Understanding the Gen 2 Smart Label Supply Chain: What Retail Supply Chain Professionals Need to Know

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Radio frequency identification (RFID) technology promises to usher in major efficiencies and enable a truly demand-driven retail supply chain based on Electronic Product Code™ (EPC). Not only can inventory be managed in an automated fashion without line of sight using wireless RFID readers, but "just in case" inventory is possible with individual items being managed at the carton, case, or pallet level.

The EPC supply chain that delivers consumer goods to retailers is similar in many ways to the supply chain that delivers Gen 2 smart labels for application to their cases and pallets. Demand-driven supply chains such as these can only be efficiently managed through cooperation among all parties in the process. While the “age of the bar code” required close partnerships among retailers, consumer product goods (CPG) manufacturers and their label suppliers, the “age of EPC Gen 2” requires an even greater level of collaboration and coordination with Gen 2 technology suppliers to reap the rewards from EPC deployments. It is becoming increasingly important for CPGs and retailers to understand the amount of lead time required to fulfill their Gen 2 smart label orders and how changes in forecasts that occur in the production phase can impact label delivery.

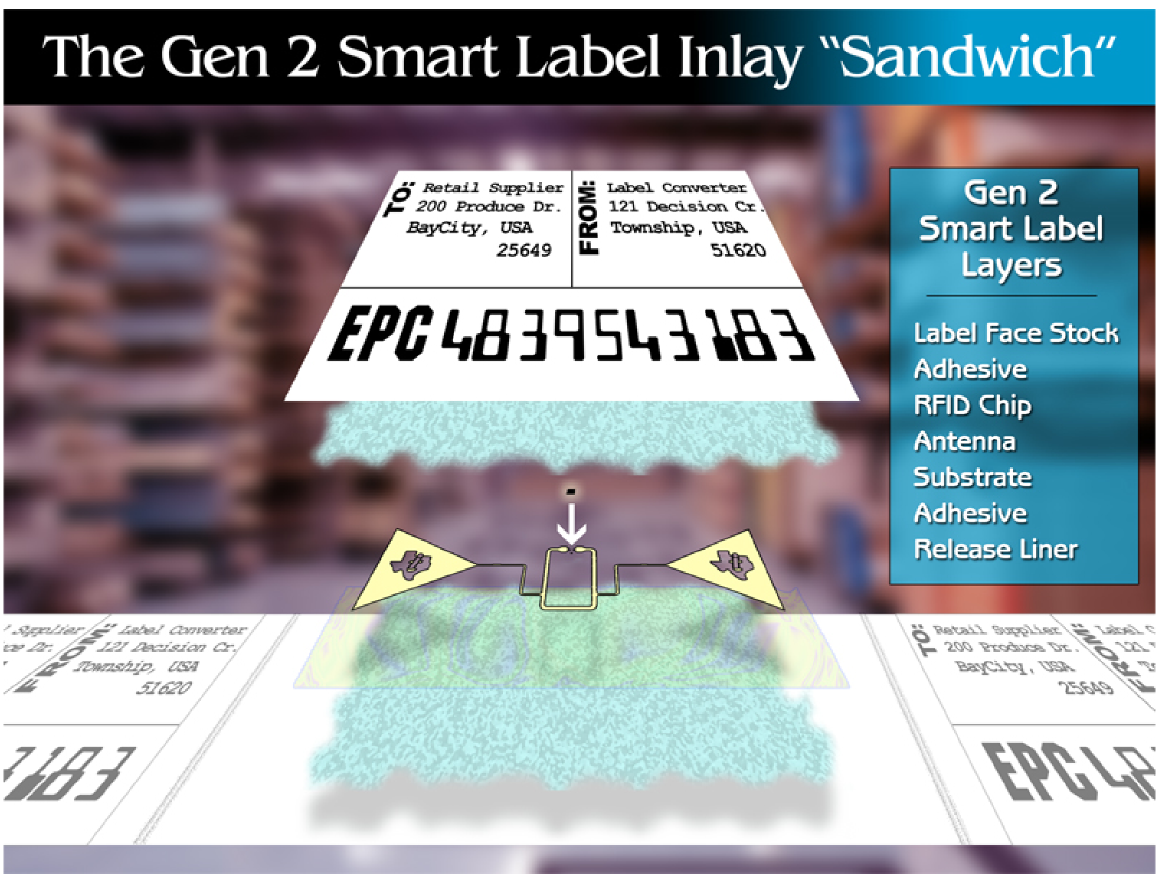
This white paper details the Gen 2 smart label manufacturing processes to make retail supply chain professionals aware of the lead time requirements and how important their initial input is in keeping the supply chain demand-driven. By leveraging the insight and experience of major RFID players, CPGs and retailers can achieve greater efficiencies in their own supply-chain management.

