RFID: The Promise of a Strategic Technology

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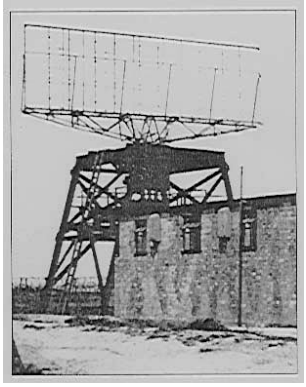
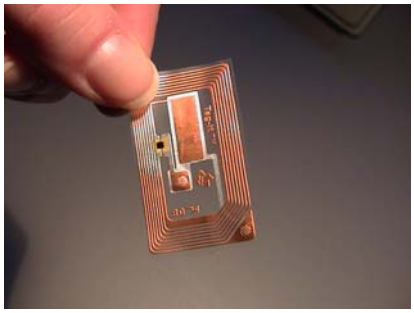
RFID Beginnings



Radio Frequency Identification (RFID) has its origins in the 1940s, when the fundamental technology that underlies modern RFID systems was developed to discriminate between inbound friendly aircraft and inbound enemy aircraft. Allied aircraft carried transponders that broadcast a unique radio signal when interrogated by radar, identifying them as a "friendly." This *Identify: Friend or Foe* (IFF) system was the basis for the development of the technology set we refer to today as RFID. Modern aircraft still use transponders to automatically and uniquely identify themselves to ground controllers (the well-known "squawk" function). Many believe that RFID is an extension of the common barcode, and while the two share some application overlap, RFID is much more than a barcode.

RFID Functionality

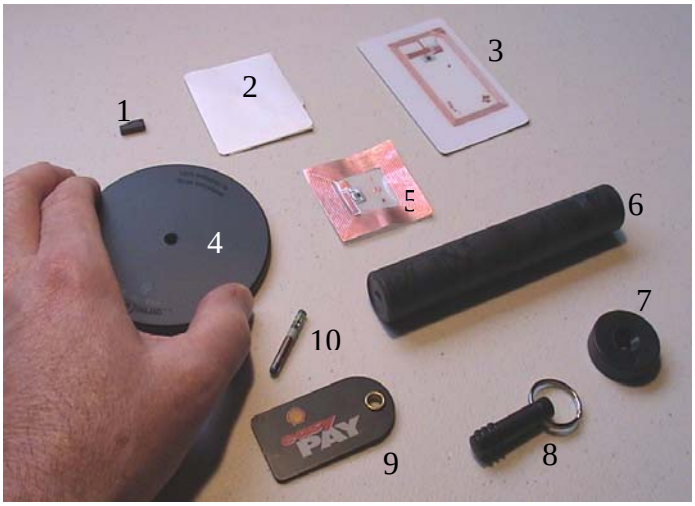
A typical RFID system is a remarkably simple collection of technology components. It comprises a collection of transponder tags, which form the heart of the system; a reader, which energizes the tags, collects information from them, and delivers the information to backroom analysis applications; and the application set that analyzes the data provided by the transponder tags to the reader. This application set is critically important, because RFID systems, by their very design, generate enormous amounts of data that must be analyzed and acted upon if the system is to have value.



Each transponder, an example of which is shown at right, has a unique "serial number" (a card ID, or CID) that identifies the tag and therefore whatever it is attached to – a pallet of products, an identification card, or a beef cow in a herd. When the tag is within the operational range of a reader the reader's magnetic field energizes the tag, causing it to go through a series of functions that culminate in the transmission of whatever piece of data is stored in the tag's memory. This information is programmable and might contain detailed product information, product perishability data, routing information, a sheep's bloodline, and so on. For the most part, the tags are passive, meaning that they have no battery but are in fact powered inductively by the RF signal emitted by the reader. These tags necessarily have a relatively short read range – as much as a foot, no more – but active tags, which do have internal power, can broadcast up to 20 feet under the right conditions. Passive tags are often used in applications where proximity to a reader is assured, such as in a warehouse or transportation-based supply chain environment. Active devices are commonly seen in such applications as automated toll-taking systems on major freeways. The EZ-Pass system deployed in the northeastern United States is a good example; the windshield-mounted transponder from Texas Instruments is shown at left.

