-based models, companies can use the vast amount of data and insights from their supply chain and technology-enabled reusable assets to develop predictive models to identify gaps and hidden patterns across their business.

"Organizations can use intelligent technologies to make smarter planning decisions, enabling them to reduce costs, remove reliance on "tribal knowledge," gain deeper and broader insights into their supply chains, and dramatically improve decision-making processes."
Source: Deloitte AI Supply Chain Planning

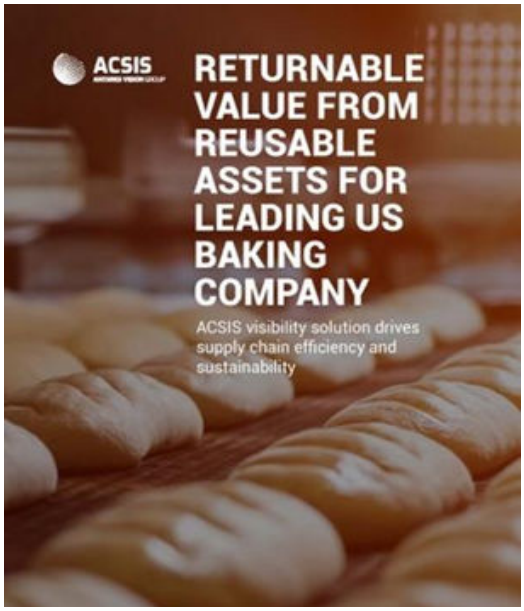
These types of tools are an emerging technology space and include examples such areas as providing:

- Improving Inventory Accuracy
- The Efficiency of Warehouse Operations
- Increased Worker Safety
- Improved On Time Delivery (OTD metrics)
- Automated Material Handling Systems

Learn more about the use and application of machine-learning-based tools at these references:

- Source: USI Machine Learning
- Source: The Master Algorithm

Returnable Value From Reusable Assets for Leading US Baking Company



Courtesy of ACSIS Antares Vision Group

WHY: the "Challenge"

A large US baking company struggled to track – and ultimately hold onto its returnable transport assets. The company transports its freshly baked goods in reusable plastic trays and dollies, supplying distribution centers and bakeries across thousands of routes. Apart from the obvious impact on the company's bottom line, the client risked falling short of its sustainability targets.

The company's real issue was a need for more visibility, with untagged trays and dollies moving blindly through the supply chain. With more than 4 million trays in use at any one time, the company was threatened with losses of more than $5 million annually.

WHAT: "Insights-based" Solution

ACSIS's insights-based solution follows assets from A to B and helps the baking company uncover hot spots where trays and dollies are most risky.

The system analyzes asset performance and lifespan, recording detailed, granular data on KPIs such as dwell time, mis-shipment, and loss - driving continuous optimization. The baking company can configure the solution to deliver automatic alerts when the conditions they have set are or are not – met.

The first step was uniquely identifying every tray and dolly, attaching RFID tags and barcodes linked to the ACSIS Cloud Platform. As stacks of trays are loaded onto trucks, they are automatically scanned by RFID portals. When they arrive in the store, they're picked up again as scanned by the retailer. This real-time tracking continues across the return journey. If a tray hasn't made its way back within the defined time (in this case, ten days), the system automatically flags it up as lost. And thanks to RFID signals and passive scanning, the ACSIS Cloud Platform knows exactly where a tray went missing.

Assets are now tracked throughout their entire lifespan, as they're re-used as was intended – over and over again. Each tray is assigned a status such as "available," "returned," or "inspected," so the baking company knows precisely how many assets are at its disposal. Tapping into automated distribution applications, the ACSIS solution confirms when assets arrive safely at the customer location or back at the company facility.

With the help of analytics, items are tracked at an incredibly granular level or analyzed en masse on transparent dashboards. Measuring performance continuously across its entire fleet of assets yielded valuable findings. One of the baking facilities was losing trays and dollies at a rate of 20%. With hard and fast data, there was no disputing the facts, giving the client the leverage to address the issue with the facility's management.

RESULT: The "Benefit"

With a system of record in place that covers all the bases, the client is reaping the benefits of its newfound visibility. Costs were down by 33% in the first year, generating savings of several million dollars. More savings are expected in the years ahead as the company continues to optimize its asset management – and re-use its trays and dollies to their full potential. Alongside saving costs, sustainability is on the docket, with a solution that closes the loop on returnable transport items, with a projected savings of more than $10 million over a five-year period.

6. How to Get Started

6.1 The Big Picture

The first step in getting started is understanding the business problem that needs to be solved clearly. As you consider finding a technology-based solution to fit your reusable packaging needs, understand the value of the information you need to accomplish your objectives. As companies consider adding technology-enabled assets, they should focus on the value delivered as a function of the cost of the technology relative to the quality and quantity of data, as discussed in an earlier section and shown below.

"The first step in getting started is understanding the business problem that needs to be solved clearly."

Inventory	Scan Accuracy: Human Errors Scale: Difficult	>98% based on the environment Scale: Easier	>98% based on the environment Scale: Easier	based on the environment Scale: Unlimited	based on the environment Scale: Unlimited	Accuracy: >98% based on the environment Scale: Unlimited
Room/Zone Visibility within a Facility	Manual scans in each area	Requires RFID readers in each area. Hard-wired install.	Requires BLE readers in each area. Hard-wired install.	Requires UWB anchors in each area. Hard-wired install.	Requires LPM readers in each area. Battery powered.	No indoor positioning unless Cellular access points with GNSS are added.
Possible to Install a Gateway	n/a	n/a	** Cost: $ BLE < Cellular Limited # BLE devices Long Battery Life	*** Cost: $$ Unlimited # UWB devices Long Battery Life	*** Cost: $ BLE * LPM Unlimited # LPM devices Longer Battery Life	- Cost: $$$
NOT Possible to Install a Gateway	n/a	n/a	* Used in conjunction with Cellular/GPS	** Visibility anywhere. Combine w any other location technology.	** Used in conjunction with Cellular/GPS	** Visibility anywhere. Combine w/ BLE, LPM
Condition Monitoring	n/a	n/a	** BLE tags can incorporate temp, shock sensors Report@ regular intervals	** UWB infra can collect data from any sensor Report real-time	** LPM tags can incorporate temp, shock sensors and Report at regular intervals	** Trackers can incorporate temp, and shock sensors and report conditions at regular intervals
Goods (Supply Chain) End User	n/a	n/a	* Manual association required at mfg.	** UWB tags support real-time data collection.	** LPM tags support bi-directional data. Possible to	** Trackers support bi-directional data. Possible to

Refer to the full table in section 4.1

Focus on making the Primary Use Case work and not try to "boil the ocean." Based upon industry experiences, it is best to build your business case and define and execute a plan to move from Pilot to Production to Permanent. Primary use cases should focus on delivering financial, operational, and sustainable benefits to a business.