Gen 2 Smart Label Components

A Gen 2 smart label consists of several key components:

1) A semiconductor wafer processed into chips that have the ability to store EPC data. These chips are small in size with enough data storage capacity to satisfy EPC requirements,
2) An antenna made of a conductive material that enables the chip to receive and send data to and from an RFID reader,
3) A substrate on which the antenna can be printed, and to which the chip can be adhered,
4) A label face stock which covers the inlay and provides a readable print area,
5) A release liner that serves as the bottom "sandwich" layer for the inlay. This layer allows the pressure sensitive face and inlay to be made into rolls for easy distribution, and is removed when the smart label is placed on the carton or pallet,
6) An adhesive that attaches the inlay to the face stock, as well as the release liner to the inlay and face stock.

Figure 1: Layers of a Gen 2 Smart Label



The first three components make up the inlay which can require 10-14 weeks to produce and deliver in reel form to the label converter. The label converter receives the reel of inlays and adds components four through six which can require an additional one to three weeks. The smart labels are ready for distribution and use when these components are combined to make a a label. This means the production process can require 15 to 17 weeks lead time for production and delivery. Put in terms of the supply chain, modifications to a label order could require months to implement and could potentially delay delivery of the labels. In addition, adjusting production to respond to large increases in demand could take months and lead to unplanned smart label stock-outs. In short, unfamiliarity with the Gen 2 chip, inlay, and label manufacturing process can lead to an undesirable extension of lead time.

The Semiconductor Manufacturing Process

Managing the semiconductor manufacturing process has a significant effect on smart label availability. Consider the Gen 2 solutions from Texas Instruments (TI). The entire processing flow for the integrated circuit (IC) consists of 20 to 30 steps to define the semi-conductor elements, interconnects, and overall modules. These enable the highest degree of scalability in the design and processing of the analog, digital, and memory components that make up the IC. The Gen 2-compliant IC is manufactured in TI's state-of-art clean room facilities using leading-edge 130nm (nanometer) process node technologies which means TI can produce high volumes faster than with older process node technologies. The finished IC is tested to ensure reliable functionality in the field.

Once the ICs are ready, the next step is the manufacture of inlays. The inlay assembly process begins with alignment of the chip bumps, typically 60-100um in diameter, with the landing pads printed as part of the inlay configuration. Each bump provides a physical electrical connection to the analog and digital circuitry that make up the Gen 2-compliant IC. The bump is pressed onto the landing pads and mechanically secured with a high-strength epoxy to ensure a good conductive electrical connection.

The inlays are processed in a web-format using a fast-curing epoxy to minimize processing time. The inlays are also tested in web-format to ensure that electrical testing does not bottleneck the assembly flow. Maximum test coverage minimizes the likelihood of failures in the field. Inlays that do not meet the electrical test requirement are marked so the label converter can easily remove them from the production process.

While high volume demands are projected for this industry, it remains important to provide a highly reliable electronic product that can withstand the label manufacturing process and the harsh environment of a retail supply chain. Optimal process conditions must exist to overcome potential "crosstalk" or interference issues while maximizing throughput, electrical test coverage and yield.

The Effects of Antenna Design on the Supply Chain

The inlay's antenna design is a key component of a Gen 2 smart label. Products shipped to retailers with an EPC RFID mandate are diverse in size, shape, material, and density. These product variations result in corresponding variations in radio frequency properties which can adversely affect the performance of Gen 2 smart labels meant for products or cartons.

Designing, building, and testing a Gen 2 antenna is an involved process that requires a significant amount of time to create an optimal implementation. RF engineers at TI use the most comprehensive antenna design software, modeling software, and testing procedures available today to design efficient Gen 2 inlay antennas. A Gen 2 antenna can be custom-designed for any consumer product, but the time it would take to accomplish this is impractical and prohibitive, given the great variety of potential products that require labeling.

To address the need of CPGs and retailers implementing EPC initiatives, TI's antenna portfolio is targeting a broad range of consumer product categories:

1) RF-friendly: generally paper and plastic products with little or no metal or water content
2) RF semi-friendly: usually pharmaceuticals and electronics products that require careful placement of label on product casing to perform well
3) RF semi-unfriendly (UHF absorbing): including liquid products
4) RF-unfriendly (UHF reflective): including products with considerable metal content

In order to manage these variables in the Gen 2 smart label supply chain, inlay providers will likely offer three or more inlays resulting in three or more part numbers. Furthermore, end-product variations require technology providers like TI to build specific inlay and antenna designs to meet customers' requirements.

