RFID
An Educational Primer
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Purpose

The intent of this document is to provide the reader with a basis of education regarding RFID technology, markets, and applications. For illustration purposes this document does discuss certain RFID technology characteristics. Readers of this document are cautioned not to dwell on the details of the RFID technology itself, but rather to apply the capabilities provided by the technology to the business problems that it can help solve.

RFID Defined

Before we can begin to understand *RFID* technology characteristics we must first understand just what is RFID. RFID (Radio Frequency Identification) is a means of storing, and retrieving data through electromagnetic transmission to an RF compatible integrated circuit. This RFID tag or integrated circuit is usually a single solid state memory chip, but could also be designed where several electronic components together are used to form an integrated circuit design. The circuit includes one or several memory chips that are used for data storage, a substrate backing material or circuit board structure, and an antenna of some type or design. This circuit may also contain a power source (battery) depending on the tag (transponder) design.

RFID System Components

Just like an *RFDC* (Radio Frequency Data Collection) system, an RFID system has several basic components. These are:

Interrogator - The interrogator or "reader" is a device that is used to primarily read and write data to RFID tags.

Transponder - A transponder is an RFID tag. As stated earlier it is an enclosed integrated circuit that stores data.

Radio Frequency - Similar to RFDC, RFID uses a defined radio frequency and protocol to transmit and receive data from RFID tags. Also similar to RFDC, these RFID radio signals are subjected to the same physical phenomenon laws that affect RFDC.

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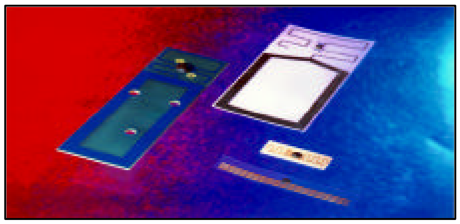
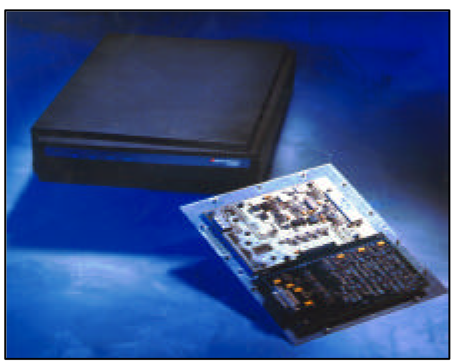
RFID – Theory of Operation

For RFID to operate from an application standpoint, several assumptions must first be made.   An item(s) must first contain an RF tag. This tag may be used as a stand-alone tracking agent (enclosed integrated circuit tag), or in conjunction with a printed bar code label (intelligent label).



(Left) Tags pictured
915 MHz cont. tag
915MHz window tag
2.45GHz meander flex
2.45GHz insert

An interrogator is then used to “scan” the tag. The interrogator (controlled by some type of host computer) transmits an RF signal out to the RFID tag(s). In order for these tags to be read by the interrogator they must be presented in a defined RF area of saturation, known as an *RF portal*, or RF field of view.   This RF signal first activates the RFID tag(s), and then interrogates each tag based on criteria received back to the interrogator from the first RF transmission.



(Left) Intermec 2100 universal access point with RFID reader board pictured in foreground

The tag(s) will then be interrogated or scanned according to logic control, or RFID application programming in the host computer. It is this level of application logic that provides the selection of a particular tag(s) and data manipulation criteria for those identified tag(s). Using a host computer application program, specific tags can be selected to be identified, and the data contained within those tags to be acted upon while those tags are active within the RF portal.

The RF portal is defined as the area where RFID tags can be read or written to. The portal can be stationary or mobile. Stationary portals are used mainly in applications where the item containing the RFID tag has to follow some prescribed physical path or flow. An example of this would be where warehouse goods flow through a dock door, or with items that travel down a conveyor or assembly line.

Portable or mobile interrogators are used in applications when the tagged items do not follow a pre-defined path. This type of RFID interrogator can be used in conjunction with a portable-computing device such as a portable data terminal, or mobile pen computer. Typical applications include asset tracking, picking or moving inventory, inspection, and quality control.

In portable or mobile applications the interrogator is aimed into a certain physical area where RFID tags need to be scanned. It is more flexible in application scope since the user will define the RF portal by orienting the longitudinal and latitudinal axis of the interrogator. However, because this device operates on batteries, it is limited in its effective range of scanning, or RF portal depth of field. The energized period of operation of this type of interrogator must also be controlled so that battery life can be maximized.

<u>Please note that the characteristics described in the following descriptions are not common to all RFID technologies currently marketed. However, these capabilities do exist within the Intermec Intellitag® 500 RFID products.</u>

A suspected popular application for a portable interrogator is that of RF tag *group selection.* Group selection allows an interrogator to be put into a "search mode" where programming logic allows the interrogator to provide feedback to the user of certain unique RF tag(s) as they come into the RF portal. This application would allow a user to search for certain items within a suspected physical location for that item while simultaneously ignoring others. An example of this type of application might be someone searching for a box or container among others in the same physical area. Once the item is found, programming logic could be used to act on the data contained within the tag(s) so the data for those item(s) could be used, changed, or ignored. It is also anticipated that most portable interrogators will provide some means of scanning, and decoding traditional linear bar codes. This provides potential users of RFID with an application crossover point from traditional bar code automated data collection applications.

