RFID Technology Series

RFID Hardware: What You Must Know

Understanding and Selecting RFID Devices

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June 2006

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** Newton's Telecom Dictionary the 22nd Edition—Wonderful reference guide on terminology for technology in RFID, Telco, and Computer Science.*

About ChainLink Research

ChainLink Research, Inc. is a Supply Chain research organization dedicated to helping executives improve business performance and competitiveness through an understanding of real-world implications, obstacles and results through supply chain practices, processes, and technologies. The ChainLink Inter-Enterprise Model is the basis for our research. It is a unique, real-world framework that describes the multidimensional aspects of the links between supply chain partners.

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It is the business of the future to be dangerous…
The major advances in civilization are processes that all but wreck the societies in which they occur.

- Alfred North Whitehead

Other ChainLink RFID Reports:

RFID Software—Middleware, Networks and Applications

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Cold Chains are Hot

RFID in Clinical Settings

RFID in Manufacturing

RFID for the Customer Experience

Value Consideration for RFID—Mini Report

Understanding EPCIS—Mini Report

Executive Summary

RFID has hit the world like lightening! But the fact is that there is little understanding of how the technology works, or how to select solutions. Even firms under mandates to implement RFID understand very little about how to get the most value for their own firm, or how to recognize whether their vendors have solid expertise in RFID. Through a series of RFID reports, ChainLink Research will address these issues.

WHAT YOU WILL LEARN IN THIS REPORT

This report—*RFID Hardware*—is for two audiences. This is a primer for those who have little or no RFID knowledge. We use the word primer, but it is comprehensive enough that we think most people, implementers and vendors alike, will learn more about RFID, even if they have already gained some expertise.

The second audience is those who are seeking knowledge about the players in the market. Though RFID is new in some applications, there are hundreds of RFID companies out there. It is hard for end-users to sort out the real players.[1]

We at ChainLink Research have spent the last few years learning about RFID. Prior to the RFID Era, we were working in warehouses and ocean ports, putting in bar-coding, mobility systems, real-time locating systems, warehousing systems, and retail in-store operations systems. We were researching the emerging RFID technology from many vantage points. We found that even though there is a plethora of information available, there are very few good approaches to learning and implementing this new technology. Through this and the subsequent reports on RFID, we will provide you with the basic background information you need to select the right RFID solution for your business.

We have included lots of graphics, charts and definitions to help you understand RFID, and we have several views of the solution providers to help you decide what hardware is right for you.

This report is not intended to rank the solution providers. There are far too many variables in each project to be able to make those judgments in a report. But the report will *guide you* in your discussions with RFID firms, as well as help you think about your RFID requirements before you go shopping.

[1] Only firms with validated case studies were considered in this report. See *Figure 20, page 47.*

HOW THIS REPORT IS ORGANIZED

- **Executive Summary** — Describes the purpose of the report and the intended audiences.
- **Introduction to RFID** — Explains what RFID means and covers the basic hardware components of RFID applications.
- **Understanding the Technology** — Provides definitions and explanations of the science behind the RFID technology.
- **RFID In My World** — Explains the mix of environmental factors that need to be considered for each unique implementation.
- **Designing the Right Solution** — Tackles the business of defining policies, processes and performance metrics, and finding the right RFID solutions for your business.
- **Standards vs. Mandates vs. Good Ideas** — Not all 'suggestions' are mandates to implement. What are the RFID standards and mandates you will need to know?
- **Considerations for Buying Technology** — Helps you answer basic questions: What do I need? What are my options? Who do I buy it from?
- **Conclusions —** A summary of recommendations.
- **Glossary and Appendices** — Includes tables and charts of RFID Providers. Definitions, sources of additional information, a summary of known standards, and vendor information.

Introduction to RFID

A basic understanding of RFID is required before you plunge into buying things. There are two fundamental levels we will address to get you up to speed on RFID: first, some really basic definitions; and second, the science of RFID. This report will help you decide what RFID approaches are ultimately appropriate for you by giving you an understanding of the frequencies, waves, and coverage (range) of the technology.

WHAT IS RFID? THE BASICS

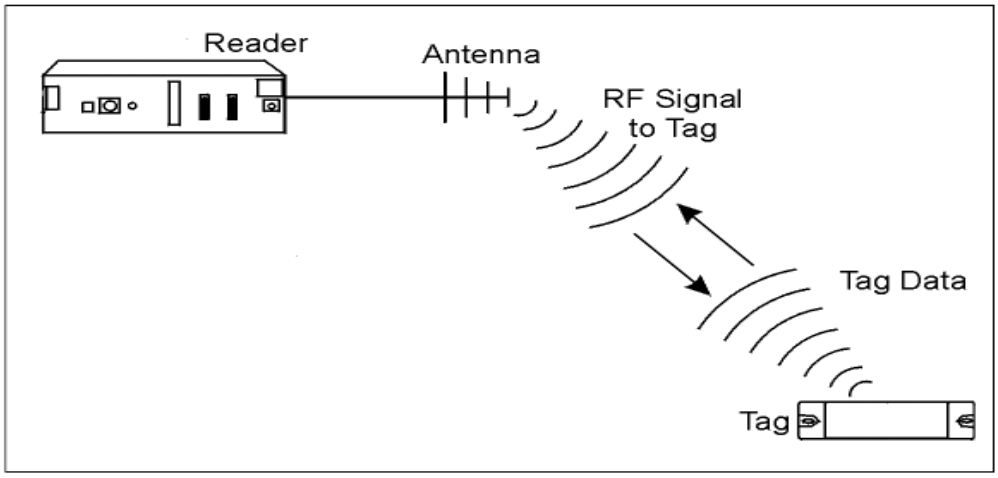


Figure 1: What is RFID ?

RFID uses radio frequency waves **(RF)** to identify **(ID)** objects or people. Thus ─ ***RFID.*** Rather than jumping into a detailed definition of RFID, I'd like to start our discussion by using the illustration above.

RFID systems are comprised of "tags" and "readers" (see *Figure 1: above*) which are within a reasonable proximity of each other and can send and receive data. As shown above, an RFID Reader uses radio waves (the same type of energy used to transmit AM or FM signals to your radio) to find/talk to a tag. You have seen this in other day-to-day applications. The antennas on your radios and TVs allow them to receive data. Where RFID differs from an earlier generation of radio frequency technology, is that the *tag responds* by sending (over radio waves) a *unique* string of data back to the source. Many RFID uses focus on uniquely identifying an object to which an RFID tag is attached, either for the life of that item, or for a specific business event (for example, passing through a dock door).

RFID Tag/Transponder	A microchip attached to an antenna (there are also chipless tags) that picks up signals from and sends signals to a reader. From one-bit tags to data-rich tags, these can store data, such as unique serial numbers, location information, and many other types of data.
Antenna	The antenna is the conductive element that converts RF into electrical energy and vice versa, thereby enabling the tag or reader to send and receive data wirelessly. Antennas can be wire, an etched conductive pattern affixed to a plastic substrate, or conductive inks made from aluminum, copper or silver.
Reader/ Interrogator/Encoder	The reader (also called an interrogator) communicates with the RFID tag via radio waves, reading (interrogator) as well as writing information (encoder) to and from the tag. A reader may store the data and/or pass the information in digital form over a network or directly to another device. Readers may also receive data from other sensory devices (e.g. motion detector) and/or they may control other devices.
Active Tag	An RFID tag that contains its own power source. This power source is used to power the microchip to receive and transmit data. Active tags generally can be read at great distances (several feet to hundreds of yards).
Passive Tag	A passive tag has no power of its own. The tag is powered solely by the RF energy emitted by the reader. The passive tags use this energy to power the microchip and transmit data back to the reader. Read distance is limited to the power received from the RF energy. Signal fall-off happens quickly. In other words, passive tags generally can receive and transmit data only several feet.

Table 1: RFID Hardware Components

Radio Frequency or RF are electromagnetic waves propagated in free space. They can be generated at various frequencies and travel for various distances. The RF waves (such as radio & radar), carry digital or analog data. RF can operate with low to minimum power at close range (inches) and with power at longer ranges (hundreds of yards). Thus, it is useful in identification and security applications.

RFID TAGS

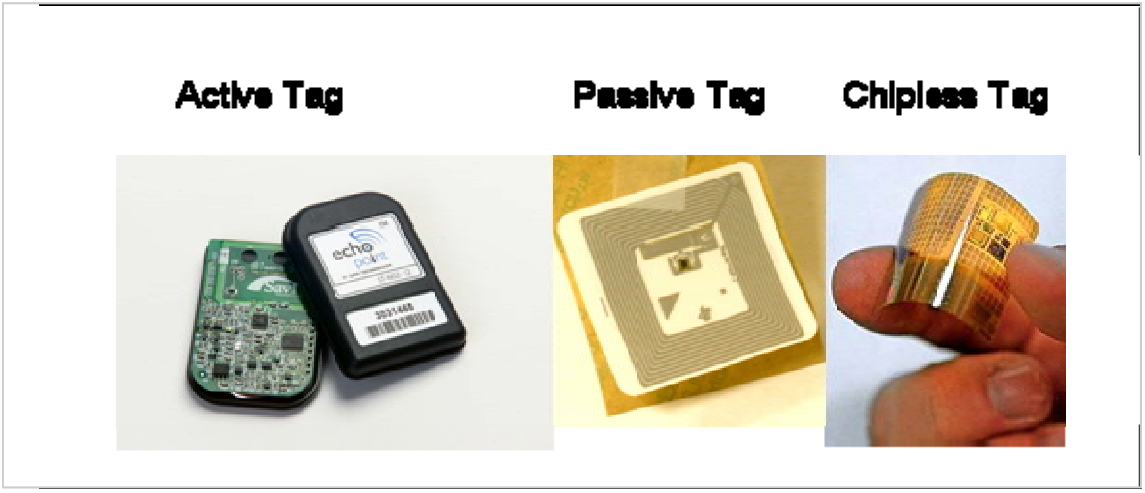


Figure 2: Example RFID Tags

RFID tags are small electronic circuits attached to a metallic antenna. Most tags are constructed of a silicon microchip. The microchip on the tag stores data. The size and type of data can vary depending on the particular application. In some applications, the data is comprised of a unique serial number plus additional space to store application-specific information. It can be a read/write tag that can store data, or it can be factory-programmed with read-only information. The attached antenna allows the data contained on the microchip to be sent to and from a reader device.

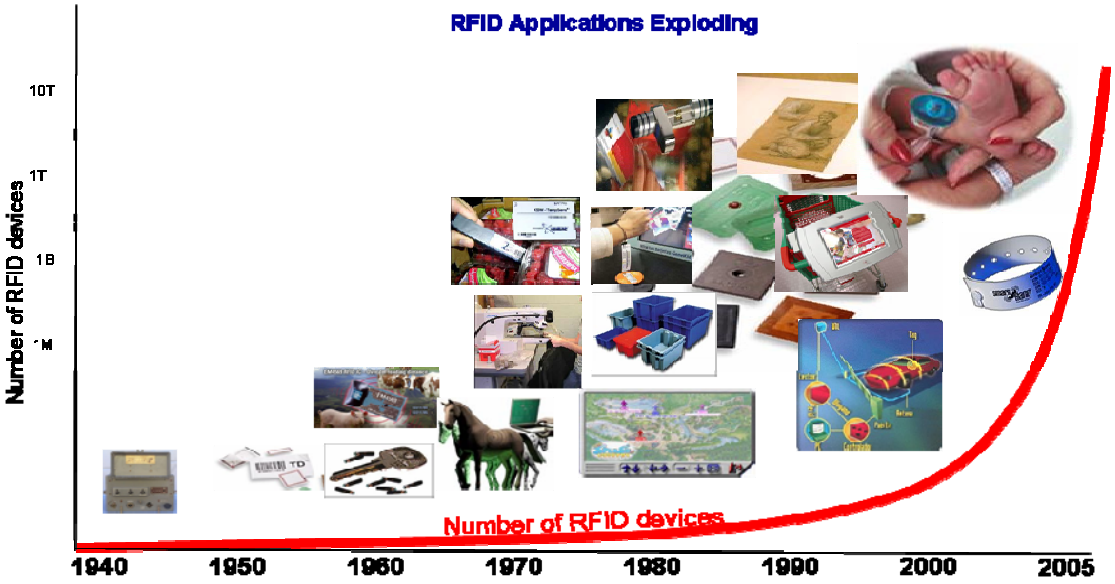


Figure 3: Explosion of RFID Applications

The explosion of available tags in the market is mind-bending in terms of the increased diversity, as well as the sheer numbers of tags. We are also seeing the very early days of chipless tags, which we expect to become increasingly popular in the market.

Specialized chipless tags with relatively small memories have already become available. These can be used effectively in extreme temperatures, with extremely low reader power, or in long-range applications.[2] Long-term, these types of tags hold great promise. Printed chipless tags will be very cheap and are probably the type of tag that could replace many barcodes—but not until the technology is tamed—years in the making. We will not spend much time on Chipless technology in this report.

In considering which tags to buy, read distances are key. Passive tags have communications fall-off within short distances. This happens quite quickly with UHF tags, which have a read distance of about 10-30 feet (this distance can be quite a bit lower, as you will read later on). HF passive tags have an even shorter range.

Active tags are able to project at greater distances due to having their own energy source. Passive tags are reliant on energy from their readers, so as they move along in the process they are not interfering with their environment until they come in contact with a relevant energy source. This can be quite an advantage in a world exploding with devices and crowded airwaves.

[2] Techniques such as SAW (Surface Acoustic Wave) technology are based on chipless technology. Printed technologies–inductive inks on thin films, are technologically possible and are beginning to be used.

Now a Word About Chips

RFID chips are made of transistors, which are tiny circuits that carry instructions. The more transistors, the more instructions. Thus, as we add more functionality to tags, the more transistors are needed.

When users ask for more functionality, more security (this should be a standard requirement of supply-chain-wide devices) and more data, it requires cramming of technology into the chip, and the tag (and probably the reader) will be more expensive. This also reduces the read range, since it requires more energy to power up more transistors—therefore, the tag must be closer to the reader to receive enough RF energy to power its chip.

Chips, even when developed to the same standard, can have different capabilities:

- **SIZE:** Depending on the manufacturer and model, they can differ in size, and smaller is typically less expensive.
- **POWER:** Can differ in power requirements. A chip needing lower activation power gets better read distance.
- **MEMORY:** Chips have different-sized writable memory, so think about whether you are writing and reading—what do I need to do? Will you be accumulating information on the chip as the product goes through its life or will you just use the chip as a 'pointer' to data stored in the database?
- **FEATURES:** Most chips have some features and commands in addition to the standard. These may be of benefit to you.[3]

Chips come in wafers, and there are 25,00 to 50,000 chips or so in a wafer. Not all the chips in the wafer work. The chip companies can test each chip and provide a map of the good and bad chips on the wafer. In this way, known bad chips can be isolated and disposed of after all the value-added steps are completed with the wafer. The wafer must also be thinned, and cut into single chips, and have bumps added to allow chip antennas to be connected (see *Figure 17, page 46: The Tag Supply Chain*). Thus, if you're asking about chip prices, always specify mapped wafers with "fully prepped" chips, so that you are comparing apples to apples.

[3] For example, the most popular chip for RFID library self-checkout has a one-bit EAS bit that turns on an off. When activated during the RFID self-checkout process, the bit would sound an alarm if carried through the exit gates without being properly checked out. Upon return, the bit is turned off.

RFID Readers

An RFID reader is an electronic device that has the ability to read and write information to and from RFID tags. RFID readers can be housed in a variety of devices. See *Figure 4, below,* for some examples of RFID readers.

Figure 4: RFID Readers

Readers emit radio waves, which contain data and commands that are received by RFID tags. For Passive RFID, the radio waves energize the passive RFID tags in the vicinity and cause the tags to be powered on and perform the requested functions.[4] Such functions may include reading serial numbers or other data, writing data, or performing security functions. The interaction with active tags is similar, but an active tag is also capable of initiating the call. In addition to more security being built into readers, more intelligence is also being built in, to enable readers to perform such basic applications as warehousing, patient care in hospitals, and reading passports.

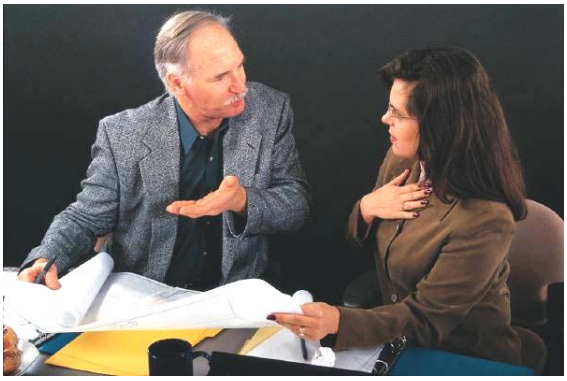
[4] Range depends on many factors, which are described later.

Readers used for active tags are frequently designed to perform in custom applications: PDA and cell phone companies are embedding readers and customizable software; other companies are embedding readers in a myriad of other devices and objects, such as automobiles, chairs, and toys. Some readers can communicate directly with the web for example, and their flexibility in dealing with more remote problems is important.

Readers can be mobile or stationary. They can be mounted in vehicles, on belt buckles, in the floor or pavement, and just about anywhere. These devices can be quite expensive, so the business application should be considered carefully.

Since readers can be mobile and remote, authenticating them to get them onto your network requires security both on the reader as well as on your host systems and networks. Applications such as RFID middleware, WMS systems, other specialized applications[5] that use RFID, or solutions that manage your whole portfolio of wireless devices, exist to manage the various types of readers. A bit of care in setting up security can go a long way in ensuring the seamless control of authenticating, operating, managing, and, when needed, de-installing these devices. If the reader gets into the *wrong hands* you will want to get it off the network quickly (think about this—after all, this is about identity, security, and accuracy, right?). So the relationship of the reader to your software solution is critical. We will talk more about this issue in our RFID Software report.

When purchasing RFID technology, you will need to think globally. As a general rule, tags have to work across the entire value chain, which could comprise multiple sites or even multiple companies. Approval for purchasing readers is generally a corporate decision—not a site decision—because again, you want to manage their entry into your network. But today, many devices used for bar-coding are bought at the local level. So implementing RFID may require a change in authority for both the site manager as well as the vendors, who will need to get more people involved in the buying decisions! Though you might not like that change in buying authority, it is important from a security perspective. Security will be extremely important, because we will eventually use these devices everywhere.



[5] Firms like Globe Ranger, BEA, Sybase, Blue Vector, Movero, Cisco, Oat, Apprion, etc. can help with this.

Understanding the Technology—The Science of RFID

Now let us begin at the beginning, and really understand the properties of this amazing phenomenon of nature! You may wonder why you need to learn about science in making business decisions. But your effort to understand a bit about the science of RFID will help you tremendously in making technology and applications decisions, as well as in being able to have informed conversations with the vendors. This will directly correlate to the success and ultimate value you derive from your RFID initiatives. This section will be deep with lots of definitions that you can refer back to.

BASIC SCIENCE

Don't get thrown off by the word science. You will not need a Physics or Electrical Engineering degree to understand this. In fact, you *should* learn this, and not rely on your resident geek. Besides, this will explain many of the day-to-day applications you are already using. Most implementations happen away from the EE contingent, and once installed, the average professional (warehouse worker, nurse, doctor, or store sales staff) will be expected to operate this, so learning is key. I learned it, so you can, too!

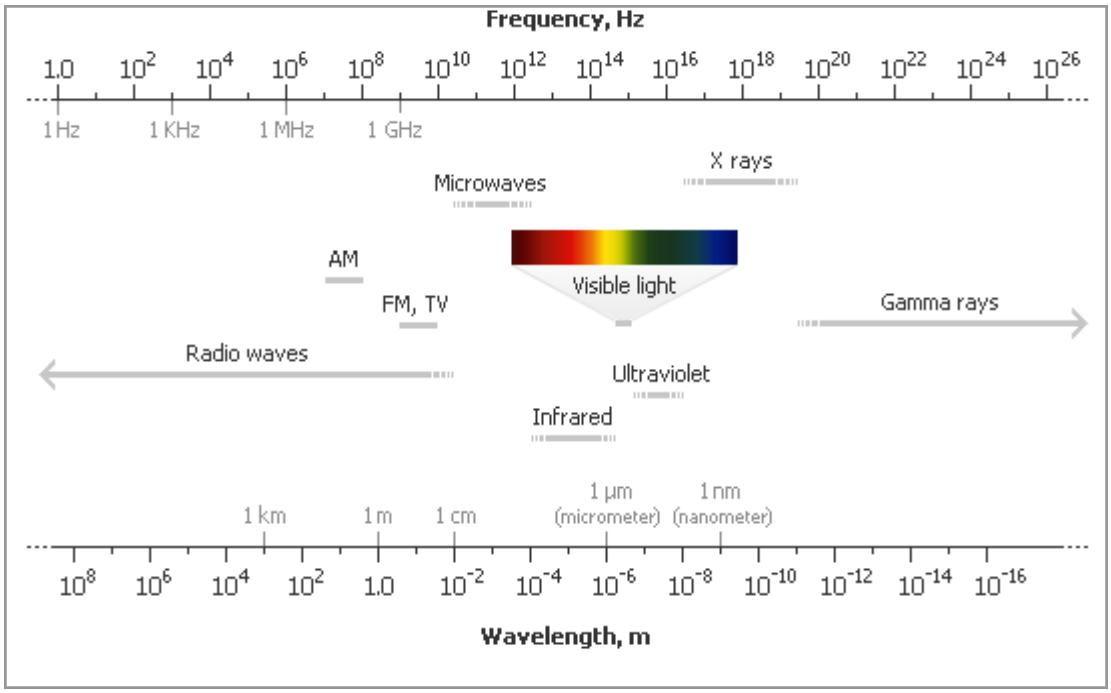


Figure 5: The Electromagnetic Spectrum

THE ELECTROMAGNETIC SPECTRUM

First, a basic understanding of electromagnetism. Electromagnetic waves have both an electrical and a magnetic field. There are many different electromagnetic wavelengths and frequencies that exist on earth *(figure 5, previous page)*, and many that we can harness for communications (and identification purposes). X-rays are towards the right end (higher frequency) of the electromagnetic spectrum and are very intense and concentrated because the wave is so small. That's how they're able to penetrate materials. Infrared waves, in the middle of the spectrum, are the size of a dot, and very close to visible light. (That is why it is great for getting in and out of shows and clubs! Another kind of identification!) And RFID, actually a relatively long wave, is to the left end of the spectrum. Wavelengths in RFID may vary from about the size of a baseball, to more than a mile long!

Electromagnetic (EM) radiation is energy propagated as electromagnetic waves through free space or through a material medium.

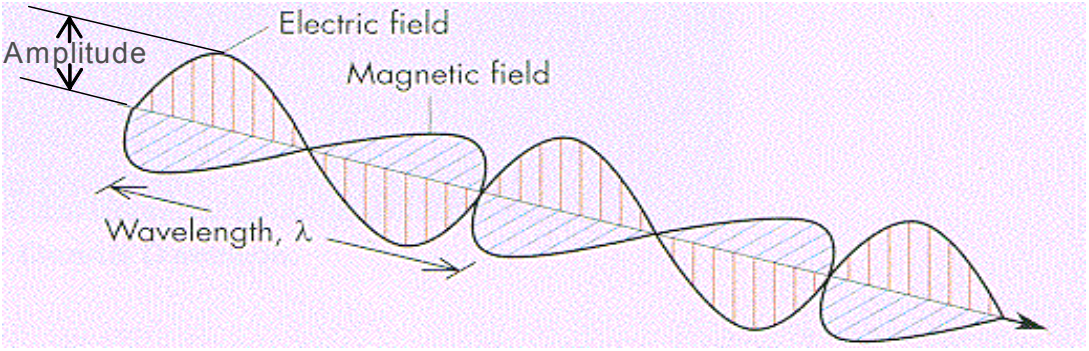


Figure 6: RF Waves

Electromagnetic waves need *no material medium for transmission*. Thus, light and radio waves can travel through interplanetary and interstellar space from the sun and stars to the earth. Regardless of the frequency, wavelength, or method of propagation, electromagnetic waves travel at a speed of about 186,272 miles per second in a vacuum. *That is the speed of light!* All the components of the electromagnetic spectrum, regardless of frequency, also have in common the typical properties of wave motion, including diffraction and interference. The wavelengths range from less than a quadrillionth of a centimeter to many billions of kilometers. The wavelength and frequency of electromagnetic waves are important in determining heating effect, visibility, penetration, and other characteristics of electromagnetic radiation.

At the beginning of the 20th century, physicists found that the wave theory did not account for all the properties of radiation. In 1900 the German physicist Max Planck demonstrated that the emission and absorption of radiation occur in finite units of energy, known as *quanta.* As it turns out, waves don't behave so well around "these parts." We will come back to this concept when we discuss the impact of physical properties on data propagation and waves.

In learning about RFID, it's important to understand the characteristics of waves, so let's look at RFID waves.

To understand RFID, you have to know more about waves than just their length. Understanding their properties is important to how you will eventually choose your hardware. X-rays, again, penetrate physical objects—we don't want to get too near; infrared, like light, is easily interrupted by any solid object but can carry a fair amount of data, usually over a short distance. (Remember that wonderful feature on your laptop!) Since infrared does not penetrate solid objects, it's usefulness is limited to applications where there is a direct line-of-sight between the tags and the readers. Barcode readers have the same limitation—the barcode applications must have a clear line-of-sight between the barcodes and the readers. But this is what is so cool about RFID, it does not need line-of-sight. RF waves can go around objects, and can even penetrate some objects that visible light cannot. That's why you can hear a radio in another room. *That's the advantage of RF over infrared and bar-coding—it does not require line of sight.*

Waves are wonderful things that can carry lots of data, including pictures, movies, sounds and so forth. How do they do that? By modulating (changing) the wave's form over time, the wave can carry information. There are a number of modulation techniques, some of which you *hear* every day. Common modulation techniques include FM (Frequency Modulation), and AM (Amplitude Modulation).