Several technologies used in reusable asset tracking have matured from 'proof of concept' to projects that should focus on the 'proof of value' for the specifically targeted use cases.

6.2 Business Case

In a recent 2023 industry survey, nearly half of supply chain leadership professionals identify budget constraints as their top challenge when implementing a technology-enabling project.

"An unclear or poorly articulated business case is often the bigger problem than a lack of budget."
Source: PWC Digtial Supply Chain Survey

The goal of a business case for implementing any labeling, monitoring, or tracking technology is to determine the potential return on investment through cost reduction, process improvements, operational efficiency gains, inventory turn, and production impacts. While only some of these are knowable before implementation, a company needs enough solid data to exceed the minimum return threshold of the organization. Once met, the investment is justified if there is a reasonable indication that any additional benefits will outweigh any unforeseen costs or negative impacts.

As shared earlier, focus on the Primary Use Case and the business case's expected financial and operational performance. Often, project teams will need more clarity on the business case with multiple use cases with softer financial performance targets.

Ultimately, the heart of any business case is quantifying the potential investment required and the estimated return on that investment in terms of cost savings and/or efficiencies gained.

1. Pre-Business Case Development

Companies evaluating tracking technologies for their reusable packaging are often overwhelmed by various solutions and uncertain about calculating these solutions' ROI. To help solve this problem, member companies of the Reusable Packaging Association (RPA) have developed a Technology Value Assessment Calculator to quantify the economic value and potential return on investment of applying innovative tracking technologies to reusable packaging assets.

This tool can provide a company with a starting point to assess reusable packaging with tracking technology. When looking at various potential technology-based solutions, it can estimate annual ROI (return on investment) levels.

The Calculator is located in the RPA's Technology Hub:

What does the calculator do?

This simple interactive tool allows a user to enter such variables as the number and cost of reusable assets, the total cost of the technology-based solution, the number of shipments, cycle time, loss rates of the reusable assets, and the type of product transported. This tool allows annual savings to be reflected in real-time so a user can better understand the key variables that may impact potential savings, including the option when a returnable asset is carrying perishable food items.

What are the critical input and output variables?

The following inputs are used in the tool to generate investment and savings estimates. A detailed explanation of each variable is located here.

Source: RPA Technology Hub

Inputs	Outputs
REUSABLE AND TECHNOLOGY INVESTMENTS • Reusable Transport Packaging (RTP) Product Type • Number of RTP Units in Inventory • Percent of RTP Units Equipped with Technology Device • Total Cost of Deployment of Tracking Technologies: All Devices, Equipment, and Software • RTP Purchase Cost per Unit	CAPITAL INVESTMENTS ▪ Technology Capital Investment ▪ CAPEX per Unit Inventory
SUPPLY CHAIN CHARACTERISTICS ▪ Number of Shipments Using RTPs Over 1-Year Period ▪ Percent of RTP Units Lost Per Year (annual pool shrink) ▪ Number of Days RTP Takes to Complete Use Cycle (average days out before return) ▪ Shortest Number of Days Possible to Complete Use Cycle (minimum days out before return)	SUPPLY CHAIN SAVINGS • Lost Reduction Savings • Asset Utilization Savings
WORKFORCE REQUIRED ▪ Number of Workers Involved in Procuring and Managing RTP Assets ▪ Percent of Time Spent Managing RTP Inventories	WORKFORCE SAVINGS ▪ Labor Efficiency Gains
END OF LIFE - REUSABLE ASSET ▪ Weight of Each RTP Product in US Pounds	FOOD WASTE IMPROVEMENT SAVINGS ▪ Retail value of Food Waste Improvement
	END OF LIFE - REUSABLE ASSET ▪ End-of-Life Material Recovery Value

Total Annual ROI Savings from Technology-Enables RTPs

How does the calculator help reusable packaging users?

With the optimization of technology tracking reusable packaging, and many proven solutions in the market, this Technology Assessment Calculator will help businesses find the solution that fits their goals and ambitions. Users will get a realistic view of investments and cost savings in this easy-to-use tool that allows them to assess different scenarios and remove any hesitancy due to past issues and assumptions.

As with all relevant parameters adjustable to individual use cases, the outcome is undeniably helpful for ROI calculations and making well-informed decisions early in the evaluation process.

Learn more: RPA Value Assessment Calculator

2. Business Case Development Process

While each company follows its own business case development process, some best practices can be tracked based on RPA member companies. They include:

Identify and Define Objective

- What is the 'primary use' case?
- What are other potential use cases?

Quantify Problem and Benefit

- -Are you considering the reusable asset owner, supply chain partners, and customers?

Determine Supply Chain Characteristics

- Do you understand the supply chain and critical partners interacting with the reusable asset and their individual requirements

Decide Short/Long Term Technology Solution(s)

- Is it a temporary or permanent solution?
- What is the expected life of the returnable asset?
- How will that impact your investment and financial returns?

Estimate Number of Enabled Assets

- What percentage of assets will you enable with technology-based solutions?

Select Technology Type(s)

- What is the right technology solution or combination (multimodal) to meet the primary use case deliverable?

Derive Costs and Investments

- Does the proposed use case, required resources, and investment meet your financial, operational, and sustainable objectives

Quantify Financial, Operational, and Sustainability Impact

- How does the technology-enabled asset impact your company's financial, operational, and sustainability objectives?

Here are some suggested considerations based on RPA member company experiences in each area as you build your business case.

1. Identify and Define Objective(s)

The first step to building a business case is to define the problem or intended benefit for each potential application of technology.

Focus on getting the "right" primary use case to be considered. Then present basic assumptions of how you think implementing a technology would affect each of your objectives. Based on these assumptions, determine the estimated financial impact.

Example objectives for creating a more intelligent supply chain:

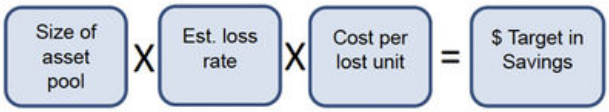
- Reduce/eliminate packaging or product loss
- Reduce/eliminate packaging or product damage
- Speed up packaging inventory turn or cycle time
- Identify specific supply chain process inefficiencies
- Create or evaluate standardized handling processes
- Monitor packaging or product flow through the supply chain
- Correct packaging asset inventory imbalances among plants

2. Quantify the Problem and Benefit

Once an objective is selected, you must first quantify the problem. Suppose the chosen goal is to "Reduce reusable packaging asset loss." In that case, you must first identify the reusable packaging asset types and quantities to be tracked—how big is each pool?