RFID technology can also employ a characteristic known as *anti-collision identification* or multi tag sorting. Anti-collision capability provides for multiple tags to be identified as they come into an RF portal. Again while these RF tags are in the RF portal, they can be write protected, (locked), write unprotected (unlocked), read, and written to. This can provide for the identification of a number of tags within a finite amount of time.

Write broadcast allows for all tags or a selected subset of tags within an RF portal to be written to using the same information. An example of this application might be where multiple RFID tags on a pallet are written to with shipping information as they pass through a warehouse dock door.

Types of RFID Tags

RFID tags can be segregated into two major classifications: *Active* and *passive.* Passive tags can be either battery-less or can contain a battery ("active / passive"). Pure passive tags do not contain an internal power source such as a battery, and are thus easier, and less expensive to manufacture. These purely passive or "reflective" tags rely upon the electromagnetic energy radiated by an interrogator to power the RF integrated circuit that makes up the tag itself. These types of tags are said to be "beam powered". There is a version of a passive tag that does contain a battery. This type of passive tag has some of the enhanced, and speed attributes of a true active tag, but still communicates in the same method, as do other passive tags. These active / passive tags that do contain an internal power source, usually are much more complex integrated circuits with multiple components. Consequently, they are more expensive to make and purchase.

Finally, there are true active tags. Active tags contain both a radio transceiver and battery to power the transceiver. Because there is an inboard radio on the tag, active tags get substantially more range (~300 feet) than passive or active / passive tags. Active tags, likewise are considerably more expensive than passive tags and, as with any battery powered product, the batteries must be replaced periodically.

RFID Tag Memory Component Characteristics

Just as there are different types of RFID tags (passive and active) there are also different types of tag memory. These two types are known by the generic terms of read only, and read / write. Read only type of tag memory is factory programmed and cannot be altered after the manufacturing process. Its data is static. Read / write memory just as the name implies, can be read as well as written into. Its data can be dynamically altered.

Today there is a cost difference associated with these two memory types, with read only memory being the less expensive of the two. As RFID markets and applications grow, this price difference will become less of a factor for overall system cost justification.

A similar analogy is the comparison of direct thermal verses thermal transfer technology used in printing conventional bar code labels. When thermal transfer technology was first introduced the cost per label was much higher in comparison to the cost per label of direct thermal labels. Today the "cost per label" price of these two technologies are virtually the same.

RFID Radio Phenomenon Affects

As mentioned earlier, because RFID uses electromagnetic RF signals to scan or interrogate a tag, it is subjected to all of the same physical laws and phenomena that affect all RF transmissions. Some of these phenomena are *reflection, cancellation, and absorption.*

Like RFDC, certain precautions, or considerations must be taken into account when designing an RFID system. These primarily involve what an application requires from an RFID implementation standpoint. For example, certain items or materials that RFID tags might be attached to could de-tune the tag, or affect its operating performance. These are primarily materials that cause an RF signal to be absorbed, or reflected at an intensity that makes a tag indistinguishable from the item to which it is attached.

Likewise, it is also important to accurately define the physical area in an RFID environment that depicts the RF portal. For all items to be accurately scanned within an RF portal, the portal has to provide appropriate physical RF coverage for the size and speed of items passing through it.

The RFID Site Survey

An *RFID site survey* should be performed to properly implement an RFID system. This survey or consultative effort should take the above mentioned factors into account.

In short an RFID site survey will be used to perform a spectral analysis to determine or confirm that the proposed RFID products / technologies meet the intended "specifications of use". It should provide the initiator of the survey with the following completed information in a report type format. This is similar to what is done today with RFDC site surveys:

- The "what" - regarding hardware, software, regulatory, and installation requirements.
- The "how" - current and future RFID operational scenarios.
- The "who" – Intermec, Intermec Partner (if applicable), and customer responsibilities for RFID system implementation.
- The "when" – when does the RFID system need to be installed, tested, and operational.