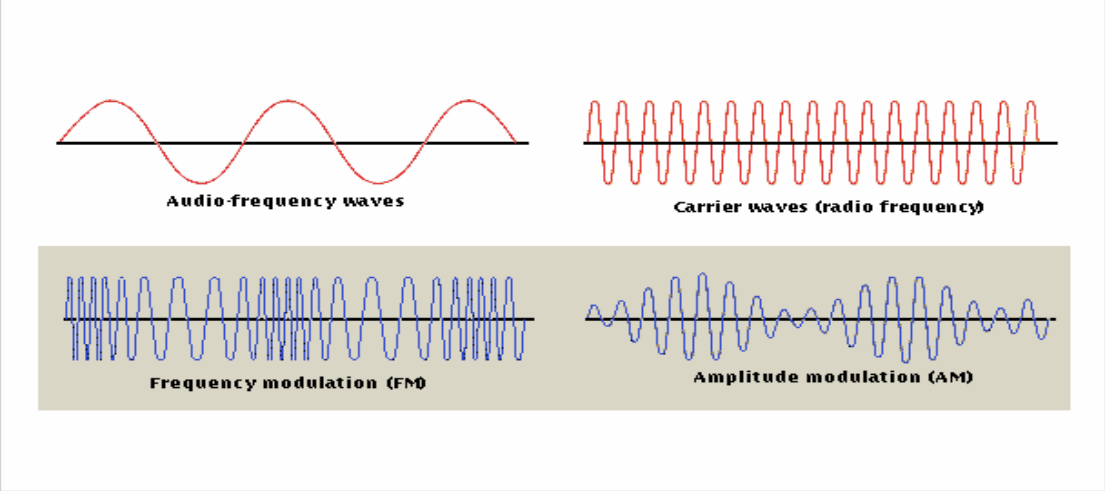


Figure 7: AM and FM Waves

Amplitude modulation—as used in AM radio—works by modulating the amplitude (height) or strength of the wave. FM modulates the frequency of the wave. (I hope you are with us here because this is actually very useful information for whatever your technology field is—or even just for idle curiosity.)

In *figure 7, previous page*, the "Audio frequency waves" on the upper left are the information that is being transmitted over the radio waves—for example Sting singing "I'll Be Watching You." The "Carrier waves" on the upper right are the radio waves, vibrating at a *much* higher frequency than the audio waves. In the FM signal on the lower left, the amplitude is constant, but the frequency (waves per second) changes to reflect the audio information you are sending. In the AM on the right, it is the amplitude that changes, and frequency remains constant.

Another common type of modulation is phase modulation, often called phase-shift, keying, or PSK. Information is encoded by modulating the phase of carrier wave, rather than its frequency or amplitude. So by modulating or altering the wave, we can transmit unique data.

UNDERSTANDING RF FREQUENCY OPTIONS

What are the characteristics of RF vs. the whole spectrum of possible waves out there?

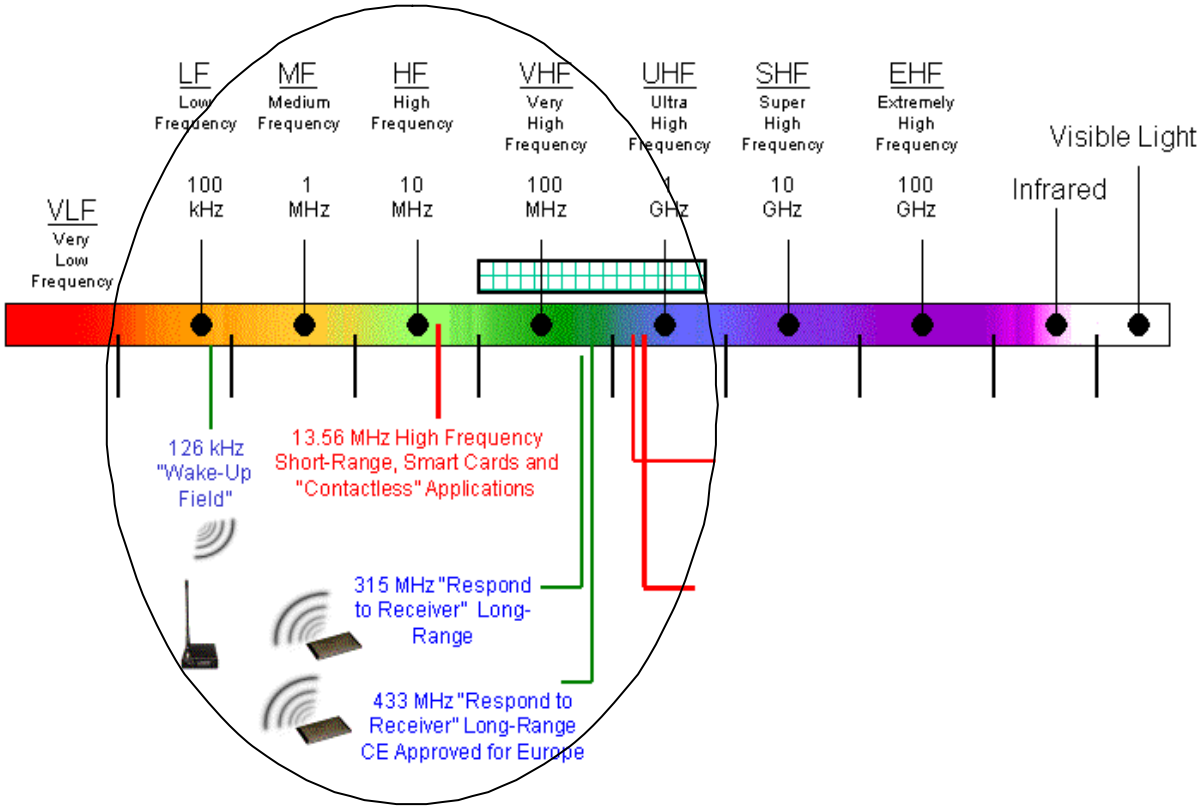


Figure 8: RFID Frequencies

Frequency, Velocity and Wave size are all linked. In the EHF (Extremely High Frequencies) range, the wave size is incredibly small.[6] In the LF (Low Frequency) and VLF (Very Low Frequency) ranges, the wave size is very large—sometimes kilometers long! Many years ago before cable TV, many people received TV broadcasts over UHF. Reading the chart in *Figure 5, page 10*, you have to understand the exponentials here—from a quadrillionth of a centimeter to many kilometers. Obviously, with such differences, the frequencies have very different characteristics and applications. We will discuss the used of differences later. But the fact is that you have many choices in frequencies.

In certain industries, these frequencies have become the norm, such as 860 MHz—960 MHz UHF in Retail, and 433 MHz in Maritime.

Acronym	Full Designator	Freq Range	Applications
ULF	(Ultra-Low Frequencies)	3 – 30 Hz	
ELF	(Extremely Low Frequencies)	30 – 300 Hz	Navy strategic communications
VF	(Voice Frequencies)	300 -3000 Hz	
VLF	(Very-Low Frequencies)	3 kHz – 30 kHz	Navy strategic communications
LF	(Low Frequencies)	30 kHz – 300 kHz	Navy Comm, Navigation (NDBs)
MF	(Medium Frequencies)	300 kHz – 3 MHz	Navigation (NDBs), AM Broadcast
HF	(High Frequencies)	3 MHz – 30 MHz	Short Wave, Ham Radio, Int'l Broadcast
VHF	(Very-High Frequencies)	30 MHz – 300 MHz	FM Broadcast, Television, Police/Fire
UHF	(Ultra-High Frequencies)	300 MHz – 3 GHz	Satellite, GPS, Cell Phone, Television
SHF	(Super-High Frequencies)	3 GHz – 30 GHz	Satellite Communication and Broadcast
EHF	(Extremely High Frequencies)	30 GHz – 300 GHz	Satellite Communications

Table 2: Using the Waves

Traditional users of waves (*Table 2, above*) that broadcast *one to many*, such as transmitting the program for Super Bowl Sunday, will now find the air space a lot more crowded. Millions of items carrying RFID tags, the cartons the items are packed in carrying additional RFID tags, and the containers the cartons are shipped in carrying even more RFID tags—multiple taggings per product across the globe—will be broadcasting *many to many*. And the tags will be able to *answer back!* But RFID architects have developed communications strategies and techniques to keep us all in harmony. More on that later!

[6] Each of the pick marks on the Frequency Scale represents a factor of 10. So that's a million, ten million, a hundred million, a billion, a trillion, quadrillion, quintillion, … gazillion, which is pretty fast, so it can carry a LOT of data.

	Definition	Bits and bytes	Frequency Cycles per second Hertz or Hz	Relationship of Frequency in the EM Universe	Wave Length Examples
Hertz	One cycle per Second.		Hz	3-300 Hz ELF or Extremely low frequency 300-3,000 Hz ILF or Infra Low Frequency	Voice Maritime communications
Kilo	One thousand or when talking about data capacities and rates, kilo means 2^{10} which is 1,024	Kilobits ~ 2^{10} bits Kilobyte ~ 2^{10} bytes	kHz 1,000 cycles per second	LF or Low frequency: 30 kHz- radio It's all radio from here up to GHz– U2, anyone? 125 kHz- RFID Use in close proximity reading and writing	30 kHz ~ 10 kilometers 134.3 kHz ~ 1.25 miles 300 kHz ~ 1 kilometer
Mega	One million or when talking about data capacities and rates, mega means 2^{20} which is 1,048,576	Megabits ~ 1,000 bits Megabyte ~ 1,000 bytes	MHz 1,000,000 or 10^6 cycles per sec-ond	HF UHF (433 MHz Cisco) 800 MHz to 900-915MHz RFID Gen2	13.56 MHz ~ 74 ft 433 MHz ~ 2' 3" 915 MHz ~ 13 inches
Giga	One billion or when talking about data capacities and rates, giga means 2^{30} which is 1,073,741,824	Gigabit ~ one billion bits Gigabyte	GHz 1,000,000,000 or 10^9 cycles per second	EHF- Microwave 2.4 RFID used passively 2.4 GHz used for wireless communications actively	2.4 GHz ~ 5 inches!!! 5.4GHz ~ 2 inches
Tera	A trillion, which is a million times a million A thousand giga or when talking about data capacities and rates, tera means 2^{40} which is 1,099,511,627,776	Terabyte ~ 2 to the 40^{th}	THz 10^{12} cycles per second	300 GHz – 400 THz is infrared light, not radio waves. This is not RFID.	

Table 3: The Language of Waves

Understanding Waves

Now, let's get some terminology again. You know there are RF waves—some smaller than others. Let's understand the language of waves, then.

Bits and Bytes—These are measures of quantities of digital data. 1 bit = 1 "binary digit," which can only have a value of either 0 or 1. 1 byte = 8 bits.

Measurements of data—In the world of computers, measurements are generally organized in "powers of two" sizes. For that reason, you will see information described in powers of two. For example a kilobyte, means 2^{10} bytes (which is 1,024 bytes) rather than meaning exactly 1,000 bytes. Similarly a megabyte is 2^{20} bytes and gigabyte is 2^{30} bytes.

Hertz—Is a measure of frequency in cycles per second. It is also used to measure bandwidth, which is the amount of frequency spectrum available for communications.
1 Hertz (Hz) is one cycle per second. A kilohertz (kHz) is one thousand cycles per second. A megahertz (MHz) is one million cycles per second. And so on.

Frequency[7]—Number of events during a time period, like frequency of trips to the coffee machine ("Joe's average coffee machine frequency is 11.6/day"). For RF, it refers to the number of electromagnetic wave oscillations per second. 1 kHz would be 1,000 cycles per second.

Wave/Wave Length—Is the distance between peaks of the electromagnetic wave, the completion of one cycle. Think of each wave coming to shore, say, one wave per 8 seconds (frequency) with a 100 foot spread (wave length). The height of the wave (the amplitude) is 20 feet—surf's up, dude! In this scenario I can get a fair amount of surfers riding a fair amount of waves in a fairly small area.

Velocity—The velocity of electromagnetic radiation through a vacuum is constant at 299,792,458 meters per second,[8] which is represented by the letter ***c***, also known as *Einstein's Constant* (remember $E=mc^2$?). Radio waves travel very slightly slower through air – 99.97% as fast as through a vacuum. Fast enough? The velocity of the wave and its frequency and wavelength are interrelated.[9]

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[7] Harry Newton, *Newton's Telecom Dictionary*, (San Francisco, CA: CMP Books, 2005) Number progressions from Kilo to Tera are not exactly straightforward and vary depending on the technology applications: telecommunications, computer storage, etc. Slight variations exist in the meanings of Giga, Tera, etc. … but for our purposes we will stick with the basic "Round numbers."

[8] Approximately 186,282 miles per second, or 670,616,629.4 miles per hour.

[9] In mathematical terms, this relationship is expressed by the equation $V=\lambda f$, where V is velocity, f is frequency, and λ is wavelength. Because V is essentially constant in the practical use of RFID, it means that a change in the frequency results in an inversely proportional change in wavelength.

Range—Range cannot be calculated precisely, because wave performance is impacted by so many different factors. However, RF waves can sometimes travel long distances, as long as nothing gets in their way.

Power—Measured in Watts. In the case of the RF wave itself, power is the average rate of energy transported by electromagnetic radiation. The power level of the wave determines the signal strength. Power is regulated, and there are guidelines for determining how much power can be used, and under what circumstances. (See standards later on.) Power can be variable based on application distances.

Putting things together—Many of these variables tie together and determine what frequency and what range you will achieve.

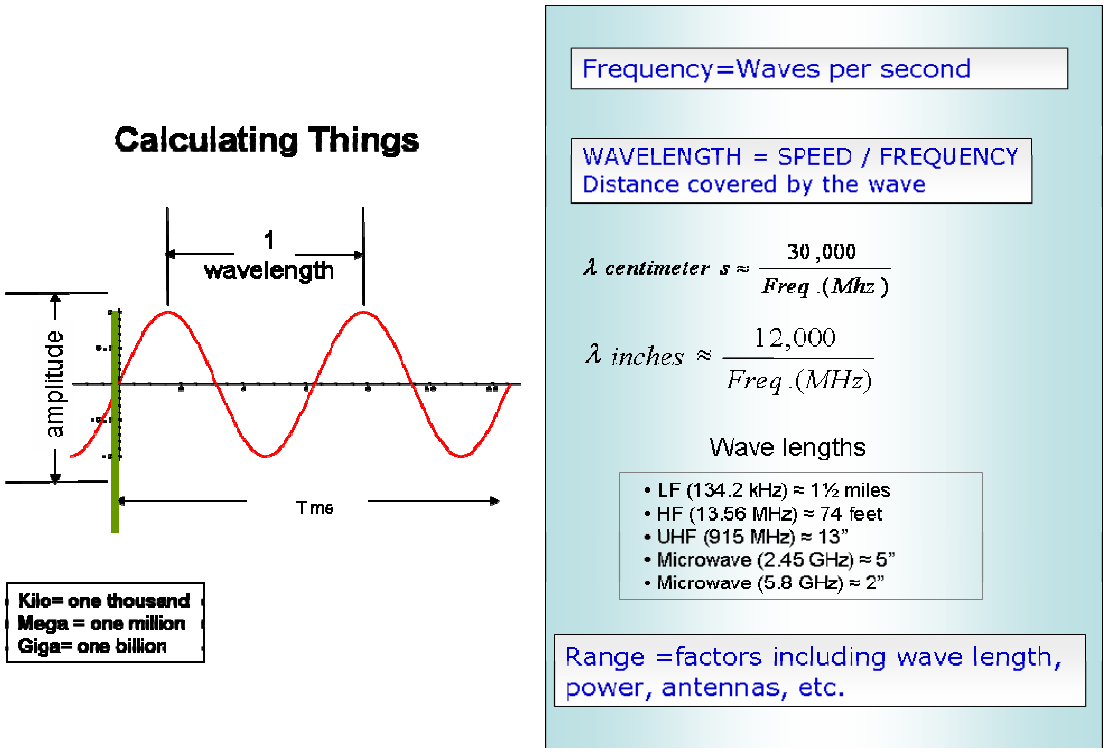


Figure 9: Calculating Things

Interference—Nothing is perfect, so interference occurs when two or more waves overlap or intersect. When waves interfere with each other, the amplitude of the resulting wave depends on the frequencies, relative phases (relative positions of the crests and troughs), and amplitudes of the interfering waves. For example, *constructive interference* occurs at a point where two overlapping or intersecting waves of the same frequency are in phase—that is, where the crests and troughs of the two waves coincide, resulting in a more powerful wave. In this case, the two waves reinforce each other and combine to form a wave that has amplitude equal to the sum of the individual amplitudes of the original waves. *Destructive interfer-*

ence occurs when two intersecting waves of the same frequency are completely out of phase—that is, when the crest of one wave coincides with the trough of the other. In this case, the two waves cancel each other out. Intersecting or overlapping waves that have different frequencies or that are not entirely in or out of phase with each other have more complex interference patterns. When two or more devices are trying to use the same frequency, in the same physical space, the resulting interference can cause higher error rates or complete loss of communications.

***Strength of Field*—**Although RF is cool stuff, energy drops off pretty rapidly as you get away from the source of that energy. You lose power, and after a certain point, the signal is lost. This concept is fairly easy to understand. There are techniques in passive RFID to help a bit with this, but obviously, power helps to keep the signal strong at greater distances.

***Data Transfer Rates*—**How fast the data moves. Data transfer rates are affected by several factors:

- **Bandwidth available —** this is determined by regulations.[10]
- **Modulation Technique —** some modulation techniques inherently make more efficient use of the available bandwidth than others. For example, AM (amplitude modulation) is less expensive to implement, but is inherently less bandwidth-efficient – i.e. you can squeeze fewer bits per second of data through each MHz of available bandwidth.

Data transfer rates are defined as part of RFID standards, so this helps us to get a handle on the actual data rate of a specific reader and tag – i.e. it depends on the RFID standard/ air interface protocol that they support.

Standard	Passive vs. Active	Frequency
ISO 18000-2	P	LF – 125kHz
ISO 18000-3	P	HF – 13.56 MHz
ISO 18000-4	P	Microwave – 2.45 GHz
ISO 18000-5	P	Microwave – 5.8 GHz
ISO 18000-6	P	UHF – 860-930 MHz
ISO 18000-7	A	UHF – 433.92 MHz
EPC Global Gen2	P	UHF – 860-960 MHz

Table 4: ISO Standard Frequencies

[10] Geographical standards in the US, EU, and Japan, etc. regulate UHF and other frequencies.

RFID in My World

These are some basic concepts, and now we will weave these together to build your knowledge of RFID, so that you can select the right solutions for your application!

You now have a working definition of RFID. You have learned that RF waves are sent between tags and readers. It seems that a spot-on direct beam would be a real advantage. Obviously, that is not always possible—rarely so. The reader and the tag may not be in close proximity, or the orientation (alignment) of the tags and reader may not be optimal. This is the real life situation that you will deal with. The dynamics of the environment, and the characteristics of the waves are all-important in designing a system, as well as selecting the right technology to work for you and your trading partners.

Now, let's begin to build on these concepts so that you can understand what kind of solutions—tags and readers, active or passive—you will need for your application.

NEAR FIELD VS. FAR FIELD

Near field and far field are concepts that are important to understand when you design and select an application for both the tag and the reader. So much about RFID is both art and science. The science is in understanding the physical properties, and the art is knowing that you can alter the factors and come up with a solution that works in your environment.

So, items that are tagged will at some point need to be read. The challenge becomes: *what and where are we reading from?* That is where far field and near field come into play.

Near field refers to the interaction between tag and reader when the tag is *less than one wavelength away* from your reader antenna. Far field is the kind of interaction that happens when the tag is *greater than one wavelength* from the reader antenna. They're completely different phenomena.

The near field uses inductive coupling, sometimes called magnetic coupling. Whenever you apply power to an antenna, a magnetic field emerges around it. In one wave length, you can use the magnetic properties of the devices to create the induction between the reader and the tag. Latent magnetic energy is built up. Every magnetic field has lines of magnetic flux. The tag antenna interrupts those lines of flux from the reader, drawing power from the field. Through inductive coupling, you can now energize the tag, read it, and transfer data back to the reader. *(See Figure 10, next page.)*

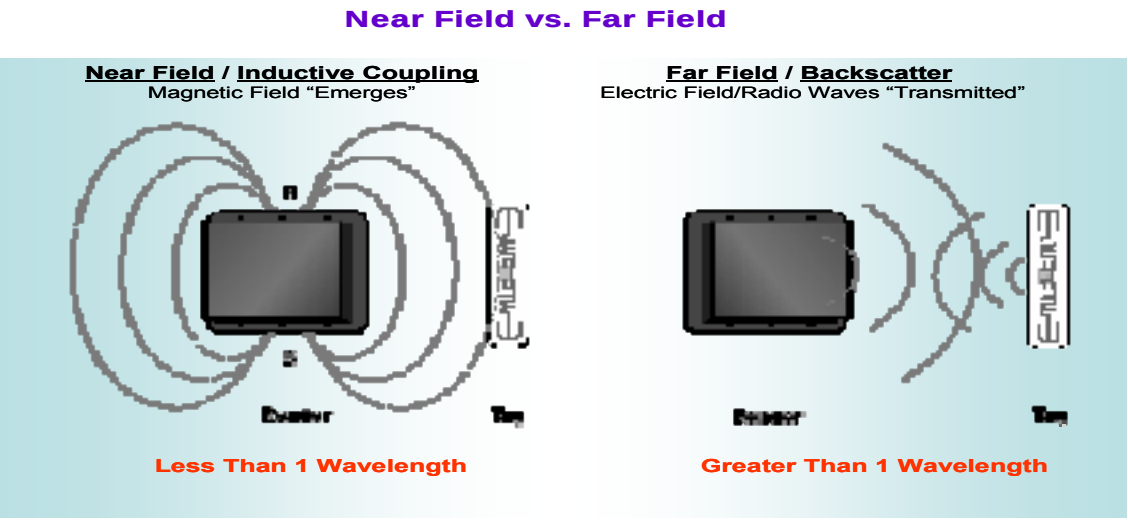


Figure 10: Near Field vs. Far Field

The far field, (again, this means operating beyond one wave length) uses backscatter. Tags using backscatter reflect the reader's signal right back and modulate incoming signals to transmit data.

Now why do you care about this? Well, it impacts a number of factors influencing performance in specific situations: what kind of antennas you should buy, and how you should set up your readers. Some applications are in close proximity. and you can control the orientation of the tag. But in many applications, items and people are in motion. Therefore, you're switching from far field to near field. *(See Figure 10, above).*

Let's take the ever-popular examples of UHF tags (865- thru ~ 915MHz) and the HF (13.56MHz) tags. UHF has a wavelength of just over a foot, so operating in UHF, we are in the near field mode from 0 to about 13 feet.[11]

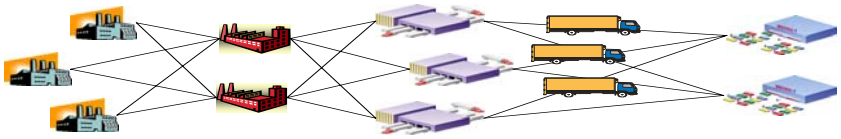
So, if a warehouse is, say, a few hundred yards long and you want to track items as they move, you will be working both outside and inside the near field—in other words, in far field and near field.

The use of UHF across the world creates challenges, since frequency, as well as tag antenna designs will vary, and therefore the tag range will vary. You will need to evaluate whether the tags on the goods that you receive at your facility will be near field or far field, so that you can set up your reader orientation properly. It is challenging to get it right when you receive goods from many sources carrying many different tag antenna styles.

[11] Across the globe the precise UHF frequencies vary, and can put your tag into far field at slightly different ranges, though the difference is quite small. More on this later.

The HF (13.56 MHz) tags, which have a global standard, do not have this problem. HF tags and LF (125 kHz) tags are being used in applications in supply chain and hospitals, etc. where there are no fixed readers, for example, because their wave length, as well as their ability to work with various physical properties gives them an advantage. UHF, though, may be your choice, regardless of the other concerns, since this is the Wal-Mart and DoD logistics choice. So learning how to work with this technology in both near field and far field is generally required.

Applicability of Frequencies- Far Field / Near Field



Entity	Warehouse / Manufacturing	Yard	Store
			
Reader / tag distance	6 inches to 30 feet	100 feet to 1 mile	Less than 2 feet
UHF-Passive 800-960MHz	Near Field....to Far Field	Out of range	Near Field
13.56 HF Passive	Near Field	Out of range	Near Field

Figure 11: Applicability of Frequencies - Far Field / Near Field

OPERATING IN NEAR FIELD AND FAR FIELD – MAKING IT WORK

So, now the issue becomes *how to ensure successful reads*.

Near Field
(Inductive Coupling)

- Operating within one wave length
- Inductive Coupling – the transfer of energy from one circuit to another (by antennas, of course)
- Receives power by breaking the bonds of flux of the magnetic field

Near Field

Applying inductive coupling, there are four major factors that you need to look at in the near field:

POWER: In near field you might not need much power, since you are operating within the lines of flux. However, in near field your field strength drops off at a faster rate than far field.[12]

ANTENNA: The larger the antenna, the more lines of flux you're going to interrupt, and the more power you will receive. This is why you see tags with lots of antenna coils, compared with horizontal antenna patterns.

ORIENTATION: Directionality of devices in relation to one another is important. In RFID devices, the antennas are either fixed or in motion. Orientation is particularly important in passive technology for successful communications. Orientation and the shape of the read field are important related concepts. In fixed environments (e.g. conveyors, or dock doors with fixed readers) you can experiment and align the tag and reader to ensure that they can send and receive signals successfully. Your reader can have several antennas to help capture the wave.

Q FACTOR: This means: how efficient your tag antenna material is in converting the signal to electric power and back. Antenna material choices are aluminum, copper and silver, and their prices increase in that same order.[13]

Far Field
(Back scatter)

- Operating beyond one wave length
- Backscatter: the deflection of waves through angles greater than 90 degrees by electromagnetic forces.

Far Field (Backscatter)

POWER: Here, more is better, but wattage is regulated, and too much creates interference with other devices (like too many people shouting). Techniques have been created to ensure that the individual items are not cross-talking. Different geographic regions have different regulations (for example, Europe requires listen before talk—oh, if people only had that protocol!). Tags can be kept asleep until they are read; signposts can be used to wake up the tag before it is read, and leave it 'asleep' in between; shields can be used to control the direction of the power radiating from your reader's antenna; cross signals can be avoided.

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[12] The inverse cube of the distance ($1/distance^3$) which is a much faster drop-off in power than far field, which falls at the inverse square of the distance ($1/distance^2$). But who's counting?

[13] As we move into Chipless technologies, the aluminum has it beat on ease of printing and price of antennas, but copper is the hands down winner on conducting electrons!

ANTENNA: Here bigger is better, but you have to pay attention to the ratio of antenna length to wave length. The wave causes the antenna to resonate at its frequency, so the antenna has to be tuned to that frequency. The length of the antenna impacts its tuning, so it should be an exact fraction of the wavelength. If the antenna is next to a material, the material itself "detunes" the antenna, so antenna length needs to be adjusted to account for the detuning effects of nearby materials. In practice, if the detuning effects of the objects you're tagging are not so large (e.g. corrugated cartons), then tags with standard off-the-shelf antennas should work fine. But if the detuning is significant, you may need a specialized or custom-tuned/ custom-designed antenna.

