REUSABLE PACKAGING ASSOCIATION

RPA www.reusables.org

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

An Industry Guide to Available and Emerging Technologies to Identify, Monitor and Track Reusable Transport Packaging

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

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EXECUTIVE SUMMARY

Reusable transport packaging products such as pallets, bins and containers have long-standing and widespread uses for the commercial distribution of goods. These products are designed and manufactured with the physical properties to ensure repeated and lasting uses in a system that features their recovery and return for the intended purpose. With common performance characteristics including durability, stacking compatibility and unitized load strength, for example, reusable packaging offers a solid and consistent shipping platform for the transport of goods through supply chains.

This shipping platform and its individual reusable packaging units also offer the protective surface space to equip with technology devices for the identification of products, the monitoring of product conditions, and the tracking of product location and movement, creating visibility in the supply chain and generating data for operational decision-making. The application of technologies to the level of transport packaging unit holds great promise in the creation of "smart assets" that can connect to communication networks, transmit real-time product data, and provide users with valuable information for effective handling and inventory management.

While technologies involving the physical scanning and transmission of data to a network (i.e. barcode scanning) are not new to reusable transport packaging, accelerating developments in hardware and software products and services are creating new automated opportunities that are increasingly within economical reach for deployment at scale. Innovations in areas involving design, size and weight, signal strength and range, and battery life, for example, are removing barriers for commercial adoption of new technologies on the reusable packaging unit.

Asset technologies applied to reusable transport packaging have two primary purposes:

(1) To communicate required or useful information to the handling parties; and

(2) To generate data for information on product conditions, unit movement tracking and inventory management.

This document aims to provide a general summary about available technology options for the identification, monitoring and tracking of reusable transport packaging assets. In addition, the information serves to offer guidance in considering available technologies to achieve desired objectives, narrowing the field of options and navigating steps for further exploration.

A general outline of technology applications available today with reusable transport packaging, as described in this white paper, include:

1. What is the information to communicate?

- ❑ Product branding
- ❑ Regulatory compliance
- ❑ Product composition
- ❑ Content properties
- ❑ Handling instructions

Permanent (Unchanging) Information

↓

Marking/Decorating

<u>In-Manufacture</u>

– Printed molded parts
– In-mold labeling (IML)

<u>Post-Manufacture</u>

– Hot or foil stamping
– Laser etching
– Digital heat transfer
– Nameplate labels
– Adhesive label barcodes

Temporary (Changing) Information

↓

Labeling/Tagging

↓

<u>Post-Manufacture</u>

– Removeable labels or stickers
– Re-writable RFID tags
– Detachable sensors or trackers

2. What is the data to generate?

- ❑ Product identification
- ❑ Environmental conditions
- ❑ Handling conditions
- ❑ Product content status
- ❑ Product location

Embedded In (Permanent)

– Sensor device
– RFID tag
– Bluetooth tag
– WIFI tag
– Cellular chip
– GPS unit

Affixed To (Temporary)

– Adhesive labeling
– Sensor device
– RFID tag
– Bluetooth tag
– IoT device (WiFi, Cellular, LPWA)
– GPS unit

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I. DEFINITIONS

A. Industry Terms

1. Asset: A reusable packaging product such as a pallet, bin or container that is owned or rented for the transport of goods and maintains its intended purpose and value over time.

2. 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.

3. Cycle (also 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.

4. 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.

5. Logistics – Forward: The coordination of moving an asset from starting point in the cycle to the completion of its intended packaging use. Forward logistics activities often include the movement of packed or filled assets to warehouse and point-of-sale or use environments.

6. 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.

7. Loop – Closed: A well-defined and closely-managed cycle that is characterized by minimum shipping and delivery points where ownership or accountability of

the asset is always maintained by the receiving party. 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.

8. Loop – Open: A complex cycle that is characterized by multiple shipping and delivery points where at least one receiving party does not have ownership or full liability of the asset. Open loops often involve rented or pooled assets that are owned by a third-party who does 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 apply.

9. Pool (also Float or Fleet): The aggregation of reusable packaging assets that have the same intended purpose or use and contain common characteristics in design and specifications.

10. Reuse (Reusable): The act of extending the utility and value of an asset following a use, often a repeat of the cycle for its intended purpose. Packaging is deemed to be reusable when both the design and manufacture achieve durability for multiple uses and a defined and managed system is in place to recover the empty asset for reuse.

11. Transport Packaging: Packaging for the movement of raw materials, commodities or finished goods from point of production or processing to 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 in the distribution of bulk items but may also be considered secondary or to a lesser extent primary packaging depending on other product packaging used.

12. Trip: The issuance of a reusable packaging asset for the purpose of completing a single cycle.

13. Turn: The completion of a trip in which 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.

B. Product Terms

1. 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.

2. Box: A generic term used to define single-use packaging products that are typically handheld sized units, include 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).

3. Container (also 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 made from plastic or other durable material for its reuse (i.e. milk crate).

4. Intermediate Bulk Container (IBC): 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.

5. 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). See "What Is a Pallet?" by *Packaging Revolution*.

6. 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.

7. Reusable Plastic Container (RPC): A container that is specifically designed and used for the packing and transport of perishable food items from farm or food processing facilities to retail or food service establishments.

8. Roll-Out Cart: A large mobile bin for trash or residential solid waste collection and removal ranging from 16 to 91 gallons in capacity.

9. Shelf Bin: Packaging product that may hold items on shelves or racks as part of transport and display within the same facility.

10. Tank: A large packaging unit, often made from steel, for the holding and transport of liquids, solids or powders in bulk that typically involve specialized fill and discharge technologies.

11. Tray: A handheld packaging unit for lightweight items or small unit quantities that typically has a lower profile and an open top and side for access in a stacked arrangement (i.e. bread tray).

C. Technology Terms

1. Barcode: An optical, machine-readable representation of data in the form of numbers and a pattern of parallel lines of varying widths; when scanned, the pattern relays information about a product.

2. Blockchain: A shared, digitized and public ledger 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.

3. Bluetooth, BLE: Short-range wireless technology that is typically used to connect devices to each other, for example, connecting a smartphone to a Bluetooth headset or speaker and for connecting sensors to a gateway or cellular communication device.

4. 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 battery or by a more permanent power source.

5. Cellular Location Tracking: Cellular-based location tracking which provides the latitude and longitude of an asset's location. A device must have a cellular radio in it and uses its location with respect to the closest cellular towers. This technology tends to be less accurate innately than GPS but is more useful when assets will be located inside a warehouse, a truck trailer, or a train car.

6. GPS Location Tracking: Satellite-based location tracking which provides the latitude and longitude of an asset's location. A device must have a GPS radio in it and must have line-of-sight to one or several satellites in orbit around the earth.

7. Heat Transfer Labels: A multicolor, preprinted graphic image applied to a film/carrier designed to be applied utilizing the "hot stamp" method of decoration.

8. 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 Polyfuze Labels) from a film/carrier to a part creating a permanent graphic image or decoration.

9. In-Mold Labeling (IML): A process of decorating or labeling injection molded plastic parts or components during the plastic injection molding cycle.

10. Internet of Things (IoT): 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.

11. Labeling: Printed information that is produced during the manufacturing process or temporarily affixed to an asset through adhesive backing or other physical containment means.

12. Mobile Application: An application on a smartphone or tablet that has been specifically developed in order 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.

13. Network – 5G: The fifth generation of cellular mobile communications succeeding today's 4G LTE mobile networks and enabling higher speed and responsiveness of wireless communications.

14. Network – NB-IoT: Also known as “Narrowband IoT;” A Low Power Wide Area Network (LPWAN) radio technology standard developed to enable a wide range of cellular devices and services focusing on indoor coverage, low cost, long battery life, and high connection density.

15. Network – LTE-M: Also known as “Long Term Evolution for Machines;” A Low Power Wide Area Network (LPWAN) supporting IoT through lower device complexity and extended coverage.

16. Portal: A desktop/tablet/smartphone internet site where customers can see the location and other IoT information about their assets which was collected by the sensors and devices on those assets. Portals can also be used to communicate with devices to make changes in how often they collect data and report it back to the cloud.

17. Reporting Frequency: With IoT, since a cellular device can communicate constantly with the network, a period of time needs to be defined for sensors and devices to report data to the cloud that makes the most sense for each particular use case. Devices can gather data from sensors at one time interval and store it until the next scheduled time to transmit that data to the cloud. Reporting frequency can have an impact on battery life, amount of data usage, and ultimately cost, so tradeoffs for more vs less frequent reporting need to be considered based on the valuable actions that can be taken based on the data for that particular use case.

18. RFID: (Radio Frequency Identification): A form of wireless communication that incorporates the use of electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically-stored information.

19. RFID Active: A RFID tag having an internal power source such as a battery and a transmitter to send signals of data to a base reader.

20. RFID Passive: A RFID tag without its own power source or battery that draws power from the reader, which sends out electromagnetic waves that induce a current in the tag's antenna.

21. 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 can be separate from it but connected to it by a wireless technology such as Bluetooth or by a wired connection.

22. Wi-Fi: A local area wireless technology that can be valuable as an addition to cellular communication. Wi-Fi can be free from a monthly data usage perspective but requires resources and capital to manage the network and security on an ongoing basis. Wi-Fi in a Communication Device can contribute an additional level of location accuracy by taking advantage of wireless signals inside of buildings.

II. INTRODUCTION

Reusable transport packaging has a long history of effective use in commercial supply chains. From the first use of the modern-day pallet in the 1920s to the multi-generational use of the popular square milk crate, the shipment of goods on or in standardized packaging units with the intention of repeated use have been a mainstay in distribution channels around the world.