Readers, an example of which is shown below courtesy of Texas Instruments, are nothing more than RF emitters connected to back end software analysis systems. The reader's role is to emit an

RF signal that activates the tag or tags within its operational area; to transmit a series of simple commands to the tags; and to collect the data returned as a result of the transmitted commands. Because of the fact that multiple tags may be activated simultaneously as in a supply chain environment, most readers have anti-collision capability that allows them to control a multi-tag environment, forcing each tag to take a turn so that simultaneously-activated devices can successfully transmit their information without interference from adjacent tags.



Tags come in a variety of forms as shown in the photo at left. The wedge-shaped device (1) is designed to be attached in a number of ways to trackable items. The wedge shape makes it possible to guarantee the orientation of the tag in environments where signal strength is weak or impeded by metal in the transmission area. The paper tag (2) is often seen in bookstores, inserted between the pages of books as a theft deterrent. The tag contains a single bit of information. If the bit is set by the "deactivator" at checkout, the book was properly purchased. If not, it sets off the alarm upon exiting the store.

The card (3) is a typical contactless smart card, used in corporate access control environments, hotel room keyless entries, etc. The large disk (4) can be attached to large pallets or other containers via the convenient hole in the center of the disk, and is reusable. The thinsheet tag (5) is affixed to a sticky backing and can be affixed to the inside of computers, library books, and other small items.

The cylindrical tag (6) is an interesting transponder tag. The one shown is designed for high heat and corrosive environments, often used, for example, in automobile painting lines that are subject to extremes of temperature and caustic substances. The tag can be attached to an automobile body, for example, and as it passes through the line broadcasts the color that is to be applied and the chassis style so that the robotic painters apply the paint correctly. The cylinder style also comes in a ceramic form factor and is designed to be embedded in the stomach of cattle. The tag contains bloodline history, shipping information, and other data that is invaluable to veterinarians tracking disease. And because the device is ceramic, it is impervious to corrosive stomach acids.

The disk (7) is similar to the larger disk described earlier; it can be attached to smaller packages and like its larger cousin is reusable. In fact, these devices often remain attached to their shipping containers.

The key fobs shown in (8) and (9) are RFID tags designed to facilitate the purchase of fuel. The Speedpass (8) is commonly seen, and replaces the need for a credit card.

The glass transponder (10) is intriguing. These devices are designed for subcutaneous use, often injected under the skin of livestock, fish, and other wildlife that veterinarians and wildlife

biologists wish to track. Sturgeon, for example, are often RFID-tagged so that aquatic biologists can track the movement and survival rate of the fish.

Spectrum Considerations

RFID systems are generally divided into two categories: *passive or near-field systems*, and *active or far-field systems*. Passive systems typically operate at very short distances between the reader and the transponder and usually operate in the 13.56 MHz range of the electromagnetic spectrum. Active systems, which are more powerful and therefore capable of operating at significantly greater distances from the reader, operate in various regions of the spectrum between 800 MHz and 1 GHz, although there are a few other frequencies within which active RFID systems occasionally operate.

Applications for RFID

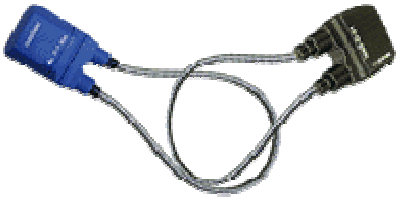
For the most part, RFID has been used as an extension of the well-known barcode system. It has numerous advantages over barcodes, however. Barcode labels can fall off, be torn or smudged, and must be properly oriented so that the laser reader can see the printed label. RFID devices do not suffer from these limitations: they are not subject to tearing or smudging and for the most part do not require specific orientation – as long as they are within the operational range of the reader they can be activated and read. As a result, accuracy is increased and corporations see a reduction over time in both operating expense (OPEX) and capital (CAPEX) due to lowered personnel and equipment requirements.