ORIENTATION: Orientation of antennas on both tag and reader is key.

ENVIRONMENT: Environmental factors play a role, since different media conduct, reflect or absorb signals at greater distances. This is a bigger factor to consider.

Putting this together, if you're going to use UHF, sometimes you will be operating in the near field and sometimes in far field. The tag has to operate in both modes. Usually tags will be tuned for the far field, but that means it may not work very well in the near field. Therefore, you should test it in both environments and find an approach that will work in both, knowing that you will not be in control of successful reads once your items leave your custody. Your customer expects successful reads. So this is not idle advice.

DETUNING

Some material can *detune* the antenna. Many of the properties we talked about (wavelength, range and speed) are characteristics that work ideally only in free space. Once you put your tag on an object, the object can change the tuning. Remember Max Planck. We mentioned his discovery on page 11. So antenna design and a bit of experimentation on tag placement are necessary to avoid the effects of detuning. Since the RFID revolution took off two years ago, over a hundred new antenna designs have come out. And there is nothing to stop your firm from having a custom-designed antenna, if it is cost justified. Your packaging or product might need that.

ANTENNA AND FIELD CHARACTERISTICS

So, hopefully you are getting the message that the antenna is a critical part of the selection discussion! So much discussion on the street talks about UHF vs. HF vs. LF, but very little discussion takes place on antennas, inlays, etc. But these are the aspects that will actually *make the difference* for your item having successful reads! As we have said several times, you may have no choice in your frequency, so getting (UHF) RFID to work for you requires thinking about antennas that can perform in your environment.

Tag Antenna Length

Antenna length offers a big opportunity for customization of RFID applications. In order to grab the signal—not just in far field or near field, but in different media and with different packaging—you need to think about your tag antenna's shape and length. For far field applications, the length of the antenna should be a wavelength. So if you're dealing with 915 megahertz, a thirteen-inch antenna (one full wave length) would be ideal. Obviously, such a huge antenna would not be practical for most applications, so antennas that are a fraction of the wave length (1/2, 1/3, 1/4, 1/5, 1/6 of a wavelength) are used. For near-field applications, the relationship of the length of the antenna to the wavelength is not critical (remember, you are still within one wavelength).

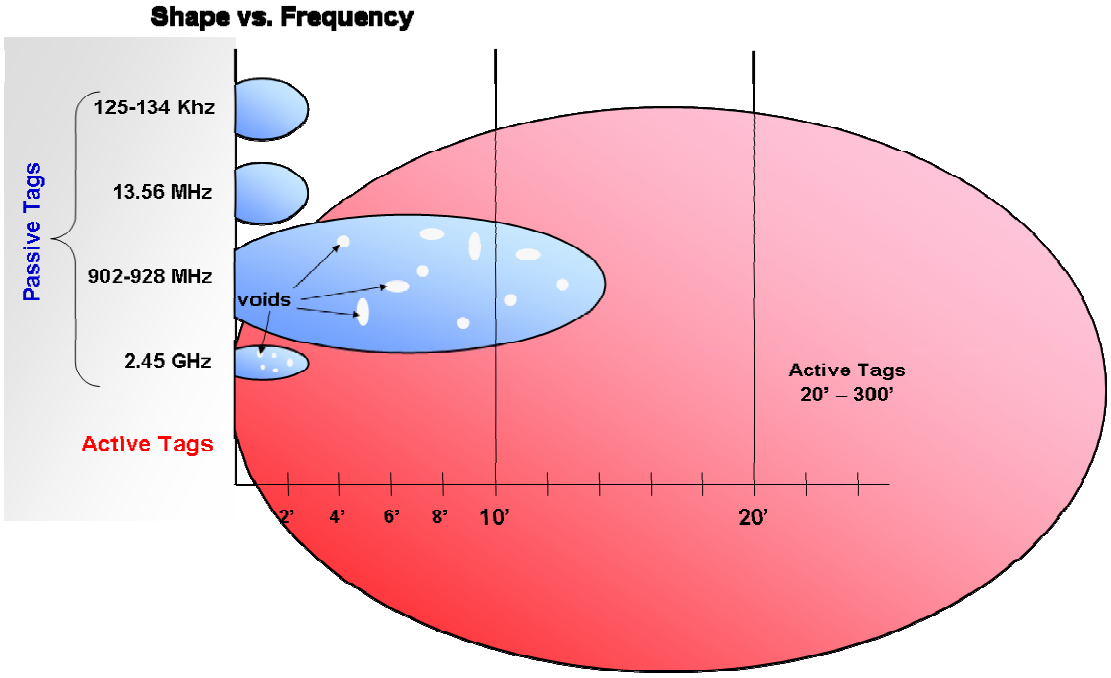


Figure 12: Shape and Frequency (not to scale)

Waves are not traveling in a vacuum, so we have to account for the impacts that the environment has on the waves. Waves also have their own characteristics in terms of wave shape and other quirks.

Frequencies and antenna designs play a role in the shape of the read field (the area where tags can be read). In general, lower frequencies have a rounder field, and as you get into the higher frequencies, it's more of a cigar-shaped field.

Nothing is perfect—and voids can exist within a read field. (See *Figure 12, previous page:)* Voids are areas of low energy within a field where tags can't be read. The higher the frequency, the more voids there are. There are a number of tactics for dealing with voids, including:

- Use two or more reader antennas (objects in a void in one antenna can still be read by the other antenna)
- Make sure that the objects will be moving through the read field, such as on a conveyor or hand truck—that way even if they are in a void for a moment, they will soon be back into the "good" part of the read field
- Map out the field and adjust the position and/or power of the antenna to make sure that the position of voids is known and they are not in critical locations where the reading is typically done

Antennas for readers can also be custom-designed, and of course, portal environments for dock doors, etc. are all the rage. Again, the art here is to test your environment to ensure that you are getting your reads, but don't overdo it! There are lots of great techniques, but we don't have the space in this report for an in-depth discussion of implementation techniques.

Linear vs. Circular Antenna Designs

You have probably seen many different shapes of antennas in the market (*Figure 13, below*). By changing the shape of the antenna, you can tweak the shape of the field. Again, think about your application: how and where will you read and what shape is the best approach for your purpose? Smart cards come in very close proximity to an antenna, vs. say, a carton on a conveyor.

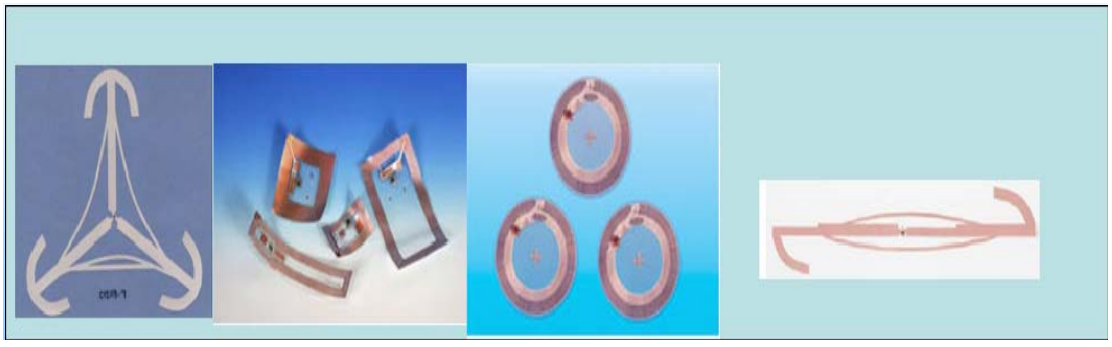


Figure 13: Shapes of Antennas

The shape of the field is also determined by the reader antenna design and its *polarization*. Linear polarization is a longer, narrower field. So you can get slightly more range, but linearly polarized fields are also more sensitive to orientation of the antenna on the tags. Circular polarization is a slightly shorter read range, but a wider span and less sensitive to tag orientation. The wider field may be important in fast-moving conveyor operations to ensure that the tag stays in the field long enough to get reliable reads. There is more to say about this topic, but it does get fairly dense. *Figure 14, below* gives you a way of thinking about it. Just remember, our world needs to be thought of in three-dimensional space.

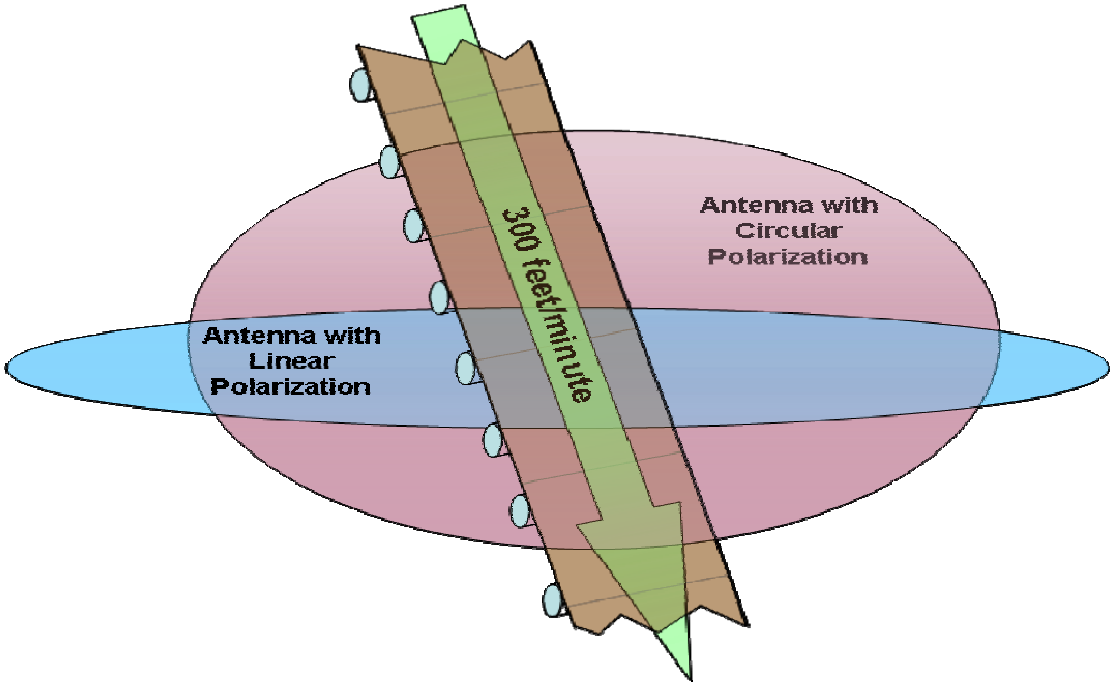


Figure 14: Shape of Read Field in Application

The Shape of Read Field in the Application

In most applications the object is in motion. So you're also going to want to consider the speed of the object going through the field. You might want a circular field so that the tag stays in the field for a longer period of time. Also, how much control do you have over the orientation of the tag antennas on objects as they pass through the reader's field? On a factory conveyor belt, the orientation of the objects and their tag's antennas may be very consistent, and so a linear reader antenna may work fine. But at dock doors or going through the front store (think—store associate balancing a pile of cartons), the orientation of tags may be pretty random, in which case you are better off with a circularly polarized reader antenna. These are some of the things you're going to have to think about. *Application, Application, Application!*

Thoughts on Antennas

Though the chip may be the same, the tag antennas are often quite different. Some—maybe yours—may need to be custom-designed to deal with the physical properties of the product and the environment. This could include the need for very small specially-shaped antennas that fit an object (e.g. an expensive pen); or antennas that must work on metal objects or on objects with large de-tuning effects, etc.

Reader	Reader Power Emitted	Watts of Power transmitted by Reader Reader Antenna Gain Proper Installation (cable lengths, connections, etc.)
Passive Tag	Tag Antenna Design	Design and Quality Matching impedance of Antenna and Reader Antenna Material: Silver, Copper, Aluminum (price/performance tradeoff)
	Antenna Size (Near Field)	Larger antenna increases near field read distance Not applicable to far field
	Tag Antenna Tuning (Far Field)	Changes when applied to object All materials detune to a lower frequency, except metal that detunes up Always test read distances with label applied to an object (not in free space)
	Chip Power Consumption	Read requires less power than writing
	Materials in Object and Packaging	Metal, Liquids
Spatial Relation-ship	Antenna Orientation	Tag Antenna vs. Polarization of Field
	Near/Far Field	Near Field power levels fall off much faster than far field Far Field has more voids
Environment	Noise	Ambient EMI noise reduces read distance and accuracy
	Objects/Materials in the Environment	Metal Structures, Vessels of Liquid, Glass

Table 5: Factors Impacting Passive Read Distance

In addition, antennas can be made of different metals—aluminum, copper, and silver—all varying in price and conductivity. Whether for chipless or chip-based tags, the antenna has as great a role to play in the success of your effort as the other issues we have discussed. Of course, a custom-designed antenna adds cost that must be amortized over all the tags used, so though it may be the best technical decision, you will need to see if it is cost-justified. Again, test before you buy to make sure that this will work for you in all the circumstances we have discussed.

As your material goes through the various processes in the supply chain, the RFID vendors will be applying their know-how to build the ultimate tag or reader for your application. But, you as the end-user/buyer have to know the properties that you are seeking. Considering the many factors along the way (*Table 5, previous page: Factors Impacting Passive Read Distance*) is critical to buying the right hardware that will actually work throughout the chain—and having a successful implementation.

And for open loop (read more on page 35—*RFID-Enabled Processes)* applications, such as manufacturers who are under a mandate, you need to consider the readers and environment at *your partners' sites* and at any other points in the chain that need to read the tag—as well as the environment between the read points— e.g. will tags be exposed to extremes in temperature, weather conditions, or radiation (such as used in sterilization), harsh chemicals, etc.? And do they need to work in multiple regions of the world, which use different frequencies for UHF? Where will the items be read? Within a yard, or many yards away; on a conveyor, at one foot or two; or at a cash register; will they be machine swiped? Tags and Readers—whether handhelds, portals, or forklifts—need to be purchased with these factors in mind.

The cry has gone out for universal or 'global' readers, that do multi-protocol and multi-frequency (active/passive, as well as HF/UHF), but you still need to capture the waves. So tag antenna design is king, and reader antenna design is queen in considering the system that you purchase. These issues can be addressed in your pilots and implementation. Consultants and labs who know their stuff can help you work through these issues.[14]

Dealing with Environments and the Impact of Physical Properties

All physical properties have some impact on RF waves and therefore the accuracy of the signal. Let's cover a few more definitions before delving into this area.

Diffraction—property of wave motion in which waves spread and bend as they pass through small openings or around barriers. Diffraction is more pronounced when the opening, or aperture, or the barrier is similar in size or smaller than the wavelength of the incoming wave (like water falling through a sieve). Diffraction is a property of the motion of all waves. And it can be a good thing. For example, if a radio is turned on in one room, the sound from the radio can be heard in an adjacent room even from around a doorway. Waves, like water, sound, light, etc. will *fill the space* they are in. This is what gives RFID an advantage over barcodes.

[14] See RFID Technology Series:
http://www.chainlinkresearch.com/cart/prodinfo.cfm?guid=B037315B-C974-F1B5-885E-E8894C4F43E6

Reflection—Here the wave "bounces off" the surface it comes in contact with. In particular, radio waves are reflected off metal. Reflected waves from passive tags that return to the source generally have a weaker signal or a signal that may be out of phase. (Active tags tend not to have this problem). So tuning and environmental tag orientation are critical to mitigate reflection and ensure accurate reads.

Diffraction and reflection have been huge hurdles to overcome in using UHF and other frequencies, because with people and things constantly in motion, the effects of diffraction and reflection can be unpredictable. They can not only cause a tag to fail to return a full string of data, but they also can create interference in the environment for other devices, as well.

Absorption—Certain materials, such as water, absorb radio waves, resulting in a loss of energy and signal strength. This occurs generally due to the contact of the wave with a physical property that creates an interaction between the material and the wave. All you need to know is that some materials, like a sponge and water, absorb the energy. Different materials have different effects on radio signals. Some materials will detune, like cardboard and metal, and human beings.[15] Plastics and liquids tend to absorb, and metals tend to reflect. *Table 6, next page: Physical Properties and RFID* highlights the basic thinking on this.

High Population Density

Lots of devices, readers, tags and other wireless devices can interfere with the signals. When trying to isolate one item, high population areas can present quite a challenge. Technologies have been developed that allow readers and tags to operate in *dense reader mode* as well as other algorithms to sort through bad reads, duplicate reads, etc. These can be part of the reader hardware or the software that manages the readers.

The actual physical properties of your tagged items can also have an impact on clarity of signal and therefore what frequency and what antennas you use. Challenges to reading include reflection, absorption, interference and ambience. There are techniques that can sometimes be used to mitigate the effects.

Frequency	125-135 KHz	13.56MHz	900-915 MHz	2.4GHz
	LF	HF	UHF	EHF-Microwave
Range	< 3ft	< 1ft	30ft	30ft
Water	Very Good	good	ok	Poor
Metal	Good	poor	Poor (requires unique antennae)	good
Paper	Ok - but absorbs signal	good	good	good
Plastic	Good	good	Good (but detunes in far field)	Good (but detunes in far field)
Animals/ Humans	Good	detunes	detunes	good

Table 6: Physical Properties and RFID

There are a lot of charts like this out in the market. None of the comments here are absolutes. Many materials and surfaces detune, absorb or reflect waves. Poor performance and detuning can sometimes be mitigated by using isolation, insulation, or barriers between the tag and the item. But frequently this is not possible if you need a really flush packaging surface.

So let's look a bit more at the effects of specific physical properties:

Metal: Reflects waves, and that can cause waves to cancel each other out. Sometimes the solution is to put a barrier between the tag and the object that's tagged. Metal is also a conductor of electricity, remember. So you might be able to leverage off the material in some way, using the metal properties as part of the antenna to use a UHF tag.

Water: Absorbs radio waves. And it turns out that the lower the frequency the less it absorbs, and the higher the frequency the more it absorbs. And that's why UHF doesn't work as well with water as HF does. The US government has communicated via radio waves with submarines thousands of feet below the water by using Extremely Low Frequencies (ELF)[15] in the 30–300 Hz (that's Hz, not kHz!). So we're able to get radio waves through thousands of feet of water. These are very low frequencies, with huge antenna—we don't expect your application to fit into this category.[16]

[15] To transmit at these extremely low frequencies, the antennas used can be 15-30 miles long.

[16] Outside your facility this is regulated by FCC, so don't get too clever.

Back to day-to-day applications. If you are using passive tags on products that are liquid, 125 kHz and 13.56 MHz are frequencies that tend to work better than the higher frequency passive tags. Active technology—the power thing, again, such as 433 MHz active tags—works well with liquids. It is used today in applications such as returnable tote and asset tracking. Active is viable to many liquid applications—hazardous chemicals, high value pharmaceuticals, high value cylinders and tanks, and other products with high water content (fish, etc.)

Paper: Many people think there is smooth sailing with paper. *But, paper does impact the radio waves* by absorption. And it does detune the antenna a bit. Think about the density of cartons of paper, or huge rolls of paper! It does detune. Again, these issues can be mitigated with some research on your part for the best solution.

New materials have been developed to mitigate these effects—these can be applied to the tag by your tag converter, as a barrier between the tag and the item. Also, as we have said, antennas are being developed to deal with the issues associated with physical properties. Working through the issues in a pilot prototype will allow you to determine the right strategy for you.

Label Placement — Boon or Bane

A lot has been learned about the importance of label placement on packaging to minimize detuning. For example, people know the challenges of liquids and RFID. Yet, bottles with narrow necks, when placed in cartons for shipping, create plenty of air space at the top of the carton. Water impacts can be mitigated by placing the label at this end. Another example would be a box filled with soup cans. If the label goes on the box right over the spot where the round can touches the box, huge detuning occurs, and read distances decrease. But if the label placement is *between* where the cans touch the box, there is less detuning and better read distances.

CHALLENGES OF READERS

Let's focus on the reader for a moment. Readers have two basic elements—they can be read-only readers—fairly dumb—but subsequently fairly cheap. And then there are read/write readers. (Also called encoders). They can write EPC codes and other information on the tags as well as perform other types of business functions.

Readers can be mobile or fixed—mounted in walls,[17] floors, ceilings, on forklifts, etc. When considering the purchase of readers, think about not only multi-purpose readers, barcode and RFID, but also multi-application mobile devices (pocket PC, Blackberries, Palms and cells, Nokia phones, etc.). Consider also the readers' suitability with unique programmable applications, wide ranges of read capabilities, and wireless and/or satellite communications.

Readers emit and receive waves. The *front end* converts the RF wave—analog signals—to digital. There are common hardware modules on the market that reader manufacturers embed in their devices. The *back end* of the reader communicates with other systems—wirelessly or wired (RS232 ports, Ethernet ports or wireless chips). The key is to procure modules that are software-upgradeable and can be upgraded from your network. Once you get a large population of readers spread across the globe (and with active tags, this can be true, too), the concept of physically finding and upgrading each unit becomes untenable.

There are several challenges that must be met in designing readers that will operate successfully in a myriad of environments. The key is signal clarity. This problem is complex and has to do with high-traffic environments which produce interference, collision of signals, ambient noise, as well as range issues, to which waves are heir.

Range and signal can frequently be addressed by adding power and by adding more appropriately placed devices into the environment. As we mentioned earlier, there are limitations on how much power you can apply, so thinking through the combination of orientation, power, number and kinds of devices can make a huge difference. But there are clever ways of improving your chances of getting clean reads:

- Proper antenna placement (readers can have multiple antennas which can increase signal strength and stabilize your signal)
- Sensors can provide directionality
- More readers can provide greater range and intelligence

Software is the key, here. Software plays a huge role in the RFID world—both at the reader and middleware level. If a signal is weak or interrupted, or there is a collision or other interference, the software can fill the gaps and surmise what the data should be. At least it can tell you, 'Sorry, I didn't get that; please try again;' or 'I read 6; weren't you expecting 8?' Readers, however, are not *mind readers*, and cannot maintain process velocity and accuracy unless great care is taken while the system is designed.

A lot has been learned about tag collision on item-level passive tags. Different systems have been invented to isolate individual tags; the system used may vary by vendor. The terms you hear are *working in dense reader mode; listen before talk;* and *sharing the wave*

[17] Will have RS232 ports, and/or Ethernet ports, generally, to connect to other computers or to the internet.

through gap pulsing (very common technique used in wireless and Telco,[18] etc.). These are software solutions. Reducing power in areas where and when you don't want to read, sleeping and waking up, through the use of sign posts (hardware solutions) are all methods that should be examined. Doing site assessment is key here, since you can also tamper with your physical environment by creating isolation portals, etc.

Security is key—readers get lost and stolen a lot! So readers should be bought with both local security and network security, or RFID or wireless device management software that can authenticate devices joining (or leaving) your network.[19]

Deploying readers into the work environment needs to be thought through. FCC regulations also apply to devices with power, and there are standards for these. In addition, any power or wireless devices that might operate in airports (FCC approval needed), hospitals (FDA approval needed), ports, and within your factory should be reviewed for the impact they have on the environment—and the environment has on them.

The more software you put on your reader, the slower it will perform, although your performance criteria may not be heavy enough to perceive this performance degradation. All the vendors have performance data—from their labs. But you, need we say this again, need to test these products in your environment in heavy use before you buy a large quantity.

Readers also come with various antenna options. You will see their specs with circular or linear polarization. Antennas can be cabled to devices, so these antennas can be strategically placed to optimize reads.

One other thought on readers, since they tend to be hefty on logic (and price)—looking for readers that are multi-purpose and will be useful with the next generation of standards[20] on the horizon would be a smart purchasing move.

There is always much more to say, but let's move on.

---

[18] "When the reader recognizes that tag collision has taken place, it sends a special signal (a "gap pulse"). Upon receiving this signal, each tag consults a random number counter to determine the interval to wait before sending its data. Since each tag gets a unique number interval, the tags send their data at different times." Source: AIM

[19] Security at the tag, reader, or network level, that is.

[20] Gen 1, 2, and 3 as well as ISO 18000 6b, 6c, etc. for Passive UHF. Globally, as we discussed earlier, the other LF and HF operate in the less ambiguous environments. FCC regulations also apply for devices with power.

Selecting the Right Solution—What do I Use?

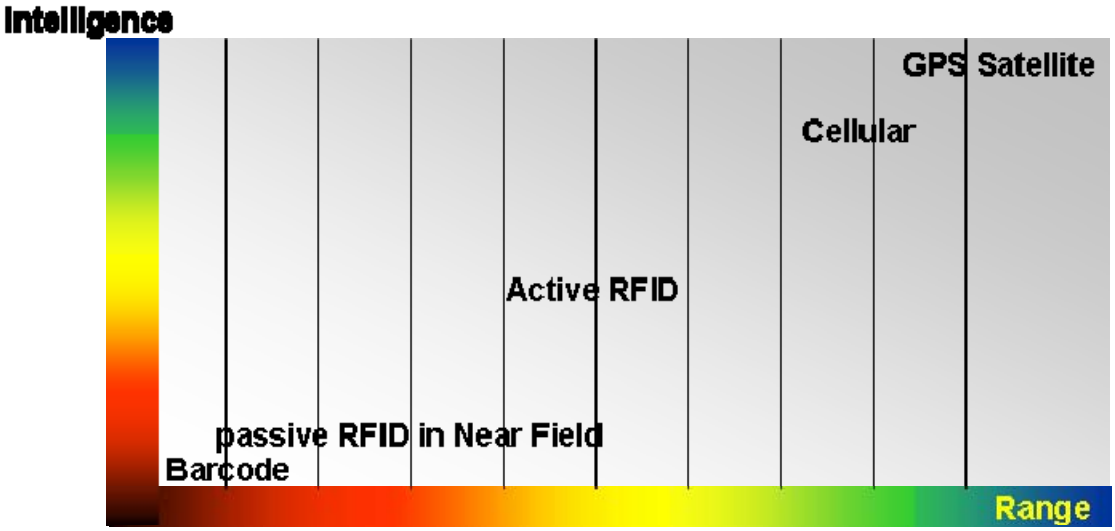


Figure 15: Range and Intelligence

THE 3Pe IS *THE SOLUTION*

3Pe rules in RFID. That is, you need to define what are the **P**rocess, the **P**olicy, and the **P**erformance objectives that determine which **e**nabler is selected. I know that all you techie types want to have a raging debate on UHF vs. LF. But if Wal-Mart says UHF, that debate is over.[21] That is **P**olicy! Your question then becomes *how do we do this?* How and where will the technology be used? What data can we gain from new data collection or identity points? Who can use the data? That is **P**rocess. And **P**erformance—what kind of outcomes do we need? What are the real goals of the project? How far can we leverage our investment?[22] How can it enrich, modify and create new processes for my business?