While the same characteristics of reusable packaging - among them product protection, load consistency and strength, and economic savings over time - continue to propel their extensive use and value, the reusable assets of the past are not equipped to take advantage of rapidly changing advancements in today's digital, data-driven commerce.

The first time a barcode was placed on a pallet or a tray moving through a factory, for example, a technology was applied to a reusable package. Those scannable barcodes identified a singular asset as part of a larger pool of the same product. But a limiting factor of barcodes is their requirement of line of sight and reach for a reader to collect the data, which can slow workflow and add labor cost.

Technologies such as Radio Frequency Identification (RFID) enable active and automated signal-broadcasting capabilities carrying pre-programmed information from the packaging unit to a database. RFID technology gives companies the ability to identify assets without line-of-site reading but requires adequate unhindered signal strength and range to a stationary reading device or portal. RFID applications on many products continue to be a popular choice today, as an estimated 16.4 billion RFID tags were sold in 2018.

In the future, connecting the reusable packaging to the Internet of Things (IoT) promises to capture real-time unit data with less restrictions on scanning range or reading equipment. Instead, data can be transmitted to expanding wireless access points, cellular towers and satellite networks, and thus removing previous equipment, distance and geography barriers. It is estimated that by 2022, according to Cisco's annual Visual Networking Index, machine-to-machine (M2M) connections that support Internet of Things (IoT) applications will account for more than half of the world's 28.5 billion connected devices.

Volume, scale and pool speed of reusable products have always been key performance indicators to drive cost-savings. Today, technologies that improve quality control and inventory management are providing new ways to maximize product performance and to reduce system waste leading to better asset utility at even lower costs. Application of information-conveying and data-generating technologies to transport packaging is quickly becoming an opportunity to get more out of the supply chain and to optimize operational decision-making and efficiencies.

For example, a recent report examining the retail sector shows that achieving greater visibility in the retail supply chain is a top business objective. 80% of retail organizations have budget allocated for visibility, and almost half of the funding is business led with IT involvement. The highest-ranking reason to invest in visibility is internal business productivity, enabling store operations to provide better experiences for customers. Second, retailers cite savings to human and other asset usage requirements, including head count, inventory, energy/fuel, and systems maintenance.

Common business operational reasons why companies invest in technologies for their reusable packaging include:

- Monitor size of packaging float or pool to satisfy need
- Measure performance of the asset pool such as dwell time, transit time and cycle time
- Alert to environmental or behavioral issues associated with the packaging such as damages, fill levels, temperature and humidity
- Prevent losses of assets by observing gaps or leakage points in the supply chain
- Recover lost assets by pinpointing their locations outside of the intended cycle
- Institute financial incentives for handling and return of assets within agree-to timeframes
- Provide recordkeeping assurances of packaging use and locations for quality control and regulatory audits

Increasing packaging technology options and changing digital supply chain requirements are leading to greater complexities in determining the right technology solution for not only today's packaging uses but tomorrow's needs as well. This paper aims to clarify leading technologies used with reusable packaging by focusing on three categories of technology applications:

1. Product *identification* through marking and labeling
2. Product *monitoring* through sensors
3. Product *tracking* through various signal broadcasting and receiving devices

Basic *identification* of reusable packaging assets can be achieved with any unique identifier like a serial number. If a barcode is added to that number then the asset becomes more easily identified using scanning technology, and the higher up the technology ladder that identifier moves, such as RFID or IOT, the more uses can be leveraged from that identifier. Identification is necessary before monitoring or tracking is possible to any measurable degree.

Monitoring the conditions of reusable assets and their contents are typically considered in the aggregate to analyze the flow or physical properties through a process and to assess material or environmental changes over time and distance.

Tracking typically refers to the need to follow the movements of individual assets for the purposes of associating it with another data point, such as what SKU was put inside that reusable asset, or for the purposes of locating a lost asset or retracing the steps an asset took through its particular journey, either internal or external.

When approaching technology applications for reusable packaging, wide variances in business objectives, use applications and operational complexities limit the ability to make universal recommendations. However, there are common considerations that can be recommended in the pursuit of technology options for any reusable packaging.

Taking a holistic view of the supply chain and engaging all distribution partners on the technology opportunity build the foundation in understanding the data potential and achievable values, current obstacles that can be overcome and improved, and design and use requirements for maximum full-cycle performance. Following these steps as explained in Section 6, “Getting Started,” can serve as a general guide in identifying technology options for your application and developing a business case and plan for justifying the investment and delivering on the technology’s promise:

1. Identify and select business and supply chain objectives
2. Quantify the problem to solve and benefit to gain
3. Determine characteristics and requirements of the supply chain
4. Decide on temporary or permanent technology solution
5. Estimate quantity of assets to enable with the technology
6. Select technology type for best fit with intended deliverables
7. Derive the costs and investments needed for positive returns

III. PRODUCT IDENTIFICATION

There are principally two reasons to place identification on reusable transport packaging. The first is product *marking* to convey desired or required information about the nature of the packaging to the handler or user. This is intended to be a permanent or lasting identification that is applicable throughout the life of the product. Marking information may involve ownership branding, the date of manufacture, material identification, and after-use return or recycling instructions, for example, and typically would be designed or embedded into the product during its manufacturing process.

The second reason is product *labeling* to convey necessary information about the goods in which the reusable packaging unit is transporting. This is intended to be a temporary identification that is added or affixed to the outside of the packaging and communicates useful or required facts about the contents. Labeling information may involve ingredients, net weight, origin, directions for use, or cautionary guidance, for example, and often is applied using adhesive labels or stickers at time of packing. Labeling on reusable products is designed for single use for the duration of the transport and for removal and recycling after the use of the contents.

For the purposes of this white paper, technology advances for both the in-manufacture permanent marking and the in-use temporary labeling are examined.

A. Reasons for Asset Marking

1. Ownership/Branding

Brand identification on the reusable packaging asset communicates the owner's company and brand differentiation in the market. 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 so increase the likelihood of recovery and return. Such information can ensure that trading partners know to whom the reusable packaging belongs, increasing likelihood that the asset is not returned to the wrong trading partner or used for unauthorized purposes. Color-marked pallets, for example, may be easily identifiable from the street, thus aiding asset managers or auditors in determining if a location is authorized to have the assets on hand. Brand markings or use of brand-associated colors on reusable containers in some cases can also provide marketing benefits, particularly for retail display.

Pallets using color for brand identification

2. <u>Manufacturer/Manufacturing Information</u>

Product manufacturer information can help users in monitoring reusable packaging performance and durability and to differentiate between various reusable packaging products that are supplied by more than one manufacturer. Reusable packaging products may be date stamped, or in some cases, color-coded for the user to easily determine the date or supplier. Packaging manufacturing date information can also help users better understand the age and relative durability of their assets, and additionally if damaged packaging is covered by warranty. In the case of solid wood packaging, the use of the ISPM 15 (International Standards For Phytosanitary Measures) stamp signifies that any solid wood components have been treated to prevent the international spread of wood-borne pests. Such a mark signifies that treated wood packaging should pass international ports of entry without incident.

3. <u>Product Composition</u>

Information about product composition can inform reusable packaging users about the material used and related recyclability at the end of the packaging item's life, or perhaps how to best repair a reusable packaging unit. Most reusable packaging items typically include a numeric recycle code. Regarding repair, the type of plastic used to make the container can be an important quality consideration for operations such as plastic welding.

4. <u>Special Instructions</u>

Special instructions can help improve 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 help improve the value proposition offered by reusables.

B. Identification Methods During Manufacture

1. Design and Appearance Considerations

An important element of reusable packaging design is to support identification that is highly visible when so desired, as well as being durable, cost-effective, and increasingly, attractive. Design best practices may include recessed locations on the reusable packaging that provide protection for permanent and temporary labels from abrasion damage, as well as location to facilitate ease of barcode scanning, for example. Special molded features such as dimples in a label placement area can help facilitate temporary label removal when no longer required.

Design considerations must also consider material handling systems. For example, when a meat packing operation switched from single-use corrugated boxes to reusable packaging, adjustments to conveyor lines and automated label applicators were required to facilitate the change.

Post-production applications of product labeling and marking need consideration too. This allows for techniques such as hot stamp, heat transfer, and Polyfuze that require significant material and build support behind the decoration area. Access to the area behind the decoration needs to be considered in design. Also, the location and significance of ribs and gates around and/or behind the decoration area need to be considered from the perspective of part flatness and sinks to be overcome during the product marking/decoration process.

2. Molding/Manufacturing Processes

In-mold labeling (IML) is used in the packaging industry as a high-quality alternative for printing molded parts. IML labels are usually printed polypropylene or polyethylene foils only a few tenths of a millimeter thick, with the potential to offer highly glossy and photorealistic decoration. Labels are inserted into the mold and in parallel, the parts are removed. The labels are held in the mold with a static charge or vacuum. Unlike hot stamping (foil printing) discussed below, IML enables multiple colors and large printed areas on all sides at once.

3. Marking/Stamping of the Finished Product

Hot-Stamping Machine by United Silicone (25-E Frame)

A variety of approaches are used to provide identification on finished products, depending upon the reusable packaging material. For plastic containers and pallets, approaches include hot stamping, laser etching, digital thermal transfer and nameplate labels.

- **Hot stamping** or foil stamping is a popular approach for product marking or branding 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.