RFID Features and Benefits

Like traditional automated data collection, RFID can be used to track many items. However, RFID technology offers some significant advantages over traditional bar code data collection. Some of these advantages are:

- Non line-of-sight – RFID tags do not have to be physically seen by an interrogator, unlike a laser that has to see a printed bar code in the proper orientation for scanning. However, RFID tags do require placement so that the tag antennae are positioned to maximize the reflected signal reception back to the interrogator.
- Tags are capable of withstanding harsh / environments – since RFID tags do not rely on printed means for data storage, they are not subjected to the same limitations of printed symbols and the materials on which they are printed.
- RFID tags are solid-state circuits and contain no moving parts – most tags can be subjected to high levels of shock and vibration.
- RFID systems can operate in an unattended mode – stationary interrogators can be controlled totally by host computer application programming, and do not require human intervention for direction or activation.
- RFID tags can be reused – reuse can occur within the same application (new data written to an existing tag) or in a new application (where a previously used tag can be reprogrammed with new data).
- Simultaneous reading of multiple tags – *anti-collision* capability.
- Secure data – tag memory can be factory or field programmed and optionally permanently locked.
- Intellitag 500® RFID tags have 128 bytes of memory storage capability.

RFID Investment Considerations

Because of the advantages mentioned above, RFID should *not* be compared to traditional ADC bar code technologies. This is especially true when comparing the costs of RFID tags and conventional labels. Let's look at one illustration to help further explain this concept.

An RFID tag having an average price point of $4.00, that is read and or written to over 100,000 data use cycles, would have a per use cost of .00004 cents. In comparison, a typical paper bar coded label has a cost of .015 cent, and is often read only once per data use cycle. Under these rules, the data use cycle cost of a conventional label would be higher in comparison to an RFID tag. Furthermore if the data on that label needs to be changed, a new label (incurring another .015 cent cost) must be printed. Also the cycle time cost for the re-printing of this label must also be considered.

As mentioned earlier, RFID interrogators can operate in an unattended mode. This attribute allows cost savings to be realized by not having to have an operator perform data collection tasks. The traditional ADC applications of shipping, and receiving validation are two examples where unattended data collection can eliminate the non-value-added costs from an operation. You might say that RFID puts the "auto" back into automated data collection.

Overview of the RFID Industry

There are several companies that participate in the RFID market. Philips Semiconductors, Texas Instruments, and Motorola all have RFID chips, and in some cases, tag manufacturing capability. Some of these companies have also produced interrogators to read their RFID tags. However, to date RFID as an emerging technology has not been widely applied to traditional ADC applications. This is due to variety of reasons, but the most basic of these are that current RFID tag manufacturers have not bridged the technology / ADC solutions gap. This is an essential point to understand, since it is Intermec's vision that this is what we will supply with our RFID product offerings…NOT JUST TECHNOLOGY BUT REAL SOLUTIONS. Intermec Technologies is uniquely positioned to accomplish this task because of our ADC market expertise, and application knowledge.

RFID Product Comparison – Why Are There Different Frequencies?

Today there are many RFID products offered in the market place from the companies mentioned above as well as a new set of products from Intermec. Before an adequate comparison can be made of any of these products, one has to first understand some basics regarding RF in general. Remember, because RFID uses electromagnetic radio signals to operate, it's effective operation is subject to the same physical laws any RF operating device is. Furthermore there are not only these operational laws of physics as it pertains to RF, but governmental regulatory ones as well.

The RF field distance or space between an RFID interrogator antenna, and the corresponding RFID tag, and the frequency of operation are directly interrelated. Thus, different RFID frequencies have different RF effective ranges.

Two terms that are used often to describe this physical read / write distance capability of an interrogator and corresponding RFID tag are *near field,* and *far field.* Think of the eye vision analogy of near sightedness when thinking of near field. An RFID interrogator that has near field capability can read RFID tags close to the interrogator's antenna (the interrogator is said to be "near sighted"). A far field interrogator and corresponding RFID tag performs just the opposite (it is far sighted). Near field reading provides the characteristic of knowing where a tag has to be when you read it. A near field RF portal is short in depth of field, and effective range. These two phenomena are just the opposite for a far field RF portal. For more detail regarding this characteristic, please see the section titled 13.56MHz verses 2.45GHz.

For the applications of *item management* in Intermec's traditional ADC supply chain markets, it is important for us to be able to have far field reading capability. For example, it would be impractical to require the placement of an RFID interrogator antenna only inches from the moving surface of a conveyor belt or assembly line so that RFID tags moving on those surfaces could be accurately read.

RFID Frequencies and Application Effects

Now that you understand some RF physics, let's proceed to see how this applies in the real world. We know from the discussion above that different RFID frequencies have, in effect, different read / write ranges. However, there is another RFID application issue that needs to be considered. That being the composition or physical make-up of the item to which the RFID tag will be applied. This is because; different materials (reflection, cancellation, and absorption) can affect RF signals. RFID tags designed for corrugated paper containers for example will perform differently if they are put on plastic containers, especially if the plastic has a high carbon content. To further illustrate some of these effects, please review the materials comparison chart below.