Since we have already discussed a bit about how we do this, with various antennas, readers, and materials, let's delve into the process.

[21] How to implement UHF

[22] Look for the article *"RFID—Yes, There is Real Value"* in our November 2006 Parallax View online magazine.

RFID-Enabled Processes

RFID has many unique properties that can help enable a myriad of process improvements. Instrumentation from location to location needs to be in place if your expectation is that RFID will provide an end-to-end value. For many applications, this is a huge issue as well as a large marketing opportunity. RFID readers may not be in place across the entire supply chain. In addition, we need to think about field application and remote implementation.

One concept that has taken hold in RFID is the concept of *closed loop* or *open loop* implementations. (*Figure 16, below.*) The concept is quite simple. Open Loop is when the product (and therefore the tag) leaves you, never to be seen again (not really a loop). Cartons with consumables or salable items are such examples. Closed Loop is when the conveyance, or package or item comes back to you. Totes, pallets, containers, vehicles, repairable units, assets that need to be tracked, fast lanes, etc. are all examples of Closed Loop applications.

Different RFID Solutions- Closed Loop/Open Loop

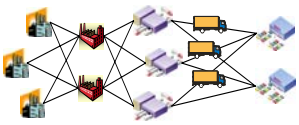
	Compliance	Closed Loop	Open Solution
			
Solution	Stand-alone solution within the four walls of a facility	Routing back to you	Across the Chain
Benefits	Keeping Customers	ROI within the enterprise	Shared values-Global Thinking
Examples	Slap and Ship	Yard, Milk Runs, Maintenance	Item-level tagging of goods through the supply chain

Figure 16: Closed Loop vs. Open Loop

Now we will make one more distinction in these standard definitions, and that is the issue of compliance. Compliance applications have a very small range of choice in the solution. This minimal approach (compliance) is where many firms are right now. So, your selection of technology can be very basic—standard industry tags (we hope) with enough technology to apply the tag and confirm that it is real and ready to ship. This is the so-called slap and ship approach. This is an Open Loop implementation that satisfies the needs of a buyer who seeks compliance only. Compliance does not address the upstream instrumentation of the supply chain.

Open Loop can have more profound goals, as we are seeing in the brand protection / ePedigree efforts within the Pharmaceutical industry. What and how will the shipments and products be read across the chain? What cross-reference or validation systems will be put in place? How will it be read? How will the data be read? What are the environmental factors that might impact the tag's condition (e.g. harsh environments, or interference)?

An advantage of a Closed Loop system is that usually you are not constrained by having to make it work in myriad trading partner environments. Although you are probably still sending out your item, it's usually going to a known or planned destination, and then back to you.

Asset tracking can be loosely called Closed Loop, as well. In fact, one of the benefits of RFID is finding things that go astray. So the environment in which tags find themselves may not be what you expected (i.e., you may not have control of the destination environment). Here GPS can make a big difference.[23]

	Closed Environment	**Open Environment**
Multi-use	Tags re-used within one organization. e.g. Tags on materials or totes within a manufacturing plant. Or tracking totes between a retailer's own DC and stores. (Milk runs). Low cost per use and can be made highly reliable because of degree of control over all aspects of the implementation. Tags on pallets or containers.	Tags re-used across multiple trading partners. Low cost per use, but need to face challenges of making them work across many trading partners with less predictable environments and instrumentation.
1-time use	1-time use, within one organization. e.g. Tesco's tags on game DVDs as they come into the back of the store. The infamous EAS tag.	1-time use, across multiple trading partners. i.e., follows the process and is then disposed of such as Wal-Mart, DoD — Tag cost must be very low or the payoff high, because of 1-time use.

Table 7: Tag Usage

[23] Complimentary solutions like GPS, RTLS, wireless mesh networks and other approaches can work with RFID to provide physical security solutions.

The nuances and variables in the process are endless, and over time the active vs. passive issues will blur a bit too, as passive techniques get better and active gets cheaper. These are factors to consider as you think about your approach.

With that, let's look at some of the issues of active vs. passive in your decision-making.

ACTIVE VS. PASSIVE TAGS

All the noise lately has been about the passive technologies. With the promise of ultra-low cost, they certainly do represent an attempt at an ubiquitous solution. Active technologies provide you with a range of visibility and data-rich devices that can be used over a lifetime. They also have a proven ROI in the Closed Loop application areas where they have been in use for many years. But like all good things, they come with some challenges.

BEWARE OF COMMON RFID MYTHS

Myth: Passive Tags are Cheaper

Conversations and terms about pricing have entered the market that we think are a bit erroneous.

Firstly, we think that it is misleading to call active expensive and passive cheap. The sensible way to think about cost is cost-per-use, rather than cost-per-tag. Users need to think about—always—the application for which they intend to use RFID. Returnable totes, reusable or Closed Loop applications, tracking high value items and asset management, and locating items in environments that are out of range, all are *active* uses for active technology! My $5 transponder has been on my auto for over ***7 years,*** and if measured in ***price for use***, is quite cheap. (And if I was measuring my supply chain velocity, I would have had a significant Cost/Benefit return in the first year!) So in this case, the cost-per-use is very low, not because it's passive or active, but because it is reused hundreds or thousands of times.

Myth: Passive tags will be cheaper—soon

If you look at the drivers that roll-up into the cost of creating a tag, you'll see that there are, as in many products, an extraordinary amount of value-added steps involved. They cross many enterprises: from design, to chip manufacturing, to assembly, and at each step the cost of handling, transportation etc. adds to the total manufacturing cost.

In addition, much is made of the ultimate reduction in the price of passive tags as semiconductor manufacturers reach some kind of *scale*. However, for years we have discussed this issue with organizations such as SIA, who have repeatedly told us that RFID tags, even at mass deployment, do not even make 1% of the total market for the semiconductor business. In other words, the myth is that Moore's law says tag cost will come down by 50% every year or two. The problem is that Moore's law only applies to the semiconductor, not to all of the other elements, and steps in creating a tag (e.g. antenna, attachment, testing, label, adhesive, etc.) All those other components typically go down in cost at a much slower rate, unless there is a major technological breakthrough. Until we see those breakthroughs (e.g. printed tags), even as semi-conductor prices fall, the non-semiconductor components of the tag will become an increasingly larger portion of the tag cost.

Having said that, if people keep their *designs* on smarter and smarter passive tags controlled, the chip price will inevitability come down somewhat.[24]

But, if you look at the basic evolution from the beginning, Sensitech's and Checkpoint's *one bit tags*, to the current Gen 2 96 bit (byte) tags, the compounding of intelligence on the tag (we think that is a good thing, by the way), tells a story for—***NO 5-CENT TAG***—not a Gen 2 or Gen 3 tag, at least.

Myth: Passive tags are not reusable

Again, a hilarious myth. It's all in the packaging, which you know about now. Ruggedized tags can be housed in material such as plastic, for example. Certain material used for inlays and packaging can withstand very high temperatures and harsh chemicals.

Myth: Items only use passive tags, not active tags

Another frustrating myth is that all item tagging will be addressed passively. Again, this might be true for tooth paste, but think about other items. Computers, Gucci handbags, Louis Vuitton luggage, art work, auto parts. Think about expensive cheeses,[25] wine, fresh items, or large economy packs of certain food items. Medical equipment items—and we really want to find these when we need them! These items can range from $10 to millions of dollars. The value of the item, or more importantly, the process it enables, places a high value on rapid identification and location, so an active tag might be the solution.

[24] Do the math. A single semi-conductor fab today costs about $2.5B to build. At the much ballyhooed 5 cent tag cost (finished/tested/delivered) assuming the chip accounts for 1/2 of that cost, one single fab needs to sell 100 billion tags just to cover the capital cost of the fab—that's 100 billion, not 100 million!

[25] Sensors plus active tag.

Myth: RFID cannot be used in the home, no home market for RFID

Some people limit their thinking about the use of RFID in the home to "reading item-level retail tags". In fact there are many innovative uses for RFID being explored. Here again, most homes are alive with expensive reusable assets. As for your reader—most homes have cell phones. Think of your cell phone, PDA, your free wifi device, or even set-top box as a potential RFID reader. The features come free: remember the camera, or the MP3 player, on your cell phone? We are already seeing RFID readers embedded in toys, stoves, and other home devices. And world-wide, with our aging population, the clinical environment is moving into the home, with home healthcare, medical devices, and monitoring equipment.[26] Any-one who has found themselves with on-going patient care in the home can attest to the need for real-time information and monitoring.

And we do want to track our kids, don't we! I think this *drives home the point*.

[26] Read ChainLink Report: *RFID in Clinical Settings:* http://www.chainlinkresearch.com/research/detail.cfm?guid=B02F1909-A043-31A8-1887-8DF7BBBF2A88

Standards vs. Mandates vs. Good Ideas

The call to action on RFID—in particular passive—has been based on mandates to the supply base by Wal-Mart and the DoD. However, RFID had been a growing, albeit slowly, market long before the "big bang" of mandates, because of its powerful properties and potential for ROI and usefulness in specific applications.

Many industries have been grappling with a few key issues that have caused various government, trade, and industry groups to focus on evaluating and then standardizing, where appropriate, on data, frequency and other factors.

It is important to note that beyond your customer mandating the use of this technology, at this time there are no other mandates or legislation imposing an implementation of RFID.

Although discussions have taken place in the very many types of organization we mentioned above (FDA, Homeland Security), and these organizations recently have come out in 'support' of RFID as an enabler to achieve their goals, it would be erroneous to justify your decision to purchase and implement RFID by claiming that its use is regulated or legislated.

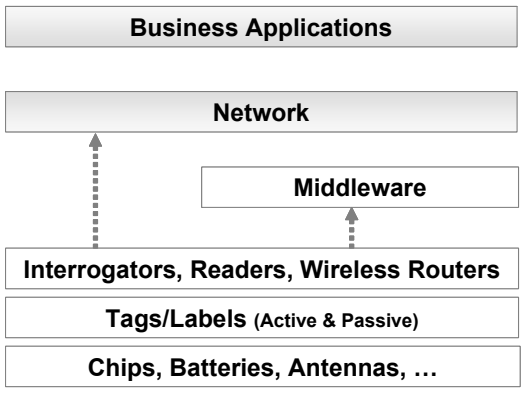


Figure 17

Both the FDA and the Department of Homeland Security have looked at RFID, and continue to have working groups and pilots focused on the topic. They see RFID as a valid enabler for achieving a digital tracking record to support acts and laws passed over the last few years.[27] Currently Homeland Security is supporting pilots in RFID, but again, there is no legislation dictating its use. (See list of organizations and their regulating authority and interests in Appendix A.)

Industry groups, though, have been very active in ensuring cross-enterprise consensus on the use of the technology and data standards. These efforts have been on-going since the birth of EDI and the barcode, so RFID is part of the evolutionary thinking here. Whether Aerospace-AITA, Auto-AIAG, AIM, or HDMA-Healthcare (to name a few), beyond EPC Global/GS1 and ISO, they all created working groups to address these issues. Your use of RFID, then, needs to look at a cross-section of guidelines and mandates—by industry, customer, and geography—to determine what solutions you will use. It is a huge concern for developers and users of the technology that frequency and power regulations, as well as data-naming guidelines, are becoming standardized.

[27] Public Health Security and Bioterrorism Preparedness and Response Act of 2002 (Title III, Subtitle a Protection of Food Supply)

RFID TRANSMISSION REQUIREMENTS

Frequency choices and other regulations are the domains of governments. Any device that emits a signal is regulated by the national or geographical governing body (for example, EU) in that part of the world. So, whatever solution you consider, you may have to span across several national borders and, therefore, you may need to consider slight alterations in your game plan.

US / Canada	EU Countries	Japan
125 KHz <15 KHz>	125 KHz <15 KHz>	125 KHz <15 KHz>
13.56 MHz <14 KHz>	13.56 MHz <14 KHz>	13.56 MHz <14 KHz>
315 MHz <.3 MHz>	-	-
-	418 MHz <25 KHz>	-
433 MHz <1.74 MHz>	433 MHz	426 MHz
915 MHz <26 MHz>	868 MHz <3.0 MHz>	953 MHz <6 MHz>
2.45 GHz <83.5 MHz>	2.45 GHz <83.5 MHz>	2.45 GHz <83.5 MHz>
5.8 GHz <125 MHz>	5.8 GHz <125 MHz>	5.8 GHz <125 MHz>

Table 8: Radio Frequency Regulation

Radio Frequency Regulation

In the US, the Federal Communications Commission (FCC) regulates emissions. The EU has its own, as do Japan and China. All have unique standards and organizations that provide regulations. (See Appendix A for list of these organizations.) Why do we regulate radio waves? To ensure reliable communication.

There are three aspects to regulation:

1. **Licensed bands:** For most frequencies, you need a license to transmit. All the major transmitters—the AM and FM radio stations and the TV stations, police, fire, and military each get their own band within a specific geography (in the case of a radio or TV station that is defined by the location of their transmitting tower and the maximum power they are licensed to transmit).[28] Amateur radio buffs also can get a license to operate at designated frequencies.

[28] You may have heard some of them bragging "transmitting at 50,000 watts of power."

2. **Unlicensed bands (also know as ISM or Industrial, Scientific and Medical bands):** These are selected frequencies set aside for unlicensed use. These don't require a broadcast license as long as you transmit below a certain level (e.g. 4 watts for the UHF band in US, 2 watts for UHF in EU). These are the bands used by RFID.

3. **EMI Emission regulation:** Anyone who makes equipment that emits electro-magnetic noise (computers, medical equipment, fluorescent lamps, TVs, micro-wave ovens) that might interfere with communications, must pass FCC, EU, FDA and other regional regulatory tests certifying that the device emissions are below the levels allowed across the radio spectrum. You will see on the back of your cell phone, for example, an FCC ID. Each 'carrier' is limited to a certain power level. This prevents interference, reduces noise and impact on living organisms.

Resolution of regulations

The trouble is that today regulations are on a national level. Although there are some agreements between countries, sometimes it's regional, like the EU. But, you do get different bands and different standards for US and Europe and Japan. Gradually we're moving towards some global accommodation, since people realize that it's an issue. But it's very difficult when a company or a nation has a large investment in an infrastructure that is all built up to support a certain set of frequencies. They can't just throw all that away and move to a different set of frequencies.

RFID Bands — Worldwide Regulations

If you look at how the bands around the world are regulated, there's actually harmony at the 125 kHz, 13.56 MHz, 2.45 GHz and 5.8 GHz level. But for UHF tags, there is a difference in the US, EU, and Japanese bands. Therefore, if your company needs to use tags worldwide, it can help to use wide band tags instead of tags that were designed for use with a specific UHF frequency (like 915 MHz).

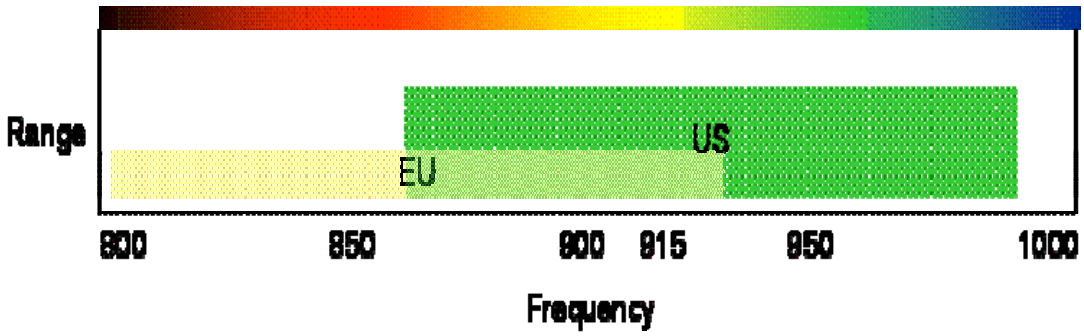


Figure 18: Wide Band

The term *Wide Band* [29] refers to UHF RFID devices designed to work across all of the UHF bands internationally (*Figure 18, above*). A shipper or firm that has product that is likely to cross major geographic boundaries needs to ensure that the technology they use can make the trip and still be usable. Many of today's RFID providers have created solutions that work adequately from, say, EU to US, by creating an antenna that can work in the UHF range from about 860 MHz to 960 MHz for UHF.

Taking a Total Systems Approach

If you are not under mandates, you have some flexibility in designing the right solution, both within your enterprise and also across the entire inter-enterprise supply chain.

We have heard many narrowing statements about how to think about RFID, but the reality is, there are a plethora of applications, uses, and technologies that work in tandem with it—and *we are just getting started.*

[29] Not to be confused with Ultra-Wide Band. This is a totally different concept.

The RFID tags and readers must be selected based not only on the factors we have discussed above (and we are sure there are more), but also on the business objectives. For example, a logistics solution vs. a patient care solution will require unique designs, unique integrations with IT systems, and unique data collection.

Also, the tag that you think is right for your environment (yard, farm, warehouse) may be dissonant with the end-use or destination environment and the distribution channels along the way. So a total approach—not just tags and reader coordination, but business application, geopolitical locations, as well as end-to-end application—should be considered.[30]

There is so much more to learn and talk about—but for now, let's move forward and look at the technology market!

[30] For further reading on end-user vertical applications: http://www.chainlinkresearch.com/research/index.cfm?topic=48

Considerations Before Buying Technology

So, now you know that there are some key points you have to discuss with your technology provider about the specific system you will need: frequencies, antenna design, and field shape and range.

Just quickly, we would like to put in context the whole RFID solution. Tags, readers, wireless devices and routers do not exist in a vacuum. The point is that they have to transmit data to business applications of all types. As the population of devices grows, so does the software market for reader management, middleware, and a variety of applications that use the data. In a subsequent report we will look at the rest of the stack and how this all fits together to create a total solution.

Now let's take a look at the RFID Hardware market.

Our purpose in this report is not to discuss market size and share. Our fellow market research firms can do this for you. However, the hardware revenue for RFID grows at a steady rate. But innovation has grown at a much greater rate. In the last two years, significant changes have occurred in the market. As more people have learned how to work with RFID, it has created lots of new elements, innovations, and players. If you are a provider, you have a few key partnership choices with firms who can supply chips, IC, printed circuit boards, programmable logic units, or complete devices waiting for your customization. You also have more retail partnerships and channels through which to sell your product. It is assumed that vendors will have labs to work in to test final solutions for their clients. Caution to end-users, though: the lab does not look like your environment—so you need a real life test which has the scale, velocity and the people who will actually operate the system.

What is exciting in this market is the current level of learning. Adoption of RFID has been slowed in the past because a whole industry—both the vendors and the end-users—had to learn together how to make this work. This is actually typical in technology markets with the early adopter paving the way. Slower than expected growth last year should not be taken as a signal of poor potential, because learning, as well as the finalization of 'the standards,' came a bit slower than expected. That said, the standard is agreed upon,[31] the chips are there, (with ever new antennas), the readers are there, and now it is time to learn and pick an adoption approach appropriate for your firm.

The sheer volume of suppliers, even with minimal end-user intentions, creates a nice environment for growth. And the competition for your business has created a plethora of 'get started kits' and methods for the novice user.

[31] Gen 2, plus Chinese cooperation, as well as the learning on wide band to make things in Europe that will work in the US. But clearly more has to be done here. ISO 180000-6C, to compliment Gen 2, is expected soon.

RFID devices, like most electronics, are made in a series of steps across a chain of value-adding steps. We have now educated you enough for you to be able to make some assessments, even if you are buying directly from a 'converter,' printer company, or consultant. You must understand that you need to know what is required at each stage to meet your *own* business requirements (*Figure 19, below*). At the right end of the chain, you will generally work with converter, reader, and printer companies for your solution. But this is not always the case. Many chip makers also have standard products that can be sold directly to your firm.

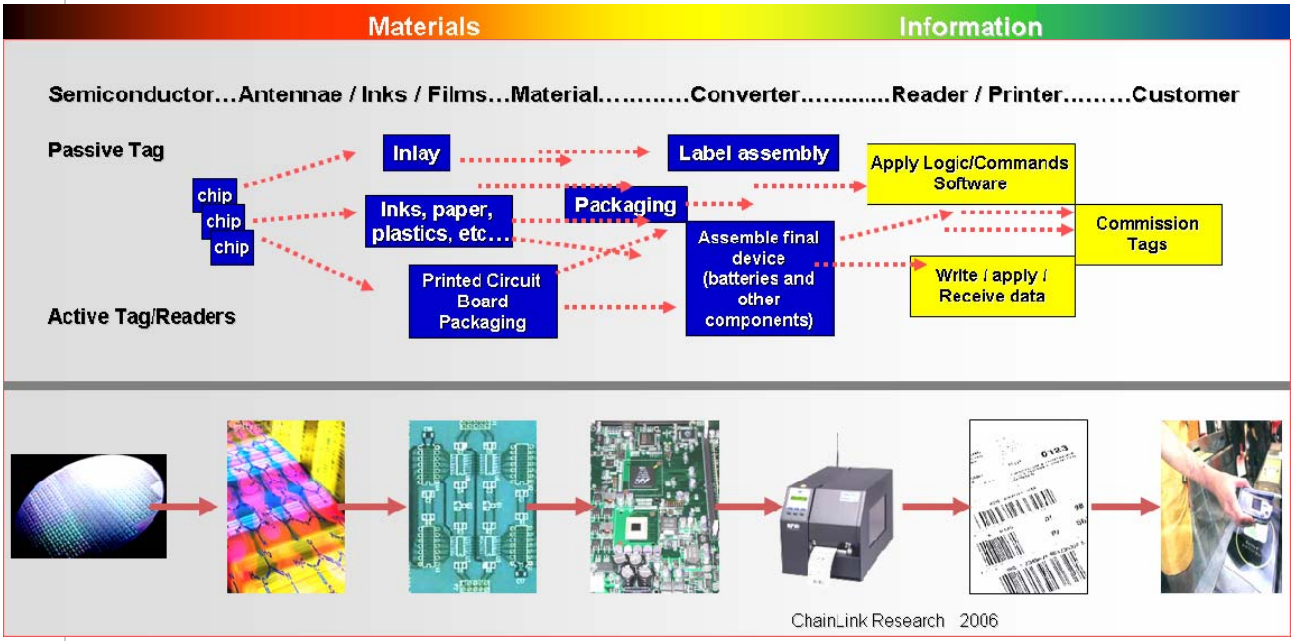


Figure 19: The Tag Supply Chain

We will align the technology firms along this continuum so you can select the right solution provider or partnership (if you are developing solutions). The charts that follow will address:

- RFID Technology Firms aligned by their position in the Value Chain
- RFID Hardware Market—how they got there—many firms come to RFID through other capabilities, of which RFID is a logical extension
- RFID Overview
- RFID Technology and Products by firm—Tags, Readers and Frequencies
- RFID by Business Application/Solutions
- RFID by Industry

RFID Market—How They Got There

When all you have is a hammer,

your world is full of nails.

If you think about the 'charter' of RFID use—sensing, identifying, and communicating information, you can understand the rich market of players who are offering RFID solutions. We like to use the term Primary Positioning, since many players are in a variety of solutions areas. (*Figure 20, below*.)

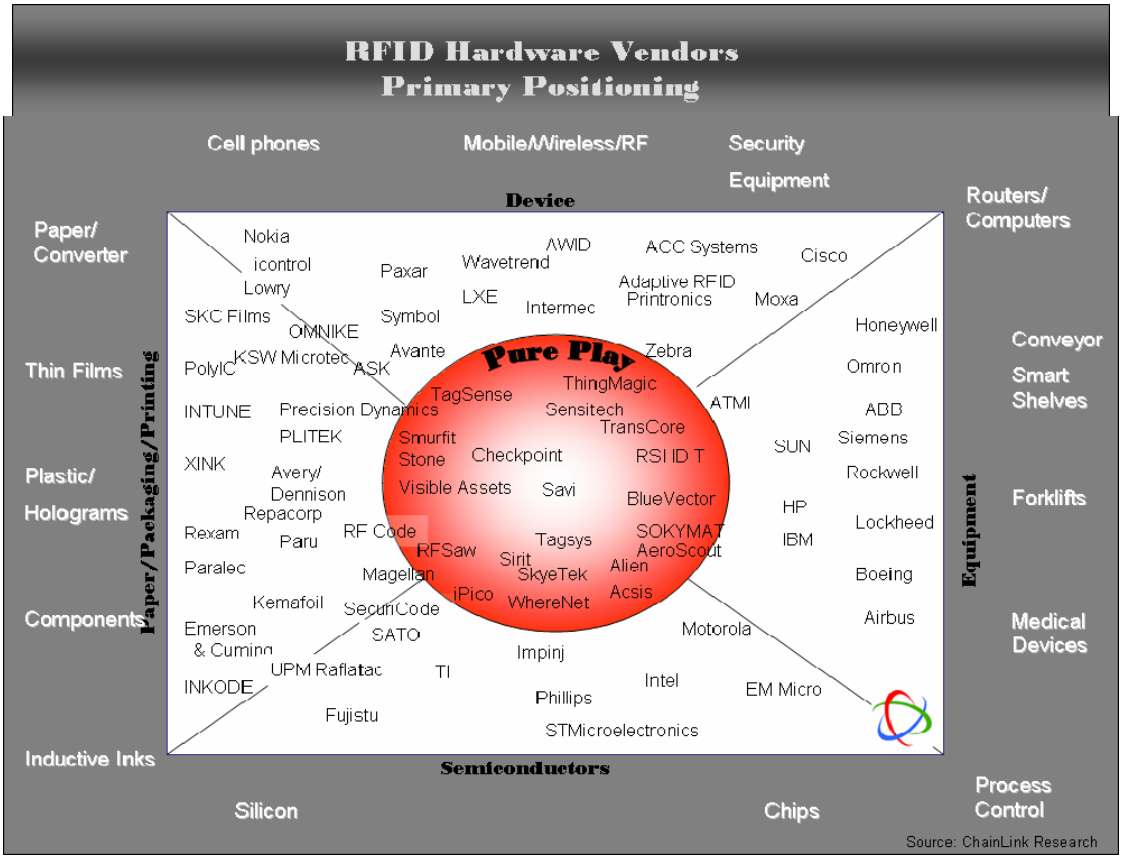


Figure 20: RFID Providers—Primary Positioning

The reality is that firms like Intermec have been in the device and data collection business for a very long time. RFID just adds more goodies to sell. Cisco rapidly got the message that messaging would not just be data, but would also be voice, video, and RF, and expanded their product line, not just functionally, but expanded the size and range of their devices to deal with the ubiquitous use of RF, wireless access points, etc. Transcor has been in Transportation and has moved into consumables.