How much is this issue costing you? For example, if reducing asset loss is your objective, consider that you own 10,000 reusable packaging assets and you think you are losing 10% of your pool each year, and they each cost $300; this loss adds up to 1,000 assets X $300 = $300,000 per year.

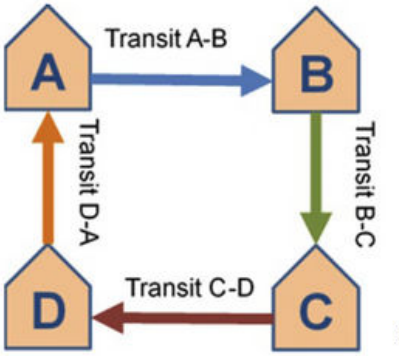
Asset Loss Calculator example:



3. Determine Supply Chain Characteristics

Considering the movements of your reusable packaging assets and the factors that may affect asset losses, it is helpful to think of a logistics loop, which consists of a series of facility locations and transportation legs.

This example has 4 locations and 4 legs in the loop, assuming Location A is the start and end location for one complete cycle.



Source: ReturnCenter

Your choice of technology will depend on several characteristics of your supply chain:

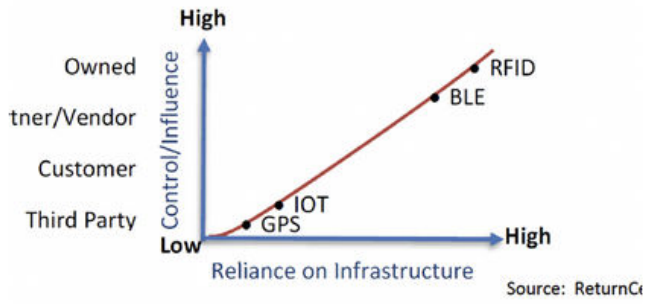
- Number of facilities/stops in the reusable asset's use cycle
- Amount of influence or control you have over facilities
- Time spent in each facility (dwell time) and the total time of a use cycle (turn rate)
- Degree of reliance you intend to have on technology infrastructure in transit and in facilities

The amount of influence and control over facilities is essential regarding the feasibility of installing monitoring technology infrastructure in those facilities.

Here is a basic range:

- Facilities You Own: Complete control and freedom to invest/install monitoring equipment
- Partner/Vendor Facilities: You can leverage your relationship to influence their willingness to install monitoring equipment
- Customer Facilities: Some influence but limited control or leverage
- Third Parties: No control, no leverage, or influence

Guiding Principle: The more control you have over facilities, the more feasible it becomes to use technology with a higher reliance on monitoring technology infrastructure (i.e., RFID). The less control you have over your loop locations, the more you should consider technologies that need little or no infrastructure (i.e., IoT/cellular). See Control vs. Reliance Figure below:



4. Decide Short/Long Term Technology Solution(s)

Temporary Technology: You have a short-term project if you can track a few assets for six months and figure out the problem enough to develop a solution.

Look at detachable technology to temporarily install on a small portion of your pool or leased tech-enabled reusable assets that will give you the data you need while you need it.

Permanent Solution: If your objective is tied to a systemic issue in your industry or the nature of your business that requires an ongoing effort, consider a more permanent solution. Look at either upgrading your pool or investing in technology that you can add to your existing pool, either using low infrastructure-intensive tech like IOT or a higher level of infrastructure that combines RFID, BLE, or Wi-Fi technologies.

5. Estimate Number of Enabled Assets

How many tracking devices would it take to solve this problem sufficiently? Do you need a device on every asset, or could you put a device on half or even 1/3 to identify the "leaks" in your logistics loop?

"*A good rule of thumb is that you should track at least twice the amount you think you are losing, so if you estimate your lost rate to be 10%, allow for monitoring at least 20% of your pool.*"
Source: RPA member companies

But there are other factors, including the value of each reusable asset compared to the cost of tracking each one and the total value of estimated lost assets with the total value of a tracking solution. Beyond cost elements, consider the number of stops in the logistics loop and the dwell time at each stop.

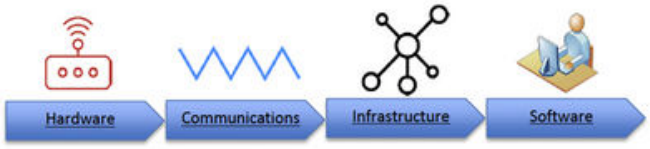
Guiding Principle: The more stops in the loop, the greater chances for leaks and, therefore, the higher percentage of assets that require technology enablement.

Similarly, the slower the turn rate (longer dwell time at each stop and longer total cycle time), the more important a higher enablement rate becomes.

If you have many stops in your use cycle (10+) or a very slow turn rate (for instance, a use cycle of 6 months+), you may want to consider enabling closer to 100% of your reusable assets.

6. Select Technology Type

Supply chain technologies have multiple parts: hardware, communications, infrastructure, and software. Most technology providers present a bundled solution with those components, and your challenge is to find the best combination of all of them to suit your needs.



Think of the hardware as the device attached to or embedded in the reusable asset - like a tag type, sensor, or unit that collects and reports multiple data types.

The communications aspect of the technology refers to how the data captured by the device is transmitted to you for visibility. Communications might consist of a Bluetooth connection to a reader on a forklift, a self-healing Low Power Mesh, a Wi-Fi gateway, or a cellular SIM card transmitting IoT data through the LTE network.

The infrastructure consists of readers you may need to install for RFID or BLE, or it may refer to cell towers for LPWA or even satellites needed for IoT communications.

In looking at costs, the usual trade-off is a low unit cost for hardware like an RFID tag that requires a high infrastructure cost for installing readers and connectivity anywhere you want to track an asset. At the other end of the spectrum are hardware options that are more expensive per unit, like IoT, but with virtually no infrastructure costs because the provider of the hardware has already invested in the satellite technology or cellular network, or other infrastructure needed, and those costs are embedded in the per unit costs, often bundled into a monthly fee or subscription model.

For software, you will typically be interested in the software that provides you visibility to the data you need. While there are levels of software at each step in the communications path, the type of software most accessible for your evaluation is what you will use daily to make your data actionable. You will be interfacing with the proverbial tip of the iceberg, which is not to say you should take for granted that all the other layers that make up the iceberg itself are optimal (such as the strength or reliability of the LTE network by a particular cellular provider).