The steps involved in manufacturing a wafer of Gen 2 chips and perfecting various antenna designs are complex. The more accurate the information that semiconductor manufacturers like TI, and label converters like NCR, have about the market and end-user's forecasted requirements, the better their ability to plan according to market demand and to roll out a more efficient supply of smart labels.

To minimize the changes in forecasted smart label requirements forward-looking companies should prove out their processes in advance to know which labels will work on their products and how products will flow through their facilities. That is where supply chain management companies like IBM can add significant value. Working with companies to incorporate RFID requirements, IBM helps design, build, and test RFID systems to identify optimal smart label configurations. Armed with this information, customers can forecast demand more accurately and share this information with the label converter and semiconductor manufacturer.

Label Conversion

To create a Gen 2 smart label, a label converter like NCR takes a flexible inlay containing an IC and an etched metal or printed antenna, and inserts these components between the face sheet and liner of a label. During inlay testing the face sheet of a pressure sensitive material is split away from the liner or laminate to a transfer adhesive. Inlays that meet the appropriate testing criteria are then attached to the adhesive that covers the back side of the pressure sensitive face sheet. After insertion of the inlay, the liner is reunited with the face sheet and die-cut to the desired label dimensions. The excess material is stripped away and the label is tested one more time before being wound on a roll for use.

Best practices for packaging inlays and shipping to label converters:

- Do not wind inlay reels too tightly or the tension can cause damage to the chips.
- Carefully calculate the quantity of inlays per reel so that the weight of the outer inlays does not damage the inner ones.
- To prevent potential shipping damage, use outer packaging with cushioning at the various pressure points. One reel per protective box is recommended.

If the labels are going to be run through an EPC-enabled variable thermal printer, placement of the inlays are critical and are defined by the specification set by the printer manufacturer. Tolerances for inlay placement are in millimeters, so even a slight deviation in the placement of the inlay can cause a thermal printer to "miss" the inlay during encoding and mark a fully functional label as void or failed.

There are generally two ways to convert an inlay into a carton or pallet smart label. The first is pre-conversion editing which tests and edits (i.e. replaces) defective inlays before they are inserted into final label constructions. The pre-conversion method typically cuts a stream of continuous inlays into individual units. In this method a parametric test is done on the inlays before they are placed into label construction in order to measure the quality and viability of the inlay and determine the reflective strength of the inlay.

The second approach is post-conversion editing which employs many of the same steps except it does not test the inlays before they are converted into labels. Inlays can be aligned with the face sheet in an "on pitch" or one-to-one ratio. After the liner is reunited with the face sheet and die cut, labels are processed onto finished rolls. These labels are then tested off-line via a separate test station where nonworking labels are manually edited and can be replaced with working labels.