Control and monitoring application have already been visible for a long time. And this gives them more elements to sell. Firms like *Omron*, *Siemens* and/or *Rockwell, Honeywell* and *Tyco* apply here.

Medical device providers, who are responsible for constant monitoring, accuracy of equipment, etc., make great candidates for RFID. So, the complete solution for end-to-end monitoring of processes, patients, or product for its lifetime, is available from multiple providers.

At the other spectrum, the paper and packaging industries are having a 'springtime' of exploration. They are figuring out how they can supplement and expand their product offerings. Inductive inks blended into gravure paper processes, for security applications, or simple ID applications.

Conclusions:

RFID is as much art as science, and there is a lot to learn. RFID can be finicky—though it can be mastered—so you need to take several key factors into account before singing up:

- Run a pilot—try before you buy.
- Look at your environmental factors—not only in your facilities, but across the Process.
- Get your trading partners involved. If you are sharing a process, RFID has to work for everyone.
- Consider building your own little lab. This is not expensive, and if you are going to use RFID for many activities, you will want to build up the knowledge of RFID in your organization.
- Knowledge—take some classes. Learn to work with RFID. You will increase your confidence and unlock your creative side in hands-on experience with RFID.

There are sometimes stormy seas and unpredictable gales that nature whips up. The seasoned sailor learns to understand the waves. The great surfer sees those particularly tough waves as an advantage, in fact! All analogies aside, nature has provided a fascinating vehicle for us to be able to see, find, and communicate. There is tremendous value to be had from learning to master these waves.

Happy sailing!

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Appendix A: Standards

REGULATORY AGENCIES:

These agencies regulate the use of RF waves and power:

FDA — (Food and Drug Administration) — Provides guidelines and regulates RFID emissions pertaining to food and drugs, as well as consumer electronics like cell phones.

FCC — (Federal Communication Commission) — Regulates the use of the full RF frequency spectrum. Grants licenses to use specific frequency bands within specific geographic areas.

FTC — (Federal Trade Commission) — Ultra high band broadcasting

EPA — (Environmental Protection Agency) — Emission 'standards'

FAA — (Federal Aviation Administration) — Wireless Broadcast of Aviation Signals

USDA — (US Dept. of Agriculture) — Live animals as well as 'food stuff'

This sets policy for: avoidance (interference, poor trade); maintaining security; enhancing/improving economy, health etc.); protecting and defending, etc.

ENABLERS

These review and advise and use RFID, or create guidelines and legislation that can indicate the use of technology to enable policies

FDA — (Food and Drug Admin.)

DHS — (Dept, of Homeland Security), Customs

CIA — (Central Intelligence Agency)

US Department of State

These organizations see technology as a way to achieve their policy charter.

STANDARDS SPECIFIC TO RFID USE

ISO — (International Standards Organization)

EPC — (Electronic Product Code)

AIM — (Global Assoc. for Automatic ID and Mobility)

INDUSTRY ASSOCIATIONS

HDMA — (Healthcare Data Mgt Assoc.)

GMA — (Grocery Manufacturers Assoc.)

AIAG — (Automotive Industry Action Group)

ATA — (American Transportation Association)

These Industry Associations gain consensus on data and business practices

KNOWING THE DIFFERENCE IS CRITICAL TO YOUR ROI

Appendix B: Tables of Survey Results

1. RFID Technology Firms aligned by their position in the Value Chain (1 of 3)

RFID HARDWARE PLAYERS BY SECTOR	Semiconductors	Inlays	Finished Tags	Sensors	Readers	Printers	Other	Outcome Guarantees
ACC Systems Inc.			●	●	■	■		Guarantee delivery of ordered goods and permormance.
Adaptive RFID, Inc.					■	■	RFID Application Software and RFID Middleware	Turnkey solution for DoD process-compliance.
AeroScout				●	■		Wi-Fi based Active RFID tags	Yes, based on system performance. (Depends on specific mix of products sold.)
Alien Technology		■	●	●	■		Alien's battery-assisted passive (BAP) RFID system extends the range over which a tag can be reliably read and written to-up to as much as 30 meters.	Alien warrants its reader products to be free from defects in materials and workmanship for a period of one year. Inlays and labels are similarly warranted for 180 days. Some Alien label converter partners guarantee 100% good labels.
Allaura, Inc.			●	●	■	■	Application development, installation, service	Guaranteed to operate per design document, and 12 month warranty on hardware.
Arnlea Systems Limited			●	●	■			Contract dependent.
ASK		■	●		■		Contactless and dual interface smart cards	Inventory reduction for RFID in textile. All over cost reduction on mass transit contactless systems.
Atmel Corp.	■		●					N/A
AVANTE International Technology, Inc.		■	●	●	■			
Avery Dennison Printer Systems						■		24 hr shipping of standard parts
Blue Vector Systems				●	■		Our portals and smart shelves are delivered fully configured with RFID readers as well as other types of sensors.	None.
BlueBean LLC			●	●	■	■	Turnkey RFID kits for specific RFID projects such as slap and ship compliance, dock doors, conveyors, receiving, shipping, labs and sales presentations.	For compliance-related projects, BlueBean guarantees that the client will be compliant upon project completion. For all projects, BlueBean also guarantees the metrics agreed upon in the customer-defined Statement of Work.
CAEN RFID			●	●	■			N/A
Catalyst International					■	■	Systems integrator and reseller of RFID readers, printers, portals, labels, and tags	Not applicable.
Checkpoint Systems, Inc		■	●				RFID design, application testing and source tagging services	
EM Microelectronic	■			●				-
Enterprise Information Systems, Inc.	■	■	●	●	■	■	RFID Integration Services	EIS evaluates and guarantees customer implemenations based on project specific criteria.
iControl, Inc.				●			we do not produce or sell RFID components, but we produce and sell devices for capturing and communicating data from RFID and other sensors	Our products are guaranteed to be defect free in materials and workmanship under normal use.
IDENTEC SOLUTIONS, Inc.			●	●	■			Qualifying customers will be granted technical performance guarantees. Metrics and consequences of failure are developed on a case-by-case basis.
InfoChip Systems Inc.			●		■			N/A

1. RFID Technology Firms aligned by their position in the Value Chain (2 of 3)

RFID HARDWARE PLAYERS BY SECTOR	Semiconductors	Inlays	Finished Tags	Sensors	Readers	Printers	Other	Outcome Guarantees
INKODE International							Chipless RFID OEM only products	Contract specifies performance before any payment
Intermec Technologies, Inc.								All products are warranteed for at least one year.
International Business Machines Corporation							Software and services	na
iPico Identification (Pty) Ltd							Middleware	1 year guarantee, see datasheets available on web for performance
KSW Microtec AG								none
Lowry Computer Products							RFID portal systems	Lowry Smart Trac labels are 100% tested.
LXE Inc.								NA
Lyngsoe Systems								These are contractually agreed on a case by case level.
Magellan Technology Pty Ltd								Ability to read and write to multiple stacked tags significantly reduces product handling time
MARKEM Corporation							Software and services	By customer agreement.
OMNIKEY GmbH								-
Omron RFID							Training and testing services	1. Guaranteed compliance in just one day 2. Guaranteed 100% label performance after application. Failures replaced, evaluated and tech assistance provided if determination made that failure is due to applicator/encoder error.
Parco Wireless								Depending upon the facilities mission and tracking coverage, ROI on systems can be expected anywhere from as little as 3 months to a year. Parco's systems have experienced uptimes greater than 99% in the field. As well, the company warrants that the data provided by its systems is the most reliable, the most accurate of any real time tracking system on the market today in terms of reporting the tags location to actual, and in terms of repeatability of the data. Granularity of reporting for sub one foot is greater than 80%. Granularities of sub one meter is greater than 95%. Room level reporting is greater than 99%.
Paxar Corp.								Our unique Smart Label Performance Guarantee (offering 100% of your money back for any failed labels- 110% when used with our Monarch printer/ encoder) offers unequalled protection through guaranteed label performance. Any failed labels that are returned to us are credited. We offer a one year warranty on our printer/ encoder family.
PLITEK								PLITEK RFID labels and tags are 100% quality inspected and certified.
Power Paper, PowerID Division								We spell out with partners and customers the levels of service required (e.g. with regard to read rates, tag failure rates, etc.) in deployments
Precision Dynamics Corporation								Quality products provide positive patron and patient identification.
Printronix, Inc.								Printronix has consistently demonstrated its first-to-market leadership with UHF RFID technology. Printronix MP2 printers deliver a dependable, flexible and stable encoding platform with its industry-proven Smart Encoding technology. Smart Encoding technology uses three key components: an EPCglobal Gen 2 Certified best-in-class reader/encoder module, the patented multi-position coupler (antenna) located in the printer, and intelligent printer firmware. With Smart Encoding technology, user-based reports consistently yield a 99.8% read and encode performance rate. Asset protection: The Printronix T5000r thermal bar code printers provide an upgrade path to RFID through a comprehensive upgrade kit solution. Available upgrades include global frequency kits and RFID upgrade kits for multi-protocol EPCglobal Class 0, 0+, 1, Philips 1.19 and EPCglobal Gen 2.
Quest Solutions, Inc.							Active tags and middleware solutions	100% System Satisfaction Guarantee
Repacorp Label Products								Repacorp ensures 100% readability-no "dead" labels.
Reva Systems							RFID Networking Equipment	Equipment reliability and up time on a par with other enterprise scale redundantly configured networking equipment

1. RFID Technology Firms aligned by their position in the Value Chain (3 of 3)

RFID HARDWARE PLAYERS BY SECTOR	Semiconductors	Inlays	Finished Tags	Sensors	Readers	Printers	Other	Outcome Guarantees
RF Code, Inc.			✓		✓			RF Code works with customers and partners on an individual site success basis.
RFID, Inc.			✓		✓			Guarantee 100% read rates
RFIDSupplyChain.com			✓	✓	✓	✓	Turnkey RFID kits for specific RFID projects such as slap and ship compliance, dock doors, conveyors, receiving, shipping, labs and sales presentations through our partners.	For RFID hardware, we honor all original manufacturer warranties. We also offer upgraded service plans. For compliance-related projects, our partner, BlueBean, guarantees that the client will be compliant upon project completion. For all projects, BlueBean also guarantees the metrics agreed upon in the customer-defined Statement of Work.
RSI ID Technologies		✓	✓		✓	✓		RSI tests and validates all tags at multiple quality assurance/validation points within the manufacturing process with the final testing and validation done after converting into a finished label. This enables us to ensure that every label on every roll is 100% good, Guaranteed.
SAMSys Technologies Inc.					✓			Trublue assurance of interoperability with industry standard tags (e.g. Gen 2)
SATO America			✓			✓		SATO Global Warranty Program SATO warrants that when purchased from SATO or through an authorized SATO distributor or reseller; this printer, its components, and accessories are in good working order and free from defects in workmanship and materials.
Savi Technology							Complete hardware and software solutions and services	We offer a warranty on our hardware products and support agreements to resolve issues with our software products.
SecuriCode Limited		✓	✓		✓		Applications	No guarantees are provided but many ROI figures are available including those on our website. Our Active solutions are 99% identity accurate (and usually 100%).
SkyeTek, Inc.					✓			We cater to OEMs.
SmartCode Corp.	✓	✓	✓	✓	✓			Results depend on specific projects/offerings.
SOKYMAT		✓	✓					Targeted clients RFID system integrators. We guarantee best price / performance ratio of RFID transponders
STMicroelectronics	✓	✓						N/A
Symbol Technologies		✓			✓			Symbol has an excellent training and services program. However, each customer is on a case-by-case basis.
TagSense, Inc.				✓	✓			Increased fucntionality, secure RFID.
TAGSYS	✓	✓	✓	✓	✓		Antennas, Multi-read Tunnels, Smart Shelves, Smart Cabinets, Smart Refrigerators	To be supplied...
ThingMagiC, Inc.					✓	✓		Dependent on customized deployments, sites and user requirements.
TransCore			✓		✓			No
UPM Raflatac		✓						n/a
Wavetrend (UK) Ltd			✓	✓	✓		Open platform middleware	We have a standard set of terms and conditions covering performance guarantees etc which are available upon request
Weber Marking Systems, Inc.			✓		✓	✓	RFID label encoder-applicator and printer-encoder applicator, plus RFID encoding software	Specific guarantees are system-dependent.
WhereNet			✓		✓		Complete Real-Time RFID Systems & Applications	WhereNet customers typically experience a rapid time to benefit of about 90 days and a complete return on investment in 9 to 12 months.
Xterprise Incorporated					✓	✓	RFID Application Software	The vast majority of our engagements are on a fixed-based pricing format, which we find results in "on-time, on-budget and as-promised" performance.
Zebra Technologies		✓	✓			✓	Maintenance and Support Services	NA

2. RFID technology and products by firm - Tags, Readers and Frequencies

Company	Tags	Readers	Printers	125-135 kHz	13.56 MHz	433 MHz	860-930 MHz	2.4 GHz	5.8 GHz	Other Frequencies
ACC Systems Inc.	T	R		LF	HF	433	UHF	2.4		303 MHz, 952-954 MHz
Adaptive RFID, Inc.	T	R					UHF			
AeroScout	T	R						2.4		
Alien Technology	T	R					UHF	2.4		950 MHz tags for Japan
Allaura, Inc.	T	R		LF	HF	433	UHF	2.4	5.8	
Arnlea Systems Limited	T	R		LF	HF	433	UHF			
ASK	T	R			HF		UHF			
Atmel Corp.	T	R		LF	HF					
AVANTE International Technology, Inc.	T	R			HF	433	UHF	2.4		
Avery Dennison Printer Systems	T		P				UHF			Partnership
Blue Vector Systems										
BlueBean LLC	T	R					UHF			
CAEN RFID	T	R					UHF			
Catalyst International			P							
Checkpoint Systems, Inc	T	R			HF		UHF			
EM Microelectronic	T	R								-
Enterprise Information Systems, Inc.	T	R			HF		UHF	2.4	5.8	
iControl, Inc.	T	R				433		2.4		ZigBee
IDENTEC SOLUTIONS, Inc.	T	R					Active			
InfoChip Systems Inc.	T	R		LF	HF					
INKODE International	T	R								24.125 - 66 GHz
Intermec Technologies, Inc.	T	R					UHF			
International Business Machines Corporation			P							
iPico Identification (Pty) Ltd							UHF			Dual Frequency, http://www.ipico.co.za/news
KSW Microtec AG	T	R			HF		UHF			
Lowry Computer Products	T	R			HF		UHF			
LXE Inc.										
Lyngsoe Systems	T	R		LF	HF	433	UHF			Unique combination of 125 KHz and 433MHz
Magellan Technology Pty Ltd					HF					
MARKEM Corporation			P							
OMNIKEY GmbH	T									Chips and Materials
Omron RFID	T	R		LF	HF		UHF	2.4		
Parco Wireless	T	R			HF		UHF	2.4	5.8	
Paxar Corp.	T	R			HF		UHF			
PLITEK	T	R			HF		UHF			
Power Paper, PowerID Division	T	R								865-956 MHz
Precision Dynamics Corporation	T	R			HF					
Printronix, Inc.			P							
Quest Solutions, Inc.	T	R		LF	HF	433	UHF			
Repacorp Label Products	T	R			HF		UHF			
RF Code, Inc.	T	R				433				
RFID, Inc.	T	R		LF	HF	433				148 KHz
RFIDSupplyChain.com	T	R					UHF			
RSI ID Technologies	T	R		LF	HF		UHF	2.4		
SAMSys Technologies Inc.										
SATO America			P		HF		UHF			
Savi Technology	T	R		LF		433				
SecuriCode Limited	T	R						2.4		
SkyeTek, Inc.										
SmartCode Corp.	T	R			HF	433	UHF	2.4		
SOKYMAT	T	R		LF	HF		UHF			
STMicroelectronics	T	R			HF		UHF			
Symbol Technologies							UHF			
TagSense, Inc.	T	R					UHF	2.4		chipless tags (HF and microwave)
TAGSYS	T	R			HF		UHF			
ThingMagiC, Inc.										
TransCore	T	R					UHF	2.4		
UPM Raflatac	T	R			HF		UHF			
Wavetrend (UK) Ltd	T	R				433	UHF			
Weber Marking Systems, Inc.	T	R					UHF			
WhereNet	T	R						2.4		
Xterprise Incorporated	T	R					UHF	2.4		
Zebra Technologies			P		HF		UHF			

3. RFID customization capabilities, by firm (1 of 3)

Company	Custom Designed Tags	Custom Designed Readers
ACC Systems Inc.	YES	NO
Adaptive RFID, Inc.	We work with converter partners to provide custom labels and tags.	N/A
AeroScout	—	—
Alien Technology	Alien works with a variety of converter partners to deliver many different form factors of RFID tags to the marketplace, including on-pitch labels, thermally-printable labels, baggage tags, smart labels, plastic-encased tags, apparel labels, smartcards, etc. Custom designs are available through many of these	Yes.
Allaura, Inc.	Potted off-set for metal and heavy duty use.	
Arnlea Systems	No	No
ASK	Yes we do. They can adapt to various sizes and form factors depending on the required	Yes, also depending on application (materials and standards)
Atmel Corp.	Transponder (antenna plus chip).	Transponder (antenna plus chip)
AVANTE International	YES. Any shapes and sizes from 0.5-inch square or larger.	YES. Any shapes and sizes from 0.5-inch square or larger.
Avery Dennison Printer Systems	—	—
Blue Vector Systems	N/A	N/A
BlueBean LLC	We provide custom design through our	
CAEN RFID	We provide custom UHF tags upon specifications for any "reasonable" dielectric	Yes
Catalyst International	—	—
Checkpoint Systems, Inc	In addition to finished tags for certain markets, Checkpoint also provides inlays and engineering and source tagging services to support our converter and packaging clients.	Checkpoint understands there is no generic business case for RFID and that one tag does not fit all applications. For this reason, Checkpoint has developed an RFID application test laboratory and source tagging test laboratory. Here, the company works with its clients to understand how RFID can be used to address their business problems and how it will integrate into their business and manufacturing process. This includes new antenna designs, packaging
EM Microelectronic	—	—
Enterprise Information Systems, Inc.	Yes - depending on customer requirements. Custom designs typically originate from applications where protecting the tag from harsh, industrial environments.	Yes, depending where regular antenna do not provide adequate coverage or only offer intermittent performance.
iControl, Inc.	—	—
IDENTEC	Yes.	Yes.
InfoChip Systems	No.	No.
INKODE International	—	—

3. RFID customization capabilities, by firm (2 of 3)

Company	Custom Designed Tags	Custom Designed Readers
Intermec Technologies, Inc.	Yes. Intermec provides tag designs developed in-house, as well as through strategic partnerships with leading tag developers and manufacturers from around the world. Intermec's Media division has the capability to convert flexible RFID inlays into smart media with virtually unlimited form factor, label stock and adhesive options. These capabilities allow Intermec to offer a portfolio of RFID tags and media for a variety of surfaces and materials and for use in both benign and harsh environments. Current product offerings support the EPC Global Generation 2 specification as well as the ISO 18000-6B international standard.	Intermec provides tag designs developed in house, as well as through strategic partnerships with leading tag developers and manufacturers from around the world. Intermec's Media division has the capability to convert flexible RFID inlays into smart media with virtually unlimited form factor, label stock and adhesive options. These capabilities allow Intermec to offer a portfolio of RFID tags and media for a variety of surfaces and materials and for use in both benign and harsh environments. Current product offerings support the EPC Global Generation 2 specification as well as the ISO 18000-6B international standard.
International Business Machines Corporation	—	—
iPico Identification (Pty) Ltd	Yes, various	
KSW Microtec AG	We offer - Flip-Chip Assembly - Wafer Services - Antenna printing - Large volume production	We offer: - Design and printing of HF/UHF antennas on foil, fabric, paper - Design and printing of samples and small volume production - Printing of crimp and dielectric thicknesses for condensers for HF/UHF-antennas
Lowry Computer Products	If needed by customers, Lowry can provide this service. Label products are packaged in static-resistant bags to ensure the safety of the tags in transit.	No
LXE Inc.	—	—
Lyngsoe Systems	We have several designs based on the application.	We design tags for specific applications.
Magellan Technology Pty Ltd	NO	YES. Application requirements analyzed and then appropriate inlay designed.
MARKEM Corporation	—	—
OMNIKEY GmbH	—	—
Omron RFID	—	Omron can custom design antennas that match antenna size and performance for a specific application. (Quantity requirements apply.)
Parco Wireless	Tag designs vary to include small one inch by one inch asset tags, and wristband type wearable patient tags, as well as ID badge type tags. Custom designs are available when quantities provide suitable metrics.	Custom designs for antennas are available when quantities provide suitable metrics.
Paxar Corp.	Yes. We have several types of finished labels and tags and are continually developing new ones at customer request. We provide woven and fabric smart labels and tags, as well as thermal paper, adhesive backed labels, and hang tags for garments.	Yes, through partners.
PLITEK	Customizable features include: Custom label face materials; Custom adhesive systems; Custom constructions; Fan-fold, roll, piece delivery format.	Through our partners with minimum orders.

3. RFID customization capabilities, by firm (3 of 3)

Company	Custom Designed Tags	Custom Designed Readers
Power Paper, PowerID Division	Custom design is available for specific materials or applications, pending volumes and pricing.	Custom antenna design is available for specific materials or applications, pending volumes and pricing.
Precision Dynamics Corporation	N/A	N/A
Printronix, Inc.	—	—
Quest Solutions, Inc.	Capability to prototype short run custom designed tags for customer applications.	Capability to prototype short run custom designed tags for customer applications.
Repacorp Label Products	No	No
Reva Systems	—	—
RF Code, Inc.	We offer our tag in a variety of application specific packages either directly or through partners. We also do customization.	RF Code can develop application specific versions of the tag antenna.
RFID, Inc.	Custom deviations of current Tag packages or new designs from ground up, private labeling with client name/logo in plastic.	Yes. What is there to describe?
RFIDSupplyChain.com	We provide custom design through our partners.	
RSI ID Technologies	RSI is able to customize the finished label with pre-printed information or specialty materials.	RSI does offer custom designs for antennas.
SAMSys Technologies Inc.	—	—
SATO America	SATO will create custom tags/labels for customers needs.	No.
Savi Technology	Generally not applicable with active tags, but we can customize packaging for specific customer needs.	Generally not applicable with active tags, but we can customize packaging for specific customer needs.
SecuriCode Limited	The casings can be customized as necessary, depending on quantity.	The tag antenna is available as standard embedded (up to 10metres range) or whip (up to 100metres range, special order).
SkyeTek, Inc.	—	—
SmartCode Corp.	Depending on Customer needs.	Depending on Customer needs.
SOKYMAT	yes. Application or custom specific regarding shape, robustness, print, read range, ISO standards, antenna design.	Yes. With scientific simulation models and methods.
STMicroelectronics	—	—
Symbol Technologies	Yes. Symbol has a team in place to provide custom design on a case-by-case basis.	All tag antennas are specially designed to suit specific purposes, i.e. to track cardboard boxes versus plastic containers.
TagSense, Inc.	Custom design is available.	Antennas are custom designed to meet read range requirements, form factor, and application.
TAGSYS	Supply inlays, converted and encapsulated tags.	N/A
ThingMagiC, Inc.		
TransCore	Finished design only, but we do custom printing.	No
UPM Raflatac	In-mould tags.	Yes, depending on the volume.
Wavetrend (UK) Ltd	We support Customer requests for non-standard tags and enclosures.	We support Customer requests for non-standard Antenna.
Weber Marking Systems, Inc.	Weber provides a wide range of tag designs to match end-user requirements.	No
WhereNet	—	—
Xterprise Incorporated	We provide industry specific tags.	We provide industry specific tags.
Zebra Technologies	Zebra provides a wide variety of smart label sizes and materials for RFID media and can create custom smart label offering for clients based on their label format requirements.	Zebra continues to look into broadening our custom portfolio to include such areas as custom design for tag antennas.