Here is a high-level idea of considering various technology choices based on the type of data you need. Keep in mind that “higher,” as shown below, does not necessarily mean very expensive; it only means that this technology is more reliant on an infrastructure that must be installed and maintained:

Type of Data	Infrastructure Cost	Technology Choices
Asset ID	Lower	IoT+LPWA/Cellular
	Higher	Barcode, RFID
Environmental (temperature, pressure, light, vibration, shock)	Lower	IoT+LPWA/Cellular
	Higher	BLE+WIFI
Content Status (full/empty/weight)	Lower	IoT+LPWA/Cellular
	Higher	BLE+WIFI
Geo Location	Lower	IoT/LPWA/Cellular or GPS
	Higher	Barcode, RFID

7. Derive the Costs/Investment Needed

Estimating the ultimate cost or investment needed to complete your business case will require consideration of all previous points noted above. In addition, the administrative expense of your team's time to research the business case itself, quantify the problem, analyze the nature of your supply chain, consider the asset types and quantities to monitor or track, and define the types of data you need in order to price the relevant technologies.

8.Quantify the Financial, Operational, and Sustainability Impact

It is essential to quantify not only the expected financial impact for the company on the proposed solution(s) but also develop and quantify the operational, regulatory, and sustainability impact on the company and your supply chain partners.

These areas should include:

Other Operational Costs

- Impact on labor retention and staffing costs
- Reduction of assets collection costs
- Optimizing 3rd party storage costs

Regulatory

- Reduced costs in meeting current and future food safety regulations
- Elimination of reporting costs internally and with partners
- Future-proofing your business regulatory reporting

Sustainability

- Reduction of secondary and tertiary packaging waste
- Eliminating extra logistic-based CO2 emissions through empty miles reductions and minimized handling
- Reduction of food waste

Additional Resources

RPA Technology member companies can help guide you toward suitable and unsuitable technologies if you communicate your needs based on the outlined process. Once you have settled on the supply chain technology you need, you can initiate an effective vendor selection process.

If your company is still trying to figure out where to start, the Reusable Packaging Association (RPA) is a resource to network with industry experts and identify technology solution providers.

RPA is a non-profit trade organization consisting of member companies that design, manufacture, use, and provide services to reusable packaging products and systems for their reuse. You can find a list of RPA member companies in the member directory at the Reusables Marketplace.

6.3 Industry Learnings

Based upon the experiences of the RPA's member companies, several industry learnings should be considered when starting a technology-enabled reusable asset project.

While each of the earlier sections of this whitepaper covers what the focus should be, this section highlights areas where technology-based implementations have yet to result in maximizing financial and overall objectives for the company.

What has not worked in the past?

Below are areas that should be considered:

1. Change Management

When implementing a significant technology investment across your supply chain, a company must also consider the change management required at leadership level of all functional areas. With several industry reports showing that:

"... just ~25% of change management initiatives are successful over the long term, change management can be a test for any organization."

Source: Towers Watson

These types of projects should not be considered functional-driven projects but rather transformational company projects that will improve the overall performance of the company, its supply chain partners, and, ultimately, its customers.

While there are various change management models, they typically include similar key elements when transitioning from a current to an improved future state.

Leading Change

- Creating a Shared Organization Need

What are we solving?

- Defining a Vision

Why do we need to solve this problem?

- Mobilizing Commitment

What will it take to solve this? Resources and Financials

Changing Systems and Structures

- Making Change Last.

Is it repeatable on day one or day 365?

- Monitoring Progress.

Is the project meeting the goals?

Source: GE Change Acceleration Process (CAP)

2. Education and Upskilling

While most companies expect training and upskilling employees will be required, less than 10% said it was a top priority.

"Without adequately training their employees, companies risk a significant investment in time, resources, and costs when implementing a technology-enabled investment in their supply chain."

Source: PWC Digital Supply Chain Survey

An example shared by an RPA member company of technology implementation:

After a technology investment using RFID sensors and RFID readers in a warehouse environment, forklift operators exceeded the speed defined by their warehouse safety policy, resulting in missed scans of reusable assets moving through the RFID sensors at each dock door. The resulting issue was causing errors in inventory levels and missed reporting to retail and CPG companies.

Once educated on the importance of this process, the forklift operators and warehouse operations leadership understood the need for speed and inventory accuracy. This education continues regularly as employee turnover occurs.

Courtesy of: Real Time Intelligence

3. Employee Turnover

With annual warehouse turnover rates of more than 40%, it is critical that companies continuously educate and upskill their employees. Losing that percentage of a 100-associate warehouse team costs more than $350,000 annually, not including the operational efficiency losses.

While technology-based investments in your supply chain can reduce the dependency on employee turnover, companies must continue to invest in both the team members developing and implementing the technology-based solution and the employee associates using the technologies.

Source: US Bureau of Statistics

4. Cultural Considerations

The final area for company leaders to consider is the cultural considerations within a company, which may include the differences between facilities or functional teams.

While it is common to protect your "functional" turf, internal disputes will undercut the potential profitability of the entire company. When going through the change management process, ensure the leadership and employees of the company are aware of the Shared Organization Needs and Vision and are not operating in a siloed mentality.

RPC Supplier Enhances Asset Visibility and Fights Baking Tray Theft

Courtesy of Real Time Intelligence

WHY: "The Challenge"

A world-leading supplier of Reusable Packaging Containers (RPC), with the intention to create a more sustainable supply chain in the fresh foods industry, developed a business model based on the concept of a circular economy. They rent out RPCs and manage the entire process from delivery to collection, saving customers money, space, and time.

Many companies struggle to manage returnable containers. The main sources of RPC loss in the food industry are product damage, contamination, theft, and mismanagement. In fact, 30% of reusable plastic trays are estimated to be lost or stolen annually. Furthermore, the return rate of RPCs varies depending on the industry, with some companies reporting return rates as low as 60%. Companies can tell that their number of trays is declining but can't determine the exact cause.

WHAT: "Successful Solution"

The use of RFID technology with specified choke points throughout the supply chain can help track the movement and location of RPCs, reducing loss and improving supply chain efficiency. This has proven to be an effective technology as many industries and government organizations are issuing mandates for the use of RFID in item-level traceability.

This returnable packaging supplier partnered with RTI to enhance their asset visibility. The device-agnostic capabilities of RTI's solution allowed them to adjust to the new tracking system quickly. They selected RTI as their technology solution to provide RFID-enabled passive scanning to key locations throughout their supply chain.