2.45 GHz and 13.56 MHz Tags and Materials

Material	2.45GHz	RF signal affect	13.56MHz
Paper	OK		OK
Cardboard	OK		OK
Clothing (cotton, polyester)	OK		OK
Wood	OK		OK
Glass	Detune		Detune
Rubber	Detune		Detune
Plastic	Detune		Detune
Water / liquid film	Block		65% of range
Water / liquid immersion	Block		30% of range
Human Body	Block		Detune

As you can see in the chart above, there are several materials that can effectively detune, an RF signal and degrade its performance. In some applications where this is going to be a known contributing factor, the RFID tag's antenna can be tuned to allow for the potential material detuning affects. An example of this is the patented vehicle windshield tag from Amtech Systems Division. This particular tag has its antenna tuned to take advantage of the detuning affects of a vehicle's windshield. It is designed to actually use the glass surface of the vehicle windshield as a tuned ground plane RF radiator so that the effective read range required for the application is not reduced. This provides for the reading of this tag at advanced distances from the interrogator's antenna. This is again why an appropriate RFID site survey to determine tag selection, placement, and attachment is critical, so that all of these issues can be considered before products are proposed, and an implementation is started.

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13.56MHz versus 2.45GHz

RFID is receiving a lot of publicity today as it pertains to being a useful technology for ADC applications.   Much of this publicity revolves around an RFID frequency known as 13.56Mhz. The reason for this attention is that there are several RFID technology providers who have architectured their product offerings based on this particular technology. 13.56Mhz is after all, an ISO standard for smart card applications. Smart cards differ from RFID tags in that they are used for more than data storage. In some smart card applications, the card itself contains a microprocessor that can define parameters for data storage, and byte allocation. Smart card applications require that certain RFID attributes be present for implementations of that technology to be successful. Since 13.56MHz provides for RFID *near field* read / write capability, it is ideally suited to smart card applications where secure financial transactions are being transmitted. Understandably, a smart card user would not want their bank account number to be able to be read at a distance of 3 – 5 meters. Why are these attributes important?   If a technology or specific frequency in this case, was targeted for a particular application (smart cards), then it may not have the necessary attributes that would be needed for another RFID application that being *item management.*

The concept and definition of item management is defined in more detail later in this document (please see **RFID Markets and Applications – Intermec's Vision**). The bottom line is that for item management applications, 13.56MHz may not be the best-suited RFID technology since it has the needed attributes that make it ideal for smart card applications.

What technologies should be used for item management?   From what has been covered thus far, you can probably guess the answer. For item management applications, it is ideal to have a *far field* capable technology. We also need a technology where the RFID tags can be manufactured at a reasonable cost, and engineered for a myriad of applications.   13.56Mhz tags use inductive technology thus making the RFID tag itself more complex (and more expensive) to manufacture.

In summary 2.45GHz, and 915Mhz provide *far field* read / write capability and have lower price points. Furthermore, the tag circuit architecture allows many individual product variations to be designed and manufactured thus allowing a proper solution to be employed.   When it comes to RFID it is important to remember and practice this concept: "Let the solution dictate the appropriate product set".

BiStatix Technology

Recently there has been some industry press regarding an RFID technology referred to as BiStatix. BiStatix technology could hold some future promise for RFID applications where, a low cost disposable RFID tag is desired. BiStatix technology works on a capacitive coupling principle. This allows for tags to be constructed without costly wire wound coils, capacitors, and rigid substrates. BiStatix tags are constructed with printed conductive inks, with a silicon chip attached, or where a thin level of silicon may be applied to the printed surface itself.

It is this attribute that allows for BiStatix tags to be constructed by essentially printing the conductive antenna, and coupled circuit. Tags could be printed by existing industry standard methods, and could also assume most any size and shape.

However, for RFID to work in most applications, the tags or transponders need to behave or operate in a consistent manner. This is true not only for the characteristics of data storage, but more importantly for read / write operational ranges.

It is this last characteristic where the current development level of BiStatix technology falls short when compared to conventional RFID tag technologies.

Since paper materials, or other randomly oriented strand substrates have different levels of ink absorption rates, it is difficult to print a conductive circuit, where the electrical transmission flow within the circuit is predictable or consistent. BiStatix tags printed using the same technology on the same machine could have far different operational attributes. Some tags may be able to be read, and written to based on the conforming specification, while others may fall far short of the performance needed or desired.

Furthermore, because BiStatix tags today engineered to operate at 125KHz, other physical RF operational laws must be considered. A practical effective range of operation of a Bistatix constructed tag could be fairly sizeable, when compared to a microwave frequency (2.45GHz) tag having the same read / write range capability.

RFID Standards

In order for most new technologies to gain a foothold in an application market, there has to be a wide spread acceptance of that technology equally by all participants involved. This is accomplished today through accepted standards established by known organizations such as ANSI (American National Standard Institute) and ISO (International Organization for Standardization).

This was true for the present ADC technologies in use today, and is also proving to be the case for RFID technologies that have been released into the marketplace.

Standards also provide several market benefits. Some of these are listed below:

- Increases customer confidence in new technologies.
- Promotes worldwide RFID acceptance and technology advancement.
- Broadens markets for manufacturers, encourages global competition, and reduces prices for end users.
- Facilitates applications development by encouraging interoperability and by reducing customization.
- Provides developmental platforms for complementary products (software, translators, and hardware peripherals / accessories).
- National and ISO standards often influence local regulatory efforts that govern operations, implementations, and coexistence of the new technology or existing complimentary technologies as well.