Applications for RFID are wide ranging, and include:

- Personnel Identification
- Access Control
- Security Guard Monitoring
- Duty Evasion
- Food Production Control
- Blood Analysis Identification
- Water Analysis
- Refuse Collection Identification
- Timber Grade Monitoring
- Road Construction Material Identification
- Toxic Waste Monitoring
- Vehicle Parking Monitoring
- Valuable Objects Insurance Identification
- Gas Bottle Inventory Control
- Asset Management
- Stolen Vehicle Identification
- Production Line Monitoring
- Car Body Production
- Parts Identification
- Barrel Stock Control
- Machine Tool Management

This list represents a sample of possible applications; others emerge daily. One of the most intriguing new areas for RFID deployment lies within the realm of Homeland Security. There are clearly traditional applications for RFID – IFF, access control, package handling and identification, fire control, personnel movement, and production management – under the purview of defense and Homeland Security that are well understood and fully deployed. A new area that is enjoying a great deal of scrutiny today, however, is *port security*. Large ports are vulnerable environments because of the number of ships that come and go, and the far larger number of containers that enter the port system every hour of every day – over 90% of the world's volume of shipped goods travel by ship. Until recently it has been next-to-impossible to examine every inbound container because of sheer volumes: Oakland, shown above, handles the equivalent of two million containers a year, while Singapore and Hong Kong, arguably the largest Roll-On, Roll-Off (RO-RO) ports in the world in terms of container volume, each move approximately 15 million units annually.

Shipboard container doors are closed and locked before the vessel leaves port. The doors are then sealed with anti-tamper protection to ensure that if they are opened in transit, the seal is broken and the fact that the container was opened will be evident to authorities upon inspection at the destination port. The concern, however, is that containers opened in transit may carry weapons or other destructive cargo, and by the time the tampered-with container is detected, the contents are already in-port.



A number of firms, including Hi-G-Tek, Savi Technology and E. J. Brooks, build RFID-based electronic seals for containers that not only show that the container door has been opened, but also transmit the fact to a shipboard reader that then notifies authorities so that the ship can be intercepted and searched before entering port. The photo at left, courtesy of Hi-G-Tek, shows an example of their container seals.

DoD and RFID

The Department of Defense is extremely interested in RFID applications. In a November 2003 summit on the technology, the DoD confirmed its commitment to RFID. The organization has mandated that all suppliers place passive RFID tags on products at the lowest possible level that is cost-effective by January 2005; placement may be at the individual product, pallet or case level, and will vary somewhat by product type.

The DoD's primary interest in RFID is based on its move toward what it calls *Knowledge-Enabled Logistics.* While the military is a unique "business," it still relies on effective supply chain management to get the job done. Naturally, RFID lends itself to improved supply chain processes and faster deployment of resources to a forward theater. Frankly, the similarities between military and civilian requirements are far greater than the differences; consider the quote in the box, below.

Final Thoughts

RFID currently falls into that wonderful Mark Twain-like space that is characterized by the quote, "The only thing worse than people talking about you is *nobody* talking about you." RFID is certainly getting its share of negative attention, largely due to concerns voiced by privacy advocates. Organizations like CASPIAN (the Committee Against Privacy Invasion and Numbering) have risen up to fight the technology's widespread deployment because of concerns about the ability of various agencies to track an individual's movements and purchases without authorization. And while it is easy to assign these concerns with conspiracy theories, organizations like CASPIAN serve the same purpose in the technology world that Greenpeace serves in the oil industry: they force the industry to be at the top of its game by creating public awareness of potential hazards, real or not. RFID does need to be monitored, and while concerns over its abuse should be heard, the advantages that RFID brings in such applications as security, law enforcement, defense, health care, product manufacturing, veterinary medicine, food and water protection, and supply chain management far outweigh the risks associated with the potential for misuse of the technology.

> *"In its ultimate form, the entire theater of operations will be networked. Sensors will reside on every piece of equipment and every person populating the field of operations, and information collected by those sensors will be processed in real time using artificial intelligence support to prioritize threats and challenges. In-charge personnel will be able to choose from a portfolio of response options to identify and select targets.*
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> *"As a result, the time between sensing, processing, deciding and acting will fall dramatically, allowing forces to target the opposition before they can respond."*
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> Retail executive, talking about his firm's current RFID product-tracking initiative

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