By scanning RPCs at these locations, they know how long each asset is:

- Dirty at inventory locations
- Clean at inventory locations
- In the possession of the grower
- Utilized by retail
- Waiting to be returned

RESULT: "The Benefit"

The partnership with RTI enhanced asset visibility and helped the returnable packaging supplier locate stolen RPCs, reduce inefficiencies, and save time. The company can take proactive steps to track crates, locate them as soon as they go missing, and ultimately replace fewer crates. They can easily track cycle time by tracking the assets as they flow through their facility or production line. Their improved turns and loss reduction resulted in a $22M cost reduction.

Additionally, with the insights provided by their data, they were able to:

- Calculate the Complete Cycle Duration
- Minimize Wasted Cycle Days
- Target Pickups to Decrease Dwell at the RLCs
- Estimate Asset Cycle Time
- Calculate How Long an RPC is Out as well as the Average Time Out by Grower/Retailer Pairing
- Determine Which Growers Hold Assets Longer than Average and Strategically Target Improvement Opportunities
- Improved Adherence to Food Safety Considerations
- Aid in FSMA 204 Compliance
- Enhanced Visibility to Usable Inventory and Associate Wash/Sanitization Data

7. Appendix

7.1 Definitions for Reusable Transport Packaging

Various terminologies are used across the reusable transport packaging industry for reusable assets' usage, handling, and technologies. This list provides some of the most common terminology used globally.

Industry Terminology

- Asset: A reusable packaging product such as a pallet, bin, or container owned or rented for transporting goods and maintaining its intended purpose and value over time.
- Asset Management: The systematic processes in which a reusable packaging asset is known and accounted for during its uses over a lifetime through operational functions, including storage, packing, shipment, handling, recovery, maintenance, and disposal.
- Cycle (also known as a Loop): The movement of a reusable packaging asset from a starting point of distribution through all intended user functions and locations and returning to an ending point of distribution where the asset is conditioned for reuse. In many cases, with a cycle, the starting and ending points are the same location.
- Logistics: The detailed coordination of managing the movement and exchange of possession of a reusable packaging asset through a cycle involving the effective transfer through several different touch points and handling environments through the supply chain.
- Logistics - Forward: The coordination of moving an asset from starting point in the cycle to the completion of its intended packaging use. Forward logistics often include moving packed or filled assets to warehouse and point-of-sale or use environments.
- Logistics - Reverse: The coordination of moving an asset from the completion of its intended packaging use in the cycle to the location for its conditioning and repositioning for reuse. Reverse logistics activities often include the movement of empty assets through consolidation, sortation, and return processes.
- Loop - Closed: A well-defined and closely managed cycle characterized by minimum shipping and delivery points where the receiving party always maintains ownership or accountability of the asset. Closed loops often involve streamlined operations and the transfer of assets between two points or locations, such as from A to B and back to A movements.

- Loop - Open: A complex cycle characterized by multiple shipping and delivery points where at least one receiving party has no ownership or full liability of the asset. Open loops often involve rented or pooled assets owned by a third party who do not perform the packing or use activities. The transfer of assets will likely occur between A to B to C and back to A movements, and third-party consolidation, sortation, and maintenance services may be applied.
- Pool (Fleet): The aggregation of reusable packaging assets with the same intended purpose or use and containing common design and specifications characteristics.
- Provenance: The chronology of the origin, development, ownership, location, and changes to a system or system component and associated data.It may also include personnel and processes that interact with or modify the system, component, or associated data.
- Reuse (Reusable): The act of extending the utility and value of an asset following a user, often a repeat of the cycle for its intended purpose. Packaging is deemed reusable when both the design and the manufacture achieve durability for multiple uses. A defined and managed system is in place to recover the empty asset for reuse.
- Traceability: Tracking the unique identification of systems and system components during development and transport activities provides a foundational identity structure for establishing and maintaining provenance. For example, system components may be labeled using serial numbers or tagged using radio-frequency identification tags. Labels and tags can provide better visibility into the provenance of a system or system component. A system or system component may have more than one unique identifier. Identification methods are sufficient to support a forensic investigation after a supply chain compromise or event.
- Transport Packaging (Secondary or Tertiary Packaging): Packaging for the movement of raw materials, commodities, or finished goods from production or processing to the point of use in a manufacturing or commercial setting involving a business-to-business item transfer or a business-to-consumer item delivery. Most transport packaging is categorized as tertiary packaging in the distribution of bulk items. Still, it may also be considered secondary or, to a lesser extent, primary packaging, depending on other product packaging used
- Trip: Issuing a reusable packaging asset to complete a single cycle.
- Turn: Completing a trip where the asset is ready for reuse. The term is used most often to calculate the number of trips that can be completed over a specified period of time, known as a "Turn Rate." Also referred to as the number of times an asset is used and reused over a specified number of days.

Product Terminology

- Bin: A large packaging unit designed to distribute bulk or heavy products, often ranging in size matching full or half pallet dimensions with varying heights. This general definition pertains to a transport packaging asset and does not relate to smaller "shelf bins" used for storage on racks.
- Box: A generic term used to define single-use packaging products that are typically handheld-sized units, includes six sides that enclose by a sealable or taped lid, and are made from corrugated fiberboard or other non-plastic material for one-time use (i.e., cardboard box).
- Container (Crate, Tote): A generic term used to define reusable packaging products that are typically handheld-sized units, may have open tops/no lids and are manufactured from plastic or other durable material for reuse (i.e., milk crate).
- Intermediate Bulk Container (IBC or pallecon): Reusable, multi-use industrial-grade containers, predominantly mounted on a pallet or designed for one-piece forklift use for the mass handling, transport, and storage of liquids, bulk solids, and powders.
- Pallet: A portable, horizontal, rigid, composite platform used as a base for assembling, storing, stacking, handling, and transporting goods as a unit load. (MH1-2016 standard).
- Rack: A vertical structure that consists of several layers in the form of shelving for holding multiple items for moving and transport, often designed with wheels for unit mobility.
- Reusable Plastic Container (RPC): A container specifically designed and used for packing and transporting perishable food items from farm or food processing facilities to retail or food service establishments and is reused for an extended period of time. They typically are collapsible for ease of movement through the reverse logistics of a supply chain.
- Roll-Out Cart: A large mobile bin for trash or residential solid waste collection and removal, ranging from 16 to 91 gallons in capacity.
- Shelf Bin: Packaging product that may hold items on shelves or racks as part of transport and display within the same facility.
- Tank: A large packaging unit, often made from steel, for holding and transporting liquids, solids, or powders in bulk that typically involves specialized fill and discharge technologies.
- Tote: Totes, also known as crates, are typically handheld-sized units, may have open tops/no lids, and are made from plastic or other durable material for reuse (i.e., straight wall, stackable/nestable totes). They are used in automation, manual handling, or storage applications.
- Tray: A handheld packaging unit for lightweight items or small unit quantities typically has a lower profile and an open top and side for access in a stacked arrangement (i.e., bread tray).