4. RFID business application/Solutions, by firm

RFID SOLUTONS	Tags	Readers	Printers	Engineering	Sourcing	Manfacturing	Quality	Logistics	Sales	Service	Legal/Finance	Merchandizing	Store Operations	Other
ACC Systems Inc.	T	R				Mfg		Log						
Adaptive RFID, Inc.	T	R				Mfg	Qua	Log	Sal	Svc			Sto	
AeroScout	T	R				Mfg	Qua	Log		Svc		Mer		
Alien Technology	T	R		Eng		Mfg	Qua	Log	Sal	Svc		Mer	Sto	
Allaura, Inc.	T	R		Eng	Src	Mfg	Qua	Log		Svc				
Arnlea Systems Limited	T	R				Mfg								
ASK	T	R		Eng	Src	Mfg		Log		Svc		Mer	Sto	
Atmel Corp.	T	R				Mfg		Log						
AVANTE International Technology, Inc.	T	R			Src			Log		Svc		Mer	Sto	
Avery Dennison Printer Systems			P		Src	Mfg	Qua	Log	Sal	Svc		Mer	Sto	
Blue Vector Systems					Src			Log		Svc				Asset/Security
BlueBean LLC	T	R		Eng		Mfg		Log					Sto	
CAEN RFID	T	R			Src	Mfg		Log	Sal	Svc		Mer	Sto	
Catalyst International			P	Eng		Mfg		Log						
Checkpoint Systems, Inc	T	R				Mfg		Log						
EM Microelectronic	T	R		Eng				Log						
Enterprise Information Systems, Inc.	T	R		Eng	Src	Mfg	Qua	Log		Svc				
iControl, Inc.	T	R				Mfg	Qua			Svc				
IDENTEC SOLUTIONS, Inc.	T	R		Eng							L/F	Mer		
InfoChip Systems Inc.	T	R				Mfg		Log		Svc			Sto	
INKODE International	T	R			Src	Mfg		Log		Svc		Mer	Sto	
Intermec Technologies, Inc.	T	R		Eng		Mfg								Asset Tracking
International Business Machines Corporation			P					Log					Sto	
iPico Identification (Pty) Ltd						Mfg	Qua	Log		Svc				
KSW Microtec AG	T	R				Mfg		Log						
Lowry Computer Products	T	R		Eng										
LXE Inc.				Eng		Mfg			Sal					
Lyngsoe Systems	T	R				Mfg	Qua	Log						
Magellan Technology Pty Ltd														
MARKEM Corporation			P					Log						IT Security
OMNIKEY GmbH				Eng	Src	Mfg	Qua	Log	Sal	Svc				
Omron RFID	T	R				Mfg		Log					Sto	
Parco Wireless	T	R			Src	Mfg		Log				Mer		
Paxar Corp.	T	R		Eng					Sal	Svc				
PLITEK	T	R					Qua			Svc				
Power Paper, PowerID Division	T	R						Log						
Precision Dynamics Corporation	T	R		Eng	Src	Mfg	Qua	Log		Svc			Sto	
Printronix, Inc.			P			Mfg		Log						
Quest Solutions, Inc.	T	R				Mfg		Log					Sto	
Repacorp Label Products	T	R		Eng	Src	Mfg	Qua	Log	Sal	Svc	L/F			
Reva Systems						Mfg								
RF Code, Inc.	T	R			Src			Log		Svc				
RFID, Inc.	T	R		Eng	Src	Mfg	Qua	Log	Sal	Svc				
RFIDSupplyChain.com	T	R			Src			Log					Sto	
RSI ID Technologies	T	R		Eng	Src	Mfg	Qua	Log	Sal	Svc		Mer	Sto	
SAMSys Technologies Inc.				Eng	Src		Qua	Log		Svc				
SATO America			P			Mfg		Log				Mer	Sto	
Savi Technology	T	R		Eng		Mfg	Qua							
SecuriCode Limited	T	R			Src	Mfg	Qua	Log	Sal	Svc			Sto	
SkyeTek, Inc.				Eng		Mfg	Qua		Sal	Svc				
SmartCode Corp.	T	R		Eng	Src	Mfg		Log			L/F		Sto	
SOKYMAT	T	R				Mfg		Log		Svc		Mer	Sto	
STMicroelectronics	T	R		Eng										
Symbol Technologies				Eng		Mfg	Qua	Log		Svc				
TagSense, Inc.	T	R		Eng	Src	Mfg		Log	Sal	Svc	L/F	Mer	Sto	Inventory
TAGSYS	T	R						Log						
ThingMagiC, Inc.				Eng		Mfg	Qua	Log		Svc				
TransCore	T	R			Src			Log				Mer	Sto	
UPM Raflatac	T	R				Mfg		Log						Asset Mgt
Wavetrend (UK) Ltd	T	R				Mfg		Log						
Weber Marking Systems, Inc.	T	R			Src	Mfg		Log		Svc		Mer		
WhereNet	T	R			Src	Mfg		Log		Svc			Sto	
Xterprise Incorporated	T	R												
Zebra Technologies			P											

5. RFID firms by Industry

RFID INDUSTRIES	Aerospace	Automotive	Building Products	Chemicals	Construction	CPG (Consumer Products)	Defense	Education	Financial/Insurance	Food and Agriculture	Forest Products and Paper	Government	Healthcare Providers	High Tech Hardware	Hospitality	Industrial Equipment	Logistics	Media & Publishing	Medical Devices	Mining & Metals	Office Products	Oil & Gas	Pharmaceuticals	Retail	Software	Telecommunications	Textiles and Apparel	Transportation & Travel	Utilities	Other
ACC Systems Inc.												☑	☑											☑				☑		RFID
Adaptive RFID, Inc.			☑			☑	☑			☑						☑														
AeroScout	☑	☑											☑			☑												☑		
Alien Technology						☑	☑																	☑				☑		
Allaura, Inc.										☑							☑						☑		☑					Loyalty and n Profit
Arnlea Systems Limited				☑												☑	☑					☑							☑	
ASK									☑			☑												☑			☑	☑		
Atmel Corp.									☑								☑						☑					☑		Access Control, Animal Id
AVANTE International Technology, Inc.						☑							☑		☑								☑					☑		
Avery Dennison Printer Systems												☑				☑	☑							☑			☑			
Blue Vector Systems						☑				☑							☑						☑	☑						
BlueBean, LLC						☑	☑			☑			☑				☑													
CAEN RFID	☑															☑	☑													Nuclear Physics
Checkpoint Systems, Inc						☑																	☑	☑				☑		Library
EM Microelectronic	☑	☑				☑											☑							☑						
Enterprise Information Systems, Inc.	☑					☑	☑			☑													☑							
iControl, Inc.	☑																											☑	☑	environmental (water) mo
IDENTEC SOLUTIONS, Inc.	☑	☑											☑			☑				☑										
InfoChip Systems Inc.				☑												☑						☑								
INKODE International	☑						☑										☑						☑	☑						
Intermec Technologies, Inc.	☑					☑						☑					☑							☑						
International Business Machines Corporation		☑				☑	☑																☑	☑						
iPico Identification (Pty) Ltd		☑								☑							☑			☑										People & Asset Tracking,
KSW Microtec AG										☑							☑						☑	☑				☑		
Lowry Computer Products		☑				☑				☑		☑					☑													
LXE Inc.		☑				☑				☑	☑						☑													
Lyngsoe Systems	☑						☑			☑							☑											☑		Postal Industry
Magellan Technology Pty Ltd												☑	☑						☑				☑							Gaming
MARKEM Corporation						☑				☑											☑		☑							
OMNIKEY GmbH												☑		☑	☑				☑		☑									
Omron RFID						☑				☑							☑		☑				☑							
Parco Wireless													☑	☑					☑						☑			☑		
Paxar Corp.						☑											☑						☑	☑			☑			
PLITEK						☑	☑						☑										☑					☑		
Power Paper, PowerID Division	☑	☑									☑						☑													
Precision Dynamics Corporation													☑		☑															Patron Management
Printronix, Inc.						☑											☑						☑	☑			☑			
Quest Solutions, Inc.						☑							☑				☑						☑					☑		
Repacorp Label Products						☑	☑										☑						☑				☑			
Reva Systems						☑																	☑	☑						
RF Code, Inc.	☑											☑	☑		☑		☑													
RFID, Inc.		☑																		☑		☑	☑					☑		
RFIDSupplyChain.com						☑	☑			☑			☑				☑													
RSI ID Technologies		☑				☑						☑					☑		☑											
SAMSys Technologies Inc.														☑										☑						
SATO America							☑					☑	☑				☑							☑						
Savi Technology	☑			☑		☑	☑					☑																		
SecuriCode Limited		☑							☑				☑				☑											☑		
SkyeTek Inc.														☑		☑			☑					☑						Meshed Networks/ Senso
SmartCode Corp.						☑	☑										☑						☑	☑						
SOKYMAT									☑	☑		☑											☑					☑		
STMicroelectronics														☑			☑						☑	☑				☑		
Symbol Technologies						☑										☑	☑							☑						
TagSense, Inc.														☑																
TAGSYS													☑				☑						☑				☑			Library
ThingMagic, Inc.						☑	☑										☑						☑	☑						
TransCore												☑					☑											☑		
UPM Raflatac						☑												☑					☑	☑			☑			
Wavetrend (UK) Ltd					☑									☑			☑			☑								☑		
Weber Marking Systems, Inc.			☑			☑				☑									☑				☑							
WhereNet	☑	☑					☑					☑					☑													
Xterprise Incorporated						☑				☑		☑		☑								☑								
Zebra Technologies						☑	☑										☑							☑	☑					

Company	Product	Areas of Focus
HW 3M www.3M.com/rfid ; St. Paul, MN, USA	3M™ RFID Tracking System	3M RFID Tracking Solutions provides a "simple to use" Radio Frequency Identification tracking system that optimizes locating and processing physical files in and out of the central file room — and throughout the office.
HW ACC Systems Inc. www.accsystemsinc.com ; Glen Head, NY, USA	Nordic ID PL3000	Hardware Distribution
HW Accucode www.accucode.com ; Denver, CO, USA	Falcon 5500	AccuCode's mission is to become the global leader in business process automation through the application of software, mobile computing and automated data collection technologies. Our hosted solutions and IT infrastructure will provide visibility of product, items, assets, orders, shipments, inventory, people and processes to global organizations.
HW Accusort www.accusort.com ; Telford, PA, USA	Fast Tag	Our vision is to be the global leader in product tracking solutions that create productivity, reduce out-of-stocks, and enable better inventory management in maufacturing and distribution applications.
HW SW Svc Adaptive RFID, Inc www.adaptiverfid.com ; Wheaton, IL, USA	RFIDShipIT!®	Adaptive RFID provides turnkey RFID solutions that integrate middleware, applications, and hardware into a managed RFID network. Adaptive RFID middleware employs open standards and a service oriented architecture to minimize cost and adapt easily to changing technologies, mandates, and operational needs. Adaptive RFID Fast-Track(SM) and RFID Success Strategy(SM) services help you profitably exploit the benefits of RFID beyond compliance. Our RFID engineering and systems integration services deliver turnkey solutions in either internally managed or outsourced configurations.
SW Svc Advanced Positioning Systems www.aps-uk.net ; London, , UK	SmartTag	Advanced Positioning Systems Ltd (APS) are software development specialists. Our team has been developing quality software products for over 10 years. Our software is quality control checked to ensure its stability, consistency and reliability. Through the integration of advanced radio systems, quality controlled software engineering and a thorough understanding of real-life business needs, we are proud to present SmartTag, a practical, reliable and incredibly flexible system.
HW SW AeroScout www.aeroscout.com ; San Mateo, CA, USA	AeroScout Tags	AeroScout is the leading provider of enterprise visibility solutions that use standard Wi-Fi wireless networks to accurately locate and manage assets and people in multiple environments. The AeroScout system includes indoor and outdoor real-time asset location (RTLS), long range Active RFID, choke-point visibility and telemetry, enabling customers in numerous industries to drive revenues and cut costs.

6. RFID Vendors Overview--2 of 27

Company	Product	Areas of Focus
HW SW Agility Healthcare Solutions www.agilityhealthcare.com ; Glen Allen, VA, USA	AgileTrac™	While obtaining and analyzing data on mobile assets and other resources is the critical first step towards improving efficiency, the information produced by automatic identification technologies like RFID must be used in conjunction with improved management processes. Our management services and technologies work in concert to ensure that the right resources arrive at the right place at the right time in the right condition.
HW Alien Technology www.alientechnology.com ; Morgan Hill, CA, USA	Alien Technology RFID Readers	Alien Technology Corporation is a leading provider of Radio Frequency Identification (RFID) products for global customers in government, retail, manufacturing, pharmaceuticals, transportation, and other industries. Using its patented manufacturing process, Fluidic Self Assembly (FSA®), Alien manufactures EPC tags in very high-volumes and at low cost. The company provides a family of RFID readers for a variety of applications including supply chain management, logistics, and anti-counterfeiting, to improve inventory management and reduce operating costs.
HW SW Allaura, Inc. www.allaura.com ; Tacoma, WA, USA	PayPortal (TM)	Custom System Integration and RFID application layer software design, reader design, and Allaura rapid develoment middleware software.
Allumis Inc. www.allumis.com ; Thornhill, Ontario, Canada	epcTrackAlert ™	Products focus: (1) Asset Tagging and (2) People Tagging using passive, semi passive and active tags. Product Sales: Pay Portal (TM), Truck Trip Tracker, Tool Tracker, Orbiter Lap Counter (TM), Unattended / Attended Truck Scale, Construction Equipment Anti Theft, Gate Time, Ticketing and Time and Attendance. Specializing in the development, integration, and support of applications to solve business problems using EPC data generated from RFID tags.
Svc Alvin Systems www.alvinsystems.com ; Da: Bostanci, Istanbul, Turkey	UHF/HF Software Solutions Platform, Sensor-based Smart Active Label	Alvin Systems provides innovative and leading software solutions that empower businesses and service providers to achieve competitive advantage from new-generation Radio Frequency Identification (RFID) and wireless technologies. With its comprehensive multi-industry focus and solutions portfolio built on its highly engineered RFID middleware platforms, Alvin Systems delivers best-of-breed, innovative and cost-effective software solutions and services custom tailored to unique business needs - and help businesses unleash their full potential and realize new opportunities.
HW SW Amtel Security Systems www.amtel-security.com ; Miami , FL, USA	Active/passive RFID Devices, Integrate RFID Controller	We offer the most complete product line, an extensive distribution network to support the most responsive customer service program, the best price-to-performance ratio and the most rigorous quality control system.

Company	Product	Areas of Focus
HW Svc AMT Systems Inc. www.amtsystems.com ; Chesire, CT, USA	Easy ePC, SURGICHIP, printers/encoders, consulting (in development)	Founded in 1988, AMTSystems provides innovative RFID and barcode-based solutions to a variety of industries with a core focus on improving business processes through the use of automated identification technologies. With 4 dedicated sales divisions focused on servicing the needs of diverse markets such as Healthcare & Life Sciences, Retail & Manufacturing Supply Chain, Educational Institutions, and the Horticultural Industry, AMTSystems has the experience and solutions your company or organization is seeking, all backed by a knowledgeable, dedicated technical sales, development and support staff.
HW SW Svc Analytica India www.analytica-india.com ; Bangalore, Kanatica, India	ARIES	Analytica provides unique middleware with the ability to integrate with a wide variety of RFID hardware and technologies from different vendors. It is the first system that supports hybrid (both Active as well as Passive) RFID equipment, allowing you to put together innovative solutions that can streamline your operations.
HW Applied Wireless Inc. www.applied-wireless.com ; Camarillo, CA, USA	T916ID & R916ID Long Range Tag and	Long Range unlicensed Wireless audio, video, RFID and Remote control products. From an RFID perspective: Long Range RFID tags and receivers.
HW Svc Argent Tape & Label Inc. www.argent-label.com ; Troy, MI, USA	Finished RFID Labels	Argent is a specialized producer of Labels and Instructional Inserts for a selective group of customers who are looking for something extra in terms of Innovation, backed by superior Quality, Service, and On-Time Delivery at competitive prices. Our commitment to keeping abreast of the latest in label technologies is shown by the range of RFID and other specialty laminated label applications that we are able to offer.
HW Arnlea Systems Limited www.arnlea.com ; Inverurie, Aberdeenshire, Scotland	Motorola/Indala industrial RFID readers & tags	Bridging the gap between the items you have and the management systems you use to manage them. 200 RFID-enabled projects delivered for inventory control, manufacturing.
HW Asia Smart Tag Co. www.astag.com ; , Taichung, Taiwan	Smart Tag and Reader Serial Series	Focus on passive UHF and HF. Also available are custom designed antenna and ISO 18000-6 products.
HW ASK www.ask-rfid.com ; SOPHIA-ANTIPOLIS, FRANCE	C.label/tags RFID	Founded in 1997, ASK is now the supplier of a comprehensive range of contactless cards, tickets, RFID tags and readers on the market. All products comply with ISO and EPC standards. ASK addresses the mass transit, access control, e-government ID, supply chain and logistics markets. 50 million contactless cards, tickets and RFID labels are already in use worldwide. ASK's manufacturing plant is located at its Sophia-Antipolis headquarters in France, with regional offices in Paris, Singapore and Westport, USA. More than 50 million products are already in the field to date.

	Company	Product	Areas of Focus
HW	Atmel Corp. www.atmel.com ; San Jose, CA, USA	LF read-only (e5530/TK5530)	Atmel® Corporation (ATML) is a worldwide leader in the design and manufacture of microcontrollers, advanced logic, mixed-signal, nonvolatile memory and radio frequency (RF) components. Leveraging one of the industry's broadest intellectual property (IP) technology portfolios, Atmel is able to provide the electronics industry with complete system solutions. Focused on consumer, industrial, security, communications, computing and automotive markets, Atmel ICs can be found Everywhere You Are(R). For RFID applications, Atmel offers a complete line of contactless RFID semiconductors (ICs, wafers, micromodules and complete transponders), operating at 125/134 kHz, 13.56 MHz, and UHF. Applications include security and access control, manufacturing and logistics (e.g. supply chain and asset management, inventory control), transportation and animal indentification.
HW Svc	Avaana www.avaana.com ; New Dehli, , India	RFID Systems, Chipless RFID, Capacitive Sensors/tags	AVAANA™ is a technology, innovation and integration services company focused on the high growth RFID technology market. Based in India and Asia, and the United States, we provide complete standards-based and custom RFID solutions to facilitate companies in creating and maintaining a competitive edge.
HW	AVANTE International Technology,Inc. www.avantetech.com ; Princeton Junction, NJ, USA	ZONER Active RFID Tags with optional sensors	AVANTE focuses on the following RFID technologis and solutions: Active RFID ZONER tag and RELAYER readers for real-time personnel and assets locating and visibility system; combined active and passive RFID badge for personnel tracking; patented reliable and/or high temperature passive RFID tags using soldered interconnections; RFID keyfob and smart cards; patented omni-directional antenna arrays and portals for passive tags; handheld and stationary readers and related hardware.
HW	Avery Dennison Printer Systems www.ris.averydennison.com ; Philadelphia, Pennsylvania, usa	Comfort Tag Bonders	Avery Dennsion printer systems primary goal is to provide solutions to customers that optimize value. We provide thermal printing, heat bonding, thermal transfer, application and software solutions.
SW	Avicon www.Avicon.com ; Westborough, MA, USA	epcTranslator	Avicon's epcTranslator™ converts legacy codes, such as UCC128 or USDOD to and from any of the multiple representations of electronic product codes, such as Class 0/Class1 64 or 96 bit binary tag representations.
SW Svc	Avonis, Inc. www.avonis.com ; Heathrow, FL, USA		Provides RFID software and services (OLTP and OLAP) for Oracle systems; systems integration services with its RFIdirector middleware for commercial and military DoD applications.
HW	Balough www.balogh-group.com ; Brighton, MI, USA	Hyper X, iGate.RF, Infra ID, 125KHz RFID-2.45GHz RFID	The Balogh RFID product line consists of a wide range of RFID tags, Transceivers (Antennas), and control interfaces adapted to a large number of applications.
SW	BEA Systems www.bea.com ; San Jose, CA, USA	RFID Product Family	BEA Systems, Inc. is a leading application infrastructure software company, providing the enterprise software foundation that allows thousands of companies to benefit from service-oriented architectures. BEA provides the enterprise software foundation for more than 15,000 customers around the world, including the majority of the Fortune Global 500.

Company	Product	Areas of Focus
Svc BearingPoint Inc. www.bearingpoint.com ; McLean, VA, USA	Human Capital Resource Services	Bearingpoint, Inc. operates as a management consulting, systems integration, and managed services company primarily in North America. The company operates in four segments: Public Services; Financial Services; Communications, Content, and Utilities; and Consumer, Industrial, and Technology. Provides traditional management consulting, and managed and systems integration services. BearingPoint, formerly known as KPMG Consulting, Inc., was incorporated in 1999 and changed its name to BearingPoint, Inc. in 2002. The company is headquartered in McLean, Virginia.
HW Bibliotheca RFID Library Systems AG www.bibliotheca-rfid.com ; Zug, , Switzerland	BiblioChip®	Bibliotheca is specialized in designing, producing and marketing of RFID systems that is hard- and software for library automation and media security. In Europe the BiblioChip® System is the Number One RFID Library System. Bibliotheca was formed to exclusively focus on the needs of librarians.
HW SW Blue Vector Systems www.bluevector.com ; Palo Alto, CA, USA	Configuration Management System	A complete, easily configurable, plug and play line of products that enables large scale, highly manageable RFID deployments. As a complete solution, Blue Vector competes in both the reader and middleware/software categories -- we don't believe that a disjointed approach is manageable in anything larger than a trial.
HW SW Svc BlueBean, LLC www.bluebeanrfid.com ; Carmel, IN, USA	BlueBean 1·2·3™ Slap and Ship RFID Compliance System	BlueBean is a RFID consulting and systems integration company that focuses exclusively on RFID solutions, RFID compliance mandates, and simplifying the implementation of RFID technology. We guarantee our clients a solution that successfully meets their business needs based on our real world knowledge, extensive expertise, and certifications from the top RFID manufacturers. BlueBean also offers packaged solutions to common RFID technology situations. Our solutions include BlueBean 1-2-3™ (RFID slap & ship compliance), EasyInbound™ (RFID receiving), and EasyOutbound™ (RFID shipping).
SW Svc Brooks Software www.brookssoftware.com ; Chelmsford, MA, USA	Brooks' Sense Decide Respond real-time RFID applications, Automation RFID	Brooks Software's focus is real-time manufacturing software. Manufacturers are recognizing the need to be more effective in responding to volatility, complexity and demands from both customers and regulators. Manufacturing based on a forecast is no longer adequate to meet business objectives in an increasingly competitive global market. Companies must operate in real-time, driving events from the supply chain directly down to the manufacturing floor.
Svc BT Auto-ID Services www.auto-id.bt.com ; London, London, United Kingdom	Strategy Consulting	BT Auto-ID Services is a market leader in complete, scalable and affordable RFID Services. Delivering supply chain improvements to the retail, aerospace, automotive, construction and pharmaceutical industries. We combine the resources of a large corporation with the agility and flexibility of a new technology start-up.

	Company	Product	Areas of Focus
HW	CAEN RFID www.caen.it/rfid/ ; Viareggio, LU, Italy	A948 - UHF long range reader (ETSI EN 302 208)	CAEN's Mission is to provide our customers with readers and tags that meet EPC/ISO requirements and ETSI/FCC standards. CAEN is pleased to offer UHF RFID systems to the following markets: Transportation & Logistics; Security Access and Control; Supply Chain Management.
SW	Calidus, LLC www.callidusllc.com ; Delmar, MD, USA	CallidusRFID	The main focus of this company is hospital functionality. Callidus software is not only intuitive and customizable but will lead to numerous benefits and a quick ROI.
SW Svc	CapTech Ventures www.captechventures.com ; Richmond Virginia, , USA	TagsWare™	CapTech is a consulting firm that manages, designs and builds information systems. The mission critical solutions we develop are built on the partnerships that we have established with industry leaders such as IBM®, BEA™ Systems, Oracle®, Microsoft®, Sun Microsystems, and Open Source products. The driving force behind our success is the close relationship that we develop with our clients, getting to know their businesses and the vision that guides them. From Fortune 500 companies to regional market leaders, CapTech can help your company manage technology and achieve results for growth.
HW SW	Catalyst International www.catalystinternational.com ; Milwaukee, Wisconsin, U.S.A.	Catalyst Command	Supply Chain Execution provider for Best of Breed and SAP LES markets.
SW	Cathexis Innovations Inc. www.cathexis.ca ; St. John, Newfoundland, Canada	RFID Engine™, IDBlue™, CathexisWEB™	Cathexis Innovations Inc. is a global provider of RFID technology, based in Atlantic Canada. Cathexis is a provider of wireless, mobile RFID readers, advanced integration software and RFID application models built on its proprietary RFID Engine™ architecture. This allows system integrators, VARs and ISVs in the AIDC and mobility space to rapidly solve real business problems with RFID. To this end, Cathexis has leveraged the RFID Engine™ architecture to develop IDBlue™ - a market leading Bluetooth® RFID reader that comes bundled with cutting-edge development and connectivity tools that make RFID adoption straightforward and cost-effective. Cathexis is also using the RFID Engine™ to address the growing need to manage RFID data through the development of CathexisWEB™ – a hosted service that allows clients to rapidly implement cost-effective systems for collecting, managing and accessing their RFID data.
HW SW	CDO Technologies Inc www.cdotech.com ; Dayton, OH, USA	AIDC	CDO is one of the largest RFID integrators in the United States.
Svc	ChainLInk Research www.clresearch.com ; Boston, MA, USA		Research and Educational Services

	Company	Product	Areas of Focus
HW	Checkpoint Systems; Inc www.checkpointsystems.com ; Thorofare, NJ, USA	Performa® RFID Tags	Founded in 1969, Checkpoint Systems, Inc. is the largest manufacturer and marketer of RF and RFID based solutions for security, identification, tracking and merchandising applications in the world. With a presence in more than 80 countries and a network of more than 25 service bureaus worldwide, the company is the global leader for scalable, sure-performing UHF and HF, EPC and ISO based RFID consumable products and services. Checkpoint's newest offering, the Performa® line of RFID tickets, tags, labels, inlays and reusables are custom designed to meet the specific application, performance, pricing and fulfillment requirements of customers in a wide variety of industries including consumer package goods, retail, pharmaceutical, public transit and library.
HW	CCL Label www.ccllabel.com ; Upland, CA, USA	RFID Labels	CCL Label has served the packaging, promotional and pharmaceutical industry for over 50 years and is the leader in the North American market for pressure-sensitive self-adhesive labels and promotional products. CCL Label designs and prints a wide range of high-quality paper and film, pressure sensitive, RFID and security labels as well as insets, outserts, in-mold, shrink sleeve, expanded content, Spinformation® rotating labels and printed promotions to help leading consumer product marketers in support of their brand strategies.
SW	CODE Plus Inc. www.code-plus.com ; Fairfax, Virginia, USA	eManageIT RFID Tag&Ship	CODE Plus, Inc., a leading provider of logistics automation solutions, is based in the Washington, D.C. metropolitan area. CODE Plus specializes in developing software and system solutions for logistics, warehousing, and distribution enterprises. Our diverse capabilities include software application development, systems design and integration, technical services, and IT staff augmentation.
HW	Cross Point www.crosspoint.nl ; Emmen, , Netherlans	XM3 MICROPROXS™, proximity readers, modules, and tags	Cross Point is a leading manufacturer of wireless identification and detection equipment, designed to provide safety and protection for both people and assets. Cross Point has experienced rapid growth since its foundation in 1993, thanks to a market driven approach combined with the courage to explore new paths in cutting edge technology. This has resulted in an impressive track record of innovative products, which enable our (international) customers to protect and maximise their business operations in a secure and efficient manner.
Svc	Celergy Networks Inc. www.celergy.com ; San Clemente, California, USA	Celergy Advantage	Our core business offerings include design and installation of structured cabling, equipment installation and maintenance, voice & data networking, wifi installation as well as staging and deployment. Over the years we have developed a distinct competency in handling large scale rollouts. Our national footprint has allowed us to service businesses with locations in the most remote corners of the US or Canada. Our professional services have ranged from small turnkey solutions to large multiple site rollouts to build outs of large campus type facilities.