Before a manufacturer of a new technology can participate in the exercise of establishing a standard for that technology, it is useful for them to first associate that new technology to a market, and application for it.

As mentioned earlier, there are some existing established standards for RFID smart card application use. However, up until recently there was no accepted draft standard for the application use of RFID for item management applications.

To define the RFID standard for item management an ANSI committee (known as the ANSI T6 committee) was created. This committee is assembled from representatives of the various RFID manufacturers. Each of these committee members made contributions to a summary of considerations, and processes necessary for the creation of an RFID item management use standard. This lead to an outline for what would become a draft (ANS 256) for the RFID item management use standard.

All of this standards work began in 1992 when the first ANSI T6 meeting was held. Let's now fast forward to 1999 to see what has been accomplished with these efforts.

1/99: The ANS 256 draft standard was approved by the ANSI T6 subcommittee and adopted by the U.S. Tag to ISO SC31 as the official U.S. position on RFID for item management.

2/99: The standard was formally submitted to ISO by the U.S., and remains the only completed national standard for RFID.

8/99: The 2.45GHz protocols within the ANS 256 standard were approved as the first international working draft standard for item management by the ISO SC31 AIDC standards subcommittee for RFID (WG4/SG3).

9/99: ANS NCITS 256-1999 – the American standard for RFID item management is approved and published by the ANSI/NCITS board (scheduled for 9/24/99).

Intermec's Intellitag® 500 RFID technology and API (application program interface) is included within the American National Standard. This ANSI T6 developed API standard is approved for use by ALL current and future ANSI-compliant RFID products for item management at every frequency. The importance of this is that it allows customers to develop RFID software solutions NOW.

Overview of the Application Space

Now that you understand some of the operational characteristics of RFID technology, lets look at the applications that exist for it, and also examine where it can improve business operations.

Many of the current RFID applications that have been implemented by our competitors exist outside of Intermec's traditional ADC target markets and applications.

Examples of these are consumer "point of sale" (POS) interfaces such as the Mobil Speed Pass™ retail gas pump application. Another is General Motor's use of RFID chips on automobile keys for theft immobilization (called immobilizers).

There are many traditional ADC applications that Intermec participates in today where RFID may be applicable. However for these applications to practically involve or make use of RFID they have to be further qualified. RFID can be useful where the characteristics that RFID provides are not found with traditional ADC labeling / tracking methods. Some examples of these qualification criteria are:

- A requirement to change data about an item at the item level (read / write capability). An application example might be the requirement to update product certification parameters that occur during a manufacturing process.
- Unattended data collection and item data updating i.e. automated data collection for items passing through a RF portal where the data on those items is read and updated automatically.
- Non line-of-sight data collection i.e. conveyance tracking of items through an RF portal.
- Harsh environmental conditions that degrade conventional labels or tags.
- Multiple, simultaneous item data collection (reading of multiple items within a container or on a pallet).
- Requirement for a reusable data storage medium for an item. An application example of the use of this feature, might be the ability to track reusable containers that have dynamic data associated with them for each cycle of use. This could be the case with regulated containers or materials with legal requirements for mandatory inspections.
- Requirements for secure data. RFID tag memory can be locked once written to providing a secure data medium for that associated item.

RFID Markets and Applications – Intermec's Vision

Several conclusions can be drawn when examining the traditional ADC market for applications where RFID might be employed.

RFID, in its present form, will most likely not replace traditional ADC methods of printed labels and linear scanning. As stated earlier, RFID should also not be compared to conventional ADC methods especially at a price point level. <u>It can however coexist with those present technologies given that the advantages it provides are used, and or required to provide a solution to a business problem. It is this last concept which is crucial to the successful sales and market positioning of RFID technology.</u>

Today there are several defined applications for RFID. They are known as *EAS* (electronic article surveillance), *transportation management*, *access control*, and *item management*. This is by no means a totally inclusive listing but it is based on the more popular RFID applications that have been implemented thus far.

Lets look at each of these applications in further detail.

By description, EAS is an application where the exit of items or merchandise out of a physical environment is monitored electronically. EAS is predominantly a retail industry application. You most likely have seen this application used, where high value retail items are tagged with an RFID transponder or security tag. This transponder is removed at the time of sale. If not removed, or deactivated the transponder would be read by an interrogator at an exit point, and result in the activation of an alarm to alert store personnel of a possible theft from their facility. There are also some other versions of this application used by other industries. One other example use of this application is in library management through the monitoring of library circulation items as they travel outside of the storage environment. EAS could also be adapted to self-checkout or perpetual inventory management applications as well, and has been most recently applied in a security application to protect newborn infants within a hospital nursery environment.