Technology Terminology

- 3GPP: The 3rd Generation Partnership Project is an umbrella term for several standards organizations that develop mobile telecommunications protocols. 3GPP is a consortium with seven national or regional telecommunication standards organizations as primary members and various other organizations as associate members.
- 3GPP LTE-M (Long Term Evolution for Machines)**:** LTE-M can greatly benefit massive IoT deployments. A Low Power Wide Area Network (LPWAN) supporting IoT through lower device complexity and extended coverage LTE-M allows up to 1.1 Mbps of data to flow and is optimized for cost, power usage, and network capacity for massive IoT systems. Note 3GPP release 14 was the first release of 5G standards in early 2016.
- 3GPP NB-IoT (Narrowband IoT): The Narrow Band Internet of Things (NB-IoT) standard was designed specifically for IoT devices with low data requirements. It limits data rates to approximately 160 kilobytes per second (kbps), providing a radio technology standard enabling cellular devices and services with low cost and long battery life.
- 3GPP 5G: 3GPP 5G was the second release of standards for the 5th generation mobile network. 3GPP 5G is the new global wireless standard after the current generation of 3GPP 3G and 3GPP 4G deployed cellular networks. 3GPP 5G enables a new kind of network to connect virtually everyone and everything together, including machines, objects, and devices. 5G wireless technology is meant to deliver higher multi-Gbps peak data speeds, ultra-low latency, more reliability, massive network capacity, increased availability, and a more uniform user experience to more users. 3GPP 5 provides higher performance and improved efficiency empowering new user experiences and connecting new industries.
- AIM: An international association and authority for AIDC (Automatic Identification and Data Capture) innovation and technologies (Automatic Identification and Mobility). The RAIN Alliance is an independent committee within AIM.
- Automated Identification Technology (AIT): The broad terminology given to various technologies that help machines identify objects.
- Anchor Point: An anchor point, often known as a gateway, Access Point (AP), hub, or reader (depending on the technology used), is a component of an indoor location implementation. These devices have a known location and are often static and placed throughout the deployment area.
- Backscatter: A technique for retrieving information from a tag in which the narrow band energy from the interrogator has reflected the interrogator in varying degrees as the impedance of the tag antenna is modulated.
- Barcode: An optical, machine-readable representation of data in numbers and a pattern of parallel lines of varying widths; when scanned, the pattern relays information about a product.
- Blockchain: Implementing a DLT using hashed identifiers for a chain of transaction blocks (see DLT).

- Bluetooth Low Energy (BLE): The Bluetooth Special Interest Group (BTSIG) and IEEE 802.15 interoperable standard for short-range wireless technology typically used to connect devices, such as smartphones, to a Bluetooth headset or speaker to connect sensors to a gateway or cellular communication device. Bluetooth operates in the unlicensed Industrial, Scientific, and Medical (ISM) band at 2.4 Gigahertz (GHz) to 2.485 GHz using a spread spectrum, frequency hopping, full-duplex signal at a nominal rate of 1,600 hops/sec. The 2.4 GHz ISM band is available and unlicensed in most countries. Its range varies from 1 Meter (m) to 100 m depending on which class of radio is used. Class 2 is the most used radio. It has a range of around 10 m in free air and uses 2.5 Milliwatts (mW) of power.
- Cellular Communication Device: A piece of hardware that contains a cellular radio to communicate with the cellular network to pass IoT data from an asset to the cloud. This device can be powered by a battery or a more permanent power source. Cellular leverages cellular radio access nodes that operate in licensed and unlicensed spectrum and have a range of 10 m to a few Kilometers (km).
- Cellular Location Tracking: Cellular-based location tracking provides the latitude and longitude of an asset's location. A device must have a cellular radio and use its location to the closest cellular towers. This technology tends to be less accurate than GPS but is more useful when assets are located inside a warehouse, a truck trailer, or a train car.
- Distributed Ledger Technology (DLT): A shared, digitized ledger, which can be either public or private, in which transactions between users belonging to the same network are stored in a secure, verifiable, and permanent way that cannot be changed once a transaction has been recorded and verified.
- Electronic Product Code (EPC): A numbering system to uniquely identify products. The Electronic Product Code is a Uniform Resource Number (URN) namespace registered to EPCglobal by the Internet Assigned Numbers Authority (IANA). Note EAN is the European Article Number.
- Far-Field Communication: When an RFID tag is outside of one full wavelength of the reader, it is said to be in the “far field.” If it is within one full wavelength away, it is said to be in the “near field.” The RAIN RFID system relies on far-field communications.
- Global Navigation Satellite System (GNSS): General term describing any satellite constellation that provides positioning, navigation, and timing (PNT) services on a global or regional basis. BeiDou, Galileo, GLONASS, GPS, IRNSS/NavIC, and QZSS are the governmentally controlled GNSS systems. Support for various systems provides regional diversity that is beneficial to worldwide operations.
- GPS Location Tracking: Satellite-based location tracking provides the latitude and longitude of an asset's location. A device must have a GPS radio and line-of-sight to one or several satellites in orbit around the Earth. GPS is operated and maintained by the U.S. Space Force. GPS.gov is maintained by the National Coordination Office for Space-Based Positioning, Navigation, and Timing.