- **Laser etching** is an approach that uses a laser to etch the surface of the material. This process can be utilized for a variety of materials, including plastic, metal, and wood.

- **Digital heat transfer** is a form of identification that uses high heat, pressure, and dwell time to apply a pre-printed digital graphic to a plastic part or product.

Kennedy Group Durable Premium Nameplate with a variable data barcode that is permanently affixed to the bin

- **Nameplate labels** can be easily applied to reusable packaging without the equipment requirements of other approaches. They are designed to be resistant to tear, UV, moisture, abrasion, and humidity, providing long-term identification of the asset. Adhesives are typically used to apply nameplate labels to the package.

Metal containers may be stamped or etched directly or onto an identification plate, while nameplate labels may also be applied. Wood packaging markings are typically applied using a stamp or stencil with indelible ink or burnt into the wood packaging material with a branding iron.

4. Product Examples

Above: IML labels can provide an enhanced visual appeal. (Source: Schoeller Allibert)

Above: Laser printed identification. (Source: Trotec Laser)

Above: Information hot stamped onto a pallet. (Source: ORBIS)

C. Identification Methods During Use

1. Labeling Requirements

In-use temporary labels are 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. In the case of reusable plastic containers (RPCs) for perishable foods, for example, labels must survive exposure to coolers and the rigors of supply chain handling yet release and remove cleanly with no adhesive residue when they are run through an automated wash line.

2. 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 both an economic (label cost) as well as a functional choice. Typically, paper labels are lower cost than film, however paper labels will not survive in any of the wet applications such as hydro cooling of fresh produce and 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 be compliant 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 on to the label surface.

3. Recommended Best Practices

When switching to reusable packaging from single-use corrugated, it is important to recognize that labels previously used may not be the best solution for reusables. Variables such as the reusable packaging material and surface texture, temperature range, handling environment, the intended method of removing labels, and other requirements can dictate the best label choice for your application. It is important to review these requirements with your label provider.

In July 2018, The Kroger Company worked with major suppliers of RPCs to identify a range of commercial label options that meet two key requirements:

(1) The label adheres to the RPC for proper identification of the products inside; and

(2) With appropriate water temperature and pressure, the label will wash off giving the RPC a fresh clean look.

The following is a list of approved labels for RPCs in the Kroger system as of 2018, with updates anticipated as new labels meet the retailer's supply chain requirements:

1. Ricoh 140LDS/LES w *G12 adhesive* a. Direct Thermal product (like a check stand receipt where heat turns the white paper black)
2. Technicote 86152 w *AT333 adhesive* a. Thermal Transfer product (white label w a black ink ribbon) b. Direct Thermal product
3. Mactac DTM0902 w *LT20 adhesive* not HLT20 a. Direct Thermal product
4. UPM Raflatac DT209J with *RP45 adhesive* a. DT209J is Direct Thermal
5. UPM Raflatac SP184W with *RP45 adhesive* a. SP184W is Thermal Transfer
6. Ritrama 4-RL2D-03464 RI-757 with AP901 adhesive a. Direct Thermal & Thermal Transfer

The existence of any traceability requirements for labeling should also be considered. The "Produce Traceability Initiative Best Practices for Formatting Case Labels Revision 1.4", updated June 12, 2019 (source: www.producetraceability.org) would be the reference for labeling compliance.

An example of a Produce Traceability Initiative (PTI) compliant label is as shown below.

IV. PRODUCT MONITORING

Designed and built for durability through rigorous supply chains, reusable transport packaging offers capabilities to affix sensory devices onto units for the detection and measurement of real-time performance conditions associated with the product. Apart from tracking of location and movement of an asset, smart sensors can be deployed that provide on-board diagnostics of the physical and environmental properties of a reusable package and its contents. Example sensor data collection include surrounding temperature and humidity, vibration and shock levels during movement, evidence of tampering, signals from operational failures such as valve status, or the depletion of contents or unit weights.

Condition sensors incorporated into reusable transport packaging aid in the measurement of current conditions of contents or materials being transported. Such data can be used on an ongoing basis to assist regular service providers in alerting them when to empty the containers, for example, or it may be used to generate alerts and corrective action when unexpected conditions increase the loss risk of goods transported. Load history data is also useful for expediting the quality assurance process as well as in supporting predictive decision making and the undertaking of operational improvements.

A variety of sensors is available to facilitate product monitoring. Temperature, vibration/shock, and content fill level sensors are popular. Additionally, sensors are increasingly available to capture other measurements as required, including pressure/vacuum, light exposure, and others. Because sensors can be incorporated into reusable packaging, they can be used over and over, thus reducing the cost of monitoring equipment on a per-trip basis. Sensors are also available on an “as a service” from some providers.

A. Reasons for Product Monitoring

The monitoring of goods in the supply chain by sensors incorporated into reusable packaging can play an important role in optimizing operations and delivered product quality. Popular monitoring opportunities include the following:

- *Alert that regular servicing is required*. Sensor-based garbage bins provide a current example of reusable containers that send an alert to service providers when they need to be emptied. Similarly, fill sensors provide the opportunity to alert operators that a container is empty and needs to be taken away and replaced.

- *Alert that an urgent, unanticipated quality risk event has occurred or is likely to occur*. When the temperature level of reusable packaging units goes outside of the accepted temperature range, for example, sensors may trigger an alert to stakeholders for follow-up and the initiation of corrective measures.

- *Provide readily available history to expedite quality assurance inspection*. The ready availability of granular, pallet-level data history is also extremely useful for expediting quality assurance inspections both during the regular receiving process as well as when prompted by condition exception alerts.

- *Provide historical data for predictive purposes and operational improvement opportunities*. The availability of historical data can help supply chain operators better predict negative events, as well as flag opportunities for operational improvements related to transportation and distribution planning.

B. Product Monitoring Use Patterns

As discussed above, 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.

Temperature sensors have great value for temperature-sensitive products such as perishable foods and pharmaceuticals, for example. In such applications, temperature readings can generate an alert in response to critical range measurements. 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 play an important role in monitoring the shipment of other expensive and sensitive products such as electronics. Such sensors can be useful in identifying the time and location of events that result in damage. Historical data can provide insights to logistics professionals regarding patterns of exposure, 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 response to such a situation.

C. Sensor Equipment, Materials and Hardware

A variety of sensors can be incorporated to provide accurate information about the load condition. The list of available sensors continues to grow, from basic applications such as temperature and vibration/shock to span an increasingly diverse range of possibilities, including humidity, weight, light, vacuum/pressure, CO2 and ethylene detection, and more. Such sensors are combined with various tracking technologies used to communicate this information. Vendors offer a variety of customer dashboard and live monitoring services to help supply chain participants interpret and make the best use of the data being generated.

In 2018, AT&T launched its first GPS asset tracker on its LTE-M network. In addition to location tracking, it also incorporates sensors to capture information about humidity, temperature, light exposure, and impacts.

In January 2019, Sequans Communications S.A. and Polymer Logistics announced the availability of the Polymer Logistics Smart IoT Tracker. The device includes a temperature sensor, an accelerometer, and a network-based geolocation capability.

EPAL, the European Pallet Association and world's largest pallet pool, has been testing NB IoT sensors which provide location, temperature and shock information.

Monitoring sensors are connected to various communication or tracking units. The tracking units themselves can be embedded in reusable packaging products during manufacturing or retrofitted to existing containers in a protected location.

D. Key Considerations

1. Fully understand the problem or use case before gravitating toward a particular technology. 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.

2. An inclusive approach works best. Various stakeholders may be impacted in different ways by product monitoring capability. 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.

3. The sensors themselves should be configured 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 only communicate exceptions. They can also be configured to sample more frequently and notify if a rate of change suggests that a risk event is likely to happen. For example, a sensor might read the temperature every 15 minutes but if it goes over a threshold, then it may be programmed to start sampling at shorter intervals.

4. The use of more sensors will also negatively impact battery life, so it is important to differentiate between "nice to have" and "must have" data.

5. A service-based monitoring technology solution is 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.

6. Sensor monitoring is not just about the device, but also ensuring that the platform utilized gives the user the ability to assess and manage the data. Business intelligence is a critical component to the point that it really will make or break the solution being implemented and the resulting ROI and payback. Tracking solutions can produce a substantial amount of data and if the platform doesn't have an effective way for communicating where the organization's attention should be focused on, there is a high chance of failure. This is where predictive analytics comes into play for the different users of the data; on the floor, with management, supply chain partners (suppliers and customers), and at a corporate level.

E. Monitoring Case Studies

Pharmaceuticals placed in a non-temperature control environment

A shipment of 9 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. An alert was received by the freight forwarder. It showed four pallets being out of temperature range, and the logistics service provider was instructed to investigate. The four pallets were found to be 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 - these are slap and stick sensors removed at the time of delivery, not affixed to reusables).*

Truck inspection window left open by mistake, resulting in 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 recorder and reported that the trailer temperature was within range. Following a second alert, the driver was contacted again and asked to investigate more fully. The back inspection window was discovered to have been left open from a Customs inspection and was 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 for that product, would have made them unsaleable. *(Source: Controlant webinar).*

V. PRODUCT TRACKING

A. Reasons for Asset Tracking

Asset tracking offers many benefits to supply chain participants, including reusable packaging and carried goods location, movement through the supply chain, and inventory management.

1. Product Location and Recovery

Tracking technologies allow stakeholders to identify the location of assets, as well as other potentially important information such as movement, dwell time and asset condition. Knowing the location of assets and the products they contain can add considerable efficiencies to the supply chain, as noted below. Asset tracking technologies can also enable more effective asset management and recovery, including pinpointing the location of asset loss and thereby aiding in the recovery process.