	Company	Product	Areas of Focus
Svc	DAG Systems www.dag-system.com ; Villeurbanne, Rhone, France	DAG Triathlon, DAG Re-usable	Dag System is the only RFID technology which is able to deal with race electronic timing, access control, industrial identification, etc. on very long distances, up to 10 metres. It has developed unconstrained detection in the band 13.56 Mhz allowing a long distance detection through 2D or 3D volume with antennas able to detect tags between 10 meters large and within a 60m3 volume. This technology was first developed and sold for sports events, but the company has recently branched into the industry market.
HW SW	Datamax Corporation www.datamaxcorp.com ; Orlando , FL, USA	I-Class , EX2	Datamax, a subsidiary of Dover Corporation (NYSE: DOV), specializes in the design, manufacture, and marketing of products for bar code and RFID labeling, including thermal demand printers, label, ticket and tag materials, and thermal transfer ribbons.
Svc	Deloitte Consulting LLP www.deloitte.com ; New York, NY, USA		A business challenge can spread across a dozen time zones before you finish your morning coffee. Or sneak up quietly, blurring familiar boundaries and unraveling rules of engagement. You know what it takes to respond. Understanding the whole picture. Productivity. Margins. Technology. Relationships. Even taxes. Then comes the hard part: figuring out how to blur your own boundaries to drive value. At Deloitte Consulting LLP, we help executives work together by offering solutions that bridge the interests of the entire organization. Our industry experience, broad capabilities and deep alliances mean we can help you make the most of opportunities and avoid unnecessary risk. Our promise is simple. We help clients create more value.
HW	Deltrix www.deltrix.co.za ; Pietermaritzburg, , South Africa		Manufactures patented, low cost, long-range (13m) readers and passive tags for UHF RFID systems, for use with tracking and logistics.
HW	Denso Wave www.denso-wave.com ; Tokyo, , Japan	IC Card	Main business in development, manufacturing and sales of automatic data capture equipments, industrial robots, programmable controllers and other apparatus and systems.
HW	Detectag Inc. www.detectag.com ; Schomberg, Ontario, Canada	Delta 15 RFID, ARF 150 Active RFID	Detectag Inc. is a company that specializes in the design and sales of easy to install anti shoplifting systems.
HW	Dialoc ID www.dialocid.com ; Harderwijk, , Netherlands	125 Khz Read-Only cards, 13.56 Mhz Read-Write cards	Dialoc ID are specialists in offering traditional retail solutions against theft, security and logistics management systems for libraries and RFID systems for various industrial and retail markets.
Svc	Direct Recruiters, Inc. www.directrecruiters.com ; Cleveland, Ohio, USA		Direct Recruiters, Inc. provides human capital resources for the RFID industry. Top companies rely on us to help build solid teams in Management, Sales, Marketing and Tech Support.
SW	DSI Online www.dsionline.com ; Overland Park, KS, USA	dcLINK®	DSI's automated data capture software solution, extends the reach and value of enterprise software applications by capturing accurate, real-time data in production, at the warehouse, and in the field.

	Company	Product	Areas of Focus
HW SW	Ekahau www.ekahau.com ; Saratoga, CA, USA	Ekahau Positioning Engine, T201 Ekahau Wi-Fi Location Tag	Ekahau is the recognized leader in location-enabling enterprise Wi-Fi networks. Ekahau's mission is to provide the easiest, most cost effective and accurate positioning solutions for locating people, assets, inventory and other objects using wireless enterprise networks. The Ekahau solution tracks wireless laptops, PDAs, VOIP phones, Wi-Fi tags and other 802.11 enabled devices.
HW	EM Microelectronic www.emmicroelectronic.com ; Colorado Springs, CO, USA	EM4094	EM Microelectronic is a semiconductor manufacturer designing and producing ultra low power, low voltage, digital, analog and mixed-signal integrated circuits (ICs) for battery-operated and field-powered devices in consumer, automotive and industrial applications. RFID chips feature read/write, anti-collision, 125kHz, 13.56MHz, UHF and 2.45GHz . Other products include microprocessor supervisors and reset ICs, microcontrollers, smart card ICs, mixed analog and digital gate arrays, ASICs, LCD drivers and displays and optoelectronic ICs. EM also produces (LCD) modules and offers bumping services. EM Microelectronic is one of the electronic systems companies within the Swatch Group, developing and producing ultra-low power, miniaturized and accurate microelectronic components and systems.
Svc	Enigmatics www.enigmatic-consulting.com ; Sunnyvale, CA, USA	Staffing Solutions with Impact Talent	Consulting on RFID physical layer implementation: antennas, tags, regulations, interferers, readers.
HW	Enterprise Information Systems, Inc. www.rfidinaction.com ; Prosper, TX, USA	Compliance 1st for DoD Suppliers	Enterprise Information Systems, Inc. is an RFID and AIDC systems integrator using proven technologies to improve supply chain efficiencies throughout various industries including manufacturing, distribution and A&D (Aerospace and Defense). With over 20 years of AIDC experience, Enterprise Information Systems develops and integrates proven solutions that combine application appropriate software and AIDC & RFID equipment to increase productivity and enhance strategic advantage.
SW	epcSolutions, Inc. www.epcsolutions.com ; Great Falls, VA, USA	RFIDTagManager	epcSolutions' RFIDTagManager provides an RFID Network platform with middleware for device and application management – epcSolutions' SensorOS – and a wizard-based RFID application for implementing retailer & DoD compliance requirements. A step by step process allows you to connect to any RFID printer and any RFID reader in minutes, helping enterprises reduce the time, cost, & effort of implementing RFID projects.
HW SW	Epic Data Inc. www.epicdata.com ; Richmond, British Columbia, Canada	RFID Systems	Epic Data develops a broad range of lean manufacturing and data collection systems. We utilize a wide range of products to deliver discrete manufacturing solutions which provide our customers with real-time visibility into their manufacturing operations while simplifying interaction with their existing enterprise applications.

	Company	Product	Areas of Focus
HW	Escort Memory Systems (A Datalogic Group Co.) www.ems-rfid.com ; Scotts Valley , CA, USA	SilverJet	Escort Memory Systems (a Datalogic Group Company) provides RFID solutions for every link of the Supply Chain. Since 1985 EMS has been developing, manufacturing and supporting RFID installations in companies around the globe. Supply Chain customers with applications such as WIP, Quality Control, Warehousing, and Logistics have all turned to EMS RFID for inventory management, tracking, and data collection systems. EMS uses technology that has the added advantage of being able to read through water, oil, concrete, and a variety of other elements without line of site requirements, or waiting for each individual tag to be read. Thanks to a constant stream of real-life application success stories, EMS has emerged as a global leader in providing RFID solutions in this rapidly expanding industry.
HW SW	Global Tracking Solutions (GTS) www.globaltracking.com ; Danvers , MA, USA	Precision Tracker, SCADA Tracker, Safety Tracker	Global Tracking Solutions, Ltd. Is a high technology company dedicated to providing leading-edge products and services to the location-based services marketplace. GTS' products are unique in providing integration of GPS devices, remote Video devices, RFID tags and Biometric devices into a single cohesive application. Furthermore, GTS' products provide the ability to display location information from a variety of diverse GPS devices using any available telecommunications service.
SW	GlobeRanger Corporation www.globeranger.com ; Richardson, Texas, USA	iMotion	GlobeRanger is a leading provider of RFID, mobility and sensor-based software solutions. Its innovative Edgeware™ platform, iMotion™, provides the critical infrastructure layer for managing devices, networks, data and processes at the edge of the enterprise, enabling real-time response. iMotion serves as the foundation for GlobeRanger and its partners to rapidly develop, deploy and manage edge solutions.
HW	HEI Inc. www.heii.com ; Victoria , MN, USA	XOA2, Mini Module, cards, labels printers	HEI is a full service developer and manufacturer of high performance components, medical and industrial products and software. ISO certified and FDA registered, we produce microcircuits and subsystems for hearing, communications, high-speed data processing, and medical applications. Products include Class I, II and III medical devices, biotechnology, drug discovery, and in vitro diagnostic systems, medical software and healthcare information technology, and identification technologies.
HW SW	HighJump Software- a 3M Company www.highjump.com ; Eden Prairie, MN, USA	Warehouse Advantage	HighJump Software, a 3M company, is a global leader in providing highly adaptable, best-of-breed supply chain execution solutions that streamline manufacturing and distribution from the point of source through consumption. HighJump's integrated solutions empower operational excellence in the warehouse and optimize the flow of inventory throughout the supply chain.
HW	Hitachi Maxell www.maxell-usa.com ; Osaka , , Japan	Coil-On-Chip™ and Minimold RFID tags,	Hitachi Maxell was founded in 1961 and today is one of the world's leading producers of optical and magnetic memory media.

Company	Product	Areas of Focus
SW Svc IBM www.ibm.com ; Dallas , Texas, USA	WebSphere®	An IBM RFID solution is made up of three different elements: Devices, WebSphere® RFID Premises Server V1.1, and a WebSphere integration
HW iControl; Inc. www.icontrol-inc.com ; San Jose, CA, USA	iDAC	"Remote control and data acquisition via the Internet"&LF;iControl produces the hardware and software that provides complete monitoring and bidirectional communication for control of remote assets.
HW IDENTEC SOLUTIONS, Inc. www.identecsolutions.com ; Lustenau, , Aust	i-Q8 Tag	IDENTEC SOLUTIONS, headquartered in Lustenau, Austria with an office in Kelowna, Canada, specializes in Intelligent Asset Management solutions, which help simplify manufacturing and logistics processes and bring more transparency to the supply chain. IDENTEC SOLUTIONS' Intelligent Long Range® (ILR®) active RFID system can identify assets at distances of up to 100 meters (300 feet).
HW ID Teck Co, Ltd www.idteck.com ; Seoul, , Korea	ASK Format iPASS Series, SMART	IDTECK is a diversified technology and manufacturing leader of security products.
HW SW Impinj, Inc. www.impinj.com ; Seattle , WA, USA	Impinj Grandprix and various RFID systems	Leading provider of UHF Gen2 chips. Also sells UHF readers and components.
HW InfoChip Systems Inc. www.infochip.com ; Wetaskiwin, Alberta, Can	Hose Trakker Online	InfoChip Systems Inc. is a provider of Data Mobilization Services, as well as Mobile RFID Asset Certification, Maintenance and Tracking Solutions.
Svc Infosys Technologies Ltd www.infosys.com ; Plano, TX, USA	Supply Chain Consulting	Infosys Technologies Ltd. provides consulting and IT services to clients globally - as partners to conceptualize and realize technology driven business transformation initiatives. With over 49,000 employees worldwide, we use a low-risk Global Delivery Model (GDM) to accelerate schedules with a high degree of time and cost predictability.
HW INKODE International www.inkode.com ; Vienna, VA, USA	CRIS (Chipless Remote Identification System)	OEM Supplier of Chipless RFID systems, Antennas (100 ft read). Tag materials and licensing VARs. Operating at 22-66 gHz. System using near field radar technology. Power is from 250 microwatts to 4 milliwatts.
SW inLogic, Inc. www.inlogic.com ; Kennesaw, GA, USA	RFConnect.NET	inLogic designs, builds, and integrates RFID software applications based on the Microsoft.NET platform.
Svc Innovision Research & Technology PLC www.innovision-group.com ; Wokingham, Ber		Innovision Research & Technology plc is one of Europe's leading Radio Frequency Identification (RFID) IC Design and solutions provider. Focusing on RFID and ultra low-cost Integrated Circuit (IC) and electronic design, the company develops innovative technologies and technology applications for commercialisation and then licenses the technology on to its customers who incorporate it into their own products. Innovision R&T is also at the heart of the emerging Near Field Communication (NFC) market, designing and developing solutions for the mobile handset and consumer device sectors. The company's work with customers includes pre-engineering studies, building of prototypes and complete product development through to production, including full custom silicon chip design. Innovision R&T products include Jewel, the world's smallest and lowest cost ITSO approved smart ticketing chip; and "io" the world's smallest standards compatible near field RFID reader.

Company	Product	Areas of Focus
HW SW Svc Integral RFID www.integralrfid.com ; Richland , WA, USA	Instant EPC Hotspot, Gen 2 Mousepad, Resonant Cavity Antenna	Integral RFID was founded as a consultancy company, but has since released various RFID related products into the market. With a large concentration on the science behind RFID, the company provides a unique combination of academic knowledge, ability, and practical experience.
Svc Intellareturn Corp. www.intellareturn.com ; New York, NY, USA		Intellareturn enables courier services to check warranty status by reading RFID stickers attached to any item. This provides individuals and organizations at every point of the process with enhanced benefits for costly and time-consuming returns, warranty and reverse logistics functions.
HW Intermec Technologies, Inc. www.intermec.com ; Everett, WA, USA	Intermec RFID Fixed Readers,	Intermec Inc. (NYSE:IN) develops, manufactures and integrates technologies that identify, track and manage supply chain assets. Core technologies include RFID, mobile computing and data collection systems, bar code printers and label media. The company's products and services are used by customers in many industries worldwide to improve the productivity, quality and responsiveness of business operations.
HW International Business Machines Corporation www.ibm.com ; Armonk, NY, USA	WebSphere RFID Premises Server	At IBM, we strive to lead in the invention, development and manufacture of advanced information technologies, including computer systems, software, storage systems and microelectronics. We translate these advanced technologies into value for our customers through our professional solutions, services and consulting businesses worldwide.
HW iPico Identification (Pty) Ltd www.ipico.co.za ; Brummeria, Pretoria, Gauteng, South Africa	UHF Readers (Read Only & Read Write)	Ultra High Frequency Readers and Tags Dual Frequency Readers and Tags Middleware
HW IRC (TT Electronics) www.irctt.com ; Corpus Christi, Texas, USA	Tantalum Nitride resistor products from IRC-AFD	Specializes in the application of various resistor film systems to substrate material to form resistors, sensors, and other resistive type devices.
HW SW Svc The Kennedy Group www.kennedygrp.com ; Willoughy, Ohio , USA	Smart Therm™, SmartOne™1000 RFID Applicators	The Kennedy Group's Radio Frequency Identification (RFID) group is a full service provider of turnkey solutions for companies looking to improve supply chain performance and meet strict Electronic Product Code (EPC) compliance mandates made by large retailers and the government. As an RFID industry leader, The Kennedy Group offers the most comprehensive solutions available for implementation of both 900 MHz and 13.56 MHz frequency RFID systems.
HW KSW Microtec AG www.ksw-microtec.de ; Dresden, -, Germany	Passive HF Inlays	- Passive RFID HF and UHF Inlays; - Smart Active Labels for temperature monitoring; - Wafer Services; - Micropackaging; - RFID antenna printing; - Flip Chip Packaging
HW Leuze Group www.bielomatik.de ; Neuffen, , Germany	Transponder Processing and Finishing	Inlay Conditioning equipment, multi-web lamination, finishing systems for smart products, high speed read/write units for RFID.
HW Lowry Computer Products www.lowrycomputer.com ; Brighton, MI, USA	Smart Trac Labels	Lowry is a manufacturer and integrator, specializing in wireless, RFID, bar code and data collection solutions.

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	Company	Product	Areas of Focus
HW	LXE Inc. www.lxe.com ; Norcross, Georgia, USA	MX3-RFID	LXE designs and manufactures industrial wireless data collection solutions including rugged computers, mobile RFID technologies, and wireless networking products that improve performance of supply chain execution applications. LXE also offers a full range of turnkey services including project coordination and network design and installation. LXE is a wholly owned subsidiary of EMS Technologies, Inc.
HW	Lyngsoe Systems www.lyngsoesystems.com ; Aars, N/A, Denm	Semi-active RFID	Lyngsoe Systems provides logistics solutions designed to significantly improve our customers' quality of service and competitiveness in the global market.
HW	Magellan Technology Pty Ltd www.magtech.com.au ; ANNANDALE, NSW,	MSTRP 5050 tunnel reader	Magellan is a technology developer of advanced read and write RFID systems operating at 13.56MHz. Magellan develops the chip, inlay, tag, reader and operating software. All products comply with ISO 18000 Part 3 Mode 2. Magellan's technology is optimised for reading and writing to hundreds of tags that are stacked touching or overlapping as found in gaming, document management, jewellery tacking, blood and blood products, pharma and medical implants applications and for high speed conveyor fed applications as found in the airline, postal, and courier markets.
SW Svc	Manhattan Associates www.manh.com ; Atlanta, GA, US		As a leading provider of supply chain planning and execution solutions, Manhattan Associates offers easy-to-use solutions to make your supply chain work better from demand to consumption. We know that different industries need specialized solutions and that every business faces unique challenges. Manhattan Associates is dedicated to meeting the needs of companies of all sizes and in key industries around the globe. In the past 15 years, we have helped more than 1200 clients around the globe.
HW	MARKEM Corporation www.MARKEM.com ; Keene, NH, USA	800 Series High Speed RFID Encoder/Applicator	MARKEM Applied Intelligence(tm) Solutions provides fully integrated solutions to help companies comply with RFID and EPC requirements and leverage them in their supply chain.
Svc	METLaboratories, Inc. www.metlabs.com ; Baltimore, Maryland, USA		Testing and Certification
HW	Microchip Technology Inc. www.microchip.com ; Chandler, AZ, USA	MCUs with transmitters, encoders with transmitters, Micro ID Ics	Microchip Technology Inc. is a leading provider of microcontroller and analog semiconductors, providing low-risk product development, lower total system cost and faster time to market for thousands of diverse customer applications worldwide.

6. RFID Vendors Overview--14 of 27

Company	Product	Areas of Focus
HW SW Microsoft Corporation www.microsoft.com ; Redmond, Washington,	RFID Infrastructure ; Microsoft Dynamics AX	Microsoft Corporation develops, manufactures, licenses and supports a range of software products for various computing devices. The Company's software products include scalable operating systems for servers, personal computers (PCs) and intelligent devices; server applications for client/server environments; information worker productivity applications; business solutions applications; software development tools, and mobile and embedded devices. Microsoft provides consulting services and product support services and trains and certifies system integrators and developers. The Company's seven product segments are: Client, Server and Tools, Information Worker, Microsoft Business Solutions, MSN, Mobile and Embedded Devices and Home and Entertainment. Its Mobile and Embedded Devices segment offers mobile software platform; embedded device software platforms used in consumer electronics devices and enterprise devices; a hosted programmable XML Web service; and software platform to create telematics solutions for vehicles.
HW Svc Miles Technologies www.RFIDLabeling.com ; Lake Zurich, IL, US	Consulting, RFID Marketplace -- to RFID Vendors	Miles has been automating the warehouse for over 20 years! Inventory control using state of the art technology is our focus. Miles committment to RFID includes the RFID Benchmark LAB near O'Hare for demonstrations of our compliance labeling and closed loop systems, seminars and training. Visit www.RFIDLabeling.com for more information on our software, seminars and training.
SW Movaro www.movaro.com ; McLean, VA, USA	SmartSourcing	Devise Authentication Software for the enterprise
HW National Module Systems www.nms.ch ; Moudon, , Switzerland	Miniaturized RFID tags	Recognised as a leader in its speciality, NMS SA manufactures low profile, fine pitch microcircuits in response to the requirements of leading companies in industries such as access control, automotive, instrumentation, medical, telecommunications and watch making.
HW National Scientific Corporation www.ncslocators.com ; Scottsdale, AZ, USA	Gotcha!	National Scientific Corporation is a publicly owned U.S. firm in the business of making electronic and electromechanical devices smaller, faster, and safer. Our focus is wireless technologies that location-enable important commercial and non-commercial activities, such as the safe and secure movement of people and goods over short and long distances. National Scientific has a special interest in the safety of children and develops and sells various types of devices intended to improve child protection.

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	Company	Product	Areas of Focus
SW	OATSystems, Inc. www.oatsystems.com ; Waltham, MA, USA	OAT Foundation Suite	OATSystems, Inc. is the recognized RFID framework leader with software that empowers businesses to achieve competitive advantage from radio-frequency identification (RFID). As pioneers in the development of RFID technology, OAT has been setting the standard in RFID for over half a decade and is responsible for industry firsts that include the largest scale and largest scope of deployments, as well as the most innovative approaches to providing enterprise-wide RFID solutions. OAT's multinational client base, which includes companies such as Hewlett-Packard and Gillette, consists of over 50 customers in retail, CPG, consumer electronics, manufacturing, life sciences, aerospace and defense. Headquartered in Waltham, MA, OAT has offices in Chicago, London, San Francisco and Bangalore and is on the Web at www.oatsystems.com.
Svc	ODIN technologies www.ODINtechnologies.com ; Dulles, VA, US		RFID is all we do. ODIN technologies is the leader in the physics of RFID solution design, deployment and testing. ODIN technologies leverages its team of RF engineers, physicists and software developers combined with its laboratory facilities to provide RFID consulting services to major retailers, consumer goods and pharmaceutical manufacturers, government agencies and other RFID early adopters. ODIN technologies has also developed a suite of products to make RFID deployments easier for end-users, such as Trifecta (UHF tag testing software) and RFID Deployment Manager (reader deployment optimization tool based on RF physics).
HW	OMNIKEY GmbH www.omnikey.com ; Walluf, Hessen, German	CardMan® 5321 Dual Interface	OMNIKEY, one of the world's leading manufacturers of innovative smart card readers, offers a diversified product portfolio available on the market today. OMNIKEY's smart card readers for PCs can be utilized by any application including logical access control, digital signature, WLAN authentication, secure banking and online transactions, loyalty programs, and healthcare solutions. OMNIKEY, headquartered in Walluf, Germany, is part of the ASSA ABLOY Identification Technology Group (ITG). OMNIKEY's US headquarters resides in Irvine, California with technical support in Atlanta, Georgia. The Asia Pacific operation is located in Hong Kong. Design, production management, and quality control of OMNIKEY's products are carried out in the company's two R&D centers in Linz, Austria and Erfurt, Germany. OMNIKEY readers are distributed worldwide through a global network of partners, including value added resellers, system integrators, and OEMs.

	Company	Product	Areas of Focus
HW	Omron RFID www.omronrfid.com ; Schaum burg, IL, USA	The Gen 2 "Wave" Global tag/V750	Headquartered in Kyoto, Japan, Omron is a global leader in the field of automation with $5.5 billion in annual revenue. Established in 1933 and headed by President and CEO Hisao Sakuta, Omron has more than 26,000 employees in over 35 countries. Omron has been in the RFID business for over 20 years. An EPCglobal member, Omron offers a wide range of RFID products including a "One Day Compliance" package, inlays, and readers for HF (13.56 MHz), UHF (915 MHz) and other frequencies. For more information, write to info@omronrfid.com, visit the Web site at www.omronrfid.com or contact Omron's U.S. office at (888) 303-RFID (303-7343).
Svc	OTA Training www.otatraining.com ; Dallas , Texas, USA	E3 Learning SystemTM	Vendor-neutral industry educator. OTA Training, LLC. provides the most Comprehensive, Vendor Neutral, Hands-on RFID training available today to enhance the skills of everyone from the novice to even the most experienced technical professional.
HW	Parco Wireless www.parcomergedmedia.com/ ; Portland, ME	Parco Integrated Wearable Wristband	Parco Wireless is a privately held company headquartered in Portland, Maine. The company has emerged as the industry leader for the health care and safety industry providing the most accurate and reliable tracking systems available to hospitals. Parco is the only one-source wireless health care communication systems provider using FCC approved UWB devices and open platform software designs. Parco's wireless healthcare communication software suite includes middleware, an application programmer's interface, and wireless operating system and software development kits.
Svc	Patni Computer Systems Ltd www.patni.com ; Mumbai, Maharashtra, INIDI		Software Services
HW	Paxar Corp. www.paxar.com ; White Plains, NY, USA	Paxar and Monarch(R) brands Smart Labels	Paxar provides smart tags and labels, RFID printer/ encoder solutions, bar code systems, and complete integration and maintenance services to industry leaders like Marks & Spencer, Del Monte Foods, and VF Corporation. We provide the industry's most reliable RFID products, including Monarch(R) brand, and the best service and support available.
HW	PLITEK www.plitek.com ; Des Plaines, IL, USA	UHF EPC RFID Labels and Tags	Whether you need an RFID label solution to satisfy a compliance mandate or to improve operational efficiency, reduce inventory, or manage assets better, PLITEK has the high quality RFID label and tag solutions you need for success. Backed by over 30 years of converting expertise, PLITEK has become an industry leading RFID label and tag supplier servicing the retail, defense, pharmaceutical, healthcare, and transportation industries. Our primary focus is to provide our customers superior quality, cost effective RFID label and tag solutions …worldwide.

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	Company	Product	Areas of Focus
HW	Power Paper, PowerID Division www.power-id.com ; Kiryat Aryeh, Petah Tikv	PowerID	PowerID is a division of Power Paper Ltd., a leading provider of micro-power source technology and devices that are based on its patented, ultra-thin and flexible, environment friendly energy cells. PowerID develops high performance RFID label systems based on a new generation of label transponders: battery-powered labels. The incorporation of the Power Paper battery into a thin and flexible, printable RFID label enables unprecedented visibility, reliability and superior performance for supply chain management, fixed asset tracking and manufacturing environments, among other applications, even in tough RF environments that include liquids, metals and foils.
HW	Precision Dynamics Corporation www.pdcorp.com ; San Fernando, CA, USA	Smart Band® RFID Wristband Solutions (Healthcare)	With 50 years of experience, PDC is the global leader and pacesetter in the development of automatic identification wristband systems for healthcare, patron management, and law enforcement. The company introduced the first patient Bar Code ID Wristband System in 1984, Smart Band® Radio Frequency Identification (RFID) Wristband System in 2000, AgeBand® Electronic Age/ID Verification System in 2004, and Smart Kiosk™ Cashless POS RFID System in 2005. PDC is committed to 100% quality in service, design, and manufacturing. ISO-9001: 2000 and ISO-13485: 2003 certified..
HW	Printronix, Inc. www.printronix.com ; Irvine, CA, US	SL5000r MP2/SmartLine RFID Printer Family	Printronix, Inc., is a global leader enabling printing technologies for the industrial marketplace and distribution supply chain. It is a world leader in line matrix manufacturing and has earned an outstanding reputation for its high-performance thermal and fanfold laser printers. Expert at adapting new technologies to create innovative programs, the company offers the next generation of RFID products and services. Printronix's RFID Smart™ technology solutions fast track RFID adoption . Printronix's integrated network programs, such as Online Data Validation (ODV(tm)) and PrintNet(r) Enterprise, improve the printing of bar codes, labels and forms while verifying accuracy and offering diagnostic technology.
SW	Progress Software www.progress.com/realtime ; Bedford, MA, U	Progress Apama ESP Platform	Progress Software, headquartered in Bedford, Massachusetts (NASDAQ: PRGS), provides event processing, data management, access and synchronization products - all of which focus on providing the low-latency infrastructure needed to support the requirements of the real-time enterprise.
HW	Quest Solutions, Inc. www.questsolution.com ; Eugene, OR, USA	RFID Printers	Quest Solutions extends applications to the mobile workforce. We provide world class RFID, AutoID, and software systems that eliminate errors, save time, reduce inventory, and improve profits. We simplify the process with the most experienced team who use best practices and proven problem solving solutions.