- GS1: A global organization that develops standards to help information and items move efficiently and securely.
- GS1 EPC™ Generation-2 UHF RFID Protocol Specification: RFID Air Interface Protocol for Communications at 860 MHz – 960 MHz
- u: GS1 ID Keys give companies efficient ways to access information about items in their supply chains and share this information with trading partners.
- GS1 Global Trade Item Number (GTIN): Global Trade Item Number (GTIN) can be used by a company to identify all its trade items uniquely. GS1 defines trade items as products or services priced, ordered, or invoiced at any point in the supply chain.
- GS1 Global Returnable Asset Identifier (GRAI): The Global Returnable Asset Identifier is one of two GS1 Keys for asset identification. This GS1 Key is especially suitable for managing reusable transport items, transport equipment, and tools. It can identify these returnable assets by type and, if needed, individually for tracking and sorting purposes.
- GS1 Serial Shipping Container Code (SSCC): Serial Shipping Container Code can be used by companies to identify a logistic unit, which can be any combination of trade items packaged together for storage and/ or transport purposes; for example, a case pallet, or parcel.
- Heat Transfer Labels: A multicolor, pre-printed graphic image applied to a film/carrier designed to be applied utilizing the "hot stamp" decoration method.
- Hot-Stamping: A dry product marking method applied directly to assets post-molding utilizing pressure and temperature to release foil pigments or pre-printed labels (heat transfer or fusion-based technologies) from a film/carrier to a part creating a permanent graphic image or decoration.
- IEEE: IEEE (Institute of Electrical and Electronics Engineers) is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity. IEEE is a leading developer of international standards that underpin many of today's telecommunications, information technology, and power generation products and services.
- In-Mold Labeling (IML): A process of decorating or labeling injection molded plastic parts or components during the plastic injection molding cycle.
- Internet of Things (IoT): This is the gateway element of the M2M network of physical objects like reusable packaging assets that provides a standardized Internet transport protocol and connectivity that allows for the communication and transfer of data to Cloud services such as an Operational Digital Twin.
- ISO/IEC 18000-63: ISO ratified UHF Gen2 as the international standard ISO/IEC 18000-63, with each new version of 18000-63 superseding the prior one.

- ISO: The International Organization for Standards Development. ISO ratified the UHF Gen2 protocol as the international standard ISO/IEC 18000-63.
- Labeling: Printed information produced during manufacturing or temporarily affixed to an asset through adhesive backing or other physical containment means.
- LPWAN (Low Power Wide Area Network): Includes both cellular (NB-IoT) and non-cellular (LoRaWAN, Mioty, and Sigfox) radio technologies. There are various associations dedicated to each standard, such as 3GPP (NB-IoT), LoRa Alliance (LoRaWAN), Mioty Alliance, and OG Association (Sigfox).
- M2M (Machine-to-Machine): M2M communication is a subset of IoT, specifically referring to the direct communication between devices without human intervention. M2M technology is the foundation for IoT, and it has been used longer to monitor and control devices and operational systems.
- Mioty Alliance: The Mioty Alliance is a global community that aims to enable the most accessible, robust, and efficient Massive IoT connectivity solution on the market. Mioty technology is a standardized wireless connectivity solution for Massive IoT deployments.
- Mobile Application: An application on a smartphone or tablet specifically developed to view and analyze IoT data collected by sensors on a particular asset. Mobile applications can be used instead of or in conjunction with a Portal. Mobile applications are highly customized and can provide a better customer experience than a Portal when someone needs IoT data while working in the field.
- Operational Digital Twin: An Operational Digital Twin is a virtual representation of an operational system comprising a physical product or system that can monitor and simulate its performance and behavior in real-time. By creating a digital twin of a product, organizations can test it in different scenarios and identify potential issues before they occur in the real world.
- Portal: A desktop/tablet/smartphone internet site where customers can see the location and other IoT information about their assets collected by the sensors and devices on those assets. Portals can also communicate with devices to change how often they collect data and report it to the cloud.
- RAIN Alliance: A global alliance representing the RAIN industry, also known as the RAIN RFID Alliance.
- RAIN RFID: An RFID standard advocated by the RAIN Alliance, a global alliance representing membership across the RFID industry and ecosystem. Also known as the RAIN RFID Alliance.
- Reader: RAIN RFID readers/writers that wirelessly access to read or write tag data.
- Reporting Frequency: With IoT, since a cellular device can constantly communicate with the network, a period needs to be defined for sensors and devices to report data to the cloud that makes the most sense for each use case. Devices can gather data from sensors at one-time intervals and store it until the next scheduled time to transmit it to the cloud. Reporting frequency can impact battery life, data usage, and cost, so tradeoffs for more vs. less frequent reporting must be considered based on a particular use case.

- RFID (Radio Frequency Identification): A form of wireless communication that incorporates electromagnetic fields to identify and track tags attached to objects automatically. The tags contain electronically stored information. Refers to the use of electromagnetic or inductive coupling in the radio frequency portion of the spectrum to communicate to or from a tag through various modulation and encoding schemes to uniquely read an RF tag's identity.
- RFID Active: An RFID tag with an internal power source, such as a battery and a transmitter, sends a data signal to a base reader (see RFID).
- RFID Passive: A RFID tag without its power source or battery that draws power from the reader, which sends out electromagnetic waves that induce a current in the tag's antenna (see RFID).
- Sensors: An electronic component that detects information about its environment, such as temperature, humidity, movement, etc. Sensors can be integrated into the Communication Device or separate from it but connected by a wireless technology such as Bluetooth or a wired connection.
- Singulation: Singulation is a method by which an RFID reader identifies a tag with a specific serial number from several tags in its field. It is a required feature because if multiple tags respond simultaneously to a query, they will interfere with each other. In a typical commercial application, such as scanning a bag of groceries, hundreds of tags might be within range of the reader. Anti-Collision is synonymous with Singulation as it applies to RFID.
- Tag: RAIN RFID inlay with tag chip and an attached antenna to items, and contains GS1 encoding for identity and other attributes. Tags may be read-only, read-write, and read-write with dynamic sensed data. For this MRD, Passive Tag, which reflects and modulates a carrier signal received from an interrogator, is considered of principal interest. However, an Active Tag, which produces a radio signal independent of an interrogator, may be supported.
- UHF Gen2: A passive-backscatter, reader-talks-first UHF RFID protocol. Version 1.1.0 (2005) delivered the core RFID functionality. Version 1.2.0 (2008), a backward-compatible update, added support for item tagging. Version 2.0.1 (2015), a backward-compatible update, added support for loss prevention, brand protection, security, files, and consumer privacy. V1.2.0 is colloquially known as V1, and V2.0.1 is V2.
- Ultra-Wide Band (UWB): A form of spread-spectrum signaling based on the IEEE802.15.4-2011 standard that can be used for real-time asset location tracking. Ultra-wideband is a wireless radio technology specifically designed and developed for accurate localization in 2011. Through its very large bandwidth of over 500MHz, it can achieve a positioning accuracy of 10cm, even in challenging environments. UWB delivers low-power signals that can penetrate objects and thin walls, a low-cost and small form factor.
- Visible Light Communication (VLC): VLC technology uses visible light between 0.4 Picohertz (PHz) and 0.8 PHz, often in the form of fast-switching Light-Emitting Diodes (LEDs), to communicate data. Data are modulated with the LED light, transmitted through the air, and received using a photodiode.