Regarding asset recovery, tracking technology can identify underutilized assets. Sometimes, for example, companies lose track of packaging assets stored on trailers or in satellite locations. Such a situation can be remedied through an effective tracking program. In a similar vein, the identification of excess assets at trading partners can prompt a dialogue toward their return, or in a more automated system, generate an automated pickup request for the removal of accumulated reusable assets at a trading partner location.

2. Product Movement and Speed

In a time when lean supply chains stretch globally and inventory levels are held as low as possible, the synchronization of product or material delivery with when it is needed is increasingly critical. Late delivery can result in production or service failure. Production may be delayed, or the emergency use of expendable packaging may be required, adding additional expense as well as customer inconvenience. Early delivery, on the other hand, can prompt the need for storage or stock buffering decisions.

Tracking technologies can enable operators to optimize their flow of materials and goods. Alerts can be set to notify operators of goods movement that is slower or faster than expected to allow early intervention in order to avoid excess costs related to the delivery timing.

3. Inventory Management

Inventory management is greatly enhanced using asset tracking. The use of barcode labels has become commonplace, and increasingly, operators are recognizing the value of other technologies such as RFID, BLE, and others that provide further opportunities for automated inventory measurement. Such approaches help reduce labor and allow participants to optimize inventory levels for both finished goods and packaging materials. One telecom company has utilized RFID tags to track inventory on its service vehicles, with that information communicated to the company through truck-mounted GPS. The company's customer service team can then ensure that a service vehicle has the necessary parts in stock before dispatching it to a job.

Inventory management of the reusable packaging assets themselves is also improved by tracking. For example, a fresh fruit processor purchased 63,000 new reusable bins equipped with RFID tags. After the conversion, a physical inventory of the bins could be undertaken in one day by a single employee, versus the previous practice of requiring several employees for several days to accomplish the same activity. Additional benefits included better insight into its bin inventory. The company identified that 20% of its inventory was overlooked and not utilized during the growing season, thus suggesting that it was running with more reusable bins than necessary. Another plus was an accurate accounting for damaged bins, including ones still covered by warranty, thus helping to avoid expenditure on new bins. (Source: Packaging Revolution)

4. Possession, Loss and Damage Accountability

Tracking technology can provide important insights into reusable packaging location and environmental conditions. Shock or temperature sensors, for example, when tied to geolocation and time coordinates, 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.

Asset tracking helps participants to identify who has possession of reusable packaging units, and if applicable, the goods that they are carrying. In the case of lost or stolen freight, tracking technology can help identify the location of the missing items. For example, one OEM inserted GPS sensors in some of its bulk bins. When they were identified as being outside of geofenced locations, an agent was sent to investigate. In more than one circumstance, bins were found at unauthorized plastic recycling operations. The agent intervened and convinced the recyclers in question to return the assets and not to accept them in the future.

5. Process Improvement

Tracking technology can help identify process improvement opportunities. Exception alerts can help flag immediate opportunities to prevent loss which may prompt root cause analysis and lead to enduring improvements. The ongoing generation of data can also provide important insights into such opportunities as identifying system bottlenecks, comparing route or carrier performance, monitoring asset dwell time, tracking damage rates, and more.

Inclusive of the reasons for asset tracking listed above, there is a vast array of potential use case opportunities for asset tracking, and there is, likewise, a wide range of technologies available to help address them. The main technologies associated with the tracking of reusable packaging units are listed below. It is important to note that increasingly, various technologies are being combined to achieve greater functionality or to reduce cost.

B. Barcodes

The most mature technology used for automated reusable packaging asset tracking is the barcode system, which celebrated its 45th anniversary in 2019. Forty-five years ago, the first official barcode was scanned at a supermarket in Troy, Ohio in the form of a Universal Product Code (UPC).

1. Barcodes for Tracking

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

In terms of tracking the location of reusable packaging units for asset management, their whereabouts are invisible from a digital perspective, between scans. The scanning of empty returning containers, however, can help operators understand key performance indicators such as dwell time or the return rate (flow-through) associated with customers in order to initiate corrective action as required. One RPC pooler uses scan data to not only monitor return rates from customers but also assess return rates from geographic areas or distribution center service areas. Low return rates from a city may indicate issues with local plastic theft, for example.

2. Types, Uses and Requirements

There are several types of barcodes in use today, including the ubiquitous UPC code, as well as many others. The barcode was originally developed to help automate grocery checkout. Today, the 12-digit UPC code is commonly used for retail point-of-sale in the United States and Canada. 2D (two-dimensional) barcodes, including QR (quick response) barcodes, enable more data to be stored than on linear barcodes.

In terms of reusable packaging for B2B applications, two commonly used barcodes are Code 128 and Code 39. Code 39 was an alphanumeric string introduced by the automotive industry in 1984 to create a single standard. It went on to be adopted by other industries as well as the U.S. Department of Defense. Code 128 barcodes are widely used for logistics and distribution operations. For example, one leading pooler of RPCs utilizes Code 128.

3. Equipment, Materials and Hardware

For the purposes of reusable packaging, a barcode system includes labels, scanners, and related software. Durable labels are required to withstand rigors related to material handling, reuse, and washing are critical for reusable packaging. Scanners, both mounted and handheld, are used to capture barcode data. The software allows for barcode license plates to be associated with other events such as time, location, products or container washing, for example. It is important to note that when converting from corrugated containers to reusable containers, some adjustment of conveyors and other material handling equipment may be required to facilitate label scanning on the reusable container due to differences in packaging design and the area of label placement.

4. Integration in Product

Permanent barcodes are typically applied to finished reusable packaging units in the form of labels. They are often located in recessed locations so that they do not become damaged by interaction with adjoining containers or material handling equipment.

Barcode label on a reusable container (courtesy Monoflo International)

5. Key Considerations

Barcode systems provide a relatively inexpensive approach to asset tracking compared to other more automated solutions. It is important to note, however, that barcode visibility is limited to scan points, which creates gaps in monitoring. Other considerations include barcode durability, the amount of data the barcode is required to store, and barcode compatibility with the supply chain application.

6. Examples

Examples of barcode systems used to track reusable packaging include:

- Tracking the shipment of watermelon to retail customers, associating product weight and customer with the barcode, and verifying of empty container return from customers. (See case study in Section F below)

- The use of barcode by an RPC pool provider to associate RPC wash and customer shipment information, and to track the return of RPCs, allowing the pool provider to understand key measures such as return rates and dwell time. (See case study in Section F below).

C. Radio frequency identification (RFID)

RFID offers a cost-effective solution for reusable packaging asset tracking in environments where it can be scanned. It helps companies achieve accurate inventory and shipping and can be useful in monitoring reusable packaging shipments and returns from trading partners.

1. RFID for Tracking

RFID offers a relatively established approach to the automated tracking of reusable packaging products. Two commonly touted benefits of RFID in comparison 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 at the same time, making the process faster than it is for barcode scanning. And like barcode systems, RFID has limitations from a tracking perspective in that tagged items are only visible at read points. At other locations, such as in transit or at trading partner locations, they may not be visible from a digital tracking perspective unless read/scan equipment is installed, which adds cost usually born by the packaging owner. Unfortunately, the loss of reusable packaging assets is often associated with empty reusable packaging during these times when it is in the custody of logistics providers or trading partners. As such, even though reusable packaging managers may know which ship-to locations are resulting in poor return rates, further intervention will be required to determine the root cause and location of asset loss.

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

2. Types, Uses and Requirements

RFID technology covers a range of tags, including active, passive and battery-assisted passive (BAP) tags. Active tags have their own transmitter and power source, usually a battery. While they have a read range of up to 100 meters, their uptake has limited to predominantly expensive items due to the cost and battery life concerns. Passive tags, by comparison, are much more attractive from a price point, and have enjoyed a much wider adoption. Passive tags draw power from the reader. Electromagnetic waves sent by the reader induce a current in the tag's antenna. BAP tags provide a semi-passive system, wherein the battery helps improve read distance and data transfer rates. BAP tags, unlike active RFID tags, do not have their own transmitter.

RFID tags can also be differentiated between read-only and read-write tags. While a read-only tag acts as a license plate, a read-write tag can have data added to the tag, without the need to upload it to the cloud. For example, read-write tags are used on reusable racks to update the status of work-in-progress directly to the tag as racks make their way through the assembly plant. If, for example, a production line quality issue is detected for a certain period of time, the tags can be analyzed to find out if they were produced during that time period.

3. Equipment, Materials and Hardware

RFID systems require tags, readers and a communications interface to a host computer system. While passive tags are inexpensive, the expense of readers may be a point of consideration for ROI when used in conjunction with reusable packaging, depending upon the number of reader installations required.

4. Integration in Product

RFID tags can be inserted into reusable packaging items during the manufacturing process or affixed after manufacturing. For example, RFID tags are inserted during manufacturing into items such as reusable bakery trays and plastic rental pallets. Combination barcode/RFID labels are also often used for reusable packaging systems and are applied to finished reusables.

5. Key considerations

Passive RFID tracking systems, like barcode, provide a relatively inexpensive approach to asset tracking compared to other alternative tracking solutions and can provide basic tracking benefits. It is important to note, however, that RFID systems rely on an infrastructure of reader locations or handheld readers. Visibility is limited to scans at reader locations, which can result in gaps in the tracking coverage. One approach being used to improve visibility is with "mother-child" or "hub and spoke" systems, leveraging BLE's with GPS, Cellular and/or WIFI tags.