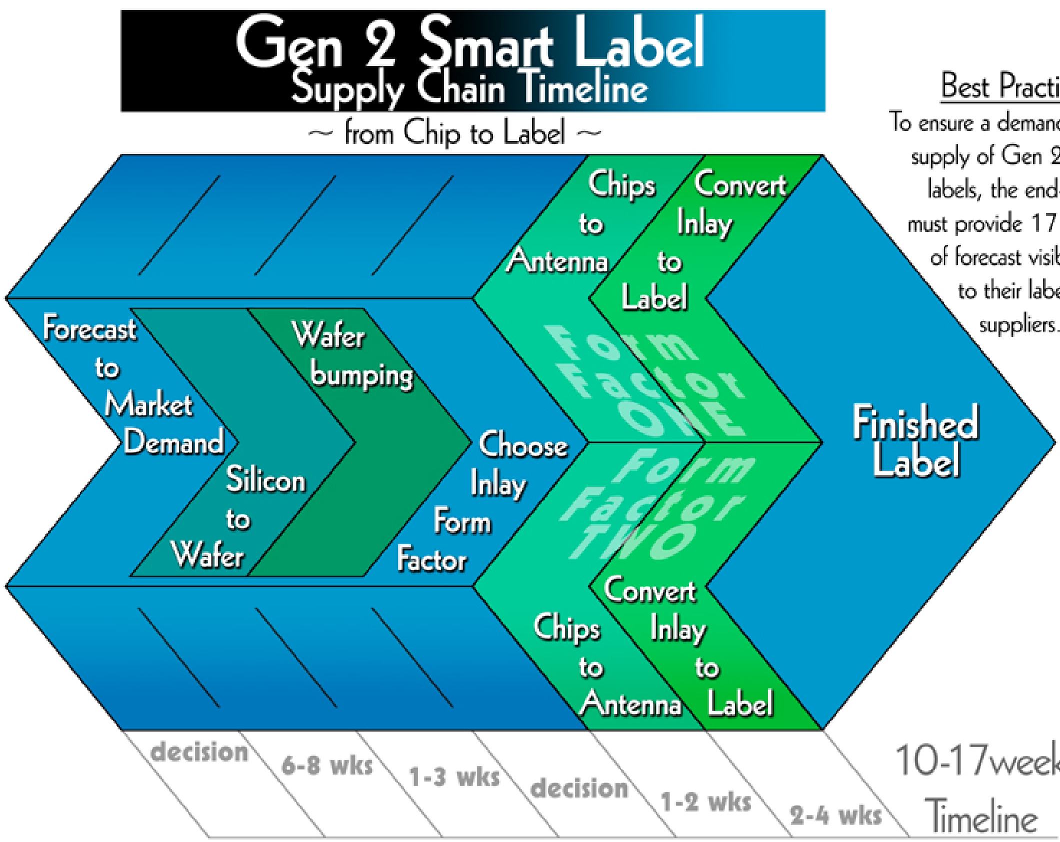
There are limitations associated with the post-converting testing method. Because post-conversion uses manual placement of labels and is not exact, this may result in printing/encoding failures further in the process. The release value of the label adhesive is also altered with label replacements, potentially leading to pre-dispensing issues and equipment jams. Pre-conversion editing is preferred over manual editing, because manual editing will not scale in the long term as Gen 2 smart label volumes increase.

On-Time Delivery

The final stage in the Gen 2 smart label supply chain is the appropriate placement of the inlay in the label. Placement is important because it determines the type of printer the end customer will need to print their labels. Because CPGs and other manufacturers have a variety of products to tag, they will likely require different types of labels. Most will use EPC-enabled printers in their packaging or shipping processes, and inlay positioning within the adhesive label may be different between printer models and manufacturers.

The ordering, manufacturing, and inventory of Gen 2 smart labels are more complex than for standard, bar code-printable adhesive labels. Label converters make a wide variety of labels available across a diverse customer base, and the challenge is to manage in-stock supplies efficiently. It is essential that a label converter have an intimate understanding of its customers' Gen 2 smart label requirements so that it can procure the appropriate materials and schedule manufacturing, testing, and shipping to reduce and ultimately prevent any negative impact or delay on the supply chain. Today, many label converters provide testing facilities and services to end-users to ensure that Gen 2 smart labels will be determined and appropriately matched for use with their stock keeping units (SKUs).

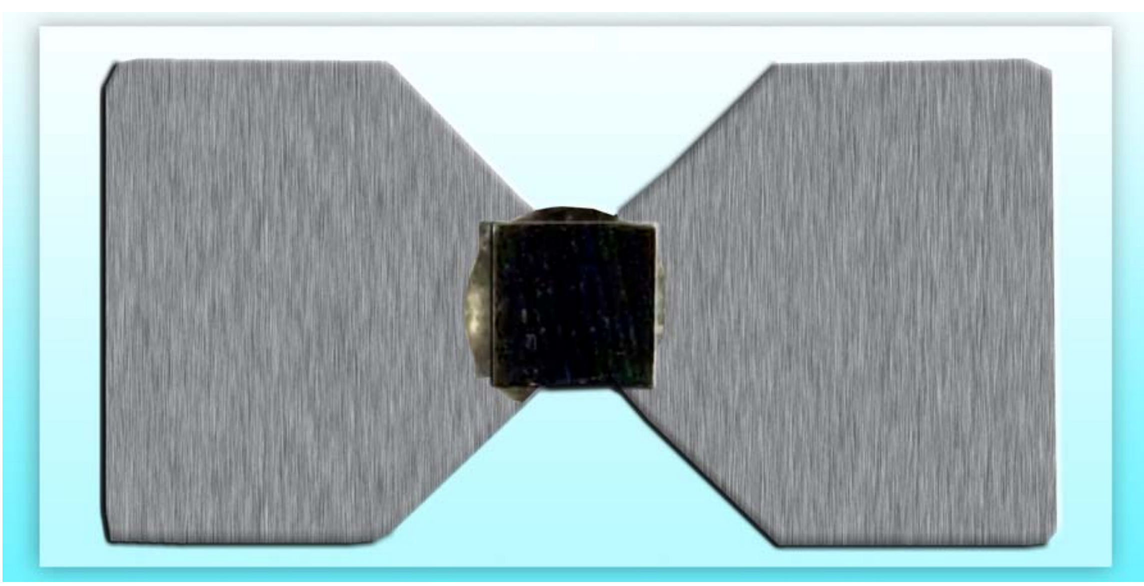
Figure 2: Timeline of Gen 2 Smart Label Production