Also, EAS usually also has the following RFID characteristics. EAS typically uses an inductive type of RFID technology with a single bit type of RFID tag. Tagged items are read with a near field interrogator and the tags are incapable of data storage. RFID tags used in these applications are programmed to be either off or on. Two companies that participate in this marketplace are Sensormatic and Checkpoint Systems.

Transportation management defines many different RFID applications. Generally, these applications fall within four categories of sub-applications. These categories are generically known as *ETTM* (electronic toll and traffic management), rail and inter-modal, fleet management (commercial, private, and government fleets), vehicle parking / security access control. The Amtech Systems Division of Intermec Technologies participates in these markets, with many different active and passive RFID tag products.

Access control is also an application that falls outside of the traditional ADC market applications. It is similar to the vehicle access control application mentioned above. In this application people are substituted for vehicles. This RFID application usually is implemented using an RFID tag equipped badge, that is read by a near field interrogator. This in turn allows entry into or exit from a secured facility or area. Most of these RFID systems operate at a frequency of 125Khz. HID Corporation and Indala are dominant providers of this type of RFID technology.

Item management, includes those processes for the identification, tracking, and tracing of goods, and commodities that are being manufactured, stored, transported, or discarded. In other words, it involves many of the traditional applications that Intermec participates in within our traditional ADC target markets. It is this market for item management applications where Intermec is focused to provide RFID solutions.

To further define this market focus, Intermec contracted with a third party ADC market consultant to conduct a study in order to determine the markets and applications for RFID technology. The study assumed an item management application market focus, as well as the current market maturity level of RFID technology.

The study identified four primary markets where RFID item management applications exist. These markets/ industries are (1) automotive, (2) electronics, (3) consumer goods, and (4) transportation/ logistics.

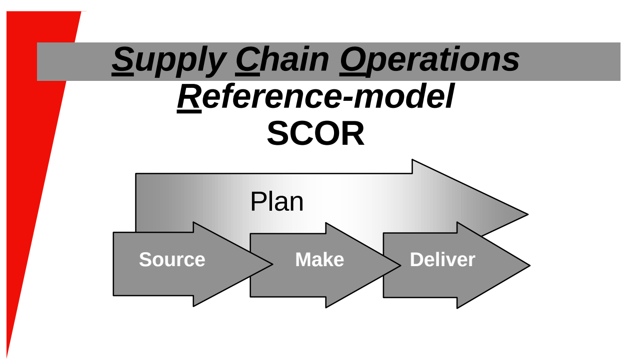
The study also identified five horizontal applications within these markets where RFID can provide benefits over traditional ADC technologies and methods of implementation. These applications are: (1) conveyance, (2) part tracking, (3) multi-pack or kitting, (4) pallet tracking, and (5) re-usable container tracking.

RFID and the Supply Chain

It is suspected that there are many applications for RFID within the *supply chain* operations of inter, and intra-company commerce. In many of these applications the needs exist to provide *item management* data for the tracking of goods, and items throughout the supply chain.

This is important because many organizations have the desire to improve the operations of their supply chain practices. Today's market attitude and concept of "I want it, or need it now" are driving this "demand for improvement". This also causes customer response time to become the standard measure of performance within all links that make up a supply chain business environment.

To understand the supply chain in general, let's look at an illustrated model. This model concept comes from an industry organization known as the Supply Chain Council. Intermec is a member of the SCC and participates in SCC sponsored events.



The supply chain model references the existence of four distinct management processes. These links start at the supplier's supplier and are interconnected all the way to the customer's customer.

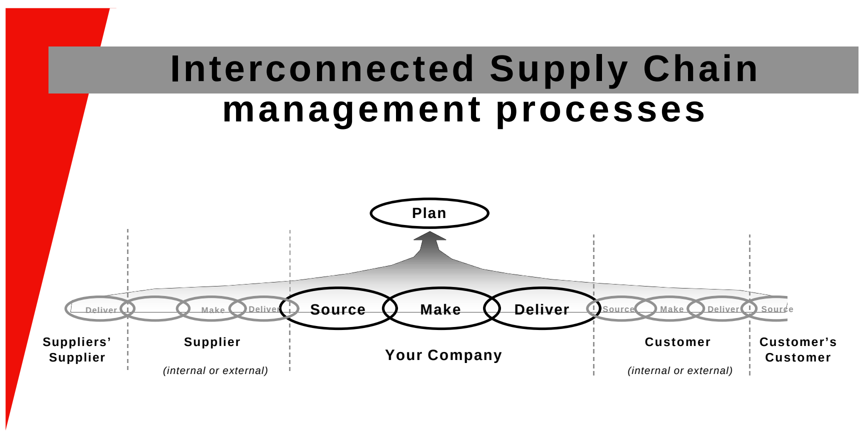
The *plan* phase of the model is when the definition of a product or item is initiated. The plan phase also further defines all of the sub components; ingredients, processes and other required sub set items that are needed to complete a product / item. Source, make, and deliver links are also detailed in the plan phase.