BXB Digital tracking leveraging GPS, Cellular & WiFi devices with BLE tags to create the "Hub & Spoke" model.

6. <u>Examples</u>

Examples of RFID tracking used for reusable packaging tracking include:

- Reusable packaging and pallet pool providers such as Japan Pallet Rental and Norsk Lastbærer AS Pool (NLP) which utilize RFID to track variables such as return rate, wash status, etc.

- Automotive suppliers to track the availability of reusable packaging so as to minimize the emergency use of expendable packaging as well as return rates from various customers.

D. Internet of Things (IoT)

1. <u>IoT for Tracking</u>

Simply put, IoT 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 be comprised of four components, including sensors/device, method of connectivity, data processing (cloud platform), and user interface.

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 in the absence of an infrastructure of proximity readers or scanners such 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 or theft, as well as points where product carried in them is most vulnerable to damage.

2. Types, Uses and Requirements

IoT networks rely on various types of network connectivity to the cloud, including cellular, LPWA, GPS, Bluetooth and WIFI. These approaches and their requirements are discussed in greater detail below.

In the context of reusable packaging, IoT systems can be used to monitor product quality and environmental conditions in the immediate vicinity, as well as to determine asset location and movement. Two popular condition monitoring sensors include temperature and shock/vibration. There is an increasing array of sensors available, but one must consider that the use of more sensors can shorten battery life.

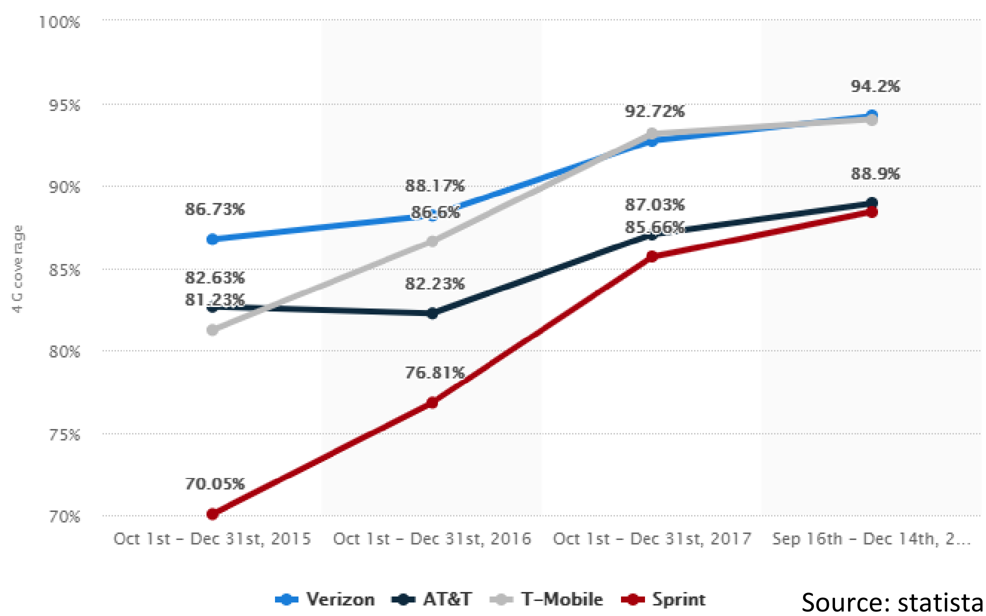
Asset location information helps operators optimize inventory flows in the supply chain, eases locating containers, and helps improve reusable packaging asset management. IoT enabled reusable packaging also can generate a wealth of data that may be useful in identifying improvement opportunities over time. The number of use cases continues to expand as technology improves.

3. Connectivity Types (cellular, LPWA, GPS, Bluetooth, WIFI)

Cellular

Cellular IoT refers to a network of physical objects that are connected to the Internet using cellular technology, which operates within the licensed spectrum. Each asset contains a cellular chip (SIM card) that communicates with the cellular network to pass IoT data to the cloud. The longitude/latitude of the device is determined by triangulating the coordinates of at least two cell towers. Cellular solutions have become increasingly popular as technologies continue to evolve and prices drop. They provide visibility of reusable packaging assets in the supply chain more affordably than GPS, for example, with a longer battery life, but with tradeoffs in terms of the degree of locational accuracy and coverage. Accuracy is often touted as being accurate to the nearest 20 meters. Cellular network coverage is best in populated areas, but recent data shows US coverage for 4G LTE to be at least 94%.

Proportion of time LTE subscribers in the United States have 4G coverage available to them from 2015 to 2018, by provider:



Source: statista.com

Cellular solutions continue to evolve, with cellular providers standardizing several technologies, including Long Term Evolution for Machines (LTE-M) and Narrow Band IoT (NB-IoT). NB-IoT is ideally suited for low bandwidth, infrequent communication from a relatively stationary device, while LTE-M suits higher bandwidth or mobile and roaming applications.

The introduction of 5G networks will allow for the rapid transmission of vast amounts of data between connected IoT devices, making it ideal for applications requiring greater bandwidth, and further broadening the breadth of Cellular's IoT capabilities and potential use cases.

LPWA

Low Power Wide Area Network (LPWA or LPWAN) is an IoT technology which operates in the unlicensed spectrum to transmit messages to a proprietary network of base stations, and then to the cloud. LPWAN technology is well-suited for connecting devices that need to send small amounts of data over a long range, such as reusable packaging, while maintaining long battery life.

Like cellular, LPWA solutions provide visibility to reusable assets and their contents in the supply chain where they are most vulnerable. LPWA is generally considered to be a lower cost solution than cellular, but the gap is closing as cellular technologies advance. Coverage is limited to the network infrastructure of the LPWA provider, however, which in North America, is still expanding. There are steps that can be taken to provide coverage where a base station does not exist, however. For example, for customers who need coverage where the public network is not yet available, Sigfox, a leading LPWA technology solution, offers a self-install connectivity kit with a limited range and not insignificant hardware costs.

GPS

GPS, or Global Positioning System, uses a network of satellites that transmit data to the earth on a regular basis. When at least three satellite signals are received, the information is triangulated to provide an accurate geographic location. In the case of reusable packaging, GPS units are typically battery powered. Because of cost and the size of GPS units, GPS usage is more commonly associated with more expensive products and larger containers that travel in areas not easily covered by other technologies, such as trans-ocean transit.

It is worth noting that the spot usage of GPS has proven to be highly effective in auditing the movement of containers through the supply chain. Several companies have used GPS devices to find the location of stolen containers, which in turn has led to investigation by police, arrests and asset recovery.

Bluetooth

BLE (Bluetooth Low Energy) is the most commonly used short range communications standard in the world. It is an IoT approach that utilizes BLE tags (beacons) to communicate to BLE readers and then to the cloud. The read range for BLE tags is increasing - now as much as 250 meters.

BLE tags have long lasting batteries and are relatively inexpensive. In that cellular charges are not applicable, they are an attractive option. Their utility is limited, however, to facilities with BLE readers, which may be linked to facility WIFI, or outside of facilities to use cases where BLE-equipped reusables can transfer data to a BLE reader on an IoT technology such as cellular that can communicate to the cloud. The more BLE readers that are installed indoors, the more accurate that the positioning of assets can be.

BLE is growing in popularity for IoT, especially in combination with other technologies such as cellular. For example, if all containers on a load are equipped with BLE, and a few are also fitted with cellular, all containers on the load can be visible for tracking purposes, while cellular charges are limited only to the containers with that technology.

WIFI

WIFI is an IoT approach that involves WIFI tags and readers to send information to the cloud. It is used within facilities to provide Real Time Location System (RTLS) functionality. Time difference of arrival and differences in signal strength are calculated from signals received at WIFI access points to provide location information. WIFI tags are characterized as expensive, power hungry and large in size. The use case is typically limited to high value loads.

4. Equipment, Materials and Hardware

From a user perspective, the basic hardware requirements for IoT include a sensor enabled, battery powered device that is affixed to the reusable packaging unit as well as equipment related to the user interface. Some IoT applications will require the user to install or coordinate additional infrastructure, such as BLE readers or WIFI network equipment within a facility. Other equipment associated with the IoT network, such as satellites, routers, gateways, and switches, etc, are typically managed by cellular or LPWA providers.

5. Integration in Product

IoT devices can be integrated into the manufacture of products or mounted to completed reusable packaging units. Increasingly, reusable packaging is designed to optimize the placement of tracking devices.

The size of the tracking device is a consideration regarding mounting it to a finished reusable packaging unit. The size of the device can be an issue, for example, when attaching a larger unit such as GPS to a smaller reusable such as a bread tray. Other considerations are device placement and concealment. When a reusable packaging asset is stolen, highly visible devices may be destroyed in order to prevent the tracking of those assets. Device placement on reusable packaging must be planned so that it is not damaged or destroyed by forklifts or manufacturing processes.

6. Key Considerations

IoT technologies such as GPS, cellular and LPWA offer the opportunity to track reusable containers without the need for infrastructure. They can provide visibility throughout the supply chain where solutions such as RFID cannot, and where product and assets are most vulnerable to loss. This opportunity makes the ROI much more compelling, despite the greater expense of IoT solutions versus other tracking alternatives. Another consideration is that the cost of technology used in conjunction with reusables can be very reasonable on a per trip basis, given the long service life of reusables and IoT devices and considering the potential for efficiency gains and loss reductions.