- WFA Wi-Fi™: The Wireless Fidelity Alliance and IEEE 802.11 interoperable standard for local area wireless technology can be valuable in addition to cellular communication. Wi-Fi can be free from a monthly data usage perspective but requires resources and capital to continuously manage the network and security. Wi-Fi in a Communication Device can contribute additional location accuracy by taking advantage of wireless signals inside buildings.
- Wirepas Mesh™**:** Wirepas Mesh is a Low Power Mesh (LPM) wireless communication protocol for M2M and IoT devices, supporting decentralized operation. The Wirepas Mesh devices make decisions locally and co-operatively, enabling reliable, optimized, scalable, and simple-to-use connectivity for embedded devices. Select the best profile based on your needs between our Mesh 2.4 GHz or our newly standardized 5G Mesh in 1.9 GHz.

Wi-Fi is also increasingly used for peer-to-peer and Wireless Personal Area Network (WPAN) connections. It provides secure, reliable, and fast wireless connectivity. A Wi-Fi network can connect electronic devices to each other, the Internet, and wired networks that use Ethernet technology. It can provide real-world performance like that of basic wired networks. Wi-Fi networks operate in the 2.4 GHz and 5 GHz radio bands, with some products that contain both bands (dual band).

Wi-Fi is also pushing into two additional bands: the 60 GHz band, using ultra-wideband channels and the baseband solution originally developed by WiGig, and the sub-1 GHz band for low-power wireless sensor network and IoT applications. Recently, the IEEE 802.11ah wireless networking protocol, also known as Wi-Fi HaLow, operated in the license-exempt Sub-1 GHz range and was developed to meet the unique requirements of the embedded IoT with its Sub-1 GHz signal coverage, allowing users to control IoT devices in one-kilometer radius. It provides ten times the range of traditional Wi-Fi, making it suited for indoor and outdoor IoT scenarios such as home and industrial automation, smart agriculture, smart city, smart building, warehouse, retail stores, campuses, and more.

- 0G Association: An international association of 0G Network Operators. 0G Network Operators and their partners enable customers to accelerate data-driven business efficiencies by connecting millions of sensors through the world's largest 0G network.

7.2 Industry References

Below are various industry references to learn more about the broader 'reuse' industry, the types of reuse products utilized, and the technologies used for reuse asset traceability and movements.

"Reusable Transport Packaging State of the Industry Report" by Reusable Packaging Association

"Reuse – Rethinking Packaging" by Ellen MacArthur Foundation

"Trade and Economic Cooperation for Circular Economy" by United Nations Economic Commission for Europe

"Pallets 101" by Packaging Revolution

"Glossary of Reusable Packaging and Technology terms" by Reusable Packaging Association

"Reusable Packaging 101" by Packaging Revolution

"IoT: The Internet of Things" by BuiltIn

"Managing and Tracking Reusable Assets" by Reusable Packaging Association

"IoT Research BLOG" by IOT Analytics

"Understanding the Benefits of LTE Cat 1bis Technology" by Qualcomm Technologies, Inc.

"IFT's Tech-Enabled Traceability Insights Report Based on the FDA's Low- or No-Cost Traceability Challenge" by Institute of Food Technologists

Technology Standards

A series of standards apply to technology and devices that are applied to reusable products and services. Global Standards organizations such as ISO (International Organizations for Standardization) or ANSI (American National Standards Institute develop and sanction guidelines to standardize the use and methods.

Technology Standards also exist to define the specifications and how a specific technology works. An example is RFID, where the technical specifications define frequency, data transfer, and communication protocols used.

In addition, there are also Application Standards that can define how a specific technology is used in a specific application or industry, including data content and the data structure and syntax.

Below is a list of various standards groups working on the standards of technologies used in the supply chain.

3GPP

- 3GPP specifications cover cellular telecommunications technologies, including radio access, core network, and service capabilities, which provide a complete system description for mobile telecommunications. The 3GPP mission continues to be the creation of the Mobile Broadband Standard, with an increasing emphasis on connecting the Internet of Things (IoT) – whether the need is for ultra-reliable, low-latency communications at one end of the scale or for energy-efficient low-cost, low-power sensors and devices at the other.

GS1

- GS1 is a neutral, global collaboration platform that collaborates with industry leaders, government, regulators, academia, and associations to develop standards-based solutions to address data exchange challenges.

Produce Traceability Initiative (PTI)

- The Produce Traceability Initiative, sponsored by Canadian Produce Marketing Association, GS1 Canada, GS1 US, and International Fresh Produce Association and is designed to help the industry maximize the effectiveness of current traceback procedures while developing a standardized industry approach to enhance the speed and efficiency of traceability systems for the future. The PTI has a bold vision that outlines a course of action to achieve supply chain-wide adoption of electronic traceability of every case of produce.

LoRa Alliance

- The LoRa Alliance® is an open, non-profit association that aims to support and promote the global adoption of the LoRaWAN® standard, a form of LPWAN. Members collaborate in a vibrant ecosystem of device makers, solution providers, system integrators, and network operators, delivering the interoperability needed to scale IoT globally using public, private, and hybrid networks.

TAG | U.S. Technical Advisory Group

- AIM Global serves as the secretariat for the U.S. Technical Advisory Group (TAG)

ISO / IEC JTC 1 / SC 31 | Automatic Identification and Data Capture Techniques

- This group formulates the U.S. position on all work related to the standardization of data formats, data syntax, data structures, data encoding, and technologies for the process of automatic identification and data capture and of associated devices utilized in inter-industry applications and international business interchanges and for mobile applications. https://www.aimglobal.org/.

RFID Standards Committee

- Within JTC-1, Subcommittee 31, Work Group 4 (JTC-1 SC31/WG4) deals with RFID. Various other ISO committees address RFID, such as Technical Committee 104 (TC104), which has issued a standard for RFID on maritime containers, and the Joint Working Group of ISO TC122 and TC104, which is working on a set of generic application standards. There are many other committees and working groups involved with RFID. https://www.aimglobal.org/.

Technology Providers to the Reusable Packaging Industry can be found in the Reusables Marketplace, an online directory of RPA member companies.

About RPA

Founded in 1999, the Reusable Packaging Association (RPA) is a non-profit trade organization representing and promoting the common and pro-competitive business interests of member suppliers and users of reusable packaging products and services. RPA connects the industry to expand, innovate and validate reusable packaging systems.

Contact

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