The *source* portion of the model identifies the procurement sources, procedures, and processes necessary to acquire the sub components, ingredients, sub items necessary to make the product / item.

The *make* portion of the model defines the manufacturing processes, assembly, and packaging, of all of the related sub components, ingredients, and or sub set items that are needed to produce the product / item defined in the plan portion of the model.

The *deliver* portion of the model defines the method(s) of market positioning, distribution, and delivery of the planned product to the final user.   It also outlines what intermediary steps the product flows through from the make step to the final user, or consumer of the product / item.

Let's now look at a model where the inter-connection of these four supply chain management processes is illustrated.



As you can see by the illustration above, it is these links within the supply chain that are interconnected.

Participants today in the supply chain include a variety of organizations. Some of these participants are, manufacturers, transit companies, warehouse providers, and destination end users or receivers.   They make up the links in the supply chain illustrated above, and perform or participate in those four distinct management processes that were defined earlier.

Again, because these links are interconnected, it can be assumed that there can be an exchange of physical items, and data to manage the exchange of those items between each of these links.

This was realized in the early stages of market maturity of bar code data collection.

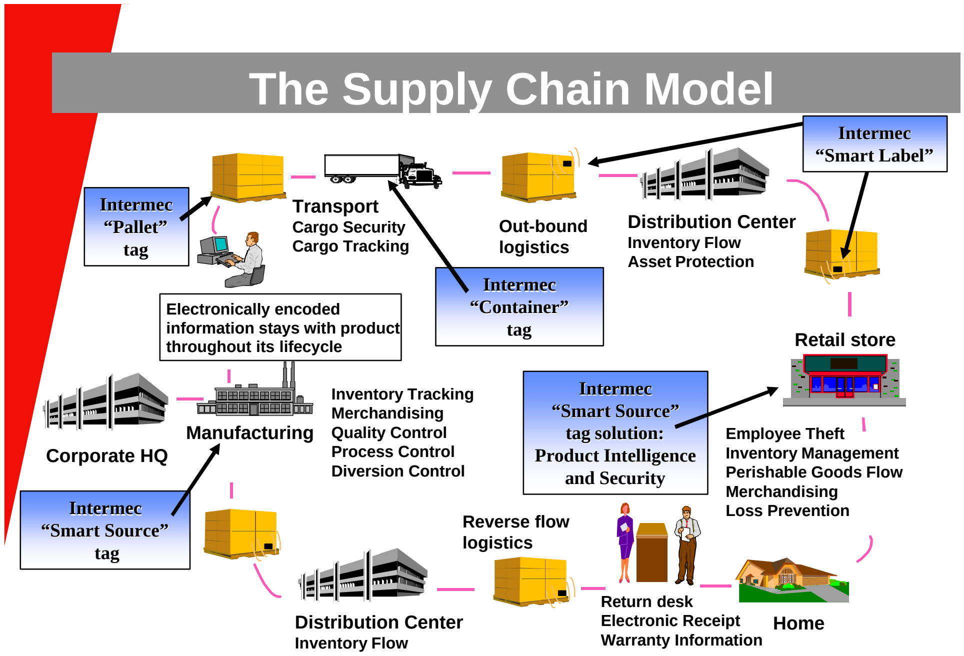
Many vertical industries implemented compliance labeling programs so that data could be provided to manufacturers about the source receipts of component items.

The automotive industry used this model to their advantage by implementing the AIAG compliance labeling standard among the different tier levels of automotive component suppliers. This practice provided a way to receive information from different supplier links within that industry supply chain. Accurate and swift data transfers from these suppliers are important to these manufacturers for many reasons. Probably the most important of these had to do with the implementation of *MRP* practices by automotive assembly plants. It is these MRP practices that provided automotive companies the ability to allocate and use "just in time" component inventories. What is lacking with this practice today is the exchange of information among all the participating links. Today this data transfer is mostly one way, from the supplier to the manufacturer at the item level.

Why haven't there been improvements to these practices? It's because there wasn't technology to support the improvements needed. How many times have ADC application users told us that the bar coded data on items they receive is not useful to them. In many instances they have to re-label items with the pertinent item data that they could use within the confines of their operational environments.

Because RFID tags can be read as well as written to, a true informational exchange among the different supply chain links can now take place. To have that provision with conventional bar code technology, would require each link in the supply chain to re-print a bar coded label to provide a data exchange. This would be cost prohibitive from a time delay, and implementation standpoint.

Lets look at one more illustration to help with this concept.



In this illustration of the supply chain model, you can see the various links within the supply chain that an item may travel to and from. You can also envision the data exchange that may take place between each one of these links. Please be aware that in most cases today, this data exchange does not take place at the item level. This is where the opportunity for the application of RFID technologies exists.

With RFID technology it would be possible to imbed an RFID tag into a manufactured item, and have that tag read and written to during the manufacturing process to gather, and exchange work in process data. That same tag could then be read or written to by shipping personnel at the manufacturer's shipping dock to release that item from the manufacturer's inventory. It could then be read and written to with shipping / route information by an LTL carrier when it was transported from the manufacturer's plant.