Cellular technologies continue to rapidly progress, bringing more competitive pricing and expanding the range of use cases. LPWA offers a lower cost IoT opportunity than cellular but is somewhat limited by coverage availability. Increasingly, providers are looking at hybrid solutions to bridge the gap between cost and performance. Hybrid tracking solutions include multiple tracking technologies within the same device, such as cellular/BLE, for example. Hybrid tracking solutions can also include mother-child/hub-spoke relationships. For example, BLE tagged containers on a trailer along with a few containers carrying BLE reader, cellular or GPS devices can capture data from the other containers to provide visibility in transit while limiting the cellular charges. Given the diversity of technologies available, there may be a variety of options available to address a particular use case.

Providers recommend the importance of starting with the business need first, rather than gravitating toward a technology too early in the process. By clearly articulating the problem needing to be resolved through tracking, experts can best match a solution to fit your needs.

7. Examples

Examples of IoT in reusable packaging solutions include the following:

- IoT-enabled pallets made of various materials (including wood, plastic and composite) in supply chains such as pharmaceutical, chemical as well as food & beverage
- IoT-enabled cable drums
- GPS-enabled bulk automotive containers to highlight flows and identify leakage points, resulting in multi-million dollar savings for one manufacturer
- GPS-enabled plastic bread trays and dollies have enabled a pooler to identify its equipment at unauthorized locations, leading to prosecution.
- BLE equipped ULDs for air freight applications

E. Blockchain

Blockchain, the technology behind Bitcoin, has been met with considerable enthusiasm. Experts believe it could revolutionize everything from food safety, logistics and banking to voting.

An Aberdeen/Oracle white paper describes Blockchain as "a **peer-to-peer** distributed ledger that offers an **immutable, validated, confidential,** and **common** version-of-truth for the participants in a given blockchain network."

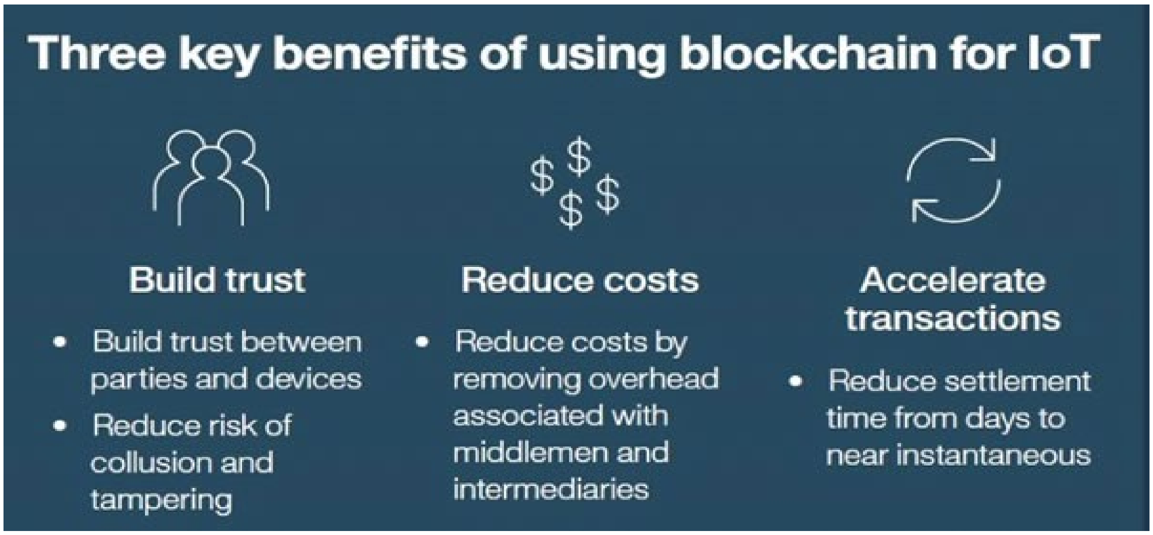
1. Blockchain for Asset Tracking

While the ROI for reusable packaging asset tracking technologies is already compelling for many applications, the emergence of blockchain platforms can be anticipated to provide further synergy, increasing the value of sensor data and IoT-tracking solutions for supply chain applications.

Whereas IoT tracking technologies provide greater quantity and quality of tracking data than other technologies, Blockchain provides a more efficient and secure means of sharing that data among stakeholders.

"Together," the Aberdeen/Oracle white paper observes, "**IoT** and **blockchain** are a powerful force. For instance, when an incident of interest happens (say, a spike in truck temperature in a cold chain shipment) while IoT is used to track and monitor, the pertinent parties that would be interested in this incident could access reliable, verified information of this incident from the blockchain ledger."

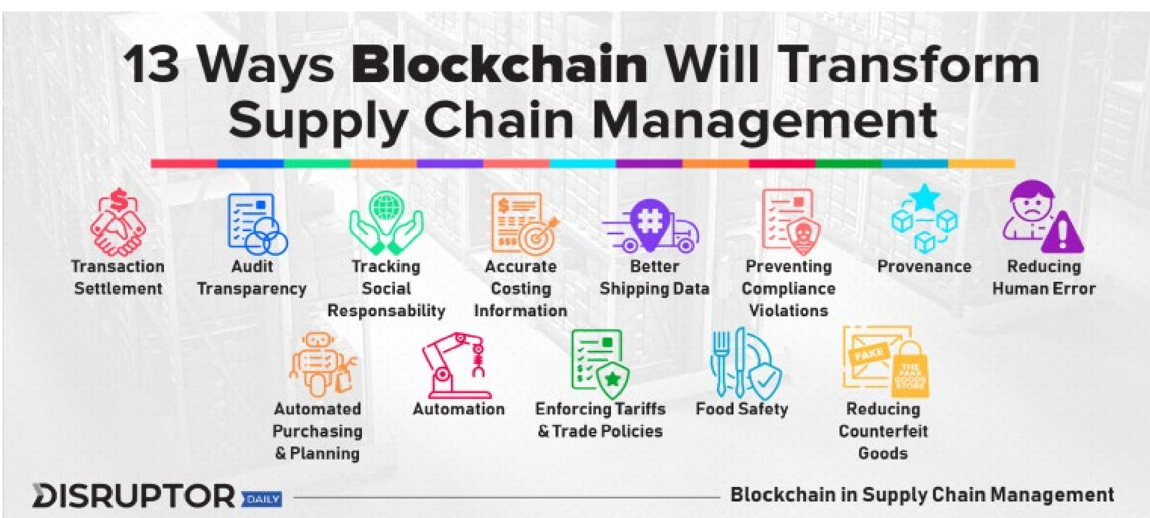
Many thought leaders are enthusiastic about the potential for blockchain in combination with data generated from IoT sensors, seeing it as an opportunity to provide a "single, definitive version of the truth to all trading partners." Trusted information harvested from IoT sensors can offer important business opportunities as outlined below.



Three key benefits of using blockchain for IoT – IBM infographic

2. Example Applications

By becoming a "single source of truth," blockchain, through the aid of IoT information, can help supply chain stakeholders build trust, improve operations, and accelerate financial transactions. There are many potential applications, as illustrated by the infographic below from Disruptor.com.



3. Industry Opportunity

Blockchain, when combined with IoT-enabled reusable packaging, holds tantalizing potential to improve supply chain efficiency, accelerate transactions, cut costs dramatically, improve food safety, reduce counterfeit goods, support social responsibility initiatives and more.

Trusted information can expedite the resolution of product quality claims, for example, as touched upon above. Because all stakeholders have access to validated information, root cause analysis is simplified, and the cause of quality issues is more easily determined.

Another attractive application is in facilitating the rapid identification of unsafe goods in the supply chain, permitting effective product recalls. The envisioned result is a cost-effective and pinpoint accurate recall which builds consumer confidence in the process. According to information from Walmart and IBM, blockchain can reduce the time taken to trace products in a recall from seven days to 2.2 seconds. Utilizing IBM's Food Trust blockchain platform, Walmart announced early in 2019 that all suppliers of leafy green vegetables for Sam's and Walmart must upload their data to the blockchain by September 2019.

Other benefits include fraud resistance as well as the potential to accelerate transactions, decreasing time of settlement from days to nearly instantaneous. The opportunity to decrease the cost of transactions is enormous. As Disruptor.com notes, time-consuming cross-border payments, which are routine in many supply chains, drain $1.6 trillion in system-wide costs per annum.

F. Tracking Case Studies

Barcode Helps Tosca Optimize its RPC Rental Pool Operations

Tosca, a leading pool provider of RPCs in the perishable goods sector uses barcode labels to track its RPCs. (It also has been integrating combination barcode/RFID tags for its other categories of reusable packaging.) Being able to scan the reusable packaging units is critical to the company's operation. If an asset hasn't been scanned, then pooler is unable to capture information crucial to the management process.

When RPCs are returned from customers to the pool operator, the units are washed before reissue. The RPCs are scanned during the automated wash process. A full pallet of scanned, washed crates is then associated with a pallet label which is applied to the load, now ready for shipment to a customer. This process captures information such as wash location, wash date and wash time, in case there is ever a need to review wash history.

The pooler also utilizes scan data to assess its asset turn rates, areas of loss related to customers or geographic areas, and to explore other opportunities for operational improvement.

Barcode Scanning Reduces Reusable Bin Loss for Watermelon Grower

Shortly after a leading watermelon producer made the switch from wood pallets and expendable corrugated sleeves to returnable plastic bulk containers, the company began to experience problems with empty bin return from customers, ranging from a two-week return lag to not returned at all.