Company	Product	Areas of Focus
SW Radio Beacon Inc. www.radiobeacon.com ; Toronto, Ontario, Ca	RADIO BEACON WMS	Radio Beacon is a developer of warehouse management software that adapts with the growing business needs of third party logistics providers, manufacturers and distributors. Working with industry-leading hardware providers, Radio Beacon's warehouse management software integrates seamlessly with barcode, RFID and material handling technology. The RADIO BEACON WMS is distributed locally through global partners.
SW RafCore Systems www.rafcore.com ; Sunnyvale, CA, USA	RAIS Manager	RafCore Systems product suite provides you powerful real-time RFID Analytics and Integration capabilities to extract the most valuable information from RFID data and bring real-time visibility to your Enterprise Information Systems.
HW Repacorp Label Products www.repacorp.com ; Tipp City, Ohio, United S	RFID Enabled Smart Labels and Tags	Founded in 1974, Repacorp Label Products has grown to become one of the nation's largest label-converting and specialty printing companies. Repacorp now offers high-volume RFID inlay insertion into label and tag stock. Our label and tag products are compliant with EPC and ISO standards and our manufacturing process is chip-neutral and compatible with any standard inlay available today.
HW SW Reva Systems www.revasystems.com ; Chelmsford, MA, US	Tag Acquisition Processor (TAP)	Reva Systems develops network-intelligent products for the emerging radio frequency identification (RFID) market. Eliminating the proprietary design and scalability problems of first-generation RFID solutions, Reva's Tag Acquisition Network (TAN) architecture and Tag Acquisition Processor (TAP) devices use proven networking concepts to enable scalable, repeatable, and reliable enterprise-wide RFID reader deployments.
HW RF Code, Inc. www.rfcode.com ; Mesa, AZ, USA	Mantis	RF Code is a leading developer of RFID asset tracking solutions and enabling technologies. Together with our partners, we make enterprise asset visibility a reality and deliver a remarkably fast ROI through the integration of AIDC (Automatic Identification and Data Collection) devices and wireless networks. Since 1997, we have designed high-performance, low cost solutions that accurately manage and track physical assets, information and personnel. RF Code offers patented radio frequency technologies, scalable RFID software, powerful development tools and domain expertise. Our TAVIS™ software suite is a comprehensive management platform for asset data collection and distribution supporting established, standards-based RFID, sensor devices and networks. Our Mantis™ active RFID tags and readers incorporate advanced technologies which provide state-of-the-art functionality at the lowest cost.
Svc RFID4U www.rfid4u.com ; , CN, USA		Educational Services

Company	Product	Areas of Focus
Svc RFID Careers www.RFIDcareers.com ; Winsted, CT, USA	RFIDShipIT!®	We provide Intelligent Staffing Solutions for the Global RFID / Wireless Industry. Our clients include companies designing, manufacturing, building, and selling cutting edge AIDC and wireless communications infrastructure integration technology. These companies focus on components and systems that provide - either as manufactured products or services - the delivery of voice, data, audio, or video signals.
HW RFID, Inc. www.rfidinc.com ; Aurora, CO, USA	R3	125 KHz - Tags and Readers; 148 KHz - Tags and Readers; 13.56 MHz - Tags and Readers; 433 MHz - Active Tags and Readers to include GPS/Cellular modems. Primary markets include 1. Process controls (factory floor) with typical Reader outputs of Profibus, DeviceNet, TCPIP, Ethernet IP, Modbus, Discrete I/O, Serials. 2. OEM/Custom Hardware Designs - Industrial identification market, customer loyalty programs, client tracking and data, verification/authentication, etc. 3. Vehicle, personnel, asset ID & tracking.
HW SW RFID Ltd. www.rfid-ltd.com ; Denver, CO, USA	Black Box RFID	Founded out of the growing demand for high quality, cost effective RFID "mandated compliance" support, RFID, LTD.(OTCBB:RFDL) formed an organization that integrates over 50 years of technology and supply chain experience, with an emphasis on understanding the business objectives and strategic direction of small-to-medium sized DoD and Wal-Mart suppliers. RFID technologies have been proven in corporate and government settings for decades; however, the once dormant industry is booming with new developments and more importantly better ways to apply and extract value from the technology.
Svc RFID Recruiters, LLC www.rfidrecruiters.com ; Addison, TX, U.S.A.		RFID Recruiters is 100% focused on RFID recruiting. RFID Recruiters finds and recruits the best people for companies engineering, manufacturing, marketing, selling, implementing, supporting, and utilizing RFID technologies, products, applications, and services.
Svc RFID Revolution, LLC www.RFIDRevolution.com ; Silver Spring, MD		RFID Revolution LLC provides RFID (radio frequency identification) marketplace consulting services to vendors and end-users. We provide a market-based perspective on how to close the gap between a promising technology and successful commercial solution.
HW RFID Sources Corp www.rfidsources.com ; Tantzu, Taichung, Tai	PVC & PETG Smart Cards, Thermo Rewrite	RFID card, tag, and transponder
HW Svc RFIDSupplyChain.com www.rfidsupplychain.com ; Mishawaka, IN, US	RFID Readers	RFIDSupplyChain.com, an online RFID store offering do-it-yourself kits and solutions to common RFID applications, is the "One-Stop Shop" for all of your RFID technology needs. RFIDSupplyChain.com is a leader in providing RFID hardware, software, services and solutions. We have partnered with the top RFID manufacturers, such as Alien, Intermec, Symbol, Omron, Printronix and Zebra, to provide the best and latest RFID tags, readers, antennas, smart labels, printers, portals, and solutions.

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Company	Product	Areas of Focus
HW RightTag Inc www.righttag.com ; Santa Clara , CA, USA	BT RIGHTReader	RightTag is a leading manufacturer of standards compliant RFID equipment and related application software. RightTag helps companies to come up with the cost effective AIDC (Automatic Identification and Data Capture) solutions.
HW RSI ID Technologies www.rsiidtech.com ; Chula Vista, CA, USA	Pressiza /RFID Tags & Inlays	RSI ID Technologies, Inc. is one of the nation's only vertically integrated providers for radio frequency identification (RFID) technology, including systems integration, data collection and all manufacturing and assembly of components. RSI also offers a full range of support services, training and consulting services.
Svc Rush Tracking Systems www.RushTrackingSystems.com ; Lenexa, K		Rush Tracking Systems is a leading end-to-end RFID systems integrator offering turnkey solutions through a proven, repeatable process based on years of real-world implementation. As RFID innovators, implementers and partners, we have used our expertise and real-world experience to generate rapid results for major companies in a wide range of industries.
HW SAMSys Technologies Inc. www.samsys.com ; Durham, NC, USA	MP9320	Aquired by Sirit
SW Svc SAP www.sap.com ; Palo Alto, California, USA	mySAP Business Suite	SAP is a leading provider of business software solutions*. Today, more than 32,000 customers in more than 120 countries run SAP® software—from distinct solutions addressing the needs of small and midsize enterprises to suite offerings for global organizations. (*) SAP defines business software solutions as comprising enterprise resource planning and related software solutions such as supply chain management, customer relationship management, product life-cycle management and supplier relationship management.
HW SATO America www.satoamerica.com ; Charlotte, NC, USA	CL408e RFID and CL412e RFID Printer	SATO Corporation, Japan, was established in 1940 to manufacture and sell packaging machinery. In 1962, SATO was a pioneer in introducing one of the first hand-held labelers and operations as an international supplier of labeling machinery. The US subsidiary was established in 1977 and eventually became SATO America, Inc. in 1987. SATO developed the world's first thermal transfer barcode printers and continues to be in the forefront of thermal printing technologies. Our product line includes direct thermal and thermal transfer printers, OEM print engines, printer accessories, label design software, labels and thermal transfer ribbons.

Company	Product	Areas of Focus
HW SW Svc Savi Technology www.savi.com ; Sunnyvale, California, U.S.A.	EchoPoint(TM)	With over 16 years experience, Savi is a proven leader in RFID solutions for the management and security of supply chain assets, shipments and consignments. Savi's integrated RFID hardware and software solutions drive business value, such as reducing supply chain assets, inventory and operational costs. The company tailors its solutions to the defense, commercial supply chain asset management and global supply chain visibility and security markets. Savi's solutions meet the supply chain needs of defense and government organizations, global shippers, manufacturers, retailers, and suppliers as well as service providers such as terminal operators, asset owners and third-party logistics providers. Founded in 1989, Savi Technology is privately held, with headquarters in Sunnyvale, Calif., and offices in Johannesburg, London, Melbourne, Singapore, and Washington D.C.
HW SW Svc SAVR Communications www.metroautomation.com/savrcom ; Irving,	Custom module design for Connect & Communicate Interrogators, RFID	SAVR Communications commits itself to producing unique, low-cost RFID products for today's dynamic global marketplace. Their goal is to offer adaptable products that serve industry requirements while still providing ease-of-use and a rapid return rate on your investment.
HW Scanning Devices Inc www.scanningdevices.com ; Burlington, MA,		SD Tag Programmer, LoadBuilder System
HW SecuriCode Limited www.securicode.co.uk ; Swindon, Wiltshire, U	Finished Tags or Inlays (Active)	SecuriCode provides secure, globally-unique active identity methods for people, allowing them to be accurately identified, authorised and/or located without fear of identity theft. A unique encrypted dual-identity system provides both a public identity that may be shared by others and a personal identity that protects the individual's identity.
HW SW Sense Holdings Inc www.senseme.com ; Sunrise , FL, USA	Smartcode Developers' Kit, RFID Tags	SENSE Holdings Inc.™ (SEHO) is a leading provider of biometric solutions, and micro-sensor identification systems. Sense develops products targeting Homeland Security, and offers solutions that improve and secure many business, military, and personal processes. Sense owns patents and intellectual property for a MEMS based explosives detection technology licensed through a national government laboratory. The company has focused its efforts on the Homeland Security initiative.
HW Shenzhen Promatic Commercial Safety Co. www.promaticgroup.com ; Futian, Shenzhen,	RFID Open Access Control System	The enterprise aim is to become the most excellent supplier of commercial security, loss prevention system and RFID technology for modern logistics and retailing in Asia through their sincerity principle and dedication to customer satisfaction.
HW SW SkandSoft Technologies, Pvt. Ltd. www.skandsoft.com ; Mumbai, Maharashtra,	SETU (TM)	SkandSoft Technologies is a RFID/ AIDC solutions company with a pioneering solution development platform SETU(TM)

	Company	Product	Areas of Focus
HW	SkyeTek, Inc. www.skyetek.com ; Westminster, CO, USA	SkyeModule M8	SkyeTek, Inc., maker of ReaderWare™, is a leading supplier of RFID reader software and reference designs that enable the pervasive adoption of RFID technology. SkyeTek's Tagnostic™ reader technology works with most industry standard tags and smart labels. Its low power requirements and a small form factor make it the optimal choice for embedding into new or existing products. SkyeTek's RFID reader technology is available in several formats including reader modules, hardware reference designs, and the ReaderWare™ software suite. SkyeTek markets to OEM customers in targeted vertical markets with several high-volume licensing options available. SkyeTek is based in Colorado.
HW	SmartCode Corp. www.smartcodecorp.com ; New York, NY, US	EPC Gen 1 / Gen 2 Labels	Lowest Cost EPC Gen 2 Inlays and Tags. ISO14443A/B Tags and Readers, NFC Tags and Readers, Active Tags.
HW	Socket Communications Inc. www.socketcom.com ; Newark, CA, USA	CompactFlash Reader Card	Controllers, readers
HW	SOKYMAT www.sokymat.com ; GRANGES-VEVEYSE, F	ACCESS & SECURITY	Development and manufacturing of RFID transponders for LF, HF & UHF applications such as access & security, industry supply chain and logistics, food & animal, governmental documents.
HW	STMicroelectronics www.st.com/rfid ; GENEVA, CH 1228 Plan-Le	Extended Range (XR) - EPCGlobal and 18000-6	Committed to high-volume/low-cost identification solutions, ST offers low-cost, standard-compliant RFID chips and complete systems through its wide partner network (reader and converter makers, inlets makers etc.).
HW SW	Stratum Global www.stratumglobal.com ; Littleton, CO, USA	TagNet RFID Solution Suite	Stratum Global is a software solutions company and systems integrator that develops and markets TagNet, a release supported, platform agnostic Radio Frequency Identification (RFID) solution suite. Stratum Global's sole business is RFID. We provide complete implementation services including site surveys, hardware installation, enterprise integration, tags, services and education to support the total RFID solution.
SW	Sun Microsystems www.sun.com ; Auburn, CA, USA	Sun Java RFID Event Manager	Computer systems, storage, networking, workstations, RFID Middleware (Event Manager, Information Server). Company tagline: "The network is the computer"
SW Svc	Supply Insight www.supplyinsight.com ; Hamdem, CT, USA	rPlatform	Provides cost effective solutions for different target markets and helps DoD suppliers meet UID, RFID compliance and WAWF integration. All of the company's custom RFID business solutions are built on it's software.
HW SW Svc	SureID www.sureid.com ; Marlton, NJ, USA	RFID Deployment Manager	Founded 1990. Sure ID is a recognized leader in the rapidly expanding market for authentication products and authentic RFID expertise. Specializing in Item-level RFID, our team of experts has helped companies derive business value from RFID since 1990. Our solutions are employed in thousands of locations, authenticate millions of items, and provide unbridled visibility.

	Company	Product	Areas of Focus
SW	Sybase/iAnywhere www.sybase.com\rfid ; Dublin, California, USA	RFID Enterprise	Sybase is an enterprise software company exclusively focused on managing and mobilizing information. Our end-to-end RFID solution simplifies every stage of enterprise RFID implementations. Our software provides complete integration and network management services for intelligent devices and data. Sybase's integrated development environment delivers modeling, programming, and data management tools to ensure that RFID data and events are stored and propagated for application integration, auditing, reporting and business intelligence purposes.
HW	Symbol Technologies www.symbol.com ; Holtsville, New York, USA	MC9000-G	Symbol Technologies, Inc., The Enterprise Mobility Company™, is a leader in enterprise mobility, delivering products and solutions that capture, move and manage information in real time to and from the point of business activity. Symbol enterprise mobility solutions integrate advanced data capture products, radio frequency identification technology, mobile computing platforms, wireless infrastructure, mobility software and world-class services programs under the Symbol Enterprise Mobility Services brand.
HW	Synergex www.synrfid.com ; Mississauga, Ontario, Can	Software and support devices including printers, tags, and mobile devices, RFID enablement and	Synergex Technology focuses on development of novel technology and delivering customized solutions for clients. Synergex' team of professionals designs, developes and implements customer focused solutions aimed at providing business processes and operations. The company has packaged solutions for a variety of industry segments.
HW	Syrma Technology pvt Ltd www.syrmatech.com ; Chennai, Tamil Nadu,	Hitag1, EM4012	Syrma Technology Pvt. Ltd. is a leading technology company into Design and manufacture of Precision Coils, RFID Passive Tags (125/134 KHz and 13.56 MHz) and Magnetics. Located at Chennai, India, Syrma Technology has an illustrious track record of over 25 years in the manufacture of electronic components. The company employs advanced technology, experienced professionals and state-of-the-art manufacturing capabilities to bring out the most precise and cost effective technology products. Syrmatech is ISO 9001:2000 Certifiedcompany.
SW	T3Ci www.t3ci.com ; Mountain View, CA, USA	T3 Analytics	T3Ci, the leading RFID analytics and applications company, offers a wide variety of RFID services and software. T3Ci develops and markets software and software-as-a-service for leaders of RFID initiatives at major retail suppliers and major retailers who are responsible for delivering business value from their company's RFID investment. T3Ci's enterprise-class solutions include RFID analytics as well as a suite of high-value applications including promotions execution and out of stock management.
HW SW	TagMaster www.tagmaster.se ; Kista, , Sweden	Tags, readers, complete software development kit, accessories	It is our aim to assume a leading role in terms of RFID technology for the most demanding applications, where the savings potential for the end-customer is crucial. To accomplish this, TagMaster takes the role of a pure product supplier, a partner with major companies and a developer of new concepts that require RFID technology.

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	Company	Product	Areas of Focus
HW	TagSense, Inc. www.tagsense.com ; Cambridge, MA, USA	Nano-UHF	TagSense is a developer of custom RFID systems and wireless sensors. Our RFID sensor platforms include: EPC Gen1/Gen2, Zigbee tags, 13.56 Mhz, chipless tags and printed inks. TagSense also sells small low-power, low-cost RFID reader OEM modules for printers, handhelds, smart shelves, and mobile devices such as cell phones and PDAs.
HW	TAGSYS www.tagsysrfid.com ; Cambridge, Massachus	ARIO 13.56 MHz HF TAGS	TAGSYS is a global leader in item-level RFID infrastructure. TAGSYS RFID provides RFID systems and tags for end-to-end item-level tracking that automates labor-intensive processes, authenticates and safeguards goods, and enables real-time inventory and asset visibility. With a proven track record of delivering Reliable, Accurate and Secure (R.A.S.) RFID systems and tags, TAGSYS has deployed over 60 million tags and 50,000 reader systems to over 500 customers in more than 40 countries. TAGSYS RFID solutions are currently being deployed in a range of highly specialized vertical markets that include pharmaceutical, fashion apparel, libraries, textile rental, cash-in-transit and gas cylinder tracking. TAGSYSRFID e-connecting goods.
HW	Tapemark www.tapemark.com ; West St. Paul , MN, US	Chipless ID	Tapemark is a leading-edge contract manufacturer, providing innovative solutions for your unique requirements. We convert a wide range of flexible materials, integrating coating, printing, die cutting and packaging in order to maximize the functionality and cost-effectiveness of every product we deliver. Offers UHF Chipless ID tag.
HW SW	TI www.ti.com/scn ; Attleboro , MA, USA	TI-Rfid UHF and High Frequency ISO Transponders, readers, antennas, software downloads	Texas Instruments Radio Frequency Identification (TI-RFid™) Systems is an industry leader in radio frequency identification (RFID) technology and a major integrated manufacturer of RFID tags, RFID smart labels, and RFID reader systems. Approaching 500 million RFID tags manufactured, TI-RFid™ technology is used in a broad range of RFID applications worldwide.
HW	ThingMagic, Inc. www.thingmagic.com ; Cambridge, MA, USA	Mercury4	Founded in 2000, ThingMagic is a leading developer of radio frequency identification (RFID) technology. Mercury4™, ThingMagic's fourth generation agile RFID reader, builds on and substantially enhances the company's original platform created for early field tests of the Electronic Product Code (EPC). Designed to meet the business needs of a future where networked objects are pervasive, the Mercury4 line of RFID readers also includes an embedded reader module, Mercury4e, and a handheld reader module, Mercury4h.
HW SW	Topflight Corporation www.topflight.com ; Glen Rock, Pa., USA	Customized tags, readers, and software	Custom designed equipment allows unlimited converting of tags and labels, along with ESD protection, short web paths and setups to drive costs down, and interchangeable stations to handle intricate constructions. We can work with a variety of chips, including rewritable and read only designs. Numerous material and adhesive options can be utilized, and more complex designs can create tamper protection with device destruction capabilities.

	Company	Product	Areas of Focus
HW	Toshiba (TEC America) www.tecamerica.com ; Tokyo, , Japan	B-SX and B-SA4T printer	As part of Toshiba's contining commitment to new technology, now we provide the ability to provide a conduit to the latest information technology. This is the ability to encode RFID chips using the B-SX and B-SA series printers. To be able to meet the various standards and frequencies, Toshiba is offering the unique ability to use different readers and antenna on the same model.
HW SW	TransCore www.transcore.com ; Hummelstown, Pa., US/	eGo Family of Tags	TransCore's 60-year heritage as a transportation services company spans the development of RFID applications at Los Alamos National Labs to the world's first RFID-based electronic toll collection system to setting the standard for rail car adoption of RFID technology, with two TransCore tags on 99 percent of all rail cars in North America. With installations in 41 countries, more than 100 patents and pioneering applications of RFID, GPS and satellite communications technologies, TransCore's technical expertise is unparalleled in the markets it serves. TransCore is a unit of Roper Industries (NYSE: ROP). TransCore provides technologies and related services in areas such as radio frequency identification (RFID), satellite-based communication, mobile asset tracking, security applications, access control and comprehensive toll system and processing services.
SW	TrueDemand Software www.tdemand.com ; Los Gatos, CA, U.S.A	TrueDemand Forecasting & Replenishment	TrueDemand Software is a pioneer in the development of new supply chain applications that take advantage of both RFID and non-RFID data to help solve supply chain planning and execution problems.
HW	Turck Inc www.turck.com ; Halver, , Germany	Series of tags, transcievers, connectors including 'OC' 'Or' 'GEI' etc.	From humble beginnings in Halver, Germany to a global company with 25 worldwide locations, TURCK has become a pioneer in industrial automation technology. Our mission, as a leading value-added supplier of products to the factory and process automation markets, is to provide customers with a comprehensive line of quality and advanced technology products in a fast, flexible and accurate manner. Our extensive line of products includes thousands of sensor, interface, cordset and connector combinations that meet clients' needs.
HW	Tursso Companies Inc. www.tursso.com ; St. Paul, MN, USA	Labeling	RFID 13.56 Mhz ISO15693
HW SW Svc	Tyco Sensormatic www.sensormatic.com ; Boca Raton, FL, USA	Agile 2 Antennas, UHF Readers, Device Commanders and EOS Software, Labels	Sensormatic solutions provide vital loss prevention and support for the retail industry. Backed by more than 1,500 patents and patents-pending for innovative, market-leading technologies, our solutions portfolio is manufactured and supported by a division of Tyco Fire & Security. From the front of the store through the entire retail supply chain, our products and services help keep losses lower – and profits higher.

	Company	Product	Areas of Focus
HW SW Svc	Unified Barcode & RFID, Inc. www.unifiedbarcode.com ; Palatine, IL, USA	Systems Integration Services	Whether you are looking to implement your first barcode system, upgrade to an RFID system, or replace outdated hardware, Unified Barcode & RFID provides expert data collection solutions to meet your organization's needs. The company carries various lines, as well as custom software and consulting.
HW SW	Unova Inc (Intermec Technologies) www.intermec.com ; Everett, WA, USA	Intellitag Genereation 2 UHF RFID, RFID Deploy Suite	With years of experience installing complete RFID systems around the world, Intermec is committed to working with companies to make sure each implementation of RFID technology is successful, today and tomorrow. Intermec supports open standards and global interoperability, ensuring companies' investment protection as RFID global standards continue to evolve.
HW	UPM Raflatac www.upmraflatac.com ; Tampere, n/a, Finlan	HF & UHF tags and inlays	UPM Raflatac is a world-leading supplier of pressure sensitive labelstock for a wide variety of needs in product and information labeling. In addition, the company is at the global forefront in the development and high-volume production of radio frequency identification (RFID) tags and inlays. The company has a global service network consisting of 11 factories on five continents. UPM Raflatac is part of UPM, a leading global forest products company.
Svc	VeriSign www.verisign.com ; Dulles, Virginia, USA		VeriSign's Intelligent Supply Chain Services platform enables trusted, secure and scalable information exchange and collaboration among global supply chain participants.
HW Svc	WAN/LAN Solutions, Inc. www.wanlan.net ; Roseville, CA, USA	Conectag products	RFID (Radio Frequency Identification) tags.
HW	Wavetrend (UK) Ltd www.wavetrend.net ; Richmond, Surrey, UK	Tags	Founded in 1999, Wavetrend is head-quartered in Richmond, London, and has offices in Washington DC and Johannesburg. Wavetrend is a world-leading provider of Ultra Long Range (ULR) Active Radio Frequency Identification (RFID) technology. In collaboration with its global network of strategic and accredited channel partners, which includes IBM, Motorola, QinetiQ, Red Prairie and Symbol, Wavetrend provides hardware and software solutions for the RFID market. At the core of the group's technology is an open platform architecture which is highly scalable and simple to integrate. ULR active RFID tags contain their own power source, enabling real-time asset monitoring and tracking over distances of less than 1 metre to greater than 250 metres. Internal battery life of up to 8 years.
HW	Weber Marking Systems, Inc. www.webermarking.com ; Arlington Heights, I	SmartTrak RFID Labels	Weber is a leading worldwide manaufacturer and supplier of labeling solutions, including label printers, applicators and printer-applicators for bar code and RFID encoding applications, plus complementary pressure-sensitive and RFID smart label materials and label design/RFID encoding software.
HW	WhereNet www.wherenet.com ; Santa Clara, CA, USA	Real-Time Wireless RFID Asset Tracking and Locating Systems	WhereNet offers a wireless location and communication infrastructure that reliably manages mobile resources and delivers a complete return on investment within 6-12 months. Based on patented, standards-compliant technology resulting from a collective 100+ years of development.

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Company	Product	Areas of Focus
HW WincoID www.wincoid.com ; Nashua, NH, USA	Smartlabel, WAWF-DD250 with integrated processing UID and RFID support	Many industries are affected by both Federal and industry compliance mandates and some will have to comply with several mandates. Each has its own set of rules, and the penalties for non-compliance down to the level of "a mistake" can cost you more than your profits on a shipment. WincoID aims at assisting those under mandate to acquire RFID tagging.
HW Svc Wireless Network Solutions www.wirelessns.com ; Wayzata, MN, USA	RFID Quick Start kit	WNS identifies key business processes that can be improved with wireless data technology, creates data collection solutions, validates and integrates the solution into your existing infrastructure utilizing Web tools or Telnet Client tools to ensure connectivity and communication completeness.
HW WJ Communications www.wj.com ; San Jose, CA, USA	RFID modules, readers, semiconductors,	WJ Communications, Inc. is a leading designer and supplier of RF solutions serving multiple markets targeting wireless communications, RFID, broadband cable, and defense and homeland security. WJ addresses the RF challenges in these multiple markets with its highly reliable amplifiers, mixers, RF integrated circuits (RFICs), RFID reader modules, chipsets, and multi-chip (MCM) modules.
HW Worldlabel.com www.worldlabel.com ; New York, New York, L	Xtrack RFID Smart labels embedded with	Labeling
HW Xterprise Incorporated www.xterprise.com ; Carrollton, TX, USA	XARM™ 1000	Xterprise develops RFID supply chain solutions comprised of material handling, system hardware and RFID Service Oriented Architecture (SOA) applications software, enterprise systems integration, data analytics, demand signaling applications and remote solution support. Xterprise works with other RFID & Supply Chain industry leaders, including Alien Technology, Zebra Technologies, Symbol, Apriso, TrueDamand, DPI, Weber and others. These technology vendor's products are displayed in Xterprise's 6,000 square foot RFID Solution Center, where their vertical market solutions are showcased.
HW Zebra Technologies www.rfid.zebra.com ; Vernon Hills, IL, USA	R110Xi	A proven pioneer in RFID, Zebra has helped lead international development for nearly 11 years. Zebra's UHF RFID printer/encoders are now available for sale in 39 countries on five continents worldwide.
HW ZeitControl Cardsystems www.zeitcontrol.de ; Minden , , Germany	BasicCard	Produces the first smart card available in BASIC.

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