When received at the distribution center (DC) the shipping, and earlier item information could be read automatically at the DC's receiving / shipping dock doors via a fixed RFID interrogator.

Finally, that same tag could be read and written to at the retail store level, to provide that retailer with pricing, receipt date, inventory, and theft prevention information.

Summary

RFID technology has some unique features, and attributes when compared to conventional ADC technologies. Just like RFDC systems, there are specific components needed to make an RFID system operate. Also like RFDC, RFID is subject to the same physical and regulatory laws, and operational phenomena that apply to all radio enabled transceiver devices. RFID technology costs cannot be compared fairly to conventional ADC methods without recognizing the advantages RFID technology provides. This is especially true with the cost comparison of RFID tags, and conventionally printed labels. There are many types of RFID tag technologies with each having unique attributes needed for specific applications. Universally accepted standards for RFID technologies, and applications must be established for RFID to gain market acceptance. Several factors must be considered to properly implement an RFID system, including the application requirements, physical environment, item substrate material, and technology cost justification. For RFID to be applied successfully into the traditional ADC market place, the application definition and concepts of item management need to be thoroughly understood. RFID can provide additional capabilities above conventional ADC technologies for solving business problems, but should not be positioned as a replacement for those technologies.

RFID Glossary of Terms (listed in order of use within this document)

RFID – a means of storing and retrieving data via electromagnetic transmission to a radio frequency compatible integrated circuit.

Interrogator – a device that is used to read and or write data to RFID tags.

Transponder – a type of integrated circuit designed to store data and respond to RF transmissions of a given frequency. A transponder is another name for a RFID tag.

RFDC – an acronym for **R**adio **F**requency **D**ata **C**ollection. An implementation of automated data collection whereby portable ADC reader devices are connected to a host computer via RF so that interactive data transfers can occur.

ADC- an acronym for **A**utomated **D**ata **C**ollection.

RF Frequency – a defined radio protocol to transmit, and receive data. RFID frequency types include 2.45GHz, 915MHz, 13.56GHz, and 125KHz.

RF portal – a defined physical area of RF signal saturation. Also known as an RF depth of field, and or physical RF field of view.

Group selection – a mode of operation whereby an interrogator can search for and identify unique tags within an RF portal, or RF field of view.

Anti-collision capability – an RFID technology characteristic that allows for multiple RFID tags to be identified while present in an RF portal.

Write broadcast capability – an RFID technology characteristic that allows data to be written to multiple tags while those tags are within an RF portal.

Active tag – a type of RFID tag that contains an internal power source, and in some cases also a radio transceiver. These additional component(s) are used to enhance the effective read / write range, and rate of data transfer characteristics of the RFID tag. This type of integrated tag circuit is usually of a complex design with many components.

Passive tag – a type of RFID tag that does not contain an internal power source. This type of tag design is less complex and is usually of a single, or dual chip design. It is said to be, "beam powered" using the electromagnetic energy of an interrogator.

RF absorption – a radio phenomenon that occurs when transmitted RF signal energy is consumed or rapidly dispersed by some material in the pathway of the RF transmission.

RF cancellation – a radio phenomenon that occurs where a transmitted RF signal is neutralized by competing RF interference.

RF reflection – a radio phenomenon that occurs when a transmitted RF signal is echoed off of another RF radiator placed within the pathway of the RF transmission.

RFID Site Survey – a comprehensive analysis to determine or confirm that a proposed RFID solution meets the intended application requirements, and technology specifications of use. It also defines the equipment needed to implement a proposed RFID system, and outlines the responsibilities of each party involved with the system implementation.

Near field – an operating specification for an RFID tag to be near or in close proximity to an interrogator's antenna. Near field capable interrogators and corresponding RFID tags typically have a read / write range of 4 – 6 inches.

Far field – an operating specification for an RFID tag to have a read / write range of greater than 1 meter.

BiStatix – a type of RFID tag design, where the enclosed circuit is manufactured using printable conductive inks, and silicon layering.

EAS – an acronym for **E**lectronic **A**rticle **S**urveillance. EAS is an RFID application where the exit of items out of some physical environment is monitored electronically. Typically used for theft, and loss prevention in the retail industry.

Transportation management – a term to reference several RFID applications within the transportation industry. These include ETTM (electronic toll and traffic management), rail and inter-modal tracking, fleet management, and vehicle parking / security access control.

Access control – an RFID application where RFID tag equipped badges are used to provide secured access to a facility.

Item management – those processes for the identification, tracking, and tracing of goods or items that are being manufactured, stored, transported, or discarded.

Supply chain – a grouping of at least four distinct management business processes that define the planning of a product, the sourcing of a product's components, the making of a product, and the delivery of a product.

MRP – an acronym for **M**anufacturing **R**esource **P**lanning.

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