With the prospect of purchasing additional bins and procuring corrugated expendables as a stop gap diminishing the ROI, the grower reached out to the reusable packaging supplier Buckhorn Inc., which had supplied the 11,000 reusable knockdown bins for the grower's system.

The Kennedy Group, a specialist in labels as well as reusable packaging tracking technologies, was introduced to the application. Because the supply chain was not overly complex (a maximum of 500 bins were being shipped daily to seven distribution centers), a simple, inexpensive and easy-to-integrate barcode solution seemed to be a practical approach.

After watermelons are washed and loaded into bins, the barcodes are scanned and weighed. The bin weight is associated with that bin. Finished packed bins are staged in a cool holding area to await shipment. Once assigned, the full bins are scanned to a load, allowing the watermelon grower to know where the bin is going, when it was shipped, along with bin weight and packing date.

Empty bins returning to the watermelon grower are scanned, allowing it to record returns from each distribution center and assess damage trends associated with the handling DCs. After the tracking system was implemented, return rates quickly jumped, and additionally, bins that had been missing now found their way back to the grower.

Active RFID System Allows OEM to reduce Reusable Rack Inventory

Working with a tier supplier, an automotive OEM tagged steel shipping racks with active RFID tags in order to better monitor rack inventory and prevent disruptions to the manufacturing process. Antennas were placed at the tier supplier's guard shack location as well as at the OEM to capture the movement of the racks.

Incoming racks arriving on trailers can be read by the antenna from inside the trailer. One initial challenge was determining whether the racks being read were incoming or outbound. This challenge was resolved by adding a second reader. Another challenge was in designing the system to make sure the trailer was in range for at least a 10-second period, as the tags pinged only every 7 seconds.

A daily inventory of available racks within the tier supplier is taken with a mobile RFID reader - a computer that an employee takes on a golf cart through the facility. Daily inventory information is used to validate the information captured from the antenna. While the accuracy of the read rate at the guard shack had been around 95%, the antenna configuration has recently been changed, which has improved the read rate. Overall, the tracking program has been successful and has played a role in reducing the shipping rack inventory requirement from 5.8 days of production to 2.7 days.

Japan Pallet Rental Utilizes RFID to Improve Operations and Optimize Transportation

Japan Pallet Rental (JPR) operates a rental pool of approximately 7.5 million RFID-tagged plastic pallets. When pallets are returned to a JPR depot they are scanned by a device (called DOA or Dead or Alive) that verified that the tag is working, and then by a forklift mounted RFID reader (Tag Reading Fork).

RFID data provide operational insights such as the depot of issue and customer, the number of days in the field, and the location of collection. According to JPR, RFID has helped it provide accurate shipping to its demanding customers. Additionally, JPR believes that such data will allow it to make more precise demand forecasts, production plans, truck scheduling and allocation decisions in the future.

One JPR customer, a soya sauce manufacturer, has started a new initiative using the pallet RFID tags to associate product-related data to them in order to provide greater shipping visibility to that company.

JPR also reports that RFID data has been integral to a freight optimization partnership involving Lion (a personal care products provider), Kewpie (processed foods) and JPR. The initiative has resulted in much higher truck utilization and corresponding reduction of empty miles, leading to a 62% reduction in CO_2 emissions.

RFID Helps Food Service Provider Reduce Reusable Tote Replacement

In 2016, a food service distributor was using 60,000 disposable cardboard cartons each week to deliver products to its many customers at around 4,000 different sites. It transitioned to reusable crates to help its customers reduce solid waste. Reusable tote loss, however, became a concern. It instituted an UHF RFID solution that captures data when crates are packed, as well as when they are shipped and returned. Using this information, the company has been able to identify where totes end up delayed or missing, and subsequently address such problems. Since instituting RFID with some of its customers, the company saved almost $200,000 in the first year in avoided reusable tote replacement and hoped to more than double that saving when fully implemented to all clients.

Cable Supplier and Customers Enjoys Real-time Geolocation, Alert system and Stock Visibility

Because complex supply chain processes can involve multiple teams, construction sites and subcontractors, expensive cable drums and cables are frequently lost, stolen or left idle on sites. DSOs (distribution service operators) can lose hundreds of thousands of euros a year due to the lack of visibility of their drums scattered across construction sites. It is also challenging for DSOs to monitor their stocks across multiple remote storage sites.

To help its customers address this issue, a leading cable supplier designed a digital solution comprised of a fleet of cable drums with integrated, tiny battery-powered sensors that connect each drum wirelessly to a cloud-based management platform (available on desktop or mobile app). This innovation provides customers with the real-time location of each drum as well as an alert system for monitoring on-site events, such as deliveries or pickup. First launched in 2016, the success has led the company to expand its Connected Drum program to six countries. Based on current results, the implementation of the Connected Drum service could lead to a reduction of up to 90 percent in the theft and loss of drums.

The solution, however, goes beyond cutting costs through improving traceability. The technology also allows customers to track how much cable is left on each drum. Thanks to a real-time interface between the connected drums platform and the cable supplier's ERP (Enterprise Resource Planning) solution, the customer can monitor their drums and access business information such as cable type and remaining lengths, sites, stock levels and other important details. Multiple KPIs can also be visualized on dynamic dashboard.

The platform helps to reduce the amount of time that empty drums are left on site waiting for pickup, saving on costs and working capital. Estimates show that the Connected Drum technology can reduce the rotation cycle (the time it takes to return a drum back to the cable supplier) by as much as 25 percent - improving efficiency for both customers and the supplier. Source: Nexans

GPS Helps Bakers Basco Recover Stolen Reusable Bread Trays from Recycling Plant

Bakers Basco is a UK pooler of plastic bakery trays (baskets) and dollies with an inventory of four million baskets and 500,000 dollies. It was created in 2006 by an alliance of bakers to standardize the baskets and dollies used throughout the bread supply chain. The baskets are modular, stack together, design to fit neatly into commonly-used delivery vans and nest together when not in use. The standardized approach reduces waste and improves logistics within the industry.

Bakers Basco equipment is clearly marked as the company's property. However, every year, several million pounds' worth of its equipment, meant purely for the safe transport of bakery products, is misappropriated by third parties who have no contractual relationship with Bakers Basco Ltd.

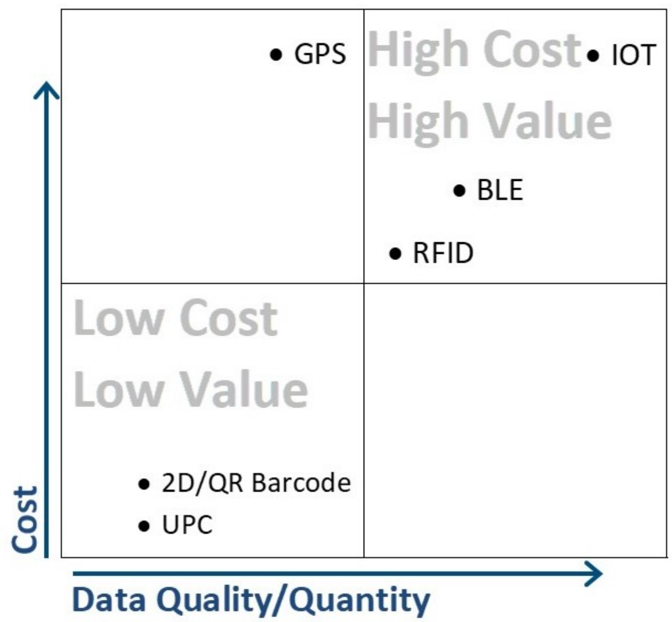
In order to combat ongoing basket and dolly theft, the company has been increasing the use of GPS tracking chips in some of its equipment in recent years, with regular updates as the technology evolves, resulting in a number of successful court cases.

Speaking after the latest successful court case, Bakers Basco stated that its investment in GPS trackers has provided a solid payback.

VI. GETTING STARTED

1. The Big Picture

One way to think about finding a technology solution to fit your reusable packaging needs is to understand the value of the information you need to accomplish your objectives. Here, one can consider value as a function of the cost of the technology relative to the quality and quantity of data, as shown here:



Cost broadly includes the expense of the tracking or monitoring units as well as the hardware (readers/scanners), including physical installation, and software needed to capture, present and analyze your data.

Data Quality includes the granularity of unit data (product/carton/pallet/truckload) and the accuracy of that data. For example, can you locate an item within a facility, or specifically in aisle 3, level 2, bin #123?

Data Quantity reflects the potential breadth and depth of data gathered beyond mere time/date/location, such as temperature, humidity, vibration/shock, weight, or empty/full status.

2. Business Case

The purpose of a business case for implementing any labeling, monitoring or tracking technology is to determine the potential return on investment in terms of cost reduction, process improvements, operational efficiency gains, inventory turn and production impacts.

While not all these are knowable before implementation, one only needs enough solid data to exceed whatever minimum return threshold makes sense for your organization. Once that threshold is met, the investment is justified if there is reasonable indication that any additional benefits will outweigh any unforeseen costs or negative impacts.

Your minimum return threshold may be considered in terms of real dollars or a percentage of investment. Either way, you will need to quantify estimated cost savings or other positive financial impacts derived from implementing any new technology.

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

For example, Widget X is a key component to your manufactured product. Because it is a delicate item, you must discard $100,000 worth of Widget X each year due to damage suffered in transit from your supplier to your plant. After following the process outlined below, you determine that a monitoring solution will enable you to reduce damage by half, but the solution will cost you $20,000 per year.

One approach is to apply an "if, then" statement to each potential application, such as, "If we reduce in-transit damage on Widget X by 50% through improved monitoring of logistics routes and providers, we would save $50,000 per year."