Future Efficiencies

The Gen 2 smart label supply chain promises to become even more efficient as label converter companies assume part of the inlay production process, bringing production closer to the end customer in the demand-driven supply chain. TI is already working to make this possible through the development of a strap product.
The strap form factor is composed of RFID silicon with two conducting paths that make it easy to attach the chip to an antenna. These straps will also be shipped to the label converter on a reel, but they are about one-tenth the size of inlays. Forty thousand straps can fit on a reel versus only 10-12 thousand inlays. This will enable semiconductor companies to ship more straps per package than with inlays and therefore meet high volume demands. Label converters can also use their own printing skills to print antennas using conductive ink. TI is working with equipment manufacturers such as NCR to make the process of attaching straps to antennas and inserting them into adhesive labels as efficient as possible.

Figure 3: Texas Instruments' Gen 2 Strap



Gen 2 Smart Label Supply Chain: Keys for Success

Any supply chain like Gen 2 smart label production that carries long lead times becomes more dependent on the demand insight from all the customers in the chain. This white paper examines how sufficient visibility and cooperation between supply chain partners can help drive the efficient flow of smart label production and support the EPC retail supply chain.

With the level of variation and complexity in the Gen 2 smart label supply chain, it is not realistic or sufficient for companies to only focus on individual improvements. The demand driven supply chain requires intentional, informed, and innovative process development between all its members. The more that the semiconductor manufacturer, the label converter, and the end customer can communicate true demand signals to drive production, the more successful each player can be in their quest to meet customer's needs cost-effectively and efficiently.

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Sheri Phillips is an associate partner within IBM's Supply Chain Management Practice. This practice is responsible for providing customers with solutions to streamline and optimize their supply chains. She has executed projects applying Theory of Constraints (TOC), Six Sigma, e-business Strategy, Business Process Reengineering, Continuous Flow / Lean Manufacturing and DesignFlow Techniques in the electronics, aerospace, general manufacturing and chemical & process industries. She has over 20 years business experience and 15 years in changing the way organizations execute their business. Methods applied include TOC, Drum-Buffer-Rope, Replenishment, Thinking Processes, Critical Chain Project, Resource and Portfolio Management, Lean concepts, continuous flow, organizational / job redesign, facilitation, Statistical Process Control, Design of Experiments and the TQM Process. She is currently a certified TOC Jonah & Six Sigma Blackbelt.

IBM provides supply chain management expertise to the semiconductor industry as well as the retail industry through supply chain consulting to reduce cycle-time, increase operational effectiveness, and improve the integration of systems by leveraging supply chain information. IBM has been recognized by industry leaders for assisting companies in deploying RFID technologies.

Peter Bloch is the global RFID program director of the Systemedia division for NCR. Peter is responsible for the development and delivery of program elements that make up NCR's RFID labeling offer. His work roles include business development, partnership & alliance negotiation, business planning, program design, training, and execution.

NCR's Systemedia division is a $500,000,000 manufacturer of printer consumables, with 12 global manufacturing locations, 1,556 employees, and 120 years of experience. NCR's RFID labeling offer consists of both product and service offerings. Program products include NCR manufactured RFID labels & ribbons (consumables), hardware, & related software. Program services include technical support line, print technology selection, material analysis and recommendation, product customization, e-media services, and business impact modeling. NCR also is one of the initial sponsors of EPCglobal (formerly the Auto-ID Center).

Tammy Stewart is an EPC business development specialist for EPC UHF solutions at Texas Instruments RFid Systems, a business unit of Texas Instruments Inc. based in Plano, Texas. In this position, she is responsible for developing strategic partner relationships with label converters that provide EPC products to end-users. Previously, Tammy was a partner relationships specialist, directing TI's RFID channel partner activities, and she also served several years as a field sales representative for TI-RFid products.

Tammy earned a bachelor's degree in business administration from the University of Texas at Arlington.

Texas Instruments is the world's largest integrated manufacturer of radio frequency identification (RFID) transponders and reader systems. Capitalizing on its competencies in high-volume semiconductor manufacturing and microelectronics packaging, TI is a visionary leader and at the forefront of establishing new markets and international standards for RFID applications.