Using this example, these are the components of the business case to consider:

Objective:	*Reduce in-transit damage on Widget X*	Specific product with a specific process in which changes can be successfully measured, analyzed and reported
Metric:	*Reduce damage by 50%*	Specific direction and the measurable goal, either in percentage, time or cost

Application:	*Monitoring of logistics routes and providers*	What the technology will be expected to measure, monitor or track
Scope of Benefit:	*We would save $50,000 per year*	The expected tangible result of the business case
Investment Required:	*$20,000 per year*	Estimated cost of implementing technology
Net ROI:	*$30,000 per year +*	The minimum return expected on investment. It may be likely that reduction in damages could be much higher than the estimated 50%, and the addition of this monitoring technology could have other visibility benefits that could add to the cost-savings or efficiencies gained.

Take a Holistic View: What other benefits or positive by-products or side effects will add to your ROI consideration? Often one tracking technology can produce a variety of opportunities for different parts of your organization to measure, track and analyze the movement of your products or packaging.

Build the Team: Who do you need on your team to help produce the business case? Projects are often started by members of the team responsible for packaging, for example, but discover that by speeding up the flow of packaging, it has impacts on accounts receivable (if customers or vendors have paid deposits on your packaging) as well as inventory management and supply chain management. If adding a tracking or monitoring technology will impact the speed to market for perishable goods, for example, then the quality assurance team should be involved in the selection of a solution. Consider building a team with a representative of each department or division that your newfound data could potentially impact.

3. Business Case Development Process

While the following is not necessarily a linear process for developing a sound business case for creating a smarter supply chain through technology, it is a solid method of framing it out:

1. Identify and select business and supply chain objectives
2. Quantify the problem to solve and benefit to gain
3. Determine characteristics and requirements of the supply chain

4. Decide on temporary or permanent technology solution
5. Estimate quantity of assets to enable with the technology
6. Select technology type for best fit with intended deliverables
7. Derive the costs and investments needed for positive returns

1. <u>Identify and Select Objective(s)</u>

What problems are you trying to solve?

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

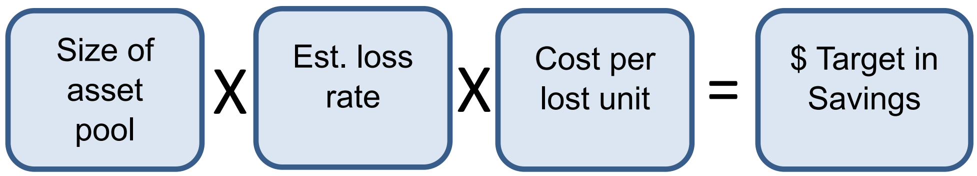
- Reduce/eliminate packaging or product loss
- Reduce/eliminate packaging or product damage
- Speed up packaging inventory turn or cycle time
- Identify specific supply chain process inefficiencies
- Create or evaluate standardized handling processes
- Monitor packaging or product flow through the supply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

2. <u>Quantify the Problem to Solve/Benefit to Gain</u>

Once an objective is selected, you must first quantify the problem. If the chosen objective is to “Reduce reusable packaging asset loss,” for example, then 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.

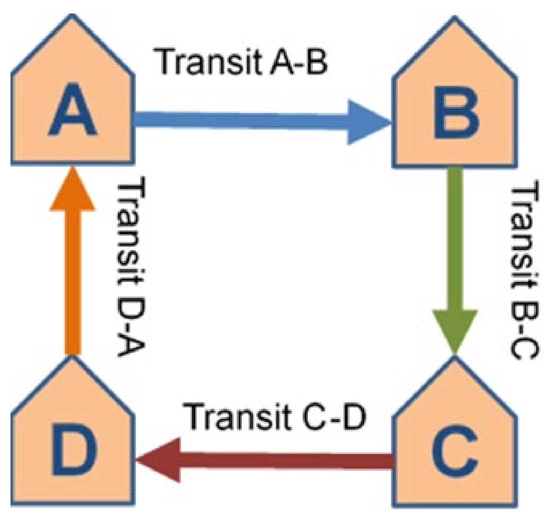
Asset Loss Calculator:



3. Determine Characteristics of Supply Chain

In terms of considering the movements of your reusable packaging assets and the factors that may affect asset losses, it is helpful to think of it in terms 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 full cycle.



Source: ReturnCenter

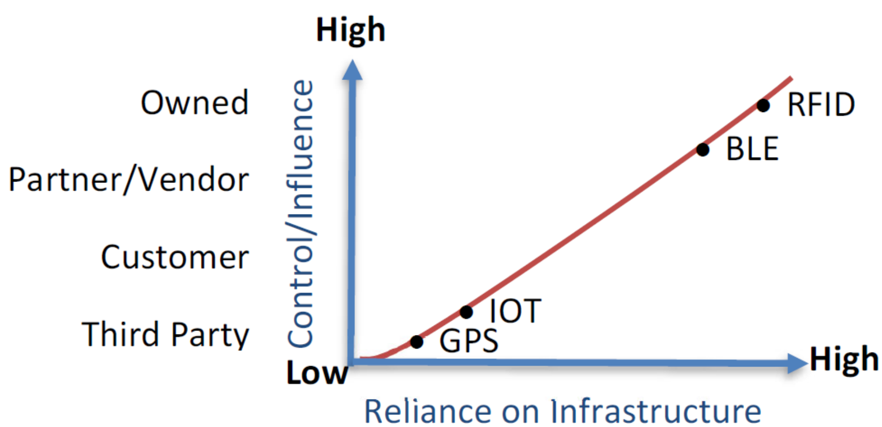
Your choice of technology will depend on several characteristics of your supply chain:

- 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 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 important in terms of how feasible it might be to install 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 a technology that has a higher degree of 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 to work (i.e. IOT/cellular). (See Control vs Reliance Figure below)



Source: ReturnCenter

4. <u>Decide on Temporary or Permanent Solution</u>

Is this a short-term or long-term solution?

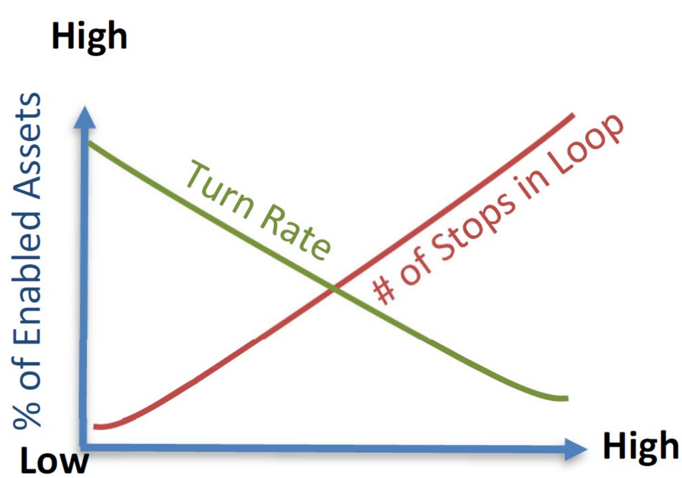
Temporary Technology: If can you track a few assets for 6 months and figure out the problem enough to develop a solution, you have a short-term project. Look at detachable technology to temporarily install on a small portion of your pool or leased tech-enabled reusable assets that will give you the data 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, then you should 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 perhaps combines RFID, BLE or WIFI technologies.

5. Estimate Quantity of Assets to Enable

How many tracking devices would it take to sufficiently solve this problem? 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 tracking at least 20% of your pool. But there are other factors as well, 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.

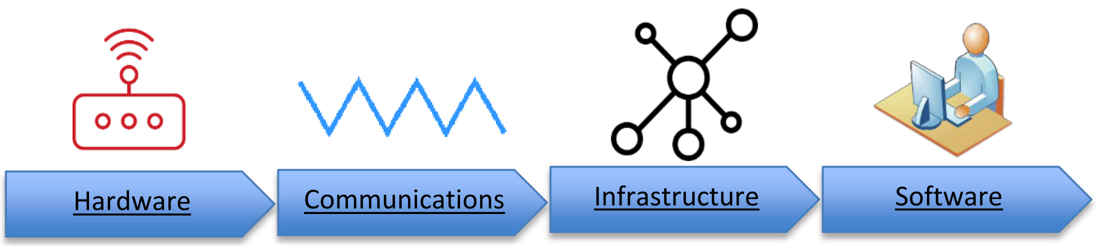


Source: ReturnCenter

Upshot: If you have either a high number of 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

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 actual device attached to or embedded in the reusable asset. This could be type of tag, a sensor or a unit that collects and/or 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 or to a WIFI gateway, or it could be a cellular SIM card transmitting IoT data through the LTE network.

Infrastructure consists of readers you may need to install for RFID or BLE, or it may refer to cell towers for use with LPWA, or even to satellites that are needed for GPS communications. In looking at costs, the usual tradeoff is a low unit cost for hardware like an RFID tag that requires a high infrastructure cost in terms of 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 GPS or 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 on a daily basis 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 rough idea of how to consider 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

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

Technology vendors can help guide you toward suitable technologies or away from unsuitable technologies if you can clearly communicate your needs based on the process outlined above. Once you have settled on the supply chain technology you truly need, then you can initiate an effective vendor selection process.

The Reusable Packaging Association (RPA) is a resource to network with industry experts and to 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. RPA members collaborate to advance common business interest in the reusable packaging industry for pro-competitive market promotion and growth. Visit www.reusables.org for more information about RPA programs and membership.